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Two-Stage Least Squares and Three-Stage Least Squares in Modelling Nigerian Economic Growth

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ABSTRACT

Every Country strives to attain economic stability. In a bid to achieve this, several economic indices are explored to make this a reality. This study focused on analysis of two stage and three stage least squares (2SLS and 3SLS) in modeling Nigerian economic growth. Considering the limitations of ordinary least squares (OLS) in dealing with simultaneous equations, we explored the use of two stage and three stage least squares which are more robust methods for this purpose. A secondary data was obtained from Central Bank of Nigeria bullion and the National Bureau of Statistics bulletin to investigate the relationship among economic growth, capital inflow and external debt servicing. Models for GDP, external debt servicing and capital inflow were obtained using R and Microsoft excel statistical packages. The study shows with coefficients of 3.9159 and -6.1878, that foreign debt- servicing has negative impact on GDP in the 2SLS and 3SLS models respectively: which is not significant in the 2SLS but significant in the 3SLS model. Also, GDP has negative, though significant effect on capital inflow with coefficient of -0.010495 and -0.0139109 in the 2SLS and 3SLS models respectively: a pointer to the effects of insecurity in Nigerian economic growth. The study recommends that Government should deplete existing external debt stock, increase utilization of capital stock and labour force, reduce borrowing rate, resort to alternative ways of enhancing both current and recurrent expenditures and deal with insecurity.

1. Introduction

Economic growth refers to a sustained increase in per capita output over a period of time. It results from increase in productive capacity and increase in capacity utilization of the economy leading to increased availability of goods and services in that economy. Economic growth is commonly measured using the Gross Domestic Product (the value of all final goods and services produced in an economy within a given period). It is the monetary value of final output of the goods and services produce within the geographical confines of a country's territory in a given year (Adoghor, Onuchukwo and Ewubare, 2008, Okidim and Tuaneh, 2012).

However, the concept of economic growth has not been quite easy to grasp and measure in real terms. This is so because often on the literature of economics, some authors have variously differentiated economic growth from the "economic development". For such authors like (Lewis, 1978), the mere increase in the aggregate level of production of goods and services in an economy tells us nothing about the "quality of life" of a citizenry, given the threats of global pollution, abysmal lop-sided distribution of aggregate output and income, environmental degradation, prevalence of chronic and deadly disease, abject poverty and the absence of freedom and justice. For such authors, attention should be focused not merely on the increase in aggregate output and income but also on the total quality of standard of living and that there is yet no satisfactory measure of "quality of life" that can be applied to quantitative measure of aggregate output and income which would be acceptable to all and sundry that will stand the test of the time (Micheal, 2020).

Notwithstanding, the consensus appears to be that the term economic growth refers to a positive increase in the aggregate level of output within a given time period in a country while economic development is seen as sustainable increase in the aggregate level of output and incomes, with due consideration given to the quality of life which hopefully takes account of such issues as equal distribution of income, healthcare, education, environmental degradation, reduction in global pollution, freedom and justice etc. Therefore, economic development could be referred

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to as a process by which an economy experiences three main phenomena namely – sustained growth in output, structural changes and institutional changes (Woodford and Smith, 2000). If these three phenomena take place, it will lead to a rise in standard of living of the populace. That is why growth could be enjoyed by many countries but not all experience development, (Yesufu,1996).

Regression analysis is one of the most important tools for analysing relationships between one response variable and one or more explanatory variables. It is widely used in our day-to-day endeavours, ranging in diverse areas of human life including social and biological sciences, economics and so on. Regression analysis has become one of the most important tools in data analysis (Presely and Ibrahim, 2018).

Ordinary least squares (OLS) is a method for estimating the unknown parameters in a linear regression model. OLS chooses the parameters of a linear function of a set of explanatory variables by the principle of least squares: minimizing the sum of the squares of the differences between the observed dependent variable (values of the variable being observed) in the given data set and those predicted by the linear function (Anthony, 2020).

