A Panel Data Modeling of the Impacts of Demographic Indicators on Human Development in Nigeria

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ABSTRACT

This study investigates the impact of demographic indicators on human development in Nigeria using panel data modeling approach. The study employed annual panel data spanning 1994-2024 across the six geopolitical regions in Nigeria. The annual data was sourced from National Bureau of Statistics (NBS), National Population Commission (NPC), Harmonized Nigeria Living Standard Survey (HNLSS) and Nigerian Demographic and Health Survey (NDHSS). The study employed descriptive statistics and normality measures, fixed effect model, random effect model and diagnostic tests. The descriptive statistics showed that HDI had the highest mean (347.01) and FLP had the lowest mean (98.60). The demographic indicators are positively skewed and leptokurtic in nature. The demographic indicators are not normal. The diagnostic tests revealed that random effect model is appropriate for modeling the demographic indicators in Nigeria and the presence of autocorrelation must be addressed to ensure valid inference. The study revealed that fertility rate (FR), urbanization rate (UR) and dependency ratio (DR) had negative impact whereas life expectancy at birth (LEB) and Female Labour participation (FLP) had positive impact on human development in Nigeria. The fixed and random effect model showed that 97.14% and 85.43% respectively of the variations in human development were explained by the demographic indicators (explanatory variables). The study concludes that LEB and FLP are important drivers of human development whereas FR, UR and DR hinders the growth of human development in Nigeria within the studied period. Based on the findings, It was recommended that government should prioritize healthcare financing, maternal and child health services, and policies enabling women's employment as life expectancy at birth and female labour force participation had positive impact on HDI. The software for estimation is E-Views.

Keywords: Panel data, Demographic indicators, Human development, Fixed effects and Random effect

1.0 Introduction

Isola and Alani (2012) examined the relationship between human capital development and economic growth employing time series econometric technique and a Solow Augmented model. In the study, the dependent variables were measured by GDP per growth while the independent variables include growth rate of labour, growth rate of capital, Structural Adjustment Programme and the human capital output method – Life literacy rate and Adult literacy rate.

Tartiyus *et al*. (2015) evaluated the impact of population growth on economic growth in Nigeria from 1980 to 2010 given that the impact of population growth on economic growth has always been a subject of disagreement among economists and given Nigeria's high rate of population growth. The data were analyzed using descriptive statistics as well as regression analysis. The result revealed that there is a positive relationship between economic growth (proxy by GDP growth) and population, fertility and export growth while negative relationships were found between economic growth (proxy by GDP growth) and life expectancy, and crude death rate. It was recommended among others that the average

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population growth rate of Nigeria should be maintained since it is found to impact positively on economic growth in Nigeria within the period of study and that measures should be adopted to check the crude death rate of Nigeria as it affects economic growth negatively.

Babatunde and Adefabi (2015) examined the long-run relationship between education and economic growth in Nigeria using the Johansen co-integration approach as a framework of analysis. The results of the co integrating technique suggest that there was long-run relationship between enrolments in primary and tertiary levels of education and the average years of schooling with output per worker. The study concluded that a well-educated labour force possessed a positive and significant impact on economic growth through factor accumulation and on the evolution of total factor productivity.

Aighokhan *et al.* (2015) analysed the impact of education expenditures on human capital development. The study used historical data to establish the correlation between public education expenditure and human capital development in Nigeria and noted that insufficient and uncertain budgetary allocations to education have resulted in the deterioration of its impact on human capital development. Education spending as percentages of annual budgets were low and unstable during the period studied.
Aidi *et al.* (2016) using more recent data investigated the relationship between population growth and economic growth in Nigeria. The researchers employed Granger- causality technique for the study and found that neither population the growth Granger-Cause economic growth nor economic growth Granger-Cause population during the period understudy

Ratna and Sari (2016) examined empirically the relationship between the health budget, human capital and population growth in Indonesia by using both quantitative and qualitative analysis. Their quantitative results from regression technique support the theory that there is significant no relationship between life expectancy and population growth, while their qualitative analysis is used to describe the role of formal and informal institutions, including financial institutions in reducing birth rates to improve human capital.

