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Estructura demográfica y crecimiento económico: Un análisis econométrico para África Occidental

Demographic structure and economic growth: An econometrics analysis for West Africa

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RESUMEN

La estructura demográfica desempeña un papel crucial en la configuración del crecimiento económico, especialmente en regiones que experimentan rápidos cambios demográficos. África Occidental, caracterizada por una población joven, altas tasas de fertilidad y urbanización, presenta tanto oportunidades como retos

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para el desarrollo económico. Si bien las transiciones demográficas pueden generar dividendos económicos, la ineficiencia de los mercados laborales y las inversiones inadecuadas en capital humano pueden obstaculizar el crecimiento. Este estudio examina el impacto de los factores demográficos en el crecimiento económico de África Occidental mediante análisis econométricos. Esta investigación emplea un modelo de regresión de datos de panel para analizar la relación entre el crecimiento económico (medido por el logaritmo del PIB per cápita en niveles) y variables demográficas clave, como la tasa de dependencia por edad, la tasa de participación en la población activa, el crecimiento demográfico, la urbanización, la esperanza de vida y el gasto sanitario. Se obtuvieron datos secundarios de 16 países de África Occidental entre 2000 y 2022 a partir de los Indicadores del Desarrollo Mundial. El estudio aplica el modelo de efectos aleatorios y la regresión por mínimos cuadrados ponderados para abordar la heteroscedasticidad y mejorar la eficiencia de las estimaciones. Los resultados revelan que una alta tasa de dependencia de la población de edad avanzada y un rápido crecimiento demográfico tienen un impacto negativo en el crecimiento económico, mientras que la urbanización y la esperanza de vida contribuyen positivamente. La participación en la población activa mostró un débil efecto negativo, lo que sugiere ineficiencias en el mercado laboral. Curiosamente, el aumento del gasto sanitario se asoció negativamente con el crecimiento, lo que indica posibles ineficiencias en la asignación de recursos. El estudio destaca la compleja relación entre la demografía y el crecimiento económico en África Occidental. Las políticas centradas en reducir los índices de dependencia, mejorar la productividad laboral y garantizar inversiones eficientes en salud son esenciales para aprovechar las ventajas demográficas y fomentar el desarrollo sostenible.

PALABRAS CLAVE

Estructura demográfica; crecimiento económico; mínimos cuadrados ponderados; África Occidental.

ABSTRACT

Demographic structure plays a crucial role in shaping economic growth, particularly in regions undergoing rapid population changes. West Africa, characterized by a young population, high fertility rates, and urbanization, presents both opportunities and challenges for economic development. While demographic transitions can generate economic dividends, inefficient labour markets and inadequate investments in human capital may hinder growth. This study examines the impact of demographic factors on economic growth in West Africa using econometric analysis. This research employs a panel data regression model to analyze the relationship between economic growth (measured by the logarithm of GDP per capita in levels) and key demographic variables, including age dependency ratio, labour force participation rate, population growth, urbanization, life expectancy, and health expenditure. Secondary data from 16 West African countries between 2000 and 2022 were obtained from the World Development Indicators. The study applies the Random Effects model and Weighted Least Squares regression to address heteroskedasticity and improve estimate efficiency. Findings reveal that a high age dependency ratio and rapid population growth negatively impact economic growth, while urbanization and life expectancy contribute positively. Labour force participation showed a weak negative effect, suggesting labour market inefficiencies. Interestingly, increased health expenditure was negatively associated with growth, indicating potential inefficiencies in resource allocation. The study highlights the complex relationship between demographics and economic growth in West Africa. Policies focusing on reducing dependency ratios, improving labour productivity, and ensuring efficient health investments are essential to harness demographic advantages and foster sustainable development.

KEYWORDS

Demographic Structure; Economic Growth; Weighted Least Square; West Africa.

Clasificación JEL: J11, O47, C23.

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1. INTRODUCTION

The world's population is changing in ways we have never seen before, affecting societies, economies, and politics (Bloom & Luca, 2023). These changes mainly come from three linked trends: older populations in rich countries, younger populations in poorer countries, and shifting migration patterns. Research from the Max Planck Institute for Demographic Research shows that global aging is happening faster than ever, with different rates in various regions (Zagheni et al., 2021). The global population structure shows clear regional differences, with Africa having the youngest population (average age 19.7 years) and Europe getting older quickly (average age 42.5 years). Japan is a prime example of this aging trend, with about 29 per cent of its people aged 65 and older, a pattern that many developed countries are starting to follow (Muramatsu & Akiyama, 2023; United Nations Population Division, 2023).

