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New Perspectives on Predicting Economic Growth in the Presence of Multicollinearity and Outliers

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Abstract: Nigeria's economic growth is a tremendous concern to policymakers, economics and scholars because of the inherent challenges of economic characteristics, consequences and contradictions. The Central Bank of Nigeria has implemented several policies such as tightening of monetary policy rate and heavy borrowing for infrastructural development to stimulate economic growth in the past few years. The prediction of economic growth from economic variables poses a challenge due to collinearity among the economic variables. In this study, we predict Nigerian economic growth using internal and external debt, interest and exchange rate as well as trade openness in the presence of multicollinearity and outliers. We employed the non-cross-validated and cross-validated partial least square regression method to quarterly data from 1986 to 2021 to predict Nigerian economic growth to simultaneously address the aforementioned problems among the predictor variables. Exploratory data analysis (EDA) and diagnostic test carried out ascertained the presence of multicollinearity and outlier. The fitted non-cross validation partial least square regression model extracted 5 components. The extracted 5 components, namely; 1, 2, 3, 4, and 5 influenced the growth of the Nigeria economy by 28.2%, -11.3%, 38.8%, 10.0% and 50.8%, respectively. The fitted cross-validated partial least square regression model extracted 2 components, namely 1 and 2, which were efficient and optimum for predicting economic growth in Nigeria. The extracted 2 components explained 100% total variation of the predictor variables. The biplot revealed that all the economic growth drivers were concentrated in the region of the two extracted components with positive contributions to the components that efficiently predict the economic growth (RGDP). Results of the variable importance projection showed that the economic growth in Nigeria depends largely on internal borrowing and economic openness. Therefore, it is concluded that the closure of all the international borders during this period affected the openness of the economy for exportation and importation activities and, as such, lowered international patronage, which hindered the growth of the economy. Hence, the need for policymakers to focus on policy formulation and implementation on the direction of internal borrowing and economic openness as essential drivers of economic growth. Also, to the researchers, a cross-validated partial least square method of selecting components required for predicting the economy's growth was the most efficient technique for dealing with multicollinearity and outliers' problems in the data set.

Keywords: Drivers of Economic Growth, Economic Growth, Multicollinearity, Outlier, Partial Least Square Method.

1 Introduction

Economic goals in Nigeria lingered and the stability of production and consumption patterns remained challenging [1]. The diversification of economy to reduce reliance on oil revenue, with intention of ensuring viable economy inclusiveness and to stem the tide of inflationary growth have not yielded the desire result. This have caused a great and serious concerns to the scholars, researchers and the policy makers despite all the claimed and huge investments from borrowing both internally and externally sources. The implication of this is to transform all economy sectors and to ensure a rapid growth that is important and critical for development. As noted, since independence in 1960, government in Nigeria trailed the goal of structural changes. The growth of the economy supposed to be spurred by the available natural resources and its exploitation. In 1960s, agriculture through food and

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cash crops production served as the main drivers of growth with 54.7 percent contributions to the GDP. Ten years after independence, the emergence of oil production became main driver of growth thereby overshadowing agricultural based economy. Government spending and investment majorly depended on income from oil and borrowing in case of shot fall and as such the pace of economic growth were seriously hampered.

According to [2] the economy wretchedness witness was as a result of shift in global monetary policy thus a serious impingement on the financial market in Nigeria. Specifically, the monetary policy rate stood at 14% in 2017 compared to 12% mark in 2016. One major determinant of economic growth is an interest rate which is the consequence of investment. Habib *et al*. as cited in [1] posited that interest rate critically affected economic growth whether it was based on capital cost outlook or opportunity cost for funding. Also, despite numerous developmental plans, programmes, visions and reforms on macroeconomic variables aforementioned in this study at different time generates hope but actually produces little impact. This is due to mismanagement and corruption that plundered resources, debased social values, and astronomical rises in unemployment with attendant increase in crime rate ranging from kidnaping, terrorist, banditry and so on. The living standards is nothing to write home about because some of the best brains needed to drive development left in seeking for greener pasture elsewhere, businesses relocated to other nations, thereby substantially contributing to the economy of the host countries putting Nigeria's economy under serious problem and threat.

As noted, monetary and fiscal policies imperatively influence economic growth. Thus, [3], [4] and [5] asserted the comparative advantage of the economy can be enhanced by the interest rate and exchange rate thus, the need to formulate policy in this direction to engender improvement. [6] and [7] posited that to ensure stable exchange rate and enhancing the growth of the industrial output, monetary policy should be redesigned. [8] observed that the financing of capital project using foreign loans by the government led to improve economic growth. However, servicing the foreign debt drained expected growth in the economy. [9] asserted that debts external or domestic had a negative impact on economic growth and as such the expected growth was not achieved even when it was growth promising. It was also noted that debt servicing was not helping the growth of the economy as a result of deep-rooted effect of debt overhang.

[7] believed that through workable diversification process, economic openness can enhance the growth of the economy. However, [10] opined that economic can be suffered as a result of trade openness constraint particularly when exports were less than imports and as such the need to encourage export led diversification to grow economy.

Empirically, several investigations have been carried out on economic growth using diverse macroeconomic variables as the driver. Some of the work done includes: [9] examined the contributions of government debt on economic growth in Nigeria (1980-2018). The collected data were empirically analysed using Autoregressive Distributed Lag method. Findings indicated that external debt contributed negatively to the economic growth and as such stalled the economic growth in Nigeria. Also, the domestic debt contributed negatively to the growth of economy both in the short and long-term. debt servicing also contributed nothing to grow the economy due to debt overhang effect. [11] examined the impact of external debt on economic growth in Nigeria (1980-2016). Data from Central Bank Nigeria were analysed using Generalized Method of Moment. Findings showed that external debt had a positive and significant impact on Nigeria's economic growth.

[12] investigated external debt and economic growth in Jordan from 2010 to 2017. The analytic method employed in the study revealed the negative and significant effect of external debt on the growth of economy. [8] examined the effect of external debt on the economic growth in Nigeria (1981-2017). Data were sourced on macroeconomic variables used from CBN Bulletin and NBS report. The result revealed by Granger Causality test and Error Correction Mechanism method indicated that foreign debt stock and capital projects expenditure positively and significantly affected the growth of economy. Also, in the result foreign debt servicing was insignificant in determining economic growth in Nigeria. [13] carried out a study on external debt and economic growth in Nigeria (1999-2015). The study adopted Johansen Co-integration and Vector Error Correction Mechanism for the analysis. The result indicated an inverse relation between external debt and economic growth in Nigeria.

[14] analyzed the impact of external debt on economic growth in Nigeria between 1985 and 2015. The data gathered for the study were analyzed using ordinary least square regression method, short run and long run stationarity test, and error correction were carried out. Thus, it was found that impact of debt servicing on economic growth was negative and insignificant. Also, the contribution of external debt to economic growth was positive and significant. during the period under consideration, a long-run equilibrium relationship and unidirectional causality were revealed between external debt and economic growth. [10] studied

trade openness and economic growth in Nigeria (1980-2016). Data were sourced from CBN Bulletin. The least square method and stationarity test carried out revealed that trade openness and economic growth were negatively related, short and the long run stability were also revealed between the two variables.

