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ADDRESSING MULTICOLLINEARITY ISSUES AND MACROECONOMIC VARIABLES IN NIGERIA: CORRELATION COEFFICIENTS AND VARIANCE INFLATION FACTORS (VIF) ANALYSIS

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ABSTRACT

The aim of this paper is to assess and address multicollinearity problems in some selected macroeconomic variables which affect Economic Growth in Nigeria, using Correlation Coefficients and Variance Inflation Factors (VIFs) as one of the methods used for detecting the multicollinearity problem. The study employed different model specifications to solve the problem and compared the results with the results obtained from the Ordinary Least Square (OLS) results in the general model in order to produce the best possible model to address the problem of the study. The Macroeconomic Variables used as explanatory variables are Unemployment (URt), Inflation (IRt), Foreign Direct Investment (FDRt) and Size of Labour Force(SLFt) while Real GDPt stands as the dependent variable. After applying the remedy, the results show that in Nigeria unemployment seems to be correlated with and Size of Labour force (SLFt). FDIt has a positive significant effect on GDP while unemployment (URt) has a negative and significant impact on economic growth. Size of Labour force (SLFt) and inflation (IRt) have no any significant impact on economic growth. The paper concludes that the use Correlation Coefficients and High Variance Inflation Factors (VIFs) are efficient ways of detecting multicollinearity. The paper recommends the removal of the correlated variables and fitting them in separate models to reduce the multicollinearity problem so as to produce the best possible model that will address the problem under study.

Keywords: Economic Growth, inflation, multicollinearity, unemployment, variables

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1. Introduction

Interrelation among macroeconomic variables is an issue that attracts the attention of researchers especially that this relation often breeds uncertainty in terms of the effect of each variable on the economy. Generally, countries of the world are affected by labour market imbalances, unemployment, inflation, labour force size and many other macroeconomic factors of which Africa in this regard, is most affected. In Nigeria for instance, the co-existence of unemployment and inflation as well as the presence of large labour force size each of which can have effect on economic growth and development. For instance, the role of foreign investments in bringing about economic growth has received the attention of policy makers, researchers and international organizations (Mohammed et al, 2011).

Looking at the relationship between unemployment and inflation in Nigeria, for instance, in inflation rose to 23.2%, 39%, 40.0% and 72.8% in 1973, 1983, 1984, 1989 and 1995 respectively (Kayode, 2015) while unemployment rate for the same period were 5.2%, 6.2%, 4.4% and 1.8%. Inflation rate fell to 29.27%, 6.93%, 13.72% and 13.25 in 1996, 2000, 2010 and 2020 amidst series of monetary policy tightening and complementary measures undertaken during the year (Mohammed et al, 2011).Yemi and Sani (2015) observed that the working age population of Nigerians stood at 101,769,739 as at Q4 2014 of which 72,931,619 were fully employed, underemployed or unemployed translating into a labour force participation rate of 71.7 per cent. This rate was lower than the one reported in the preceding quarter and the corresponding quarter of 2013 by 20 and 180 basis points, respectively. Theoretically, Phillips Curve depicts a negative relationship between unemployment and inflation rates but the trend of inflation-unemployment does not constantly support the Phillips Curve.

For the economic growth, Nigeria with an approximately 25 percent annual real GDP growth, Nigeria was one of the fastest growing economies in the world, the most populous country in Africa and accounts for one in five of Sub-Sahara's people (Tartiyus, Dauda, and Peter, 2015) cited in (Ademola, 2018). Nigeria's real Gross Domestic Product (GDP), measured in 1990 basic prices, grew by 7.4 per cent in 2011, compared with 7.9 per cent in 2010 (NBS, 2011) in (Mohammed et al, 2011). According to Mohammed et al, (2011), the major contributors to this growth were: "services, agriculture, wholesale/retail, building/construction, oil & gas and industry sectors". The development was attributed largely to the conducive macroeconomic environment which included favourable credit conditions that enhanced the financing of the private sector, increased crude oil production and favourable weather conditions that boosted agricultural output, among others.

