PANEL REGRESSION MODEL ON THE IMPACT OF SOME SELECTED MACROECONOMICS VARIABLES ON GROSS DOMESTIC PRODUCT IN AFRICAN COUNTRIES

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ABSTRACT

The Gross Domestic Product (GDP) of a country is a key indicator of its economic performance and growth. In Africa, understanding the factors that influence GDP is crucial for policymakers to make informed decisions that promote economic development. This study aims to investigate the impact of these selected macroeconomic variables on GDP in African countries using panel regression analysis. The study investigates the relationship between selected microeconomic variables and gross domestic product in African countries. Using panel regression models, the study analyzes the impact of consumer price index (CPI), interest rate (IR), exchange rate (ER), and trade balance (TB), on GDP across 54 African countries over the period 2010-2023. The study specifically employs pooled regression, fixed effects (FE), and random effects (RE) models. The Hausman specification test result revealed that the fixed- effect model is more efficient for modelling the impact of some selected microeconomic variables (Housman specification test statistic = 21.063, $p < 0.05$). The study revealed further that CPI has positive and insignificant impact on GDP (B_1= 0.016, $p>0.05$) while IR and ER has negative and insignificant impact on GDP (B_2 = -0.414, $p >0.05$ and B_4 = -0.005, $p >0.05$). The study also revealed that trade balance has positive and significant impact on GDP (B_3= 3.748, $p<0.05$). This implies that increase in trade balance significantly increase gross domestic product of Africa countries for the period under study. Based on these findings, it was recommended that government should improve monetary and fiscal policies and also promotes economic stability.

Keywords: *Economic Growth, Fixed Effect, Microeconomic Variables, , Panel Data and Random Effect.*

1.0 INTRODUCTION

Panel data is a type of data structure that includes a collection of people (households, businesses, and local government representatives) who have been watched across a number of time periods (Hsiao, 2014). There are three benefits to having access to data on the individual and temporal dimensions when it comes to cross-sectional data. The presence of unobservable heterogeneity can

ISSN NUMBER: 1116-249X

be taken into consideration thanks to the extra knowledge about the utilization of the data's individual dimensions. The estimations' accuracy is increased by the increasing sample sizes.

Panel regression models, sometimes referred to as longitudinal or panel data models, are a type of statistical and economic models used to examine data gathered over time for several people, businesses, nations, or other entities (Baltagi, 2020). In order to investigate the interactions between variables and monitor changes over time, these models are extensively utilized in sociology, economics, finance, and other social sciences.

A crucial stage in characterizing the relationships between the dependent and independent variables in panel regression models is parameter estimation, which empowers researchers to reach defensible conclusions and wise choices. Estimating the coefficients that represent the strength and direction of the correlations between variables is part of this procedure.

Countries' integration into the global economy is frequently cited as a key contributor to rising incomes and economic expansion. In addition to strengthening the world economy, international trade can play a significant role in a nation's economic development. International trade facilitates the efficient allocation of resources, allows a nation to achieve economies of scale, disseminates knowledge, advances technology, and increases competition in both domestic and foreign markets, all of which contribute to the development of new products and the optimization of production processes (Blavasciunaite et al, 2022). The measurement of the difference between a nation's imports and exports of commodities and services over a given time period provides an explanation of trade balance. The tangible balance, which shows the difference between export revenue and import expenses, is part of the trade balance (Nga, 2020).

ISSN NUMBER: 1116-249X

The price of one nation's currency represented in terms of another is known as the exchange rate. It establishes the strength of the external sector's involvement in global trade as well as the relative costs of domestic and foreign commodities. As more economies embrace trade liberalization as a necessary condition for economic success, interest rates and exchange rate regimes continue to be significant topics of discussion in both emerging and international finance (Obansa et al, 2013).

Interest rate changes have an impact on all macroeconomic variables, including GDP, price levels, employment levels, the international balance of payments, the pace of economic growth, and more. They can also reveal the fundamental state of the macroeconomy's operation. It goes without saying that the interest rate is a significant economic factor that affects both macro and microeconomic activity (Khurshid, 2015).

