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Examining the presence of nonlinear relationship between natural gas consumption and economic growth in nigeria

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ABSTRACT: *This paper examines the Presence of Nonlinear Relationship between Natural Gas Consumption and Economic Growth in Nigeria from 1981 to 2015. The Ramsey Reset test, Incremental F-test, and Wald test have been employed to test for non-linearity in the relationship between natural gas consumption and economic growth in Nigeria. The nonlinearity test results revealed that the relationship is nonlinear. However, the results are suggestive of the fact that linear models might not be the appropriate statistical tools for estimating the relationship between natural gas consumption and economic growth in Nigeria. Therefore, the paper recommends that the Nigeria's policymakers consider taking into cognizance nonlinear modeling techniques as alternative tools for modeling, estimating and forecasting the relationship between natural gas consumption and economic growth in the country.*

Keywords: *Nonlinearity; Relationship; Natural Gas Consumption; Economic Growth*

INTRODUCTION

In the ordinary least squares analysis, violations of linearity assumption could be statistically problematic and worrisome. Misspecification of the true mathematical form of an econometric model has a number of statistical consequences. In particular, violation of the assumption of linearity might imply wrong regressors, changing parameters and non-linearity in the relationship which if not properly handled could result in the model being incorrectly specified and hence, inconsistent estimates and mis-leading statistical inferences. Therefore, examining non-linearity in the relationship between / among economic variables is necessary for the reasons outlined. In effect, this shows that while investigating a relationship between variables, it is imperative to check whether the relationship is linear so as to know the appropriate model to use. Although studies such as Chiou-

Wei *et al*. (2008), Huang *et al*. (2008), Aloui and Jammazi (2009), Gabreyohannes (2010), Rahman and Serletis (2010), among others have found that the relationship between energy consumption and economic growth is nonlinear in other countries, to the best of the authors' knowledge, this is the first paper to pore over non-linearity in the relationship between natural gas consumption and economic growth in Nigeria.

The paper is structured into five sections. Section one is the introduction, section two is review of the related literature, section three is methodology, section four presents and discusses the results obtained and, section five is the conclusion.

LITERATURE REVIEW

Recent findings in the literature have shown that not all economic relationships are linear. However, extending forecasting models beyond linear models has nowadays been construed as the focus of macroeconomic forecasting models (Calhoun and Elliot, 2012). Paul (2013) has argued that linearity is analogous to shooting an arrow in a straight line through a data cloud. Although, a large number of studies have examined nonlinearity in the relationship between energy consumption and economic growth, albeit, a very few if any have investigated that in Nigeria. Zhao *et al*. (2007) conducts a research on the relationship between economic growth and energy consumption in China using Smooth Transition Regression (STR) model and found that the effect of energy consumption on Chinese economy has nonlinear, asymmetric and periodic characteristics. Huang *et al*. (2008) has analyzed nonlinear relationship between energy consumption and economic growth for 82 countries using Threshold Regression models with various candidates for the regime-switching variable. The result revealed a nonlinear relationship between energy consumption and output growth in majority of the countries. Cheng-Lang *et al*. (2010) has examined the causality between sectoral electricity consumption in Taiwan using linear and nonlinear Granger causality tests. The paper found a bi-directional causality between total electricity consumption and output level, and unidirectional causality running from output level to residential electricity consumption. Aslan (2011) investigates whether natural gas consumption follows a nonlinear path over time in 50 US States by applying a mechanism transition models, Markov Regime Switching (MRS) model, Threshold Regression (TR) and, Smooth Transition Regression (STR) models. The results revealed that natural gas consumption in approximately over 60% of 50 states follows a nonlinear behavior. Kani *et al*. (2014) examined the relationship between the demand function for natural gas and gross domestic product in Iran using Smooth Transition Regression (STR) model. The results showed that there exists a nonlinear relationship between the demand for natural gas and gross domestic product in Iran. Jian *et al*. (2016) examined the relationship between natural gas consumption of emerging economies in the industrialization process by applying the Panel Smooth Transition Regression (PSTR) model. They found nonlinear relationship between natural gas consumption and GDP per capita in the countries.