Istaiteyeh (2017) investigated the impact of socio-economic determinants (including per capita GDP, public spending on health, urban population, and secondary school enrolment) on life expectancy in Jordan. The study covers the period from 1990 to 2014 and employed Vector Auto-Regression technique (VAR). The empirical findings indicate that unemployment and secondary school enrolment explains longevity in Nigeria.

Ilori *et al*. (2017) examined empirical evidence of the specific impact of public health expenditure on life expectancy in Nigeria using time series data spanning between 1981 and 2014. Their study employs bounds testing co-integration and Autoregressive Distributed Lag (ARDL) procedures to determine the relationship between public spending on health and life expectancy in Nigeria. The results indicate that School Enrolment and carbon-dioxide emission significantly and directly influenced life expectancy in Nigeria, while School Enrolment was found to be insignificant in both short and long runs contrary to economic theory.

Dorian (2017) employing a neoclassical framework estimated a structural growth model in which he included education and health as explanatory variables. The study found a positive relationship between economic growth and health. The relationship between education and

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economic growth was found to be insignificant. Adebiyi and Oladele (2019) empirically investigated the relationship between public education expenditure and defense spending in Nigeria. The study employed the error correction mechanism and the vector autoregressive (VAR) models and found a negative trade-off between defense spending and public education expenditure.

Popoola (2018) empirically investigated the effects of population growth on average life expectancy in Nigeria taking into account the explicit role of healthy citizens in economic development as well as other control variables not considered in prior studies. Predicted on country-specific regression and Granger Causality test using time series data between 1986 and 2015, the findings reveal that rising population growth have positive and insignificantly impacts life expectancy, but 1% decrease in fertility rate and population of 65-and-above dependency ratio could positively stimulate an improvement in longevity by 5.84, and 81.5 respectively in Nigeria. Furthermore, the granger causality test shows that population growth could granger cause low life expectancy in Nigeria at least at 10% level of significance. The findings, therefore, make a case for strengthening efforts towards reducing both fertility rate and age 65 and above dependency ratio with priority given to the welfare of ages 65 and above population in Nigeria.

Nyoni (2018) examined the determinants of population growth in Pakistan from 1960 to 2017. Using the ordinary least squares technique, the study indicated that a 1% increase in contraceptive prevalence rate, life expectancy at birth and infant mortality decrease in population growth in Pakistan while a 1% increase in unemployment, total fertility rate and per capita income increase population growth in Pakistan.

Despite gains in global income, life expectancy, and school enrollment between 1960 and 2000, population growth still presents multifaceted challenges. These include heightened demand for essential goods and services, job creation, infrastructure expansion, and environmental protection. Although the notion of a global population “explosion” has lessened, concerns persist about specific regions, especially less developed areas where most future population growth will occur. Today, 84% of the global population resides in less developed regions, up from 68% in 1950 (Balcı and Özcan, 2019).

The world is undergoing profound demographic changes marked by rapid population growth, declining fertility and mortality rates, and shifts in population age structure. It took over 50,000 years for the global population to reach 1 billion, but since the 1960s, the pace has quickened, with billions added every few decades. By 2037, global population is projected to surpass 9 billion, although the annual growth rate has steadily declined from above 2% in the 1960s to about 1% today, and will likely fall further (Figueiras *et al*., 2020).

A study conducted to ascertain the impact of income inequality on GDP by Manyeki and Balázs (2020) utilizing an ARDL and secondary data ranges 1990 and 2015 discovered a positive but insignificant long-run impact of income inequality on GDP while positive and significant impact of income inequality on GDP in the short-run.

Ade-omonijo (2021) carried out a study investigating the cause effect relationship between income inequality, income, poverty and economic growth in Nigeria. Secondary data from yearly time series were used in this investigation. The acquired data was analyzed using econometric approaches, namely the ARDL bound test for long-run analysis and Phillip and Perron (PP) test for unit root test as well as the lag order of the ARDL models utilizing VAR

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lag selection criteria. It was established that, income inequality and poverty had inverse but insignificant influence on Nigeria economic growth.