[15] carried out study on trade openness makes sense, using Nigeria trade policy as yardstick. An Autoregressive Conditional Heteroscedasticity, Generalized Autoregressive Conditional Heteroscedasticity and Pairwise Granger causality were used in the study. The result indicated a significant relationship between trade openness and economic growth. Also, interest rate and exchange rate were significant in determining economic growth. [16] examined the nexus between the trade openness and economic productivity (1970-2010). Data collected on macroeconomic variables used were analysed using Least Square Method and result revealed that trade openness and economic growth were positively and significantly related. [7] examined exchange rate and economic growth in Nigeria between 1980-2019. Secondary data sourced from CBN were analysed using econometric method: Unit Root, Cointegration and Error Correction Model. In the result, it was revealed that exchange had a positive and significant impact on economic growth while, trade openness had a negative impact on economic growth.

[5] empirically examined economic competitiveness in Nigeria: the contributing impact of interest rate and exchange rate. Data sourced on interest rate, exchange rate and gross domestic product the proxy for economic competitiveness spanning the period 1981-2016. Findings from OLS method adopted showed both interest rate and exchange rate had a significant impact on economic competitiveness. [6] did an empirical studied on exchange rate fluctuation and industrial output in Nigeria (1986-2015). In the study, gross domestic product used as a measure of industrial output, response variable, while exchange rate, inflation, interest rate and net exports were the explanatory variables. Data from NBS and CBN were analysed using stationarity test, co-integration, granger causality and VECM. The results showed a unidirectional causality from exchange rate to industrial output growth, that is, exchange rate had a significant influence on industrial output. Hence, establishing exchange rate potential of enhancing industrial output.

[22] studied exchange rate fluctuation and economic growth in Nigeria spanning (1970-2012). The study considered exchange rate, inflation, money supply and oil revenue (explanatory variables), while, gross domestic product (dependent variable) was proxy for economic growth. A multiple linear regression technique used reveled that exchange rate was a sustainable economic growth. [1] investigated efficient estimation technique for determining economic growth in the presence of multicollinearity. The macroeconomic variables considered in the study were economic growth, internal debt, external debt, interest rate, exchange rate and trade openness. An exploratory data analysis and diagnostics carried out established the presence of multicollinearity. Thus, it was revealed that a ridge regression technique with appropriate ridge constant serve as a robust method for efficient estimate of economic growth.

However, in summary of various literature reviews, the presence of outlier and interdependency of the explanatory variables as common assumptions violation in classical linear model have not been examined together or jointly put into consideration in various analyses been carried out. As such, the detection of outlier and interdependency among the explanatory macroeconomic variables thus, becomes an important problem in modelling, analysis and inference about the fitted regression model. Specifically, we can only find a few study that investigate the existing relationship among the "economic growth (RGDP), internal debt (INDT), external debt (EXDT), interest rate (RINR), exchange rate (REXR) and trade openness (OPEN)" for Nigeria that jointly put outlier and interdependency among explanatory macroeconomic variables into consideration in their study thus, a worthy gap to fill in literature. We also estimate of the parameters for RGDP considering INDT, EXDT, RINR, REXR and OPEN as the drivers when the aforementioned assumptions violation is observed using partial least square regression as an efficient estimation technique that was lacking in various work and study previously carried out in relation to the macroeconomic variables under investigation.

2 Materials and Methods

In this study, data on macroeconomic variables extracted from CBN bulletin were considered for examining relationship among economic growth ($RGDP_t$) as endogeneous variable, internal debt ($INDT_t$), external debt ($EXDT_t$), interest rate ($RINR_t$), exchange rate ($REXR_t$), and trade openness ($OPEN_t$) between 1986Q1-2021Q1. The variables assumed a linear model stated in both functional and econometrical form as (**??**) and (**??**)

$$RGDP_t = F(INDT_t, EXDT_t, RINR_t, REXR_t, OPEN_t) \quad (1)$$

$$RGDP_t = \propto_0 + \propto_1 INDT_t + \propto_2 EXDT_t + \propto_3 RINR_t + \propto_4$$

$$\text{REXR}_t + \propto_5 \text{OPEN}_t + \in_i \quad (2)$$

where, $\propto_i$ and $\in_i$ are the parameters to be estimated and error term respectively.

However, the multiple linear regression model stated in (**??**) and (**??**) were transformed and expressed in general form as given in (**??**) where Y represent the dependent variable RGDP_t and $\boldsymbol{X}$ represent the explanatory variables INDT_t, EXDT_t, RINR_t, REXR_t, OPEN_t.

$$\text{Y} = \text{X}' \propto + \varepsilon \quad (3)$$

The ordinary least square estimator of $\propto$ is given in (**??**)

$$\propto = (\boldsymbol{X}'\boldsymbol{X})^{-1}\boldsymbol{X}'\text{Y} \quad (4)$$

The covariance matrix of $\propto$ can be obtained as given in (**??**)

$$\text{Cov}(\widehat{\propto}) = \sigma^2(\boldsymbol{X}'\boldsymbol{X})^{-1} \quad (5)$$

where $\boldsymbol{Y}$ is an observational vector of dimension $n \times 1$, $\boldsymbol{X}$ is an $n \times p$ data matrix of regressors, $\propto$ is a $p \times 1$ vector of estimated coefficient and ε is an $n \times 1$ vector of errors.

Outlier and multicollinearity problem as common assumptions violation in classical linear model and these shall be simultaneously addressed in this study using a partial least square estimation technique. According to Barnett and Lewis (1994) and cited in [1], it was noted that an outlier is a figure that seem to be varying from other observations in a given dataset which can influences or causes a substantial change of some expected result of the regression analysis such as estimated parameters and the variance or standard error. Thus, the need for diagnostics to check for the presence of outlier and multicollinearity. In this study, Grubbs' test and variance inflation factor were used to establish the violation of the assumptions.

Grubbs' test

The Grubbs' test for outliers was recommended by International Statistical Organisation (ISO) and as such it will be used in this study. The test is the comparison of the difference in suspect value and sample mean divided by standard deviation of the sample with Grubb's critical value. The suspect value is the extreme value among the data set. In Grubbs' test, the null hypothesis (H_0) is there no outliers in the dataset under investigation. The statistic G_m is calculated as expressed in (**??**):

$$\widehat{\text{G}}_\text{m} = \frac{\left|\text{X}_\text{s}^* - \overline{\text{X}}\right|}{\text{S}} \quad (6)$$

$$\text{G}_\text{m} = \frac{\left|\text{Suspect value} - \overline{\text{X}}\right|}{\text{S}}$$

Correlation coefficients particularly that of explanatory variables to check for multicollinearity. A strong correlation between any of the two variables is a suspect for multicollinearity. Thus, the used of variance inflation factor (VIF) to check and ascertained the multicollinearity.

Variance Inflation Factor

The VIF is given by (**??**)

$$\text{VIF}_j = \frac{1}{1 - R_j^2},\ j = 1,\ 2,\ \ldots,\ k \quad (7)$$

R_j^2 represents the coefficient of determination when the regression between X_1 an the remaining X_{1+j} explanatory variables are fitted. Khalaf and Iguernane (2016) opined as cited by Allison (1999) and Freund and Littell (2000) that VIF increased the variance of estimated parameters when compared if the explanatory variables were uncorrelated. Thus, $\text{VIF}_j > 10$ shows multicollinearity that make ordinary least square estimator inefficient and as such, an alternative means to obtain efficient estimate through other estimators.

