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ARTICLES

Simple Sequential Procedure for Modeling of Item Non-Response in Econometric Analysis: Application to CV Survey Data

William M. Fonta[1,2], Elias T. Ayuk[1] and H. Eme Ichoku[2]

Item non-response occurs when respondents fail to provide answers to some or all of the questions posed during survey interviews. The standard procedure is to exclude such responses from the econometric analysis. This may be appropriate if the sample included does not differ significantly from those excluded in the analysis. If this is not the case, the econometric analyst faces a sample selection bias problem. The aim of this paper is to provide further evidence using a simple sequential procedure to deal with the problem when using non-randomly selected samples in social science research. The procedure entails different levels of estimation and diagnostic with the Ordinary Least Squares (OLS), Heckman's 2-step and Full Information Maximum Likelihood (FIML) estimators. In the application context, we found the FIML estimator to be more efficient in dealing with sample selection bias than the Heckman's 2-step approach.

Key Words*:* Survey data; Item non-response; Sample selection bias; Sequential procedure; OLS, Heckman 2-step and FIML estimators.

JEL Classification: C13, C25, C42, C51.

1.0 Introduction

One of the most widely encountered problems in sample survey is to record a large number of responses with zero or missing values (i.e., item non-responses). This may be ascribed to a variety of reasons such as free riding, adverse reaction to the interview in general, inadequate comprehension of the intent of the survey question or possibly, the lack of willingness or motivation to disclose the required information (Beatty and Herrmann, 2002; Krosnick, 2002; Strazzera *et al.*, 2003a; Amahia, 2010; Okafor, 2010; Fonta *et al.*, 2010). In most applied social science research work, the standard procedure for handling item non-response problem is to delete such responses from the econometric analysis. However, from a statistical point of view, this may be incorrect if the sub-sample that is excluded is systematically different from that which is included at least in terms of the covariates employed in the econometric analysis. When this is the case, the econometric analyst faces a sample selection bias problem. This could generate inconsistent parameter estimates for reasons similar to those described in Heckman (1976 and 1979), Madalla (1983), Amemiya (1984 and 1985), Vella (1992 and 1998), Melino (1992), Breen (1996), Fonta and Ichoku (2006), Fonta and Omoke (2008), and Fonta *et al.*, (2010). In such circumstance, a sample

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selection model is required to detect, and if necessary, to produce correct estimates for the econometric parameters of the model (Heckman, 1979; Madalla, 1983; Strazzera *et al*., 2003a & 2003b).

The use of the Heckman's 2-step technique to detect and correct for sample selection bias problem, has largely dominated the econometric literature. Although widely used, it has been shown to sometimes perform poorly due to the presence of collinearity problems between the regressors of the 2-step equations (Winship *et al*., 1992 and Strazzera *et al*., 2003a). The main objective of this paper is therefore to illustrate with the aid of a survey data, a simple econometric procedure for simultaneously dealing with the problems of sample selection bias and collinearity when 'item non-responses' are excluded on ad hoc basis in econometrics estimation. The econometrics procedure involves different levels of estimation and diagnostics with the OLS, Heckman's 2-step and the Full Information Maximum Likelihood (FIML) estimators. The duration of the estimation procedure will depend on the diagnostic test results obtained at each stage of the modeling process (Fonta *et al*., 2010).

The rest of the paper is sub-divided as follows: in section II, we present the structural econometric models developed for the empirical estimation followed by the sequential guidelines. In section III, the empirical application is presented using a contingent valuation method (CVM) survey data. Section IV reports the empirical findings while sub-section V concludes the paper.

2.0 Econometric Models and Sequential Procedure

For empirical purposes, let us consider the following two-equation latent dependent variable model given by,

$$u_i^* = w_i'\alpha + \mu_i \tag{1}$$

$$v_i^* = y_i'\beta + \varepsilon_i \tag{2}$$

where w_i and y_i are k and j row vectors of exogenous explanatory variable that are assumed to be determinants of u_i and v_i, and α and β are k and j column vectors of parameters to be estimated for the model. In this simplistic model, it is assumed that,

$$u_i = \begin{cases} 1 & if \quad u_i^* > 0 \\ 0 & \quad u_i^* \le 0 \end{cases} \quad \text{and} \quad v_i = \begin{cases} v_i^* & if \quad u_i = 1 \\ 0 & \quad u_i = 0 \end{cases} \tag{3}$$

In words, we observe u_i a dummy variable, which is the realization of an unobserved (or latent) continuous variable u_i^* with error term μ_i. For values of $u_i = 1$, we observe v_i, which is the realization of a second latent variable v_i^* with

error ε_i. The joint distribution of (μ_i, ε_i) is assumed to be bivariate normal with zero means, variances equal to 1 and correlation ρ.

In Heckman (1979), u_i^* expresses the desire of women to join the work force (i.e., participation equation) and v_i^* measures the observed wages of working women (i.e., outcome equation). Heckman showed that if we estimate the determinants of wages based only on the sub-sample of women working, it could be incorrect if there is bias introduced by self-selection of women into the work force as follows:

$$E[v_i^* | u_i = 1] = y_i'\beta + E(\mu_i | \varepsilon_i > -w_i'\alpha)$$
$$= y_i'\beta + \rho\varepsilon \frac{\phi(w_i'\alpha)}{\Phi(w_i'\alpha)} \quad (4)$$

where the term $\rho\varepsilon \frac{\phi(w_i'\alpha)}{\Phi(w_i'\alpha)}$, is the bias due to self-selection of female participants into the work force. Heckman termed it a simple specification error or omitted variable problem, which is akin to the problem of excluding item non-responses from econometric estimation on *ad hoc* basis (Heckman, 1979). Heckman therefore proposed a consistent 2-step estimator that will allow for the possible correction of the bias, and hence, produce correct estimates of the parameters of the models and the central tendency measures.

The Heckman procedure is carried out in two stages. First, note that the conditional expected value of v_i conditional on $u_i = 1$ and on the vector y_i is given by,

$$E[v_i | u_i = 1, y_i] = y_i'\beta + \rho\sigma_i\lambda_i(w_i'\alpha) \quad (5)$$

where, $\lambda(w_i'\alpha) = \frac{\phi(w_i'\alpha)}{\Phi(w_i'\alpha)}$ is the inverse of the Mills ratio, and ϕ and Φ are the standard normal density and standard normal distribution functions respectively. The first step of Heckman's proposal is to use a Probit model of equation (1) to obtain a consistent estimator of α and then use the estimated α to construct the variable λ (i.e., the inverse mills ratio). In the second step, including λ as a regressor in equation (2), allows us to estimate y and ρ consistently by OLS (Heckman, 1979). A by-product of the 2-step approach is a relatively simple test for identifying the presence of sample selection bias. Under the null hypothesis of no selection bias, (i.e., $\rho = 0$), the usual formula provides a consistent estimate of the covariance matrix of y. Under the alternative hypothesis $\rho \neq 0$, Heckman suggests the use of t-test of the coefficient on the λ variable as a test of sample selection bias (Heckman, 1979).

However, as earlier indicated, a well-known weakness of the 2-step approach is the problem of collinearity between the regressors of the Probit and OLS equations. Based on this, Strazzera *et al.*, (2003a) suggested the use of the following sequential guidelines to simultaneously deal with the problems of selectivity bias and collinearity: (a) First, estimate a two-part model for the separate equations (i.e., participation and outcome) using an OLS estimation technique (i.e., Craig's model), (b) Second, based on the two equations, estimate the models using Heckman's 2-step approach and control for the significance of the coefficient on λ (i.e., the inverse mills ratio), (c) Third, check for the presence of collinearity by regressing λ against the covariates of the outcome equation. If there are no collinearity problems (i.e., judging from the resultant R^2 from the OLS estimation procedure), and the coefficient on λ is not statistically significant, accept the plain OLS estimates obtained at the first stage. If there are no collinearity problems but the coefficient on λ is statistically significantly, accept the 2-step estimates obtained at the second stage. However, if there are some collinearity problems, proceed to the fourth stage as follows, (d) Based on the two equations, estimate a FIML sample selection model, and check for the presence of correlation by observing the significance of the parameter ρ. If ρ is not statistically significant, accept the plain OLS estimates obtained at stage one; otherwise, accept the estimates obtained from the FIML sample selection model.

The log-likelihood to maximize to obtain the FIML estimates is given by,

$$L = \sum_0 \ln(1-\Phi_i) + \sum_1 \frac{\ln 1}{\sqrt{2\pi\sigma^2_{\varepsilon_i}}} - \sum_1 \frac{1}{2\sigma^2_{\varepsilon_i}[v_i - y_i\beta]^2} + \sum_1 \ln \Phi_i \left(\frac{w_i'\alpha + \rho[(v_i - y_i\beta)/\sigma_{\varepsilon_i}]}{(1-\rho^2)^{\frac{1}{2}}} \right). \quad (6)$$

Maximization of this function produces simultaneous estimation of the parameters of both the participation and outcome equations.

3.0 Application to Contingent Valuation (CV) Survey Data

In 2008, the researchers conducted a study of the willingness to pay (WTP) of households to finance one aspect of the new National Health Insurance Scheme (i.e., community-based health insurance - CBHI) in the Nsukka Local Government Area (LGA) of Enugu State, Nigeria, using the contingent valuation method(CVM). The broad objective of the study was to design an improved planning technique that could help elicit information on the value placed by the Nsukka inhabitants on communal financing of the scheme, and decide appropriate household insurance premiums or levies. A key concept in such an improved planning technique is that of the WTP of households in the area to finance the scheme. Eliciting households' WTP, with the aid of the CVM, to inform the design of CBHI schemes is not a novelty in Africa. It has been used by Asenso-

Okyere *et al*., (1997); Asfaw and Braun (2004); Dong *et al*., (2003); Binam *et al.*, (2004); Fonta and Ichoku, (2005); Basaza et al., (2008); Ataguba *et al.,* (2008); Onwujekwe *et al*., (2009 and 2011); Fonta *et al.*, (2010 and 2011), to inform the design and initiation of CBHI schemes in Ghana, Ethiopia, Burkina Faso, Cameroon, Uganda and Nigeria, respectively.

The survey instrument was a pre-tested interviewer-administered structured questionnaire that was divided into two broad categories. The first category elicited information on households' socio-economic and demographic characteristics, health status, assets holding, housing and wealth information and community variables. The second mainly focused on the contingent valuation (CV) scenario under which the evaluation of the proposed CBHI scheme took place. This scenario detailed the nature of the new CBHI initiative being proposed in Nsukka, the current health service delivery situation in Nsukka, the institutional setting in which the proposed scheme will be provided, and how each household will have to pay to finance the scheme (i.e., quarterly contributions). The value elicitation formats used was the Dichotomous Choice (DC) format buttressed with open-ended follow-up and debriefing questions. Our choice of using the DC elicitation format is because of its incentive-compatibility feature compared to other formats (Mitchell and Carson, 1989). Five starting prices were used in the DC question as follows: N200, N400, N600, N800 and N1000. These bids were based on an earlier pilot study in the community. These prices were assigned randomly and roughly proportionately to the number of households in the study sample.

A two-stage selection procedure was adopted for the study design. The first stage was a random selection of five communities out of the 15 communities in Nsukka namely; Obukpa, Edem, Nsukka, Ibagwa-Ani and Ehalumona. From these five communities, the Federal Office of Statistics (FOS) now National Bureau of Statistics (NBS) enumeration-listing booklet was used to select four Enumeration Areas (EAs) from each of the five communities. In the second stage, a simple systematic random sampling technique was used to select 19 households from each of the EAs. This gave a total sample size of 380 households[3]. The sampled households were appropriately weighted during analysis. Under the weighting, each household selected from each EA was weighted to make it representative of the entire EA such that the sum of the weights for each EA equaled the approximate number of households in that EA.

During the CV interview, if a respondent said yes to the initial WTP bid proposed to him/her, a follow-up question was asked to elicit his/her maximum WTP

[3] This optimal size was obtained using the Taro Yamane (1967) specification. That is, $n = N / (1 + N(e)^2)$ where n equals to the sample size to be estimated, N stands for the population size (i.e., household size), and e represents the margin of error.

amount to finance the scheme. However, if the answer was no, another follow-up question was asked, to find out the respondent's actual WTP amount if different from that of the proposed bid. If no WTP amount was reported at this stage, a debriefing question was posed to the respondent to find out the reason(s) for not being willing to pay to finance the scheme. This was basically to distinguish 'item non-responses' or invalid responses from the valid responses. Overall, out of a total of 380 households randomly selected for interview, 235 (61.8%) provided valid responses to the valuation question, 74 respondents (19.5%) provided invalid responses (i.e., item non-responses)[4] to the valuation question, while about 71 households refused outright to be interviewed.

4.0 Empirical Results

4.1 Sample Statistics

Table 1 presents the summary statistics describing the sampled population. On average there are 6 members in a household living in an average of four rooms. Over 95% of thes households have bathrooms while only about 46% reported having toilet facilities. Also, most of the household heads interviewed (99%) are either employed in the formal sector by the Local Government Authority (though, mainly menial labourers and clerks) or the informal sector as craftsmen, petty-traders and farmers. Equally, most of the respondents were engaged in farming, which may not necessarily be as a full time occupation. This limited the direct observation of household income. Based on the pilot testing, a proxy measure of wealth was adopted as also suggested by Fonta (2006). Thus, the average income for the sample was calculated to be about NGN121,714.20 (US$936.3)[5] per annum or NGN10,142.85 (US$78) per month. By gender distribution, about 63% of the sampled respondents were male while only about 37% were females. In terms of age distribution, the average for the sample was about 51 years. The average distance from a household to the nearest health centre was estimated to be about 3.3km.

[4] The main reason for such invalid responses was because of 'protests' zeros and outliers. 'Protests' zeros, according to Freeman (1993:187), occur when respondents reject some aspect of the constructed CV market scenario by reporting a zero value even though they place a positive value on the amenity or resource being valued. On the other hand, outliers are determined by the researcher based on some measures such as the share of WTP in income or what Mitchell and Carson (1989: 226 –227) called α -trimmed mean where the analyst chooses the value of α.

[5] At the time of the survey, USD1 was approximately ₦130.

Table 1: Descriptive Statistics for the Sampled Households

Variable	Measurement/Definition	Mean/ Proportions	Std. Dev.
Age	Age of the respondent at the last birthday (in years)	51.69	12.56
Bathroom	1 if own a bathroom and, 0 otherwise	0.96	0.19
Bid	Starting prices in Naira	598.71	283.3
Borrowed_amount*	Amount borrowed for treatment in the last four weeks prior to survey	666.36	3,251
Distance	Km to nearest health centre	3.33	2.09
Dwelling	1 if building is constructed with cement/concrete and, 0 otherwise	0.85	0.36
Educ	Education attainment of household head and 1 if above primary school and 0, otherwise	0.89	0.95
Employed	1if employed and, 0 otherwise	0.89	0.11
Floor_material	Nature of floor material and 1if cement/tiles/concrete and 0, otherwise	0.82	0.39
HHnumber	No. of adults and children being fed	6.1	3.09
Hstate	Respondent's health status at time of the interview and 1 if good and, 0 otherwise	0.67	0.79
Know_insurance	1 if knowledgeable about health insurance, 0 otherwise	0.11	0.31
Male	1 if male and, 0 otherwise	0.63	0.48
Meanstreat	Means of seeking treatment during illness. 1 if orthodox means and, 0 otherwise	0.55	0.5
Numrooms	Number of sleeping room	4.13	1.61
Participation	1 if participated/participating in any health insurance scheme and, 0 otherwise	0.03	0.18
Qhcentre	Rating of the quality of the health centers. 1if judged as being good and, 0 otherwise	0.68	0.75
Sick	1 if sick two weeks prior to survey and, 0 otherwise	0.40	0.49
Toilet	1if own toilet, 0 otherwise	0.46	0.5
Treatamount*	Direct + indirect cost incurred in treatment a household member in the last four weeks prior to survey (Naira)	763.35	2,612
Trust	1 if confidence in trust fund and, 0 otherwise	0.78	0.82
Wealth_measure*	Assets and other household durables (in Naira)	121,714	114,741

Furthermore, about 40% of the respondents reported that a household member fell sick within the last two weeks prior to the survey. In terms of the cost of treatment, on the average, the rural households spend about ₦763 ($5.87) within four weeks. Equally, the amount borrowed for treatment including money realized from the sale of valuable assets and property was estimated to be about ₦666 (US$5.1). This is equivalent to over 87% of the amount spent on treatment across all respondents. In terms of health insurance knowledge, only about 11% of the sample were knowledgeable about what health insurance is and only 3% reported having ever participated in any form of insurance (not necessarily health related) in the past or at present.

Additionally, the literacy level of the respondents was quite low as over 77% of the respondents have not had more than 7 years of formal education. Conversely, about 78% of respondents expressed confidence in the proposed community trust fund where funds are to be pooled together and managed by the community. This gives a high indication of credibility for establishing such a scheme. Further still, more than half (60.2%) of the sampled household heads reported their health status as being better than 'Good' at the time of interview. In terms of household health seeking behavior, about (55%) of the sample reported seeking health care services from orthodox[6] health care providers while about 45% reported patronizing unorthodox health care providers. Finally, more than half (59%) of the respondents adjudged the quality of the health care centers nearest to them as being better than 'Good'.

4.2 Sample Selection Results

Having so far discussed the characteristics of the sample, we now turn to the econometric analysis. First, it is necessary to distinguish between responses that can be considered valid (i.e., $WTP \succ 0$) and those that appear invalid (i.e., $WTP \prec 0$). Of a total of 309 interviews that were actually completed, 74 respondents (19.5%) were considered to have invalid responses to the valuation question. As earlier indicated, the main reasons for such invalid responses were because of protests respondents (30) and outliers (44). It was therefore necessary in the analysis to determine whether excluding those with invalid responses from the econometric analysis would lead to a sample selection bias problem. As noted in Strazzera *et al.*, (2003a), Fonta and Ichoku (2006), and Fonta *et al.*, (2010), a preliminary test for the presence of sample selection bias is to compare the means of household covariates between the two groups (i.e., 'valid' and 'invalid' responses) using sample mean comparison test. Any significant difference between the two groups of responses is an early warning indicator of the presence

[6] Orthodox providers are categorized as clinics, maternity centres, dispensary, and hospitals. The unorthodox providers are categorized as patent medicine stores, traditional healers and herbalists, etc.

of sample selection bias and justifies the use of a sample selection model. For some of the variables (e.g. gender of respondent, the floor type, household size, respondent's health status, means of seeking treatment, nature of dwelling unit, confidence in trust fund and distance to health centres), the difference between the two groups (i.e. 'valid' and 'invalid' responses) are quite significant at 1 and 5% levels, respectively (Table 2). If these variables influence the respondents' WTP for the new social health insurance scheme in Nsukka, then we expect the final estimates obtained from the sub-sample of households with valid responses to be affected by selectivity bias.

Table 2: Comparison of Means by Groups of Respondents

Variable Name	**Valid WTP Responses**		**Invalid WTP Responses**		**Comparison** $(\mu_1 - \mu_0)$
	Mean(μ_1)	**Std. Dev.**	**Mean**(μ_0)	**Std. Dev.**	**t-stat.**
Male	0.70	0.46	0.42	0.5	4.54***
Floormaterial	0.85	0.36	0.72	0.45	2.65***
Numrooms	4.31	1.61	3.55	1.5	3.59***
Hstate	2.71	0.76	2.53	0.88	1.78*
Meanstreat	0.59	0.49	0.42	0.5	2.62***
Dwelling	1.14	0.43	1.24	0.43	-1.72*
Trust	3.13	0.82	2.95	0.79	1.72*
Distance	3.54	2.17	2.66	1.67	3.21***
Obs.		**235**		**74**	

*, **, *** Showing significance of parameter estimates at 10%, 5% and 1% levels respectively.

Tables 3 and 4 report the results of the econometric estimations of equations (1) and (2)[7] using different covariate specifications (i.e., reduced form models) related to the effects of households socio-economic characteristics listed in table 1. However, note that the tables report the parameter estimates for the best-fit specifications (most valid reduced form models) from the two equations (i.e., participation and outcome) selected by means of likelihood ratio tests.

Starting first with the Probit results (Table 3), to explain included versus excluded households in the participation equation (i.e., Probit estimation), the gender of the respondent seems to have an effect on the probability to participate or not to finance the scheme. In particular, being a male-headed household increases the probability to participate in financing the scheme. This could be linked to the

[7] Note that in our empirical context, equation (1) expresses the desire of households to participate in financing the scheme, while equation (2) measures the observed WTP amounts of households. w and y are the exogenous explanatory variable listed in Table 1, which are the determinants of u_i and v_i respectively.

roles of men in the community who have traditionally been charged with the responsibility of catering for the family financially. Similarly, falling sick two weeks prior to the survey increased the probability to participate. This may perhaps be because implementing the scheme in the area is expected to improve health care delivery services and hence, household health status.

Table 3: 2-steps (No Selection) and FIML Estimates (No Selection)

	Participation Equation			
Parameter	**Probit Estimates**		**FIML Estimates**	
	Estimates	**Std. Err.**	**Estimates**	**Std. Err.**
Constant	2.28	1.393*	2.28	1.351*
Male	0.821	0.185***	0.784	0.183***
Sick	1.183	0.704*	1.178	0.690*
Floor_material	0.485	0.245**	0.573	0.237**
Ln_Distance	-0.408	-0.138***	-0.432	-0.134**
Ln_wealthmeasure	0.278	0.106***	0.281	0.105***
Ln_Bid	-1.016	0.189***	-1.021	0.184***
% correctly predicted		94.49%		94.50%
Observation		**309**		**309**

*, **, *** Showing significance of parameter estimates at 10%, 5% and 1% levels respectively.

Equally, household income also had an effect on the probability to participation in financing the scheme and those with higher income had higher participation rates: possibly because, a higher-income earner apparently has a greater demand for better health care facilities than a lower-income earner. Finally, households that were farther away from the existing health care facilities in the community had a higher participation rate than those closest. Possibly because the farther away a household is from the nearest health center, the higher the cost of transportation and frequency of visits is lower. This may explain why such households are more willing to pay to finance the scheme than those living closer to existing healthcare facilities.

In Table 4 (i.e., the outcome model) where the observed WTP amounts of households' is the dependent variable, richer household heads were willing to pay higher amounts than poorer household heads (presumably for the same reason that they are also more willing to participate to finance scheme). Another important determinant of households WTP for the scheme is household knowledge about health insurance and, the more knowledgeable a household head is, the higher the stated amount for the scheme. Similarly, the health status of a household head was a significant determinant of the WTP amount. Heads of households with better health status were willing to pay less than those with poor health status. Education

was equally a significant determinant of household WTP for the scheme and the higher the educational attainment, the higher the stated amount for the scheme.

Table 4: OLS (No Selection), 2-step (Selection) and FIML (Selection)

	Outcome Equation					
Parameter (1)	**OLS (No selection)**		**2-Step Estimates**		**FIML Estimates**	
	Est. (2)	**S. Err. (3)**	**Est. (4)**	**S. Err. (5)**	**Est. (6)**	**S. Err. (7)**
Constant	2.614	0.904***	2.212	0.642***	2.277	0.640***
Age	-0.005	0.004	-0.007	0.003*	-0.007	0.003**
Knowinsurance	0.335	0.153**	0.386	0.122***	0.381	0.122***
Hstate	-0.084	0.068	-0.112	0.058*	-0.116	0.058**
Floor	-0.300	0.135**	-0.255	0.113**	-0.238	0.113**
Toilet	0.271	0.100***	0.375	0.082***	0.363	0.082***
Ln_Wealth measure	0.152	0.056***	0.137	0.048***	0.139	0.048***
Ln_Bid	0.392	0.078***	0.437	0.070***	0.43	0.069***
Mills lambda (λ)			0.357	0.146**		
Rho (ρ)					0.470	0.177***
Sigma (σ)				0.621		0.611
Adjusted R^2		0.26		0.15		
Observation		309		235		235
Log-Likelihood	-337.674					

*, **, *** Showing levels of significance of parameter estimates at 10%, 5% and 1% respectively.

Also, male headed households are more willing to pay higher amounts than their female counterparts, which might be as a result of cultural reasons where the males are responsible for most financial decisions within the household. Other important determinants of household WTP for the scheme includes; the household size, distance to health care facilities, and the number of rooms in a household.

4.3 Implications of Sequential Procedure on Mean WTP Estimates

Having analysed the determinants of households WTP for the scheme in the light of sample selection bias, we now turn our attention to the empirics of the different estimation techniques (i.e., the OLS, 2-step and FIML estimators). Columns 2 and 3 of table 4 report the parameter estimates obtained from the plain OLS estimation technique at stage (a) of the modelling process. As observed, the parameter estimates are slightly higher than those obtained using Heckman's 2-step approach and the FIML estimator. This is partly as a result of including all the observation (i.e., 'valid' and 'invalid') in the estimation procedure without correcting for sample selection bias. Since there is no way to judge *a priori* from

the OLS estimates any evidence of sample selection bias, wrong conclusions can be deduced that excluding 'invalid responses' from the analysis may have little or no effects on the final WTP estimates obtained from only the sub-sample of households with valid responses. However, when we considered the 2-step estimates obtained at stage (b) of the sequential procedure when sample selection bias correction took place (i.e., columns 4 and 5 of same table), the interpretation becomes slightly different. The standard errors for the coefficient estimates showed higher levels of significance with also more significant parameter estimates. However, besides this information, the result gives us no additional clue about the degree of correlation between the regressors of the participation and outcome equations: a well-known weakness of the method and a critical assumption of econometric estimation in general (Fonta *et al.*, 2010).

To therefore check for the presence of collinearity in the 2-step estimates obtained at stage (b), we ran an OLS regression of mills lambda (i.e., λ) against the covariates of the outcome equation as suggested in the sequential guidelines[8]. The resulting $R^2 = 0.51$ from the estimation procedure indicates a moderate level of correlation. Since the 2-step estimates suffer from collinearity problems, we proceeded to stage (d) by estimating a FIML sample selection model. The regression results are reported in columns 6 and 7 of Table 4. As expected, ρ is statistically significant indicating a high level of correlation between the regressors of the two equations. However, note that if the coefficient on ρ was not statistically significant, the plain OLS estimates obtained at stage (a) would have been preferred to the FIML estimates obtained at stage (d). Equally, if the 2-step estimates obtained at stage (2) were somehow free from collinearity problems, the results would have been as efficient as those obtained with the FIML estimates at stage (d).

Table 5: Descriptive Stats of Quarterly Mean WTP Estimates for the Scheme

Modeling Method	Obs.	Mean	95% Conf. Int.
All Respondents (OLS)	309	392.20($3.0)*	337.0 – 447.5 ($2.6 – 3.4)
OLS (Selection)	235	509.94($3.9)	485.1 – 534.8 ($3.7 – 4.1)
Heckman's Model	235	458.67($3.5)	434.3 – 483.0 ($3.3 – 3.7)
FIML Estimator	235	466.68 ($3.6)	442.2 – 491.2 ($3.4 – 3.8)

* The figures in parenthesis represent the US Dollars equivalence

Although the parameter estimates obtained using the Heckman's 2-step estimator are not much different from that of the FIML estimator, differences normally occur when calculating the final mean WTP estimates for project or policy

[8] The regression results are however not reported here but the procedure for doing this could be obtained from the authors on request.

purposes. Table 5 reports the calculated mean WTP estimates using the three different estimators. The first row of table 5 reports the mean WTP estimates calculated for all the respondents (i.e., 'valid' and 'invalid' responses) based on the plain OLS estimation at stage (a). As shown, for all the respondents, the mean quarterly WTP estimate for scheme is about NGN392.20 ($3.0) with associated confidence intervals of 337.0 – 447.5 ($2.6 – 3.4). The second row reports the estimates calculated for only the sub-sample of respondents with valid responses without correcting for sample selection bias. As observed, the estimates are quite high when compared to the other mean WTP estimates obtained from the different estimation methods. It is biased upwards as equally suggested by the positive sign of ρ. Note that if ρ had been negatively signed; the WTP estimates obtained from plain OLS without sample selection bias correction, would have been biased downwards. The third and fourth rows report WTP estimates calculated using Heckman's 2-step approach and the FIML sample selection model when sample selection bias correction took place. As further observed, the two estimates are slightly different although the parameter estimates of the two estimators are not much different from each other. The same can be said about their confidence interval estimates; those of the FIML estimators are slightly higher than those of the 2-step approach. This obviously suggests that the choice of the estimation technique in econometric analysis of survey data can significantly affect the final parameter estimates obtained from a given sample for welfare estimates and policy conclusions. This is, if care is not taken to address peculiar sample survey problems that might arise from modeling of item non-response such as selectivity bias and the problem of collinearity.

5.0 Conclusion

This paper had several motivations. Firstly, the study was motivated by the need to highlight the importance of choosing appropriate econometric techniques when using non-randomly selected samples to estimate behavioral relationships in applied social sciences research works. Secondly, it was equally motivated by the need to design an improved planning methodology that could help elicit information on the value placed by rural households in Nigeria to finance one aspect of the new National Health Insurance Scheme (i.e., the community-based social health insurance scheme).

In the application context, some important methodological and policy findings we equally arrived at towards the study objectives. Firstly, the study found out that when item non-responses are excluded from econometric estimation on *ad hoc* basis, the social science researchers may encounter a sample selection bias problem, which may have two consequences namely; (a) the empirical analysis may generate inconsistent parameter estimates for reasons similar to those described in Heckman (1976 & 1979), and the final estimate obtained for policy purposes from the included sub-sample is likely to be biased. Secondly, the study

also revealed that in the absence of any collinearity problems between the regressors of a two-equation latent dependent variable models, the Heckman's 2-step estimator would produce parameters estimates that are equally as efficient as the FIML sample selection estimator. Thirdly, the results further revealed that the CV survey device can be successfully used to support the design and implementation of CBHIS in rural Nigeria.

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Reactions of Stock Market to Monetary Policy Shocks During the Global Financial Crisis: The Nigerian Case

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This paper seeks to assess the reactions of Nigeria's stock market to monetary policy innovations during the period of global financial crisis on the basis of monthly data over the period January, 2007 to August, 2011. In particular, stock market return was regressed against major monetary policy instruments; money stock (M_1, and M_2) and monetary policy rate (MPR). The theoretical basis for the paper stems from the works of new classical macroeconomics and rational expectation hypothesis (REH). Lucas (1972) postulated that only the unanticipated monetary shock influences real economic activity. Using the GARCH by developed Engle and Bollerslev (1986) and EGARCH by Nelson (1991) methodologies, the paper empirically assessed the impact monetary policy innovations exerts on stock returns in the Nigeria's Stock Exchange (NSE) market during the period of the crisis. Results from the empirical analysis revealed that the unaticipated component of policy innovations on M_2 and MPR exerts distabilizing effect on NSE's returns, whereas the anticipated component does not. This lends support to the REH argument for the Nigerian stock market. The pqper strongly recommends realistic and timely policy pronouncements by the MPC to achieve stability in the market.

Key Words*:* Monetary Policy, GARCH, EGARCH, Rational Expectation Hypothesis.
JEL Classification: E44, E52, G01

1.1 Introduction

Among others, the mandate of the Central Bank of Nigeria (CBN) is the promotion of monetary and price stability and a virile financial system. Achieving these would entail the use of wide range of instruments at the disposal of the CBN such as the monetary policy rate, open market operations through buying and selling of government securities and changes in monetary aggregate; narrow and broad money, CBN certificates, special Nigerian treasury bills (NTBs), discount window operations, repurchases transactions (repo) bills discounting, pledges and open buy back (OBB). The overall aim is to maintain a favorable and conducive environment for economic growth and development.

Literatures abound on the link between monetary policy and other broad macroeconomic aggregates; output, employment, prices, exchange rates, balance of payments, and the like. Equally, there is a strong connect between stock market performance and sound financial system, which monetary policy seeks to create.

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The theoretical basis for this stems from the works of new classical macroeconomics, *rational expectation hypothesis (REH),* in the early 1970s. The hypothesis according to Lucas (1972) postulates that unanticipated, and not anticipated monetary shocks can influence real economic activity. The anticipated component according to him would be rationally taken into account by economic agents in their decision making, and hence will evoke no effect on output and employment. In a way, the hypothesis supports the neutrality[2] of anticipated monetary shock. Early investigations in the area started with the works of Blanchard (1981) and Svensson (1986) on the theoretical analyses of stock market response to monetary shocks using rational expectations models with sticky goods prices and flexible asset prices. A classic empirical study by Kuttner (2001) verified the effect of unanticipated changes in the US policy rate on financial variables in line with rational expectations arguments and discovered it had no impact. Other empirical studies focusing on stock market response to monetary shocks, report that a 25-basis point increase in the Fed funds rate is associated with an immediate decrease in broad US stock indices that ranges from 0.6 to 2.2 percent, sample size and estimation method aside; Craine and Martin (2004), Rigobon and Sack (2004), Bernanke and Kuttner (2005) and Bjornland and Leitemo (2009). Earlier, Christiano *et al.* (1999) carried out an extensive survey of empirical studies on the effect of monetary policy shocks on macroeconomic variables. Juat-Hong (2009) reveals that only the anticipated component of money supply shock affects the volatility of equity returns in Malaysian market but the unanticipated components do not.

1.2 Background of the Study

Monetary policy management is a routine thing, while the desire to attain a specific macroeconomic objective often conflicts with the attainment of other competing objectives. More so, financial integration and unrestricted trade flows exert influences on domestic financial policies. It is, therefore difficult, especially given the above theoretical underpinning, to disentangle the conduct of monetary policy from events at the global and domestic stage/ economy and the Nigerian

[2] The proponents of *neutrality* of money argued that a change in the stock of money affects only nominal variables in the economy such as prices, wages and exchange rates but no effect on real (inflation-adjusted) variables, like employment, real GDP, and real consumption. The term was originally coined by Friedrich Hayek (1933), and then later the Keynesian economists.