Geometrically, this is seen as the sum of the squared distances, parallel to the axis of the dependent variable, between each data point in the set and the corresponding point on the regression surface-the smaller the differences, the better the model fits the data. The resulting estimator can be expressed by a simple formula, especially in the case of a simple linear regression, in which there is a single regressor on the right side of the regression equation.

In ordinary least square method, there is a basic assumption that the value of the error terms is independent of predictor variables. When this assumption is broken, Two-Stage least squares (2SLS) regression technique is used to solve this problem (Panshak *et al.* 2020). Two-Stage least squares (2SLS) assumes that, there is a secondary predictor that is correlated to the problematic predictor but not with the error term.

2. Methods

2.1 Source of Data

Secondary data was obtained from Central Bank of Nigeria bullion and the National Bureau of Statistics bulletin to investigate the relationship among economic growth, capital inflow and external debt servicing in Nigeria.

2.2 Method of Data Analysis

Two-stage least squares (2SLS) Estimation method developed by Theil and independently by Basmann, 1957 was employed. Gallant and Dale, (1979) claims that the basic idea behind the 2SLS method is to replace the stochastic endogenous explanatory variable by a linear combination of the predetermined variables in the model and use this combination as the explanatory variable in lieu of the original endogenous variable. The 2SLS method thus resembles the instrumental variable method of estimation in that the linear combination of the predetermined variables serves as an instrument, or proxy for the endogenous regressors. It is specifically designed to handle over identified equation; the method can also be applied to exactly identified equation. This method of estimation involves two successive applications of OLS. The process is as follows:

Stage (1): To get rid of the likely correlation between Y's and u's, Y's are regressed on all the predetermined variables in the whole system not just that one equation. In our model, this means regressing Y_1, Y_2 and Y_3 on X_1, X_2, X_3 andX_4. The following models can be derived:

$Y_{1t} = \prod_0 + \prod_1 X_{1t} + \prod_2 X_{2t} + \prod_3 X_{3t} + \prod_4 X_{4t} + u_t$ (1)

$Y_{2t} = \prod_0 + \prod_1 X_{1t} + \prod_2 X_{2t} + \prod_3 X_{3t} + \prod_4 X_{4t} + u_t$ (2)

$Y_{3t} = \prod_0 + \prod_1 X_{1t} + \prod_2 X_{2t} + \prod_3 X_{3t} + \prod_4 X_{4t} + u_t$ (3)

Where U_t are the usual OLS residuals for equation 1, 2 and 3, we obtain $\hat{Y}_{1t}$, $\hat{Y}_{2t}$ and $\hat{Y}_{3t}$ which are the estimates of the mean value of Y conditional upon the fixed X's.

Stage (2): the over identified growth, capital inflow equations and the exactly identified debt services can now be written as

$$Y_{1t} = \beta_{10} + \beta_{12}\hat{Y}_{1t} + \gamma_{11}X_{1t} + \gamma_{12}X_{2t} + u_{1t} \quad (4)$$

$$Y_{2t} = \beta_{20} + \gamma_{22}X_{3t} + \gamma_{23}X_{4t} + \beta_{21}\hat{Y}_{1t} + u_{2t} \quad (5)$$

$$Y_{3t} = \beta_{30} + \beta_{31}\hat{Y}_{1t} + \beta_{32}\hat{Y}_{2t} + u_{3t} \quad (6)$$

The estimates thus obtained will be consistent.

Where

$\beta_{i0}, \beta_{i2}, X_{1t}, X_{2t}, u_t$ are intercept, constant, independent variables and residuals in stage two

$\prod_0, \prod_1, \prod_2, \prod_3, \prod_4$ are intercept, constant, independent variables and residuals in stage one

2.3 Correlation Matrix

The correlation matrix helps to identify the level of correlation that exists among the independent variables. It is also a simple way to summarize the correlations between all variables in a dataset. Furthermore, a correlation matrix serves as a diagnostic for regression. One key assumption of multiple linear regression is that no independent variable in the model is highly correlated with another variable in the same model. When two variables are highly correlated, this results to multicollinearity. One of the easiest ways to detect a potential multicollinearity problem is to look at the correlation matrix.

