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A Time Series Regression Modelling Approach on Economic Growth Control Variables

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Abstract

Economic growth and development have become so necessary among African countries like Nigeria for proper improvement in the quality of life. Thus, this research estimates the relationship effect of Gross Domestic Product on economic growth through the dependent (gross domestic product) and independent (food security, exchange rate, import) variables, exploring an annual time series data covering the period of 2005 to 2019 using Auto Regressive Distributed Lag (ARDL) Bounds Test Procedural Algorithm approach. The empirical result, therefore, reveals the special presence of a long-run relationship among gross domestic product, food security, and exchange rate variables. While in short term, the importance of food security, exchange rate, and import on economic growth is confirmed, as the coefficient of the ECT (− 0.22665) is negatively significant. This clearly shows that in the next year, the error in Gross Domestic Product is corrected by 22.67%, thus and so there would be a restored effect of the long-run equilibrium within the of 22.67%. Hence, the study proved the basic importance of the exchange rate and as well clarified it as one of the best tools to manage the country's economic system. For upturned economic sustainability, policymakers should always maintain a high exchange rate in the process.

Keywords: Economic growth, Cointegration, Estimation, Homoskedasticity, Long and Short Run

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Introduction

Since the economic growth of a nation is usually quantified by an increase in its gross domestic product (GDP), then the nation's economy's productivity ability rises, whereby upturn of the production of more goods and services time after time. In order words, sustainability development on economic growth has been so keened and focused afterwards on mostly African countries like Nigeria for proper improvement on the quality of life (Olufemi & Laseinde, 2019).

Onuoha et al. (2015) and Karen & Louise (2018) described the gross domestic product as the equality of individual expenditures on consumption, gross domestic private investment, goods and services, government expenditures, and gross investment, and as one of the main features used to estimate the country's economic state of healthiness, as well to ascertain the rate of individuals standard of living in an economy. In an unsteady instance, the growth of Gross Domestic Product (GDP) according to Aziz & Azmi (2017) always leads to an increase in poverty and a decline in a country's development in health and education. Hence, this showed an intensive motivation in earnest on a retest to double-check the constant eligibility strictness of the gross domestic product on the nation's economy using some selected growth variables. Among several conceptual and methodological viewpoints, Oluwafemi & Laseinde (2019) using Auto Regressive Distributed Lag, observed the effect of some selected econometric variables on the growth of the economy in Nigeria. In their study, they further showed that the indicators considered in the research have a significant effect on the Nigerian economy and in one way or the other, improve its economic growth.

Muhammad et al. (2015) employed the usage of multiple linear regression techniques in modeling the impact of macroeconomics on the economic growth of Pakistan. It was therefore revealed that all variables have a lower degree of impact on the growth of the country's economy. Sergio et al. (2018) in their research determined the volatility of economic growth variables and suggested that an increase in one of the independent variables to GDP might positively affect the volatility in both the short and long-run threshold. Eyas (2014) investigated the factors contributing to Saudi Arabia's economic growth, using the cointegrated model approach. In their research, long-run and short-run relationships were ascertained. Furthermore, Ali & Mahmoud (2018) examined the effect of economic growth variables using the co-integration bound test approach. It was proven in their research the existence of long-run relationship effects between the economic variables. Marcin et al. (2019) adopted the use of the Bayesian modeling approach to determine essential factors responsible for differences in countries' Gross Domestic Products. Hence, variables associated with the Asian development model were revealed mostly in their research as an important determinant within the scope.

In line with the study of Manap and Ismail (2019), examining the effect of economic growth control variables such as food security (fsc), an exchange rate (exr), and import (imp) on Gross Domestic Product (GDP) using the cointegration approach has become an area of interest in this research. Therefore, the study intends to estimate the long-run cointegration effect on economic growth control variables using the Autoregressive Distributed Lag (ARDL) approach.

Methodology

An annual time series data obtained from the Central Bank of Nigeria (CBN) data site, which covers a period of 15 years ranging from 2005-2019 was used in this study to estimate the relationship effect on the selected economic growth control variables. Adopted techniques in this process, were the unit root testing to affirm the stationarity status of the data, Kwiatkowski, Phillips, Schmidt and Shin (KPSS) unit root test, and co-integration test for checking the relationship of the variables under research. Auto Regressive Distributed Lag was evaluated as well for each output of the study test, a diagnostic check was carried out, while Cumulative Sum (CUSUM), and Cumulative Sum of Squares (CUSUMQ) as a recursive residual were employed for the stability test of the model. According to Samingun (2019), Autoregressive Distributed Lag (ARDL) is an infinite lag model that inclusively showed both flexible and parsimonious effects. Furthermore, the model as well distinguishes short and long-term responses from non-independent variables to one unit of change in the value of explanatory variables.

