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Energy, Population, and Development: Understanding Growth Determinants in Sub-Saharan Africa

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Abstract

This study examines the determinants of economic growth within the energy–growth–environment nexus in Sub-Saharan Africa by integrating endogenous growth theory, human capital theory, and structural transformation perspectives. Using panel data for 40 Sub-Saharan African countries over the period 1990 to 2024, obtained from the World Bank and international energy databases, the analysis evaluates the roles of energy consumption, human development, labour dynamics, population growth, and foreign direct investment in shaping economic performance. A dynamic panel data approach is employed, incorporating descriptive statistics, panel unit root tests, and cross-sectional dependence diagnostics. The core estimation is conducted using the Sequential Two-Stage Generalised Method of Moments to address endogeneity, heterogeneity, and dynamic adjustments. The results reveal the presence of significant cross-sectional dependence and mixed integration properties among variables, justifying the use of advanced panel techniques. Empirical findings indicate that human development exerts a strong and statistically significant positive effect on economic growth, highlighting the critical role of education, health, and skills in enhancing productivity and innovation. Labour force participation contributes positively, while unemployment negatively affects growth, reflecting labour market inefficiencies. In contrast, energy consumption, population growth, and foreign direct investment exhibit statistically insignificant effects, suggesting that their contributions depend on structural conditions, efficiency, and absorptive capacity. Furthermore, the insignificance of lagged growth variables indicates weak persistence and volatility in economic performance across the region. The study demonstrates that economic growth in Sub-Saharan Africa is primarily driven by human capital development rather than energy expansion, emphasising the importance of structural reforms and institutional strengthening for sustainable growth.

Keywords: Economic Growth, Human Development, Energy Consumption, Sub-Saharan Africa
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1. INTRODUCTION

The issue of economic growth in Sub-Saharan Africa has been a key development economics topic due to its associated structural issues, energy shortages and environmental pressures. Although in many countries in the region there have been major policy reforms and greater integration in the global economy, many countries in the region are still suffering from volatile and uneven growth. These oscillations have been associated with structural weaknesses: low level of industrialisation, poorly developed institutional systems and human capital. Simultaneously, the area is witnessing an increase in energy consumption and environmental challenges, within the context of an energy-growth-environment nexus that is an emerging area of research (Eregba et al., 2023; Ashiq et al., 2023; Xuan, 2024; Khan et al., 2025; Jiang et al., 2025). Energy consumption has been traditionally considered one of the major factors behind economic growth, especially in developing economies where industrialisation and development of infrastructure are heavily dependent on energy inputs. Theoretical and empirical research indicates that higher energy consumption helps production processes, boosts

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productivity, and enables economic growth. Recent literature, however, indicates that the energy-growth nexus is not a one-way street and that it may be influenced by other factors like energy efficiency, technological progress and structural conditions in economies (Al-Silefanee, 2024; Umair et al., 2025; Fan et al., 2025; Arshi et al., 2025). The pro-growth impact of energy consumption could be reduced in Sub-Saharan Africa, where energy systems often suffer from energy inefficiencies, low availability, and traditional energy sources. This poses questions about the effectiveness of expanding energy as a means for economic development in the region. In addition to energy, human capital development has become an important factor in economic development. Human capital theory focuses on the value of investments in education, health and skills in improving the productivity of labour, innovation and the ability of workers to adopt new technologies. Human development is especially significant to break the vicious circle of structural constraints in developing countries and support sustainable growth. The facts show that countries with a higher level of human capital also have superior and stable economic outcomes (Soubbotina, 2004; Abdulkarim, 2023; Jie & Lan, 2024; Marc, 2024; Naeem et al., 2025; Hameed et al., 2025; Longston et al., 2025). Education and health systems are critical to unlocking growth potential and increasing economic resilience in Sub-Saharan Africa, where human development indicators are still relatively low when compared to the rest of the world.