Global demographic patterns reveal distinct regional differences and unique challenges. Asia, home to approximately 60% of the world's population, exhibits a wide range of demographic trends (Chen et al., 2023). Countries in East Asia are experiencing rapid population aging and very low birth rates, similar to trends seen in Europe. In contrast, South Asia has a younger population, though its birth rates are slowly decreasing. Africa holds the world's youngest demographic profile and the highest global birth rates, averaging 4.6 children per woman. This situation presents an opportunity for demographic growth but also brings significant development challenges (Canning et al., 2015). Meanwhile, Europe faces the world's lowest birth rates, averaging 1.6 children per woman, and has the highest median age. The continent is increasingly dependent on migration to maintain its population (Sobotka & Beaujouan, 2023). Current global fertility rates average approximately 2.3 children per woman, though this figure masks significant regional variations. East Asia and Europe have similarly low rates of 1.6 children per woman, while Sub-Saharan Africa maintains substantially higher fertility levels. The proportion of the elderly population is expected to rise dramatically. Projections indicate that one in six people worldwide will be over 65 by 2050 (KC et al., 2024), with the global population aged 80 or above expected to triple between 2020 and 2050.

These demographic shifts present complex policy challenges that require nuanced, region-specific responses. Developed nations must adapt their social security and healthcare systems to support aging populations while maintaining economic productivity (Acemoglu & Restrepo, 2023). Conversely, developing regions, particularly those with a youth bulge, face the crucial task of creating sufficient economic opportunities to harness their demographic dividend (World Economic Forum, 2023). West Africa's demographic landscape features one of the world's most dynamic and rapidly evolving population structures, characterized by distinctive patterns that set it apart from other global regions (Odimegwu & Abimbola, 2022). The region, encompassing 16 countries from Senegal to Nigeria, has emerged as a critical focal point for understanding global population dynamics and their implications for sustainable development (Mberu et al., 2023). Analyses indicate the region's population reached approximately 400 million in 2023, with growth trajectories suggesting continued rapid expansion through mid-century (Tabutin & Schoumaker, 2004). This growth pattern, combined with the region's unique age structure, pre-

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sents both unprecedented opportunities and significant challenges for socioeconomic development (WAHO, 2023; UNECA, 2023).

The demographic profile of West Africa exhibits distinct characteristics that differentiate it from other world regions (Casterline & Agyei-Mensah, 2017). The region maintains one of the world's youngest age structures, with a median age of 18.2 years, significantly below the global median of 30.9 years. This youth-centric demographic structure results from persistently high fertility rates combined with declining child mortality over recent decades (Guengant & May, 2020). This age structure creates a potential demographic dividend, though realizing this potential requires substantial policy interventions and strategic investments in human capital (Bloom & Luca, 2023). Detailed analyses reveal significant intraregional variations in demographic patterns across West Africa. Nigeria, the region's demographic giant, exemplifies these variations with a population of approximately 220 million and a Total Fertility Rate (TFR) of 5.1 children per woman (Adebowale & Palamuleni, 2023). Comparative studies show that countries like Ghana and Senegal are at different stages of demographic transition, with Ghana (TFR: 3.8) showing more advanced patterns compared to Sahelian countries (African Development Bank, 2023). These variations correlate strongly with socioeconomic development levels, urbanization rates, and the effectiveness of family planning programs (OECD, 2023). The demographic transformation of West Africa's urban landscape has garnered considerable scholarly attention. The region's urbanization rate of 4.1% per year significantly surpasses the global average, leading to substantial effects on population distribution and socioeconomic advancement. Prominent urban areas like Lagos, Abidjan, and Accra are witnessing annual growth rates ranging from 2.9% to 3.5%, which presents both opportunities and challenges for urban planning and service provision (Beauchemin & Bocquier, 2024). This swift urbanization interacts with other demographic trends, ultimately transforming social structures and economic prospects throughout the region (World Bank, 2023b). Despite various studies, the relationship between demographic structure and economic growth in West Africa presents numerous research deficiencies. The intricate nature of this relationship, compounded by methodological challenges and limited data availability, has resulted in substantial knowledge voids that hinder the development of effective policies. Addressing these gaps is crucial for identifying more effective strategies to leverage demographic changes for economic growth (Tabutin & Schoumaker, 2004).

Looking ahead, demographic projections for West Africa suggest continued significant population growth, highlighting the need for comprehensive policy responses. Projections estimate the region's population will reach approximately 800 million by 2050. This necessitates integrated policy approaches that simultaneously address education, healthcare, and economic development. Successful navigation of these challenges requires annual investments of approximately $35 billion in social infrastructure and human capital development (UNDP, 2024). Therefore, this study seeks to examine how demographic factors influence the economic growth of the West African region through econometric analysis.

2. MATERIALS AND METHOD

This study uses Gross Domestic Product (GDP) per capita, which measures economic growth by showing the average output per person, reflecting a country's living standards and economic health. It is calculated by dividing total GDP by the population, allowing for easier comparisons of productivity across countries and time. (Mankiw, 2020). However, for the independent variable, the researcher captured the use of Age dependency ratio (percentage of working-age population), Population growth (annual percentage), Urban population (percentage of total population), Labour force participation rate, total (percentage of total population ages 15-64), Life expectancy at birth, total (years), and current health expenditure as they perfectly explain demographic variables. The data used in this research were secondary time series, panel data of sixteen West African countries (Benin, Burkina Faso, Cape Verde, The Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Liberia, Mali, Mauritania, the Niger, Nigeria, Senegal, Sierra Leone, and Togo) ranging from 2000–2022, and they were obtained from World Development Indicator 2024.