We recall that every economy wants to achieve four macroeconomic policy objectives namely: attainment of economic growth, price stability, full employment and favourable balance of

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payment. This paper has made attempt to examine some research issues of concern about selected macroeconomic variables that are used to evaluate or assess whether or not an economy can achieve its macroeconomic objectives over the years. One of the research issues is the presence of multicollinearity among the macroeconomic variables such inflation, unemployment, foreign Direct investment and economic growth in Nigeria. Bager, et al (2017) while addressing multicollinearity in regression model buttress that in 2005 Kabbani and Kothari determined the factors that contributed to the high rates of unemployment among young people in the Middle East and found that among the most relevant factors are the high demand for work places and the high rates of population growth. also Samuel (2016) conducted multicollinearity test on some Macroeconomic Variables and Shares' Performance at the Nairobi Securities Exchange and found inflation rate to highly correlated.

The objective of this paper is to examine and address multicollinearity issues present among inflation, unemployment, size of labour force and foreign direct investment and test their effects on economic growth in Nigeria using ridge regression estimation model. The justification for this remains that in many cases, macroeconomic variables or indicators are subject to multicollinearity. The paper contributes to the existing literature by paying attention to address issues of correlations existing in many macroeconomic models used in researches. This paper is organized as follows: section 1 is the introduction, Section 2 explains the concepts of general linear regression and multicollinearity. Section 3, deals with the methodology in which is OLS regression method is explained and in Section 4 we use different model specification method on sample data. Lastly, section 5 contains conclusions and recommendations.

1.2 Research Questions

1. What effects do Multicollinearity issues in Macroeconomic variables on Econometric Models?
2. How can Multicollinearity issues in Macroeconomic variables Econometric Models be addressed?

2. Review of Literature

2.1 General Regression Model

There is a large variety of regression models (i.e. simple, linear, non-linear) and their use depends on the specific type of problem that is studied. Multiple regression models are used when the response variable Y depends on a set of explanatory variables (X1,X2,…,Xk) (Bager, et al, 2017).The classical linear regression model is defined by a dependent variable (Y) explained through a set of multiple explanatory variables and it is a way of examining the nature

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and form of the relationships among two or more variables. Therefore, we refer to the two variables as the dependent variable (usually denoted by Y) and the independent or explanatory variables (usually denoted by X_i). /Values of Y can be predicted given different values of the explanatory variables X_i. Let us assume that $X_i$and Y_j are linked by a simple linear relationship:

$\in (Y_{jt}) = \beta_0 + \beta_i X_{it}$

Where $\in (Y_{jt})$denotes that average value of Y for given X and unknown population parameters β_0 and β_1 (the subscript t indicates that we have time series data).

Equation (1) is called the population regression equation. The actual value of Y_{jt}will not always be equal its expected value ($\in (Y_{jt})$). There are various factors that can disturb its actual behaviour and therefore we can write actual as:

$Y_t = \in (Y_{jt}) + U_t$……2

or

$Y_{jt} = \beta_0 + \beta_i X_{it} + U_t$……..3

Where U_t is known as the disturbance term.

The explanatory variables are not linked to each other by a complete or almost complete linear relationship; in addition, the number of parameters to be estimated should be less than the size of the sample under research.

COV(X_{it},X_{jt})=0∀i≠j Rank (X)=m+1<n

Violations of any of these hypotheses affect the quality of the estimators and therefore must be treated carefully, especially when the purpose of the research is statistical inference. Violations of any of these hypotheses affect the quality of the estimators and therefore must be treated carefully, especially when the purpose of the research is statistical inference

According to Ethington (2013), multicollinearity is a problem in multiple regression that develops when one or more of the independent variables is highly correlated with one or more of the other independent variables. If one independent variable is a perfect linear combination of the other independent variables; that is, if it is regressed on the other independent variables and the resulting R^2 = 1.0, then the matrix of intercorrelations among the independent variables is singular and there exists no unique solution for the regression coefficients.If, however, the independent variables are not perfectly correlated, but only highly correlated, there exists a

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solution for the regression coefficients but the estimates, while unbiased, are unstable, and their standard errors are typically large. (As a rule of thumb, if reading an article or seeing a presentation, whenever you see estimated beta weights larger than 1.0, you should consider the possibility of multicollinearity.