Labour resources are found to affect production capacity, income generation and overall economic performance. An increasing number of people working can help with growth, but a high jobless rate and underemployment indicate inefficiencies that impede economic progress. The literature has pointed out that unemployment results in wasted resources, and that the participation of the labour force increases the supply of productive labour (Abuselidze & Zoidze, 2023; Alam et al., 2024; Farras et al., 2025; Ghosh et al., 2025; Rafique et al., 2025; Abbas et al., 2025). Labour markets in Sub-Saharan Africa tend to be informal, rigid and skill-biased, thereby reducing the role of labour in boosting economic growth. The dynamics highlight the need for policy measures on the labour market side and training investment for sustainable economic growth (Ali & Rehman, 2015; Audi & Ali, 2017). The growth process becomes more complicated due to population growth, especially in developing countries where the population is growing rapidly. An increase in population can also increase the size of the workforce and market but may also be a strain on resources and infrastructure and on the provision of public facilities. The effect of population growth on economic performance is therefore ambiguous and depends on the nature of the population growth, the level of human capital formation, employment opportunities and economic structure (Ali & Naeem, 2017; Sun et al., 2023; Lee & Lee, 2024; Abdelkawy, 2024; Borre et al., 2025). A high birth rate coupled with limited economic opportunities in Sub-Saharan Africa can make growth more difficult and worsen development issues, underscoring the need for policies to balance economic capacity with the population growth rate.

Foreign direct investment is also a significant contributor to the growth process because it allows capital inflows, technology transfer and managerial skills. According to the theories, foreign investment can improve productivity and global economic development, especially in economies which have good institutional systems and absorptive capacities. But empirical studies show that the advantages of FDI are not guaranteed and require the presence of human capital, infrastructure, and policy factors (Abbas et al., 2022; Ahmad et al., 2022; Li & Geo, 2025; Ali et al., 2025; Cheng, 2025). The growth impact of FDI might be small in Sub-Saharan Africa, where institutional and structural constraints remain in place, and its contribution to economic performance is questionable. While a lot of literature has been written on the determinants of economic growth, there is a lack of consensus on the relative importance of energy, human capital, labour dynamics, demographic factors and foreign investment in determining economic outcomes in Sub-Saharan Africa. There are many studies that address different aspects of the energy-growth nexus without integrating the different aspects into a broader framework. Moreover, standard empirical methodologies would not capture the dynamic relationship, endogeneity and cross-sectional dependence that would be important in a region with interconnected economies and where external shocks are common. To address these, this study seeks to explore in detail the factors that drive economic growth in the energy-growth-environment nexus in Sub-Saharan Africa. The study combines three theories: endogenous growth theory, human capital theory and structural transformation theory and investigates the interactions between energy use, human development, employment dynamics, population growth and FDI in determining economic performance for 40 countries between 1990 and 2024.

2. LITERATURE REVIEW

Given the structural features and development constraints of Sub-Saharan Africa, the literature on economic growth in the region has increasingly begun to look at the relationship between energy use, human development, labour and population. There is a large literature that links human development to economic performance, especially in countries that have a strong link between productivity and education, health, and skills. For example, Ranis et al. (2000) show that human development and economic growth go hand in hand: an improvement in education and health results in higher productivity and higher income. Likewise, Baldacci et al. (2008) demonstrate that capital expenditures in human capital gains, in return, have a significant positive impact on the growth in the labour force through the improvement of labour productivity and innovation potential. The results are corroborated by empirical evidence from African economies; for example, Gyimah-Brempong et al. (2006), Anyanwu (2014) and Tchamyou (2017) found that human development indicators are highly correlated with economic growth in Africa. The results point to the key importance of human capital for economic performance in the region.