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An econometric model can be developed to assess how demographic variables influence economic growth. The model can take the form of a multiple linear regression equation as follows in general mode

In (GDPpc) = β0+β1 ln(Age Dependency Ratio) + β2 ln(Labour Force Participation) + β3 (Population Growth) + β4 ln(Urban Population) + β5 ln(Life Expectancy) + β6 ln(current health expenditure) + ϵ

2.1. VARIABLES AND DEFINITIONS:

1. Dependent Variable (Y):

- GDP per capita (Y): measured in levels (current US dollars).

2. Independent Variables (X):

- Age Dependency Ratio (X1): Ratio of dependents (under 15 and over 64) to the working-age population.
- Labour Force Participation Rate (X2): Percentage of the working-age population actively employed or seeking employment.
- Population Growth (X3): Annual percentage increase in population.
- Urban Population (X4): Urban population refers to people living in urban areas as defined by national statistical offices.
- Life Expectancy (X5): Average number of years a person is expected to live.
- Current Health Expenditure (X6): Level of current health expenditure expressed as a percentage of GDP.

3. Error Term (ϵ): Captures unobserved factors affecting economic growth.

2.2. ESTIMATION APPROACH:

1. Data Collection:

- Gather data from sources such as the World Bank, (World Bank, 2023a) United Nations, and national statistics offices for a specific region or globally.

2. Model Estimation:

- Use Ordinary Least Squares (OLS) to estimate the coefficients (β0,β1,β2,...).

3. Functional Form (Optional Adjustments):

- Logarithmic transformation if variables like GDP or population have exponential growth patterns:

In (GDP Growth Rate) = β0+β1ln (Population Growth) +

2.3. HYPOTHESES:

- H0: βi = 0 (Demographic variable i has no effect on GDP growth).
- H1: βi ≠ 0 (Demographic variable i significantly affects GDP growth).

2.4. OUTPUT INTERPRETATION:

- Coefficient Signs:
  - o Positive (+) implies the variable promotes GDP growth.
  - o Negative (-) implies the variable hinders GDP growth.

- Statistical Significance:

  o Use p-values and t-statistics to determine the impact's significance.

- Goodness of Fit:

  o R2 and Adjusted R2 indicate the proportion of GDP growth variation explained by the model.

2.5. MODEL TESTING AND REFINEMENT:

- Heteroskedasticity: Apply the Breusch-Pagan test and correct using robust standard errors if needed.

2.6. MODEL SPECIFICATION AND ECONOMETRIC MODEL

1. Levin-Lin-Chu (LLC) test

The Levin-Lin-Chu (LLC) test for a unit root in a panel data setting tests the null hypothesis that all panels have a unit root (non-stationary).

Null hypothesis: $\alpha i = 0$ for all panels (unit root).

Formula for the LLC test statistic: $^{\tau}LLC = (\hat{\alpha}) / \hat{\sigma}$ (adjusted for panel size)

where $\hat{\alpha}$ is the estimated autoregressive parameter and $\hat{\sigma}$ is its standard error.

2. Heteroskedasticity Test

This tests for heteroskedasticity using a Breusch-Pagan or White test, where the null hypothesis is homoskedasticity. If heteroskedasticity is present, the formula for the error variance is not constant:

$Var(\varepsilon i) = \sigma^2 i$, where $\sigma^2 i = \theta 0 + \theta 1\ Xi$

where Xi represents the explanatory variables.

3. Husman Test

The Hausman test compares the fixed effects and random effects models to test for endogeneity. The test statistic follows a Chi-squared distribution:

$H = (\hat{\beta}fe - \hat{\beta}re)' * [Var\ (\hat{\beta}fe) - Var\ (\hat{\beta}re)]^{-1} * (\hat{\beta}fe - \hat{\beta}re)$,

where $\hat{\beta}fe$ and $\hat{\beta}re$ are the coefficient estimates from the fixed and random effects models, respectively.

4. predict uhat, e

This generates the residuals from the regression model:

$\hat{\varepsilon}i$ = Actuali - Fittedi

gen uhat2 = uhat*uhat

This creates the squared residuals: $\hat{\varepsilon}^2 i = \hat{\varepsilon} i^2$

Followed by generating the natural logarithm of the squared residuals: $\log(\hat{\varepsilon}i^2)$

Performs a regression of the logarithm of the squared residuals, typically used for heteroskedasticity modelling: (e.g., a regression model for the log of the squared residuals)

$\log(\hat{\varepsilon}i^2) = \gamma 0 + \gamma 1\ lnGDPpci + \gamma 2 lnAgedepRi + ... + \gamma 7\ lnCurrenthealthEXPi$

Then finally performed a weighted least squares regression where the weights are the inverse of the predicted values $\hat{h}i$, typically used in heteroskedasticity correction:

$$\ln GDPpc_i = \beta 0 + \beta 1 \ln AgedepR_i + \beta 2 \ln LaborforcePRT_i + \ldots + \beta 6 \ln CurrenthealthEXP_i, + \epsilon_i$$

with weights $w_i = 1/\hat{h}_i$, where $\hat{h}_i$ is the predicted value from an earlier model.

