

Energy consumption and inclusive growth in Sub-Saharan Africa: Does foreign direct investment make a difference?

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ABSTRACT

In line with the quest to achieve inclusive and sustainable growth, this paper examines the potential impact of energy consumption and foreign direct investment (FDI) and their interactive effect on inclusive growth for 32 Sub-Saharan Africa (SSA) countries from 2000 to 2019. The results of the two-stage system generalised method of moment (2SGMM) show that energy consumption induces inclusive growth. However, there is evidence of a non-linear relationship between FDI and inclusive growth, where FDI dampens inclusive growth to a certain point and begins to induce it after that point. Notably, the results reveal that FDI can effectively form synergies with both renewable and non-renewable energy consumption to promote inclusive growth in SSA. Also, our empirical results from the GMM is robust to Diskroll and Kraay methodology, which caters for cross-sectional dependence. We recommend that African leaders focus on attracting FDI to finance their energy needs, particularly in the area of low-carbon or renewable energy sources, by leveraging private sector capital investments to achieve inclusive growth and also promote sustainable development.

1. Introduction

Recent developments have necessitated the need for policymakers, donors, institutions, and non-governmental organisations (NGOs) to focus on promoting a growth agenda that ensures that a greater number of the citizenry benefits from national economic growth (Anyanwu, 2013; Odusola et al., 2017; World Bank, 2018). The devastating impact of the coronavirus (COVID-19) pandemic has further heightened the need for developing countries, including those in Sub-Saharan Africa (SSA), to adopt a paradigm shift from the traditional income growth agenda to one that promotes shared prosperity (inclusive growth), which emphasises that economic growth must enhance the overall wellbeing of the citizenry. Inclusive growth is the integration of various variables, such as income levels, poverty rates, employment opportunities, and the distribution of resources, aiming to provide fair and just advantages to all sectors of society (Anyanwu, 2013; Odusola et al., 2017; World Bank, 2018; World Bank, 2020a). This approach goes beyond the conventional measure of economic growth (Gross Domestic Product (GDP) or Gross National Product (GNP)) and is in harmony with broader welfare and development objectives, as articulated in Sustainable Development Goals (SDGs) (Anyanwu, 2013; Odusola et al., 2017;

World Bank, 2018.

Despite the remarkable economic growth achieved by most SSA economies, the stark reality is that high poverty rates, high unemployment rates and high socioeconomic inequalities remain high, a clear indication that the growth recorded has not benefited people experiencing poverty that much (African Development Bank, 2020; World Bank, 2020b; Zamfir, 2016). This situation may worsen income inequality and poverty in Africa, leading to job losses, increased food prices, slow recovery of informal sectors, and insufficient social protection (United Nations Development Programme (UNDP, 2020). About 87% of the world's poorest people will likely reside in SSA by 2030 if current economic challenges are not tackled head-on (World Bank, 2020b). Achieving social progress in SSA is imperative for addressing possible human capital development, social cohesion, and political stability setbacks. This study, therefore, contributes to the current shared growth policy discourse on SSA by deviating substantially from the traditional economic growth approaches (GDP or GNP); in doing so, we focus on how policymakers can achieve all-inclusive growth in SSA with a rigorous empirical study. In this regard, we identify two channels that align with the SSA's shared growth agenda: energy consumption and foreign direct investment.

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The literature notes that energy consumption enhances factors of production towards achieving economic growth and development (Romer, 1990a; Bhattacharya et al., 2016; Amin and Alam, 2018; Stern, 2019). As captured in SDG 7, access to clean, affordable and reliable energy is required to foster socioeconomic and environmental sustainability. At the national level, greater access to reliable energy has been identified as a means for boosting economies and lives through income generation, as well as greater economic specialisation and economic efficiency. At the household level, access to cheap and reliable energy can also free up both time and income to induce welfare (Fouquet and Johansson, 2008; Iddrisu et al., 2023c). In marginalised settings like SSA where population growth outweighs durable employment generation, access to energy can contribute to welfare by supporting the creation of small businesses and enterprises, facilitating the reallocation of household time (especially by women) from energy provision to improved education, and ensure access to greater market size due to lower transportation and communication costs (Odhiambo, 2009).

Additionally, access to affordable energy could contribute to human capital development and the quality of life through reduced indoor smoke, cleaner water, and improved refrigeration (Dinkelman, 2011; Lipscomb et al., 2013; Barreca et al., 2022). Notwithstanding the recognition of the opposing view stressing the minimal role of energy in growth as apparent in the neutrality hypothesis and its implication for the quality of life (Menegaki, 2011; Narayan and Doytch, 2017; Umurzakov et al., 2020) we reckon that the current development agenda of SSA places energy at the heart of shared prosperity. Hence, safe, cheap and reliable energy consumption could prove crucial for fostering equitable income growth and distribution by directly functioning as an input for sustained growth.¹