Stock exchange market (NSE) in particular. More profoundly, is when such permutations coincide with a particular episode – the global financial crisis, 2008 - 2011. The impact of the crisis on the financial sector of the economy in general and the NSE was limited, largely owing to the low level of financial integration with the global economy. Earlier, activities in the market peaked during the banking sector consolidation/ recapitalization which started in 2005 and up until 2008. Thus, the market experienced sustained increase in stock prices with investors reaping tremendous profits[3].

The advent of the crisis rattled the market and caused the market indices to crash. Evidences, for instance, from the market showed that market capitalization (MC), which stood at 10.18 trillion Naira in the year 2007, dropped to 6.96 trillion in 2008 and further down to 4.99 in 2009. This heaved up in 2010 to 6.29 trillion. In similar vein, the All-Share index (ASI), which was 57,990.12 Naira in 2007, dropped to 31,450.78 and 20,827.17 in 2008 and 2009, respectively, and eventually picked up at 25,861.93 in the year 2010. Policy responses during the turmoil by the NSE and regulators like the Securities and Exchange Commission (SEC) were: review of trading rules and regulations and delisting of some 19 moribund companies. The corporate governance framework was also strengthened in both the NSE, and the regulator, SEC, market signals were sharpened and standards were raised.

In what seems to be a bail out attempt by the CBN and the Bank of industry (BOI), a number of schemes and revival funds were established for revitalization of the real sector of the economy. For instance, N200 and N300 billion were raised through debenture stock issued by the BOI for restructuring and refinancing of small and medium scale enterprises (SMEs) and as intervention fund in the power and aviation industries. Similarly, the CBN in collaboration with affected ministries packaged credit guarantee schemes in the areas of agriculture, SMEs and Textile industries in the country to the tune of N500 billion. Last, but by no means the least, the CBN injected N620 billion into 10 ailing banks in June, 2009 as a long-term capital loan at 11.0 percent and later 8.0 percent to ease illiquidity in the banks. Given the magnitude and short span of the intervention – between early 2009 and 2010, the combustion and meltdown in the

[3] Aliyu, S. U. R. (2009) "Stock Prices and Exchange Rate Interactions in Nigeria: A Maiden Intra-Global Financial Crisis Investigation", The Icfai University *Journal of Financial Economics*, Vol. VII, Nos. 3 & 4, pp. 5 – 17.

global economy, the combined effects of these policy interventions, no doubt posed serious monetary policy challenges, especially to the CBN and the specific implications for the NSE.

Macroeconomic indicators such as the level of foreign reserves, for instance, dramatically went down due to large scale monetization of the economy and the shortfall in the level of oil revenues. The reserve, which stood at $62.08 billion as at September, 2008, before the crises, dropped to $42.4 billion as at December, 2009. The exchange rate, which has a strong tie with stock market, which hitherto remained stable at ₦116.20, depreciated by up to 12.95%, that is, ₦131.5 in December, 2008. Although the CBN returned to the Retail Dutch Auction System (RDAS), yet the exchange rate keeps on depreciating. It stood at ₦162.00 in June, 2010. This was largely due to mounting pressure from the demand side.

The broad money supply, M_2 was equally expanded through the indirect instruments in order to ease pressure on both money and capital markets in the economy. According to the CBN (2010), the persistence of illiquidity in the banking system against the backdrop of global financial crises, prompted the adoption of far-reaching liquidity enhancing measures by the monetary authorities. The combined effects of a cut in the liquidity ratio from 40 percent to 30 percent, reduction in monetary policy rate to 9.75 percent from 10.25 percent, cash reserve ratio to 2 percent from 4 percent and open market operations (OMO) by the CBN, for instance, led to the growth in the reserve money above the benchmark level by 3.9 percent, that is, from ₦1,606 billion to ₦1,668 billion, in 2009. Consequently, the policy induced monetary expansion resulted in an end of year inflation rate of 13.9 percent in 2009, which noentheless, is slightly lower than 15.1 percent recorded a year before. The rate, however, fluctuated between 12.9 and 15.6 percent in 2010.

Given these developments, evaluating and discerning the effects of monetary policy on stock markets is important to monetary authorities for many reasons. This study adopts a micro-level approach by examining the roles of smoothed and cyclical monetary shocks on stock returns and volatility of the NSE. This is useful in the following areas:

- It helps in better understanding of the effects of anticipated and unanticipated policy shocks on stock returns and volatility. This lend support to the relevance of the so called “stock market channel” of the

monetary transmission mechanism – see Chami, Cosimano and Fullerkamp (1999).

- The study moves away from the traditional approach adopted by most empirical studies of using output or employment by using stock returns and volatility as a measure of economic activity.
- In line with standard life cycle and permanent income models, stock can affect households' consumption; reason because assets are components of life time wealth. The effect is larger in those countries where stock ownership is higher among household.
- Lastly, results will help to determine whether monetary policy shocks favorably supports stability of the NSE.

Against this background, this paper seeks to assess the reactions of the Nigeria's stock market returns to monetary policy innovations during the period of global financial crisis. The empirical analysis covers the period of January, 2007 to August, 2011, which incorporates not only the global financial crisis era, but, post banking sector consolidation era, as well. The *before-after* approach employed by the paper allows for the effect to be tracked up to and after the global financial crisis, while at the same time yielding a reasonable sample for the kind of methodology employed. The variables of interest are the stock market returns, M_1, and M_2 money supply aggregates and the monetary policy rate (MPR). The rest of the paper is structured as follows. The next section, which follows the introduction, provides short survey of related theoretical and empirical literature on the link between monetary policy shocks and stock market responses. Section three discusses the methodology of the paper while section four contains the empirical results and discussions. Lastly, section five summarizes and concludes the paper.

2.1 Theoretical and Empirical Evidences

In recent times, the relationship between monetary policy and asset prices has attracted considerable attention among researchers and policymakers. Academics and policymakers alike have debated whether monetary policy should respond to developments in financial markets (see Bernanke and Gertler, 2000, and Rigobon and Sack, 2001), and when it does, the extent to which such swings might have been caused by monetary policy itself. To understand all these, a strong theoretical underpinning becomes very necessary. Chami, Cosimano and Fullerkamp (1999), for example, suggest the existence of a stock market channel of monetary policy besides the traditional interest rate and the credit channels. In

their view, inflation induced by monetary expansion reduces the real value of the firms' assets which acts as a tax on capital stock. This could be viewed from two perspectives: first, the real value of the flow of dividends is reduced with higher inflation, and second, dividends are reduced because higher inflation reduces the supply of labor, and hence fall in production. The traditional interest rate channel was also equally investigated by Bernanke and Blinder (1992), Thorbecke (1997) and Rigobon and Sack (2003).

Alternatively, the discounted cash flow model argues that stock prices are equal to the present value of expected future net cash flows. A model by Campbell (1991) applied by Bernanke and Kuttner (2005), showed that a surprise increase in the MPR decreases stock prices in three ways: (i) decreasing the expected future dividends, (ii) increasing the future risk-free rate (iii) increasing the equity premium (above the risk free rate) required to hold equities. Monetary policy should, thus, play an important role in determining equity returns either by altering the discount rate used by market participants or by influencing market participants' expectations of future economic activity. In this regard, restrictive monetary policy is associated with lower stock prices given the higher discount rate for the expected stream of cash flows and/or lower future economic activity, while expansionary policy is commonly viewed as good news because it is usually associated with low interest rates, increases in economic activity and higher earnings for the firms in the economy. A study by Fair (2002) showed that one-third of the changes in the equity prices are associated with news on monetary policy.

From the foregoing, the impact of monetary policy shocks on stock prices during crisis can be different in a number of direct and indirect ways – Pennings, Ramayandi and Tang (2011). A rise in the MPR, which leads to first round falls in stock prices, they argued could lead to a second round of selling induced by margin calls. Mishkin (2009) found that a cut in the MPR during crisis leads to a larger-than-normal rise in expected future dividends, and hence a larger-than-normal rise in stock prices. Conversely, when MPR cuts are passed on to firms, then the effect of policy on future profitability is weaker, and so policy changes during the crisis have smaller effect on stock prices. However, policy announcements that involve keeping the rates lower for longer period during crisis, such as in the US during the global financial crisis, may reduce the expected risk free rate by more than is normally expected. Mishkin (2009) further argued that a change in MPR may also have a stronger effect on risk premia

during crisis and this concurs with the earlier study by Bernanke and Kuttner (2005) for the US economy.

Another important channel of monetary policy transmission identified in the literature is expectation or perception of economic agents on the actions of the monetary authorities. Monetary shocks could influence expectations about the future course of real activity – labor income, unemployment, sales and profits, in the economy, and the confidence with which those expectations are held (in addition to the inflation expectations already mentioned). The direction in which such effects work is hard to predict, and can vary from time to time. A rise in the monetary policy rate (MPR) could, for instance, be interpreted as indicating that the monetary policy committee (MPC) believes that the economy is likely to be growing faster than previously thought, giving a boost to expectations of future growth and confidence in general. In contrast, same could be interpreted as signaling that the MPC recognizes the need to slow the growth in the economy in order to hit the inflation target, and this could dent expectations of future growth and lower confidence. Jensen and Johnson (1995) demonstrated that monetary policy developments are associated with patterns in stock returns. They showed that long-term stock returns following discount rate decreases are higher and less volatile than returns following rate increases. Their study builds on Waud (1970), that discount rate changes affect market participants' expectations about monetary policy. In line with the earlier argument by the rational expectation model, this paper seeks to distill the effect of monetary policy shocks into anticipated and transitory components.

From the empirical corridor, a number of studies have applied different methodologies to assess the effects of monetary policy shocks on stock market returns volatility. Jensen, Mercer and Johnson (1996) suggested that monetary environment affects investors' required returns. See also Fama and French (1989), Jensen *et al.* (1996), Booth and Booth, 1997). Other empirical studies indicated an asymmetry between business conditions and stock returns; business conditions could predict future stock returns only in periods of expansive monetary policy. Relating this to the US stock market, Conover, Jensen and Johnson (1999) argued that not only the US stock returns, but also returns on foreign markets hinge with the US monetary environments (as well as their local monetary environment). They found that stock returns in twelve OECD countries over the period 1956-1995 are generally higher in expansive US and local monetary environments than they are in restrictive environments.

Thorbecke (1997) using a VAR methodology found that that monetary policy shocks have a greater impact on smaller capitalization stocks, which is in line with the hypothesis that monetary policy affects firms' access to credit (see Gertler and Gilchrist, 1993). Furthermore, he showed that expansionary monetary policy exerts a large and statistically significant positive effect on monthly stock returns. Similarly, Cassola and Morana (2004) applied the cointegrated VAR system which includes real GDP, inflation, real M_3 balances, short term interest rate, bond yield, and real stock prices to examine the transmission mechanism of monetary policy in the Euro area. Their results from impulse response analysis indicate that a permanent positive monetary shock has a temporary positive effect on real stock prices.

Chiang and Chiang (1996) examined the impact of predicted money growth volatility, predicted real output volatility, predicted exchange rate volatility and predicted US stock market volatility on the market volatility of Canada, Japan, United Kingdom and Germany markets. Their findings showed that only the US market volatility has a significant positive impact on the four countries' stock return volatility. Kearney and Daly (1998) presented evidence that the conditional volatility of interest rate and inflation are directly related to the Australian stock market volatility whereas money supply, industrial production and current account deficit are indirectly related to the market's stock volatility. Money supply was found to be the most significant variable in the model. Moreover, Beltratti and Morana (2006) explored the casual linkages from macroeconomic volatility to stock market volatility. They reported that a prolonged period of high stock market volatility during the phase of economic growth is associated with an increase in money growth volatility.

Empirical findings by Farka (2008) indicated that an unanticipated rise in policy rate by 1 percent causes a decline of around 5.6 percent in stock returns. This exceeds the typical estimates of 2.5 – 4 percent found in previous studies (see, for example, Jensen, Johnson, and Mercer (1996), Reinhart and Simin (1997), Thorbecke (1997), Fair (2002), Jensen and Mercer (2002), Rigobon and Sack (2004), and Bernanke and Kuttner (2005)). Farka (2008) further showed that policy shocks have a significant impact on the conditional volatility of stock returns with the latter displaying a tent-shaped pattern, that is, abnormally low several hours before announcement — *calm-before-the-storm-effect*, increasing significantly during the announcement period, declining steadily while still remaining elevated after the announcement, and continuing to decrease on the day

following the policy release. See also Lobo (2000, 2002) and Bomfim (2003) who report similar volatility pattern using a daily data on

A more recent study by Qayyum and Anwar (2011) showed that markets returns in Pakistan are not only affected significantly by its lag, but, by monetary policy via variations in the repo rates. An increase (decrease) in the repo rates, indicating a monetary policy tightening (expansionary), according to them decreases (increases) the returns to the stock market. This implies that the monetary policy has a positive impact on the volatility of the stock market.

3.1 Methodological Issues

GARCH models are the most widely used econometric models to describe the unique features of financial markets; volatility clustering, leptokurtic and asymmetry of the stock return distribution. Derived from the work by Engle (1982), Autoregressive Conditional Heteroscedasticity models (ARCH) explains the effects of previous error terms to the conditional variance of current term. Later Bollerslev (1986) extended the concept of ARCH models to General Autoregressive Conditional Heteroscedasticity (GARCH) models which broaden the sources of current conditional variance to both previous error terms and previous conditional variance.

However, GARCH models cannot capture the leverage or asymmetric effect. As a result, several asymmetry GARCH models were developed among which the exponential GARCH was introduced by Nelson (1991). The EGARCH model incorporates the asymmetric or leverage effect[4] and specifies the conditional variance in the logarithmic form. This paper, which seeks to assess the response of stock returns to monetary innovations, applied both the GARCH and the GARCH and EGARCH methodologies. Meanwhile, in line with the applications by Aliyu (2009) and Juat-Hong (2009) the paper employed the Hodrick-Prescott filter (HP) to disaggregate the monetary policy instruments; M_1, M_2 and MPR, into trend (anticipated) and cyclical (unanticipated) components. Ash, et al. (2002) evaluated the usefulness of the Hodrick-Prescott filter as a proxy for rational expectation. Their study concluded that although the HP series are not fully rational in the sense of Muth (1961), but they do meet the criterion of "weak rationality". The Augmented Dickey-Fuller (ADF) and the Kwiatkowski-Phillips-

[4] *Leverage effect*: the tendency for volatility to rise more following a large price fall than following a price rise of the same magnitude, (Brooks, 2008)

Schmidt-Shin (KPSS) unit root test were applied to assess the time series properties of the variables.

3.1.1 Generalized Autoregressive Conditional Heteroskedasticity (GARCH)

The GARCH model of the Bollerslev (1986) allows for the conditional variance to depend on past information and, therefore, vary over time. Thus, the conditional variance is predicted by past forecast errors and past variance. GARCH model addresses the issues of heteroskedasticity and volatility clustering, which largely characterize financial time series data. We begin with the simplest GARCH (1, 1) specification:

$$Y_t = X_t'\theta + \varepsilon_t \quad (1)$$

$$\varepsilon_t = Z_t\sqrt{h_t} \quad (2)$$

$$Z_t \sim N(0,1) \quad (3)$$

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 \quad (4)$$

in which the mean equation given in (1) is written as a function of exogenous variables with an error term, which is distributed as z_t given in equation(2). Equation (3) shows that the variance h_t is identically and independently distributed (iid). In this paper, Y_t is the dependent variable and stands for monthly continuously compounding return[5], calculated as: 100 x log (P_t /P_{t-1}), where P_t is the end of month *All Share Price* index in the Nigeria's Stock Exchange. X_t is a *1'k* vector of lagged endogenous variables, that is, the monetary policy variables decomposed into trend and cyclical components, included in the information set. θ is a *k'1* vector of unknown parameters. Summarily, the conditional variance equation specified in (4) is a function of three terms:

- A constant term: ω.
- News about volatility from the previous period, measured as the lag of the squared residual from the mean equation: ε^2_{t-1} (the ARCH term).
- Last period's forecast variance: σ^2_{t-1} (the GARCH term).

[5] See: Kun, Huang (2011) *Modeling Volatility in S&P 500 Index Daily Returns: A comparison between model based forecasts and implied volatility*, Department of Finance and Statistics, Hanken School of Economics, Vasa

σ^2 is measurable with respect to Y_t, which is the monthly stock market returns, $\omega > 0$, $\alpha > 0$, $\beta \geq 0$, and $\alpha + \beta < 1$, such that the model is covariance stationary, that is, the first two moments of the unconditional distribution of the return series is time invariant.

3.1.2 Exponential Generalized Autoregressive Conditional Heteroskedasticity (EGARCH)

The EGARCH model unlike the GARCH model imposes no restriction on parameters. The specification for the conditional variance is:

$$\ln(\sigma^2) = \omega + \beta_j \ln(\sigma_{t-1}^2) + \gamma \left[\frac{u_{t-1}}{\sqrt{\sigma_{t-1}^2}}\right] + \alpha \left[\frac{|u_{t-1}|}{\sqrt{\sigma_{t-1}^2}}\right] \quad (5)$$

The left-hand side is the *natural log* of the conditional variance. This implies that the leverage, that is, asymmetric effect is exponential, rather than quadratic, and that the forecasts of the conditional variance are guaranteed to be nonnegative. The γ parameter measures the leverage effect, which is usually negative, implying that positive shocks generate less volatility than negative shocks of the same magnitude. This feature sanctions the capture of the sign effect by allowing negative and positive innovations to have different effects on volatility. For instance, when $\gamma = 0$, then the model is symmetric, meaning that negative and positive shocks have the same effect on volatility. When $\gamma < 0$, then positive shocks (good news) generate less volatility than negative shocks (bad news). When $\gamma > 0$, it implies that positive innovations are more destabilizing than negative innovations. Meaning, the anticipated innovations should exert a stabilizing effect on stock volatility and vice versa for unanticipated innovations.

The EGARCH model is more preferred over the symmetrical GARCH model because of its unique advantages. First, since the conditional variance is modeled in the logarithmic form, the variance will always be positive even if the parameters are negative. Second, asymmetries are allowed in the EGARCH. Meaning, if the relationship between volatility and stock returns is negative, the parameter of the asymmetry term, γ, will be negative. Third, the EGRCH, model is stationary and has finite kurtosis if $\beta_j < 1$. Thus, there is no restriction on the leverage effect that the model can represent imposed by the positivity, stationary or the finite fourth order moment restrictions.

4.1 Empirical Results and Discussions

This section presents the results of empirical analysis. As stated earlier, data are monthly from January, 2007 to August 2011, a total of 55 observations. The summary of statistics from preliminary analysis is reported in Table 1.

Table 1: Preliminary Data Analysis – Summary of Statistics

Variable / Statistic	Log of Nominal Stock Returns	M_1 Money Stock	M_2 Money Stock	Monetary Policy Rate (MPR)
Mean	-0.8520	15.2501	15.9509	8.0545
Median	-0.8701	15.3244	16.0212	8.0000
Maximum	32.3515	15.5854	16.3325	10.250
Minimum	-36.5883	14.5935	15.1765	6.0000
Std. Dev.	9.62471	0.26015	0.31230	1.6664
Skewness	-0.40314	-0.97269	-0.83937	-0.0964
Kurtosis	7.4815	2.86193	2.59979	1.3646
Jarque-Bera	46.6525**	8.71652*	6.82530*	6.2143*
Probability	0.00000	0.01280	0.03295	0.0447
Ljung-Box (24)	32.470	246.8**	296.89**	319.3**

Source: Authors computations.

Notes: ** (*) indicate significance at the 1% and 5% level. The Ljung-Box *Q*-statistic at lag *k* is a test statistic for the null hypothesis that there is no autocorrelation up to order *k.* If there is no serial correlation, the autocorrelations and partial autocorrelations at all lags should be nearly zero, and all *Q*-statistics should be insignificant with large *p*-values.

As can be seen in Table 1, all the series are non-normally distributed. The null hypothesis of normal distribution is rejected for the log of stock returns at the 1% level, and at the 5% level for the rest of the series. The mean and median of log stock return were negative and high at 0.85% and 0.87%, respectively. This suggests that stock returns especially at the beginning of the financial crisis were significantly negative and in line with traditional asset pricing theory, higher average returns either ways – negative or positive, implies larger risk exposure, Su and Fleisher (1998) and Su (2010). Figure 1 further depicts the upheavals in the stock market returns from mid-2008 up to early 2009. The market, however, slowly inched up afterwards. Except the index of nominal stock returns, the rest

of the series show evidence of platykurtic distribution with a Kurtosis less than 3.0. The ARCH test carried out using the LB Q-statistic shows evidence of serial correlation at all lag levels at the 1% level.

The ADF and KPSS tests of stationarity showed mixed results (Table 4). Some series were found to be stationary at level; log of stock returns, M_2 and MPR – although the latter two were at a lower level of significance. All the variables were found to be stationary at first difference at the 1% level for both the ADF and KPSS tests. See appendix 1 for the results.

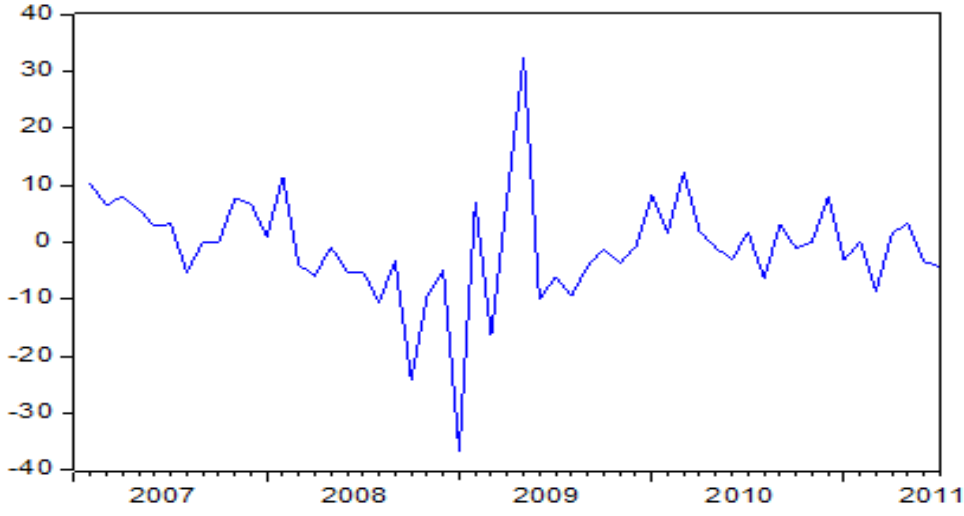

Figure 1: Log of Stock Returns Volatility

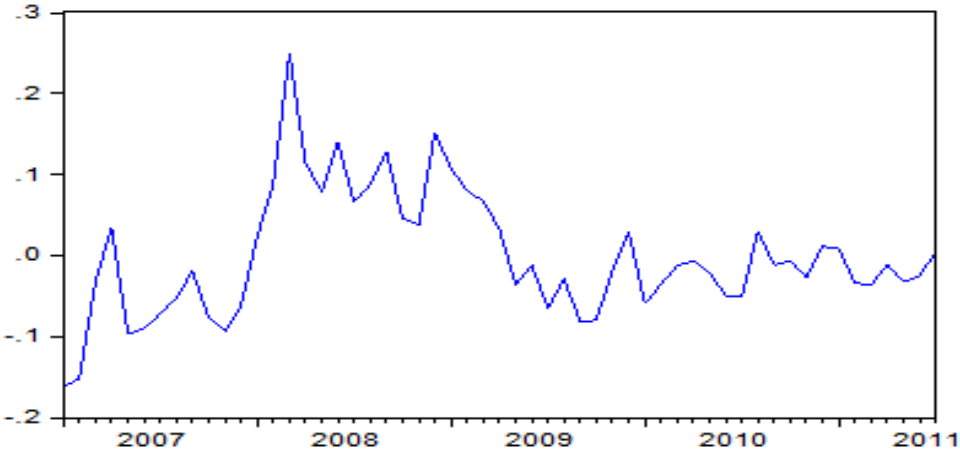

Figure 2: M1 Aggregate – Cyclical Component

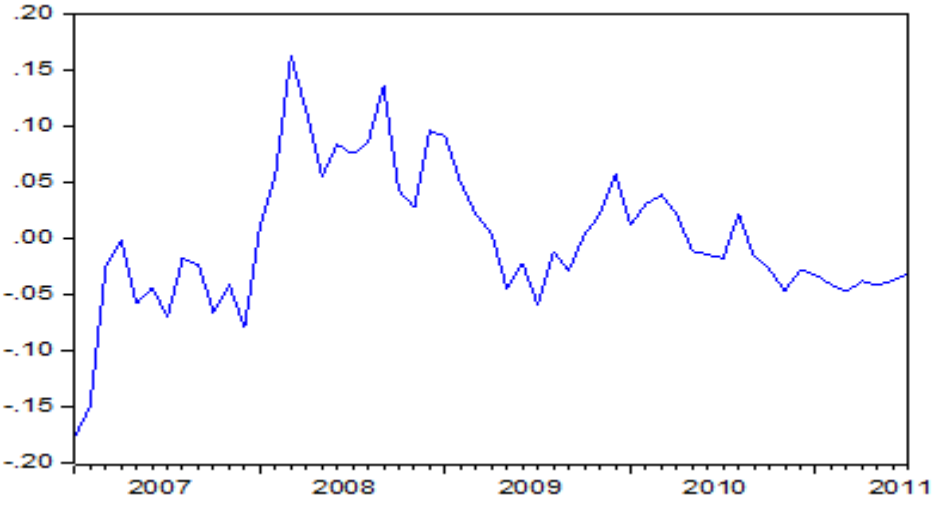

Figure 3: M2 Aggregate – Cyclical Component

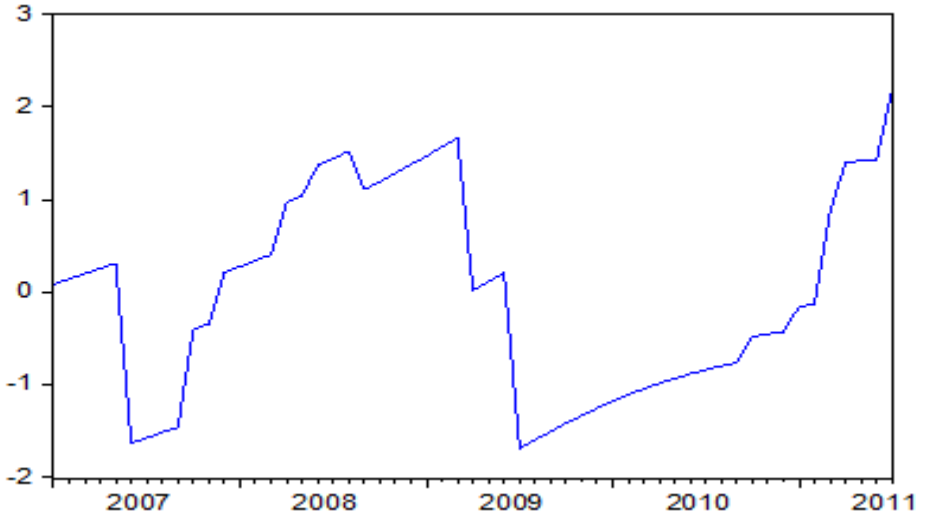

Figure 4: Monetary Policy Rate – Cyclical Component

4.1.1 Evidence of Time-varying Volatility

Table 2 presents results of restricted GARCH and EGARCH models. The mean equations for the two models reveal strong and statistically significant

coefficients[6]. The intercept of the variance equation, ω representing the long term average is not statistically significant. However, the value of the coefficient of ARCH, information about volatility observed in the previous period, and GARCH, last period's forecast variance, in the GARCH(1,1) model show statistically significant and consistent estimates, implying the presence of both ARCH and GARCH effects. The *Wald* test for volatility persistence, that is, the sum of $(\alpha + \beta)$ is above one, indicating that volatility is quite persistent. This is a common result often observed in high frequency financial data and in particular, this confirms volatility persistence in the Nigeria's stock market returns.

Table 2: Results of Restricted GARCH and EGARCH Models

	GARCH (1,1)			EGARCH (1,1)		
Variance Equation	Coeff	S.E	Prob.	Coeff.	S.E	Prob.
ω	0.0004	0.0005	0.3813	-3.0652*	1.1474	0.0076
α	0.4137	0.2140	0.0532	0.9827*	0.3357	0.0034
β	0.6309*	0.1877	0.0008	0.3662	0.2586	0.1568
γ				0.5553*	0.2182	0.0109
ARCH LM (2)	0.7734*		0.467	0.1882*		0.829
LB Q-stat.	18.619*		0.669	23.359*		0.382
(24)	17.819*		0.717	33.538		0.055
LB Q^2-stat.	3.9733*		0.137	1.9814*		0.371
(24)	-1.87			-1.74		
Jacque-Bera	61.40			59.93		
SC						
LL						

Source: Regression output using Eviews 5.0
* Indicates significance at the 5% or better level.

Similarly, the variance equation for the EGARCH (1,1) model show a strong and statistically significant intercept, and although the GARCH coefficient is not statistically significant, the ARCH and leverage effect coefficients are correctly signed and significant ant the 5 percent or better level. Moreover, the positive sign of the leverage coefficient implies that positive innovations play more significant impact on stock return than negative innovations of the same magnitude. A simple interpretation would be that good macroeconomic policies, stable prices and exchange rate, strong institutions, are better determinants of stock returns as against bad macroeconomic policies, unstable prices and exchange rate and weak

[6] Results for the mean equation for all the estimated models – restricted and unrestricted, are not presented here but available with the author upon request.

institutions. Equally, the *Wald* test reveals very high degree of volatility persistence, that is, larger positive or negative return will lead future forecasts of the variance to be high for a protracted period. The results for instance, suggest that stock return volatility in Nigeria in the current period is explained by the forecast error variance in the GARCH and EGARCH model approximately 63.1 percent and 36.6 percent, respectively. Somewhat similar results using the GARCH model of 60 percent was reported by Aliyu (2010), while using the EGARCH model, Sarmidi (2010) reported a moderate level of 15.3 percent for Nigeria.

To test the robustness of the results, the ARCH effects in the residuals were investigated in the models using the Lagrangian multiplier and the LB (Q) and LB (Q^2) statistics. Results for both GARCH(1,1) and EGARCH(1,1) models indicate that null hypothesis of autocorrelation and partial autocorrelation in the residual is rejected. Furthermore, Jacque-Bera statistic shows that the residuals in the two models are normally distributed. The SC model selection criterion, however, suggests that the GARCH(1,1) model is superior to the EGARCH(1,1) model.

4.1.2 Monetary Policy Innovations and Stock Returns Volatility

The paper sets out to assess the responses of stock market response to monetary policy innovations in Nigeria. The methodology employed allowed the effect of monetary policy shocks to be decomposed into two components; anticipated and unanticipated components. Using the M_2[7] money supply and MPR as policy instruments, an unrestricted GARCH and EGARCH models were estimated. Results presented in Table 3 show that like its corrollary above, the unrestricted GARCH model has an intercept which is not statistically significant although it maintains a low value. The ARCH and the lagged conditional variance coefficients are statistically significant although the later violates the nonnegative sign restriction imposed by the GARCH model. However, the sum of the two coefficients is less than one (0.9168), suggesting that the model is covariance stationary with high degree of persistence and long memory in the conditional variance.

Evidences further show that the coefficients of anticipated monetary innovations on the MPR and M_2 monetary aggregate are statistically insignificant though the latter is correctly signed. Conversely, the coefficients of the unanticipated

[7] M_1 aggregate was dropped because it consistently yields statistically insignificant coefficient, besides, as a narrow measure of money supply, it is not a widely used in policymaking.

components are all statistically significant at the 5 percent or better level. A logical explanation is that that a positive shock (expansionary policy) on M_2 aggregate which lowers MPR and improves availability of credits would increase the cash-rate in the economy and henceforth, would also raise the speculative behavior of the stock market. Similarly, effect of a positive shock (tightening) on the MPR could trigger higher stock return volatility in the NSE through inflow of financial resources. Furthermore, Campbell (1991) adapted by Bernanke and Kuttner (2005) stated that a surprise increase in the MPR decreases stock prices in three ways: (i) decreasing the expected future dividends, (ii) increasing the future risk-free rate (iii) increasing the equity premium (above the risk free rate) required to hold equities. While the above findings show that a 1 percent change in the policy variables; MPR and M_2 result in 5 basis points and 1.34 percent increases in stock volatility, respectively, Farka (2008) indicated that an unanticipated rise in policy rate by 1 percent causes a decline of around 5.6 percent in stock returns. The range reported in the literature lies between 2.5 and 4 percent.

Relating the findings to the theoretical arguments of the *REH*, it is clear that the smoothed component (anticipated) of M_2 has the expected sign although not statistically significant. However, the coefficients of unanticipated components for both the MPR and M_2 are positive and this suggests that monetary policy shock on either instrument has more destabilizing effect on stock returns than a shock negative of the same magnitude.

Although Juat-Hong (2009) reported negative sign for both cyclical and trend effects using broad and narrow money supply, Abdul Qayyum and Anwar (2011) reported a positive leverage and repo rate effects on stock returns volatility using an EGARCH methodology for Pakistan. Thus, the finding by this paper affirms the argument of the REH that only the unanticipated as against the anticipated monetary shocks influences real economic activity.