3. RESULT AND DISCUSSION

Table 1 illustrates pronounced variations in socioeconomic and demographic metrics across different regions, significantly affecting development strategies. The considerable disparity in GDP per capita, ranging from a mere $138.71 to $3903.05, underscores stark economic inequalities. Regions with lower income levels will likely encounter obstacles such as poverty, insufficient infrastructure, and restricted access to education and healthcare services. These challenges subsequently affect other indicators, such as life expectancy, which averages 58.78 years but varies between 45.05 and 76.59 years. Conversely, regions with elevated GDP per capita tend to experience improved living conditions, thereby highlighting the relationship between economic prosperity and human development outcomes. The age dependency ratio, averaging 63.72 per cent, indicates a significant economic strain in various regions, necessitating that the working population sustain a considerable number of dependents. This situation can place considerable pressure on public resources, including pensions and healthcare systems, especially in areas with low GDP. Additionally, the labour force participation rate, which stands at an average of 63.72 per cent, exhibits considerable variability; low participation rates may be associated with insufficient employment opportunities or obstacles to workforce inclusion, such as gender disparities or mismatches in skills.

Rapid population increase in certain areas, reaching as high as 5.79 per cent, presents a duality of opportunities and challenges. While significant growth can yield a demographic dividend through sufficient investments in education and employment generation, it may also exert pressure on essential resources such as food, housing, and healthcare. Furthermore, the comparatively low average urbanization rate of 42.22 per cent indicates that numerous regions remain largely rural, thereby limiting their access to the economic and social advantages typically found in urban environments. Effective urban planning and rural development strategies are essential to harmonize growth and mitigate the risk of urban overcrowding. The significant variation in healthcare spending as a proportion of GDP, which spans from 2.28 to 19.69 per cent, highlights the inequities in access to health services. Regions with lower healthcare expenditures are likely to experience worse health outcomes and reduced life expectancy, whereas areas with higher spending must focus on the effective use of resources to attain the best possible health results.

Table 1: Descriptive statistics of analyzed data

Variable	Obs	Mean	Std. Dev.	Min	Max
GDPpc	368	1056.294	799.815	138.7139	3903.05
AgedepR	368	63.72114	9.342705	41.416	80.649
Laborforce~T	368	2.647203	0.6588046	0.7997085	5.785413
PopulationGR	368	42.21515	11.41473	16.186	67.545
UrbanPOP	368	58.77742	5.842221	45.05	76.593
LifeEXP	368	4.975477	2.446026	2.279068	19.69005
Currenthea~P	368	1056.294	799.815	138.7139	3903.05

To determine the stationarity properties of the variables, the Levin-Lin-Chu (LLC) unit root test was applied. The null hypothesis (H0) of the test assumes that each variable contains a unit root, meaning it is non-stationary. The alternative hypothesis (H1) suggests that the variable is stationary. The results indicate that GDP per capita (GDPpc), Labor Force Participation Rate (LaborforcePRT), Population Growth Rate (PopulationGR), Urban Population (UrbanPOP), Life Expectancy (LifeEXP), and Current Health Expenditure (CurrenthealthEXP) are all stationary, as evidenced by their significantly negative test statistics and p-values below the 5 per cent significance level. However, the Age Dependency Ratio (AgedepR) is non-stationary, suggesting that it follows a stochastic trend. The presence of non-stationarity in certain macroeconomic variables is consistent with previous studies (Engle & Granger, 1987; Baltagi, 2021), which emphasize that many economic variables exhibit long-term trends and require transformations to avoid spurious regression results.

Table 2: Panel Unit Root Tests (Levin-Lin-Chu Test)

Variable	Test Statistic	p-value
GDP per capita (GDPpc)	−3.6215	0.0001
Age Dependency Ratio (AgedepR)	1.6050	0.9458
Labor Force Participation Rate (LaborforcePRT)	−4.7003	0.0000
Population Growth Rate (PopulationGR)	−2.7314	0.0032
Urban Population (UrbanPOP)	−15.8543	0.0000
Life Expectancy (LifeEXP)	−4.9008	0.0000
Current Health Expenditure (CurrenthealthEXP)	−3.2165	0.0006

Null Hypothesis (H_0): The variable has a unit root (non-stationary). Alternative Hypothesis (H_1): The variable is stationary.

Adjusted t statistic: * If significant (p-value < 0.05), reject H_0 (stationary variable). Non-significant p-value (>0.05) means the variable has a unit root.