Model Specification and Estimation

By specification, the ARDL (p, q) model can be expressed as follows:

$$y_t = \mu + \beta_0 x_t + \beta_1 x_{t-1} + \delta_1 y_{t-1} + e_t \qquad (1)$$

Where p is the order of the polynomial lag distribution of the dependent variable, while q is the order from distributed lag polynomials of each regression X, x_t .

The transformation from equation (1) above, expressed the lagged value y_{t-1} as:

$$y_{t-1} = \mu + \beta_0 x_{t-1} + \beta_1 x_{t-2} + \delta_1 y_{t-2} + e_{t-1} \qquad (2)$$

By substituting equation (2) into equation (1), then becomes:

$$y_t = \mu + \beta_0 x_t + \beta_1 x_{t-1} + \delta_1[\mu + \beta_0 x_{t-1} + \beta_1 x_{t-2} + \delta_1 y_{t-2} + e_{t-1}] + e_t \qquad (3)$$

After rearrangement in equation (3), we have;

$$y_t = \mu(1+\delta_1) + \beta_0 x_t + (\beta_1 + \delta_1\beta_0)\, x_{t-1} + \delta_1\beta_1 x_{t-2} + \delta_1^2 x_{t-2} + (\delta_1 e_{t-1} + e_t) \quad (4)$$

Therefore,

$$y_{t-2} = \mu + \beta_0 x_{t-2} + \beta_1 x_{t-3} + \delta_1 y_{t-3} + e_{t-2} \quad (5)$$

Substitute equation (5) into equation (4), we obtain$\mu(1+\delta_1+\delta_1^2) + \beta_0 x_t + (\beta_1+\delta_1\beta_0)\, x_{t-1} + \delta_1(\beta_1+\delta_1\beta_0)x_{t-2} + \delta_1^2\beta_1 x_{t-2} + \delta_1^3 y_{t-3} + (\delta_1^2 e_{t-2} + \delta_1 e_{t-1} + e_t)$ (6)

By assumption of cointegration, let $|\delta_1| < 1$ and in a continuous process an infinite distributed lag model is obtained below as: $y_t = \alpha + \beta_0 x_t + \sum_{t=1}^{\infty} \delta_1^{(i+1)} (\beta_1 + \delta_1\beta_0)\, x_{t-1} + u_t)$ (7)

Where the **long-run multiplier** is obtained in equation (8) below as:

$$\alpha = \mu(1+\delta_1+\delta_1^2+\delta_1^3+\cdots) = {}^{\mu}\!/_{(1-\delta_1)} \quad (8)$$

and the **stationary error term** in equation (9) as:

$$u_t = e_t + \delta_1 e_{t-1} + \delta_1^2 e_{t-2} + \delta_1^3 e_{t-3} + \cdots \quad (9)$$

Further transformation in equation (7), becomes:

$$y_t = \alpha + \sum_{i=0}^{\infty} \alpha_i x_{t-1} + u_t, \quad (10)$$

where α is the intercept, α_i $(i = 1,2,\ldots,k)$ represent the **short-run multiplier** expanded in equation (11-15), also called a distributed lag weight, which measures the effect of x_{t-1} on y_t when all other things are held constant, u_t is a stationary error term. Convoluting equation (7) and (8), yields an infinite lag model with weights given as:

$$\alpha_0 = \beta_0 \quad (11)$$

$$\alpha_1 = (\beta_1 + \delta_1\beta_0) \quad (12)$$

$$\alpha_2 = \delta_1(\beta_1 + \delta_1\beta_0) = \delta_1\alpha_1 \quad (13)$$

$$\alpha_3 = \delta_1^2\alpha_1 \quad (14)$$

⋮

⋮

⋮

$$\alpha_s = \delta_1^{(s-1)}\alpha_1 \quad (15)$$

Hence, it can be shown from the preceding algorithm process, that the infinite lag arising from the ARDL (p, q) model is flexible enough to approximate any shape infinite lag distribution with sufficiently large values of p and q.

Long and Short-Run Model Estimation

$$lngdp_t = \alpha_1 + \sum_{i=1}^{p} \beta_{1i} lngdp_{t-i} + \sum_{i=m}^{q1} \gamma_{1i} lnfsc_{t-i} + \sum_{i=m}^{q2} \partial_{1i} lnexr_{t-i} + \sum_{i=m}^{q3} \delta_{1i} lnimp_{t-i} + \varepsilon_t \quad (16)$$

Equation (16) shows the coefficients of the level variables in the long run at optimal lag and declares the impact of the level variables up to p in the long run.

$$\Delta lngdp_t = \alpha_2 + \sum_{i=1}^{p} \beta_{2i} \Delta lngdp_{t-i} + \sum_{i=m}^{q1} \gamma_{2i} \Delta lnfsc_{t-i} + \sum_{i=m}^{q2} \partial_{2i} \Delta lnexr_{t-i} + \sum_{i=m}^{q3} \delta_{2i} \Delta lnimp_{t-i} + \varphi ecm_{t-1} + \varepsilon_t \quad (17)$$