The optimism with FDI in spurring inclusive growth is that the SSA remains a fast-growing destination for foreign investors due to the liberal investment policies (UNCTAD, 2018; Jinapor et al., 2024). Policy interventions such as the Special Economic Zones (SEZs) and the African Continental Free Trade Area (AfCFTA) could be game-changers in incentivising FDI inflows to SSA, which could be significant in revitalising SSA's quest to achieve a continent of shared income growth and distribution (Iddrisu et al., 2023c; Ofori and Asongu, 2024). To foster shared prosperity in unequal societies like SSA, FDIs can help generate durable and equitable wealth through technological transfer, innovation diffusion, industrialisation, macroeconomic stability, employment, and poverty alleviation (Sakyi and Egyir, 2017; Opoku et al., 2019; Ofori and Asongu, 2024).

FDI flow may form the necessary synergies with energy consumption to further influence inclusive growth through project selection (Moudatsou, 2003; Mohanasundaram and Karthikeyan, 2015; Udeh and Odo, 2017; Susilo, 2018; Mohamed et al., 2021). For example, the literature shows institutional investors help reduce firms' carbon emissions (Safullah et al., 2022). Implicitly, institutional investors may choose to be involved in cross-border deals that potentially have lower carbon emissions. Further, investors are noted to consider their business activities' environmental and social impact before making investment decisions (Boffo and Patalano, 2020). Domestic businesses also consider the ecological effects of their choices, including energy consumption (Chatterji et al., 2009; Liesen et al., 2017). By implication, cross-border fund flow or FDI would gravitate towards projects with lower carbon emissions. This has important implications for the inclusive growth prospects of economies, taking cognisance of the critical role of renewable (REC) and non-renewable energy consumption (NREC).

Nevertheless, the extant literature examining energy consumption and economic growth and development has largely not considered inclusive economic growth (Omri and Kahouli, 2014; Iyke, 2015; Abdouli and Hammami, 2017a; Zeng et al., 2020; Awodumi and Adewuyi, 2020; Fon et al., 2021; Olanrele and Awode, 2022). This paper used an inclusive growth index generated using Principal Component Analysis (PCA), a method that isn't novel but offers potential for innovation in research methodologies. Using an inclusive economic growth measure

based on PCA is an innovation as it goes beyond higher production and enables a better alignment between policy interventions and the general welfare in emerging countries. From the existing inclusive growth models such as the Human Development Index (HDI), and other frameworks proposed by empirical literature (Ianchovichina and Lundstrom, 2009; Anand et al., 2013; Asian Development Bank, 2013; Mlachila et al., 2016), we find the inclusive growth framework by the ADB most appropriate for this study due to its extensive and comprehensive coverage. For instance, the ADB framework captures poverty and inequality, economic growth and employment, infrastructure, education and health access, essential infrastructure utilities and services, gender equality, social safety nets, energy consumption and governance.

Although there are some studies on the relationship between FDI and inclusive growth (Adegboye et al., 2020a; Ofori and Asongu, 2021a, 2021b; Iddrisu et al. 2023a, 2023c), none of these studies examined the moderation role of FDI on energy consumption nexus. This paper contributes to the extant literature in several ways. First, the paper explores the effect of energy consumption on inclusive growth. Kahia et al. (2017) suggest the need to disaggregate energy consumption to examine their unique impact on economic growth. Also, given the recent push towards promoting REC, total energy consumption may mask the unique effects of the various sources towards inclusive growth.

Consequently, the paper examines the impact of disaggregated energy consumption on inclusive growth. Further, the paper examines the direct effect of FDI and its squared term on inclusive growth to determine whether there is a threshold of FDI beyond which any increase boosts inclusive growth or otherwise. This is to determine whether the relationship between FDI and inclusive growth is non-linear. Also, the paper investigates the joint effect of energy consumption and FDI on inclusive growth in SSA. Particular attention is paid to the interaction term to determine whether FDI flows channelled into energy consumption can help spur inclusive growth in SSA.

By applying the two-stage system GMM on 32 SSA countries covering the period 1995–2019, we report that REC and NREC exert significant influences on inclusive growth, while FDI exhibits a non-linear relationship on inclusive growth, declining initially and rising after a turning point. Notably, the interaction term between FDI and energy consumption is positive and statistically significant, emphasising the importance of FDI in achieving inclusive growth. Thus, FDI inflows could be a critical pathway to increase energy sector investments in SSA, which can promote inclusive growth. The contributions from this research are important to SSA's effort to develop its energy potential to promote shared growth and prosperity without compromising environmental sustainability.

The remainder of the paper is organised as follows: Section 2 presents the theoretical reasoning and empirical literature. Section 3 outlines the material and methods. While Section 4 presents the results and discussions, Section 5 provides the conclusion, implications and limitations.