Omolua and Tamunowariye (2021) investigated the impact of poverty as well as income inequality on Nigerian output growth from 1985 to 2020. Secondary sources for yearly time series data on the target variables were the CBN as well as WDI statistical bulletin (different years). ARDL method was used to evaluate the data and according to the ARDL estimations, the Gini coefficient (income inequality indicator) and the inflation rate coefficient show negative impact on RGDP but poverty rate coefficient had a positive impact on RGDP.

Chinonye (2022) demonstrated that income disparity has an inverse relationship with the country economic growth, but poverty had a positive impact on economic growth. Similarly, it was found that poverty and income disparity had an insignificant impact on Nigeria economic growth. The methodologies employed by the study were ADF test for stationarity, cointegration test for long-run relationship and ECM for short run dynamic analysis using annual secondary data spanning 1981 to 2019 which were sourced from NBS and CBN statistical bulletins.

Ibekwe and Ibekwe (2022) also evaluated the impact of wealth disparity on Nigerian economic development from 1981 to 2021. ADF unit root test, Ordinary least squares (OLS) approach of data analysis and ECM were employed for data analysis of the study while data were sourced from CBN Statistical Bulletin. It was discovered that; income inequality shows positive but no significant impact on Nigerian GDP while poverty shows inverse and significant impact on Nigerian GDP for the period of the study.

Omotor (2023) analyzed the determinants of federal government expenditures in the education sector in Nigeria using the ordinary least squares (OLS) methods. The study revealed that the trend in education expenditure in Nigeria is unstable which reflects the instability in government earning. Government revenue was the only significant determinant of education expenditures as revealed by the results of the regression. The study recommended a diversification of the sources of funding education so as to reverse the unstable trend in that sector.

Few studies (Risikat and Onyebuchi, 2022; Olabisi and Effiong, 2023) conducted in Nigeria looked at the impact of demographic indicators on economic growth and impact of human development on economic growth in Nigeria. But none of the literatures investigated the impact of demographic indicators on human development in Nigeria. Therefore, this current study fills the gap in the existing literatures by investigating the impact of demographic indicators on human development in Nigeria using Panel data modeling technique (fixed effect and random effect model). The remaining part of the paper are arranged as follows: Panel data models are specified in section 2, section 3 presents the result obtained from the utilization of the stated model in section 2. Discussions of results are done in section 4 and concluding remarks are in section 5.

2.0 Methods

2.1 The Data

The data is obtained from National Bureau Statistics (NBS), Harmonized Nigeria Living Standard Survey (HNLSS), Nigerian Demographic and Health Survey (NDHSS) and National Population Commission (NPC) and spanned from 1994 to 2024 (30 years). The

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demographic indicators are Life Expectancy at Birth (LEB), Fertility Rate (FR), Urbanization Rate (UR), Female Labour Force Participation Rate (FLP) and Dependency Ratio (DR). The software for estimation is E-Views.

2.2 The Models

2.2.1 The Fixed Effect of Model (FEM)

The central premise of the FEM is that individual-specific effects are correlated with the explanatory variables (Greene, 2018). The basic structure of the FEM can be written as:

$$y_{it} = \alpha_i + \boldsymbol{X}'_{it}\beta + \varepsilon_{it},\ i \in \{1, 2, \dots, N\}, t \in \{1, 2, \dots, T\} \quad (1)$$

where y_{it} = denotes the dependent variable for individual i at time t; α_i = time-invariant, entity-specific intercept; $\boldsymbol{X}_{it} \in \mathbb{R}^k$ = k-dimensional column vector of explanatory variables; $\beta \in \mathbb{R}^k$= vector of unknown parameters to be estimated; ε_{it} = idiosyncratic error term assumed to satisfy $E(\varepsilon_{it}|\boldsymbol{X}_{it}) = 0, Var(\varepsilon_{it}) = \sigma^2$ and no serial correlation.