Oyeleke (2018) examined the average price behavior of a basket of goods and services, including food, housing, healthcare, education, and transportation, is examined by the consumption price index (CPI). Finding the changes in the costs of different commodities and services that reflect a representative sample of national consumption is the primary goal of the CPI. Additionally, price changes for each item in the predefined basket of goods and services are used to construct the CPI.

Growth of the gross domestic product (GDP) is often regarded as the main goal of economic policy, impacting choices about taxation, public spending, and fiscal and monetary policy (Al-kasasbeh et al, 2022). GDP facilitates worldwide comparisons and informs policy decisions by acting as a standard for assessing a nation's economic stability, competitiveness, and global influence (Nikolic & Krajisnik, 2019). Since GDP estimates serve as the foundation for resource allocation and economic policymaking, their precision and dependability are essential.

ISSN NUMBER: 1116-249X

On empirical basis, using panel regression models, Tanko et al. (2024) investigated how trade openness and energy consumption affected economic growth in a few Sub-Saharan African (SSA) nations. From 2010 to 2022, the World Bank Data Base provided the study's data. Pooled Regression, Fixed Effect (FE), and Random Effect (RE) regression models were used to examine the gathered data. According to the results of the Hausman specification test, the random effect model is more effective at simulating how trade openness and energy consumption affect economic growth in SSA countries (Housman specification test statistic = 5.31, $p > 0.05$). The investigation also showed that the data had cross-sectional independence and a random effect. Furthermore, it was shown that both energy usage and trade openness have negative and significant impact on economic growth of selected SSA Countries

Ogunmuyiwa & Akinlo (2016) examined how the stock market is affected by macroeconomic factors. For the study, a sample of fifty (50) quoted companies from eight (8) significant market sectors was chosen. From 2007:1 to 2013:12, monthly data from the Central Bank of Nigeria (CBN) and the Nigeria Stock Exchange (NSE) were subjected to the static panel regression technique. The study's findings demonstrated a substantial correlation between the sampled companies and macroeconomic indicators in Nigeria, as well as a relationship between firm share returns and these variables. The results of the pooled, fixed, and random regressions confirm that the most important macroeconomic factors influencing changes in share returns and stock market prices are the inflation rate, interest rate, and exchange rate.

Sun & Gou (2022) conducted a study to evaluate the panel regression method's applicability to economics and the influence of human capital and technological innovation on firm value. Using data from listed IT companies from 2018–2021 as samples, the Stata-based panel regression method was used to examine the impact of human capital and technological innovation on

ISSN NUMBER: 1116-249X

company value. Lastly, the study discovered that both technology innovation and human capital may greatly increase firm value, and that the panel regression method and economics work well together.

Rjoub *et al* (2017) looked at the connection between a number of micro and macro factors and the stock prices of Turkish banks. From the third quarter of 1995 to the fourth quarter of 2015, the study was conducted using a fixed panel data analysis and the Dumitrescu and Hurlin panel Granger causality test. Generally speaking, bank stocks may be accurately priced using both macro and micro factors. In particular, the results demonstrate a considerable relationship between stock price and asset quality, management quality, earnings, size, money supply, and interest rate. Additionally, a two-way causal relationship between bank stock price, money supply, asset quality, and bank size were discovered. In other words, when making a selection, investors should consider information relevant to a bank. Furthermore, the outcome shows that bank stock prices have a negative response to economic crises.

Using the system general method of moment (GMM) dynamic panel data estimator, Bayar (2019) investigated the macroeconomic, institutional, and bank-specific determinants underlying nonperforming banking loans as a measure of how well the banking sector functioned in emerging market economies between 2000 and 2013. The dynamic panel regression analysis's findings demonstrated that nonperforming loans were negatively impacted by economic growth, inflation, economic freedom (institutional development), return on equity and assets, regulatory capital to risk-weighted assets, and noninterest income to total income, while they were positively impacted by public debt, unemployment, credit growth, lagged values of nonperforming loans, the cost to income ratio, and financial crises.