METHODOLOGY

This section discusses the econometric methodology availed in the paper. It begins by decscribing the data type and its sources, the estimation technique employed.

Data and Its Sources

The data used is annual time series comprising of observations (1981-2015) on the real GDP and natural gas consumption, labour and capital. The data for real GDP (*Y*), labour (*L*), and capital (*K*) were sourced from the World Bank while that for natural gas consumption was sourced from the 2016 statistical bulletin of the Organization of Petroleum Exporting Countries (OPEC). All variables have been transformed into their respective logarithms.

Estimation Techniques

The estimation techniques / statistical tests that were employed in this paper include the Ramsey RESET test, Incremental F-test, and Wald test.

The Ramsey (1969) RESET Test

The Ramsey's RESET (Regression Specification Error Test) could be applied to test nonlinearity in a relationship involving time series. In statistics, the Ramsey Specification Error Test (RESET) is a mis-specification test for linear regression usually employed for testing the following types of specification errors:

i. Omitted variables; X does not include all relevant variables.

ii. Incorrect functional form; some or all of the variables in Y and X should be transformed to logs, powers, reciprocals, or some other mathematical forms.

iii. Correlation between X and μ, which may be caused by measurement error in X, simultaneous equation considerations, combination of lagged Y values and serially correlated disturbances.

However, under these specification errors, least squares estimators will be biased and inconsistent, and conventional inference procedures will be invalidated because any or all of these specification errors produce a non-zero mean vector for μ (Ramsey, 1969).

Consider the following model:

$$\hat{y} = E\{y \mid x\} = \beta x \quad (1)$$

The Ramsey test then tests whether $(\beta x)^2, (\beta x)^3 ..., (\beta x)^k$ which are the polynomial terms added to the existing equation are necessary in the model. This test is based on following equation

$$y = ax + \gamma_1 \hat{y}^2 + \cdots + \gamma_{k-1} \hat{y}^k + \varepsilon \quad (2)$$

The test is an F-test that tests the null hypothesis that γ_1 through γ_{k-1} are zero. If the null-hypothesis that all the γ coefficients are zero is rejected (i.e. if the *p-value* of the F-statistic is significant), then the model suffers from mis-specification.

The Incremental F-test

The incremental *F*-test (also called a partial *F*-test or an extra sum of squares *F*-test) is the appropriate test to use when the simultaneous test of the statistical significance of a group of variable is needed.

- the test equation can be stated as:

$$y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \sum_{k=i}^{k} \beta_k X_k + \varepsilon \tag{3}$$

- A reduced model is a model that includes all the variables of interest except those whose statistical significance are to be tested. The test equation can be stated as:

$$y = \alpha + \beta_1 (X_1 + X_2) + \sum_{k=i}^{k} \beta_k X_k + \varepsilon \tag{4}$$

The incremental *F*-test using the reduced model assesses whether the improvement in the model fit (as assessed by a reduction in prediction error) using the full model is too large to be ascribed to chance alone. If the F-statistic is significance, it can be inferred that the relationship in the first model is nonlinear because the regressors are contributing meaningfully to explanatory power of the model otherwise the model / the relationship is deemed linear.

Wald Test

The Wald test computes the test statistic by estimating the unrestricted regression without imposing the coefficient restrictions specified by the null hypothesis. The Wald statistic measures how close the unrestricted estimates come to satisfying the restrictions under the null hypothesis. If the restrictions are in fact true, then the unrestricted estimates should come close to satisfying the restrictions.

Consider a general nonlinear regression equation given by (5) given below

$$y = x(\beta) + \varepsilon \tag{5}$$

where β is a k vector of parameters to estimate. Any restrictions on the parameters can be written as:

$$H_0 : g(\beta) = 0$$

where g is a smooth q dimensional vector imposing q restrictions on β. The Wald statistic is then computed as in equation (6).

$$w = ng(b)' \left(\frac{\partial g}{\partial \beta} V \frac{\partial g}{\partial \beta'} \right)^{-1} g(b) \quad (6)$$

where n is the number of observations and b is the unrestricted parameter estimates. V is the estimated variance of b given by equation (7).

$$V = ns^2 \left(\frac{\partial x}{\partial \beta} \frac{\partial x}{\partial \beta'} \right)^{-1}, \; S^2 = \frac{\mu' \mu}{n-k} \quad (7)$$

where μ represents the unrestricted residuals.