2.2.2 The Random Effect (RE) Model

According to Baltagi (2021), consider a balanced panel with $i = 1, 2, \dots, N$ cross-sectional units observed over $t = 1, 2, \dots, T$ periods. The random effects model is specified as in Equation (2)

$$y_{it} = \alpha + \boldsymbol{X}'_{it}\boldsymbol{\beta} + u_i + e_{it} \quad (2)$$

where, y_{it} = dependent variable for unit i at time t, α = common intercept, $\boldsymbol{X}'_{it} = (k \times 1)$ vector of explanatory variables, $\boldsymbol{\beta}$ = vector of slope parameters to be estimated, u_i = unobserved individual-specific random effect and e_{it} = idiosyncratic error term

2.3 Diagnostic Test

2.3.1 Test of Multicollinearity

Multi-collinearity refers to the situation in regression analysis where two or more explanatory (independent) variables are highly correlated with each other. Consider the standard panel model as in Equation (3)

$$y_{it} = \alpha_i + \boldsymbol{x}'_{it}\boldsymbol{\beta} + \varepsilon_{it,}\ i = 1.2, \dots, N,\ t = 1, 2, \dots, T \quad (3)$$

where $\boldsymbol{x}'_{it} = (x_{1,it}, x_{2,it}, \dots, x_{k,it})'$, $\boldsymbol{\beta} = (\beta_1, \beta_2, \dots, \beta_k)'$. For each regressor x_k, regress it on all the other independent variables (excluding the dependent variable):

$$x_{k,it} = \delta_0 + \sum_{j \neq k} \delta_j x_{j,it} + \varepsilon_{it} \quad (4)$$

Stack over all i and t (pooled regression), or use within-transformed data (for fixed effects model). If R_j^2 is the coefficient of determination from the regression above, the variance inflation factor (VIF) is computed as shown in Equation (5)

$$VIF_j = \frac{1}{1 - R_j^2} \quad (5)$$

This is done for each regressor $j = 1, 2, \dots, k$.

2.3.2 Breusch-Pagan Lagrange Multiplier Test

Consider the panel data model:

$$y_{it} = \boldsymbol{x}'_{it}\boldsymbol{\beta} + \alpha_i + \varepsilon_{it}$$

where y_{it} is the dependent variable for entity i at time t, $\boldsymbol{x}'_{it}$ is a vector of explanatory variables, $\boldsymbol{\beta}$ is vector of parameters, α_i are random individual-specific effect and ε_{it} is the idiosyncratic error term. Run a pooled OLS regression ignoring the panel structure as:

$$y_{it} = \boldsymbol{x}'_{it}\boldsymbol{\beta} + u_{it}$$

Obtain residuals as:

$$\hat{u}_{it} = y_{it} - \boldsymbol{x}'_{it}\hat{\beta}_{OLS} \quad (6)$$

Compute the average residual for each individual i and compute the variance of the residuals as shown in Equation (7) and (8)

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$$\bar{u}_i = \frac{1}{T}\sum_{i=1}^{T} \hat{u}_{it} \quad (7)$$

$$\hat{\sigma}_u^2 = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T} \hat{u}_{it}^2 \quad (8)$$

The Breusch-Pagan LM test statistic is computed as shown in Equation (9)

$$LM = \frac{T^2}{2N}\left[\sum_{i=1}^{N} \bar{u}_i^2 / \hat{\sigma}_u^2\right] \quad (9)$$

This statistic follows a chi-squared distribution with 1 degree of freedom under the null:

$$LM \sim \mathcal{X}^2(1) \quad (10)$$

The decision rule is to reject H_0 if $LM > \mathcal{X}_{1,\alpha}^2$, the critical value of the chi-squared distribution at significance level α; or fail to reject H_0 if $LM \leq \mathcal{X}_{1,\alpha}^2$, implying that the pooled OLS model is appropriate. The test checks the following pair of hypothesis: $H_0: \sigma_\alpha^2 = 0$ (no random effects; pooled OLS is appropriate) versus $H_1: \sigma_\alpha^2 > 0$ (random effects exist; RE model is preferred).