ISSN NUMBER: 1116-249X

Nga (2020) concentrated on analyzing the factors that influence Vietnam's trade balance. Vietnam has a very high level of trade openness and has significantly increased the volume of its imports and exports in recent years. The study concludes that foreign direct investment had a significant and adverse impact on the trade balance using the sample and secondary data collected from the General Statistics Office, the State Bank of Vietnam, publications, and other Vietnamese data with the theoretical framework of trade balance. The data covered the period from 2005 to 2018. This outcome shows that a rise in FDI could make the trade balance worse. The trade balance is significantly and negatively impacted by economic openness. Lastly, the exchange rate has had a negligible impact on the shift in trade. from the empirical literature reviewed, it was observed that there is no specific study that has examined the impact of consumer price index, interest rate, exchange rate and trade balance on GDP across 54 African countries. This necessitated the current study.

2.0 MATERIALS AND METHODS

2.1 Data and Variables

The data use in this research were sourced from World Bank Data Base from year 2010-2023, which comprises of data from GDP, CPI, IR, EXR and TB of all the fifty-five Africa countries. The models used in this research include; Fixed Effect (FE) regression, Random Effect (RE) regression and pooled regression.

2.2 ESTIMATION OF PANEL DATA REGRESSION

Techniques for estimating panel data regression models include:

Common Effect Model or Pooled Least Square

In pooled regression, the data are aggregated and used to estimate a single model. This is predicated on the idea that variable relationships are constant between groups. Additionally, there are two

ISSN NUMBER: 1116-249X

primary forms of pooled regression: Generalized Least Squares (GLS), which takes heteroscedasticity and/or correlation between mistakes into consideration, and Pooled Ordinary Least Squares (POLS), which assumes homoscedasticity and no correlation between errors. The model is expressed as follows:

$$Y_{it} = \theta + \beta_i X_{it} + \varepsilon_{it} \quad (1)$$

Where:

Y_{it}= is the dependent variable for individual i at time t; X_{it} = is the vector regressors for individual i at time t; θ = is the individual specific effect (fixed or random); β_i is the vector of regression coefficient; ε_{it} = error term for individual i at time t; $N =$ the number of individuals or cross sections (Firm, Countries e.t.c.) and $T =$ the time period.

Fixed Effect Model

This model makes the assumption that individual differences can be accommodated by varying intercepts. Panel data uses a dummy variable technique to capture the variations between the intercepts of individual cross sections, which is then used to estimate the Fixed Effects model. The intercept, however, remains constant across different cross sections. This estimating methodology is frequently referred to as the Least Squares Dummy Variable (LSDV) technique. The ordinary least squares method is still applied by the Fixed effect model, which is distinct from the common effect (pooled regression). To capture the difference, more models are required than the assumption of modeling that yields a constant intercept for every cross section and time, as this is thought to be less realistic.

Fixed effects make the assumption that variations in intercepts can account for individual differences (cross section). The dummy variable technique is used to estimate the Fixed Effects

ISSN NUMBER: 1116-249X

Model with varied intercepts amongst individuals. These estimate models are commonly known as the Least Squares Dummy Variable methodology, or just LSDV for short. The Fixed Regression Model is expressed as follows:

$$Y_{it} = \theta_i + \beta_i X_{it} + \varepsilon_{it} \quad (2)$$

Where:

Y_{it}= is the dependent variable for individual i at time t; X_{it} = is the vector regressors for individual i at time t; θi = is the individual specific intercept effect (fixed); βi = is the vector of regression coefficient; ε_{it} = error term for individual i at time t; N = the number of individuals or cross sections (Firm, Countries e.t.c.) and T = the time period.