2.2 Multicollinearity

Multicollinearity is a multivariate problem, not a bivariate problem as it involve many variables. That means that a simple perusal of the bivariate correlation matrix is not sufficient to eliminate consideration of the problem of multicollinearity (Ethington, 2013), The problem is not only that two independent variables are highly correlated, but that one independent variable is highly correlated with all of the other independent variables. That means we need Thus, it is 1 - R^2, with the R^2 resulting from regressing that particular independent variable on all other independent variables. Another clue is provided by the covariance matrix among the regression coefficients. If these are "large", it indicates a problem of multicollinearity. However, the use of the variance inflation factors (VIF) is the most reliable way to examine multicollinearity. As a rule of thumb, if any of the VIF are greater than 10 (greater than 5 to be very conservative) there is a multicollinearity problem. Prior to estimating the regression equations, if you notice that any of the bivariate correlations among the independent variables are greater than .70, you may be facing the problem of multicollinearity. But even that rule of thumb is subject to debate. Use the VIF (Ethington, 2013),

In a nutshell, Multicollinearity is detected through the following measures:

i. High Correlation Coefficients

Pairwise correlations among independent variables might be high (in absolute value). Rule of thumb: If the correlation > 0.8 then severe multicollinearity may be present.

ii. High R^2 with low t-Statistic Values

Possible for individual regression coefficients to be insignificant but for the overall fit of the equation to be high.

iii. High Variance Inflation Factors (VIFs)

A VIF measures the extent to which multicollinearity has increased the variance of an estimated coefficient. It looks at the extent to which an explanatory variable can be explained by all the other explanatory variables in the equation. The Detection of Multicollinearity.

The Consequences of Multicollinearity

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i. Imperfect multicollinearity does not violate Assumption 6. Therefore the Gauss- Markov Theorem tells us that the OLS estimators are BLUE. So then why do we care about multicollinearity?

ii. The variances and the standard errors of the regression coefficient estimates will increase. This means lower *t*-statistics.

iii. The overall fit of the regression equation will be largely unaffected by multicollinearity. This also means that forecasting and prediction will be largely unaffected.

iv. Regression coefficients will be sensitive to specifications. Regression coefficients can change substantially when variables are added or dropped

Remedies for Multicollinearity

No single solution exists that will eliminate multicollinearity. Certain approaches may be useful:

i. **Do Nothing:** Live with what you have.

ii. **Drop a Redundant Variable:** If a variable is redundant, it should have never been included in the model in the first place. So dropping it actually is just correcting for a specification error. Use economic theory to guide your choice of which variable to drop.

iii. **Transform the Multicollinear Variables:** Sometimes you can reduce multicollinearity by re-specifying the model, for instance, create a combination of the multicollinear variables. As an example, rather than including the variables GDP and population in the model, include GDP/population (GDP per capita) instead.

3. Methodology

3.1 Source of data and Model Specification

For this study, the data on the real Gross Domestic Product (Rgdp), Inflation Rate (inftr), Unemployment (Ur), Size of labour Force (Slf) and Foreign Direct Investment (Fdi) were obtained from the Central Bank of Nigeria (CBN), National Bureau of statistics (NBS) and World Bank. Kolawole (2022) examined the Effect of Unemployment on Nigeria's Economic Development and found a significant inverse relationship between the variables , Kayode (2015) studied the relationship between inflation and unemployment in Nigeria and found that inflation and unemployment shows a negative relationship in Nigeria economy in the short and long-run. Mohammed, Y., Okoroafor, O.K. and Awe, E.O. (2015) Analyzed the relationship between inflation, unemployment and economic Growth in Nigeria and revealed the existence of a causal linkage between inflation, unemployment and economic growth in Nigeria. In this paper, we

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tried to adopt a model of economic growth with inflation and unemployment as explanatory variables but also modified the model by adding the foreign direct investment and size of labour force as used by Bager et al (2017). Our model specification is as follows:

Rgdp=f(infr, ur, slf , fdi)

$Rgdp_t = \beta_0 + \beta_i infr_t + \beta_i ur_t + \beta_i slf_t + \beta_i fdi_t + U_t$

where

$Rgdp_t$ is the dependent variable and a measure of economic growth

$infr_t$ is inflation rate and one the explanatory variables. Other explanatory variables are:

ur_t is unemployment rate, slf_t is the size of labour force and fdi_t is the foreign direct investment.

Time series data from 1990 to 2021on the variables under study was used leading to a sample size of 31 observations. In the variables selection process, the study adopted Bager et al (2017) by neglecting the potential correlations existing between independent variables, since one of the purposes of this paper was to test the performance of the regression model, when there is multicollinearity.

4. Results and Discussion

The section consists the descriptive analysis, unit root test, multicollinearity test of the data. It also presents the OLS results of the models used for the study.