The Breusch-Pagan test was conducted to determine whether heteroskedasticity was present in the regression model. Heteroskedasticity occurs when the variance of the error terms (ϵi) is not constant across observations, which violates one of the key assumptions of the classical linear regression model (CLRM) under ordinary least squares (OLS) estimation. If heteroskedasticity is present, the OLS estimators remain unbiased but become inefficient, leading to biased standard errors, invalid hypothesis testing, and unreliable confidence intervals (Gujarati & Porter, 2009; Wooldridge, 2010).

The Breusch-Pagan test was applied because the nature of the data-panel data covering multiple countries over time-often exhibits heteroskedasticity due to economic disparities across entities. Countries with higher GDP per capita may experience different levels of variability in economic indicators compared to lower-income countries. Additionally, economic data tends to have scaling effects, meaning that variables measured in large absolute values (such as GDP per capita) often exhibit greater variance. If heteroskedasticity is present, the OLS model would provide inefficient and misleading estimates, necessitating a weighted regression approach or robust standard errors to correct for this issue (Greene, 2020).

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Table 3: The Breusch-Pagan heteroskedasticity test

Test	Chi-square (χ^2)	p-value	Conclusion
Breusch-Pagan Test	21.70	0.0000	Heteroskedasticity detected

The chi-square statistic (21.70) and its associated p-value (0.0000) indicate that the null hypothesis of homoskedasticity is strongly rejected.

This confirms that the error variances are not constant, meaning heteroskedasticity is present in the regression model.

The presence of heteroskedasticity means that the OLS standard errors are unreliable, leading to incorrect statistical inferences. The standard errors may be underestimated or overestimated, which could result in inflated t-statistics and misleading significance levels (Baltagi, 2021). This issue is particularly relevant in economic studies using panel data, where variations in economic indicators across different countries introduce non-constant variance.

To address this problem, the study applied a weighted least squares (WLS) regression, which assigns weights to correct for heteroskedasticity, ensuring efficient and unbiased standard errors. This approach improves the reliability of the estimates and provides more accurate hypothesis testing.

The Breusch-Pagan test results confirmed that heteroskedasticity was present in the regression model, meaning that OLS estimators were inefficient and led to unreliable standard errors. Given this finding, the study applied a heteroskedasticity-corrected regression using weighted least squares (WLS) to obtain more accurate estimates. This correction ensures that the findings remain robust and statistically valid, allowing for more precise policy recommendations.

4. PANEL REGRESSION ANALYSIS

4.1. Fixed Effects Model

To account for unobserved heterogeneity across countries, both Fixed Effects (FE) and Random Effects (RE) models were estimated. The FE model explains 71.33 per cent of the within-group variation in GDP per capita, while the RE model explains 44.64 per cent of the overall variation. The Hausman test (χ2=1.31, p=0.9711) failed to reject the null hypothesis, indicating that the Random Effects model is more efficient and preferable to the Fixed Effects model. This finding suggests that unobserved country-specific effects are not significantly correlated with the explanatory variables, making the RE model preferable due to its efficiency and ability to capture between-country variation (Baltagi, 2021; Wooldridge, 2010).

Dependent Variable: Log GDP per capita (lnGDPpc)

Table 4: The Breusch-Pagan heteroskedasticity test

Independent Variable	Coefficient (β)	Std. Error	t-value	p-value
lnAgedepR	−0.618	0.217	−2.85	0.005
lnLaborforcePRT	0.307	0.388	0.79	0.430
PopulationGR	0.112	0.079	1.42	0.157
lnUrbanPOP	1.895	0.203	9.34	0.000
lnLifeEXP	3.183	0.370	8.60	0.000
lnCurrenthealthEXP	0.109	0.051	2.14	0.033

Within R^2 = 0.7133 (Explains 71.33 per cent of the variation in GDP per capita)

Prob > F = 0.0000 (Model is significant)

4.2. Random Effects Model

In the RE model, AgedepR continues to have a significant negative impact on GDP per capita (-0.617, p=0.005), while UrbanPOP and LifeEXP retain their positive effects (1.527, p=0.000 and 3.438, p=0.000, respectively). Interestingly, LaborforcePRT and PopulationGR remain statistically insignificant, suggesting that labor force participation and population growth do not directly affect GDP per capita in this sample. The negative coefficient for CurrenthealthEXP (-0.548,p=0.000) remains significant, reinforcing concerns regarding health expenditure inefficiencies.

Table 5: The Breusch-Pagan heteroskedasticity test

Independent Variable	Coefficient (β)	Std. Error	z-value	p-value
lnAgedepR	−0.617	0.221	−2.79	0.005
lnLaborforcePRT	0.050	0.340	0.15	0.883
PopulationGR	0.110	0.081	1.36	0.175
lnUrbanPOP	1.527	0.179	8.51	0.000
lnLifeEXP	3.439	0.346	9.93	0.000
lnCurrenthealthEXP	0.093	0.052	1.80	0.072

Overall R^2 = 0.4464 (Explains 44.64 per cent of GDP per capita variation)

Prob > chi^2 = 0.0000 (Model is significant)

4.3. Hausman Test (Fixed vs. Random Effects)

The Hausman Test determines whether the Fixed Effects (FE) model or the Random Effects (RE) model is more appropriate. The test compares the efficiency and consistency of the two models. The high p-value (0.9711) means we fail to reject the null hypothesis. This indicates that the RE model produces efficient and unbiased estimates. If the p-value were low (< 0.05), we would have rejected the RE model in favor of the FE model. Thus, RE is preferred because the FE estimates do not provide significantly better results in terms of bias correction.