For the EGARCH unrestricted model, the intercept and the ARCH information effect are strong and statistically significant suggesting that volatility is sensitive to market events, while the GARCH effect is negative and insignificant as was obtained in the restricted model. However, since the conditional variance is modeled in the logarithmic form, the variance will always be positive even if the parameters are negative. The leverage effect (γ) of policy innovations is positive and very strong at the 1 percent level. This implies that monetary policy has a positive effect on volatility of stock returns in the NSE, and this conforms to findings by empirical studies reported above. The coefficients of MPR and M_2

money supply are both correctly signed and statistically significant at the 1 percent level. The two suggest positive effect of policy innovations on stock returns volatility.

Table 3: Results of Unrestricted GARCH and EGARCH Models

	GARCH (1,1)			GARCH (1,1)		
Variance Equation	Coeff	S.E.	Prob.	Coeff.	S.E.	Prob.
Constant (ω)	0.0058	0.0068	0.3943	-4.6230*	0.8228	0.0000
ARCH (1) (α)	-	0.0239	0.0000	-0.7027*	0.0295	0.0000
GARCH (1) (β)	0.1420*	0.0076	0.0000	-0.3655	0.4214	0.3857
Anticipated MPR (ζ)	1.0588*	0.0001	0.8736			
Unanticipated MPR (λ)	1.95E-	0.0002	0.0298			
Anticipated M_2 (ζ)	05	0.0004	0.4007			
Unanticipated M_2 (λ)	0.0005*	0.0041	0.0010			
EGARCH (1) (γ)	-0.0003			0.8393*	0.1376	0.0000
MPR (φ)	0.0134*			0.1182*	0.0129	0.0000
M_2 (θ)				0.2073*	0.0000	0.0000
Diagnostic Test	Coeff.		Prob.	Coeff.		Prob.
ARCH LM (2)	0.1668*		0.8468	1.8794*		0.1637
LB Q-stat. (24)	18.227*		0.6920	18.597*		0.6700
LB Q^2-stat. (24)	10.200*		0.9840	10.576*		0.9800
Jacque-Bera	2.372*		0.3055	1.233*		0.5397
SC	-1.98			-2.17		
LL	72.37			75.45		
DW	2.02			1.62		

Source: Regression output using Eviews 5.0

***** indicates significance at 5 percent or better level.

LB stands for Ljung Box statistic and

SC for Schwarz Criterion.

SC criterion is superior to the Akaike Information Criterion (AIC) because it imposes a larger penalty for additional coefficients.

Trends depicted in Figures 5 and 6 affirm the numerical accuracy of the two models in terms of capturing volatility of stock returns in the NSE during the period of the crisis. According to Zivot (2008) the numerical accuracy of model estimates can be examined by comparing the volatility estimates of the GARCH model with the volatility estimates from ARCH (*p*) models. If the volatility estimates from the different models exhibit similar dynamics, then coefficient estimates from of the models are appropriate. Looking at the shapes of the residual plots of the GARCH and EGARCH models, it is clear that both explicitly

track the tremendous volatility of stock returns in the NSE from mid of 2008 until 2009.

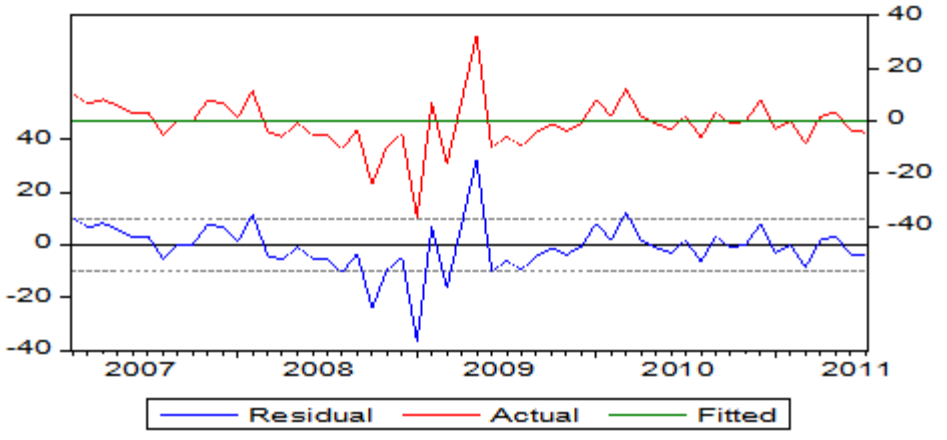

Figure 5: Unrestricted GARCH (1,1) Model

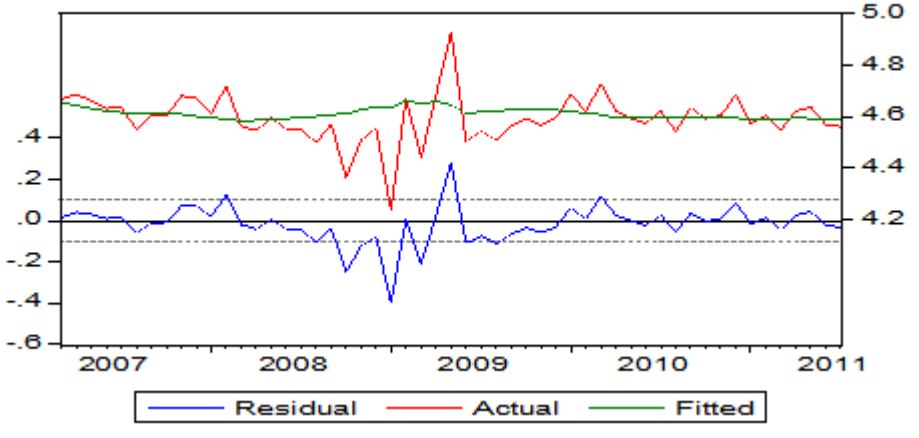

Figure 6: Unrestricted EGARCH (1,1) Model

Results of robustness tests reveal that the SC model selection criterion suggest that the EGARCH model proves to be superior to GARCH because it records significantly smaller value. Furthermore, Likelihood ratio test between EGARCH models using conventional Gaussian error distribution demonstrates that an EGARCH model specification offers a better fit of the sample data than GARCH model. Investigation of the ARCH effect in the residuals using the Lagrangian multiplier and the LB (Q) and LB (Q^2) statistics was carried out. Results for both

GARCH(1,1) and EGARCH(1,1) models indicate that null hypothesis of autocorrelation and partial autocorrelation in the residuals is rejected. This is further supported by the D.W statistic, which reveals absence of first order serial correlation in the residuals from the two models. The Jacque-Bera statistic for normal distribution shows that the residuals in the two models are normally distributed.

Table 4: Stationarity Test

Variable	Series at Level		First Difference		Decision
	ADF	KPSS	ADF	KPSS	
LASI	-6.622**	0.137**	-9.147**	0.069**	*I*(1)
LM_1	-2.397	0.905	-7.945**	0.334**	*I*(1)
LM_2	-3.101*	0.842	-7.223**	0.567*	*I*(1)
MPR	-1.418	0.549*	-6.772**	0.201**	*I*(1)

Source: Regression output using Eviews 5.0

Note: **(*) 1 (5) % levels of significance ADF & KPSS. Statistics are: 3.56 (2.93) and 0.739 (0.463) at the 1 and 5% levels, respectively. 271–93.

5.1 Conclusions and Recommendations

The paper seeks to assess the responses of the Nigeria's stock market to monetary policy innovations during the period of global financial crisis and post banking sector consolidation. The study period is from January, 2007 to August, 2011, including a total number of 55 observations. Uniquely, the paper in line with some empirical studies in the area decomposed monetary policy innovations into anticipated and unanticipated components in order to test the theoretical postulation of the rational expectation hypothesis. The monetary policy instruments used are the M_1, M_2 and MPR as regressors while All Share Index stands as the regressand.

The paper's preliminary investigation into the nature and time series properties of the data reveals that the data is characterized by a non normal distribution and a negative average monthly returns (in natural log) of -0.85% and a standard deviation of monthly returns of 9.62%. Evidence of autocorrelations using the Ljung-Box statistic was also established in the variables. With exception of log of dtock returns which was stationary at level, others were stationary at first difference. These portray a picture of a market in turmoil with evidence of high volatility in the level of stock returns during the study period.

Results from restricted GARCH(1,1) and EGARCH(1,1) show evidence of tstrong ARCH and GARCH effects. The *Wald* test, for instance, suggests that volatility is quite persistent. Moreover, the positive sign of the leverage coefficient from the EGARCH model implies that positive innovations play more significant impact on stock returns than negative innovations of the same magnitude. The unrestricted GARCH model confirms strong evidence of ARCH GARCH effects, while the EGARCH speicfication yields a strong ARCH effect. The later model however, offers a strong and statistically significant positive leverage effect. Furthermore, only the unanticipated component of policy innovations on the broad money supply, M_2 and MPR carry statistically significant coefficients whereas the unanticipated component does not. Results show that the unaticipated monetary policy innovations matter for stability of NSE because of their distabilizing effect on stock returns volatility. This confirms the postulations of the *Rational Expectation Hypothesis* that only the unanticipated components of policy changes would work while the anticipated component would be brought to naught because of economic agents' rationally behavior. The study's findings are in consonance with those reported by Qayyum and Anwar (2011) on Pakistan's stock market, notwithstanding the fact that it is dissimilar to the finding by Juat-Hong (2009) on Malaysian stock market.

One key policy implication policymakers should rekon with is that market participants at the NSE do not buy in for surprises in monetary policy pronouncements. The MPC should unequivocally declare realistic and achievable monetray targets on broad money supply, MPR and exchange rate as well. It should also strive to maintain low level of inflation through a realistic and robust inflation targeting framework. These will go along way in promoting stability and confidence desired in the market.

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Threshold Effect of Inflation on Economic Growth in Nigeria

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It is widely believed that price stability promote long-term economic growth, whereas high inflation is inimical to growth. This paper utilized a quarterly time series data for the period 1981 – 2009 to estimate a threshold level of inflation for Nigeria. Using a threshold regression model developed by Khan and Senhadji (2001), the study estimated a threshold inflation level of 13 per cent for Nigeria. Below the threshold level, inflation has a mild effect on economic activities, while above it, the magnitude of the negative effect of inflation on growth was high. The negative and significant relationship between inflation and economic growth for inflation rates both below and above the threshold level is robust with respect to changes in econometric methodology, additional explanatory variables and changes in data frequency. These finding are essential for monetary policy formulation as it provide a guide for the policy makers to choose an optimal target for inflation, which is consistent with long-term sustainable economic growth goals of the country.

Key words: Inflation, Growth, Threshold

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1.0 Introduction

Rapid output growth and low inflation are the most common objectives of macroeconomic policy in both developed and developing economies. In Nigeria, the formulation and implementation of monetary policy by the Central Bank of Nigeria (CBN) was aimed at maintaining price stability which is consistent with the achievement of sustainable economic growth. The monetary authority strives to achieve the government's overall inflation objective through effective monetary management, which entails setting intermediate and operating targets in tandem with the assumed targets for GDP growth, inflation rate and balance of payments.

The growing interest in price stability as a major goal of monetary policy is an acknowledgement of the observed phenomenon that high inflation disrupts the smooth functioning of a market economy. High inflation is known to have many adverse effects: it imposes welfare costs on the society; impedes efficient resource

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allocation by obscuring the signaling role of relative price changes; discourages savings and investment by creating uncertainty about future prices; inhibits financial development by making intermediation more costly; hits the poor excessively, because they do not hold financial assets that provide a hedge against inflation; and reduces a country's international competitiveness by making its exports relatively more expensive, thus impacting negatively on the balance of payments, and perhaps more importantly, reduces long-term economic growth (See Ghosh and Phillips, 1998; Khan and Senhadji, 2001; Billi and Khan, 2008; Frimpong and Oteng-Abayie, 2010). Overall, businesses and households are thought to perform poorly in periods of high and unpredictable inflation, Barro (1996).

Most policymakers, however, agree that they should not allow inflation to fall below zero because the costs of deflation are thought to be high, Billi and Khan (2008). Even though some evidence suggests that moderate inflation helps in economic growth, Mubarik (2005), the overall weight of evidence so far clearly indicated that inflation is inimical to growth. Consequently, policymakers should aim at a low rate of inflation that maximizes general economic well-being. But how low should inflation be in Nigeria? Should the target inflation be 10 per cent or 5 per cent? How much inflation impedes economic growth in Nigeria?

A considerable amount of literature examining the relationship between inflation and economic growth in both developed and developing economies are available. However, several of those studies focused specifically on whether the relationship between inflation and long-run growth is negative and a nonlinear one – positive or nonexistent relationship at low rate of inflation but becomes negative at higher rates, see Fischer (1993) who first identified the relationship. If such a nonlinear relationship exists, then it should be possible, in principle, to estimate the inflexion point, or a threshold, at which the sign of the relationship between the two variables would switch. Consequently, Khan and Senhadji (2001) produced the threshold level for both developed and developing countries in a cross-country panel data framework. The authors arrived at a threshold level range of 11 - 12 per cent for developing countries, including Nigeria. Even though cross-country studies were justified based on their ability to generalize empirical findings, specific country studies can provide specific evidence relevant for the country under study, as Kremer *et al.* (2009) suggested that inflation threshold in non-industrial countries and the appropriate level of inflation target might be country-specific. This becomes necessary due to heterogeneous factors obtainable in different countries. Although Chimobi (2010) examined the relationship between

inflation and growth in Nigeria, no attempt was made to provide an optimal inflation rate for policy decisions. Fabayo and Ajilore (2006) arrived at a threshold level of 6 per cent for Nigeria using annual data from 1970 – 2003. However, Bruno and Easterly (1998) argue that the negative relationship between inflation and growth, typically found in cross-country regressions, exists only in high frequency data and with extreme inflation observations, which Khan and Senhadji (2001) confirmed that the extent of the relationship is stronger at high frequencies.

This paper follows the Khan and Senhadji (2001) methodology in providing evidence of a threshold level of inflation in Nigeria; beyond which inflation exert a negative impact on economic growth. The study goes beyond the works of Chimobi (2010) and Fabayo and Ajilore (2006) by extending the analysis to the estimation of the threshold effect of inflation on growth in Nigeria, using quarterly time-series data for the period 1981 – 2009.

The rest of the paper is organized as follows. Section 2 reviews the relevant literature on inflation and growth and the theoretical framework for the study; Section 3 outlines the threshold model; Section 4 presents the estimation results of the threshold model; Section 5 concludes.

2.0 Literature Review and Theoretical Framework

2.1 Literature Review

This section examines past and related research studies on the relationship between inflation and economic growth both in Nigeria and in other economies of the world with particular interest on data used, methodology adopted, nature of the relationship and the estimated inflation thresholds. Most studies on the threshold effect of inflation on economic growth are dominated by cross-country panel studies (Sarel, 1996; Khan and Senhadji, 2001; Mallik and Chowdhury, 2001; and Kremer *et al*., 2009). On the other hand, due to the peculiarity of certain economies, especially developing economies, specific country studies might reveal specific evidences fundamental to the country under study. This is what instigated the study. In this regard, we identified some country specific studies, especially on developing countries, on the inflation-economic growth nexus, which include Ahmed and Mortaza (2005) for Bangladesh; Hussain (2005) and Mubarik (2005) for Pakistan; Singh (2003) for India; Hodge (2005) for South Africa; Fabayo and Ajilore (2006) and Chimobi (2010) both for Nigeria and Frimpong and Oteng-Abayie (2010) for Ghana.

Sarel (1996) examined the non-linear effects of inflation on economic growth using annual panel data on GDP, CPI, population, terms of trade, real exchange rate, investment rates and government expenditures of 87 countries from 1970-1990. The 20 year sample period was divided into four equal periods of five years each, obtaining a total of 248 observations for the study. He found a significant structural break (inflation threshold) in the function that relates economic growth to inflation. The threshold was estimated at 8 per cent, below which inflation did not have any effect on economic growth or it may have a slight positive effect. When it rose above the 8 per cent threshold, however, the estimated effect of inflation was significant, robust and extremely powerful. He demonstrated that when the existence of the structural break is ignored, the estimated effect of inflation on economic growth for higher inflation rates decreased by a factor of three.

Khan and Senhadji (2001) re-examined the issue of the existence of threshold effects in the relationship between inflation and economic growth using a new econometric technique that allows for appropriate estimation procedures and inference. They utilized an unbalanced panel dataset covering the period 1960-1998 from 140 countries, comprising industrialized and developing countries. They estimated inflation threshold levels of 1-3 per cent and 11-12 per cent for industrialized and developing countries, respectively. The empirical results suggested that beyond threshold levels of 3 and 12 per cent for industrialized and developing countries, respectively, the relationship between inflation and economic growth became negative. The authors noted that the peculiarities of industrialized economies remained different from those of the developing economies. However, they did not acknowledge the peculiarities existing among developing countries in terms of resources base, population size, level of corruption, poverty level, etc.

Mallik and Chowdhury (2001) studied the relationship between inflation and GDP growth for four Asian countries, namely, Bangladesh, India, Pakistan and Sri Lanka. The study used un-even sample size of 1974-97 for Bangladesh, 1961-97 for India, 1957-97 for Pakistan and 1966-97 for Sri Lanka. The variables used for the study were CPI and real GDP to measure inflation rates and economic growth, respectively. They found evidence of a long-run positive relationship between inflation and GDP growth rate for all the four countries with significant feedbacks. According to the authors, moderate inflation level helps economic growth but faster growth feedbacks into inflation, thus, the countries are on a 'knife-edge'. However, this study did not estimate what the moderate inflation

rate (threshold level) that will help economic growth in the four countries should be.

A study by Kremer *et al*. (2009) using panel data from 63 countries (comprising industrial and non-industrial countries) confirmed the effect of inflation on long-term economic growth. Their findings revealed that inflation affected growth when it exceeded 2 per cent threshold for industrial countries and 12 per cent for non-industrial countries, and that below these levels the relationship between inflation and economic growth was significantly positive. However, they suggested that the inflation threshold in non-industrial countries and the appropriate level of inflation target might be country specific. Therefore, they recommended that the identification of country specific threshold might provide useful information about the appropriate location and width of an inflation targeting band. The authors' recommendation is valid because it is indeed an important policy issue for economies adopting or planning to adopt inflation targeting approach to monetary management such as Nigeria to study the relevant threshold level to serve as a guide.

In Bangladesh, Ahmed and Mortaza (2005) found a statistically significant long-run negative relationship between inflation and economic growth using annual data on real GDP and CPI covering the period 1980 to 2005. The study utilized co-integration and error correction models. They estimated an inflation threshold level of 6 per cent (structural-break point) above which inflation will adversely affect economic growth. They concluded that their findings have direct relevance to the conduct of monetary policy by the Bangladesh Bank.

Hussain (2005) and Mubarik (2005) examined inflation and growth in Pakistan using annual time series data for the periods 1973-2005 and 1973-2000, respectively; and estimated the threshold levels of inflation to be 4-6 per cent and 9 per cent, respectively, beyond which inflation will deter economic growth. Similarly, Singh (2003) suggested an inflation threshold range of between 4-7% for India. We note that both Pakistan and India are developing countries but the findings of the authors differ significantly from the findings of Khan and Senhadji (2001) and Kremer *et al.* (2009) for developing countries. This might be partly because of difference in methodology adopted or data set used. This reiterate the validity of Kremer *et al*. (2009) recommendation that conduct of country specific study due to peculiarities of economies would reveal more useful information.

Hodge (2005) conducted a study on the relationship between inflation and growth in South Africa in order to test whether South African data support the findings of

cross-section studies that inflation has long-run negative effect on growth and if higher growth can be gained at the cost of higher inflation in the short-run. According to Hodge (2005), inflation drags down growth over the long-term, while in the short run growth above its trend requires accelerating inflation. It is generally noted in literatures that high inflation has negative impact on economic growth in the long run and relates positively in the short run. Therefore, Hodge (2005) would have estimated a threshold at which authorities needed to take measures to ensure inflation does not hamper economic growth.

Fabayo and Ajilore (2006) in their paper titled "inflation – How Much is too Much for Economic Growth in Nigeria" using annual data from 1970-2003 suggested the existence of threshold inflation level of 6 per cent for Nigeria. They explained that above this threshold, inflation retards growth performance of the economy while below it, the inflation-growth relationship is significantly positive. They suggested that the goal of macroeconomic management in Nigeria should be to bring down inflation to a moderate single digit of 6 per cent (optimal inflation target policy). Our study will build on what Fabayo and Ajilore (2006) has done though we will use quarterly series (high frequency data). This is because Nigerian data are highly volatile especially inflation rate, exchange rate, etc; thus, we expect better explanation to when inflation will endanger economic growth in Nigeria. Moreover, the negative relationship between inflation and growth holds mostly in high frequency observations (See Bruno and Easterly, 1998)

Also, Chimobi (2010) used Nigerian data on CPI and GDP for the period 1970-2005 to examine the existence or not, of a relationship between inflation and economic growth and its causality. He adopted the Johansen-Juselius co-integration technique and Engle-Granger causality test. A stationarity test was carried out using Augmented Dickey-Fuller (ADF) and Phillip-Perron (PP) tests and stationarity was found at both 1 and 5 per cent level of significance. After testing for causality at two different lag periods (lag 2 and lag 4), he found the result suggesting unidirectional causality running from inflation to economic growth. Thus, the study maintained that the unidirectional causality found is an indication that inflation indeed impacts on economic growth. However, this study did not estimate or suggest any threshold level at which the impact could be positive or negative, significant or not, in the long run or short run. Thus, a study that attempt to estimate the inflation threshold level would have added to the debate especially that most economies are turning towards adopting inflation targeting.

Frimpong and Oteng-Abayie (2010) attempted to find out whether inflation is harmful or not; and if it is at what level does it become harmful to economic growth in Ghana. They adopted a threshold regression model designed to estimate the inflation thresholds instead of imposing them, using annual data on CPI and GDP covering 1960-2008. They found evidence of threshold effect of inflation on economic growth, which was estimated at 11 per cent. Below this level, inflation is likely to have mild effect on economic growth, while above it inflation would significantly hurt economic growth. They concluded that the current medium term inflation target of 6-9 per cent annual average set by the Bank of Ghana and the Government is in the right direction as it is below the estimated 11 per cent threshold.

Empirically, evidence from the literature suggest that any developing country with actual level of inflation of about 11 per cent (maximum) is very likely to record sustained growth in its output level (GDP) and will surely perform better with a single-digit inflation rate. This indeed reiterated why the West African Monetary Zone (WAMZ) convergence criteria prescribed single-digit inflation rate to be achieve by member countries, of which Nigeria is one.

2.2 Theoretical Framework

Economic theorization has reached varying conclusions about the relationship between output growth and inflation. Theories are viewed to be useful because they account for some observed phenomenon. Historically, there were several inflation-growth theories ranging from pre-world war era where the term 'persistent inflation' was absent – theories were built on cyclical observations to post world war era when inflation was described as a "lazy dog", or having linear, non-linear, positive, negative, short run, or long run relationship with economic growth.

The classical growth theory was laid by Adam Smith, who postulated a supply side driven model of growth, and production function where output (Y) depends on labour (L), capital (K) and land (T). That is $Y = f(L, K, T)$.

Consequently, he argued that output growth is driven by population growth, investment, land and increase in overall productivity. He viewed savings as the creator of investment and hence growth; and income distribution determines how fast or slow a nation's economy grows. However, he implicitly suggested a negative relationship between inflation and growth.

The Keynesians in their traditional model illustrated the inflation-growth nexus using the aggregate demand (AD) and aggregate supply (AS) curves. They showed that the AS curve is upward sloping rather than vertical. If AS is vertical, changes in AD of the economy will only affect prices; but if it is upward sloping, changes in AD affects both prices and output. They argued that in the short run, changes in factors like expectations, labour, prices of other production factors and fiscal and or monetary policy drive inflation as well as output. But in the long run, those factors and the shock on the steady state of the economy result in 'dynamic adjustment' of the model through a path which exhibits initial positive inflation-growth relationship and returns to negative at the latter part of the 'adjustment path' (Dornbusch *et al.*, 1996). The model also notes that the economy does not move directly to a higher inflation rate but it follows a transitional path where it rises then falls. The negative relationship theorized for output growth and inflation often occurs in practice as ascertained by empirical literatures. Under this model, there is no permanent trade-off between the two variables.

Monetarism has several important features that focus on the long run supply side properties of the economy as opposed to short run dynamics (Dornbusch *et al*., 1996). Milton Friedman laid emphasis on several key long run properties of the economy including the quantity theory of money and neutrality of money. He proposed that inflation was the product of an increase in supply or velocity of money at a rate greater than output growth in the economy. He argued that inflation can adversely impact on capital accumulation, investment and exports, and consequently, impact on a country's growth rate. It is said that in the long run, prices are mainly affected by growth in money supply with no real effect on growth; but when money supply is higher than the output growth, inflation will result.

Theoretical framework of the Neo-classicalists demonstrates that their models can yield varying results as regards inflation-growth relationship. Tobin (1965) effect postulates that an increase in inflation can result in high output; Stockman effect proposed lower output should inflation increase; while Sidrauski (1967) showed that an increase in inflation does not affect the steady state capital stock – that is neither output nor economic growth is affected.

3.0 Econometric Methodology

3.1 The Threshold Regression Model

The threshold regression model was developed by Khan and Senhadji (2001) for the analysis of threshold level of inflation for both industrial and developing countries. The model was also applied by Mubarik (2005) and Hussain (2005) in computing the threshold inflation rate for Pakistan, and Frimpong and Oteng-Abayie (2010) for Ghana.

This study applies the model to estimate the threshold level of inflation above which inflation may affect economic growth in Nigeria.

The threshold level of inflation is based on the following equation:

$$Y_t = \beta_0 + \beta_1 P_t + \beta_2 D_t (P_t - \pi) + \beta_{2+i} X_{it} + \mu_t \qquad (1)$$

where economic growth and inflation are computed as: $Y_t = \Delta \ln(RGDP)$; $P = \Delta \ln(CPI)$ and RGDP and CPI denote real gross domestic product and consumer price index, respectively; P_t is inflation, π is the threshold level of inflation, and μ_t is a random error term. The quarterly growth rates of RGDP and inflation used in the analysis were computed by taking the first difference of the current and the corresponding quarter values of RGDP and CPI i.e. current quarter value of the current year less the corresponding quarter value of the previous year. This is mathematically presented as $Y_t – Y_{t-4}$ where Y_t is the current quarter and Y_{t-4} is the corresponding quarter value. The variable X_{it} is a vector of control variables. The growth rate of gross domestic investment (INV), considered to be an important determinant of economic growth, was the only variable included as a control variable in the main threshold regression model. Other variables, which were included in the sensitivity analysis as control variables to check for the impact of additional explanatory variables, were Openness to foreign trade (OPNES), Financial Deepening (FINDEEP) and Population growth (POP). The growth rates of INV and POP were computed using similar method as Y_t and P. The dummy variable D_t is defined as:

$$D_t = \begin{cases} 1, P_t > \pi \\ 0, P_t \leq \pi \end{cases} \qquad (2)$$

The parameter π represents the threshold inflation level with the property that the relationship between output growth and inflation is given by: (i) β_1 representing low inflation; (ii) $\beta_1 + \beta_2$ representing high inflation. The high inflation means

that when β_2 is significant, then both $(\beta_1 + \beta_2)$ would be added to see their impact on economic growth and that would be the threshold level of inflation. By estimating regressions for different values of π which is chosen in an ascending order (that is 1, 2, 3 and so on), the optimal value of π is obtained by finding the value that minimizes the sum of squared residuals (maximizes the adjusted R^2) from the respective regressions. Inflation at this level has a significant impact on growth. (See Mubarik (2005) and Frimpong and Oteng-Abayie (2010))

3.2 Data

The model was estimated using quarterly time series data for the period 1981 to 2009 sourced from the CBN Annual Report and Statement of Accounts, CBN Statistical Bulletin and the National Bureau of Statistics Annual Abstract of Statistics. The study utilized the quarterly dataset on Consumer Price Index (May 2003=100), real GDP (1990 constant basic prices) and total investment proxied by Gross Fixed Capital Formation.

Annual growth rates of GDP, CPI and total investment were computed using log transformation method that eliminates, at least partially, the strong asymmetry in inflation distribution (Sarel, 1996). The log transformation also helps in smoothing time trend in the dataset (Mubarik, 2005) and provides best fit in the class of non-linear models (Khan and Senhadji, 2001).

4.0 Estimation Results and Discussion

4.1 Relationship between Real GDP Growth and Inflation

Nigeria has experienced high volatility in inflation rates. Historical inflation data indicated that the country has experienced three major episodes of high inflation in excess of 30 per cent since 1981. For instance, headline inflation increased to 40.7 per cent in 1984, from 23.2 per cent in 1983. The sharp increase in inflation rate was attributable to the austerity measures introduced in 1983 to stem the imminent collapse of the economy. Some of the factors adduced for this situation included import restriction and foreign exchange constraints, which led to severe shortages in the supply of goods and services. Similarly, the expected devaluation of the Naira arising from debt agreements with the International Monetary Fund (IMF), excess money growth, increase in credit to the government and worsening terms of external trade experienced by the country led to the inflationary pressures (Masha, 2000). Meanwhile, output growth deteriorated as economic growth declined by 1.1 per cent in 1984.

Even though inflation decelerated to 4.7 per cent in 1985, it increased to 56.0 and 50.5 per cent, respectively, in 1988 and 1989. This was attributed to the fiscal expansion that accompanied the 1988 budget and its initial financing by credit from the Central Bank of Nigeria (Masha, 2000), fuel price adjustments in 1988 and a significant depreciation of the naira exchange rate emanating from the implementation of Structural Adjustment Programme (SAP) – Mordi *et al.* (2007). In spite of the fact that inflation declined to 7.5 per cent in 1990, it rose to 44.8, 57.2 and 57.0 per cent, respectively, in 1992, 1993 and 1994. It reached an all-time high of 72.8 per cent in 1995. This was due to excess money supply, scarce foreign exchange and severe shortages in commodity supply, as well as continual labour and political unrest following the annulment of the June 1993 elections (Mordi *et al.*, 2007). In view of the excessive inflationary pressure, real GDP growth averaged only 1.5 per cent during the period 1992 – 1995. Since 1996, however, inflation rate has been below 30 per cent, averaging 12.7 per cent between 1996 and 2009, whereas real GDP growth averaged 5.4 per cent during the same period.

To corroborate the above position, we ran a simple regression analysis between the two major variables earlier described in the methodology: economic (real GDP) growth and inflation using quarterly data for the period 1981 – 2009.. The estimated regression results indicated an inverse relationship between inflation and economic growth. The coefficient was negative and statistically significant at the 5 per cent level. Similarly, a correlation coefficient between those two variables showed a value of -0.2, indicating that the variables were negatively related.

4.2 The Threshold Inflation Level

Following conclusions from the extant literature, the study hypothesizes that high inflation in Nigeria has an adverse effect on economic growth after it exceeds a certain limit. Khan and Senhadji (2001) estimated the threshold level of inflation above which inflation significantly slows growth at 11 per cent for developing countries, including Nigeria. Consequently, we estimate the threshold level for Nigeria within 11% ± 6% band i.e. 5 per cent to 17 per cent.

The estimation of equation (1) gives a specific value of the threshold inflation level and also measure the impact of that level on economic growth. The equation was estimated and the adjusted coefficient of determination (R^2) for each threshold level of inflation was computed. The optimal threshold level is the one

that maximizes the adjusted coefficient of determination (R^2). Table 1 reports the results of the estimation of the threshold levels.