3.0 Result and Discussions

Table 1.Descriptive Statistics

Column1	EXTDSTK	LABOR	CAPINF	GDP	CAPSTK	EXCHRT	EXTDSRV
Mean	2.06E+10	43579756	3.42E+09	4.7E+10	2.69E+12	121.8153	1.7E+09
Standard Error	2.1E+09	1805254	5.17E+08	3.66E+09	3.98E+10	16.2221	3.4E+08
Median	2.73E+10	42275760	2.01E+09	4.54E+10	2.68E+12	127.2424	1.35E+09
Standard Dev.	1.15E+10	9887785	2.83E+09	2.01E+10	2.18E+11	88.85212	1.86E+09
Kurtosis	-1.55921	-1.02098	-0.91672	1.985585	-0.76324	-0.03724	8.029398
Skewness	-0.41805	0.332992	0.665229	1.101926	0.097764	0.6142	2.662952
Minimum	3.54E+09	29286950	3E+08	1.36E+10	2.31E+12	8.037808	2.52E+08
Maximum	3.59E+10	62447230	8.84E+09	1.05E+11	3.12E+12	306.9206	8.8E+09
Sum	6.18E+11	1.31E+09	1.03E+11	1.41E+12	8.06E+13	3654.46	5.09E+1
Count	30	30	30	30	30	30	30

Source: Authors computations with R-studio.

Where:

GDP = Gross Domestic product produced as growth rate;

EXTDSRV = External Debt Servicing;

CAP_STK = Capital Stock;

LABOR = Labor Force;

EXCHRT = Exchange Rate;

EXTDSTK = External Debt stock;

CAP_INF = capital Inflow.

Table 2. The correlations of the residuals of Two- Stage Least Squares

	GDP	EXTDSRV	CAPINF
GDP	1.0000000	0.25834137	0.04827265
EXTDSRV	0.2583414	1.00000000	-0.00416109
CAPINF	0.0482726	-0.00416109	1.00000000

From our correlations of the residuals of Two- Stage Least Squares in Table 5, it is observed that the correlation coefficients along the diagonal of the table are all equal to 1 because each variable is perfectly correlated with itself. Also notice that our correlation matrix is perfectly symmetrical i.e. the top right cell shows the exact value as the bottom left cell. This is because both cells are measuring the correlation between GDP and Capital inflow. Similarly, GDP and external debt servicing have a weak positive correlation (0.258). Capital inflow and GDP are also positively correlated but the existing correlation is very weak (0.048), while capital inflow and external debt servicing is a very weak negatively correlated (-0.004).

Table 3. The correlations of the residuals of Three- Stage Least Squares

	GDP	EXTDSRV	CAPINF
GDP	1.0000000	0.637767	0.0924115
EXTDSRV	0.637767	1.00000000	0.0189740
CAPINF	0.0924115	0.0189740	1.00000000

From our correlation of the residuals of three- Stage least squares in Table 3, it is observed that each variable is perfectly correlated with itself. While external debt servicing and GDP have a positive moderate correlation (0.638), Capital inflow on the other hand has a very weak positive correlation with GDP (0.092). It is also observed that external debt servicing has a very weak positive correlation with capital inflow (0.019).