Labour market conditions also matter with respect to growth outcomes, though the impacts differ depending on the specific attributes of the labour market and the structure of the labour market. Empirical analysis shows that labour force participation has a positive effect on economic growth as it adds productive labour to the market. For instance, Bloom

and Canning (2008) show that an increase in the labour force participation rate is associated with an increase in growth because it increases the pool of productive people in the economy. Likewise, Dabla-Norris et al. (2015) reflect the importance of the efficiency of the labour market for the realisation of economic performance from human capital. There is, however, a constant issue in Sub-Saharan Africa: unemployment, as evidenced by empirical studies that show how unemployment constrains growth through lower income and aggregate demand. The negative correlation between unemployment and economic growth, as seen by Okun (1962), Fosu (2011), and Bhorat et al. (2017), has been observed in various studies. The results indicate that the efficient use of the labour force can help to fully harness the potential growth impact of human capital.

Until recently, energy use was seen as a key factor in economic development, especially in industrialised economies. Empirical evidence for Sub-Saharan Africa, however, is more complex. In some studies, it is found that there is a positive correlation between energy consumption and economic growth, as a result of which the availability of energy has a positive impact on production and economic activity. Wolde-Rufael (2005), for example, is able to identify a causal link between energy use and growth for some African countries. Likewise, Akinlo (2008) demonstrates that energy usage affects economic performance in Sub-Saharan Africa, especially in sectors that depend on energy for their operation. Other studies, however, indicate that the relationship is weak and insignificant, indicating that the effect of energy consumption is related to energy efficiency, infrastructure and the economic structure. For instance, Eggoh et al. (2011) note that the energy-growth link is absent in most African countries, and Ouedraogo (2013) notes that the estimation method and country sample also affect the results. Policymakers should be aware that these results suggest that energy usage alone may not be enough to ensure growth if it is not used effectively and is not complemented with other elements. Another significant factor impacting economic performance is population growth, especially in areas with fast-growing populations. Empirical evidence indicates that population growth may stimulate or retard economic growth, depending on the interaction between population growth and labour-supply and resource-demand issues. Population growth, as measured by the growth of the labour force and market size, may have positive effects on economic performance, as found by Kelley and Schmidt (2005). Likewise, Bloom et al. (2003) emphasise the demography-economic growth connection in the case of demographic transitions, and especially when investments in human capital follow. Rapid population growth, however, has been found to create problems in many Sub-Saharan African countries, such as unemployment, stress on public services, and slow capital accumulation. Headey and Hodge (2009) conclude that high population growth rates can place a limit on economic performance as they reduce per capita income and increase dependency ratios. These mixed results imply that the effect of population growth on economic performance is related to the capacity of economies to absorb and use the increase in the labour force.

There has been extensive research on the potential of FDI to stimulate economic growth in terms of capital inflows, technology transfer and the positive productivity spillovers that FDI can generate. Empirical studies suggest that foreign direct investment (FDI) has a positive effect on growth when the host country has adequate absorptive capacity, such as human capital and institutional quality. Borensztein et al. (1998) show that FDI can boost economic growth through the dissemination of state-of-the-art technology, especially in those nations with greater human capital stock. Likewise, Alfaro et al. (2004) have demonstrated that financial market development influences the growth impact of FDI. Regarding the African context, research conducted by Asiedu (2002), Adams (2009) and Iamsiraroj (2016) shows mixed results, with some countries gaining from foreign investment, and others not showing any significant or noticeable gains. These results indicate that the effect of FDI depends on other structural variables like institutional quality, infrastructure and human capital.

The interplay between these variables highlights the importance of structural conditions in shaping economic growth outcomes in Sub-Saharan Africa. However, empirical studies highlight that the contribution of growth drivers is contingent on the mainstream economic context, comprising institutional quality, governance, and policy environment. For example, Rodrik et al. (2004) conclude that the quality of institutions is an important determinant of growth performance as it affects both investment and productivity. Likewise, Acemoglu and Robinson (2010) demonstrate that inclusive institutions help to ensure long-term economic growth. In Africa, traditional growth drivers frequently fail to generate strong growth because of weak institutions and structural constraints, resulting in country-by-country variations. In recent empirical studies, dynamic panel data analysis has gained increasing traction to overcome the problems of cross-sectional dependence, heterogeneity and endogeneity in growth models. The generalised method of moments is widely used to obtain consistent estimates when there are endogenous regressors and dynamic relationships. This method has been found to control for unobserved heterogeneity and simultaneity bias in panel data models, as shown by Arellano and Bond (1991). Blundell and Bond (1998) build on this by developing an estimation methodology that is more efficient and robust through the use of system estimation techniques. The empirical literature suggests that economic growth in Sub-Saharan Africa is mainly attributable to human development and labour market factors, with energy use, population growth, and foreign direct investment contributing only under certain conditions and as a residual factor.