Table 1: Estimation of Inflation Threshold Model at $\pi = 5$ to $\pi = 17$
Dependent Variable: Y_t (1981:Q1 – 2009:Q4)

π	Variable	Coefficient	Std. Errort-statistics	Probability	R^2	Adj. R^2	
	P_t	-0.0859	0.0286	-2.9969	0.0034		
5%	$D_t(P_t-\pi)$	-0.0219	0.0145	-1.5039	0.1358	0.1447	0.1188
	INV	0.1743	0.0686	2.5394	0.0127		
	C	0.0791	0.0159	4.9562	0.0000		
	P_t	-0.0829	0.0285	-2.8995	0.0046		
6%	$D_t(P_t-\pi)$	-0.0174	0.0133	-1.3072	0.1942	0.1400	0.1140
	INV	0.1671	0.0693	2.4099	0.0178		
	C	0.0744	0.0146	5.0692	0.0000		
	P_t	-0.0849	0.0291	-2.9151	0.0044		
7%	$D_t(P_t-\pi)$	-0.0091	0.0112	-0.8098	0.4200	0.1309	0.1046
	INV	0.1802	0.0691	2.6084	0.0105		
	C	0.0661	0.0125	5.2572	0.0000		
	P_t	-0.0845	0.0290	-2.9090	0.0045		
8%	$D_t(P_t-\pi)$	-0.0088	0.0110	-0.8016	0.4247	0.1308	0.1045
	INV	0.1818	0.0691	2.6279	0.0100		
	C	0.0657	0.0122	5.3603	0.0000		
	P_t	-0.0815	0.0290	-2.8099	0.0060		
9%	$D_t(P_t-\pi)$	-0.0020	0.0105	-0.1940	0.8465	0.1255	0.0990
	INV	0.1796	0.0693	2.5908	0.0110		
	C	0.0600	0.0116	5.1749	0.0000		
	P_t	-0.0827	0.0286	-2.8837	0.0048		
10%	$D_t(P_t-\pi)$	-0.0105	0.0101	-1.0454	0.2984	0.1347	0.1085
	INV	0.1811	0.0689	2.6259	0.0100		
	C	0.0660	0.0109	6.0493	0.0000		
	P_t	-0.0847	0.0284	-2.9824	0.0036		
11%	$D_t(P_t-\pi)$	-0.0178	0.0097	-1.8226	0.0714	0.1536	0.1279
	INV	0.1865	0.0683	2.7303	0.0075		
	C	0.0705	0.0104	6.7397	0.0000		
	P_t	-0.0851	0.0283	-2.9984	0.0034		
12%	$D_t(P_t-\pi)$	-0.0176	0.0095	-1.8562	0.0664	0.1546	0.1290
	INV	0.1858	0.0682	2.7223	0.0077		
	C	0.0697	0.0101	6.8980	0.0000		
	P_t	-0.0873	0.0279	-3.1197	0.0024		
13%	$D_t(P_t-\pi)$	-0.0236	0.0092	-2.5724	0.0116	0.1800	0.1551*
	INV	0.1679	0.0672	2.4963	0.0142		
	C	0.0734	0.0098	7.4497	0.0000		
	P_t	-0.0900	0.0281	-3.1991	0.0019		
14%	$D_t(P_t-\pi)$	-0.0231	0.0091	-2.5218	0.0133	0.1780	0.1531
	INV	0.1743	0.0672	2.5924	0.0110		
	C	0.0722	0.0096	7.4804	0.0000		
	P_t	-0.0885	0.0282	-3.1402	0.0022		
15%	$D_t(P_t-\pi)$	-0.0218	0.0092	-2.3527	0.0206	0.1715	0.1464
	INV	0.1712	0.0675	2.5349	0.0128		
	C	0.0701	0.0094	7.4525	0.0000		
	P_t	-0.0880	0.0283	-3.1088	0.0025		
16%	$D_t(P_t-\pi)$	-0.0203	0.0093	-2.1680	0.0326	0.1648	0.1395
	INV	0.1710	0.0678	2.5213	0.0133		
	C	0.0688	0.0093	7.3675	0.0000		
	P_t	-0.0864	0.0280	-3.0877	0.0026		
17%	$D_t(P_t-\pi)$	-0.0234	0.0093	-2.5040	0.0139	0.1773	0.1523
	INV	0.1816	0.0672	2.7014	0.0081		
	C	0.0685	0.0089	7.6792	0.0000		

From the estimated results, it is observable that at low threshold inflation levels (π<13%), the coefficient of β_2, which represent the threshold inflation dummy, was not significant in all the equations, indicating that there is a statistically insignificant relationship between the threshold dummy and economic growth. At that level, the relationship between inflation and economic growth was accounted for by the coefficient of β_1. As π increases, from 13 per cent, β_2 becomes statistically significant at the 5 per cent level, indicating a significant relationship between the threshold inflation dummy and growth. Thus, inflation and growth relationship was accounted for by $\beta_1 + \beta_2$. This implies that if inflation was below the 13 per cent threshold level, output growth would decline by the coefficient of P_t. However, if inflation increases beyond the 13 per cent threshold, economic growth would approximately change by the sum of the coefficients of P_t and P_t-π.

Consequently, the threshold level was identified at the 13 per cent level. At this level, the coefficient of determination was maximized (the Residual Sum of Squares, RSS, was minimized). The coefficient of determination, R^2, was found to be low across all the equations due to the limited number of variables included in the equations. A substantial number of variables were found to be strongly related to growth but growth theories were not explicit enough about what variables are to be included in growth regressions (Sala-i-Martin, 1997). Consequently, the inclusion of only inflation and investment rates, out of about 60 variables found to be significantly related to growth (see Sala-i-Martin, 1997) made the R^2 lower than expected.

The threshold level of inflation at 13 per cent means that this was the break-even level of inflation, above which inflation has a higher negative impact on the growth rate of output. On average, for inflation rates higher than the 13 per cent threshold level, growth rate was hindered by 0.11 per cent (-0.0873 + -0.0236) quarterly during the sample period. To state the impact annually, approximately 1 per cent higher than the threshold level of 13 per cent will result in 0.44 per cent decline in output growth annually.

Meanwhile, the coefficient of inflation levels (β_1) has been negative and statistically significant at the 1 per cent level for all inflation threshold levels, indicating that inflation hampers output growth even at low inflation levels in Nigeria, but the effect was mild. On average, for inflation rates lower than the 13 per cent threshold level, growth rate declined by 0.08 per cent quarterly, or 0.32 per cent (compared with 0.44 per cent), annually during the sample period. The high inflation observations recorded within the sample period, particularly in the

1990s, may have largely accounted for this phenomenon. For instance, annual inflation rates, which reached 56.0 and 57.2 per cent respectively in 1988 and 1993, peaked at 72.8 per cent in 1995 before slowing down to 29.3 per cent the following year. Consequently, the relationship may have largely reflected the Bruno and Easterly (1998) and Easterly (1996) hypothesis that the negative relationship between inflation and economic growth holds only for high-inflationary economies.

Meanwhile, we found a statistically and economically significant positive relationship between investment rates and economic growth in line with theoretical and empirical growth literature. According to the estimation results, holding other things fixed, a 1 per cent increase in investment rates will result in 0.17 per cent increase in output growth at the inflation threshold level.

4.3 Robustness Checks

4.3.1 Sensitivity to Changes in Econometric Methodology

There is the possibility that, for such high frequency time series data of inflation and output growth, the causality may not, as assumed, run from inflation to growth, but the other way round. If this is the case, then the magnitude of the effect that inflation has on growth is biased. In addition, investment rates also appear endogenous, since investments rise when the economy achieves sustainable growth, since it makes the country more attractive for investments. Under this circumstance, applying the standard OLS may result in inconsistent estimates. To remedy the problem and also check the robustness of the estimated model, the threshold model was re-estimated using the Two-Stage Least Square (TSLS) estimation procedure. The set of instruments included first lags of real GDP growth, investment rates and inflation rates. The results of the TSLS regression, as produced in Table 2, also indicated a 13 per cent threshold inflation level for Nigeria. Furthermore, the coefficients of the TSLS were identical with that of the main model.

4.3.2 Sensitivity to Additional Explanatory Variables

The endogenous growth literature emphasizes that anything that enhances economic efficiency no matter what, is good for growth. In line with this, other variables that can be found in growth literature including openness to foreign trade, financial deepening and population growth were added to the main equation.

Table 2: Two-Stage Least Squares (TSLS) Estimation of the Inflation Threshold Model at $\pi = 5$ to $\pi = 17$, Dependent Variable: Y_t (1981:Q1 – 2009:Q4)

π	Variable	Coefficient	Std. Error	t-statistics	Probability	R^2	Adj. R^2
	P_t	-0.1091	0.0311	-3.5046	0.0007		
5%	$D_t(P_t-\pi)$	-0.0227	0.0147	-1.5452	0.1255	0.1333	0.1068
	INV	0.1852	0.1283	1.4432	0.1521		
	C	0.0842	0.0177	4.7381	0.0000		
	P_t	-0.1080	0.0311	-3.4720	0.0008		
6%	$D_t(P_t-\pi)$	-0.0178	0.0136	-1.3097	0.1934	0.1289	0.1022
	INV	0.1534	0.1308	1.1727	0.2438		
	C	0.0810	0.0172	4.6873	0.0000		
	P_t	-0.1110	0.0319	-3.4763	0.0008		
7%	$D_t(P_t-\pi)$	-0.0103	0.0113	-0.9101	0.3650	0.1167	0.0897
	INV	0.2010	0.1296	1.5510	0.1241		
	C	0.0716	0.0143	4.9913	0.0000		
	P_t	-0.1104	0.0318	-3.4626	0.0008		
8%	$D_t(P_t-\pi)$	-0.0100	0.0112	-0.8972	0.3718	0.1157	0.0887
	INV	0.2096	0.1298	1.6145	0.1096		
	C	0.0707	0.0138	5.0944	0.0000		
	P_t	-0.1065	0.0317	-3.3508	0.0011		
9%	$D_t(P_t-\pi)$	-0.0026	0.0106	-0.2506	0.8026	0.1115	0.0843
	INV	0.2055	0.1292	1.5908	0.1149		
	C	0.0644	0.0133	4.8323	0.0000		
	P_t	-0.1074	0.0314	-3.4216	0.0009		
10%	$D_t(P_t-\pi)$	-0.0105	0.0102	-1.0355	0.3030	0.1207	0.0938
	INV	0.2014	0.1285	1.5667	0.1204		
	C	0.0702	0.0126	5.5407	0.0000		
	P_t	-0.1100	0.0311	-3.5351	0.0006		
11%	$D_t(P_t-\pi)$	-0.0181	0.0099	-1.8225	0.0714	0.1374	0.1110
	INV	0.2149	0.1276	1.6833	0.0955		
	C	0.0746	0.0121	6.1572	0.0000		
	P_t	-0.1106	0.0311	-3.5549	0.0006		
12%	$D_t(P_t-\pi)$	-0.0179	0.0096	-1.8530	0.0669	0.1384	0.1121
	INV	0.2124	0.1276	1.6639	0.0993		
	C	0.0738	0.0118	6.2279	0.0000		
	P_t	-0.1131	0.0306	-3.6873	0.0004		
13%	$D_t(P_t-\pi)$	-0.0236	0.0093	-2.5419	0.0126	0.1658	0.1402*
	INV	0.1735	0.1258	1.3792	0.1709		
	C	0.0786	0.0121	6.4655	0.0000		
	P_t	-0.1162	0.0308	-3.7652	0.0003		
14%	$D_t(P_t-\pi)$	-0.0234	0.0092	-2.5273	0.0131	0.1626	0.1370
	INV	0.1858	0.1262	1.4720	0.1442		
	C	0.0773	0.0118	6.5243	0.0000		
	P_t	-0.1143	0.0309	-3.6952	0.0004		
15%	$D_t(P_t-\pi)$	-0.0219	0.0093	-2.3315	0.0218	0.1563	0.1305
	INV	0.1808	0.1268	1.4259	0.1571		
	C	0.0751	0.0117	6.4093	0.0000		
	P_t	-0.1136	0.0310	-3.6586	0.0004		
16%	$D_t(P_t-\pi)$	-0.0203	0.0095	-2.1410	0.0348	0.1497	0.1237
	INV	0.1804	0.1273	1.4170	0.1596		
	C	0.0737	0.0116	6.3110	0.0000		
	P_t	-0.1115	0.0307	-3.6273	0.0005		
17%	$D_t(P_t-\pi)$	-0.0234	0.0095	-2.4532	0.0159	0.1590	0.1333

Openness was proxied by a ratio of total trade to nominal GDP while financial deepening was represented by the ratio of broad money (M2) to nominal GDP.

All the three variables came out statistically insignificant[3]. Furthermore, their inclusion does not significantly change the results. Infact, the threshold level remains the same.

4.3.3 Sensitivity to Data Frequency

To analyze how changes in data frequency may affect the location and magnitude of the threshold level and parameter estimates, equation 1 was also estimated using quarterly data from 1990 to 2009. Table 3 gives the threshold estimate and parameter estimates of equation 1. The results indicated that, there were no changes in the inflation threshold level over different periods, as the threshold level remained at 13 per cent. However, the coefficient of the inflation dummy was more powerful for the lower frequency data and their significance level was higher when compared to the main regression results.

4.3.4 Sensitivity to High Inflation Observations

Bruno and Easterly (1998) and Easterly (1996) have argued that the inverse relationship between inflation and economic growth holds only for high-inflationary economies. They added that excluding observations with annual inflation rates of 40 per cent or more weakens the negative relationship between inflation and growth. To test the hypothesis within this study, equation 1 was re-estimated with data covering the original period excluding observations with inflation rates higher than 40 per cent. The results are presented in Table 4. It indicated a threshold level of 9 per cent. In addition, the coefficient of the inflation dummy below the threshold level turned out to be positive, while the coefficient of inflation were negative and all but one of them were significant at 5 per cent levels. Consequently, the magnitude of the relationship between inflation and output growth was being affected by high inflation observations.

4.4 Policy Recommendations

The study estimated a threshold inflation level of 13 per cent for Nigeria, implying that below this level, inflation has mild effect on economic activities; while above it, the magnitude of the negative effect of inflation on growth was high.

[3] This results were not included in the study, but were available on request

Table 3: Estimation of Inflation Threshold Model at $\pi = 5$ to $\pi = 17$, Dependent Variable: Y_t (1990:Q1 – 2009:Q4), Sensitivity to Changes in Data Frequency

π	Variable	Coefficient	Std. Error	t-statistics	Probability	R^2	Adj. R^2
	P_t	-0.1000	0.0325	-3.0783	0.0029		
5%	$D_t(P_t-\pi)$	-0.0181	0.0195	-0.9264	0.3572	0.1563	0.1230
	INV	0.1468	0.0783	1.8739	0.0648		
	C	0.0847	0.0211	4.0005	0.0001		
	P_t	-0.0975	0.0325	-3.0014	0.0036		
6%	$D_t(P_t-\pi)$	-0.0109	0.0169	-0.6443	0.5213	0.1514	0.1179
	INV	0.1433	0.0796	1.8000	0.0758		
	C	0.0774	0.0184	4.1940	0.0001		
	P_t	-0.1000	0.0329	-3.0381	0.0033		
7%	$D_t(P_t-\pi)$	-0.0060	0.0133	-0.4558	0.6498	0.1491	0.1155
	INV	0.1531	0.0784	1.9519	0.0546		
	C	0.0726	0.0151	4.8016	0.0000		
	P_t	-0.0994	0.0328	-3.0305	0.0033		
8%	$D_t(P_t-\pi)$	-0.0053	0.0130	-0.4085	0.6840	0.1487	0.1151
	INV	0.1542	0.0785	1.9631	0.0533		
	C	0.0718	0.0146	4.9122	0.0000		
	P_t	-0.0977	0.0327	-2.9892	0.0038		
9%	$D_t(P_t-\pi)$	-0.0000	0.0124	-0.0063	0.9949	0.1468	0.1131
	INV	0.1526	0.0786	1.9421	0.0558		
	C	0.0675	0.0137	4.9036	0.0000		
	P_t	-0.0994	0.0322	-3.0808	0.0029		
10%	$D_t(P_t-\pi)$	-0.0150	0.0119	-1.2640	0.2101	0.1644	0.1314
	INV	0.1557	0.0777	2.0026	0.0488		
	C	0.0782	0.0130	5.9889	0.0000		
	P_t	-0.1007	0.0317	-3.1723	0.0022		
11%	$D_t(P_t-\pi)$	-0.0234	0.0114	-2.0522	0.0436	0.1916	0.1597
	INV	0.1641	0.0766	2.1410	0.0355		
	C	0.0829	0.0123	6.7276	0.0000		
	P_t	-0.1004	0.0318	-3.1577	0.0023		
12%	$D_t(P_t-\pi)$	-0.0217	0.0110	-1.9755	0.0518	0.1885	0.1564
	INV	0.1627	0.0767	2.1196	0.0373		
	C	0.0805	0.0117	6.8262	0.0000		
	P_t	-0.0995	0.0310	-3.2056	0.0020		
13%	$D_t(P_t-\pi)$	-0.0294	0.0105	-2.7811	0.0068	0.2256	0.1950*
	INV	0.1383	0.0750	1.8440	0.0691		
	C	0.0844	0.0113	7.4556	0.0000		
	P_t	-0.1005	0.0311	-3.2305	0.0018		
14%	$D_t(P_t-\pi)$	-0.0287	0.0105	-2.7244	0.0080	0.2227	0.1920
	INV	0.1492	0.0749	1.9897	0.0502		
	C	0.0822	0.0109	7.4832	0.0000		
	P_t	-0.0980	0.0310	-3.1568	0.0023		
15%	$D_t(P_t-\pi)$	-0.0295	0.0106	-2.7738	0.0070	0.2252	0.1947
	INV	0.1484	0.0748	1.9826	0.0510		
	C	0.0802	0.0106	7.5722	0.0000		
	P_t	-0.0974	0.0313	-3.1110	0.0026		
16%	$D_t(P_t-\pi)$	-0.0273	0.0108	-2.5142	0.0140	0.2123	0.1812
	INV	0.1479	0.0755	1.9591	0.0538		
	C	0.0782	0.0105	7.4281	0.0000		
	P_t	-0.0919	0.0310	-2.9602	0.0041		
17%	$D_t(P_t-\pi)$	-0.0312	0.0110	-2.8300	0.0060	0.2241	0.1941

Table 4: Estimation of Inflation Threshold Model at $\pi = 5$ to $\pi = 17$, Dependent Variable: Y_t (1981:Q1 – 2009:Q4), Excluding Observations with Inflation Greater Than 40 Per Cent

π	Variable	Coefficient	Std. Error	t-statistics	Probability	R^2	Adj. R^2
	P_t	-0.1442	0.0657	-2.1943	0.0320		
5%	$D_t(P_t-\pi)$	-0.0014	0.0186	-0.0799	0.9366	0.1136	0.0700
	INV	0.1770	0.0892	1.9840	0.0518		
	C	0.0763	0.0216	3.5234	0.0008		
	P_t	-0.1416	0.0646	-2.1911	0.0323		
6%	$D_t(P_t-\pi)$	0.0028	0.0167	0.1696	0.8659	0.1139	0.0703
	INV	0.1795	0.0902	1.9909	0.0510		
	C	0.0722	0.0194	3.7108	0.0004		
	P_t	-0.1346	0.0653	-2.0610	0.0436		
7%	$D_t(P_t-\pi)$	0.0090	0.0146	0.5399	0.6164	0.1190	0.0757
	INV	0.1804	0.0890	2.0268	0.0471		
	C	0.0670	0.0174	3.8510	0.0003		
	P_t	-0.1346	0.0651	-2.0664	0.0430		
8%	$D_t(P_t-\pi)$	0.0093	0.0144	0.6505	0.5178	0.1196	0.0763
	INV	0.1784	0.0888	2.0076	0.0491		
	C	0.0670	0.0168	3.9721	0.0002		
	P_t	-0.1260	0.0642	-1.9608	0.0545		
9%	$D_t(P_t-\pi)$	0.0188	0.0136	1.3848	0.1711	0.1405	0.0983*
	INV	0.1819	0.0878	2.0702	0.0427		
	C	0.0602	0.0158	3.8077	0.0003		
	P_t	-0.1396	0.0641	-2.1765	0.0334		
10%	$D_t(P_t-\pi)$	0.0079	0.0132	0.6013	0.5499	0.1187	0.0754
	INV	0.1798	0.0890	2.0205	0.0477		
	C	0.0695	0.0148	4.6878	0.0000		
	P_t	-0.1433	0.0641	-2.2343	0.0291		
11%	$D_t(P_t-\pi)$	-0.0012	0.0131	-0.0917	0.9272	0.1136	0.0700
	INV	0.1770	0.0892	1.9848	0.0517		
	C	0.0755	0.0143	5.2810	0.0000		
	P_t	-0.1430	0.0640	-2.2316	0.0293		
12%	$D_t(P_t-\pi)$	0.0006	0.0130	0.0467	0.9629	0.1135	0.0699
	INV	0.1774	0.0892	1.9878	0.0513		
	C	0.0745	0.0137	5.4278	0.0000		
	P_t	-0.1442	0.0637	-2.2632	0.0272		
13%	$D_t(P_t-\pi)$	-0.0112	0.0134	-0.8328	0.4082	0.1235	0.0804
	INV	0.1614	0.0906	1.7805	0.0800		
	C	0.0805	0.0137	5.8760	0.0000		
	P_t	-0.1466	0.0640	-2.2899	0.0255		
14%	$D_t(P_t-\pi)$	-0.0094	0.0138	-0.6844	0.4963	0.1203	0.0770
	INV	0.1677	0.0899	1.8661	0.0668		
	C	0.0792	0.0135	5.8602	0.0000		
	P_t	-0.1436	0.0641	-2.2403	0.0287		
15%	$D_t(P_t-\pi)$	-0.0033	0.0149	-0.2220	0.8250	0.1142	0.0707
	INV	0.1731	0.0910	1.9022	0.0619		
	C	0.0760	0.0131	5.7855	0.0000		
	P_t	-0.1429	0.0640	-2.2306	0.0294		
16%	$D_t(P_t-\pi)$	-0.0011	0.0155	-0.0723	0.9426	0.1136	0.0700
	INV	0.1758	0.0912	1.9281	0.0585		
	C	0.0752	0.0128	5.8626	0.0000		
	P_t	-0.1417	0.0641	-2.2080	0.0310		
17%	$D_t(P_t-\pi)$	-0.0048	0.0164	-0.2941	0.7697	0.1148	0.0712

The findings have some policy implications, thus:

a. The findings are essential guide for monetary policy management in Nigeria. It confirms the appropriateness of the single digit inflation rate being

currently pursued, which is believed to engender long-run sustainable economic growth. It provides a guide for the policy makers to choose an optimal target for inflation, which is consistent with long-term sustainable economic growth goals of the country.

b. In the short to medium term, monetary policy makers and other stakeholders should harness all pointers of inflation movements and or expectations in order to ensure relative stability of general price changes due to seasonality and business cycles. The use of the outcome of expectations surveys could make a big difference in tracking of inflation movements in the short-run.

5.0 Summary and Conclusion

Governments and central banks worldwide might want to achieve price stability for several reasons, with the most compelling being the potential for long-term growth. This was so as the overall weight of empirical evidence so far clearly indicated that high inflation was inimical to output growth. Utilizing quarterly data for the period 1981 – 2009, this study attempted to estimate the threshold level of inflation for Nigeria, beyond which inflation exert a negative impact on economic growth. Using a threshold regression methodology developed by Khan and Senhadji (2001), the study found a threshold inflation level of 13 per cent for Nigeria. Below the threshold level, inflation has a lower negative effect on output growth. Above it, the magnitude of the negative effect of inflation on growth was higher. The study also found that there was a negative and significant relationship between inflation and growth in Nigeria for inflation rates both below and above the threshold level. The threshold level regression was found to be robust with respect to changes in econometric methodology, additional explanatory variables and changes in data frequency. It was, however, very sensitive to the exclusion of high inflation observations, thus, validating the Bruno and Easterly hypothesis. This result is consistent with the findings of Khan and Senhadji (2001) that estimated a threshold level of 11 – 12 per cent for developing economies, and Frimpong and Oteng-Abayie (2010) that indicated a threshold level of 11 per cent for neighboring Ghana. These findings are essential for monetary policy formulation by the Central Bank of Nigeria, whose primary objective is the achievement and maintenance of price stability, as it provides a guide for the Bank to choose an optimal inflation rate, which is consistent with long-term sustainable economic growth goals of the country.

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Fiscal Federalism in Nigeria: A Cluster Analysis of Revenue Allocation to States and Local Government Areas, 1999 – 2008

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Existing literature on revenue allocation in Nigeria shows more concern for merits and demerits of sharing principles and /or formulae. Several alternatives have been proposed and will continue to be developed to address the unending agitations from beneficiaries. Contrary however, this paper analyzes two items of revenue (statutory and VAT) shared among the states including FCT and all the Local Government Areas (LGAs) between May 1999 and December 2008. The net statutory allocation after deductions was also analyzed. Using Cluster analysis to evaluate revenue allocation in Nigeria, States and LGAs exhibiting similarity in revenue received were grouped and their common features highlighted. The result of this exercise may be a pointer to resolving the issue of viability when combined with other statistics.

Key Words: Cluster Analysis, Revenue Allocation, Fiscal Federalism, Statutory Allocation, VAT.
JEL Classification: C38, H71, H77

1.0 Introduction

The importance of revenue generation, allocation as well as its distribution towards maintaining both the existing and new socio-politico-economic structure in any economy be it centrally planned, market or mixed economies cannot be overemphasized. To this end, what revenue is to an individual or a firm is what it is to the government. Thus, revenue allocation and its distribution remain a vitally sensitive issue which continues to spark off reactions from all stakeholders at all times. This is more so in the sub-Saharan region and particularly in Nigeria where ethnic plurality and language heterogeneity characterize the country's existence.

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In recent years, the issues of resource control, revenue allocation and fiscal federalism have dominated discussions at various levels of Nigeria's political debate. Like most federal systems, Nigeria has a revenue distribution system in which the federal government shares revenue with the states and local governments. Different formulas at different times have been adopted. Similarly, at different times, ad hoc commissions have been set up to determine the allocation formulae and criteria. Between 1946 and 1979, there were eight of such commissions on revenue allocation. These were: Phillipson (1946), Hicks-Phillipson (1951), Chick (1953), Raisman (1958), Binns (1964), Dina (1968), Aboyade (1977), and Okigbo (1980). It was not until 1988 that a permanent body was created to monitor, review, and advise the federal government on RAS on a continuing basis. The new body, called the ***National Revenue Mobilization, Allocation, and Fiscal Commission,*** represents a structured attempt to replace the ad hoc approaches to effecting changes in the RAS. This body is enshrined in the 1989 Constitution.

Despite these efforts, revenue allocation has remained a contentious issue among the three tiers of government in Nigeria. In the last eight years, the 36 state governments have been at daggers-drawn with the Federal Government over the formulation of a revenue sharing formula that would be acceptable to all the stakeholders. One major impact of this seemingly never ending controversy is the fact that fiscal federalism in Nigeria has not been able to contribute optimally to social and economic development. Despite the considerable increase in the number of administrative units, the rate of real economic growth has been low and the country's per capita income has declined considerably over the years compared with the level that was attained in the 1980s. As the nation operates a new era of democracy under a federal constitution, there is the need to critically review the division of functions among the various tiers of governments, as well as the revenue sharing arrangements in order to substantially improve the delivery of public goods and services as well as promote real economic growth.

The available literature on revenue allocation in Nigeria focuses mostly on justifying a particular sharing formula or proposing a new one. Notable among this category are: Phillips (1991) and Aluko (2002, 2004). Other studies including Anyanwu (1999), Aigbokhan (1999), Ebajemito and Abudu (1999), Okon and Egbon (1999), seem to discuss generally about fiscal federalism by diagnosing the Nigeria situation and proffering solutions. Hitherto, no attempt has been made to even analyse the various allocations made to all the tiers of government. Some of

the immediate puzzling issues that need to be examined critically from the previous allocations include the following:

- To what extent is similarity or difference in the revenue allocation in Nigeria distributed at the state and local government levels?
- Is the similarity or difference consistent across the basic components of the revenue allocation?

The present study aims at providing answers to these immediate questions as well as serving as a platform for raising a number of pertinent issues as basis for further research into areas that are likely to be of great interest for policy analysis, political analysts, and the parliamentarians who have responsibility for creating states. Thus, the study specifically intends to analyze and conduct a comparative analysis of revenue allocation among geo-political zones, states and local governments and attempt to classify them using cluster analytical framework. The study's contributions are in two-fold: first, employing cluster analysis to examine the state and local governments with similar (dissimilar) features in terms of revenue allocation using specific item of revenue such as statutory allocation, value-added tax, and net statutory allocation. Second, attempt is made to group these tiers of government based on financial resources available to them.

Following the introduction, the rest of this paper is structured as follows: section two presents a brief review of relevant literature on revenue allocation in Nigeria; section three presents the methodology while section four gives the analysis of results, section five provides the concluding remarks.

2.0 Literature Review

A large number of studies have been conducted on fiscal federalism and revenue allocation both in the developed and developing countries. However, the focus of majority of these studies usually revolves around examining the structure, pattern, trends and impact analysis of revenue allocation on economic growth. In a panel data analysis, Davoodi and Zou (1998) find a weakly significant negative relation between the degree of fiscal federalism and the average growth rate of GDP per capita for a sample of 46 countries over the period from 1970 to 1989. For the sub-sample of industrial countries, this effect is not significant. The negative influence for developing countries is robust though only weakly significant as well. According to these estimates, an additional decentralization of spending by 10 percent reduces the growth of real GDP per capita in developing countries by 0.7 – 0.8 percentage points.

Woller and Philipps (1998) also cannot find a robust relation between economic growth and decentralization, using a sample with a lower number of developing countries and a shorter time period.

In an empirical analysis for average economic growth of the past 25 years in a cross-section of 91 countries, Enikolopov and Zhuravskaya (2003) show that the effects of fiscal decentralization depend to a large extent on the structure of the party system as well as on the degree of "subordination" of subnational levels. According to them, especially in developing and transition countries, the age of the most important political parties is favorable to the positive effects of decentralization on economic growth. In countries with a – in this respect weaker – party system, a 10 percent increase of decentralization of revenue decreases real per capita GDP growth by 0.14 percentage-points. These results are in contrast to those of Martinez-Vazquez and McNab (2002). The latter finds that the decentralization of revenue significantly reduces the growth of real GDP per capita of developed countries, but not of the developing and transition countries.

Yilmaz (2000) analyzes the different effects of fiscal decentralization in 17 unitary and 13 federal countries for the period 1971-1990 with annual data. Decentralization of expenditures to the local level increases the growth of real GDP per capita in unitary states more strongly than in federal states. However, the decentralization to the intermediate level in federations is not significant. Thießen (2003) analyzes the average growth rates of real GDP per capita for a cross-section of 21 developed countries in the period 1973-1998 and in a parallel study (Thießen, 2003a) for a panel of 26 countries between 1981 and 1995. According to his estimates, a 10 percent increase of decentralization of expenditures increases the growth of real GDP per capita by 0.12-0.15 percentage points in high-income countries. However, the relation between federalism and economic growth might be non-linear, because the quadratic term of expenditure decentralization is significantly negative.

The empirical results concerning the impact of decentralization on economic growth for individual countries also appear to be ambiguous. To date, the discussion is limited to China, the US, and Germany. Zhang and Zou (1998) note a significantly negative effect of expenditure decentralization on economic growth in 28 Chinese provinces, using annual data between 1987 and 1993. Jin *et al*. (1999) however, report a weekly significant positive effect of expenditure decentralization on economic growth of almost the same sample of Chinese provinces over time. The most important difference between the studies is the use

of time dummies that are not included by Zhang and Zou (1998). Consequently, symmetric shocks are not adequately controlled for. Lin and Liu (2000) strengthen the result of a positive relation between decentralization and economic growth in Chinese provinces for the period 1970 to 1993 also for the revenue side. In addition, higher responsibility of public budgets at the provincial level is connected with increased economic growth. These authors also use time dummies in addition to fixed cross-section effects. The relevance of using time dummies points to the strong economic dynamics in China. The sometimes enormously high Chinese growth rates apparently cannot be captured by structural variables alone so that auxiliary variables for the individual years are necessary for correctly specifying the econometric model. Thus, for China, there might well exist a positive relation between decentralization of governmental activity and economic growth.

In a time-series analysis for the US from 1951 to 1992, Xie, Zou and Davoodi (1999) claim that the US is in a decentralization equilibrium. They ascribe this to the fact that differences in decentralization at the state or local level do not exert statistically significant effects on real GDP growth. Akai and Sakata (2002) however, offer evidence to the contrary for US states. Considering additional explanatory factors and various indicators for the degree of fiscal federalism, they find a positive influence on economic growth. If expenditure decentralization increases by 10 percent, the growth of GDP per capita increases by 1.6 to 3.2 percentage points. However, decentralization on the revenue side and indicators for fiscal autonomy of sub-national levels, measured by the share of own revenue in total revenue, do not show significant effects. Both studies might not necessarily contradict each other because of the different perspectives adopted. While the first study starts from a national perspective, the second one adopts the perspective of the single states. As mentioned in Section 2, both perspectives might well coincide with each other.

The same argument might hold for Germany. Berthold *et al.* (2001) analyze the effects of horizontal fiscal equalization between states and supplementary federal grants on economic development of the 16 Lander in a panel analysis with annual data from 1991 to 1998. According to their estimates, higher grants in horizontal and vertical fiscal relations significantly reduce the growth of nominal GDP per capita of the Lander. Behnisch *et al.* (2002) however, find a positive effect of increasing federal activities – measured by the share of expenditure at the federal level – on total German productivity growth in a time series analysis from 1950 to 1990.

Similarly in Nigeria, a number of studies have analyzed dynamics of fiscal federalism in the country. For example, Akinlo (1999) using the OLS technique, examines the fiscal responsiveness of State governments to formal intergovernmental flows in aggregate and according to the type of central government assistance schemes. He finds that state governments' Fiscal expenditure was stimulated by federal grants during the period of analysis. More importantly various grants examined were found to have positive effects on the expenditure profiles of the state governments. Above all, statutory grants appear to account for the most stimulative effect of federal funds on total state governments' capital and recurrent expenditure.

Aigbokhan (1999) also employs the OLS technique to investigate the fiscal decentralization on economic growth in Nigeria. The study finds evidence of high concentration ratio of both expenditure and revenue. It also finds evidence of mismatch in spending and taxing responsibilities with states being harder hit. In a similar vein, Jimoh (2003) provides concrete statistical evidence on the impact of the extent of decentralization of government expenditures and/or revenue collection on the levels of economic activities in Nigeria. Based on regression analysis, the paper finds that more decentralized governance, especially in terms of increased local governments and increased transfer of revenues to lower tiers of government would stimulate economic activities and/ or economic growth. It also suggests that the major determinants of the prevalence of poverty in Nigeria are economic and population growths.

Akujuobi and Kalu (2009) focus on the role of the financing sources of Nigerian State governments in the financing of their real asset investments. Using the OLS technique, the paper finds that Federal allocation and stabilization fund are significant in the financing of real asset investments at both 5% and 1% levels of significance. Internally-generated revenue (IGR), loans (LNS), Grants (GT) and value added tax (VAT) are found insignificant in the financing of the real asset investments of Nigerian state governments for the period 1984-2008. Our work differs from the previous studies as we evaluate statistically the extent of similarities or dissimilarities in revenue allocation at the state and local government levels. This provides some statistical evidence for any observed variations in the revenue allocation in Nigeria and also raises other pertinent issues that may provide basis for future research.