Partial Least Square Method:

Partial Least Square is practically another technique proposed by Helland (1990) as a method that can be used to construct predictive models with many collinear explanatory variables. This technique can be used even if the number of parameters to be estimated is more than sample sizes, an advantage over ordinary least square regression and principal component regression method. In this technique, Y variable is regressed against $x_1,\ x_2,\ x_3,\ \ldots,\ x_p$ the explanatory variables, in an efforts to obtain new factors that will satisfactorily replace X's, the new factors or components of X are called latent variables thus, each component serve as a linear combination of $x_1,\ x_2,\ x_3,\ \ldots,\ x_p$ that can serve as a new explanatory variables to determine Y variable. Thus, partial least square intends to generate components that can define the general information contained in the X variables. Thus, Garthwaite (1994) emphasized that the basis of this is to reduce the dimension of the regression through the uses of few components rather than the whole explanatory variables (X). Therefore, in other to derive the partial least square estimates for β, the matrix X assume are decomposed into bilinear form that can be expressed in the form (**??**):

$$\text{X} = t_1 P_1' + t_2 P_2' + t_3 P_3' + \cdots + t_p P_p' \quad (8)$$

$$X = \sum_{i=1}^{p} t_i P_i' = TP'$$

Where t_i are the linear combinations of X, which can be written as X_{ri} . The P x 1 vectors denoted by P_i

are usually known as Loadings. Unlike the weights in principal component regression that is the eigenvectors (j_i), the r_i are not orthogonal. However, t_i are orthogonal like Z_i for principal components. The two major algorithms used to obtain partial least square estimators are non-linear iterative partial least square (NIPALS) and simple partial least square (SIMPLS). In the first method, the orthogonality is imposed through the computation of t_i as the linear combination of matrix of error denoted by E_i as given (**??**):

$$t_i = E_{i-1} w_i E_i \tag{9}$$

Such that,

$$t_i = X - \sum_{j=1}^{i} t_j P_j' \text{ and } E_0 = X$$

where w_i are orthogonal. Thus, making two sets of weighted vectors w_i and r_i, $i = 1, 2, 3, \ldots, m$. In most the algorithms for multivariate and univariate partial least square, the first step is to compute either w_i or r_i, $i = 1, 2, 3, \ldots, m$, that will help in calculating the linear combination of the t_i. Thereafter, p_i are computed through the regression X on t_i. Putting m factors into consideration, the following relationship express in (**??**), (**??**) and (**??**) can be obtained:

$$T_m = XR_m \tag{10}$$

$$P_m = X'T_m(T_m'T_m)^{-1} \tag{11}$$

$$R_m = W_m(P_m'w_m)^{-1} \tag{12}$$

In this case, m is the dominant factors that capture most of the variance in X which has the ability to maximize efficiency. In (**??**), two sets of weight vectors are linked through linear transformation. From (**??**) and (**??**), $P_m'R_m = I_m$, thus, the existence of this transformation can be obtained in (**??**), (**??**) and (**??**) as follows:

$$R_m'P_m = R_m'X'T_m(T_m'T_m)^{-1} \tag{13}$$

$$R_m'P_m = T_m'T_m(T_m'T_m)^{-1} \tag{14}$$

$$R_m'P_m = I_m \tag{15}$$

After the extraction of m dimensional vectors, the vector of fitted values for the partial least square can be used to represent the first m partial least square linear combinations denoted by T_m. The derivation can be obtained for the univariate case by equation (**??**) given as follows:

$$\hat{Y}_{PLS}^m = T_m(T_m'T_m)^{-1}T_m'y \tag{16}$$

According to Huber *et al*. (2005), the multivariate case can be obtained by replacing the vector $\hat{y}_{PLS}^m$ with the matrix $\hat{y}_{PLS}^m$. Thus, substituting XR_m for T_m and $\widehat{\beta}_{OLS}$ for y in (**??**) and it results express in (**??**):

$$\hat{Y}_{PLS}^m = XR_m(R_m'X'X)^{-1}R_m'X'X\widehat{\beta}_{OLS} \tag{17}$$

Then, it is cleared in (**??**) that:

$$\widehat{\beta}_{PLS}^m = R_m(R_m'X'XR_m)^{-1}R_m'X'X\widehat{\beta}_{OLS}^m \tag{18}$$

This can be somewhat made simple for $\widehat{\beta}_{OLS}$ by first substituting equation (**??**) into (**??**) to yields (**??**) as given below:

$$P_m = X'XR_m(R_m'X'XR_m)^{-1} \tag{19}$$

Hence, using this result in equation (**??**) and (**??**) results to the expression given in (**??**):

$$\widehat{\beta}_{PLS}^m = R_mP_m'\widehat{\beta}_{OLS}$$

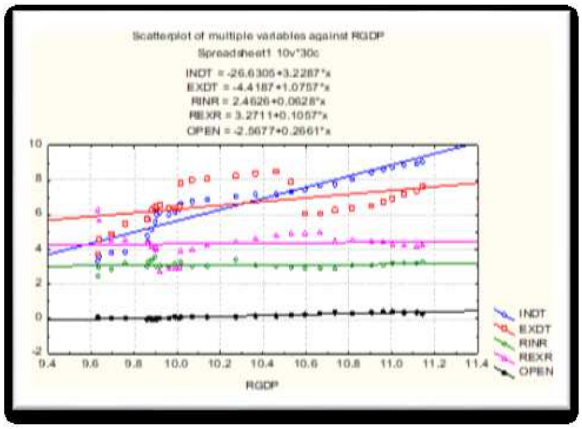
$$\widehat{\beta}_{PLS}^m = w_m(P_m'w_m)^{-1}p_m'\widehat{\beta}_{OLS} \tag{20}$$

Thus, in the next session, data exploration, descriptive analysis, test for outliers and multicollinearity as well as fitting partial least square regression model and its associated diagnostics carried out were presented.

3 Result and Discussion

3.1 Data Exploration

The economic growth (RGDP) and drivers that includes internal debt (INDT), external debt (EXDT), interest rate (RINR), exchange rate (REXR) and trade openness (OPEN) were explained using trend analysis in this section to explore the nexus among the variables mentioned. Thus, it was showed the how RGDP related with "INDT, EXDT, RINR, REXR, and OPEN" which can be in inverse or direct form and as such we carried out descriptive analysis and diagnostic properties of fitted model such as outliers and multicollinearity among the variables. In view of this, a linear model is fitted and the presence of outliers and multicollinearity as assumptions violation among macroeconomic variables is examined to ensure efficiency in parameters estimation. Therefore, Figure 1 showed the relation among the macroeconomic variables under consideration.



Source: Researcher's Computation, 2023
Figure 1: Trend showing how independent variables related with RGDP

Figure 1, presented the scattered plot and various trends of independent variables such as INDT, EXDT, RINR, REXR and OPEN and their relation with RGDP in the years considered. Hence, linear trends were seen among the aforementioned drivers and economic growth. We also done Grubb's test (Table 2) to determine the presence of outliers among the macroeconomic variables. Also, in Table 1 we presented the detail descriptive analysis of the macroeconomic variables under consideration.

3.2 Descriptive Analysis

In Table 1 the descriptive statistic was presented for the macroeconomic variables under consideration in this study.