3. THEORETICAL FRAMEWORK

Theoretically, the energy–growth–environment nexus in Sub-Saharan Africa can be explained by combining endogenous growth theory, human capital theory and structural transformation theories. According to endogenous growth theory, endogenous growth factors like human capital accumulation, technological progress and institutional changes are more responsible for long-run economic growth than exogenous factors (Romer, 1990; Dias & Tebaldi, 2012; Li et al., 2020; Rahman et al., 2023; Adeyemo et al., 2024; Yan et al., 2025). In this context, energy consumption is a traditional input of the production process, which has been essential for industrialisation and economic growth. But the relatively small

importance of energy in this study indicates that the energy effect alone is not enough to stimulate growth in SSA because of structural inefficiency and less productive integration. The human capital theory gives a more convincing explanation of the results found, where education, health and skills (measured by the Human Development Index) are seen as fundamental factors for productivity and economic growth (Appleton & Teal, 1998; Adawo, 2011; Shi & Wang, 2024; Xiao et al., 2025). The positive and significant relationship between HDI reflects that better human development leads to greater productivity, innovation capabilities, and the ability to make effective use of energy and capital resources (Siddiqi et al., 2014). This is in line with the perception that human capital is a key driver of economic transformation in developing regions. The dynamics of the labour market also strongly influence economic outcomes. Labour force participation contributes positively to growth, as it is related to an expansion of the active workforce and the production capacity. The low importance of the latter is, however, due to structural factors like underemployment and low productivity. On the other hand, the negative effect of unemployment on growth is a sign of inefficiencies in the matching process and underutilization of human resources (Okun, 1962). The growth process is complicated by population growth. Demographic growth can deliver a larger labour force and a bigger potential market size, but it can also be a strain on resources and infrastructure if it is not matched by investment in human capital and jobs (Mahlberg et al., 2006; Harris et al., 2018; Ahmad et al., 2018; Alexandro, 2025; Poly et al., 2025). The lack of any significant effects of population growth on the empirical results indicates that the demographic aspect cannot guarantee economic growth in SSA. Foreign direct investment is expected to have a positive effect on growth as it brings in capital, technology transfer, and managerial skills (Borensztein et al., 1998; Alfaro et al., 2004). However, as it is not a significant factor, its presence suggests a lack of absorptive ability within SSA economies, which is likely to be linked with weak institutions, poor infrastructure and low human capital in these economies, thereby limiting the effective use of foreign investments. Growth persistence is represented by the inclusion of lagged dependent variables in the model, which allows for the dynamic nature of the model. The absence of notable persistence is an indication of short-term shocks driving economic growth in SSA rather than long-term trends.

The functional form of the model can be expressed as:

$$LNRGDP_{it} = \alpha + \beta_1 LNRGDP_{it-1} + \beta_2 LNTEC_{it} + \beta_3 LNHDi_{it} + \beta_4 LNTLF_{it} + \beta_5 UEM_{it} + \beta_6 POPGR_{it} + \beta_7 FDI_{it} + \mu_{it}$$

Where LNRGDP represents economic growth, LNTEC captures energy consumption, LNHDi reflects human development, LNTLF denotes labour force participation, UEM represents unemployment, POPGR captures population growth, and FDI denotes foreign direct investment. The presence of cross-sectional dependence, as indicated by diagnostic tests, suggests that SSA economies are influenced by common external shocks such as global commodity prices and financial conditions. This aligns with globalisation theory, which emphasises the interconnectedness of economies and the transmission of shocks across countries. World Development Indicators, international energy databases, and macroeconomic datasets for Sub-Saharan African countries.