Random Effect Model

The error terms of each group in the Random Effect model account for the variation in intercepts. Heteroscedasticity is eliminated when the Random Effect model is applied. This approach is also known as the Generalized Least Square (GLS) technique or the Error Component approach (ECM). Random effect models, as opposed to fixed effect models, made the assumption that group-specific effects are uncorrelated and randomly distributed with respect to the independent variables. Also, rather than being estimated as fixed parameters, the group-specific effects are evaluated as random variables. This makes it possible to estimate the variance in the result caused by independent variables as well as individual differences between groups. The Random effect model is expressed as follows:

$$Y_{it} = \theta + \beta_i X_{it} + \lambda_i + \varepsilon_{it} \quad (3)$$

Where:

$\boldsymbol{Y_{it}}$= is the dependent variable for individual $\boldsymbol{i}$ at time $\boldsymbol{t}$; $\boldsymbol{X_{it}}$ = is the vector regressors for individual $\boldsymbol{i}$ at time $\boldsymbol{t}$; $\boldsymbol{\theta}$ = is the constant term; $\boldsymbol{\beta i}$ = is the vector of regression coefficient; λ_i is the random

ISSN NUMBER: 1116-249X

effect for group $\boldsymbol{i}$ (normally distributed with mean zero and variance $\boldsymbol{\sigma^2}$), $\boldsymbol{\varepsilon_{it}}$ = error term (normally distributed with mean zero and variance $\boldsymbol{\sigma^2}$).

2.3 Model Specification

The impact of trade balance (TB), exchange rate (EXC), interest rate (IT), and consumers price index (CPI) on economic growth were represented using the functional form of the model for Pooled, fixed and random effect model respectively as below:

$$GDP_{it} = = \theta + \beta_1 CPI_{it} + \beta_2 IR_{it} + \beta_3 EXC_{it} + \beta_4 TB_{it} + \varepsilon_{it} \quad (4)$$

$$GDP_{it} = = \theta_i + \beta_1 CPI_{it} + \beta_2 IR_{it} + \beta_3 EXC_{it} + \beta_4 TB_{it} + \varepsilon_{it} \quad (5)$$

$$GDP_{it} = = \theta + \beta_1 CPI_{it} + \beta_2 IR_{it} + \beta_3 EXC_{it} + \beta_4 TB_{it} + \boldsymbol{\lambda_i} + \varepsilon_{it} \quad (6)$$

Where;

GDP_{it} = is the gross domestic product for Country $\boldsymbol{i}$ at time $\boldsymbol{t}$;

CPI_{it} = is the consumers price index for Country $\boldsymbol{i}$ at time $\boldsymbol{t}$;

$\boldsymbol{IRit =}$ is the interest rate for Country $\boldsymbol{i}$ at time $\boldsymbol{t}$;

EXC_{it} = is the exchange rate for Country $\boldsymbol{i}$ at time $\boldsymbol{t}$;

TB_{it} = is the trade balance for Country $\boldsymbol{i}$ at time $\boldsymbol{t}$;

$\boldsymbol{\theta}$ = is the intercept

θ_i = is the Country specific intercept effect (fixed)

$\boldsymbol{\beta_1}$ $\boldsymbol{\beta_2}$ $\boldsymbol{\beta_3}$ and $\boldsymbol{\beta_4}$= Vector of Regression Coefficient

$\boldsymbol{\mu_i}$ = is the random effect for group $\boldsymbol{i}$ (normally distributed with mean zero and variance $\boldsymbol{\sigma^2}$).

$\boldsymbol{\varepsilon_{it}}$ = error term (normally distributed with mean zero and variance $\boldsymbol{\sigma^2}$).