Table 4. Two-Stage Least-Squares Estimates of three equations (p-value in Parentheses)

	Dependent variable		
	GDP	EXTDSRV	CAP_INF
Constant	-2.6449e+11 (0.24039)	2.76567e+09(0.02562**)	7.830e+09 (1.659e-09***)
EXTDSRV	-3.9159e+00 (0.0684)	-	-
CAP_STK	1.97966e-01 (0.13267)	-	-
LABOUR	-4.9059e+03 (0.0958)	-	-
EXCHRT	-	-3.68788e+06(0.3771)	-
EXTDSTK	-	3.98498e-02(0.2512)	-1.9037e-01(1.008e06***)
GDP	-	-3.06777e-02(0.0998)	-1.04959e-02(0.55099)
R-Squared	0.185998	0.161767	0.647651
Adj. R-Squared	0.092075	0.065048	0.621551

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Source:Authors computations with R-studio

From table 4, both external debt servicing and Labour have a negative relationship with our dependent variable (GDP). While capital stock has a positive relationship with GDP, Exchange rate and economic growth have a negative impact on external debt servicing while external debt stock is positively related to our dependent variable (external debt

servicing). Conclusively, capital inflow is impacted negatively by external debt stock and GDP.
R-Squared for GDP and External debt (0.185998 and 0.161767) means that their variations are not well explained in the model while (0.647651) 64 percent of the variation in Capital Inflow was explained.

Table 5. Three-Stage Least-Squares Estimates of three equations (p-value in Parentheses)

	Dependent variable		
	GDP	EXTDSRV	CAP_INF
Constant	-2.02681e+11 (0.3504)	3.7569e+09 (0.0027**)	7.9865e+09 (1.09e-09***)
EXTDSRV	-6.1878e+00(0.0046**)	-	-
CAP_STK	1.67833e-01 (0.1856)	-	-
LABOUR	-4.378e+03 (0.12329)	-	-
EXCHRT	-	-4.4048e+06 (0.2874)	-
EXTDSTK	-	3.8704e-02 (0.24977)	-1.902e-01 (1.013e-06***)
GDP	-	-4.9421e-02 (0.0088**)	-1.39109e-02 (0.43007)
R-Squared	0.141465	0.120365	0.64708
Adj. R-Squared	0.042404	0.018869	0.620938

Signif. Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Source:Authors computations with R-studio

From table 5, external debt servicing and labour have a negative impact on economic growth while capital stock has a positive impact on it. Our external debt servicing is impacted negatively by exchange rate and economic growth while it is positively impacted by external debt stock. External debt stock and economic growth have a negative impact on capital inflow. Values The R-Squared R-Squared for GDP and External debt (0.14 and 0.12) means that their variation are not well explained in the model while (0.64708) 65 percent of the variation in Capital Inflow was explained.

3.1 Conclusion

This study has examined foreign debt servicing, Capital inflow and economic growth in Nigeria. The study employed Two-stage Least-Square and Three-Stage Least-Square methods of estimation to analyse the aforementioned economic variables. The result showcased that the impact of external debt servicing on economic growth is negative while capital stock and labour positively impact economic growth. Similarly, exchange rate and economic growth positively influence external debt servicing with external debt stock having a negative relationship. The last result indicated that capital inflow was negatively and positively affected by external debt servicing and economic growth respectively. However, the effect of economic growth on capital inflow may have been affected by insecurity, hence it was not significant.

3.2 Recommendations

In view of the above findings which revealed that there is both a direct and indirect relationship between economic growth, Foreign debt service and Capital inflow in Nigeria and considering the current economic realities in the Country; Policies of the Government should be channelled towards:

i. Depleting existing external debt stock in order to avert the problem of debt overhang which has serious implications on the economy.

ii. Increase in the utilization of capital stock and labour force which will increase economic growth thereby increasing capital inflow
iii. Reducing borrowing rate and resorting to alternative ways of financing both current and recurrent expenditures in the Country. This is due to the negative impact of external borrowings on economic growth and capital inflow
iv. Effective utilization of borrowed funds for capital projects in order to increase economic growth within the country.
v. Insecurity should be tackled to ensure significant increase in capital inflow.

In conclusion, policy makers should channel their efforts towards policies that will decrease the rate of external borrowings but rather increase the rate of capital inflow because of its huge impact on macroeconomic variables in the Country.