Table 6: Hausman Test Result

Test	Chi-square (χ^2)	p-value	Conclusion
Hausman Test	1.31	0.9711	Fail to reject H0 so RE is preferred

Null Hypothesis (H_0): The RE model is preferred because there is no significant difference between FE and RE estimates.

Alternative Hypothesis (H_1): The FE model is preferred because the RE estimates are inconsistent (i.e., correlated with the regressors).

According to the result of the regression analysis The R2 value in a panel data model (like RE or FE) does not carry the same importance as in an OLS regression, because in Random Effects models, R2 is divided into three types as follows, (1) Within R2 Variation explained within each group (country, region, etc.) (2) between R2 Variation explained across groups and (3) overall R2 Combination of within and between.

Table 7: Low R2 in Panel Data Models

Model	Within R2	Between R2	Overall R2
Fixed Effects (FE)	0.7133	0.3730	0.4284
Random Effects (RE)	0.7110	0.3857	0.4464

- FE model has a higher Within R2 (71.33 per cent), meaning it explains more of the variation within each entity.
- RE model has a higher Between R2 (38.57 per cent) and Overall R2 (44.64 per cent), meaning it explains more variation across entities.

Thus, R2 is not the only model selection criterion. Panel models focus more on efficiency, consistency, and unbiased estimates rather than just R2 and a model with low R2 can still be preferred if it provides more reliable parameter estimates.

4.4. The Random Effects Model Assumption

The RE model assumes that the unobserved heterogeneity (panel effects) are uncorrelated with the independent variables. This assumption allows for more efficient estimates than FE and Provides estimates for time-invariant variables (FE drops time-invariant variables).

Since the Hausman test indicated no significant difference between FE and RE, the RE model was retained because, It is more efficient (fewer degrees of freedom lost). It provides estimates for variables that FE would omit, and It assumes individual differences (panel effects) are random, rather than forcing entity-specific fixed effects. The Random Effects model was chosen because the Hausman test did not show significant differences between FE and RE estimates. Low R2 does not disqualify a model if it provides unbiased and efficient estimates. RE model retains variation across entities and is more efficient when individual effects are uncorrelated with regressors. FE would be better if individual effects were correlated with independent variables, but Hausman test suggests otherwise.

5. WEIGHTED LEAST SQUARES (HETEROSKEDASTICITY CORRECTED)

The results show that economic growth is a multifaceted process driven by demographics, urbanization, health, and labour dynamics. The mix of positive and negative relationships highlights the complexity of development economics, where certain factors (like life expectancy and urbanization) spur growth, while others (such as high dependency ratios and inefficiencies in spending) act as constraints. In terms of **Model Fit**, it explains about 59.54 per cent of the variation in GDP per capita (R-squared = 0.5954), suggesting a reasonably good fit. However, unexplained variance indicates room for additional factors (e.g., technology, education quality).

The regression analysis reveals several key factors influencing GDP per capita. The Age Dependency Ratio shows a statistically significant negative coefficient (-0.625, p = 0.042), indicating that a one-percentage-point increase in the dependency ratio is associated with a 0.625 percent decrease in economic growth. This finding is consistent with literature that highlights the constraints high dependency ratios place on economic productivity and savings (World Bank, 2021; UNDP, 2020), as seen in East Asia's economic growth following a reduction in dependency ratios (Bloom & Williamson, 1998) and the detrimental effects on per capita income due to decreased output (Mason & Lee, 2007). Labor Force Participation Rate shows a marginally significant negative effect (-0.296, p = 0.064), indicating that a 1 per cent increase in labor force participation leads to a 0.297 per cent decrease in GDP per capita. This counterintuitive result suggests potential structural challenges like underemployment or low productivity within the labor force, as increasing participation alone often provides limited economic gains in developing economies without corresponding productivity improvements (ILO, 2021). Furthermore, the Population Growth Rate exhibits a significant negative correlation (-0.539, p = 0.000), suggesting that a one-percentage-point increase in population growth is associated with a 0.539 percent decrease in economic growth. This finding is consistent with research emphasizing the burdens that rapid population growth imposes on available resources and infrastructure (Bloom & Williamson, 1998; Acemoglu & Johnson, 2007). Unregulated population expansion frequently undermines economic progress, particularly in nations with limited resources (Bloom & Canning, 2008), a concept of population pressure which posits that rapid increases lead to the depletion of both capital and natural resources (Ehrlich & Holdren, 1971).