Table 1: Descriptive Statistics

Variable	N	Mean	Std. Deviation	Minimum	Maximum
RGDP	31	41773403	31069664	16826.89	174000000
INFr	31	18.03063	16.37743	5.380000	72.84000
UR	31	5.634063	3.111718	1.800000	10.40000
SLF	31	48746706	11147705	31936586	70620041
FDI	31	5270000000	46600000000	5.83E+09	1.38E+12

Source: Author's computation using Eviews 10

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Table 1 above shows the descriptive statistics of the variables of the model, in order to describe the nature of the variables under study. The following are the descriptive analyses of for each variable of the model. The mean Real GDP is 41773403 with the standard deviation 31069664 while the lowest value is 16826.89 and the highest value is 174000000 The mean inflation rate is 18.03% with the standard deviation 16.4 %, while the lowest value was 5.4% and the highest value was 72.8 %.. Mean unemployment rate in the sample was 5.6%%, with the standard deviation 3.1%, while the lowest value is 1.8% and the highest value is 10.%.. the mean size of labour force as 48746706 with the standard deviation of 11147705, the highest value is 70620041while the lowest value is 31936586.The results of the descriptive statistics show that the mean of the foreign Direct Investment is 52700000000 naira with the standard deviation of 4660000000,

After the descriptive test, K.M.O test was conducted to determine the sufficiency of the data. The condition is that the acceptable score should be greater than 0.5 for the sample size to be sufficient. The value of the K-M-O statistic is equal to 0.65, implying that the size of the sample used for the analysis is sufficient**.**

4.2 Unit Root Test Results

Prior to the estimation of the regression model, this paper investigated the integration properties of each of the variables by applying unit-root testing procedure. The results show that it is only the real GDP (RGDP) that is significant (stationary) at level but all the explanatory variables are stationary at first difference and at all significant levels except that of the size of labour force (Slf) which is stationary at the first difference I(1) but at 5% level of significance. The results of the unit root tests are shown on table 1 below:

Table 2: Unit root Test

ADF			
Variables	**Level**	**1st Difference**	**Stationarity**
RGDP	-4.963315***		I(0)
Infr	-2.11750700000	-4.523427***	I(1)
Ur	-1.45-0.917780	-6.422006***	I(1)
Slf	-1.95 1.621980	-2.791074**	I(1)
Fdi	0.192-0.928306	-7.248228***	I(1)

***, ** and * indicate 1%, 5% and 10% levels of significant respectively.

Source: Author's computation using Eviews 10

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Note: the intercept terms are included in the test equations and the AIC is used to select the optimal lag order in the ADF test equations.

4.3 Multicollinearity Test Results

Multicollinearity diagnostic tests were conducted given the fact that it is possible for explanatory variables to exhibit collinearity among themselves. This test was conducted using correlation analysis and variance inflation factor. The correlation analysis which examines a degree of correlation between any two explanatory variables in the same model. The multicollinearity tests results are:

Table 3: Multicollinearity Test

	Infr	Ur	Slf	Fdi
Infr	1.000000	0.394	.418	0.371
Ur	-0.393	1.000000	0.813	0.805
Slf	-.418	0.813	1.000000	0.772
Fdi	-0.371	0.805	0.772	1.000000

Source: Author's computation using Eviews 10

Table 3 shows the results of the pairwise correlations among the variables under study. The results indicate presence of multicollinearity in all the model between slf and ur. Thus, it is evidence of the existence of severe multicollinearity.

4.4 Variance Inflation Factor

The measures used for testing the existence of the multicollinearity in the model are, as previously described, CN and VIF. These indicators were computed for the regression parameters of all the explanatory variables of the model. The multicollinearity between the explanatory variables was revealed, as proven by the following results:

Table 4: Variance inflation factor (VIF) Test

Variables	VIF
INFR	2.761226
UR	16.89444
SLF	70.79468
FDI	7.496528
C	44.15545

Source: Author's computation using Eviews 10

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We notice from Table 4 that the values of the VIF for some of the explanatory variables (Ur and Slf) are greater than 10 and these variables suffer from inflation in the variance of their parameters: two variables are the cause of the multicollinearity problem. This means that there is multicollinearity between these explanatory variables and in the following

4.5 OLS Results for Model I

$Rgdp_t = \beta_0 + \beta_1 infr_t + \beta_2 ur_t + \beta_3 slf_t + \beta_4 fdi_t + U_t$……..1