Table 1: Descriptive Analysis

	RGDP	INDT	EXDT	RINR	REXR	OPEN
Mean	10.304	6.628	6.657	3.105	4.317	0.166
Med.	10.205	6.739	6.462	3.113	4.380	0.120
Max.	11.142	9.086	8.495	3.586	6.319	0.460
Min.	9.631	3.347	3.724	2.484	2.776	0.010
Std. Dev.	0.450	1.498	1.065	0.192	0.695	0.130
Skew.	0.371	-0.409	-0.163	-0.573	-0.174	0.671
Kurt.	1.857	2.557	2.707	4.171	3.627	2.124
Jarque-Bera (P-value)	10.91 (0.00)	5.09 (0.08)	1.13 (0.57)	15.79 (0.00)	3.03 (0.21)	15.08 (0.00)
Sum	1452.9	934.6	938.6	437.8	608.7	23.4
Sum-Sq Dev.	28.39	314.49	158.93	5.21	67.65	2.37
Observations	141	141	141	141	141	141

Source: Researcher's Computation, 2023

Table 1 we presented the descriptive result of "RGDP, INDT, EXDT, RINR, REXR, and OPEN". The estimated mean for RGDP was 10.30 which ranged between 9.63-11.14. The estimate for INDT & EXDT stood at 6.63 & 6.66 with range given 3.35-9.09 & 3.72-8.50 respectively. The mean estimate for RINR & REXR were 3.11 & 4.32 and were ranged from 2.48-3.59 & 2.78-6.32 respectively. The mean estimate for OPEN was 0.17 with ranged between 0.01-0.46 in period under study. The standard deviation of the estimate for "RGDP, INDT, EXDT, RINR, REXR, and OPEN" were 0.45, 1.50, 1.07, 0.19, 0.70 and 0.13 respectively.

In Table 1, the skewness result reveal that RGDP and OPEN were positive skewed and their skewness coefficients were 0.37 and 0.67 respectively. Also, INDT, EXDT, RINR and REXR were negative skewed and their skewness coefficients were -0.41, -0.16, -0.57 and -0.18 respectively. This implies that RGDP and OPEN were skewed right and other macroeconomic variables were skewed left. The kurtosis values 4.17 and 3.63 showed that RINR and REXR which were mesokurtic while other macroeconomic variables had a kurtosis value < 3 and such were platykurtic.

Table 2: Correlation Matrix

	INDT	EXDT	RINR	REXR	OPEN
INDT	1.000	0.607	0.127	-0.092	0.820
EXDT	0.607	1.000	0.387	-0.289	0.253
RINR	0.127	0.387	1.000	-0.459	-0.009
REXR	-0.092	-0.289	-0.459	1.000	0.241
OPEN	0.820	0.253	-0.009	0.241	1.000

Source: Researchers' Computation, 2023

In Table 2, we presented the correlation indicated the degree of relationship among the explanatory variables (INDT, EXDT, RINR, REXR and OPEN). From Table 2, it was revealed that EXDT, RINR and OPEN had a positive correlation with INDT and their coefficient of correlation 0.61, 0.13 and 0.82 respectively. Also, in Table 2, it was showed that correlation between EXDT and RINR was positive with 0.39 as the coefficient, the correlation coefficient of 0.25 showed that EXDT and OPEN were positively correlated. The correlation between REXR and OPEN with coefficient of 0.24 revealed their positively correlated. Hence, it must be emphasized that higher or stronger correlation between any of the two macroeconomic variables was a sign and the need to check for multicollinearity.

Therefore, in order to check for the outliers and multicollinearity among the macroeconomic variables (INDT, EXDT, RINR, REXR, and OPEN)

used as drivers of economic growth (RGDP), we carried out Grubb's and variance inflation factor (VIF) test for large data in detecting the assumptions violation. In Table 3, the results of the tests were presented.

Table 3: Test for Outliers and Multicollinearity using Grubb's Test and VIF

Variable	Grubb's Value	G (Critical value)	VIF
INDT	2.189	3.497	14.265
EXDT	2.752	3.497	3.529
RINR	3.215	3.497	1.436
REXR	2.880	3.497	1.757
OPEN	2.254	3.497	9.564

Source: Researcher's Computation, 2023

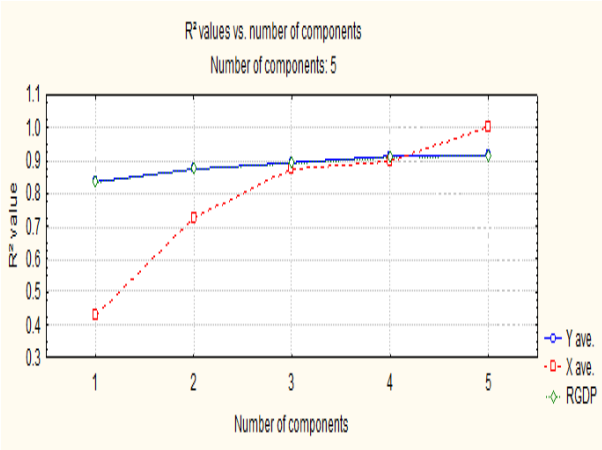
Result presented in Table 3 showed Grubb's test carried out with the null hypothesis (H_0) stated as "there is outliers in the data set under consideration". The rule here is that, if calculated Grubb's value is less than critical value at given significance, H_0 is accepted. Therefore, from result presented in Table 3, it was revealed that the Grubb's value of 1.860, 2.189, 2.752, 3.215, 2.880 and 2.254 were less than the Grubb's critical value of 3.497 for RGDP, INDT, EXDT, RINR, REXR, OPEN respectively. Thus, it can be emphasized from the result that outliers were in the macroeconomic data set under investigation. Also, in Table 3, variance inflation factor (VIF) revealed that "INDT, EXDT, RINR, REXR and OPEN" were 14.265, 3.529, 1.436, 1.757, and 9.564 respectively. Thus, Khalaf and Iguernane (2016), it can be asserted that VIF of 14.265 > 10.00 showed statistical significance for the presence of multicollinearity as a result of INDT. The two tests evidently affirmed the presence of outlier and multicollinearity as an assumption violation for linear model. Hence, a partial least square method was adopted to address the problems in order to obtain an estimate that can efficiently predict economic growth.

Table 4: Partial Least Square for Model Selection

Comp X	Variance	Error	R-Sq (X)	PRESS	Y (pred)
1	0.429	4.686	0.834	4.889	0.827
2	0.726	3.591	0.873	3.867	0.863
3	0.875	3.019	0.893	3.313	0.883
4	0.900	2.462	0.913	2.842	0.899
5	1.000	2.420	0.914	2.783	0.902

Source: Researcher's Computation, 2023

In Table 4, it was revealed that the variance of the 1, 2, 3, 4, and 5 estimated components of the explanatory variables were 0.429, 0.726, 0.875, 0.899 and 1.000 respectively with associated error of 4.686, 3.591, 3.019, 2.462 and 2.420 respectively. In the result component 1 contributed the largest variability in predicting economic growth but highest estimated error of 4.686. Thus, it can be emphasized based on the error associated with the various estimated component for predicting economic growth (RGDP), it was found that using the entire 5 estimated components is the most efficient because of the small error of 2.420 when compared with using any other components. In Table 4, the R-square indicate the amount of variance that can be explained by various component of X and it show that component 1, 2, 3, 4 and 5 components explained 83.5, 87.4, 89.4, 91.3 and 91.5 percent respectively for the variance of various linear combination of economic growth drivers under consideration respectively also, R-square (pred) amount of variance of economic growth (RGDP) that each estimated component is explained and it was found that 1, 2, 3, 4, and 5 components can explain 82.8, 86.4, 88.3, 90.0 and 90.2 of the variance of Y. In examining the efficiency of the estimate, a predictive residual sum of square (PRESS) and it was found that 1, 2, 3, 4, and 5 components have a predictive residual sum of square of 4.889, 3.867, 3.313, 2.842 and 2.783 respectively. The graph presented in the Figure 2 below also revealed the amount of variance explained by the linear combination of economic growth drivers that includes "internal debt (INDT), external debt (EXDT), interest rate (RINR), exchange rate (REXR) and degree of economy openness (OPEN)" and the economic growth (RGDP) in relation with estimated components that are obtained after the transformation of the economic growth drivers mentioned.