More formally, under the null hypothesis (H_0), the Wald statistic has an asymptotic $\chi^2(q)$ distribution, where q is the number of restrictions under H_0.

RESULTS AND ANALYSIS

The results presents under this component include the results of Ramsey's RESET test, Incremental F-test, and Wald test.

The Ramsey RESET Test

The Ramsey Specification Error Test (RESET) was employed to test the presence of nonlinearity in the relationship. The hypotheses tested under this test are:

H_0: $\epsilon \sim N(0, \sigma^2 I)$ (The model is specified correctly i.e. it does not require nonlinear combinations to explain the response variable)

H_1: $\epsilon \sim N(\mu, \sigma^2 I)$, $\mu \neq 0$ (The model is not specified correctly i.e. it requires nonlinear combinations to explain the response variable)

Table 1: Ramsey RESET Test Results

	Value	df	Probability
t-statistic	2.676027	30	0.0120
F-statistic	7.161121	(1, 30)	0.0120
Likelihood ratio	7.492300	1	0.0062

Source: Researchers' computation

Looking at the F-statistic from Table 1 above, it can be observed that the results of the Ramsey RESET test indicate that the null-hypothesis null hypothesis of linearity can be rejected which implies that Y is correctly specified, since the *p-value* of the F-statistic is < 5% this suggests nonlinearity in the relationship.

The Incremental F-Test

The hypotheses tested under this test are:

H_0: No need for polynomial term in the model

H_1: At least one polynomial term should be in the model

Table 2 below reports the results of the incremental F-test based on testing the hypothesis whether or not polynomial terms are needed in the relationship. Looking at the *p-value* of Block 2, it can be fathomed that at least one polynomial term should be in the model and as such, the relationship can be considered non-linear in nature.

Table 2: Incremental F-test Result

. nestreg, quietly: reg y x1 (x2 x3 x4)
Block 1: x1
Block 2: x1 x2 x3 x4

Block	F	Block Residual df	df	Pr > F	R2	Change in R2
1	225.25	1	33	0.0000	0.8722	
2	16396.23	3	30	0.0000	0.9999	0.1277

Source: Researchers' computation
Note that X1, X2, X3, and X4 represents Log Y, Log G, Log L, and Log K respectively

The Wald Test

This test seeks to test the following hypotheses:

H_0: The Wald statistic has an asymptotic $\chi^2(q)$ distribution (where q is the number of restrictions under H_0)

H_1: The Wald statistic has no asymptotic $\chi^2(q)$ distribution (where q is the number of restrictions under H_0). The statistical results of this test are reported in Table 3 below.

Table 3: Wald Test Result

. quietly: reg y x1 x2 x3 x4
. test x2 x3 x4

Constraints	Constraint dropped	F	Pr > F
(i) x2 = 0 (i) x3 = 0 (i) x4 = 0	No constraint dropped	F(3, 30) = 16396.23	Prob > F = 0.0000

Source: Researchers' computation

Note that X1, X2, X3, and X4 represents Log Y, Log G, Log L, and Log K respectively but tested in the following example, x2 is x^2, x3 is x^3, and x4 is x^4.

From the table, it can be observed that the *p-value* of the F-statistic is < 5% which implies that the null hypothesis of linearity can be rejected which commensurates with the earlier results and further corroborates the fact that the relationship between natural gas consumption and economic growth in Nigeria is non-linear.

CONCLUSION AND POLICY RECOMMENDATIONS

The paper has examined / tested non-linearity in the relationship between natural gas consumption and economic growth in Nigeria from 1981 to 2015.The results obtained revealed evidence of non-linearity in the relationship as all the statistical tests employed in the paper pointed to the rejection of the null hypothesis of linearity in the relationship. However, the policy implication of the results is that linear models might not be appropriate statistical tools for modeling, estimating and forecasting the relationship between natural gas consumption and economic growth in Nigeria. Hence, policy-makers need to take this into consideration while designing policies for energy consumption, energy conservation and economic growth.

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