Table 5: OLS Results 1

Variable	t-Statistic	Prob.
INFR	0.402438	0.6905
UR	0.123806	0.9024
SLF	1.128295	0.2691
FDI	1.603845	0.1204
R-squared		
0.452551		

Source: Author's computation using Eviews 10

Table 5 shows the OLS estimation of the general model containing all the variables under study. It was noticed in tables 3 and 4 that multicollinearity is present in the model and the affected variables are the unemployment rate and the size of labour force. From the results, none of the explanatory variables has a significant impact on the dependent variable (i.e RGDP-Economic Growth). The insignificance of the variables may be due to the presence of multicollinearity in the model as this could be seen from the R-squared value of 0.452551 implying that the model is not a good fit. To address this problem, one of the most highly correlated variables is removed thereby reducing the number of the explanatory variables to 3 as presented in model 2

4.6 OLS Results for Model II

$Rgdp_t = \beta_0 + \beta_1 infr_t + \beta_2 ur_t + \beta_3 fdi_t + U_t$…….2

Table 6: OLS Results 2

Variable	t-Statistic	Prob.
INFR	1.168357	0.2522
UR	-2.782399	0.0452
FDI	2.979458	0.0373
R-squared	0.408041	

Source: Author's computation using Eviews 10

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Table 6 shows that unemployment rate and FDI are significant at 5% while inflation rate still remains insignificant. The OLS results of this model gave more reliable results than the ones given by Model one. This is because multicollinearity does not exist in model 2. The result shows that unemployment has a negative and significant impact on Economic Growth ion Nigeria. Also noted is the change in the value of R-squared which is 0.608041 in model 2 implying that the model is fairly good.

4.7 OLS Results for Model III

$Rgdp_t = \beta_0 + \beta_1 infr_t + + \beta_2 slf_t + \beta_3 fdi_t + U_t$……..1

Table 7: OLS Results 3

Variable	t-Statistic	Prob.
INFR	0.401780	0.6909
SLF	1.385624	0.1768
FDI	1.926783	0.0442
R-squared	0.552240	

Source: Author's computation using Eviews 10

Table 7 shows that only FDI is significant at 5% while inflation rate and size of labour force still remain insignificant. The OLS results of this model is still better than the ones given by Model1 because of absence of multicollinearity in model 3. The result shows that size of labour force has a positive but insignificant impact on Economic Growth in Nigeria. Also noted is the change in the value of R-squared which is 0.552240 in model 3 implying that the model is better than model 1.

4.8 Addressing the Research Questions

Research Question One: What effects do Multicollinearity issues in Macroeconomic variables on Econometric Models?

Table 5 shows the OLS estimation of the general model containing all the variables under study. It was noticed in tables 3 and 4 that multicollinearity is present in the model and the affected variables are the unemployment rate and the size of labour force. From the results, none of the explanatory variables has a significant impact on the dependent variable (i.e RGDP-Economic

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Growth). As a results of the multicollinearity in the model, all the explanatory variables are insignificant based on the values of t-statistics and probability values as shown in table 5 above.

Research Question Two: How can Multicollinearity issues jn Macroeconomic variables Econometric Models be addressed?

The results obtained in Table 6 shows that unemployment rate was used in the model while the size of labour force was removed as a result of which both unemployment and FDI are significant at 5% while inflation rate still remains insignificant. The OLS results of this reduced model gave more reliable results than the ones given by Model one.

5. Conclusion and Recommendation

In this paper, the multicollinearity issues in regression models are the subject under research, In an attempt to find practical solutions to deal with this violation of a regression model assumption. The solution adopted in our research is the removal of one of the correlated variables in the model and using each of them in a separate model. The study showed that in the cases when explanatory variables are affected by multicollinearity dealing with them in separate models can be one of the successful ways to solve this issue applying the method used in this paper is simple and is recommended in other studies since it provides better estimators than the when the explanatory variables are related and still used a single econometric model.

By applying the method of using each of the correlated variables in a separate model, the paper found that there are two variables with a significant impact on Economic Growth in Nigeria which are unemployment and foreign direct investment while inflation and size of labour force have no significant impact on economic growth in all the models used in this study. The paper recommend the removal of the correlated variables and fitting them in separate models to reduce the multicollinearity problem so as to produce the best possible model that will address the problem under study.

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