The Urban Population shows a positive effect (0.471, p = 0.000), meaning a 1 per cent increase in urban population increases economic growth by 0.471 per cent indicating that urban populations drive higher economic productivity through better infrastructure, education, and industrialization. According to UN-Habitat (2020), urban areas contribute disproportionately to GDP due to economies of scale and innovation hubs. Glaeser (2011) emphasized cities as engines of economic growth, boosting productivity and innovation. Life Expectancy shows the most substantial positive coefficient (1.343, p = 0.000), with a 1 per cent increase in life expectancy increasing economic growth by 1.343 per cent. This highlights the role of health and longevity in enhancing economic output. Improved life expectancy is often linked to better human capital development. Bloom et al. (2020) argued that life expectancy is a key determinant of human capital, directly boosting economic output. Also, in accordance with Weil (2007), who found that a 1 per cent increase in life expectancy significantly raises GDP by extending workforce longevity and reducing healthcare burdens. Current Health Expenditure exhibits a notable negative impact (-0.548, p = 0.000), a 1 per cent increase in health expenditure decreases economic growth by 0.548 per cent indicating that increased health spending may lead to a decrease in GDP per capita. This phenomenon could be attributed to inefficient allocation of resources or the economic strain

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imposed by health emergencies. The World Health Organization (2021) emphasized that inefficiencies within healthcare systems represent a significant barrier to economic advancement in low- and middle-income nations. Furthermore, Baumol (2012) observed that the rate of growth in healthcare expenses frequently outpaces that of GDP, thereby constraining the potential economic advantages.

Table 8: Weighted Least Square

Independent Variable	Weighted Coefficient (β)	Std. Error	t-value	p-value	Conclusion
AgedepR (Age Dependency Ratio)	−0.625	0.306	−2.04	0.042	Significant negative impact
LaborforcePRT (Labor Force Participation Rate)	−0.296	0.160	−1.86	0.064	Weak negative impact
PopulationGR (Population Growth Rate)	−0.539	0.135	−4.00	0.000	Strong negative impact
UrbanPOP (Urban Population)	0.471	0.088	5.34	0.000	Significant positive impact
LifeEXP (Life Expectancy)	1.343	0.285	4.72	0.000	Significant positive impact
CurrenthealthEXP (Health Expenditure)	−0.548	0.061	−8.96	0.000	Significant negative impact
Constant (_cons)	4.979	2.387	2.09	0.038	Significant

$R^2 = 0.5954$ → 59.54 per cent of the variation in GDP per capita is explained by the model (higher than OLS).

Prob > F = 0.0000 → The model remains statistically significant.

6.CONCLUSION

The analysis reveals several critical factors that impact GDP per capita, offering valuable insights into the dynamics of economic growth. A high age dependency ratio is shown to adversely affect economic growth, as it signifies a substantial economic burden due to the proportion of dependents-namely children and the elderly-relative to the working-age population. This imbalance restricts savings, investment, and overall productivity. Such findings are consistent with existing research that highlights the difficulties posed by elevated dependency ratios, particularly in developing countries. Therefore, implementing policies that enhance workforce participation and mitigate dependency, including family planning initiatives and support for eldercare, is essential. Additionally, the labor force participation rate demonstrates a slightly significant negative impact, suggesting inefficiencies in the utilization of the labor market. Elevated participation levels do not necessarily translate into economic growth when structural challenges, such as underemployment or skill mismatches, are present. This underscores the necessity of enhancing labor productivity through focused skill development and the creation of jobs in high-value sectors. Furthermore, the population growth rate is found to have a strong negative correlation with economic growth. Rapid increases in population can place significant pressure on resources, infrastructure, and social services, thereby undermining economic progress, especially in resource-limited settings. Strategies such as family planning and investments in education and healthcare are vital for managing population growth and addressing its associated economic challenges.

Urban populations significantly contribute to economic growth, as urbanization facilitates development through enhanced infrastructure, education, healthcare, and industrialization. Nevertheless, if urbanization is not managed effectively, it can lead to issues such as congestion and social inequality, underscoring the necessity for sustainable urban development strategies. Life expectancy emerges as a critical factor positively influencing economic growth, illustrating the importance of health and longevity in economic performance. A higher life expectancy promotes a healthier and more productive workforce, thereby decreasing the costs associated with illness and premature death. Investments in public health and preventive measures can amplify these advantages. Current health expenditures exhibit a notable negative correlation with economic growth, indicating potential inefficiencies in healthcare spending. Elevated expenditures may not necessarily translate into improved health outcomes or economic gains, possibly due to the misallocation of resources, especially in healthcare systems that emphasize curative approaches over preventive care. It is essential for policymakers to enhance healthcare efficiency and reallocate spending towards more cost-effective interventions.