The main purpose of this study is to use a dynamic panel data method to analyse some of the factors affecting economic growth in 40 Sub-Saharan African countries between 1990 and 2024. Panel data methods are suitable since they can combine cross-sectional data with time-series data for more efficient estimation and the control of unobserved heterogeneity. The empirical analysis starts with descriptive statistics and correlation analysis to get an understanding of the distribution and relationships between variables. The stationarity properties of the variables are tested using panel unit root tests to prevent the results of spurious regression. The use of stationary and non-stationary variables makes it appropriate to use dynamic panel estimation techniques. Inter-country dependence tests such as the cross-sectional dependence tests (CD) by Pesaran and Fan are used to identify inter-country dependence. The important results suggest that there are common shocks, and that estimation methods must take into account these common shocks. The core estimation approach is the Sequential Two-Stage Generalised Method of Moments suitable for models involving dynamic panel data where there are potential endogeneity and autocorrelation problems (Arellano and Bond, 1991; Blundell and Bond, 1998). The method involves using lagged variables as instruments to get consistent and unbiased estimates. The incorporation of lagged dependent variables accounts for persistence in growth and for dynamic adjustment processes.

4. RESULTS AND DISCUSSION

Table 1 summarises descriptive statistics for the macroeconomic variables that are analysed, giving a complete picture of the distributional properties and variability of these variables. The mean of real GDP is relatively high compared to the median value, suggesting that the distribution of real GDP has a right-skew, which means that there are several higher values. The large overall standard deviation also reinforces the idea that there is a lot of variance between countries or over the years and time, and within mean years and countries, indicating a larger difference between countries than within the countries. The total energy consumption also exhibits a similar distribution with a large difference between the mean and median values, which points to a skewed distribution and the presence of outliers, possibly due to differences in industrialisation and energy demand between the economies. Human development shows low dispersion relative to the other indicators, indicating that gains in human development are not very sudden and volatile over time. The relatively small within variation further supports the notion that human development evolves slowly within countries. There is significant variation in total labour force (the between standard deviation is higher than the within standard deviation), and the differences in labour force size are mostly accounted for by structural and demographic differences across economies rather than by short-term changes. The unemployment rate varies moderately between countries, showing higher between-variation, which reflects persistent differences in labour market conditions across countries. There is considerable variation in the population growth rate, including very low and very high values, which may reflect demographic shocks or measurement idiosyncrasies in some observations. Foreign direct investment shows significant

within-variation and a high degree of dispersion, especially in the within variation, indicating its volatility over time and sensitivity to economic conditions, policy changes, and global investment trends.

Table 1: Descriptive Statistics

Variables	Mean	Median	Overall SD	Between SD	Within SD	Min	Max
Real GDP	26.6	8.49	66.21	47.4955	30.8556	0.17	400.26
Total energy consumption	7.18	1.09	29.35	21.5623	3.5795	0.01	220.4
Human development index	0.48	0.47	0.11	0.0681	0.0292	0.22	0.82
Total labour force	7.07	3.6	10.33	11.9978	3.7549	0.1	70.62
Unemployment rate	7.71	4.94	6.53	7.6845	1.8849	0.32	28.77
Population Growth Rate	2.52	2.66	1.29	0.6718	0.8852	-16.88	16.63
Foreign Direct Investment	3.27	1.7	7.58	2.4679	8.5123	-18.92	161.82