3.0 Methodology

Cluster Analysis is a statistical technique that seeks to organize information about variables so that relatively homogeneous groups, or "clusters," can be formed. The clusters formed with this family of methods should be highly internally homogenous (in terms of similarity proximity, resemblance, or association features) and highly externally heterogeneous (that is, unrelated to members of other clusters).

Cluster analysis is a useful technique for classifying similar and dissimilar objects and has continued to gain prominence in social sciences where the geography of data forms an integral part of scientific analysis.

The computational procedure for cluster analysis includes data collection and selection of the variables for analysis, generation of a similarity matrix, decision about number of clusters and interpretation and validation of cluster solution. Fortunately, however, there are standard statistical packages such as STATA that can perform cluster analysis.

In this study, cluster analysis was carried out to examine the states and local governments with similar (dissimilar) features in terms of revenue allocation. We have used data covering revenue allocation to all the states and local governments in Nigeria. The specific variables of interest for our cluster analysis are statutory allocation, value-added tax, and net statutory allocation.

4.0 Analysis of Cluster Results

4.1 A Cluster Analysis for Statutory Allocation in Nigeria

Our cluster analysis for statutory allocation was carried out separately for states and local governments in Nigeria. For the state governments, we specified the arrangement of statutory allocation into four clusters to see the similarity or dissimilarity in state governments' statutory allocation in Nigeria. For the purpose of this analysis, we have regarded FCT Abuja as a state in the North Central zone. Tables 1 and 2 below show the results of our cluster analysis involving four clusters.

Table 1: Cluster Analysis of Statutory Allocation in Nigeria by States

Range of Allocations (N Billion)	Cluster	Rank of Clusters	States	No. of States	Remark
174.81 – 184.84	Cluster 3	1	FCT Abuja, Kano, Lagos	3	Highest Beneficiaries
139.68 – 161.79	Cluster 4	2	Bauchi, Benue, Borno, Jigawa, Kaduna, Katsina, Niger, Oyo, Rivers	9	
120.58 – 131.95	Cluster 1	3	Adamawa, Akwa Ibom, Anambra, Cross River, Delta, Edo, Enugu, Imo, Kebbi, Kogi, Ogun, Ondo, Osun, Plateau, Sokoto, Taraba, Yobe, Zamfara	18	
101.30 – 117.46	Cluster 2	4	Abia, Bayelsa, Ebonyi, Ekiti, Gombe, Kwara, Nassarawa	7	Least Beneficiaries

Source: Computed by the authors

Table 1 shows the distribution of the clusters by states. The table depicts the extent of similarity and dissimilarity in the statutory allocation among states in Nigeria. The first and second values in the column under the range of allocations represent the allocation to the state with the minimum and maximum allocation in the cluster. The clusters of highest and least beneficiaries of statutory allocation have 3 and 7 states respectively. It is interesting to know that 18 (50%) of the states fall within cluster 3. Table 2 shows distribution of the states within each cluster according to geopolitical zones. None of the states from NE, SE and SS geopolitical zones is listed in the cluster of highest beneficiaries of statutory allocation. It is also very obvious from the table that SE geopolitical zone alone

has no representation in the first and second cluster. On this basis, the zone could be regarded as the least beneficiary in respect of statutory allocation.

Table 2: Cluster Analysis by Geo-political Zones

Cluster	Geo-political Zone						Number of States
	North West (NW)	North East (NE)	North Central (NC)	South West (SW)	South East (SE)	South-South (SS)	
Cluster 1	3	3	2	3	3	4	18
Cluster 2	0	1	2	1	2	1	7
Cluster 3	1	0	1	1	0	0	3
Cluster 4	3	2	2	1	0	1	9

Source: Computed by the Authors

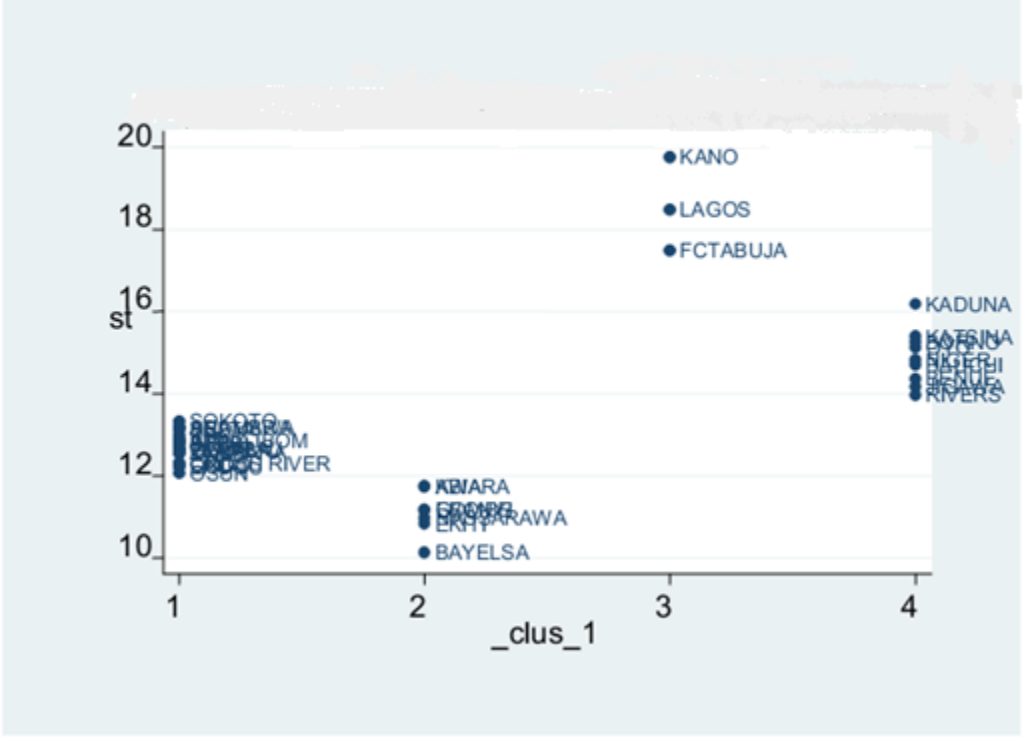

Figure 1: Cluster Analysis of Statutory Allocation to States in Nigeria

In the same vein, we conducted cluster analysis for statutory allocation to local governments (LGs) in Nigeria. We **s**pecified the arrangement of statutory allocation into ten clusters (because of the large number of LGs in Nigeria) in order to see clearly the similarity or dissimilarity in local governments statutory allocation in Nigeria. The results are presented in the graph below. The graph shows the existence of a strong similarity in statutory allocation of some local governments (as shown in each cluster) as well as a strong dissimilarity among the clusters (when one compares one cluster to the other).

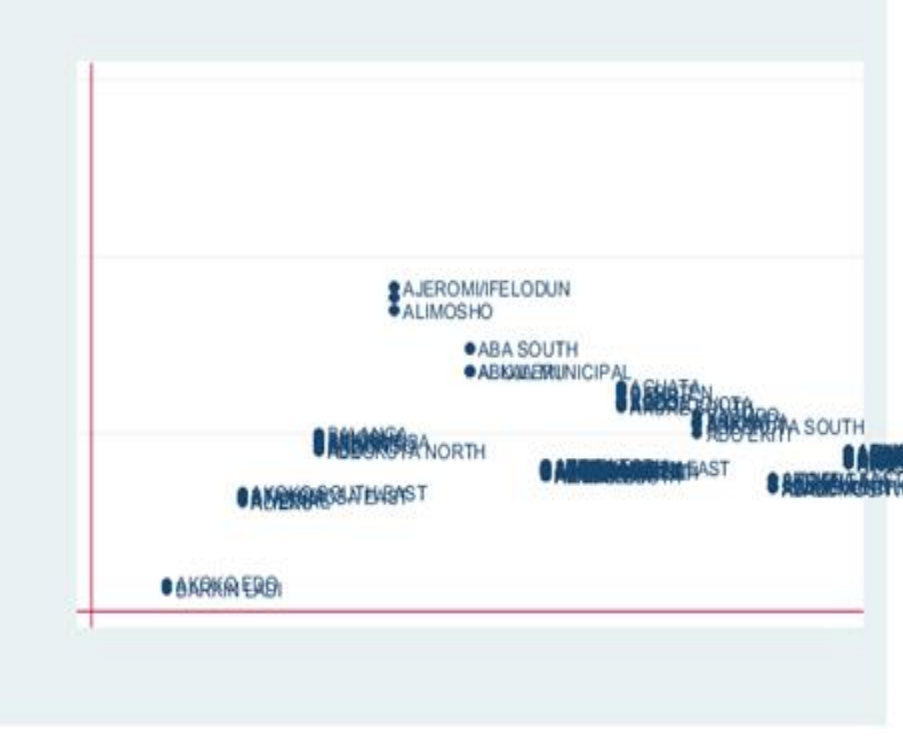

Figure 2: Cluster Analysis of Statutory Allocation to LGs in Nigeria

Like what we observed in figure 1 and 2 also shows that a very small number of LGs occupy the extreme cases (that is, highest and lowest statutory allocation). Cluster 2 shows that as low as 7 LGs out of 776 LGs fall within the range of values for the highest statutory allocation. Similarly, cluster 4 depicts that just about 13 LGs fall within the range of values for the lowest statutory allocation. In terms of the number of LGs constituting the clusters, it is seen that cluster 8 has the highest number of LGs (179 LGs to be precise) followed by cluster 2 has the least with 7 LGs respectively. Overall, a good number of LGs in Nigeria have similar features in terms of statutory allocation.

4.2 A Cluster Analysis for Value Added Tax in Nigeria

Like statutory allocation, cluster analysis for value added tax (VAT) was carried out separately for states and local governments in Nigeria. For the state governments, we also **s**pecified the arrangement of VAT into four clusters to see the similarity or dissimilarity in allocation. The tables 3 and 4 and the graph below show the results of our cluster analysis involving four clusters.

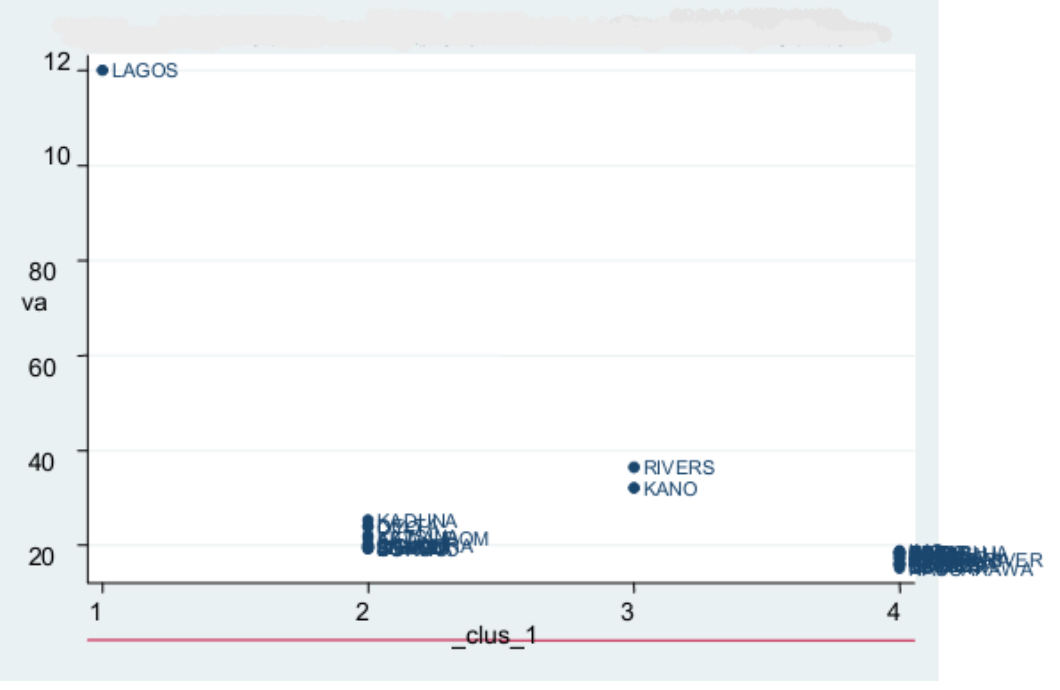

Figure 3: Cluster Analysis of VAT in Nigeria by States

Table 3 shows the distribution of the clusters by states. The table depicts the extent of similarity and dissimilarity in VAT among states in Nigeria. It is very striking to see that Lagos alone is in the cluster of top beneficiary of VAT allocation. The extent of the gap between its cluster and the next cluster can be seen in Figure 3. Lagos is clearly a leading beneficiary of VAT allocation for obvious reasons which include large population and level of industrialization. The second cluster has two states – Kano and Rivers while majority (21) is in cluster 4. This is a clear indication of the low level of industrialization and even capacity to generate fund internally in all the 21 states. By looking at the distribution of the clusters by geo-political zones (table 4), it can be seen that NW states benefited more than other zones while NC dominates the cluster of least beneficiaries.

Table 3: Cluster Analysis of VAT Allocation in Nigeria by States

Range of Allocations (N Billion)	Cluster	Rank of Clusters	States	No. of States	Remark
119.94	Cluster 1	1	Lagos	1	Highest Beneficiary
32.16 – 36.47	Cluster 3	2	Kano, Rivers	2	
19.20 – 25.41	Cluster 2	3	Akwa Ibom, Anambra, Bauchi, Benue, Borno, Delta, Enugu, Jigawa, Katsina, Ogun, Oyo, Kaduna, Sokoto	13	
15.23 – 18.63	Cluster 4	4	Abia, Adamawa, Bayelsa, Cross River, Ebonyi, Edo, Ekiti, FCT Abuja, Gombe, Imo, Kebbi, Kogi, Kwara, Nasarawa, Niger, Ondo, Osun, Plateau, Taraba, Yobe, Zamfara	21	Least Beneficiaries

In the same vein, we conducted cluster analysis for VAT to local governments (LGs) in Nigeria. Similarly, we **s**pecified the arrangement of VAT into ten clusters. The results are presented in Figure 4.

Table 4: Cluster Analysis of VAT Allocation by Geo-political Zones

Cluster	Geo-political Zone						Number of States
	North West (NW)	North East (NE)	North Central (NC)	South West (SW)	South East (SE)	South-South (SS)	
Cluster 1	0	0	0	1	0	0	**1**
Cluster 2	4	2	1	2	2	2	**13**
Cluster 3	1	0	0	0	0	1	**2**
Cluster 4	**2**	**4**	**6**	**3**	**3**	**3**	**21**

The graph shows the existence of a strong similarity in VAT for virtually all local governments in Nigeria (as shown in each cluster) as well as a strong dissimilarity among the clusters (that is, moving from one cluster to the other).

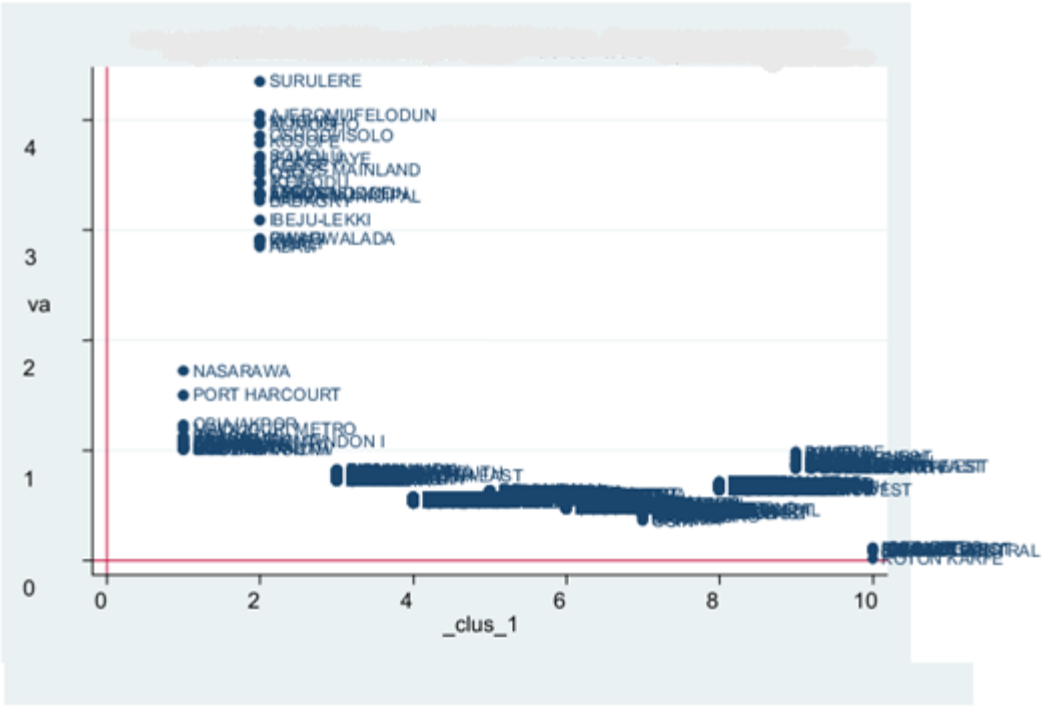

Figure 4: Cluster Analysis for VAT in Nigeria by LGs

Like what we observed in figure 3, figure 4 also shows that a very small number of LGs occupy the extreme cases (that is, highest and lowest VAT). Cluster 2 shows that as low as 26 LGs out of 776 LGs fall within the range of values of the highest VAT beneficiaries and it is dominated by LGs in Lagos State. This trend can also be attributed to the earlier reasons adduced for VAT allocation to States in which Lagos is the highest beneficiary. Similarly, cluster 10 depicts that just about 13 LGs fall within the range of values of the lowest VAT beneficiaries dominated by North Central. This also confirms our earlier evidence and in fact gives an indication that North Central seems to be the least industrialized in the Country. In terms of the number of LGs constituting each cluster, it is seen that cluster 6 has the highest number of LGs (165 LGs to be precise) and cluster 10 has the lowest with 13 LGs. Overall, a good number of LGs in Nigeria have similar features in terms of VAT.

4.3 A Cluster Analysis of Net Statutory Allocation in Nigeria

Like statutory allocation and VAT, our cluster analysis for net statutory allocation (netstat) was carried out for states in Nigeria. The intention actually is to ascertain the impact of derivation fund and charges on debt incurred by some states on the available funds at their disposal. For the state governments, we also **s**pecified the arrangement of netstat into four clusters to see the similarity or dissimilarity in state netstat allocations. Tables 5 and 6 as well Figure 5 show the results of our cluster analysis.

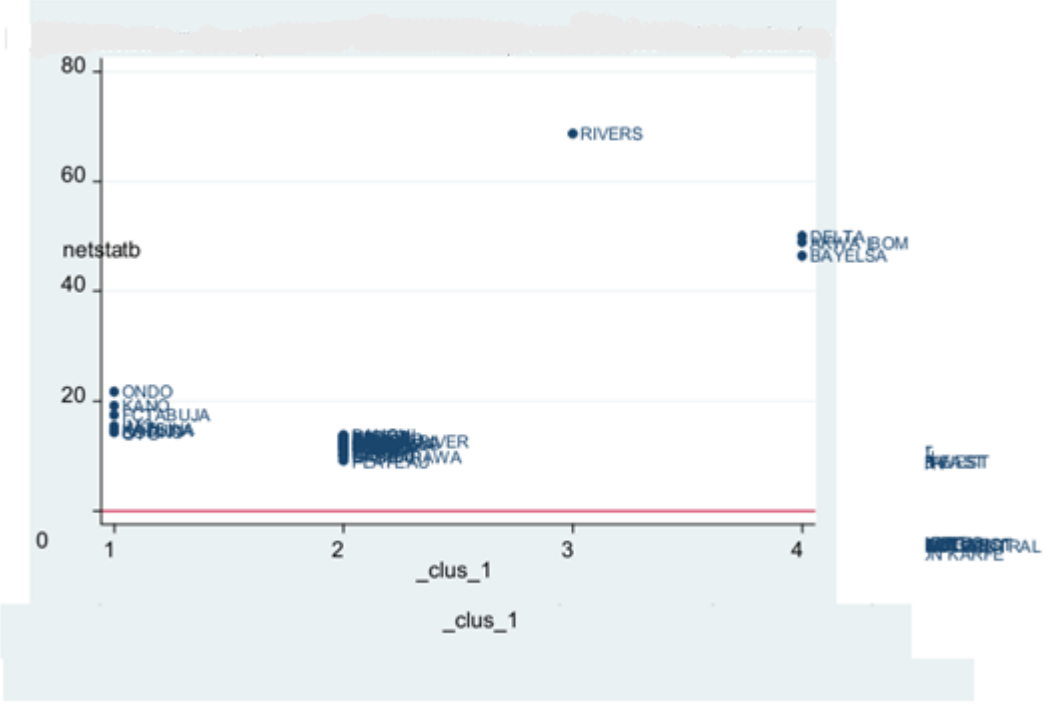

Figure 5: Cluster Analysis for Net-Statutory Allocation in Nigeria by States

The netstat is determined by subtracting charges on debt incurred by each state from its gross allocation. The gross allocation actually is the sum of statutory allocation, derivation fund and VAT. The cluster analysis as presented in tables 5 and 6 for the netstat in Nigeria by states reflects the significant impact of derivation fund and charges on debt incurred by some states as virtually all the states of the Niger Delta (South- South geo-political zone) occupy the range of values for high netstat (see tables 5 and 6). Specifically, table 5 shows that cluster 3 with 1 state (Rivers) occupy the highest range of values of netsat followed by

cluster 4 with 3 states (Akwa Ibom, Bayelsa and Delta), cluster 1 with 8 states and cluster 2 with 25 states.

These findings suggest that the oil producing states seem to receive the largest net statutory allocation even far above the highest industrialized state in Nigeria – Lagos. The single factor responsible for this trend is the Derivation fund allocated to the oil producing states.

Table 5: Cluster Analysis of Net Statutory Allocation in Nigeria by States

Range of Allocations (N Billion)	Clusters	Rank of Clusters	States	No. of States	Remark
686.69	Cluster 3	1	Rivers	1	Highest Beneficiary
465.12 – 500.51	Cluster 4	2	Balyesa, Akwa Ibom and Delta	3	
142.96 – 217.18	Cluster 1	3	Borno, FCT Abuja, Imo, Kaduna, Kano, Katsina, Ondo, Oyo	8	
91.41 – 137.97	Cluster 2	4	Abia, Adamawa, Anambra, Bauchi, Benue, Cross River, Ebonyi, Edo, Ekiti, Enugu, Gombe, Jigawa, Kebbi, Kogi, Kwara, Lagos, Nassarawa, Niger, Ogun, Osun, Plateau, Sokoto, Taraba, Yobe, Zamfara	25	Least Beneficiaries

Table 6: Cluster Analysis of VAT Allocation by Geo-political Zones

Cluster	**Geo-political Zone**						**Number of States**
	North West (NW)	North East (NE)	North Central (NC)	South West (SW)	South East (SE)	South-South (SS)	
Cluster 1	3	1	1	2	1	0	8
Cluster 2	4	5	6	4	4	2	25
Cluster 3	0	0	0	0	0	1	1
Cluster 4	0	0	0	0	0	3	3

By looking at the distribution of the clusters by geo-political zones (Table 6), it can be seen that all the geopolitical zones are represented only in clusters 2 while clusters 3 and 4 featured only the SS zone, cluster 1 featured all the geo-political zones excluding the SS.

Unlike what we observed in Tables 2 and 3, Tables 5 and 6 show that a very large number of states occupy one of the extreme cases (that is, the lowest netstat). Cluster 2 shows that 25 states out of 37 fall within the range of values for the lowest netstat. This observation may not be unconnected with the fact that just about 6 out of the 37 states in Nigeria are eligible for the derivation fund that often shoots up the gross allocation for these states. Overall, a good number of States in Nigeria have similar features in terms of statutory netstat.

5.0 CONCLUDING REMARKS

Though, a large body of study exists on fiscal federalism and revenue allocation both in the developed and developing countries but with the bulk of these studies focusing majorly sharing principles and formulae. This paper however, analyzed allocations since the inception of the third republic to examine the distribution pattern among the states and the LGAs. The results from cluster analysis showed that a small number of states constituting each of the clusters in terms of statutory allocation, VAT and net statutory allocation occupied the range of values for highest and lowest allocations. Specifically, the SE zone was found to be the least beneficiary of statutory allocation. In the case of VAT, NW zone benefited more than other zones while NC dominates the cluster of least beneficiary states. The story changed completely in the case of net statutory allocation. The oil producing

states received the largest net statutory allocation even above the most industrialized state in Nigeria – Lagos simply because of the derivation fund enjoyed solely by them. Nonetheless, a good number of LGs in Nigeria have similar features in terms of both statutory allocation and VAT. Subsequent analysis hopes to combine other statistics to examine the question of state and local government viability.

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A Business Cycle Model for Nigeria

Philip O. Alege[1]

The current global financial meltdown draws, once again, attention to the existence of business cycle fluctuations. Experts are of the view that the ongoing crisis is far deeper than the great depression of the 1930s. It should be recalled that the Keynes and Keynesianism was a response to that depression. Therefore, the objective of this paper is to develop a small business cycle model in the spirit of Dynamic Stochastic General Equilibrium (DSGE) model for Nigeria designed to examine the sources of business cycles, and use the model for policy analysis. This paper considers the implications of three policy shocks namely: monetary supply, technology and export supply on some macroeconomic aggregates. While the paper adopts the Nason and Cogley (1994) and Schorfheide (2000) models, it, however, introduces export sector into the model with a view to capturing the transmission channel of terms of trade. The method of estimation is the Bayesian and the paper uses DYNARE codes (dyn_mat_v4). The results obtained in this study show that the Nigerian business cycle is driven by both real and nominal shocks.

JEL Classification: E52, D58, C11, O55

Keywords: Shocks, Calibration, DSGEM, DYNARE, Bayesian Estimation

1.0 Introduction

The current global financial meltdown draws, once again, attention to the existence of business cycle fluctuations. Experts are of the view that the ongoing crisis is far deeper than the great depression of the 1930s. It should be recalled that the Keynes and Keynesianism was a response to that depression. Path breaking researches explaining the cyclical nature of the crisis came to the limelight with the seminal paper of Kydland and Prescott (1982). Under the nomenclature of Real Business Cycle, the class of models that emerged is essentially built on rational–expectations. These models incorporate explicitly microeconomic behaviour of forward looking economic agents in the system. Prices are assumed to be perfectly flexible and the models in this category postulate that only real shocks can propagate business cycle fluctuations in the economy. RBC models are also known to have the ability to incorporate

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uncertainties (see Mendoza, 1991). Finally, the strong theoretical foundation of RBCs improved supply side and allowed direct calculation of welfare.

In spite of the ability of RBC to replicate the real economy, its short run dynamics necessitated some kind of reviews. In effect the assumption of flexible prices left little room for analysis of macroeconomic policies (Rajan, 2004:7). In addition, inability to recognize nominal sources of shocks restricted the usefulness of the RBC models. In order to respond to these limitations of RBCs, models that can combine explicit microeconomic foundations with nominal factors were developed (Christiano, Eichenbaum and Evans, 2001). This method of approach is non-Walrasian in view of the assumptions of imperfect market, sticky prices and monopolistic competition in the spirit of New Keynesian macroeconomics.

The outcome of this is the upsurge of new waves of dynamic and stochastic models that integrates aggregate supply and demand responses based on microeconomic theory. These models are tagged Dynamic Stochastic General Equilibrium Models (DSGEMs): Nason and Cogley; (1994); Schorfheide, (2000); Kydland and Prescott, (1982); Smets and Wouiters (2003); Bergeoing and Soto, (2002). (See Alege (2008) for an extensive review of literature on business cycle phenomenon). These DSGE models have several benefits which make them attractive for macroeconomic policy analysis. According to Peiris and Saxegaard (2007) these models (a) have structural equations in the sense that they have economic interpretations; (b) are micro-founded because they are explicitly derived from the optimizing behaviour of economic agents in the economy (firms, households, financial intermediaries and rest of the world); (c) are stochastic in the sense that they explicitly discuss how random shocks, such as monetary policy, and trade shocks affect the economy; (d) monopolistic competition and sticky/sluggish prices and wages and (e) are forward–looking in the sense that agents optimize from rational or model consistent forecasts about the future evolution of the economy.

Indeed, understanding and distinguishing short-run (fluctuations) and long-run (growth) determinants of the macro-economy has been emphasized in the literature (Agenor *et al.* 2000; Lane, 2002). In this respect, there is a large amount of literature on Industrial, Latin America and Asian economies. However, there are little or no studies in this area based on the African economies and in particular the Nigerian data. Indeed the amount of literature based on studies from Sub-Sahara Africa (SSA) is very paltry. This situation may be due to the fact that

DSGE models are at various stages of development and there is the apparent difficulty to build and run them.

Among the few papers in this area of research is the paper by Peiris and Saxegaard (2007) which attempts to evaluate monetary policy trade-offs in low-income countries using a DSGE model estimated on data for Mozambique for the period 1996:1 to 2005:4. To date, the paper by Olekah and Oyaromade (2007) set the tone for DSGE modeling in Nigeria. The authors attempt to develop a model that can be used for monetary policy decision in Nigeria. Using a small DSGE model so constructed, the authors concluded that "changes in prices are influenced mainly by volatility in real output while exchange rate and inflation account for significant proportion of the variability in interest rate. A major shortcoming of the paper lies in the type of data and the method of estimation. In effect, the authors use VAR methodology in the estimation, simulation and forecasting of their model. The disadvantages of VAR are not unconnected with the fact that the method is (1) atheoretical, (2) the presence of large number of parameters involved made estimated models difficult to interpret, and (3) some lagged variables may have coefficient which change signs across the lags and this increases the interconnectivity of the equations which could make it difficult to see what effect a given change in a variable would have upon the future values of the variables in the system Brook (2008).

Thus, this paper attempts to improve on Olekah and Oyaromade (2007) by using quarterly data which is more often used in DSGE estimation on the one hand and on the other adopt the Bayesian method in addressing the challenges imposed by the VAR method. Several advantages can be adduced to the Bayesian approach including ability to cope with potential model misspecification, opportunity for researchers to review their belief on the initial values of a parameter and the fact that the procedure is in terms of probabilistic statements rather than the classical hypothesis testing procedure.

Consequently, the objective of the paper is to develop a small business cycle model in the spirit of Dynamic Stochastic General Equilibrium (DSGE) model for Nigeria designed to examine the sources of business cycles, and use the model for policy analysis. This study examines the implications of three policy shocks namely: monetary supply, technology and export supply on major macroeconomic aggregates namely consumption, labour, price level, deposits, loans, interest rate, wage rate, money supply, export, and aggregate output and capital stock. While the study attempts to adopt the Nason and Cogley (1994) and Schorfheide (2000)

models, this paper, however, introduces export sector for Nigeria with a view to examining the transmission channel of terms of trade given that crude oil export on which Nigerian economy firmly relies has constituted the Dutch Disease phenomenon. The method of estimation is the Bayesian and the paper uses DYNARE codes (dyn_mat_v4).

Thus, the rest of the paper is sectioned as follows. In Section 2, the paper examines macroeconomic shocks and their implications for the Nigerian economy. Section 3 addresses the issues of theoretical foundation of the paper and the method of research, while Section 4 presents the empirical results and discuss some policy analysis. In Section 5, we conclude and highlight the direction for further research.

2.0 Macroeconomic Shocks: The Nigerian Experience

The deep crises that have pervaded the Nigerian economy since early 1970s posed considerable challenges to policy makers and economists. At each turn of events efforts are made to design and implement appropriate policy responses. Nigeria, no doubt, has witnessed periods of boom and also recessions. In the 1970s, the economy was expanding due to large inflow of crude oil income and by the period 1981-1985, at the wake of the falling oil revenue, the economy declined, precipitating a rapid deterioration of the living standard of Nigerians. Iwayemi (1995) points out that "the cycle of oil price booms and precipitous decline and the associated transfer problem, in terms of the net resource outflow associated with debt repayments, triggered profound changes unparalleled in the history of the economy".

The subsequent periods were not too different as the consequences of the preceding period dragged into the following period. Macroeconomic indicators point to the grave economic situations. In particular, there were sharp fluctuations in the gross domestic product (GDP), remarkable fluctuations in inflation rates, unemployment rate, growing size and composition of government expenditure and slow growth of the domestic production. Others are chronic fiscal deficit, decline in traditional agricultural output, rural-urban drift, etc.

These outcomes can be traced to multiplicity of exogenous and endogenous factors (shocks) which in the case of Nigeria could have combined to generate business cycles. See Table 1(a) below.

Table 1(a): Topology of Shocks for Nigeria

S/No.	Shock	Origin	Immediate Consequence
1.	Crude Oil Price	OPEC decision to quadruple the price of crude oil: 1973	Economic boom
2.	Low Crude Oil demand	Another round of crude oil price increase: 1979	World economic recession
3.	Foreign debt	Fiscal Policy Stance	Financing Socio-economic programmes
4.	Inappropriate policy	Poor macroeconomic management	Macroeconomic instability
5.		Rural-Urban movement	Pressure on socio-economic infrastructure
6.	Terms of Trade	Currency overvaluation	Immizerization growth
7.	Changes in Economic structure	Structural Adjustment Programme (SAP)	Mixed grill
8.	Institutional	Transition from state-controlled to market-based economy	Sale of government-owned companies, loss of job

Source: Author's Synthesis

Among these shocks are: crude oil price shock resulting in economic boom of the early 1970s; low crude oil demand shock that led to world recession following the 1979 increases in oil prices; foreign debt shock creating financial short falls in the execution of socio-economic developmental programmes; stochastic shocks resulting from inappropriate policy response to observed economic trends in terms of timing, direction and magnitude; disequilibrium between rural and urban sectors prompting extensive rural-urban drift; terms of trade shocks resulting from currency over-valuation; changes in economic structure; and institutional shocks engendered by transition from state controlled economy to market-based economy.