In our analysis, we utilize the Hausman test to tackle a particular form of endogeneity, specifically the correlation between unobserved country-specific effects and regressors. However, we acknowledge that this approach does not eliminate all types of endogeneity. The existence of other endogeneity sources is still a possibility, and if they are present, they may result in biased and inconsistent coefficient estimates. Two potential sources of endogeneity identified in our model are: Reverse Causality (Simultaneity): It is conceivable that a bidirectional relationship exists between certain explanatory variables and economic growth. For instance, while we examine the impact of health (represented by life expectancy) on economic growth, an increase in GDP per capita might also enhance healthcare services, subsequently improving life expectancy. This reciprocal causation could lead to a biased estimation of the coefficient for health. Omitted Variable Bias: Similar to any econometric model, our framework cannot encompass every variable that affects economic growth. If a significant variable is excluded and is correlated with one of the regressors included in our model, its influence will be absorbed into the error term. This situation can create a misleading correlation between the regressor and the error term, thus biasing the estimated coefficient.

These potential challenges indicate that our findings, although consistent within the specific panel data framework analyzed, may not entirely reflect the genuine causal relationships. Future investigations could mitigate these limitations by applying more robust econometric methods, such as Instrumental Variables (IV) or Two-Stage Least Squares (2SLS) regression, to isolate the exogenous impact of demographic variables and achieve more dependable estimates.

In summary, the analysis underscores the intricate relationships among demographic, social, and economic elements that influence economic growth. Factors such as urbanization and advancements in health contribute positively to growth, whereas challenges like labour market inefficiencies, elevated dependency ratios, swift population increases, and healthcare expenditures act as limitations. Comprehensive policy strategies that tackle these issues can promote sustainable economic development.

KEY DIFFERENCES BETWEEN MODELS

1. OLS vs. FE and RE

- OLS shows stronger effects for AgedepR (-24.30) and PopulationGR (-157.53), but these effects shrink in FE and RE.
- Population Growth Rate (PopulationGR) is significant in OLS but not in FE or RE, indicating that time-invariant factors explain much of its effect.
- Health Expenditure (CurrenthealthEXP) is negative in OLS but positive in FE and RE, suggesting that controlling for unobserved heterogeneity influences its effect.

2. FE vs. RE (Why RE Was Preferred)

- The Hausman test (χ^2 = 1.31, p = 0.9711) failed to reject the null hypothesis, meaning the RE model is more efficient.
- FE explains more within-country variation (R2=0.7133R^2 = 0.7133R2=0.7133), while RE captures more between-country variation (R2=0.4464R^2 = 0.4464R2=0.4464).
- The RE model provides estimates for variables that FE would drop, making it preferable.

3. Weighted Regression vs. OLS

- WLS corrects for heteroskedasticity, producing more reliable estimates.
- The negative impact of Population Growth Rate (PopulationGR) remains significant in WLS, unlike in FE/RE.
- Health Expenditure (CurrenthealthEXP) remains negative in WLS, confirming concerns about inefficient health spending.
- WLS provides a slightly higher R2R^2R2 (0.5954) than OLS (0.5769), meaning it explains more variation after correcting heteroskedasticity.

Finally

- OLS overestimates the impact of AgedepR and PopulationGR, while FE and RE models show weaker effects due to controlling for fixed country-specific characteristics.
- FE and RE suggest that Health Expenditure (CurrenthealthEXP) may have a positive effect, whereas OLS and WLS indicate a negative effect, pointing to possible inefficiencies in health spending.
- The Random Effects model is preferred over the Fixed Effects model, as indicated by the Hausman test.
- Weighted Regression (WLS) provides more robust estimates by correcting for heteroskedasticity, making it more reliable than OLS.

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TABULATED RESULTS OF ALL REGRESSION MODELS

Table 9: Tabulated Results for all Regression Model

Variable	OLS (β)	FE (β)	RE (β)	WLS (β)	Key Differences
AgedepR	−24.30***	−0.618***	−0.617**	−0.625**	Strong negative effect in all models but reduced in FE and RE.
LaborforcePRT	0.71 (NS)	0.307 (NS)	0.050 (NS)	−0.296 (NS)	Not significant in all models; slightly negative in WLS.
PopulationGR	−157.53***	0.112 (NS)	0.110 (NS)	−0.539***	Significant and negative in OLS and WLS, but insignificant in FE and RE.
UrbanPOP	15.77***	1.895***	1.527***	0.471***	Significant and positive in all models; higher in OLS.
LifeEXP	26.87***	3.183***	3.439***	1.343***	Significant and positive in all models but smaller in WLS.
CurrenthealthEXP	−78.73***	0.109**	0.093*	−0.548***	Negative in OLS and WLS but positive in FE and RE.
Constant (β0)	1684.69**	−12.02***	−10.62***	4.979**	Significant across models but varies in magnitude.
R2 (Overall Goodness of Fit)	0.5769	0.7133 (Within)	0.4464	0.5954	FE explains more within-group variation; RE explains less.
Hausman Test (χ2)	–	1.31 (p = 0.9711)	–	–	RE is preferred over FE due to efficiency.

***p<0.01p < 0.01p<0.01 (Highly significant), *p<0.05p < 0.05p<0.05 (Significant), p<0.10p < 0.10p<0.10 (Marginally significant), (NS) Not significant.

R2 measures how well each model explains GDP per capita variation.

The Hausman test confirms that the RE model is preferable over the FE model.

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