3.0 Results and Discussions

The summary statistics reported in Table 1 revealed that Human Development Index (HDI) has a mean value of 347.01, with a minimum of 165.76 and a maximum of 616.70, suggesting moderate but widely varying level s of human development across the study period. Life Expectancy at Birth (LEB) averages 54.49 years, which is relatively low compared to global standards, and ranges between 42.48 and 56.04 years. Fertility Rate (FR) has an average of 95.76 births per 1,000 women, while Female Labour Participation (FLP) averages 98.60%, indicating a relatively high level of women's involvement in the labour market. Urbanization Rate (UR) and Dependency Ratio (DR) have mean values of 101.29% and 103.55% respectively, with wide variations across the data, reflecting fluctuations in demographic pressures and urban growth. The standard deviation for HDI (110.58) indicates notable variation, while LEB (30.91), FR (31.43), UR (60.65), DR (62.87), and FLP (36.18) equally show substantial variability, especially UR and DR, which highlight significant structural demographic imbalances. The skewness values reveal that all variables are positively skewed, with UR (7.36) and LEB (4.36) being highly skewed, implying the presence of extreme values in the distributions.

Table 1: Summary Statistics of Demographic Study Variables

	HDI	LEB	FR	UR	DR	FLP
Mean	347.01	54.49	95.759	101.29	103.55	98.60
Maximum	616.70	56.04	188.45	765.08	573.71	189.35
Minimum	165.76	42.479	17.613	17.273	18.345	19.383
Std. Deviation	110.58	30.914	31.434	60.654	62.872	36.178
Skewness	0.3881	4.3594	0.5129	7.3565	4.1057	0.7155
Kurtosis	2.4632	37.889	4.5580	80.956	26.462	3.5081
Jarque-Bera	6.6786	9699.8	26.101	47202	4634.2	17.294
p-value	0.0355	0.0000	0.0000	0.0000	0.0000	0.0002
N	180	180	180	180	180	180

Similarly, kurtosis statistics show that most variables are leptokurtic, with LEB (37.89), UR (80.96), and DR (26.46) being particularly peaked and heavy-tailed, further suggesting the influence of outliers.

From the model diagnostic checks reported in upper panel of Table 2, the Breusch–Pagan LM test reports a Chi-square statistic of 40.912 with a p-value of 0.0000, leading to the rejection

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of the null hypothesis of no panel effects. This means that the pooled OLS estimator is inappropriate, and a panel estimator (Fixed Effects or Random Effects) is preferred.

Table 2: Model Diagnostic Checks for Fixed Effects and Random Effects

Test	Statistic	Df	p-value	Decision (1% Level)
Breusch–Pagan LM	Chi-sq= 40.912	1	0.0000	Reject H_0: Pooled OLS rejected (panel effects exist)
Hausman	Chi-sq = 4.123	5	0.5312	Fail to reject H_0: Random Effects preferred over Fixed Effects

df = degree of freedom, p-value = probability value, Chi-sq = chi-square and LM = Lagrange Multiplier

The Hausman test result yields a Chi-square statistic of 4.123 with 5 degrees of freedom and a p-value of 0.5312, which is not statistically significant at the 1% level. Hence, the null hypothesis that the Random Effects model is consistent cannot be rejected. This suggests that the Random Effects specification is preferred over the Fixed Effects model, as it provides efficient estimates without evidence of systematic correlation between individual effects and the regressors.

The results of fixed effects model reported in Table 3 show that the fixed effects model has a strong explanatory power, with an R-squared of 0.971, indicating that about 97% of the variation in HDI is explained by the included variables. The adjusted R-squared of 0.963 further confirms the robustness of the model fit. The F-statistic (121.88) is highly significant ($p < 0.01$), suggesting that the demographic variables collectively have a strong effect on HDI.