The correlation matrix shown in Table 2 offers some ideas of the relationships between the variables. Total energy consumption and total labour force have a strong and positive correlation with real gross domestic product, indicating that increased economic activity is related to increased energy use and labour force. The positive correlation between income level (measured by the real gross domestic product) and social and human development outcomes suggests that there is a positive relationship between the two. The correlation between economic growth and other variables, however, seems rather weak, which implies that the short-term growth dynamics might not be strongly related to structural variables in a linear fashion. Labour force and human development are also both positively correlated with energy consumption, suggesting that the higher the level of development and labour force size, the greater the energy consumption, which in turn is indicative of the level of production and consumption activities. Human Development Index and labour force have both a positive relationship with the unemployment rate, which indicates that this relationship is not straightforward and that a rise in development could be a reflection of labour market shifts. The population growth rate has weak relationships with most variables, suggesting that its effect on economic performance could be indirect or nonlinear. Foreign direct investment and economic growth are in moderate positive correlation, and other variables have weak correlation, indicating that the impact of foreign direct investment may be influenced by the institutional and other conditions of the country.

Table 2: Correlation Matrix

Variables	LNRGDP	GDPGR	LNTEC	LNHDI	LNTLF	UEM	POPGR	FDI
LNRGDP	1.000							
GDPGR	-0.014	1.000						
LNTEC	0.881	-0.079	1.000					
LNHDI	0.346	-0.024	0.423	1.000				
LNTLF	0.780	-0.027	0.650	-0.219	1.000			
UEM	-0.018	-0.057	0.196	0.531	-0.430	1.000		
POPGR	0.082	0.184	-0.070	-0.208	0.174	-0.271	1.000	
FDI	-0.074	0.314	-0.073	0.073	-0.100	0.034	0.101	1.000

Table 3: Panel Unit Root Test

Variables	Level Z	Level P	First Diff Z	First Diff P	Status
LNRGDP	-0.5139	0.351	-12.3214	0	I(1)
GDPGR	-6.5654	0			I(0)
TEC	1.6177	0.989	-9.9254	0	I(1)
LNTEC	-1.3744	0.046			I(0)
LNHDI	-6.5331	0			I(0)
LNTLF	-0.2579	0.435	-6.3243	0	I(1)
UEM	7.47	1	-7.5144	0	I(1)
POPGR	-3.5456	0.001			I(0)
FDI	-4.4625	0			I(0)

The panel unit root test results (Table 3) show that several variables are integrated while others are not. Real gross domestic product, total energy consumption, total labour force and unemployment rate are non-stationary at level but

stationary after first-differencing. This implies that these variables exhibit stochastic trends and, as a result, are not stationary; they need to be differenced in order to be stationary. Economic growth, human development index, population growth rate and foreign direct investment, on the other hand, do not show any trends over time and are stationary at level. The mix of stationary and non-stationary variables indicates that the data set has a combination of integration orders, making panel econometric models that are appropriate for both stationary and non-stationary data suitable, like autoregressive distributed lag models. Overall, the findings from the unit root tests eliminate the possibility of spurious regression issues and properly reflect the short- and long-term relationships between the variables in the subsequent analysis.

The cross-sectional dependence results presented in Table 4 strongly suggest that interdependencies exist among the panel units. All the variables have large Pesaran CD statistics and p-values close to zero, which reject the null hypothesis of cross-sectional independence. The Fan CD statistics also confirm these results and are all large and significant. This uniformity of the tests shows that strong cross-sectional dependence exists between the variables. The findings suggest a high degree of interconnectedness between the economies of the sample countries and cross-sectional units, as the shocks in one country or cross-sectional unit are likely to spread to others. This dependency can be caused by integration of the global economy, trade connections, financial market integration, technology spillovers, or common macroeconomic shocks. An example of this is that changes in energy use levels or FDI in one country can affect energy use or FDI in another country because of similar economic systems or regional integration. The size of the test statistics indicates that this dependence is not "weak" but "all-pervasive" in all variables. Among others, real gross domestic product, human development index, and total labour force show particularly high values, reflecting a high level of synchronisation in economic and social indicators among the panel units. There are also significant interdependencies among energy-related variables, which could be due to common energy price fluctuations or to technological or industrial similarities. Similarly, variables such as population growth rate and unemployment rate, which are typically thought of as more country-specific, exhibit significant cross-sectional dependence and therefore also appear to be subject to influences beyond the regional and global dimension of unemployment and demographic dynamics. This is because cross-sectional dependence has implications in econometrics. It suggests that first-generation panel data methodology based on the assumption of independence among cross-sectional units could lead to biased and inconsistent estimates. Thus, it is legitimate to apply second-generation panel methods such as the cross-sectionally augmented autoregressive distributed lag model or common correlated effects estimators, which explicitly address such interdependencies.