Source: Researcher's Computation, 2023

Figure 2: Plot showing the amount of variance explained by the components and RGDP

Table 5: Loading Weight for Variables (Economic growth and its determinants)

Loading (X)	COMP 1	COMP 2	COMP 3	COMP 4	COMP 5
INDT	0.668	-0.062	0.051	0.751	-0.149
EXDT	0.413	-0.698	-0.355	-0.043	0.080
RINR	0.111	-0.546	0.735	-0.655	0.692
REXR	0.028	0.630	-0.669	-0.189	0.700
OPEN	0.628	0.342	0.078	-0.646	-0.048
Loading (Y)					
RGDP	0.631	0.184	0.174	0.482	0.054

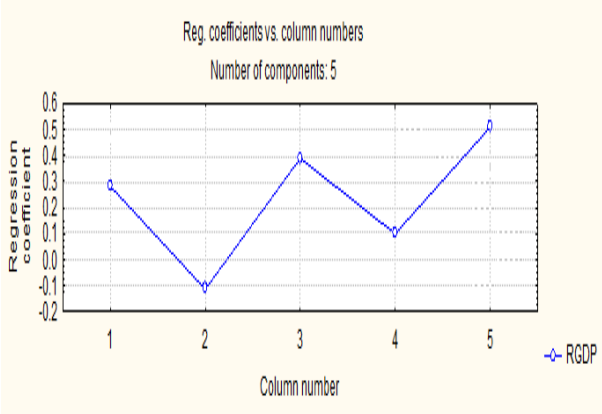
Source: Researcher's Computation, 2023

Table 5 showed that loading weight for drivers of economic growth identified in the study and used in predicting economic growth (RGDP). Thus, the loading weights can either positive or negative value and it indicates the contribution of economic growth drivers (explanatory variables) to the components. From the result presented in the Table 5, it showed that "INDT, EXDT, RINR, REXR, and OPEN" contribution to the one component factor were 66.8, 41.3, 11.2, 2.9 and 62.8 percent respectively. Also, INDT, EXDT, RINR, REXR, and OPEN contribution to the two component factors were -6.3, -69.8, -54.6, 63.1 and 34.2 percent respectively. The contribution of INDT, EXDT, RINR, REXR, and OPEN to three component factors were respectively 5.2, -35.5, 73.5, -66.9 and 7.9 percent. INDT, EXDT, RINR, REXR, and OPEN contribution to the three component factors were 5.2, -35.5, 73.5, -66.9 and 7.9 percent respectively. For 4 component factors, the contribution of INDT, EXDT, RINR, REXR, and OPEN were 75.2, -4.3, -65.5, -18.9 and -64.6 percent respectively and for the five component factors, INDT, EXDT, RINR, REXR, and OPEN contributed -14.9, 8.0, 69.2, 70.0 and -4.9 percent respectively. Thus, it can be established that the respective amount of explanation of the components by the identified determinants of the economic growth in Nigeria needed for efficient prediction of the economic growth. Also, in Table 5, the result of loading for the economic growth (RGDP) and the components obtained from the linear combination of the economic growth drivers under consideration indicated that the 1, 2, 3, 4, and 5 components were 63.1, 18.4, 17.4, 48.3 and 5.4 percent efficient in predicting economic growth in Nigeria. After obtaining the components, the next step is to estimate the coefficient of model as presented in Table 6.

Table 6: Coefficients of partial least squared model

Variables	RGDP	RGDP Standardized
Constant	7.466	0.000
COMP 1	0.281	0.937
COMP 2	-0.112	-0.266
COMP 3	0.388	0.166
COMP 4	0.099	0.154
COMP 5	0.507	0.146
Sum of square regression		25.968
Mean sum of square regression		5.193
Sum of square residual		2.420
Mean sum of square residual		0.017
F-ratio		289.63
Prob of F-ratio (5, 135)		0.000

Source: Researcher's Computation, 2023.

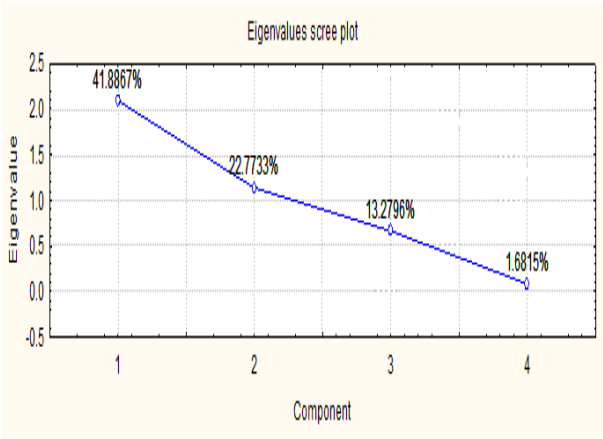


Source: Researcher's Computation, 2023

Figure 3: The graph showing the coefficient of estimated parameter for components

Table 6 and Figure 3, we presented the coefficient of estimated parameters for predicting economic growth (RGDP) in Nigeria. Thus, from the result, it was found that after the extraction of the components through the linear combination and transformation, INDT, EXDT, RINR, REXR, and OPEN were discovered in predicting economic growth in Nigeria by 28.2, -11.3, 38.8, 10.0 and 50.8 percent respectively. The was obtained through the standardization of the estimated parameters. In the result, the partial least square model revealed that the mean sum of square regression (MSSR) and mean square of error (MSE) were 5.193 and 0.017 respectively. The result indicated that the error margin of predicting economic growth using aforementioned technique was less than 5 percent

thus, emphasizing the efficiency of the technique for prediction. The F-ratio and the probability of F-ratio value of 289.63 and 0.000 revealed the overall statistical significance of partial least square regression model in predicting the economic growth in Nigeria.



Source: Researcher's Computation, 2023

Figure 4: Scree plot showing the eigenvalue of estimated for the components

Figure 4 the eigenvalues screen plot was presented for the various components that was generated from the linear combination and transformation of the explanatory variables for the drivers of the economic growth such as INDT, EXDT, RINR, REXR, and OPEN. Thus, from the plot presented in figure the eigenvalues showed that the first, second, third, and fourth component factors contributed 41.9, 22.8, 13.3, and 1.7 to the prediction of the economic growth in Nigeria. Thus, it can be emphasized that even though the multicollinearity problem in the original data set have been addresses, it was evidence that from the Figure 4, that outliers still exist which was addressed through the cross validation and selection method result of the components presented as follows:

Partial Least Squares Analysis Summary Number of component is 2 and 87.35% of sum of squares of the dependent variables has been explained by all the extracted components

Table 7: Cross Validation Result of Partial Least Square

RÂ²X	Eigen value	RÂ²Y	RÂ²Y Cum	QÂ²	QÂ² Cum	Sig
0.429	2.094	0.834	0.834	0.782	0.782	S
0.297	1.138	0.038	0.873	0.005	0.783	S

Source: Researcher's Computation, 2023

In Table 7, the cross-validation result of the partial least square regression model was presented and it revealed that two component factors of the linear combination of the economic growth drivers identified as explanatory variables under consideration which accounted for the 87.4 percent variation of the economic growth in Nigeria were efficient and appropriate for the prediction. It was discovered that the variance denoted by R-square of X for the for the first and second component estimated and selected from the economic growth identified as explanatory variables in this study were 0.429 and 0.297 respectively which showed that 42.9 and 29.7 percent of the variance of the components with eigenvalues of 2.094 and 1.138 can be accounted for in predicting economic growth. Thus, emphasizing that a total of 72.6 percent in the variance as result of the linear combination explanatory variable can be explained. In the result, R-square Y(pred) amount of variation in the economic growth (RGDP) that can be explained by each estimated components and as observed 83.5 and 3.9 percent of the proportional variation in economic growth can be explained by component one and two respectively with Q-square the cross validated predictive value of 0.783 and 0.005 indicating that a total of 87.4 percent proportional variation of the components can be efficiently and significantly explained in predicting economic growth with cross validated predictive of 78.9. In a quest to know the order of importance of the economic growth drivers in generating the two cross validated components to predict the economic growth, the variable importance for projection result was presented in Table 8.