ISSN NUMBER: 1116-249X

3.0 RESULTS

Table 1: Summary Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP	756	2609.193	3263.189	199.581	19141.512
CPI	756	427.485	2323.476	66.211	38796.559
IR	756	5.774	12.826	-82.979	61.883
TB	756	55.828	31.317	7.235	266.316
EXR	756	1097.898	3972.289	1.224	38565.68

Source: Extracted from STATA output

From Table 1, it can be observed that the overall number of observations for each variable is 770. This is because the study includes all the fifty -four (54) Africa countries with the study period of 14 years (2010 – 2023). The gross domestic product (GDP), consumers price index (CPI), interest rate (IT), trade balance (TB), exchange rate (EXC) has a mean value of 2609.193, 427.485, 5.774, 55.828, and 1097.898 resepctively. The minimum and maximum GDP were 199.581 and 19141.5`2; CPI were 66.211 and 38796.559; IT were -82.979 and 61.883; TB were 7.235 and 266.316; while that of EXC were 1.224 and 38565.68 respectively.

Table 2: Ordinary Least Square Regression Results (OLS)

	Coef.	Std. Error.	t-value	p-value	[95% CI]		Sig
CPI	-0.041	0.048	-0.85	0.398	-0.136	.054	
IR	-19.284	8.752	-2.20	0.028	-36.465	-2.103	**
TB	37.482	3.493	10.73	0.000	30.625	44.338	***
EXR	-0.075	0.028	-2.73	0.007	-0.129	-.021	***

Mean dependent var	2609.193	SD dependent var	3263.189
R-squared	0.150	Number of obs	770
F-statistic	33.810	Prob > F	0.000
Akaike crit. (AIC)	14528.128	Bayesian crit. (BIC)	14551.360

Source: Extracted from STATA output

Table 2 presents the OLS regression results of the impact of consumers price index, interest rate, trade balance and exchange rate on gross domestic product. The results revealed a coefficient of determination (R-square) value of 0.150 indicating that 15% of the total variation in the dependent

ISSN NUMBER: 1116-249X

variable is explained by the independent variables. The F-statistic = 33.810, $p < 0.05$ indicate that the overall model is significant suggesting that at least one of the independent variables is significant in predicting the dependent variable. The results revealed further that interest rate and exchange rate has negative and significant impact on gross domestic product (B_2 = -19.284, $p < 0.05$ and B_4 = -0.075, $p < 0.05$) while trade balance has positive and significant impact on gross domestic product (B_2 = 37.482, $p < 0.05$). However, consumer price index has negative and insignificant impact on gross domestic product (B_1 = -0.041, $p > 0.05$).

Table 3: Panel Regression Results for fixed effect (FE)

	Coef.	Std. Error.	t-value	p-value	[95% CI]	Sig	Coef.
CPI	.016	.017	0.94	.346	-.018	.051	
IR	-.414	3.769	-0.11	.912	-7.813	6.985	
TB	3.748	1.993	1.88	.06	-.166	7.661	*
EXR	-.005	.032	-0.15	.884	-.067	.058	
Constant	2400.44	122.032	19.67	0	2160.863	2640.034	***
Mean dependent var		2609.193	SD dependent var			3263.189	
R-squared		0.007	Number of obs			770	
F-test		1.177	Prob > F			0.180	

Source: Extracted from STATA output

Table 3 presents the regression results of fixed effect model on the impact of consumers price index, interest rate, trade balance and exchange rate on gross domestic product. The results of the analysis revealed that CPI has positive and insignificant while IR and EXC has negative and insignificant impact on GDP (B_1= 0.016, $p>0.05$, B_2 = -0.414, $p >0.05$ and B_4 = -0.005, $p >0.05$). This implies that increase in consumers price index, interest rate and exchange rate significantly decreased gross domestic product though statistically insignificant. The study also revealed that trade balance has positive and significant impact on GDP (B_3= 3.748, $p<0.05$). This implies that increase in trade balance significantly increase gross domestic product of Africa countries for the period under study.