It is evident that managing such an economy plagued by a multitude of shocks requires effective management tools given the policy options available. Nigeria has attempted to reverse the adverse economic outcomes on the welfare of the citizenry through various macroeconomic policies including fiscal, monetary,

trade and income. The objectives of policies were laudable as they were directed at full employment, price stability, high and sustainable rate of economic growth and balance of payments equilibrium. However, short-run gains at the expense of long-run growth coupled with inaccurate and inadequate data base could have precipitated macroeconomic fluctuations in Nigeria.

In response to these various shocks, authorities in Nigeria adopted various policy choices usually in the form of economic policy measures including Stabilization Policy, 1981-1983, Structural Adjustment Programme, (SAP), 1986-1992; Medium Term Economic Strategy, 1993-1998 and the Economic Reforms 1999-2007. The latter continues in the present administration. A major fact in macroeconomic analysis of developing economies, like Nigeria, is that they are small open economies in the sense that they cannot influence world prices and output. Domestic macroeconomic policies are thus buffeted by external shocks which eventually distort the path of sustainable economic growth. Given the unpredictable nature of these shocks and the measures to curtail them, it is pertinent to examine how the various shocks can help to unravel macro-economic fluctuations in the economy and by implication the sources of business cycle phenomenon in Nigeria. In what follows, the paper identifies the theoretical mainstream and develops the appropriate model.

3.0 Theoretical Framework and Methodology

3.1 Theoretical Framework

There two approaches to business cycle analysis: atheoretical and theoretical. This paper adopts the latter whose philosophical foundation is the New-Keynesian School (NKS) of thought. However, its main difference from other economic school of thoughts lies in the methodological approach to analyzing business cycle phenomenon. It assumes the existence of (1) involuntary unemployment (2) monetary non-neutrality and (3) short-run inflexibility of wages and prices. The proponents of this school rely on sticky wages and prices to explain the existence of involuntary unemployment and why monetary policy is non-neutral on economic activities. The theoretical model of NKS is based on rational expectations and microeconomic foundation and usually summarized in three equations that depict the optimizing behaviour of economic agents in the economy. These are the aggregate demand curve or the traditional Keynesian IS curve; the aggregate supply which takes the form of money demand relationships; and forward-looking version of the Phillips curve. In general, NKS characterizes the dynamic behaviour of output, inflation and nominal interest rate.

The NKS share common features with the earlier generations of RBC by retaining the idea that technology shocks can be quite important in shaping the dynamic behaviour of key macroeconomic variables (Ireland, 2004). The proponents of this school believe that other shocks might be important and in particular that the presence of nominal price rigidities "helps determine exactly how shocks of all kinds impact on and propagate through the economy".

Thus, based on formal DSGEM, NKS proponents have been examining quantitatively and with the aid of econometric methods the features and business cycle fluctuations of an economy. In general, their results have reinforced the conclusion that nominal shocks are as well important as technology shocks. In spite of its small size, the DSGEM is popular among researchers including Mankiw (1989), Clarida *et al.* (1999), and Negro and Schorfheide (2003).

3.2 Methodology

The DSGE model envisaged in this paper is built on the following assumptions: a large number of infinitely-lived, identical consumers; a large number of identical firms; open economy; cash-in-advance economy; two-good economy; labour and wage rigidities, monetary authorities and a financial intermediary. The model economy is characterized by monopolistic competition, situation of uncertainty in the economic environment and conditions of rational expectation behaviour. The economic agents namely households, firms and government maximize expected utility, profit and ensure balanced budget, respectively. The economy is driven by technology, monetary supply shocks, a law of motion for export and stochastic processes to the state variables. The model is developed as follows:

3.2.1 Structure of the Model

(a) The households

In a study by Nason and Cogley (1994), the households' objective is to maximize their utility function which depends on consumption, C_t and hours worked H_t. The households' also determine how much money to hold next period in cash, M_{t+1} and how much to deposit with the bank, D_t in order to earn $R_{H,t} - 1$ interest. The households' objective is therefore to solve the following optimization problem, i.e. maximize the sum of discounted expected future utility:

$$\max_{\{C_t, H_t, M_{t+1}, D_t\}} E_0\left[\sum_{t=0}^{\infty} \beta^t \left[(1-\phi)\ln C_t + \phi \ln(1-H_t)\right]\right]. \quad (1)$$

where β^t : discount factor; ϕ: disutility of labour; C_t: current level of consumption; H_t: hours worked; M_{t+1}: money to be held in the next period; D_t: household deposit with banks; and E_0: expectation operator of information available at time 0.

The above maximization of the households' utility function is subject to three constraints. The first postulates that the household face cash in advance (CIA) constraints. This implies that the households can purchase the single consumption good with the cash that they carry over from the previous period and with their current period labour income. The households also have the possibility of depositing some of their income each period with the financial intermediary, FI: this relation can be written as:

$$P_t C_t \leq M_t - D_t + W_t H_t \quad (2)$$

where P_t: price level; M_t: cash carry over from previous period; D_t: deposit with banks; W_t: nominal wage rate; and H_t: hours worked.

The second constraint stipulates the inability to borrow from the bank i.e.

$$0 \leq D_t \quad (3)$$

The third constraint describes the resources of the household. It postulates that households use their resources to make deposits with the financial intermediary FI, consume and purchase cash to carry into the future. The resources of the households can therefore come from their dividend income, labour income, interest income on deposit and current cash holding. This is represented by the following equation:

$$M_{t+1} \leq f_t + b_t + R_{H,t} D_t + W_t H_t + M_t - D_t - P_t C_t \quad (4)$$

where f_t: nominal dividends households receive from firms; b_t**:** nominal dividends the households receive from FI; and $R_{H,t}$: gross nominal interest rate the households face in the market for deposits.

(b) The Firms

In the monetary business cycle model considered in Nason and Cogley (1994) and the work of Schorfheide (2000), the firm chooses next period capital stock, K_{t+1}, labour demand, N_t, dividends F_t and loans L_t. Since household value a unit of nominal dividend in terms of the consumption it enables during the period $t+1$, and the firms and the financial intermediary are owned by households, date t nominal dividends are discounted by date $t+1$ marginal utility of consumption. Hence, the firm solves the optimization problem:

$$\max_{\{F_t, K_{t+1}, N_t, L_t\}} E_0\left[\sum_{t=0}^{\infty} \beta^{t+1} \frac{F_t}{C_{t+1}P_{t+1}}\right] \tag{5}$$

where, C_{t+1}: consumption next period; P_{t+1}: price level next period; N_t: labour demand; β^{t+1}: expected discount factor in time $t+1$; L_t: loans; K_{t+1}: next period capital stock; and F_t: dividends. There are two constraints in the case of the firm. The first is derived from the combination of a Cobb-Douglas production function $Y_t = K_t^{\alpha}(Z_t N_t)^{1-\alpha}$, and the real aggregate accounting constraint (gross market equilibrium) and where $C_t + I_t = Y_t$ and $I_t = K_{t+1} - (1-\delta)K_t$ and such that this first constraint could be written as:

$$F_t \leq L_t + P_t\left[K_t^{\alpha}\left(Z_t N_t\right)^{1-\alpha} - K_{t+1} + \left(1-\delta\right)K_t - W_t N_t - L_t R_{F,t}\right] \tag{6}$$

where $R_{F,t}$: gross nominal interest return on loans to the household. The second constraint stipulates that wage bill is financed through borrowing so that the constraint can be written as:

$$W_t N_t \leq L_t \tag{7}$$

(c) The Financial Intermediary:

The banks represented by the financial intermediary receive cash deposits from the households and a cash injection, X_t from the central bank which equals net change in nominal money balances, $M_{t+1} - M_t$. It uses these funds to disburse loans to firms, L_t, on which they make a net return of $R_{F,t} - 1$. Therefore, the financial intermediary, FI solves the trivial problem (Scorfheide, 2000):

$$\max_{\{B_t, L_t, D_t\}} E_0 \left[\sum_{t=1}^{\infty} \beta^{t+1} \frac{B_t}{C_{t+1} P_{t+1}} \right] \tag{8}$$

This is also subject to the following two constraints. The first constraint states that the level of bonds in period t is equal to money deposit by households, interest earning on loans, and monetary injection less interest paid on deposits and total loans. This relation can be written as follows:

$$B_t = D_t + R_{F,t} L_t - R_{H,t} D_t - L_t + X_t \tag{9}$$

The second constraint defines the balance sheet of the FI and is given as:

$$L_t = X_t + D_t \tag{10}$$

where $X_t = M_{t+1} - M_t$ is the monetary injection B_t: bond in period t; D_t: deposits; L_t: loans; $R_{F,t}$: gross nominal interest return on loans; and $R_{H,t}$: gross nominal interest on deposits by households.

(d) The Export Sector

In the spirit of open economy DSGE models, an export sector EP, can be introduced into the system using Duncan approach. Another approach for EP is from Dervis *et al.* (1985). This is in conformity with the classical trade theory which posits that a Small Open Economy (SOE) faces a perfectly elastic demand for its exports. This assumption may not be realistic in the case where trading with such SOE may result in a declining market share as domestic prices rise. In such a situation, activities in the export sector, EP, can be specified as a constant elasticity demand function of the form (Dervis *et al.*, 1985):

$$EX_i = EX_0 \left(\frac{\Pi_i}{PX_i} \right)^{\eta_i} \tag{11}$$

where EX_i: export of sector/branch I; Π_i: weighted average of world price for good; EX_0: is a constant; η_i: elasticity of demand; and PX_i: price of exports.

A major factor that affects export is price and price signals. Export supply may respond elastically to changes in domestic prices. In this circumstance, as domestic price rises producers tend to increase supply and consumers will rationally reduce their demand. The overall effect is an expectation of an increase

in exports. In practical terms, exports may not rise as fast as being predicted because the markets for domestically consumed and exported commodities in the same sector may be quite different. Some goods are tradable while others are non-tradable. In addition, there may be a difference in the quality of exported goods vis-à-vis goods for domestic consumption in the same sector. To capture these characteristics of export market, output is postulated as a constant elasticity of transformation (CET) function between domestically consumed, XD_i, and exported, EX_i, goods (Atta and Monnathoko, 1996) ; Dervis *et al.,* 1985):

$$Y_i = A_i\left[\mu_i EX_i^{\phi_i} + (1-\mu_i)XD^{\phi_i}\right]^{\frac{1}{\phi_i}} \tag{12}$$

where Y_i: domestic output; A_i: productivity parameter in sector/branch i; μ_i: share parameter of tradeables in output of Y_i; ψ_i: elasticity of substitution and such that $\psi_i = \frac{1}{1-\phi_i}$; XD_i: domestic demand; and EX_i: export supply. Equation 12 explains the relationship between output in a branch/sector and the quantities sold in the domestic and international markets. This allows for substitution between the goods desired for the two markets. The revenue for a given output P_iY_i is the sum of sales on both markets: domestic and international. This can be formalized as follows (See Dervis *et al.,* 1985):

$$P_iY_i = PD_i.XD_i + PX_i.EX_i \tag{13}$$

Under very restrictive assumptions, the price of imports PM_i could be approximated by the domestic price PD_i. Similarly, since the price of crude oil is a component of the world price basket and given its importance in the world economy, it could be reasonably assumed that the price of export, PX_i, will be affected by the price of crude oil as shown in equation 13. Consequently, given the assumption of the law of one price (Chacholiades, 1985), exports will be influenced by the ratio of PX_i/PM_i i.e. the international terms of trade. It is theoretically expected that this terms of trade (TOT) is an indication of the actual pattern of specialization between the model economy and the rest of the world (ROW) - considered separately. In addition, the equilibrium value of the TOT will be such as to cause each country to specialize in that commodity in whose production it is relatively more efficient i.e. commodity in which it has comparative advantage in its production.

The hypothetico-deductive inference from the preceding paragraph may not be the case for a country like Nigeria as the TOT has become a source through which the

vagaries of international economy can be transmitted into the economy and in particular, business cycle phenomenon in Nigeria. This two-good economy classification seemingly reflects the Nigerian economy. In effect, the economy can be described as producing one domestically produced good and one export good: the crude oil. The last assumption result from the fact that the proportion of non-oil in total export is paltry. Therefore, the TOT may be used to examine the transmission channel of the natural resource (crude oil) curse hypothesis.

In effect, international transmission channel consists of the effects of natural resources on the degree of openness of the economy and its TOT. Considering the TOT as it applies to this study, crude oil propelled booms increase domestic income and consequently, the demand for consumable goods. This leads to general price rise, i.e. inflation, and an overvaluation of the domestic currency. Hence, the relative prices of all non-traded goods increase and the terms of trade deteriorate. Consequently, exports become expensive relative to world market prices and thus the decline. This is the phenomenon characterized as Dutch Disease Syndrome (Papyrakis and Gerlagh, 2004).

In order to optimize the behaviour of the EP, there is the need to aggregate the different goods in the economy under the assumption of homogenous goods in both markets per discrete time $t = 0, 1, 2, 3, ...$ In view of this, output in the economy is either intended for domestic consumption or for export. In addition it should be assumed that EP is forward-looking and advent of 'manner from heaven' in imported goods for which no payment is required. Therefore, the optimizing behaviour of EP becomes that of maximizing expected discounted future stream of income subject to production function given in equation 12.

This can be formally written as follows:

$$Max\ E_t\left[\sum_{t=0}^{\infty}\beta^{t+1}\left(PD_t XD_t + PX_t EX_t\right)\right] \tag{14}$$

$$\text{s.t.} \quad Y_t = A_t\left[\mu EX_t^{\phi} + (1-\mu)XD_t^{\phi}\right]^{\frac{1}{\phi}} \tag{15}$$

where β^{t-1} the discount factor; Y_t: output; XD_t: domestically consumed good; EX_t: exported good; ϕ: CET parameter; PX_t: export price; and PD_t: domestic price. The first order condition, FOC, of this optimization gives the following demand functions:

$$EX_t = \left[\left(\frac{1-\mu}{\mu}\right)\left(\frac{PX_t}{PD_t}\right)\right]^{\frac{1}{1-\phi}} .XD_t \tag{16}$$

where $XD_t = Y_t - EX_t$ and PX_t is defined according to Dervis *et al.* (1985) as follows:

$$PX_i = \frac{PWE_i.ER}{1+te_i} \tag{17}$$

PWE_i: dollar price of exports; te_i: export tax (subsidy) rate; EX_t: Total exports at time t; and setting $PM_t - PD_t$, then rP_t=PX_t/PM_t, that is, terms of trade at time t.

(e) The Model Closure

In any general equilibrium model, the flow of funds accounts must specify the entire circular flow in the system such that there are no leakages. Thus, the problem of reconciling aggregate savings and investment is also an inherent part of the model. In the literature, this reconciliation is referred to as the closure'' problem because it involves closing the flow-of-funds accounts (Dervis *et al.*, 1985). The market clearing conditions for each market is given as follows:

Labour market: $$H_t = N_t \tag{18}$$

Goods market: $$P_tC_t = M_t + X_t \tag{19}$$

where M_t and X_t are money held in time t and monetary injection, respectively.

$$C_t + \left(K_{t+1} - \left(1-\delta\right)K_t\right) + EX_t = K_t^{\alpha}\left(Z_tN_t\right)^{1-\alpha} \tag{20}$$

$$R_{F,t} = R_{H,t} \tag{21}$$

Equation 21 states that at equilibrium gross interest rate on loans equals gross interest rate on deposits i.e. equal risk profiles of the loans.

(f) The stochastic Process

One distinguishing feature of DSGE models is the manner in which the stochastic processes are considered and treated. In the model adopted for this study, three sources of exogenous perturbations are considered. Two of them are real shocks namely the technology and terms of trade shock (export supply growth) and a nominal shock: the money supply shock. The equations of these shocks can be expressed as follows (See Nason and Cogley, 1994):

$$\ln z_t = \gamma + \ln z_{t-1} + \varepsilon_{z,t} \tag{22}$$

$\varepsilon_{z,t} \sim N(0, \sigma_z^2)$; where $\varepsilon_{z,t}$ are innovations to capture unexpected changes in productivity.

$$\ln m_t = (1-\rho)\ln m^* + \rho \ln m_{t-1} + \varepsilon_{M,t} \tag{23}$$

$\varepsilon_{M,t} \sim N(0, \sigma_M^2)$.

The basic assumption underlying equation (23) is that the money authorities (central bank) allow money stock, M_t to grow at the rate $m_t = M_{t+1}/M_t$. This equation is being interpreted as a simple monetary policy rule without feedbacks. The innovations, ε_t, capture unexpected changes of the money growth rate due to "normal" policy making. Changes in m^* or ρ correspond to rare regime shifts.

The third stochastic process is due to export supply growth shock measured by the terms of trade $rp_t = PX_t / PM_t$ and is also assumed to be an autoregressive process of order one, AR (1). It is given as:

$$rp_t = \rho_{rp} rp_{t-1} + \left(1-\rho_{rp}\right) rp_0 + \varepsilon_{rp_t} \tag{24}$$

where rp_t: terms of trade at time t; ρ_{rp}: coefficient of autocorrelation; $\varepsilon_{rp,t} \sim N(0, \sigma_{rp}^2)$ and $rp_0 > 0 \; and \; 0 < \rho_{rp} < 1$.

It is evident that this system cannot be estimated as they are presented. These equations are characterized by multiple objective functions, the presence of forward-looking and backward-looking variables, uncertainties, and shocks to the system. Literature in this branch of study contends the fact that this class of DSGE models cannot be solved analytically. Consequently, a numerical method is adopted which makes use of the model's structure and the first order conditions as

suggested by Christiano and Eichenbaum (1992). This will lead to the equilibrium system of the equations.

Conceptually, the household problem is a dynamic programming problem which can be solved using the Bellman's criterion. Solving the model thus requires the following steps: writing down the model, deriving the equilibrium system of equations, solving for steady-state equilibrium, and calibrating/estimating the parameters of the models. To solve this system of equations, decentralized optimization technique is often used in order to find the first order conditions. In this respect, each agent maximizes its own objective function. It should be noted that the dynamic optimization alluded to above is equivalent to the Lagrangian method. With the latter approach, we define the Lagrangian function or the Bellman equation with a view to finding the necessary conditions and resolving the system of equations in order to get the demand functions of the control variables.

The issue of equilibrium within the framework of dynamic general equilibrium is very important. According to Nason and Cogley (1994), equilibrium requires clearing in the goods, labour, credit and money markets. All markets assumed to be perfectly competitive. In the goods market, clearing means that output equals consumption plus investment and export:

$$C_t + K_{t+1} - (1-\delta)K_t + EX_t = K_t^{\alpha}\left[A_t N_t\right]^{1-\alpha} \tag{25}$$

In the money market, the requirement is that money demanded must be equal to money supplied. Nominal consumption demand can be equated with money demand. Money supply equals current nominal balances and monetary injections. Therefore, in the money market, equilibrium is represented by the following equation: $P_t C_t = M_t + X_t$. For the credit market to clear, there must be equality between the dividends paid by FI to households and product of money injection and nominal interest rate, i.e. $B_t = R_t X_t$ such that: $RH_t = RF_t \equiv R_t$. Finally, the export market clears when export demand equals export supply.

3.2.2 Equations to be estimated

The first order conditions, the equilibrium conditions, the model closure as well as the stochastic processes constitute the system of equations to be solved. In solving the model, we find the steady state, take log-linearization around the steady state and solve the model for the recursive law of motion. The model is then estimated and simulated using detrended variables. Hence, the system of equations to be

estimated and simulated simultaneously is constituted by final stochastically detrended model is presented in Nason and Cogley (1994) and Griffoli (2007), and updated with the equations from the EP agent.

The linearized equations from the DSGE model leads to linear rational expectation (LRE) system in eleven equations and eleven endogenous variables namely: $c_t, y_t, w_t, R_t, l_t, x_t, P_t, k_t, n_t, m_t$ and d_t. The deep or structural parameters of the model are: $\Omega = \{\alpha, \beta, \gamma, mst, \rho, \psi, \delta, \mu, \phi\}$. These variables and parameter definitions are summarized in Tables 1(b) and 2.

Table 1(b): Parameters of the Model

Parameter	Description
β	Discount factor
α	Output elasticity of capital
δ	Depreciation rate
γ	Deterministic trend component of technology growth
ψ	Consumption-output ratio
mst	Steady state money growth rate
ρ	Persistence parameter
μ	Proportion of exports in total output
ϕ	Constant Elasticity of Transformation parameter

3.2.3 Technique of Estimating the DSGE Model

The estimation/simulation of the DSGE-VAR is achieved by the use of DYNARE codes (MATLAB version). The choice of this software package is informed by being relatively user friendly. In general, DYNARE is able to compute the steady state, compute the solution of the deterministic models, compute the first and second order approximation to solutions of stochastic models, estimate parameters of DSGE models using either a maximum likelihood or Bayesian approach, and compute optimal policies in linear-quadratic models.

Since this paper employs the Bayesian method, it is then useful to highlight the approach. In doing this, it is required to describe the prior using a density function of the form:

$$p(\theta_m \mid m) \qquad (25)$$

where m stands for a given model; θ_m represents the parameters of the model and $p(\cdot)$ is the probability density function (pdf), adopted in the model estimation. The class of pdf that could be envisaged includes normal, gamma, inverse gamma, shifted gamma, beta, generalized beta and uniform.

Having stated the pdf, the next stage is to obtain the likelihood function which describes the density function of the observed data given the model and the parameters:

$$L(\theta_m \mid Y^T, m) \equiv p(Y^T \mid \theta_m, m) \tag{26}$$

where Y^T are observations, $1, 2, 3, \ldots, T$ and assuming that the likelihood is recursive, then equation 26 can be written as:

$$p(Y^T \mid \theta_m, m) = p(y_0 \mid \theta_m, m)\prod_{t=1}^{T} p(y_t \mid Y_{t-1}, \theta_m, m) \tag{27}$$

We now need the prior density, $P(\theta)$, and the likelihood $P(Y^T|\theta)$ so as to obtain the posterior density $P(\theta|Y^T)$, , desired. This is precisely achieved by recalling the Bayesian theorem in order to obtain the density of the parameters given the data. This theorem can be stated as follows:

$$p(\theta \mid Y^T) = \frac{p(\theta; Y^T)}{p(Y^T)} \tag{28}$$

Consequently, from the following identities:

$$p(Y^T \mid \theta) = \frac{p(\theta; Y^T)}{p(\theta)} \Leftrightarrow p(\theta; Y^T) = p(Y^T \mid \theta)\, p(\theta) \tag{29}$$

We can obtain the prior density with the likelihood function to get:

$$p(\theta_m \mid Y^T, m) = \frac{p(Y^T \mid \theta_m, m)\, p(\theta_m \mid m)}{p(Y^T \mid m)} \tag{30}$$

where $P(Y^T|m)$ is the marginal density of the data conditional on the model:

$$p(Y^T \mid m) = \int_{\theta_m} p(\theta_m; Y^T \mid m) d\theta_m \tag{31}$$

The final step is to get the posterior Kernel which is obtained by reviewing the data as constants whose distributions do not involve the parameters of interest. This means that the data are treated as fixed set of additional information to be used in updating beliefs about the parameter. In this case, the marginal density, i.e. $P(Y^T|\theta)$, is constant. In view of this, the posterior Kernel corresponds to the numerator of the posterior density i.e.

$$p(\theta_m \mid Y^T, m) \propto p(Y^T \mid \theta_m, m)\, p(\theta_m \mid m) \equiv K(\theta_m \mid Y^T, m) \tag{32}$$

Equation 8 is often interpreted as the product of likelihood function and the prior density.

The symbol $\propto$ means "is proportional to." The first term on the right is the joint distribution of the observed random variables y, given the parameters. The second term is the prior beliefs of the analyst. The left-hand side is the posterior density of the parameters, given the current body of data, or our *revised* beliefs about the distribution of the parameters after "seeing" the data. The posterior is a mixture of the prior information and the "current information," that is, the data. Once obtained, this posterior density is available to be the prior density function when the next body of data or other usable information becomes available.

4.0 Empirical Results

4.1 Data Sources

In estimating the model, the informal econometric method of calibration and the Bayesian method are considered. In carrying out empirical analysis, quarterly data are preferred. These type of data are however uncommon in the economy. Thus, the quarterly data to be used are obtained from the International Financial Statistics (IFS) published by International Monetary Fund (IMF) for the period 1970-2004. Most of these data are available both in annual and quarterly forms. Their availability in these forms enables us to tackle the problem of missing values which occurred in the quarterly data. To bridge such gaps we used the Gandalfo algorithm to covert the annual data to quarterly. The details of the data are available from the author.

4.2 Presentation of Results

The immediate goal of this study is to provide a framework for understanding business cycle fluctuations in Nigeria. In this paper, obtaining preliminary values for the parameters of the model will be done through calibration. The model will

then be simulated. Estimations are undertaken using DYNARE codes, MATLAB version. This package for solving the DSGEM is holistic as it is specifically designed to address business cycle models based on DSGE for which the Bayesian has been chosen.

4.2.1 Calibration

According to Romer (1996) and Fukac, Pagan, and Pavlov (2006), the method of calibration consists of a wide range of procedures including matching of moments, use of opinions and intuitions, evidences from previous micro- and macro-economic studies as well as institutional factors. This method is designed to provide preliminary estimates of the parameters of a model in an attempt to obtain an accurate and true evaluation of the model parameters. The process of choosing the values of these parameters in order to make the model match the observed data is known as calibration. This method of choosing parameter values is, according to Krueger (2005) ensures that the long-run implication of the model matches long-run average observations from the data. In this study and in view of relative scarcity of data from similar studies as the one being attempted in this study in Nigeria, we adopt the calibrated parameters from Scorfheide (2000) as contained in DYNARE package fs2000a example. This approach is common to a host of business cycle studies (See Bergoeing and Soto, 2002 and Weltz, 2005). The values obtained from the calibration are used as priors in the simulation of the model.

In spite of the properties of the Bayesian approach, its main weakness is in the specification of the prior distribution of the parameter, θ, since such selection is essentially arbitrary Theodoridis (2007). Fully specifying priors is infeasible when the set of possible regressors is large or when the sample size is small or when the likelihood is flat. In the applications of Bayesian theory, if a researcher is incapable or unwilling to specify prior beliefs a standard remedy is to apply diffuse priors Doppelhofer *et al.* (2000). However, the ultimate goal of the Bayesian approach is in learning about the unknown parameters through the use of the posterior probability distributions of the parameters given the data. Thus, given the apparent difficulties in using the diffuse priors, it is one way to represent initial ignorance of the parameters. This is the approach adopted in this study.

In effect, with the fact that there are few studies in this area in the country, this study has resulted to using the results obtained from similar studies in the USA, as contained in Table 1(b), as the priors designed to represent a measure of study's ignorance of the true parameters of the model. It is expected that the posterior distributions will coincide asymptotically with the likelihood of the parameter estimates.

Table 2: Definition of Variables

Variable	Description
$\tilde{y}$	Total Output
$\tilde{c}$	Consumption
$\tilde{n}$	Labour Demand
$\hat{x}$	Total export
$\tilde{k}$	Capital stock
$\tilde{m}$	Money supply
$\tilde{P}$	Price level
$\tilde{R}$	Nominal interest rate
$\tilde{w}$	Wage rate
$\tilde{l}$	Loans by banks
$\tilde{d}$	Deposits with banks

4.2.2 Results

The optimization of the model in Section 4.2 produces a system of equations. The DSGE model being estimated here is one that has been augmented by a Vector Autoregressive (VAR) representation. Consequently, the model solved was through the process of estimation/simulation of the DSGE-VAR method (Ireland 2004, and Liu, Gupta and Schaling 2007). This estimation/simulation process uses the Bayesian-based DYNARE (Matlab version) package. The DYNARE contains several variants of solving DSGE models including Scorfheide (2000).

The steady-state values form the starting point for dynamic analysis where the dynamic system is linearized (log) around the steady-state with the hope of obtaining a good approximation to the optimal decisions of the agents in the economy. The steady-state values of the endogenous variables of the model indicate the values of these variables that ensure that the system will evolve along a steady-state path without any tendency to diverge from it. These endogenous variables are log-deviations representing the optimal values of these variables

In simulating the model, the parameters of the model were kept fixed from the beginning of the estimation. This can be seen as strict prior (Smets and Wouters, 2002). These parameters can be directly related to the steady state values of the state variables and could therefore be estimated from the means of the observable variables. The discount factor, β, is calibrated at 0.99 and the depreciation rate, δ, is set equal to 0.020 per quarter , which implies an annual depreciation on capital equal to 8 per cent. The share of capital in total output, α, is set at 0.33. The share of the steady state consumption in total output, ψ, is assumed to be 0.650 while the steady state of γ, deterministic trend component of technology growth is 0.003. Finally, the unconditional mean of monetary injection growth, mst, is 1.011 and ρ, correlation coefficient is 0.7. See Table 3.

Table 3: Estimated Parameters Using Bayesian Method

Parameter	**Calibrated ***	**DSGEM Estimates ****
β : discount factor	0.99	0.9995
δ :depreciation rate	0.02	0.0031
α :output elasticity of capital	0.33	0.3457
γ :deterministic trend of technology	0.003	0.0010
ψ :consumption-output ratio	0.787	0.6405
mst :steady state money supply	1.011	1.0251
ρ : persistence (autocorrelation coeff.)	0.70	0.1287

Source: (*) Scorfheide (2000) examples in DYNARE codes, Matlab version (**) Table 5 of this study

Table 4 contains the results from the posterior maximization. The table shows the assumptions regarding the prior distributions of parameters of the model. Two prior distributions were considered for this study: Beta and Normal. The Beta distribution covers the range in the open interval $(0,1)$. In this study $\alpha, \beta, \rho, \psi \; and \; \delta$ were assumed to be Beta distribution, while γ and mst were assumed to be Normal distribution. This means that they can be tested for statistical significance. Essentially, the table contains the prior mode, the standard deviation, the t-statistics and the posterior standard deviation. In addition, Table 5 also contains the standard deviation of shocks showing the prior mean, prior mode standard deviation, t-statistic, the 90% confidence interval as well as prior and posterior distribution. Furthermore, Table 6 depicts prior mean, posterior mean as well as the 90 percent confidence interval.

Table 4: Results from Posterior Maximization

Parameters	S T A T I S T I C					
	Prior Mean	**Mode**	**SD**	**t-stat.**	**Prior**	**Posterior dev.**
α	0.356	0.3566	0.0002	1788.1408	beta	0.0200
β	0.993	0.9995	0.0000	264256.405	beta	0.0020
γ	0.009	0.0031	0.0000	843.7479	normal	0.0030
mst	1.000	1.0002	0.0014	718.8420	normal	0.0070
ρ	0.129	0.1290	0.0015	86.0633	beta	0.2230
ψ	0.650	0.6498	0.0003	2083.0699	beta	0.0500
δ	0.010	0.0041	0.0000	2108.5630	beta	0.0050

In general, all the parameters estimated are significantly and statistically very different from zero at the level of 5 percent. In the same sense, the prior mode of the productivity shock, e_a: money supply shock, e_m: and export supply shock, e_x are significantly different from zero as could be seen in Table 5.

Table 5: Standard Deviation of Shocks

Shocks	S T A T I S T I CS							
	Prior Mean	**Prior Mode**	**Std.**	**t-stat**	**Prior Mean**	**90% CI**	**Prior**	**Pstdev.**
Productivity: e_a	0.035	0.0358	0.0000	985.3634	0.0362	[0.0349, 0.0375]	Invg.	inf.
Money Supply: e_m	0.009	0.0095	0.0000	616.2160	0.0093	[0.0089, 0.0098]	Invg.	inf.
Export supply: e_x	0.009	0.0277	0.0000	1739.2073	0.0233	[0.0215, 0.0250]	Invg.	inf.

Note: *Pstdev. ≡ Posterior deviation. Invg. ≡ Inverted Gamma. inf. ≡ Infinity.*

The table also indicates the posterior mean and the confidence interval. Further information on the estimation results are found in Table 6. In it are contained the prior mean and posterior mean, the confidence interval as well as the posterior deviation. The table also shows a relatively close value between the prior means and the posterior means except in the case of parameters γ and δ which are (0.009, 0.0010) and (0.010, 0.0031) respectively.

Table 6: Estimation Results

Parameters	S T A T I S T I C				
	Prior Mean	**Posterior Mean**	**90% CI**	**Prior**	**Pstdev.**
α	0.356	0.3457	[0.3359 , 0.3551]	beta	0.0200
β	0.993	0.9995	[0.9995 , 0.9995]	beta	0.0200
γ	0.009	0.0010	[0.0003 , 0.0017]	normal	0.0030
mst	1.000	1.0251	[0.0032 , 1.0447]	normal	0.0070
ρ	0.129	0.1287	[0.0864 , 0.1986]	beta	0.2230
ψ	0.650	0.6405	[0.6238, 0.6600]	beta	0.0500
δ	0.010	0.0031	[0.0028 , 0.0035]	beta	0.0500

Note: *Pstdev = Posterior deviation*

α **:** output elasticity of capital;

β : discount factor;

γ : deterministic trend of technology;

mst: steady state money supply;

δ : depreciation rate;

ρ : persistence (correlation coefficient);

ψ : consumption-output ratio.

According to the estimates of the deep (structural) parameters of this model as contained in Table 3, output elasticity of capital, α, is 0.3457 or 34.57 percent. The discount factor,β, is 0.9995 or 99.95 percent. This implies an annualized steady-state real interest rate of about 4 percent. The technology growth rate, , is estimated to be 0.0010, that is, 0.1 percent while the steady state money growth, mst, is found to be 1.0251 or 102.51 percent. The depreciated rate, δ, gives an estimated value of 0.0031 while consumption-output ratio, ψ, is estimated at 0.6405 or 64.05 percent. Finally, the coefficient of autocorrelation, that is, persistence coefficient, ρ, is estimated at 0.1287.