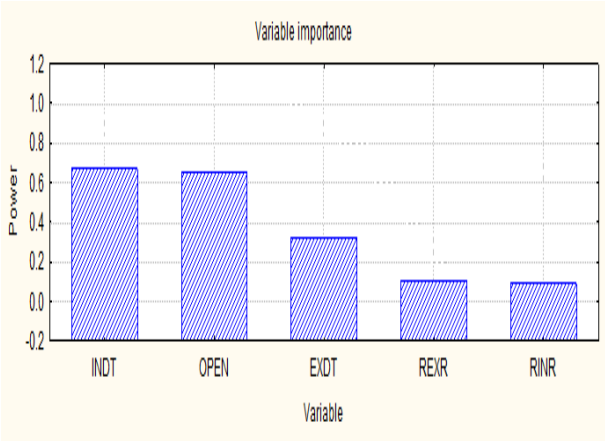
Table 8: Variable Importance for Projection the Economic Growth

Variables	Variable number	VIP	Importance
INDT	1	0.667	1
OPEN	5	0.655	2
EXDT	2	0.325	3
REXR	4	0.101	4
RINR	3	0.089	5

Source: Researcher's Computation, 2023

Table 8 revealed the result of the explanatory variables identified in this and the level of their importance or rank in projecting the economic growth in Nigeria. As presented in the Table 5, it was discovered that INDT, OPEN, EXDT, REXR and RINR with the variance importance projection (VIP) values of 66.8, 65.6, 32.5, 10.1, and 9.0 percent were ranked as first, second, third, fourth, and fifth as the order of importance in predicting the economic growth (RGDP) in Nigeria. The result thus emphasized the relevance of internal debt (INDT) or domestic borrowing and high degree of economy openness (OPEN) in growing the Nigeria economy. This result was also presented in the Figure 5 for

better description understanding of the importance of identified economic growth drivers (explanatory variables) in predicting the growth of the economy in Nigeria. Next in Table 10, 11 was the partial least square weights and loadings obtained from the macroeconomic variables under consideration for the generation of the cross validated components and its coefficients required for the efficient and optimal prediction of the economic variable (RGDP).



Source: Researcher's Computation, 2023
Figure 5: Variable Importance Representation for Projection the Economic Growth

Table 9: The Weight of the Economic Growth Drivers for the Cross Validated Components

Variable	Comp 1	Comp 2
INDT	0.682	0.092
EXDT	0.271	-0.892
RINR	0.083	-0.177
REXR	0.078	0.315
OPEN	0.668	0.254

Source: Researcher's Computation, 2023

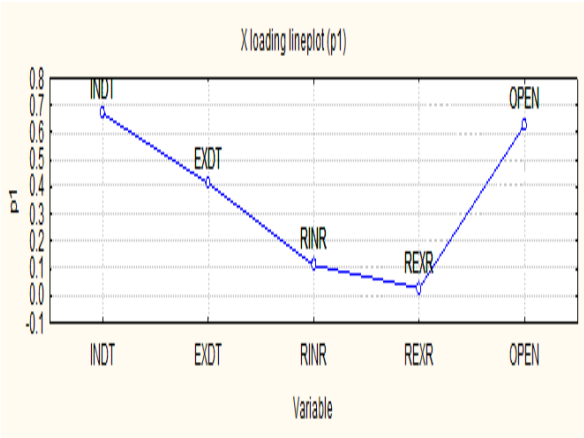
In the Table 9, the drivers of economic growth (explanatory variables) weight showed cross validated component been dominated by INDT and OPEN as emphasized in Table 8 and Figure 5. In the result presented in Table 9, it was observed that INDT and OPEN contributed highly and positively 68.3 and 66.8 to the estimation of first component compared with others such as EXDT, RINR and REXR which contributions were 27.2, 8.4 and 7.9 percent respectively. In the second component, it was discovered that INDT, REXR and OPEN were the one contributed positively to the estimation of the component to the turn of 9.2, 31.6, and 25.4 percent respectively. Others such as EXDT and RINR were negatively contributed to the estimation of the second component to the 89.2 and 17.8 percent respectively. The same result was also observed in the economic growth drivers loading as presented in Table 10.

Table 10: Economic Growth Drivers Loading for Obtaining Cross Validated Components

X loading (Number of components is 2)			
Variable	Variable number	Comp 1	Comp 2
INDT	3	0.668	-0.062
EXDT	4	0.413	-0.698
RINR	5	0.111	-0.546
REXR	6	0.028	0.630
OPEN	7	0.628	0.342

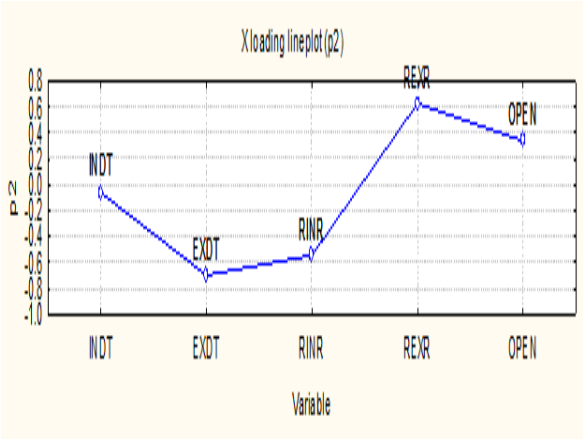
Source: Researcher's Computation, 2023

Table 10 showed the result of the partial least square loading for the drivers of economic growth identified in this study to predict economic growth (RGDP) in Nigeria. Thus, the loadings were either positive or negative as revealed which indicates the contribution of economic growth drivers (explanatory variables) to the generated cross validated components. From the result presented in the table above, it was discovered that INDT, EXDT, RINR, REXR, and OPEN contribution to the first component factor were 66.8, 41.3, 11.2, 2.9 and 62.8 percent respectively. Also, INDT, EXDT, RINR, REXR, and OPEN contribution to the second component factor were -6.3, -69.8, -54.6, 63.1 and 34.2 percent respectively. Thus, it can be established the respective amount of variation of the components that can be explained by the identified determinants of the economic growth in Nigeria that is required for efficient and optimal prediction of the economic growth. This result was also presented in graphical form as shown in Figure 7a, 7b and 7c for the first second and combined components. In Figure 7a, it was specifically revealed that all the economic growth drivers were in positive position which showed their positive contribution to the first component while, in Figure 7b, INDT, EXDT and RINR were in negative position of the second component and REXR and OPEN were in positive position of the second component to show their respective positive and negative contributions to the cross validated second component. The combined graphical presentation and the position which also indicated the contributions of the economic growth drivers to the cross validated components was presented in Figure 7c.