ISSN NUMBER: 1116-249X

Table 4: Panel Regression Results for random effect (RE)

	Coef.	Std. Error.	t-value	p-value	[95% CI]	Sig	
CPI	.015	.017	0.88	.378	-.019	.05	
IR	-.757	3.773	-0.20	.841	-8.152	6.638	
TB	4.625	1.985	2.33	.02	.734	8.516	**
EXR	-.014	.031	-0.46	.646	-.074	.046	
Constant	2364.176	411.683	5.74	0	1557.291	3171.061	***
Mean dependent var		2609.193	SD dependent var			3263.189	
Overall r-squared		0.136	Number of obs			770	
Chi-square		6.687	Prob > chi2			0.153	
R-squared within		0.006	R-squared between			0.192	

Source: Extracted from STATA output

In table 4, the regression result based on RE model revealed that CPI has positive while IR and EXC has negative and insignificant impact on GDP (B_1= 0.015, p>0.05, B_2 = -0.757, p >0.05 and B_4 = -0.014, p >0.05). This implies that increase in consumers price index, interest rate and exchange rate significantly decreased gross domestic product. The study also revealed that trade balance has positive and significant impact on GDP (B_3= 4.625, p<0.05). This implies that increase in trade balance significantly increase gross domestic product of Africa countries for the period under study.

Table 5: **Hausman Specification and Diagnostic Test**

	TEST Statistic	**P-Value**	**Remark**
Hausman specification	21.063	0.0000	FE
Heteroskedasticity	418.73	0.0000	Present
Breusch-Godfrey LM test for autocorrelation at lag 1	618.177	0.0000	Present
Breusch-Godfrey LM test for autocorrelation at lag 12	624.241	0.0000	Present

Source: Extracted from STATA output

The Hausman specification test is used to determine whether to use fixed or random effect models because there is a trade-off between the consistency of the fixed effect (FE) approach and the efficiency of the random effect (RE) method. Therefore, the criterion used to choose between the two regression models and assess the effectiveness of fixed and random effect regression findings is prob>chi2. Fixed effect results are therefore more effective than random effects and will be

ISSN NUMBER: 1116-249X

chosen if prob>chi2 is less than 0.05. Conversely, the situation will be the opposite if prob>chi2 is greater than or equal to 0.05. The data analysis results shown in Table 5 showed a prob>chi2 values of 0.0000, which is less than 0.05. Thus, the fixed effect model was considered to be more efficient in modelling the impact of some selected microeconomic variable in all the Africa countries.

The findings of the diagnostic test indicated that the OLS models had heteroskedasticity. Nonetheless, the FE Model showed signs of groupwise heteroskedasticity and autocorrelation. Pesaran's test for cross-sectional independence yielded a p-value of less than 0.05, indicating the cross-sections' independence. The fixed effects are substantial, as indicated by the test statistic and p-value (624.241 and 0.0000, respectively) for the Breusch and Pagan LM test at lag 1.

Table 6: Multicollinearity Test using Variance Inflation Factor

Variable	VIF	1/VIF
Consumers price index	1.070	0.939
Interest rate	1.070	0.939
Trade balance	1.010	0.989
Exchange rate	1.010	0.989

Source: Extracted from STATA output

Variance inflation factor (VIF) was employed in this work to check if multicollinearity existed in the calculated OLS model. It will be challenging to distinguish between the distinct impacts of the explanatory variables when multicollinearity is present, and the OLS estimators may be biased or possibly have high variances (Murray, 2006). Multicollinearity should be assumed if the VIF is greater than 10 (Gujarati, 2003). In order to determine if the model's explanatory variables suffer from multicollinearity, this study used VIF. Since the VIF values were less than 10, the test results showed that multicollinearity was not present (Table 6).

ISSN NUMBER: 1116-249X

4.0 CONCLUSION AND RECOMMENDATIONS

This study employed panel regression models to investigate the impact of selected microeconomic variables (consumer price index, interest rate, exchange rate and trade balance on gross domestic product in African countries from 2010-2023. based on the Hausman specification test, the fixed-effect model is more efficient for modelling the impact of the selected microeconomic variables on gross domestic product in Africa. Based on this model, CPI has positive and insignificant impact on GDP while interest rate and exchange rate have negative and insignificant impact on GDP. However, trade balance has positive and significant impact on GDP. Based on these findings, it was recommended that government in African Countries should improve on monetary and fiscal policies and also promoting economic stability.

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