Table 3: Parameter Estimates of Panel Fixed Effect Regression Model

Variable	Coefficient	Std. Error	t-Statistic	p-value	VIF	I/VIF
C	5.860856	0.099920	58.65564	0.0000	-	-
LLEB	0.551187	0.008045	68.51299	0.0000	4.1284	0.2422
LFR	-0.307298	0.019421	-15.82298	0.0000	3.5817	0.2792
LUR	-0.422012	0.016333	-25.83799	0.0000	2.6451	0.3781
LDR	-0.066628	0.016677	-3.995120	0.0001	2.1274	0.4701
LFLP	0.143860	0.016705	8.611793	0.0000	1.8932	0.5282
R-squared	0.971390					
Adj. R^2	0.963420					
F-statistic	121.8814					
Prob(F-stat.)	0.000000					
DW statistic	2.360314					

The Durbin-Watson statistic (2.36) indicates the absence of serious autocorrelation, supporting the reliability of the estimates. Life expectancy (LLEB) has a positive and significant coefficient (0.551), showing that a 1% increase in life expectancy is associated with a 0.55% rise in HDI. Female Labour Participation (LFLP) also exerts a positive and significant effect (0.144), implying that greater female involvement in the workforce improves human development outcomes. Fertility rate (LFR) and urbanization rate (LUR) both have negative and highly significant coefficients, with elasticities of -0.307 and -0.422 respectively, suggesting that higher fertility and rapid urban growth reduce HDI. The dependency ratio (LDR) also has a negative impact (–0.067), though relatively smaller compared to fertility and urbanization. The variance inflation factor (VIF) values are all below 5, and the inverse VIF values are close to 1, indicating that multicollinearity is not a problem.

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The results of random effects model reported in Table 4 demonstrates good explanatory power, with an R-squared of 0.854, suggesting that about 85% of the variation in HDI is explained by the demographic indicators.

Table 4: Parameter Estimates of Panel Random Effects Regression Model

Variable	Coefficient	Std. Error	t-Statistic	p-value	VIF	1/VIF
C	6.095295	0.365339	16.68394	0.0000	-	-
LLEB	0.498244	0.033775	14.75186	0.0000	3.8515	0.2596
LFR	-0.807065	0.080303	-10.05025	0.0000	3.1271	0.3198
LUR	-0.148678	0.062487	-2.379343	0.0052	2.4359	0.4105
LDR	-0.182519	0.065751	-2.775912	0.0012	2.0875	0.4790
LFLP	0.218092	0.063408	3.439503	0.0004	1.7762	0.5630
R-squared	0.854272					
Adj. R-squared	0.827096					
F-statistic	11.997050					
Prob(F-stat.)	0.000039					
DW statistic	2.074809					

The adjusted R-squared of 0.827 further confirms the robustness of the estimates. The F-statistic (11.99) is highly significant ($p < 0.001$), implying that the explanatory variables jointly have a strong effect on HDI. The Durbin-Watson statistic (2.07) indicates no evidence of serious autocorrelation, strengthening the reliability of the model. The coefficients, life expectancy (LLEB) has a positive and significant impact (0.498), indicating that a 1% increase in life expectancy leads to about a 0.50% rise in HDI. Female Labour Participation (LFLP) also exerts a positive and significant effect (0.218), suggesting that greater inclusion of women in the labour market enhances human development. Conversely, fertility rate (LFR) has the strongest negative influence (–0.807), showing that a 1% rise in fertility reduces HDI by about 0.81%. Both urbanization (LUR, –0.149) and dependency ratio (LDR, –0.183) are negatively signed and statistically significant, implying that rapid urban growth and high dependency burdens hinder improvements in human development. The variance inflation factor (VIF) values are below 5, with inverse VIFs close to 1, ruling out multicollinearity problems. The results indicate that life expectancy and female labour participation are key drivers of human development in Nigeria, while high fertility, urbanization, and dependency ratios remain significant constraints.

4.0 Conclusion

The Summary statistics of normality and measures of the demographic indicators exhibit considerable variability, skewness, and leptokurtosis, with strong evidence against normality. This has important implications for econometric modeling, as it underscores the need for robust estimation techniques or variable transformations to account for non-normal distributions. Overall, the findings highlight that improvements in life expectancy and female labour participation are key drivers of human development, while high fertility, dependency, and rapid urbanization hinder progress. The diagnostic checks confirmed that the Random Effects model is preferred over Fixed Effects, and the presence of autocorrelation must be addressed to ensure valid inference. The study recommended that government should prioritize healthcare financing, maternal and child health services and policies enabling women's employment such as childcare support since life expectancy at birth and female labour participation had positive impact on HDI.

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