4.3 Policy Analysis

The main objective here is to examine the impulse response functions (IRFs), that is, what happens to the path of the endogenous variables when some perturbations occur in the economy namely, productivity, money supply and export as well as the variance decomposition, that is, proportion of the total variations of a variable due to itself and all the other endogenous variables. In this respect, DYNARE reports the matrix of covariance of exogenous shocks, policy and transition functions, and moments of simulated variables, correlation of simulated variables and autocorrelation of simulated variables.

A positive productivity shock caused consumption to increase over time. On impact, the effect was negative but gradually became asymptotic to the steady state over the time horizon. The stock of capital, k; interest rate, R; export, x; and output Y, also behave in a similar manner. In contrast, price level, P; deposit, d; loans to firms, l; labour force, n; and wages, w, depict an inverse relationship indicating that a positive productivity shock at impact causes these variables to fall and then converge non-linearly to the steady state as time goes on in the horizon[2].

From these observations, it follows that relationships between productivity and some macroeconomic variables do not follow standard patterns. In effect, a positive productivity shock is expected to cause rise in output as indicated above and a concomitant increase in labour supply, increase in wages and even fall in prices. A possible explanation in these discrepancies could be found in the sources of productivity. If it is due to technology growth, there is the likelihood that such changes will not cause increase in labour supply and wage increases. However, all these variables converge to the steady state in the long run. From a policy prescription perspective, the results suggest that policy in form of productivity shock must be backed-up by complementary policies in order to bring about the desired fall in unemployment, increase in wages and price stability.

Going also by Table 3, a positive money supply shock on consumption; interest rate, R; total export, x; and output y has the same effect similar to those of a positive productivity shock. In the same vein, bank deposit d, and labour force, n also shows similar response. However, a positive money supply increases from 1 at impact to a peak around the 8th quarter only to decrease monotonically into the horizon. Similarly, R, x and y indicate similar effect since they all rose from a negative position at impact only to converge around the steady state. The variables price level (P) and loan (l) present a different visual observation. They both decline right from the impact of the money shock and decrease monotonically coinciding with the steady state into the horizon.

The above discussion is reinforced by examining the effects of monetary policy shocks; a positive monetary policy shock leads to a rise in nominal interest rate. This causes an increase in nominal wage rate since price level has also increased nominally. Contrary to stylized facts, following a monetary policy shock,

[2] The graphs of impulse response functions are not reported due to space but are available on request from the author.

expansive monetary policy, real wages are expected to fall in the face of rising inflation. In this case, price level increases at the same rate so that the wage rate remains nominally high. This will discourage export supply, output production, consumption, bank deposits and labour force since the demand for labour falls following the fall in demand for goods and fall in production as a consequence. This assertion is drawn from Table 4. This result also corroborates the monetarist predictions to the extent that real variables do not affect nominal variables. In this case, in particular, the future path of money supply is affected by previous state of money supply and the current monetary supply growth shock.

This paper suggests that there are many potential determinants of business cycles in Nigeria. And without doubt a leading candidate is export. In term of business cycle analysis, higher trade between one or more countries means more co-movement of business cycles[3]. In effect, a positive export supply shock led to a sharp fall in export and reached the steady state value within the first quarter. In particular, the fall in the case of gx_obs variable fell below the steady state only to return to it within the second quarter. This result seemingly suggests little or no relationship between export shocks and the other endogenous variables in the model.

These results suggest and amplified the "marginalization'' of the Nigerian economy in the world trade. This maginalization of the economy is due to lagging growth in GDP and not due to low trade ratios. Another issue is the fact that the economy is monocultural depending for most of its earnings from the export of crude oil. Consequently, the export sector both oil and non-oil export are not linked to the economy and hence no much value addition. Though our model do not explicitly incorporate the import sector, Nigeria is excessively dependent on the international economy and she is thus exposed to international shocks and the boom-burst cycles of the world macro- economy are not strange to her. However, the incorporation of the import sector could amplify the transmission of international business cycles into the Nigerian economy.

In terms of policy prescriptions a set of policy mix is required to safeguard the economy from external vagaries. The boom-burst cycles that accompany commodity exports are one of the consequences of mono-cultural and structural vulnerability and impact adversely on the sustainable provision of essential public infrastructure. The non-correlation between the export supply shock and the other

[3] The graph is not reported but is available on request from the author.

endogenous variables may not be unconnected with the restrictions placed on our model. In effect, the latter does not explicitly incorporate exchange rate, foreign direct investments, and other external trade variables. It is not impossible that a model that incorporates all these external sector variables may adequately capture the structural behaviour of the Nigerian economy.

Table 7: Comparing Estimation Results

Parameter	**This Study**	**FS (2000)***	**NC (1994)****
α	0.3457	0.4168 (0.0218)	0.345
β	0.9995	0.9901 (0.0021)	0.993
γ	0.0010	0.0038 (0.0010)	0.003
mst	1.0251	0.0141 (0.0017)	1.011
ρ	0.1287	0.8623 (0.0343)	0.728
ψ	0.6405	0.6837 (0.0479)	0.773
δ	0.0031	0.0020 (0.0011)	0.022

here: α**:** output elasticity of capital; β: discount factor; γ: deterministic trend of technology; mst: steady state money supply; ρ: persistence (correlation coefficient); ψ: consumption-output ratio; and δ: depreciation rate.

The contributions of each structural shock on all the endogenous variables can also be appreciated using the variance decomposition technique. The variance decomposition shows the percentage of error variance in one variable due to one standard deviation shock of the variable itself and other variables in the system. The variance decomposition decomposes variations in an endogenous variable into the component shocks to the endogenous variables in the system. The results of variance decomposition help in ascertaining the relative importance of the various variables in explaining the variations in the variable being considered in other words the computation of variance decomposition assist in gauging the importance of individual shocks. See Tables 8 and 9.

5.0 Conclusion

In this paper, the DSGE-VAR model has been estimated and simulated using the DYNARE codes. Three shocks were introduced into the model as major drivers of Nigeria's business cycles. These are productivity shock, money supply growth shock and export supply shocks. Our endogenous variables are consumption, labour, price level, deposits, loans, interest rate, wage rate, money supply, export, aggregate output and capital stock.

Table 8: Variance Decomposition (in percentage)

Variable	Definition	e_a	e_m	e_x
c	Consumption	96.75	3.25	0.00
d	Deposits	97.78	2.22	0.00
dA	Stochastic Process	100.00	0.00	0.00
e	Exogenous stochastic process	100.00	0.00	0.00
gp_obs	Observed Price	37.21	62.79	0.00
gx_obs	Observed Export	41.08	0.03	56.89
gy_obs	Observed Output	99.83	0.17	0.00
k	Capital Stock	99.80	0.20	0.00
l	Loans	91.49	8.51	0.00
m	Money Supply	0.00	100.00	0.00
n	Labour Supply	99.23	0.77	0.00
P	Price level	80.73	19.27	0.00
R	Interest Rate	46.58	53.42	0.00
w	Wage Rate	20.74	79.26	0.00
x	Export	7.49	0.16	92.36
y	Output	97.95	2.05	0.00

where: e_a: Productivity shock; e_m: Money supply shock; and e_x: Export supply shock.

The results obtained in this study show that productivity shock, money supply growth shock and export supply growth shock contributed in the statistical sense in explaining business cycle as driven by both real and nominal shocks. These results have implications for the economy. In effect, it is a known fact that Nigerian economy is highly dependent on her export earnings especially crude oil exports. Foreign currency generated from this source is known to be often injected back into the economy without being sterilized for long. The consequence of this is the unprecedented growth rate of money supply into the economy. The impact of this confirms theoretical underpinnings in the sense that price increases, engendered by high money supply into the economy, have manifested in high nominal wage and interest rate over the most part of the period under study. High growth rate of money supply in the economy may also be explained by excessive non sterilization of foreign exchange earnings to finance expansionary monetary and fiscal policies.

The magnitude of the parameter estimates is reinforced by the results of similar studies using the same methodology (DSGE) and the same variant (cash-in-balance) (Nason and Cogley, 1994 and Scorfheide, 2000). (See Table 7). This shows that not only do business cycles exist in the Nigerian economy; modern computational methods can be used to capture the phenomenon. The results also suggest that productivity shock is relevant to the Nigerian economy in the same way Kydland and Prescott (1982) propose. The results also confirm the New Keynesian analysis (which forms the theoretical base of this study) that both real and nominal factors do explain business cycles.

Table 9: Coefficient of Autocorrelation

Variable	**Definition**	**Order**				
		1	**2**	**3**	**4**	**5**
c	Consumption	0.9374	0.8810	0.8294	0.7820	0.7381
d	Deposits	0.9429	0.8900	0.8407	0.7946	0.7514
dA	Stochastic Process	0.0000	0.0000	0.0000	0.0000	0.0000
e	Exogenous stochastic process	0.0000	0.0000	0.0000	0.0000	0.0000
gp_obs	Observed Price	0.2620	0.1921	0.1426	0.1075	0.0826
gx_obs	Observed Export	-0.2927	0.0016	0.0016	0.0015	0.0014
gy_obs	Observed Output	0.0059	0.0057	0.0054	0.0052	0.0049
k	Capital Stock	0.9468	0.8963	0.8486	0.8033	0.7605
l	Loans	0.9234	0.8579	0.8008	0.7501	0.7046
m	Money Supply	0.7000	0.4900	0.3430	0.2401	0.1681
n	Labour Supply	0.9459	0.8949	0.8468	0.8014	0.7585
P	Price level	0.8958	0.8124	0.7441	0.6869	0.6381
R	Interest Rate	0.8104	0.6718	0.5692	0.4921	0.4331
w	Wage Rate	0.7474	0.5681	0.4402	0.3484	0.2819
x	Export	0.0719	0.0677	0.0639	0.0603	0.0570
y	Output	0.9407	0.8864	0.8362	0.7896	0.7461

A major finding of the study is the fact that the export sector which is supposed to be the engine of growth of the economy is exhibiting weak linkages with the rest of the economy. This may not be unconnected with outward-looking nature of the Nigerian economy with import value almost matching the export value. Obviously, this is one of the consequences of Dutch Disease syndrome which can affect the economy in two ways: resource movement effect and spending effect.

Going by the results obtained in this paper, and given the methods of estimation applied more elaborate model for the study of business cycle fluctuations in Nigeria can be envisaged.

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Testing the Weak-form Efficiency Market Hypothesis: Evidence from Nigerian Stock Market

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In recent years, the Nigerian Stock Exchange (NSE) has witnessed an unprecedented growth in market capitalization, membership, value and volume traded. By December 2007, the All Share Index has grown massively over 57,990.2 from 1113.4 in January 1993. This rising interest in investment opportunities in the NSE raises questions about its efficiency. This paper tests the Weak-form Efficient Market Hypothesis of the NSE by hypothesizing Normal distribution and Random walk of the return series. Daily and weekly All Share Index and five most traded and oldest bank stocks of the NSE are examined from January 2007 to December 2009 for the daily data and from June 2005 to December, 2009 for the weekly data. The empirical findings derived from the autocorrelation tests for the observed returns conclusively reject the null hypothesis of the existence of a random walk for the market index and four out of the five selected individual stocks. In general, it can be concluded that the NSE stock market is inefficient in the weak form. Given the empirical evidence that the stock market is weak-form inefficient, it is believed that anomalies in stock returns could be existent in the market and reduction of transaction cost so as to improve market activities and minimizing institutional restrictions on trading of securities in the bourse were therefore recommended.

JEL Classification: G1, C1.

Keywords: Weak-form Efficiency; Random-walk; Autoregression; Nigerian Stock Exchange; Runs and Variance Ratio tests

1.0 Introduction

During the past decades, the efficient market hypothesis (EMH) has been at the heart of the debate in the financial literature because of its important implications. Fama (1970) defined a market as being efficient if prices fully reflect all available information, and suggested three models for testing market efficiency: the Fair Game model, the Submartingale model, and the Random Walk model. Also, according to Fama (1970), EMH can be categorised into three levels based on the definition of the available information set, namely weak form, semi-strong form, and the strong form. Following the work of Fama, the EMH has been widely investigated in both developed and emerging markets. Especially, in emerging

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stock markets, most empirical studies have focused on the weak form, the lowest level of EMH because if the evidence fails to support the weak-form of market efficiency, it is not necessary to examine the EMH at the stricter levels of semi-strong and strong form (Wong and Kwong, 1984). Although many empirical studies have been devoted to testing for the weak form of EMH in emerging stock markets such as the Nigerian stock market (Mikailu and Sanda, 2007), but no published research exists for the Nigerian stock market index and the five most traded and the oldest stocks in recent years on the NSM. This paper aims to seek evidence of the weak form market efficiency in the Nigerian stock market. In order to achieve the objective, a set of complementary tests, namely autocorrelation tests, runs and variance ratio tests are employed in this paper. The data used for these tests primarily comprise daily and weekly observed returns of the market index and five individual stocks listed on the market. Then, the data are adjusted for thin (infrequent) trading that is a prominent characteristic of the Nigerian stock market and that could seriously bias the results of the empirical studies on market efficiency.

The rest of this paper is organized as follows, literature review in section two, section three compresses of materials and methods while section four is the result and discussion. The final section is section five, conclusion and recommendations.

2.0 Literature Review and Theoretical Framework

The EMH, which plays an important role in the financial economics literature, relies on the efficient exploitation of information by economic actors. Generally, an asset market is referred to be efficient if the asset price in question must fully reflect all available information. If this is true, it should not be possible for market participants to earn abnormal profits. Based on the definitional statement of an efficient market above, Fama (1970) suggested three models for testing stock market: the Expected Return or Fair Game model, the Submartingale model, and the Random Walk model.

2.1 The Fair Game Model

In general, the fair game model states that a stochastic process X_t with the condition on information set I_t, is a fair game if it has the following property:

$$\varepsilon(x_{t+1}|I_t) = 0 \qquad (2.1)$$

In the case of stock markets, Fama (1970) introduced a model of the EMH that is derived from the Fair Game property for expected returns and expressed it in the following equations:

$$x_{j,t+1} = p_{j,t+1} - \varepsilon(p_{j,t+1}|I_t), \quad (2.2)$$

with

$$\varepsilon(X_{t+1}|I_t) = \varepsilon[p_{j,t+1} - (p_{j,t+1}|I_t)] \quad (2.3)$$

where $x_{j,t+1}$ is the excess market value of security j at time $t+1$, $p_{j,t+1}$ is the observed (actual) price of security j at time $t+1$, and $\varepsilon(p_{j,t+1}|I_t)$ is the expected price of security j that was projected at time t, conditional on the information set I_t or equivalently

$$z_{j.t+1} = r_{j,t+1} - \varepsilon(r_{j,t+1}|I_t) \quad (2.4)$$

with

$$\varepsilon(r_{j,t+1}|I_t)] = \varepsilon[r_{j,t+1} - (r_{j,t+1}|I_t)] \quad (2.5)$$

where $z_{j.t+1}$ is the unexpected (excess) return for a security j at time $t+1$, $r_{j,t+1}$ is the observed (actual) return for a security j at time $t+1$, and $\varepsilon(P_{j,t+1}|I_t)$ is the equilibrium expected return at time $t+1$ (projected at time t) on the basis of the information set I_t.

This model implies that the excess market value of security j at time $t+1$ ($p_{j,t+1}$) is the difference between actual price and expected price on the basis of the information set It. Similarly, the unexpected (excess) return for a security j at time $t+1$ ($z_{j.t+1}$ z) is measured by the difference between the actual and expected return in that period conditioned on the set of available information at time t, I_t.

According to the Fair Game model, the excess market value and excess return are zero. In other word, Equations (2.3) and (2.5) indicate that the excess market value sequence $\{x_{j,t+1}\}$ and $\{z_{j.t+1}\}$ respectively are fair games with respect to the information sequence $\{I_t\}$.

2.2 The Submartingale Model

The Submartingale model is the Fair Game model with a small adjustment in expected return. In this model, the expected return is considered to be positive instead of zero as in the Fair Game model. The adjustment implies that prices of securities are expected to increase over time. In other word, the returns on investments are projected to be positive due to the risk inherent of capital investment. The Submartingale model can be mathematically written as follows:

$$E\left(\frac{r_{i-1}}{I_t}\right) \geq P_{j,t} \tag{2.6}$$

$$E\left(\frac{r_{i-1}}{I_t}\right) = \frac{E\left(\frac{r_{i-1}}{I_t}\right)}{P_{j,t}} \geq 0 \tag{2.7}$$

This model states that the expected return sequence $\{r_{j,t+1}\}$ follows a submartingale, conditional on the information sequence $\{I_t\}$, which is meaningless in forecasting stock prices, except that the expected return, as projected on the basis of the information I_t, is equal to or greater than zero (Fama, 1970). The important empirical implication of the submartingale model is that no trading rule based only on the information set I_t can have greater expected returns than a strategy of always buying and holding the security during the future period in question.

2.3 The Random Walk Model

According to Fama (1970) an efficient market is a market in which prices reflect all available information. In the stock market, the intrinsic value of a share is equivalently measured by the future discounted value of cash flows that will accrue to investors. If the stock market is efficient, share prices must reflect all available information which is relevant for the evaluation of a company's future performance, and therefore the market price of share must be equal to its intrinsic value. Any new information, which is expected to change a company's future profitability, must be immediately reflected in the share price because any delay in the diffusion of information to price would result in irrationality, as some subsets of available information could be exploited to forecast future profitability. Thus, in an efficient market, price changes must be a response only to new information. Since information arrives randomly, share prices must also fluctuate unpredictably. The Random Walk model can be stated in the following equation:

$$P_{t+1} = P_t + e_{t+1} \tag{2.8}$$

where:

P_{t+1} : Price of share at time $t+1$; P_t : price of share at time t;

e_{t+1}: random error with zero mean and finite variance.

Equation (2.8) indicates that the price of a share at time $t+1$ is equal to the price of a share at time t plus given value that depends on the new information (unpredictable) arriving between time t and $t+1$. In other word, the change of price, $e_{t+1} = P_{t+1} - P_t$ is independent of past price changes.

Fama (1970) argued that the random walk model is an extension of the expected return or fair game model. Specifically, the fair game model just indicates that the conditions of market equilibrium can be stated in terms of expected returns while the random walk model gives the details of the stochastic process generating returns. Therefore, he concluded that empirical tests of the random walk model are more powerful in support of the EMH than tests of the fair game model.

The EMH can be more specifically defined with respect to the available information set (I_t) to market participants. Fama (1970) classified the information set into three subsets and suggested three forms (levels) of EMH, depending on the definition of the relevant information subsets, namely the weak, semi-strong, and strong form. This section highlights these forms with their practical implications.

2.4 The weak form of EMH

The weak form of EMH is the lowest form of efficiency that defines a market as being efficient if current prices fully reflect all information contained in past prices. This form implies that past prices cannot be used as a predictive tool for future stock price movements. Therefore, it is not possible for a trader to make abnormal returns by using only the past history of prices.

2.5 Semi-strong form of EMH

The semi-strong form of the EMH states that current market prices reflect all publicly available information, such as information on money supply, exchange rate, interest rates, announcement of dividends, annual earnings, stock splits, etc. If by increasing the information set to include private information, it is not possible for a market participant to earn abnormal profits, then the market is referred as strong form of EMH. In other words, under the strong form of EMH

market prices of securities reflect all relevant information, including both public and private information. The strong form of EMH implies that private information (inside information) is hard to obtain for making abnormal returns because if a market participant wants to have it, he/she has to compete with many active investors in the market. It is important to note that an assumption for the strong form is that inside information cost is always zero. However, this assumption hardly exists in reality, so the strong form of EMH is not very likely to hold.

The empirical literatures on the weak form efficiency in emerging stock markets by authors show conflicting result, some authors support while many others oppose the efficient market hypothesis. The weak form of EMH implies that current market prices of stocks are independent on their past prices. In other words, a market is efficient in the weak form if stock prices follow a random walk process. Therefore, tests of weak form efficiency are naturally based on an examination of the interrelationship between current and past stock prices (Fawson *et al.,* 1996). Practically, several statistical techniques, such as runs test, unit root test, serial correlation tests, and spectral analysis, have been commonly used for testing weak form efficiency. Most studies on the weak form of EMH in emerging stock markets have used the runs test and/or unit root test as a principle method for detecting a random walk, a necessary condition for market efficiency in the weak form. Specifically, the runs test is adopted by Sharma and Kennedy (1997), Barnes (1986), Dickinson and Muragu (1994), , Karemera *et al.* (1999), Wheeler *et al.* (2002), Abraham *et al.* (2002), and the unit root test was employed by Groenwold *et al.* (2003), and Seddighi and Nian (2004) while Fawson *et al.* (1996), Moorkerjee and Yu (1999), and Abeysekera (2001) conducted both techniques in their study. A further test for market efficiency in the weak form that has been applied by a number of researchers is the serial correlation test, including the correlation coefficient test, Q-test, and variance ratio tests. Indeed, a combination of correlation coefficient test (testing for significance of individual serial correlation coefficient) and Q-test (testing for significance of a set of coefficients) is adopted by Dickinson and Muragu (1994), Fawson *et al.* (1996), Moorkerjee and Yu (1999), Abeysekera (2001), and Groenwold *et al.* (2003) while , Dockery and Vergari (1997),), Karemera *et al.* (1999), Alam *et al.* (1999), Chang and Ting (2000), Cheung and Coutts (2001), Abraham *et al.* (2002), and Lima and Tabak (2004) apply variance ratio tests as the main methodology to determine the weak form of market efficiency in their study. Finally, a few researchers use some other techniques, such as spectral analysis (Sharma and Kennedy, 1977; Fawson *et al*., 1996), GPH (Geweke and Porter-Hudak) fractional integration test (Buguk and Brorsen, 2003), and autoregressive conditional

heteroscedasticity (ARCH) test (Seddighi and Nian, 2004) in order to find evidence for market efficiency.

Data obtained for testing weak form of EMH in emerging stock markets include stock price indices and/or individual stock prices series. Specifically, stock price indices are used in studies of Sharma and Kennedy (1997), , Fawson *et al.* (1996), Dockery and Vergari (1997) Abeysekera (2001), Abraham et al. (2002), Lima and Tabak (2004) also Mikailu and Sanda (2007), while individual stock prices are employed by Dickinson and Muragu (1994), Olowe (1999), Wheeler *et al*. (2002). Especially, Barnes (1986), Seddighi and Nian (2004) employed both kinds of data for their tests in order to detect the weak form of market efficiency. Another aspect of data used for testing weak form efficiency hypothesis in emerging stock markets is frequency of time series. Based on this respect, the data consist of daily (Mookerjee and Yu, 1999; Cheung and Coutts, 2001; Groenewold *et al.*, 2003, Lima and Tabak, 2004 and Seddighi and Nian, 2004), weekly (Dickinson and Muragu, 1994; Dockery and Vergari, 1997; Abraham *et al*., 2002; and), monthly (Sharma and Kennedy, 1977; Barnes, 1986; Fawson *et al*., 1996; Olowe, 1999; Karemera *et al.*, 1999; and Alam *et al.*, 1999) and even yearly time series (Chang and Ting, 2000). Empirical findings derived from the studies in emerging stock markets have been mixed. Indeed, some studies provide empirical results to reject the null hypothesis of weak form market efficient while the others show evidence to support the weak form of EMH. Regarding emerging European stock markets, for instance, the empirical evidence obtained from Wheeler *et al.* (2002) fails to support the weak form efficient hypothesis for the Warsaw Stock Exchange (Poland). On the other hand, Dockery and Vergari (1997) document that the Budapest Stock Exchange is efficient in the weak form. In addition, Karemera *et al.* (1999) shows empirical evidence to support the null hypothesis of weak form market efficiency for the stock market in Turkey. Surprisingly, in the perspective of Africa, Dickinson and Muragu (1994), Olowe (1999) and Mikailu & Sanda (2007) find that the Nairobi and Nigerian stock exchanges respectively are efficient in the weak form. Turning to stock markets in the Latin American region, Urrutia (1995) provides mixed evidence on the weak form efficiency for the stock markets in Argentina, Brazil, Chile, and Mexico. Specifically, results of the variance ratio test reject the random walk hypothesis for all markets while findings from the run tests indicate that these markets are weak form efficient. Consistent with the results reported by Urrutia (1995), Grieb and Reyes (1999) show empirical findings, which are obtained from the variance ratio tests, to reject the hypothesis of random walk for all stock market indexes and most individuals stock in Brazil and Mexico. Moreover, Karemera *et al.* (1999) find that stock

return series in Brazil, Chile, and Mexico do not follow the random walk, based on the results of single variance ratio tests, but Argentina does. However, when the multiple variance ratio test is applied, the market index returns in Brazil is observed to follow the random walk process (the others are not changed).

In the Southern part of Asia, Sharma and Kennedy (1977) and Alam *et al.* (1999) report that the random walk hypothesis cannot be rejected for stock price changes on the Bombay (India) and Dhaka Stock Exchange (Bangladesh) respectively. However, Abeysekera (2001) and Abraham (2002) show evidence to reject the hypothesis of weak form efficiency for stock markets in Sri Lanka, Kuwait, Saudi Arabia and Bahrain, while Sanda (2009) used stock prices of 24 companies show evidence to reject the hypothesis of weak form efficiency in the case of Nigerian stock market. However, some recent studies on the EMH on the Nigerian Stock Market shows that the hypothesis of the market efficiency not rejected; study by Bashir (2009) using weekly returns for the 69 most actively traded shares over the period 1995-2005. His paper tests the weak-form of the EMH using a battery of tests including tests of autocorrelations and technical trading strategies. Overall, the analysis indicates that the Nigerian market may be weak-form efficient for ordinary investors who operate in a costly trading. According to Godwin (2010), the weak form hypothesis has been pointed out as dealing with whether or not security prices fully reflect historical price or return information. To carry out this investigation with the Nigerian stock market data, he employed the run test and the correlogram/partial autocorrelation function as alternate forms of the research instrument. His results of the three alternate tests revealed that the Nigerian stock market is efficient in the weak form and therefore follows a random walk process. He concluded that the opportunity of making excess returns in the market is ruled out. However, there are many conflicting studies on the issue of EMH on the Nigerian Stock Market. Our own shall take a position whether or not to reject EMH or not to reject, best on the data and the period of study.

3.0 Materials and Methods

The data used in this study primarily consist of daily and weekly price series of the market index (NSINDEX) and the five oldest stocks listed on the Nigerian stock exchange. Specifically, the market index, namely NSINDEX, is a composite that is calculated from prices of all stocks traded on the STC while individual stocks selected for this study are FIRSTB, UBA, UNIONB, CADBURY and NESTLE. All data are obtained over the period from January, 2005 (the first trading session in the year) to Dec., 2009 from the NSE, Kaduna branch. Then, a

natural logarithmic transformation is performed for the primary data. To generate a time series of continuously compounded returns, daily returns are computed as follows:

$$r_t = \log(p_t) - \log(p_{t-1}) = \log(p_t/p_{t-1}) \quad (3.1)$$

where p_t and p_{t-1} are the stock prices at time *t* and *t-1*.

Similarly, the weekly returns are calculated as the natural logarithm of the index and the stock prices from Wednesday's closing price minus the natural logarithm of the previous Wednesday's close. If the following Wednesday's price is not available, then Thursday's price (or Tuesday's if Thursday's is not available) is used. If both Tuesday's and Thursday's prices are not available, the return for that week is reported as missing. The choice of Wednesday aims to avoid the effects of weekend trading and to minimize the number of holidays (Huber, 1997).

3.1 Autocorrelation tests

The first approach to detecting the random walk of the stock returns summarized here is the autocorrelation test. Autocorrelation (serial correlation coefficient) measures the relationship between the stock return at current period and its value in the previous period. It is given as follows:

$$\rho_k = \frac{\sum_{t-1}^{N-K}(r_t-\overline{r})(r_{t+k} \quad -\overline{r})}{\sum_{t=1}^{N}(r_t-\overline{r})^2} \quad (3.2)$$

where ρ_k is the serial correlation coefficient of stock returns of lag k; N is the number of observations; r_t is the stock return over period t; r_{t+k} is the stock return over period $t+k$; r is the sample mean of stock returns; and *k* is the lag of the period. The test aims to determine whether the serial correlation coefficients are significantly different from zero. Statistically, the hypothesis of weak-form efficiency should be rejected if stock returns (price changes) are serially correlated ρ_k is significantly different from zero). To test the joint hypothesis that all autocorrelations are simultaneously equal to zero, the Ljung–Box portmanteau statistic (*Q*) is used. The Ljung–Box *Q*statistics are given by:

$$Q_{LB} = N(N+2)\sum_{j=1}^{k}\frac{\rho_j{}^2}{N-j} \quad (3.3)$$

ρ_j is the jth autocorrelation and *N* is the number of observations. Under the null hypothesis of zero autocorrelation at the first *k* autocorrelations ($\rho_1 = \rho_2 =$

$\rho_3 = \ldots = \rho_k = 0$), the Q-statistic is distributed as chi-squared with degrees of freedom equal to the number of autocorrelations (k).

3.2 Runs test

The runs test is a non-parametric test that is designed to examine whether or not an observed sequence is random. The test is based on the premise that if a series of data is random, the observed number of runs in the series should be close to the expected number of the runs. A run can be defined as a sequence of consecutive price changes with the same sign. Therefore, price changes of stocks can be categorized into three kinds of run: upward run (prices go up), downward run (prices go down) and flat run (prices do not change). Under the null hypothesis of independence in share price changes (share returns), the total expected number of runs (m) can be estimated as:

$$M = \frac{\{N(N+1) - \sum_{i=1}^{3} n_i^2}{N} \quad (3.4)$$

where *N* is the total number of observations (price changes or returns) and n_i is the number of price changes (returns) in each category (N = $\sum_{i=1}^{3} n_i$).

For a large number of observations ($N > 30$), the sampling distribution of m is approximately normal and the standard error of m (σ_m) is given by:

$$\sigma_m = \left\{\frac{\sum_{i=1}^{3} n_i^2 \left[\sum_{i=1}^{3} n_i^2 + N(N+1)\right] - 2N \sum_{i=1}^{3} n_i^3 - N^3}{N^2(N-1)}\right\}^{1/2} \quad (3.5)$$

The standard normal Z-statistics that can be used to test whether the actual number of runs is consistent with the hypothesis of independences is given by:

$$Z = (R \pm 0.5 - m)/\sigma_m \quad (3.6)$$

where *R* is the actual number of runs, *m* is the expected number of runs, and 0.5 is the continuity adjustment (Wallis and Roberts, 1956) in which the sign of the continuity adjustment is negative (- 0.5) if $R \geq m$, and positive otherwise. Since there is evidence of dependence among share returns when R is too small or too large, the test is a two-tailed one.

3.3 Variance ratio test

The variance ratio test, proposed by Lo and MacKinlay (1988), is demonstrated to be more reliable and as powerful as or more powerful than the unit root test (Lo and MacKinlay, 1988; Liu and He, 1991). The test is based on the assumption that the variance of increments in the random walk series is linear in the sample interval. Specifically, if a series follows a random walk process, the variance of its q-differences would be q times the variance of its first differences.

$$Var(p_t - p_{t-q}) = qVar(p_t - p_{t-1}) \tag{3.7}$$

where q is any positive integer. The variance ratio, $VR(q)$, is then determined as follows:

$$VR(q) = \frac{\frac{1}{q}\mathrm{Var}(p_t - p_{t-q})}{\mathrm{Var}(p_t - p_{t-1})} = \frac{\sigma^2(q)}{\sigma^2(1)} \tag{3.8}$$

For a sample size of n_{q+1} observations $(p_0, p_1, \dots, p_{nq})$, the formulas for computing σ^2 (*q)* and σ^2 (1) are given in the following equations:

$$\sigma^2(q) = \frac{\sum_{i=q}^{nq}(p_t - p_{t-q} - q\hat{u})^2}{h} \tag{3.9}$$

where

$$h = q(nq + 1 - q)\left(1 - \frac{q}{nq}\right) \tag{3.10}$$

and

$$\hat{u} = \frac{1}{nq}\sum_{t=1}^{nq}(p_t - p_{t-1}) = \frac{1}{nq}(p_{nq} - p_0) \tag{3.11}$$

$$\sigma^2(1) = \frac{\sum_{t=1}^{nq}(p_t - p_{t-1} - \hat{u})^2}{(nq-1)} \tag{3.12}$$

Under the assumption of homoscedasticity and heteroscedasticity increments, two standard normal test-statistics, $Z(q)$ and $Z^*(q)$ respectively, developed by Lo and MacKinlay (1988), are calculated by Equations (3.13) and (3.14):

$$Z(q) = \frac{VR(q) - 1}{[\emptyset(q)]^{1/2}} \sim N(0,1) \tag{3.13}$$

$$Z^*(q) = \frac{VR(q) - 1}{[\emptyset^*(q)]^{1/2}} \sim N(0,1) \tag{3.14}$$

where $\emptyset\,(q)$ is the asymptotic variance of the variance ratio under the assumption of homoscedasticity, and $\emptyset^{*}\ (q)$ is the asymptotic variance of the variance ratio under the assumption of heteroscedasticity:

$$\emptyset(q) = \frac{2(2q-1)(q-1)}{3q(nq)} \tag{3.15}$$

$$\emptyset^{*}(\mathrm{q}) = \sum_{j=1}^{q-1} [\frac{2(q-j)}{q}]^2\, \delta(j) \tag{3.16}$$

Where $\delta(j)$ is the heteroscedasticity – consistent estimator and computed as follows:

$$\delta(j) = \frac{\sum_{j+1}^{nq}(p_t - p_{t-1} - \hat{u})^2\,(p_{t-1} - p_{t-j-1} - \hat{u})^2}{[\sum_{t=1}^{nq}(p_t - p_{t-1} - \hat{u})^2\,]^2} \tag{3.17}$$

4.0 Results and Discussion

4.1 Autocorrelation tests

To test the weak form of EMH for the Nigerian stock market, first the autocorrelation tests with 12 lags are performed for daily weekly returns of the NSINDEX and five individual stocks. The results of these tests are as summarized in Table1.