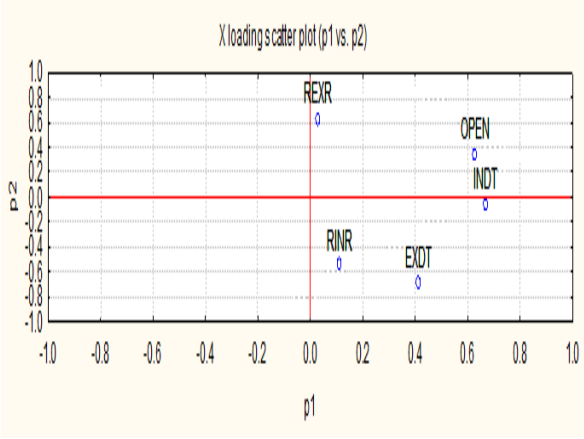
Source: researcher's computation, 2023

Figure 7a: loading plot the contribution of economic growth drivers for the first cross validated component



Source: researcher's computation, 2023

Figure 7b: loading plot and the contribution of economic growth drivers for the second cross validated component



Source: researcher's computation, 2023

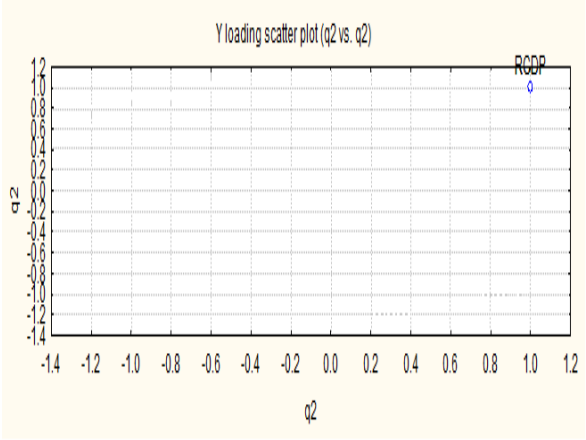
Figure 7c: loading plot and the contribution of economic growth drivers for the combined cross validated component

Table 11: The Economic Growth RGDP Loading (Y loading for components)

Variable	Variable number	Comp 1	Comp 2
RGDP	2	1.000	1.000

Source: Researcher's Computation, 2023

Following from Table 10, Table 11 showed the result of the loading for the economic growth (RGDP) and cross validation components obtained from the linear combination of the economic growth drivers under consideration in this study. from the result presented in Table 11 and in Figure 8, it was indicated that the first and second generated cross validated components were 100 percent efficient in predicting economic growth in Nigeria compared to non-cross validated result obtained for the first and second component which were only 63.1 and 18.4 percent respectively as presented in Table 5 that indicated the presence of outliers even when the multicollinearity problem had been sorted out which was also emphasized from the eigenvalues plots of the non-cross validated components presented in Figure 4. Thus, it can be emphasized that with this cross validated component result obtaining from linear combination of the economic growth drivers identified in this study, the economic growth (RGDP) can be efficiently and optimally predicted using the two generated cross validated components.



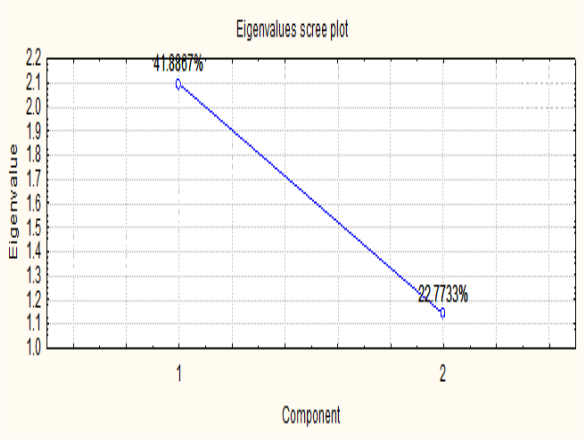
Source: researcher's computation, 2023 **Figure 8**: Graph that shows the contribution of components to economic growth (RGDP)

Table 12: Partial Least Square Estimated Coefficient for Cross Validated Components

Comp	Coef	Eigen value	Total variance (%)	Cum eigen value	Cum. (%
1	0.631	2.094	41.886	2.094	41.886
2	1.138	1.138	22.773	3.233	64.660

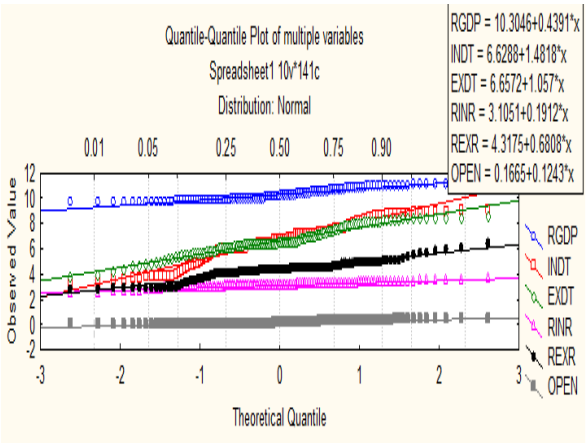
Source: researcher's computation, 2023

In Table 12, the cross validated coefficient of estimated components for predicting economic growth (RGDP) were presented. From the result, it was found that after the cross validation and extraction, first and second components were efficient and optimum for predicting economic growth in Nigeria to the turn of 63.1 and 18.4 percent with the eigenvalue of 2.094 and 1.138 respectively. Also, from Table 9 and Figure 9, it was discovered that the variance of the first and second cross validated component estimated were 41.9 and 22. 8 percent respectively. This result is more efficient than the variance obtained without the cross validation which were given as 42.9 and 29.7 respectively. In cumulative, the total variance for the two components obtained through cross validation which stood at 64.7 percent showed it efficiency in predicting economic growth (RGDP) over the value 72.7 percent through non cross validation method presented in Table 2.



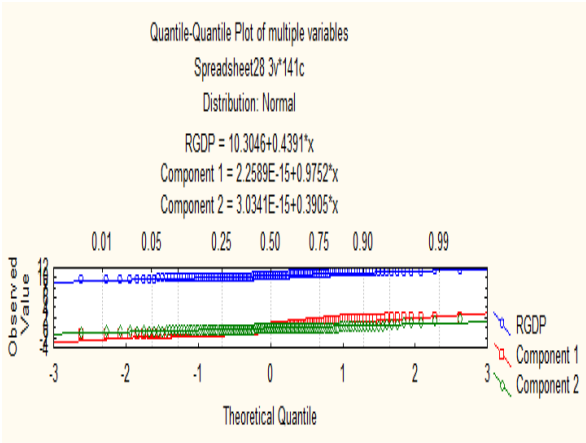
Source: Researcher's Computation, 2023

Figure 9: Eigenvalues scree plot of the generated components



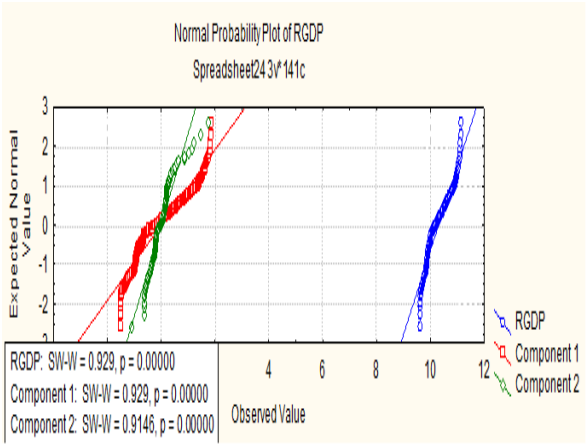
Source: Researcher's Computation, 2023

Figure 10: The Q-Q Plot showing the normality of economic growth and its drivers



Source: Researcher's Computation, 2023

Figure 11: Q-Q Plot showing the normality of economic growth and the contribution of components