Table 4: Cross-Sectional Dependence

Variable	Pesaran CD	P-value	Fan CD	P-value
LNRGDP	141.02	0.0000	4031.57	0.0000
GDPGR	18.17	0.0000	752.45	0.0000
TEC	117.47	0.0000	3608.12	0.0000
LNTEC	116.42	0.0000	3579.53	0.0000
LNHDI	154.98	0.0000	4441.57	0.0000
LNTLF	158.51	0.0000	4546.84	0.0000
UEM	20.22	0.0000	2258.54	0.0000
POPGR	7.17	0.0000	1536.66	0.0000
FDI	23.41	0.0000	1082.42	0.0000

The generalised method of moments estimation presented in Table 5 offers valuable insights into the dynamic determinants of economic growth and overcomes potential endogeneity and unobserved heterogeneity issues. Lagged dependent variables confirm the dynamic specification of the model, reflecting economic growth over time. The coefficients of the lagged variables of economic growth are positive and statistically insignificant; in this context, past economic performance does not appear to have a strong or consistent effect on current performance. This suggests a low degree of persistence in growth dynamics in the sample, possibly due to structural differences among economies or to shocks from the outside that alter the continuity of growth. These results are in line with studies that have stressed the importance of structural breaks and heterogeneous growth processes in the presence of panel data (Arellano & Bond, 1991; Blundell & Bond, 1998; Roussel & Audi, 2024). The coefficient of energy is negative but statistically insignificant, suggesting that the higher the levels of energy use, the less likely it is to have a significant impact on economic growth in this specification. This can be an indication of inefficient use of energy or the use of non-productive energy use habits. Furthermore, it implies that the growth impacts of energy consumption are not only a function of its quantity but also the quality and structure of energy consumption. This is consistent with the literature which focuses on the conditional relationship between energy and growth, given the energy structure, technological development and policy frameworks (Audi & Ali, 2022; Michailidis et al., 2025; Nguyen et al., 2025).

Human Development Index shows a positive and very significant relationship with economic growth; thus, it is concluded that the improvement of education, health and living standards is an important factor in improving economic performance. This discovery backs the human capital theory that capital investments in human development can lead to growth potential and productivity. The strength and significance of this coefficient underlines the significance of social development as a

major factor in economic growth (Abdelbary & Benhin, 2019; Marc et al., 2022; Nyandwe et al., 2024; Audi & Al-Masri, 2024). Labour force participation has a positive effect and is marginally significant, indicating that the more people are in the workforce, the greater the economic growth. This is indicative of the importance of labour as a key input in economic activity and production. But the relative lack of significance suggests that the quantity of labour alone is not enough and that other important factors—productivity, skills, and labour market efficiency—will influence growth outcomes (Marc et al., 2023; Wang et al., 2024; Acemoglu, 2025).

Unemployment has a negative and marginally significant coefficient, meaning that with an increase in unemployment rates, there is a decrease in economic growth. This is consistent with macroeconomic theory because unemployment is a measure of the idleness of the labour resources and a measure of inefficiencies in the economy. The negative relationship highlights the importance of labour market policies that aim at reducing unemployment and improving workforce participation (Okun, 1962; MacGinty, 2024; Marc et al., 2022; Adam & Yunus, 2025). The effect of population growth is not statistically significant, which implies that demographic growth does not directly or immediately affect economic growth in the sample. This could be a sign that the impacts of population growth are indirect and go through other factors like labour force, human capital and investment. The mixed effects of population growth have been extensively documented in the literature, depending on the structure of the population, dependency ratios and economic conditions (Bloom et al., 2003; Kelley & Schmidt, 2005; Audi et al., 2021; Marc et al., 2025; Khalid et al., 2025). The coefficient of foreign direct investment has a negative but not statistically significant sign, suggesting that foreign capital investment does not significantly stimulate economic development in this context. This implies that the advantages of FDI might be subject to absorptive capacity, institutional quality, and technological readiness. Without these conditions, foreign investment can lead to lower productivity or not stimulate the economy. This result is consistent with studies that have shown that the impact of FDI on growth is conditional (Borensztein et al., 1998; Alfaro et al., 2004; Ali & Audi, 2023). The constant term has a positive and statistically significant sign, which represents the current level of economic growth without any explanatory variables.