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Appendix

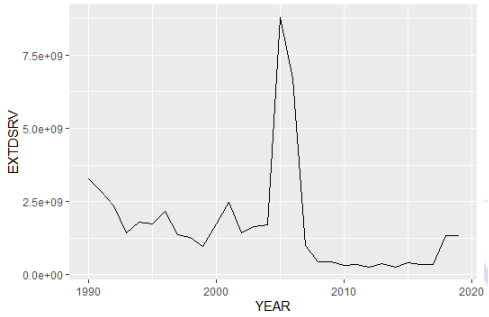

Figure 1: Plot of Annual External Reserves

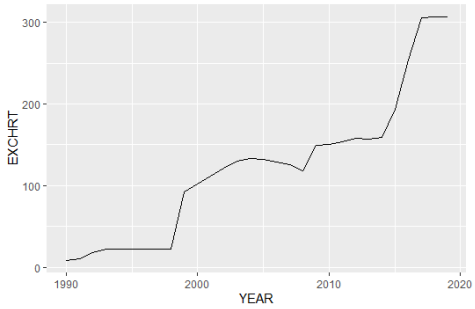

Figure 2: Plot of Annual Exchange Rates

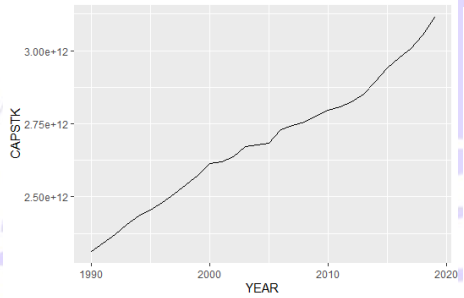

Figure 3: Plot of Annual Capital Stock

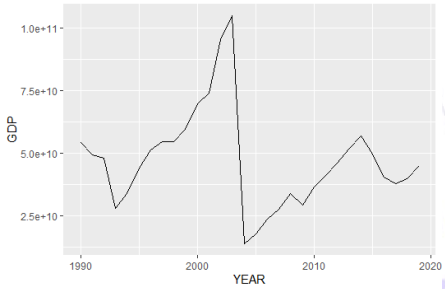

Figure 4: Plot of Annual GDP

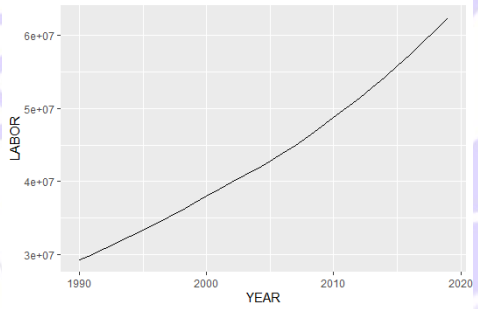

Figure 5: Plot of Annual Labour

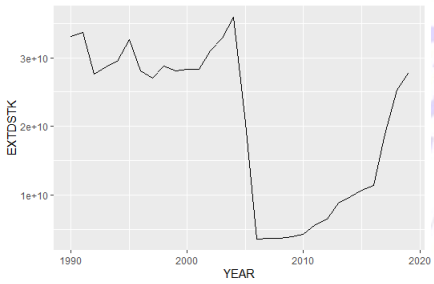

Figure 6: Plot of Annual External Stock

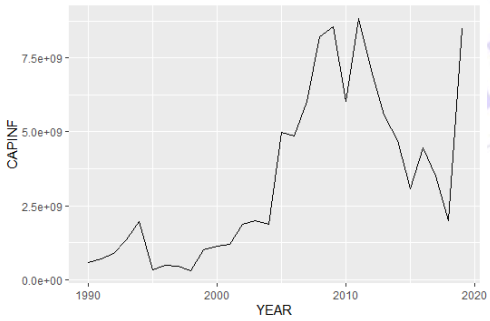

Figure 4.7: Plot of Annual Capital Inflow