While equation (17) indicates the short-run model estimation derived from the construction of an error correction model (ecm) in equation (18) below. In order words, the parameter φ in equation (17) is expressed as the speed of adjustment parameter. The coefficient of the lagged error correction term (φ) is expected to be negative and statistically significant to further confirm the existence of a cointegrating relationship.

$$ecm_{t-1} = lngdp_{t-1} - \alpha_1 - \sum_{i=1}^{p} \beta_{1i} lngdp_{t-i} - \sum_{i=m}^{p} \gamma_{1i} lnfsc_{t-i} - \sum_{i=m}^{p} \partial_{1i} lnexr_{t-i} - \sum_{i=m}^{p} \delta_{1i} lnimp_{t-i} \quad (18)$$

Where: gdp = gross domestic product, fsc = food security, exr = exchange rate,

imp = import. While γ, ∂, δ are the respective coefficients of $lnfsc_t$, $lnexr_t$, $lnimp_t$

Results and Discussion

Since the KPSS unit root test has the null hypothesis of 'stationarity' against the alternative, however, 'not stationary', the unit roots tests clarified on the time-series data, after all, indicates the process to be integrated at the first difference in table 1. Table 2 shows that the F- statistic at 5.5384 is greater than the upper bound I (1) at 5% where the null hypothesis was rejected, and therefore confirmed the existence of a long-run relationship in the research study. Therefore, long run, short run and ecm can be estimated through the Auto Regressive Distributed Lag Model. Table 3 deduces the Auto Regressive Distributed Lag estimation which carefully checks the relationship among the macroeconomic variables. Thence, revealed the long-term Gross Domestic Growth at one period lagged ($lngdp_{t-1}$), food security($lnfsc$), and foreign exchange rate ($lnexr$), with exception of the import ($lnimp$) variables are statistically significant at 5% level. While all, including the import ($lnimp$) variable, are positively related to the Gross Domestic Growth (gdp) in Nigeria nation. All things being equal, a one per cent increase in all the selected variables will bring about a respective 8.659e-01, 1.208e+00, 6.734e+00, and 6.237e-01 percentage increase in the Gross Domestic Growth (gdp). In order words, the adjusted degree of freedom, R^2 is 99.8%, with an explanatory variable in economic growth by changes within the selected variables respectively. Hence, the null hypothesis was rejected since the equation is statistically significant at a 1% level with a p-value declared as 1.074e-12. More so, Table 4, shows the presence of Auto Regressive Distributed Lag short-run error-correction model, where the coefficients of $\Delta lngdp_{t-1}, \Delta lnfsc_{t-1}, \Delta lnexr_{t-1}$ demonstrated a negative relationship, and was significant at 1%, 1%, and 5% respectively. While $\Delta lnfsc_t$, $\Delta lnexr_t$, and $\Delta lnimp_t$, exhibited a positive relationship, and significance at 5%, 5% and 1%. But $\Delta lnimp_{t-1}$ only showed a positive relationship with no significance. However, the coefficient of the error-correction term (ecm_{t-1}), displayed a significance level of 1% with a negative sign appearance. In order words, the error correction term indicates that almost 23% of the dis-equilibrium in the Gross Domestic Growth arising due to the years back shock is adjusted with a lower speed back to the long-run equilibrium in the present year. Table 5 shows, the p-value of the studentized Breusch-Pagan test, Ramsey's RESET Test, and Shapiro-Wilk normality test is greater than 5% at an acceptable level, which indicates that the model is free from homoscedasticity, functional misspecification and it is well normally distributed respectively.

Unit Root Test

Table 1: Kwiatkowski, Phillips, Schmidt and Shin (KPSS) Unit Root Results

Variables	Test@1st diff	KPSS-values@ 5%	Remarks
Gdp	0.19423	0.1	I (1)
fsc	0.44375	0.1	I (1)
exr	0.1953	0.1	I (1)
imp	0.13657	0.1	I (1)

Source: RStudio Extraction

Bound Test for Co-integration

Table 2: Co-integration Test Results

Co-integration F-bound test	Null Hypothesis: Relationship exists	Lower Bound	Upper Bound

Test statistics Value	Significant	I (0)	I (1)
F-statistics:5.5384	10%	2.676	3.586
K=3	5%	3.272	4.306
	1%	4.614	5.966

Source: RStudio Extraction

Autoregressive Distributed (ARDL) Lag Model Estimation

Table 3: Long Run Model Estimation observed on AIC (1,0,0,0)

Variables	Estimate	Std. Error	t-value	Pr $(>\|t\|)$
C	-6.303e+03	3.153e+03	-1.999	0.07670
$\boldsymbol{lngdp_{t-1}}$	8.659e-01	5.607e-02	15.443	8.76e-08***
lnfsc	1.208e+00	5.155e-01	2.343	0.04380 *
lnexr	6.734e+00	1.982e+00	3.397	0.00791 **
lnimp	6.237e-01	3.007e-01	2.074	0.06791 .