4.2 Results for daily returns

The result shows that the autocorrelation tests for daily observed and corrected returns for thin (infrequent) trading respectively. When the observed returns are used, it is found that the null hypothesis of random walk is rejected for all studied series (except UNIONB). Specifically, for the NSINDEX, it is evident that autocorrelation coefficients are significantly different from zero with a positive sign for 1st, 4th, 5th, 6th and 7th lag. It is worth to note here that the positive sign of the autocorrelation coefficients indicates that consecutive daily returns tend to have the same sign, so that a positive (negative) return in the current day tends to be followed by an increase (decrease) of return in the next several days. Especially, the results of the Liung-Box Q-test reveal that the autocorrelation coefficients of all 12 lags are jointly significant at 1% level. Regarding the individual stocks returns, it is observed that serial correlation coefficients are significant at 1^{st} , 4^{th} , 5^{th} , 6^{th} and 7^{th} lag for FIRSTB; at 1^{st} , 2^{nd}, 3^{rd} and 6^{th} for CADBURY; at 1^{st} , 7^{th} and 10^{th} lag for UBA and at 1^{st} and 3^{rd} lag for NESTLE. Importantly, the results of Q-test fail to support the joint null hypothesis that all

autocorrelation coefficients of 12 lags are equal to zero for all individual stocks return series in question.

The empirical results for the corrected returns, again reject the random walk hypothesis for the Index and all selected individual stocks (except UNIONB). However, the rejection of the null hypothesis is less pronounced for FIRSTB and NESTLE when observed returns are corrected for thin 28. They are significantly different from zero trading. Specifically, the joint hypothesis that all autocorrelation coefficients are simultaneously equal to zero is only rejected for some lags, not all 12 lags as in the case of observed returns presented above.

Table 1: Descriptive statistics for the NSINDEX and the individual stocks returns

	NSINDEX	FIRSTB	UBA	UNIONB	CADBURY	NESTLE
Daily returns						
Observations	802	802	802	802	802	802
Mean	0.0001	-6.35E-05	0.0002	-0.0003	-6.28E-05	9.38E-05
Median	-0.0003	0.0000	0.0000	0.0000	0.00000	0.0000
Maximum	0.0204	0.1811	0.1798	0.2168	0.2942	0.1447
Minimum	-0.0206	-0.1811	-0.1798	-0.2117	-0.2942	-0.1567
Std. Dev.	0.0046	0.0138	0.0152	0.0196	0.0182	0.0110
Skewness	0.9	-2.8	-2.0	-1.3	-1.1	-0.8
Kurtosis	7.9	121.5	106.2	83.5	204.3	100.3
Jarque-Bera	800.7[a]	415,586.2[a]	314,917.0[a]	191,786.2[a]	1,196,997.0[a]	279,808.7[a]
Weekly returns						
Observations	300	285	285	255	250	245
Mean	0.0016	0.0007	0.0014	0.0007	0.0016	0.0013
Median	0.0003	0.0000	0.0011	0.0011	0.0000	0.0000
Maximum	0.0840	0.0834	0.0853	0.1718	0.2850	0.1567
Minimum	-0.0894	-0.1774	-0.1768	-0.2553	-0.3010	-0.1467
Std. Dev.	0.0189	0.0259	0.0240	0.0365	0.0376	0.0283
Skewness	-0.4	-1.5	-2.0	-3.1	-0.97	-0.1
Kurtosis	8.0	13.6	17.8	26.4	36.97	11.0
Jarque-Bera	239.9[a]	1,129.9[a]	2,201.8[a]	5485.9[a]	10,808.3[a]	543.5[a]

a : Indicates that the null hypothesis of normality is rejected at the 1% significant lev

4.3 Results for weekly returns

Similar to the results for the daily observed returns, it is found that autocorrelation coefficients of the weekly observed index returns are significant with a positive sign at 1^{st} , 2^{nd} , 3^{rd} , 4^{th} , and 5^{th} lags. Additionally, based on the Q-statistics, the null hypothesis of no autocorrelation on the index returns for all lags selected is strongly rejected at the one percent significant level.

Furthermore, results of the autocorrelation tests on weekly observed returns for the individual stocks show significant autocorrelation coefficients at the first lags for each individual stock returns series. Specifically, significant autocorrelation coefficients are found at 1^{st} , 2^{nd} , and 4^{th} lag for FIRSTB; at 1^{st} , 2^{nd} , 4^{th} , and 5^{th} lag for UBA; at 1^{st} and 2^{nd} lag for UNIONB; at 1^{st} , 2^{nd} , 3^{rd} , 4^{th} , 5^{th} and 7^{th} lag for CADBURY; and at 1^{st} , 2^{nd} , 3^{rd} , and 5^{th} lag for NESTLE. Once again, the Q-statistics fail to support the joint null hypothesis that all autocorrelation coefficients from lag 1 to 12 are equal to zero for all individual stocks observed return series.

Further, the results of the autocorrelation tests for the corrected returns indicate that the random walk hypothesis is also rejected for the market index and all selected individual stocks, except FIRSTB. However, the extent of rejection is less pronounced for these series, especially for the market index, UBA and UNIONB, as the returns are adjusted for thin trading. On the basis of the empirical results obtained from autocorrelation tests for the observed returns, it can be concluded that the null hypothesis of random walk is rejected for the market index and all selected individual stocks (except UNIONB). When the corrected returns for thin trading are used, the random walk hypothesis is also rejected for the market index and four out of five selected individual stocks although the extent of rejection is less pronounced.

4.4 Run tests

To detect for the weak form efficiency of the Nigerian stock market, the nonparametric runs test is also used in this study. The runs test is considered more appropriate than the parametric autocorrelation test since all observed series do not follow the normal distribution, (sess the Jarque-Bera test in appendix). Specifically, the results of the runs test for daily observed returns, the results indicate that the actual runs of all series are significantly smaller than their corresponding expected runs at 1% level, so that the null hypothesis of independence among stock returns is rejected for these series. Moreover, the results of runs test based on the corrected returns also support the null hypothesis of random walk for NSINDEX, FIRSTB, UBA and CADBURY. However, these results fail to reject the null hypothesis for UNION and NESTLE. For the weekly observed returns, the results indicate that the null hypothesis of independence among stock returns is rejected for the market index and all selected individual stocks, except UNIONB.

However, when the corrected returns are used, the results of the runs test reveal that the null hypothesis cannot be rejected for UNIONB, but it is rejected for FIRSTB and NESTLE. For the remaining series, the rejection of the null hypothesis is unchanged, but the extent is less pronounced as compared with the results for the weekly observed data.

In summary, the runs test provides evidence to reject the null hypothesis of random walk for both daily and weekly observed returns of the market index and all selected individual stocks (except weekly returns for UNIONB). However, when the corrected returns are used, the empirical results obtained from the test fail to reject the null hypothesis for UNIONB and NESTLE with the daily data and for FIRSTB and NESTLE with the weekly one.

4.5 Variance ratio tests

This study employs variance ratio tests for both null hypotheses, namely the homoscedastic and heteroscedastic increments random walk. In addition, the variance ratio is calculated for intervals (q) of 2, 4, 8, 16 and 32 observations. The results of the variance ratio tests are reported in Table

4.6 Results for daily returns

Empirical evidence obtained from the variance ratio tests for daily observed returns indicates that the random walk hypothesis under the assumption of homoscedasticity is rejected for all series. In the case of NSINDEX, for instance, the Z-statistics suggest that the variance ratios are significantly different from one for all values of q at the one percent level. Therefore, the null hypothesis of random walk is strongly rejected for the market index series. Similarly, the empirical findings reveal that the null hypothesis of random walk for all selected individual stocks cannot be accepted for all levels of q at the one percent level of significance. Moreover, the rejections of the random walk hypothesis under both homoscedasticity and heteroscedasticity assumptions for all series do not change even when the daily corrected returns for thin trading are used. Indeed, all the test-statistics of Z(q) and Z*(q) are still larger than the critical statistic at one percent level of significance.

4.7 Results for weekly returns

Results of the variance ratio tests on the weekly observed return data confirms again that the null hypothesis of random walks under the assumption of homoscedasticity is strongly rejected for all series at all cases of q. Indeed, all Z-

statistics are greater than the conventional critical value (1.96 for the five percent level). In addition, the heteroscedasticity-consistent variance ratio test provides consistent evidence that the null hypothesis of random walk cannot be accepted for all weekly observed return series. Specifically, a comparison the Z*-statistic to the conventional critical value reveals that the random walk hypothesis is rejected at q = 2, 4, 8, and 16 for CADBUTY and FIRSTB, and at q = 2, 4, and 8 for NSINDEX and NESTLE. Moreover, the evidence against the null hypothesis under the assumption of heteroscedasticity in the case of UNIONB is weak because only two rejections (q=2 and q=4) are reported. Further, when the corrected returns are employed, similar results are obtained from the tests. Specifically, the null hypothesis of random walks under the assumption of homoscedasticity is strongly rejected for all series at all cases of q while the null under the assumption heteroscedasticity cannot be accepted for all series at some cases of q. The rejection of the null hypothesis is less pronounced for NSINDEX, FIRSTB, CADBURY and NESTLE, but more pronounced for UBA and UNIONB as compared with the results for the weekly observed returns.

On the basis of empirical evidence provided above, it can be concluded that the null hypothesis of random walk is rejected for the market index and all selected individual stocks. Moreover, thin trading is unlikely to affect the market efficiency.

5.0 Conclusion and Recommendations

This paper first provides an overview of the theoretical literature on the EMH. Specifically, three theoretical models suggested by Fama (1970), namely the Fair Game model, the Sub-martingale model, and the Random Walk model, are briefly summarised. The theoretical models of efficient market consistently imply that the future price of stock is unpredictable with respect to the current information, so market participants cannot earn abnormal profits. Additionally, this paper also highlights three different levels of EMH, weak form, semi-strong form, and the strong form. Following the theoretical literature, empirical studies on the weak form of EMH in emerging stock markets have been extensively conducted, especially in recent years. The empirical evidence obtained from these studies is mixed. Indeed, while some studies show empirical results that reject the null hypothesis of weak form market efficiency, the others report evidence to support the weak form of EMH. In general, emerging stock markets are unlikely to be efficient in weak form possibly due to their inherent characteristics, such as low liquidity, thin and infrequent trading, and lack of experienced market participants.

On the basis of the theoretical and empirical literature that is reviewed in this paper, the weak form of market efficiency for the market index and five selected individual stocks is tested by using both daily and weekly return data for the period from January 2007 to December, 2009 and from July, 2005 to December 2009. In addition, to deal with the problem of thin (infrequent) trading, which would seriously bias the results of the empirical study on market efficiency, the observed returns are corrected by using the methodology proposed by Miller *et al*. (1994). Moreover, in order to test the weak form of EMH for the Nigerian stock market, three different techniques are employed, namely autocorrelation, runs, and variance ratio tests. The results obtained from the autocorrelation indicate that the null hypothesis of random walk is conclusively rejected for the market index and four out of five selected individual stocks, even in the case where the returns are corrected for thin trading. In addition, the runs test shows evidence to reject the null hypothesis of a random walk for both daily and weekly observed returns of the market index and all selected individual stocks (except weekly returns for UNIONB). However, when the corrected returns are used, the empirical results given by the tests fail to reject the null hypothesis for the daily returns of UNIONB and NESTLE and weekly returns for FIRSTB and NESTLE. Moreover, the results of the Lo and MacKinley's variance ratio test under both homoscedastic and heteroscedasticity assumptions for both observed and corrected returns fail to support the random walk hypothesis for the market index and all selected individual stocks. In general, it can be concluded that the Nigerian stock market is inefficient in the weak form. A question arises here is whether investors can make abnormal profits by establishing a trading strategy on the basis of past information. Motivated by this interesting question, further studies on the issue of market efficiency are conducted.

The policy implications of this analysis are that the NSE, as an emerging market, must be closely monitored to achieve an optimal maturity level. Greed and bad choices should not take the place of risk management capacity and market discipline. Investors must be aware that, in inefficient stock markets, heavy gains are just as likely as heavy losses. Furthermore, the Securities and
Exchange Commission should take a leading role in regulating abnormal financial activities. In the meantime, an inefficient market could suffer over inflated stock prices, speculation, and insider trading, all potentially intensified by herding behaviour. Several policy challenges need to be confronted to enhance the efficiency of the NSE, including (and not limited to):

- Increase market activities through reduction in transaction cost and increase in membership of the NSE.

- The NSE and SEC also need to strengthen their regulatory capacities to enhance market discipline and investor confidence. This will involve training personnel to enforce financial regulations, perform market surveillance, analytical and investigative assignments.
- Establishing a stock exchange news service, which will be responsible for early, equal and wide dissemination of price sensitive news such as financial results and other information that are material to investors' decision. This will ensure that participants and investors have equal access to high quality and reliable information.
- Minimize institutional restrictions on trading of securities in the bourse. This will make all other markets to flow as a deregulated market.

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Enhancing Data Generation for National Development in Nigeria: Institutional and Structural Issues[1]

Olu Ajakaiye[2]

1.0 Introduction

The concept of data has been defined in various ways depending on the context and purpose. For the present purposes, data can be defined as "factual information used as basis for reasoning, discussion or calculation" (Merriam-webster Dictionary). Correspondingly, data generation for development can be conceived as the process of gathering a body of factual information about the aspects of development of interest for the purposes of reasoning, discussion and calculations around the development status, process and prospects of the society. In this presentation, attention is focused on data generation for the purposes of reasoning, discussing and calculating the status, process and prospects of economic development.

Economic development has also been defined in various ways. Again for the present purposes, economic development will be conceived as the process of economic growth and structural transformation (Ajakaiye, 2002). Clearly, data, as a gathered body of facts about the economy, is a basic requirement in the process of economic growth and transformation. Foremost, facts about the economy are necessary in order to appreciate the current state of the economy in terms of growth and structural change. It is also required to understand the functioning of the economic system and how the growth and structural changes are occurring. On the basis of the knowledge of state and functioning of the economic system, plausible, realistic and attainable targets of growth and structural change can be set for the economy over a specified period of time, be it short (annual or quarterly or monthly), medium (typically 5 years) and long term (usually 10 years and beyond). For these purposes, some form of formal and/or intuitive model would have been constructed and simulated to inform the targets

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set. Analyses of data are required for the design of policies and programmes likely to attain the set targets. Data are also required for effective monitoring and impact/outcome assessment.

Against this background, the quality, frequency, timeliness and comprehensiveness of data are of paramount importance for effective development planning, plan implementation and plan outcome. Happily, these pertinent issues are already slated for discussion in this retreat. Therefore, in this presentation, attention is focused on institutional and structural issues in enhancing data generation for development in Nigeria

The rest of the presentation is organized as follows. In the next section, institutional and structural features of the Nigerian economy and their implications for data generation for economic development policies and actions are discussed. Thereafter, some suggestions for enhancing data generation for economic development policies and actions in Nigeria are proposed. This is followed by some concluding remarks.

2.0 Institutional and Structural Features of the Nigerian Economy: Implications for Data Generation for Development

A salient institutional feature of the Nigerian economy is that it is a mixed economy characterized by the existence of institutional arrangement in which the private and public sectors exist and the productive resources are owned and controlled by these economic agents. Available data from the National Bureau of Statistics (NBS) shows that the share of government final consumption expenditure in total expenditure on GDP increased steadily from around 10% in 2007 to about 12.5% in 2011. Similarly, data from the latest release of the World Development Indicators (WDI) suggests that total government revenue excluding grants which was around 8 % in 2004 increased to around 10% by 2008. The indication is that while evidence suggests that, contemporarily, the private sector is dominant in national economic activities, government is the single largest controller of a significant component of national income and expenditure.

Turning to the structural features of the Nigerian economy, there is ample evidence to show that a large part of the economy is dominated by peasant and informal activities. For example, as at 2010, agriculture accounted for about 41% of GDP and distributive trade accounted for about 19% of GDP. Agriculture in Nigeria is peasantry and distributive trade is basically informal.

Each of these features has implications for data generation for development and these are considered in the rest of this section.

2.1 Implications of Institutional (Mixed Economy) Feature

An implication of the mixed economy feature of the Nigerian economy for data generation is that data from the public sector can be obtained administratively while data from the private sector can be obtained through establishment, household and mixed surveys. Administrative data are expected to be generally easier to collect as the various ministries, departments and agencies (MDAs) at all levels of government are expected to keep records of their operations and make them available to interested and eligible parties. When, as part of the civil service reforms of 1988, the departments of planning research and statistics (DPRSs) were established in all MDAs, a major lacuna in administrative statistics was expected to have been solved.

In the minimum, the MDAs at Federal, State and Local Government levels are expected to collect, collate, analyze and publish administrative data on the operations of the ministry. In addition, each ministry is expected to consolidate the data from their parastatals and agencies with theirs to produce a comprehensive administrative data on their areas of operation. Similarly, state ministries are expected to collate, consolidate, analyze and publish the administrative data from their agencies and the relevant departments of the local governments in the state.

The state ministries are thereafter expected to furnish the corresponding Federal Ministries with the state level data for consolidation and publication. Finally, each federal ministry is expected to forward the consolidated administrative data to the National Bureau of Statistics which should, in turn, make these available to all interested parties, including the CBN. For comparability, the processes for data collection and analysis are expected to be standardized.

Experience, however, shows that staff of the DPRSs found it more convenient (and probably more attractive) to concentrate on procurement activities as opposed to the planning, research and statistics duties. Moreover, the skills required to carry out the functions of data generation to aid research, planning and impact assessment within the MDA were generally lacking and there were no sustained efforts to build capacity of the staff. This problem is more severe at the state levels and very precarious at the local government level.

Moreover, in an environment characterized by corrupt practices, data generated by the DPRSs of the MDAs are unlikely to be reliable even if the requisite skills are present in the relevant DPRSs. Relatedly, the integrity of administrative data from the MDAs may also be contaminated by the perceived or real implications for budgetary allocations. The result is that the expectation that accurate and comprehensive administrative data will flow regularly from NDAs remains unfulfilled.

Turning to data from the private sector, two groups of sources can be identified, namely, establishment and household. In modern economies, establishment surveys are the veritable sources of information about production, employment, factor incomes, depreciation, indirect taxes, subsidy on production, corporate income taxes, investment exports and imports. Household surveys are sources of information about household income, consumption expenditure and savings. In such economies, establishments maintain copious data for use internally, for rendering statutory returns to government agencies and for responding to specialized surveys by statistical agencies and researchers.

It turns out that, with the possible exception of the financial institutions, especially banks and other financial institutions, several modern establishments do not maintain copious records even for internal uses. This is particularly the case with small and medium enterprises. Large scale enterprises, including financial sector establishments that do have such data, typically, are reluctant to make them available for various reasons including corrupt practices, tax avoidance and fear of free ridership especially with respect to information on technology, business strategy and related issues. In such situations, establishments tend to maintain different records for different purposes – one for internal management uses, another for mandatory returns to various agencies and yet another for shareholders!! There are indications that this phenomenon is not limited to developing countries as obviated by the startling revelations of the practices of several organizations in the developed countries in recent times. The upshot of the foregoing is that data from establishment surveys should be carefully scrutinized before use.

2.2 Implications of Economic Structure

Data from households are normally obtained through household surveys. Such surveys include employment, income and expenditure surveys conventionally referred to as integrated household surveys. There are also demographic and

health surveys. In the Nigerian context, where a large part of production activities takes place at the household level, especially agricultural production, wholesale and retail trade, establishment surveys will necessarily miss out these activities. Meanwhile, these activities account for about 59 per cent of GDP in 2010. In order to capture data on these activities, the integrated household surveys also include modules on production activities. For agriculture, the practice is to carry out a census of agricultural activities usually every 10 years and carry out sample surveys at intervals between censuses. The benchmarks obtained from the census and surveys are used to estimate agricultural sector output for intervening periods. For distributive trade which is largely informal, the approach is to capture the data as part of the integrated household surveys.

Like establishment surveys, household surveys also have their own challenges in terms of data reliability. Whereas establishments maintain different records for different purposes, households also tend to respond differently to different questionnaires depending on the perceived intention of the questioner by the respondent. Moreover, there are socio-cultural and even political considerations that may influence the reliability of data collected from households. What is generally true is that the response rate tends to be higher and the speed of data collection tends to be faster in the case of household surveys as opposed to establishment surveys. Also, statistical properties of household survey data tend to be better especially if the population census frame is used in the sampling.

2.3 Implications of Federalism

In a federation, data collection is usually on the concurrent legislative list. The only exception is the national population census which is normally on the exclusive legislative list. However, collection of vital statistics is typically on the concurrent legislative list. Needless to say, the institutional (mixed economy) and structural (sectoral composition) attributes of the economy at the national level are manifest in the states and local governments. It has been mentioned that the challenges of administrative data collection, collation, analysis and publication are more severe at the state level and precarious at the local government level. Therefore, the integrity of sectoral administrative data is generally in doubt. Foremost, several states and local governments do not collect the relevant administrative data implying that consolidated data at the federal level is based on incomplete data for lower levels of government. This situation is partly responsible for the incomplete data on state and local government fiscal operations contained in the CBN Annual Reports over the years.

At the Federal level, the National Bureau of Statistics (NBS) is a parastatal of the National Planning Commission. The NBS is charged with the responsibility of coordinating national statistical system, consolidate, publish and store data on all aspects of the Nigerian economy and society with the exclusion of Population Census and related activities which is the responsibility of the National Population Commission. The NBS, therefore, is expected to conduct necessary censuses and surveys required to gauge status of development, illuminate the functioning of the socio-economic system and lately, present prospects of the economy over the medium term. Of note, the NBS conducts monthly surveys and produces the monthly consumer price index and the associated price inflation rates. The organization has been responsible for the computation of the national accounts of Nigeria. Recently, and with active support and encouragement of the CBN, the NBS has started producing quarterly GDP series which are quite instrumental to the conduct of monetary policy. It is also quite remarkable that the NPC and NBS are spearheading the estimation of state GDP in collaboration with the state governments. This initiative should provide vital statistics to the state governments which can be used to gauge growth and structural transformation at that level of government.

The NBS also conducts a series of integrated household surveys on the basis of which it produces analysis of the poverty situation in the country at intervals depending on availability of funds often from donor organizations. The survey results and analysis, like those of other surveys, are presented by state and by geopolitical zones. Quite often, the reports generate considerable controversy as the findings tend to be disappointing to some stakeholders.

Perhaps the most popular data produced by the NBS is the consumer price index (CPI). The CPI is produced monthly on the basis of which the all important inflation rate is computed. Again, this data is presented at state level and by commodity groups. Probably because of its popularity and importance to the monetary authorities, this activity is carried out regularly implying that it is well funded.

Over the years, surveys of establishments in the various sectors are less regular perhaps because they are not directly of interest to major domestic and international constituencies. Meanwhile, it is these sectoral establishment surveys that are necessary for credible national accounts statistics and the input-output tables which reveal the structure and intensity of inter-industry transactions in the economy. Clearly, the accuracy and integrity of the national accounts statistics

will be enhanced if resources are provided to enable the NBS carry out the establishment surveys necessary to provide appropriate and realistic benchmarks for estimating national accounts. Reliance on historical benchmarks and failure to produce input-output tables as well as the Social Accounting Matrix at regular intervals will detract from the accuracy, reliability, integrity, comprehensiveness and information contents of the national accounts statistics. The implication is that such data may not really be reflecting the status and functioning of the economy and hence weaken the analysis of its prospects based on such data. In essence, the development process is likely to be blind!!

Virtually all states have state statistical bureau which is typically part of the ministry of finance and economic planning. These bureau are supposed to develop sampling frames for various sectors of their economy and conduct sample surveys (and censuses where necessary) of activities in their states. However, relatively few of the state statistical agencies are active as many of them face capacity problems in addition to poor funding. The result is that the much desired integrated national statistical system where national statistical data for national development are standardized and consolidated from local government to state government level and subsequently to federal level remains unrealized.

Relatedly, because of the weak statistical systems at the state level in terms of weak capacity and poor funding, most states and virtually all of the local governments do not make effective use of the data produced by the NBS, the CBN and other agencies. In essence, development processes in most states and local governments are relatively blind!!

3.0 Suggestions for Enhancing Data Generation for National Development

From the foregoing, it is clear that there is need for enhancing the data generation processes for development in order to illuminate the development status, processes and outcome. Towards this end, the integrity of administrative data should be enhanced. To begin with, the MDAs at all levels of government should be encouraged to support their DPRSs through provision of necessary funding, equipment and well capacitated staff so that they can produce credible data on all areas of operations of the MDAs, use them internally and publish them for other users. Each DPRS should also be supported to hold regular sectoral producers and users consultative forums with a view to ensuring that the data produced meet the needs of the users and enlighten the users about the strengths and weaknesses of the data set.

All state ministries and agencies should regularly forward their respective administrative data sets to the corresponding federal ministries and agencies for collation, consolidation and publication. The federal ministries and agencies should, in turn transmit the consolidated data sets to the NBS for further dissemination and achiving.

The NBS should regularly interact with the state statistical bureaus to standardize the processes for collecting, processing and analyzing administrative data to facilitate comparability and achiving. Each state bureau should do the same with the local governments in the state.

The NBS and all state statistical bureaus should be properly funded so that they can conduct credible surveys in all sectors of the economy and society at regular intervals. Failure to do so may jeopardize the quality and integrity of the data and hence blur the actual status, processes and prospects of the economy and society. Specifically, the NBS should be fully funded by government to carry out all requisite surveys necessary to produce credible, consistent and comprehensive data. Data collection activities of the NBS should not be dictated almost exclusively by the desires and preferences of international organizations through funding. This situation has resulted in apparent concentration on household surveys at regular intervals than establishment surveys thus rendering the benchmarks used in compiling the national accounts obsolete. Moreover, paucity of such surveys blinds the policy makers to the challenges and opportunities of growth and structural transformation processes in the sectors. Policies and programmes made on the basis of such inaccurate data are likely to be ineffective and, indeed, misdirected.

Correspondingly, the state governments should adequately fund their statistical bureaus so that they can do state level surveys necessary to illuminate the development status, processes and prospects of the states. These bureaus should be well staffed by very competent personnel who can carry out such surveys, process the data and present the results in useful ways to all stakeholders.

Finally, NBS and the state statistical bureaus should regularly dialogue with users of their data in order to enhance the relevance and utility of the data they produce.

In order to standardize the processes and ensure that the most current methodologies are adopted by all state statistical bureaus, the NBS should regularly hold workshops for staff of the state statistical bureaus. Such workshops should also provide opportunity for NBS to enlighten the staff of state

statistical bureaus on the best ways to use the data produced by the NBS and how state level data can be complementary to those of NBS. This will also avoid wasteful duplication of efforts.

The challenges of inaccurate data from establishment and household surveys in developing countries are enormous. With respect to establishment survey data, large and small scale establishments should be encouraged to create and maintain very good statistical units that will produce data for their internal use as well as for other users.

The problem of manipulated data is more daunting in such establishments. One way to address it partially is to regularly audit the data through cross referencing. For example, the responses to key components of industrial survey questionnaires should be compared with the returns the establishments submitted to NEC, CAC, FIRS and PENCOM.

The impurities in the data from household surveys can be addressed through well designed survey instruments with appropriate filters and cross referencing. It may also be useful to translate the questionnaires to local languages ensuring that the translations are as accurate as possible. Survey instruments should be designed taking account of the socio-cultural tendencies in the locality.

4.0 Concluding Remarks

In conclusion, it must be acknowledged that the quality, frequency, integrity and timeliness of the monetary sector data are generally the highest in Nigeria. However, recent events in the developed world suggest that the CBN should not rest on its laurels. It may therefore be useful to occasionally audit the data from the financial institutions by comparing what they supply to the CBN with what they supplied to other regulatory agencies and the FIRS, for example.

It must also be acknowledged that the CBN supports and collaborates with NBS, universities and research organizations in data collection and analysis. The series of studies on Nigeria's informal sector of the 1990s, the quarterly GDP and indeed the regularity and integrity of the CPI are outcomes of these collaborations. The CBN should consider extending the collaboration with NBS to include decent and regular establishment surveys as this is necessary to produce more current benchmarks, more comprehensive, more reliable and more consistent data to illuminate the growth and structure of Nigerian economy. This is important because the conduct of monetary policy depends critically on data

from the financial sector as well as from the real sectors of the economy. High quality monetary sector data combined with low quality real sector data may result in misdirected monetary policy. In order to avoid this risk, a more elaborate collaboration between the CBN, the NBS and hence state bureaus of statistics should be actively encouraged.

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INSTRUCTIONS:

The Statistics Department of Central Bank of Nigeria (CBN) welcomes submissions of research articles to be published in its Journal of Applied Statistics (CBN-JAS). The journal is a refereed publication and publishes original articles with the potential to affect statistical practice in the central banking field of application. Such articles should achieve one of the followings:

(i) present statistically innovative, scientifically and practically relevant statistical analyses of monetary, banking, financial and general economic datasets;

(ii) substantially contribute to the applied statistics field through the use of sound statistical methods;

(iii) evaluate the quality of important data sources, even if there are no methodological innovations.

Articles presented for publication should be original articles not yet published elsewhere.

However, apart from articles section, the journal has a review section that would publish all review type articles and reviews of recently published books relevant to monetary, banking, financial and general economic statistics. There is also a document section where key note addresses or special remarks by distinguished personalities on money, banking, financial and general economic statistics would be published.

Structure of Manuscripts: Articles should include Abstract, Key words, Introduction, Methodology, Results, Discussion and Reference sections. The formatting of all articles selected for publication must conform to the following guidelines:

i. The article must be based on original research, not to have been published or submitted in part or whole for publication elsewhere. All articles will undergo the peer review process in accordance with generally accepted standards.

ii. The manuscripts should be submitted in MS Word, typed in double space on A4 size paper having margins 1.0" on both sides. Type face: Times New Roman, and font size: 12.

iii. Each article should include abstract not exceeding 250 words on a separate sheet of paper. At least 3 Keywords of the paper should be specified below the abstract. The JEL classification must be provided.

iv. The title of paper must be brief and contain words useful for indexing. The title page must contain the title of the paper and the full name and affiliation of all authors. The address for correspondence (along with e-mail address) should be given.

v. Referencing (in an alphabetic ascending order) should be made on separate sheet(s) and at the end of the paper where all publications cited in the text are presented. In case of

(a) **Periodicals:** The citation should be as follows:

Author's last name, first name, and middle initial, year of publication, "Title of the article", Name of the Journal (to be underlined/italicized), Volume number (month): and Page number (pp). For example:
Alade, S.O. (2003). "Fiscal Adjustment in Nigeria: Issues in Capital Expenditure". Bullion 27(2). April/June.

Doguwa S.I. and Upton G.J.G (1989). Edge-corrected estimators for the reduced second moment measure of point processes. *Biom. Journal*, 31:563-575.

(b) **Online Periodicals:** The citation should be as follows:
Author, A. A., Author B. B., & Author C. C. (2000). Title of article, Title of Periodical, year, from source (Http ://…….) For example:
Federal Reserve Board (2006). Monetary Policy, 2006 (http://www.federalreserve.gov/policy.htm).

(c) **Symposia and book of proceedings etc:** The citation should be as follows:
Alade, S.O., M. Ajayi, C.I. Enendu, and A.E. Idowu (2003). "The Supply and Demand for Loanable Funds in Contemporary Economic Policy Issues". Ed. O.J. Nnnana et al Central Bank of Nigeria.

Demirguckunt, A and Detragiache, E. (1998). "Financial Liberalization and Financial Fragility", in proceeding of the Annual Bank Conference in Development Economics, Washington D.C., World Bank.

(d) **Text Books:** The citation should be as follows:

Author's last name, first name, and middle initial, year of publication, "Title of the book", Name of the Publisher, Year and Or Chapter No. For example:

Bamanga, M.A. and M.I. Abdulkarim (2007). A First Course in University Statistics. Ahmadu Bello University Press, Zaria, Nigeria.

(e) **Citation of published papers/books in the Journal**,

Refer to the author's name and year of publication. Example: "Since Doguwa (1989) has shown that ….." If the authors are more than two, the name of the first author should be used followed by "*et al*". In the list of references however, names of first author and co-authors should be mentioned.

vi. **Tables and Figures:** Tables should be positioned in the body of the work and should be numbered in Arabic numerals. Figures (should be only provided if they improve the article) should be sharp computer generated drawings should be numbered in Roman numeral.

vii. **Proof:** A marked copy of the proof may be sent to the corresponding author who must return the corrected proof to the Editor-in-Chief with minimum delay.

General Instruction:

i. Soft copy of the Manuscripts must be sent to the **Editor-in-Chief, CBN Journal of Applied Statistics, Statistics Department, Central Bank of Nigeria, PMB 0187, Abuja, Nigeria** (e-mail: cbn-jas@cbn.gov.ng).

ii. The copyright of the paper will be reserved by the Central Bank of Nigeria once it is accepted for publication in the journal.

iii. Papers accepted for publication must have been recommended by at least 2 reviewers and each accepted article will attract a grant/remuneration of fifty thousand naira only.

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