Table 5: GMM Outcomes

Variables	Coefficient	Robust SE	Z	P-value
lnrgdp_L1	0.1601	0.4067	1.3249	0.316
lnrgdp_L2	0.0607	-0.1085	1.3159	0.167
Lntec	-0.0009	-0.1531	1.7378	0.221
Lnhdi	2.0174	0.5491	3.3045	0
Lntlf	0.3976	0.3005	1.6296	0.078
Uem	-0.1757	-0.0917	-1.8046	0.073
Popgr	0.101	-0.0995	-0.4824	0.698
Fdi	-0.1291	0.1797	0.9776	0.156
Constant	16.1789	2.8292	3.9417	0

5. CONCLUSIONS

This paper aimed at examining the factors at the structural and macroeconomic level that explain variations in the energy–growth nexus in Sub-Saharan Africa from 1990 to 2024. As endogenous growth, human capital growth and structural transformation theories are coupled in a dynamic panel framework, the analysis offers a complete picture of the impact of energy consumption, human development, labour dynamics, demographic factors and foreign direct investment on economic growth in the region. The empirical results show that the traditional view of energy influencing economic growth is not valid for the Sub-Saharan Africa case. The small, non-significant effect of total energy consumption implies that growth in energy use is not enough to drive up economic performance. This is a result of the underlying structural inefficiencies, lack of industrial integration and the dominance of non-productive energy use. It suggests that, if no improvements in energy quality, energy efficiency and sectoral allocation are made, the growth in energy use might not lead to significant economic benefits. Human development, however, grows to be the strongest and most important factor of economic growth as compared to its counterparts. The importance of the Human Development Index is highlighted by its positive correlation and impact on education, health and human capital, which play a pivotal role in improving productivity, innovation and effective use of resources. The discovery strengthens the case for human-capital-led sustainable growth in Sub-Saharan Africa, and not resource-led growth. The role of labour market variables is also important but not straightforward. Labour force participation has a positive but limited effect, suggesting that a larger labour force can help to boost economic activity. But the negative impact of the unemployment rate reveals underlying inefficiencies in the labour market, such as lack of full employment and skill shortages. The dynamics indicate that boosting the quality of labour and market efficiency is as important as boosting the quantity of labour. Population growth and foreign direct investment are shown to be statistically insignificant. Thus, their effects on growth are indirect and conditional. The importance of population growth implies that population increases are not a necessary precondition for economic development unless the increases in population are accompanied by investment in human resources and employment. Likewise, the limited absorptive capacity, as indicated by the weak impact of foreign direct investment, is caused by limited institutional quality, infrastructure and technological readiness, which limit the capacity to convert

external investment into productivity gains. The poor growth persistence also suggests that Sub-Saharan Africa's economies are volatile and subject to exogenous shocks and structural disruptions. This further underscores the need for tackling structural problems and promoting stable growth. In short, the findings of the study suggest that human development and, to some extent, labour market factors are more important to economic growth in Sub-Saharan Africa, whereas energy consumption, demographic factors and foreign direct investment are of limited importance when taken alone. The results underline the importance of comprehensive policy approaches focusing on human capital development, labour market reforms, energy usage efficiency, strengthening institutions and boosting absorptive capacity for sustainable and inclusive economic growth.

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