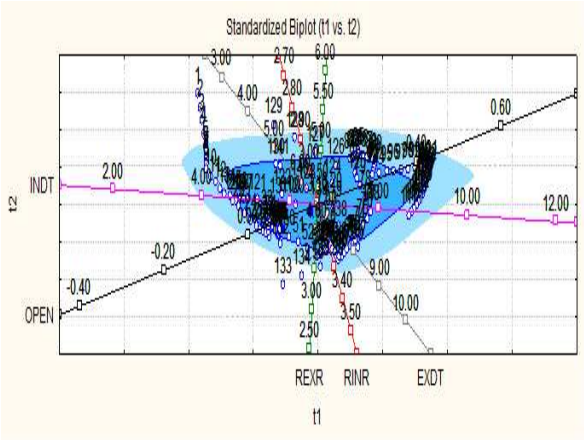


Source: Researcher's Computation, 2023

Figure 12: graph that showing normality of the contribution of components and RGDP

The Q-Q plot showed that economic growth (RGDP) and the drivers such as internal debt (INDT), external debt (EXDT), interest rate (RINR), exchange rate (REXR) and trade openness (OPEN) were from normal population that contained outliers as revealed by their values in Figure 10. However, from the cross validated result obtained and showed in Figure 11, it was revealed from the first and second component obtained from the linear combination of the economic growth drivers that the outliers have been addressed based on the values of the components with approximate mean and standard error of 2.258E-15 + 0.975 and 3.034E-15 + 0.390 respectively which were less than the one obtained for economic growth drivers revealed in Figure 10 thereby suitable and appropriate for predicting economic growth. Also, in Figure 12, Shapiro-Wilk test statistics which is the most efficient test for normality showed that 0.929, 0.929, and 0.914 for RGDP, first component

and second component obtained from the linear combination of INDT, EXDT, RINR, REXR OPEN respectively and the probability value of the Shapiro-Wilk statistics with p-value < 0.05 revealed that all the macroeconomic variables under investigation were from normally distributed population



Source: Researcher's Computation, 2023

Figure 13: Standardized biplot showing the efficiency of the two Cross Validated Components

In Figure 13, the standardized biplot showed validate the cross validated of obtained two components from the linear combination of the identified economic growth drivers such as INDT, EXDT, RINR, REXR and OPEN and their contributions each component estimated for predicting the economic growth (RGDP). The two coloured showed in the biplot established the first and the second component with respective inner deep blue colour and the light blue colour obtained through cross validation as the major determinant for economic growth (RGDP) prediction. In the inner deep blue colour region of the biplot, it was found that all the economic growth drivers such as INDT, EXDT, RINR, REXR, and OPEN values were concentrated in the region to form the first component for predicting economic. This also inform the reason why it was revealed in table 7, the positive contribution of the linear combination of economic growth drivers in obtaining the first component to predict the economic growth (RGDP). In the light blue colour region, the major values concentrated there were the one from REXR and OPEN and the reason for their positive contribution to the linear combination of the economic growth drivers to obtain the second component. The values of the economic growth outside the two identified region were evidence why the five components generated before the cross validation would be inefficient in predicting the economic growth in Nigeria.

4 CONCLUSSION

An examination of an estimation of economic growth's parameters in Nigeria among the identified determinants (INDT, EXDT, RINR, REXR, and OPEN) in the presence of multicollinearity and outliers as basic assumptions violation. An exploratory and diagnostics analysis established a relationship between the economic growth (RGDP) and the aforementioned drivers. The presence of multicollinearity and outlier were established by VIF and Grubb's test carried out on data set under consideration. Consequently, to jointly handling the problems and to obtain efficient parameter estimate for INDT, EXDT, RINR, REXR, and OPEN, a partial least square regression technique was adopted to simultaneously addressed the problems to provide an efficient estimate of the model that optimally predict the economic growth in Nigeria. The result revealed that in a non-cross validated partial least square method, five components were generated and selected from the linear combination and transformation of the economic growth drivers identified in this study while, in a cross validated partial least square method, two components were generated and selected from the same process of linear combination and transformation of the same economic growth drivers under consideration to predict the economic growth (RGDP).

From the non-cross validated partial least square method and cross validated partial least square selection method, the R-square indicated that 91.5% and 72.6% of the variance in economic growth drivers can be explained by the five and two generated and selected components from the respective method. Also, R-square (pred) showed that 90.2% variability in the economic growth (RGDP) can be explained by the five selected components with the efficiency of the predictive residual sum of square (PRESS) stood at 2.783 which was less and better than other four individually generated components from the linear combination of the economic growth drivers. However, in cross validated partial least method 87.4% variation in economic growth can explained by two components with cross validated predictive of 78.4% thus, a better efficiency and significance prediction of the two components over the non-cross validated five components. In a non-cross validated partial least square selection method, the result of loading for the economic growth (RGDP) and the components obtained from the linear combination of the economic growth drivers under consideration indicated that the 1, 2, 3, 4, and 5 components were 63.1%, 18.4%, 17.4%, 48.3% and 5.4% respectively in predicting economic growth in Nigeria.

However, in cross validated, the result showed that the first and second generated and selected

components were 100% in predicting economic growth which was more efficient than using the five components selected by non-cross validated method. It was also found that after the extraction of the components through the linear combination and transformation, that 1, 2, 3, 4, and 5 components influence the growth of the economy by 28.2%, -11.3%, 38.8%, 10.0% and 50.8% respectively while, in cross validated selection method, it was found that after the cross validation and extraction, first and second components were efficient and optimum for predicting economic growth in Nigeria to the turn of 63.1% and 18.4%. Thus, from the variance and the eigenvalues scree plot for the first and second cross validated component which were 41.9% and 22. 8% respectively it can be emphasized that both outliers and multicollinearity problem in the data set have been addressed because the eigenvalue scree plot gave a perfect straight line that was not in the case of non-cross validated selection method. To further validate this result, the quantile plot and normal probability plot and Shapiro-Wilk statistic value with p-value < 0.05 showed the that the estimated selected component were normally distributed while the biplot revealed that all the economic growth drivers: INDT, EXDT, RINR, REXR, and OPEN values were concentrated in the region of first and second components and the positive contribution of the linear combination of economic growth drivers in obtaining the components that efficiently predict the economic growth (RGDP). Also, from the variable importance projection, it was discovered that the economic growth in Nigeria depend largely on the internal borrowing and economy openness to engender international patronage.

Therefore, it can be concluded economic recession, crash in crude oil price at international market, insecurity, terrorist activities all these lead to insufficient availability of fund and inadequate internal funding through borrowing to growth the economy. The production level particularly agricultural and manufacturing products which are the alternative source through which economy can grow was also hampered. The closured of all international borders during this period affect the openness of the economy for exportation and importation activities and as such international patronage was low which hindered the growth of the economy and astronomical increase in naira to dollar exchange rate and above all the Covid-19 pandemic that was heavily witnessed during the aforementioned period greatly affect the identified determinants of economic growth in which the impact was translated to the Nigeria's economic growth (RGDP) during the period under investigation. Hence, this served as a great benefit to the policy makers as the study provide a better understanding of the relationship that exist between economic growth and the aforementioned determinants particularly as it was established that internal borrowing and economy openness are essential for the growth of the economy and the need for policy direction in this area. Also, a cross validated partial least square method of selecting the components required for predicting the growth of the economy was established as the most efficient technique to be adopted when dealing with multicollinearity and outlier problem in a data set.

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