Source: RStudio Extraction

Where Significant Codes are: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Multiple R-squared: 0.9985, Adjusted R-squared: 0.9978 F-statistic: 1499 on 4 and 9 DF, p-value: 1.074e-12.

From equation (16) and table 3, the ARDL Long Run model estimation is equated below:

$$lngdp_t = -6.303e{+}03{+}8.659e - 01_{8.76e-08} lngdp_{t-i} + 1.208e + 00_{0.04380} lnfsc_{t-i} + 6.734e + 00_{0.00791} lnexr_{t-i} + 6.237e - 01_{0.06791} lnimp_{t-i} + \varepsilon_t \quad (19)$$

Table 4: Short-run Error-Correction Model Estimates

Variables	Estimate	Std. Error	t-value	Pr $(>\|t\|)$
$\boldsymbol{\Delta lngdp_{t-1}}$	-0.50002	0.11880	-4.209	0.008417 **
$\Delta lnfsc_t$	1.16908	0.21214	5.511	0.002691 **
$\Delta lnfsc_{t-1}$	-2.01921	0.27170	-7.432	0.000695 ***
$\Delta lnexr_t$	6.23602	1.11161	5.610	0.002489 **
$\Delta lnexr_{t-1}$	-9.18504	1.71308	-5.362	0.003035 **
$\Delta lnimp_t$	0.37226	0.08403	4.430	0.006829 **
$\Delta lnimp_{t-1}$	0.19995	0.15633	1.279	0.257024
ecm_{t-1}	-0.22665	0.01926	-4.209	7.8e-05 ***

Source: RStudio Extraction

Diagnostic check

Table 5: Diagnostic Test

Test	F-statistics	P-value

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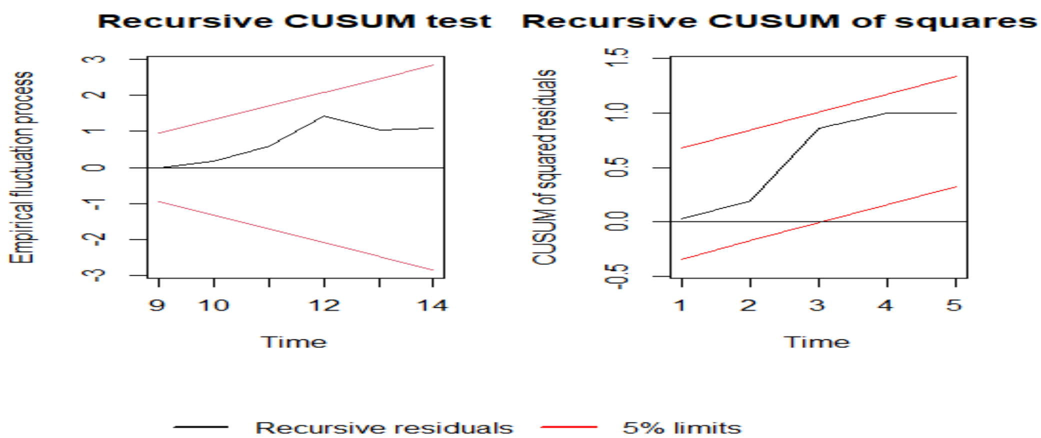
Homoscedasticity Test: Breusch-Pagan Test	12.497	0.3275
Normality of residuals	0.95202	0.6291
Ramsey's RESET	0.025996	0.9746

Source: RStudio Extraction

Figure 1 shows, that the plot of CUSUM and CUSUMQ satisfies the 5% critical bounds condition. Therefore, confirms the long-run relationships among study variables and thus indicates the stability accuracy of the coefficients in a relative manner



. **Figure 1: Graphs of CUSUM and CUSUMQ**

Conclusion

This research estimated the effect of macroeconomic variables (food security, exchange rate, import) on Gross Domestic Growth (a proxy for Economic Growth) using Auto Regressive Distributed Lag (ARDL) as a Time Series Modelling approach. However, deduced that the long-term Gross Domestic Growth at one period lagged, food security, exchange rate, and import variables are positively related to the Gross Domestic Growth (gdp), and significance at 5%, 5% and 1%. Thence, the study empirically concluded that food security is not only a significant benefit for human health but also serves as the basis to achieve sustainable economic growth. While on the other hand, the exchange rate showed a high level of responsiveness in Nigeria's economic growth as well.

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