2. Theoretical reasoning and empirical literature

2.1. Theoretical reasoning

The theoretical link between energy consumption and economic growth originates from Solow (1956) neoclassical growth theory. The model suggests that total output in an economy is produced using capital and labour, which continuously vary and are linked through the production function with constant returns to scale. Romer (1990a,b) extends the Solow (1956) model by including technological progress as an endogenous variable in the growth process. The model attributes output growth to capital accumulation and technological change, driven by profit-maximising agents' investment decisions in response to market incentives. As Hidalgo (2011) reckons, the traditional wisdom that only two factors (i.e., capital and labour) drive growth, as espoused in the Solow (1956) model, is flawed. Amin and Alam (2018) highlight the critical role of energy consumption in the production process. They

suggest that the second law of thermodynamics underscores the necessity of energy in all matter transformations, including production processes. Thus, the underlying assumption of this model is that production relies on a mix of capital, labour, and energy sources (not only capital and labour).

Also, the effectiveness of technology hinges on energy availability, confirming the important role of energy in the growth model. Ecological economists emphasise that without energy, the factors of production cannot substitute for or operate effectively, thereby limiting economic growth (Belloumi, 2009; Stern, 2011). The attendant theory, often referred to as the energy-growth theory, highlights the possibility of improvement in technical efficiency through energy consumption (Brown and Wolk, 2000; Solow, 1974, 1998; Stiglitz, 1997, 2010). Apart from its impact on income growth, access to energy is fundamental for people to realise their innovative and entrepreneurial potential (Gaye, 2007; International Energy Agency (IEA), 2019). Therefore, improving accessibility to energy services remains critical for reducing poverty, income inequalities, gender inequalities and spatial inequalities. This intuition stems from the claim that energy accessibility can influence income distribution by increasing private sector productivity and job opportunities (Dinkelmann, 2011; IRENA, 2021).

The theoretical linkages between FDI and shared growth stem from the argument that by specialising in cross-border production activities in which they have abundant factors, countries can put natural resources to use to the benefit of the masses. Thus, FDIs can drive shared growth through job creation, the revival of the industrial capacity of recipient countries, and corporate social responsibility (Ohlin, 1933; Ofori and Asongu, 2021b; Bello et al., 2022). The neoclassical theory of economic growth by Swan (1956) and Solow (1956) considers FDI as an important growth factor for emerging countries as it enhances productivity via capital accumulation, technological know-how, and input imports for sustainable economic growth (Herzer et al., 2008). The dependency theory also suggests that foreign investors inject capital and technology, which can boost host countries' industrial capacity, create jobs, and promote corporate social investments (Kotler and Lee, 2005). However, there is an offsetting effect as it may also create unemployment due to new production techniques and innovations and income inequality in the short term due to skill set mismatch (Girling, 1976). Foreign enterprises gaining assets in host nations may lead to macroeconomic instability, capital flight, and domestic firm failures (Ndikumana and Sarr, 2019). Similar to the dependency theory, the modernisation theory also suggests that FDI can accelerate the transfer of new technologies, employment creation and economic linkage to host countries, thereby affecting energy sector investments for inclusive growth (Lucas, 1988; Grossman and Helpman, 1993; Kotey and Abor, 2019). Also, the Bhagwati hypothesis emphasises that the inflow of external finance can boost innovation and productivity (Sakyi and Egyir, 2017; Bhagwati, 2021; Ofori and Asongu, 2021b). Thus, FDIs may stimulate economic growth and shared wealth from different perspectives.

2.2. Empirical literature

2.2.1. Energy consumption and economic growth

The empirical relationship between energy consumption and economic growth can be categorised into four testable hypotheses: the growth, conservation, feedback, and neutrality hypotheses (Apergis and Payne, 2010). Initially proposed by Kraft and Kraft (1978), the growth hypothesis holds that energy consumption drives economic growth. Several studies have documented evidence supporting this hypothesis. For example, Esen and Bayrak (2017) used panel data analysis of 75 developed and developing net energy-importing countries from 1990 to 2012, show that energy consumption positively impacted economic growth. Also, Dogan et al. (2020) found that REC increased economic growth in 32 European nations, using data between 1995 and 2014. Further, Kouton (2021) found that REC increased inclusive growth, proxied by GNP, in 44 African countries. The use of GNP as a proxy for

inclusive growth is, nevertheless, problematic as its focus is national income but not social equity.

The conservation hypothesis presumes that the main factor of energy consumption will follow economic growth. A strand of empirical studies provides evidence confirming the *conservation hypothesis*. For instance, Abosedra and Baghestani (1989) document evidence suggests that the US GNP causes energy usage. In support of this hypothesis, Ashraf et al. (2013) also show that Pakistan's economic growth between 1971 and 2008 increased energy demand. Using a panel Granger causality test (Umurzakov et al., 2020), found unidirectional causation from economic growth to energy consumption for 26 countries, using data from 1995 to 2014.

Other studies have provided evidence supporting the *feedback hypothesis*, which emphasises a bi-directional causality between energy consumption and economic growth. Apergis and Payne (2010), using heterogeneous panel cointegration to test for causality between REC and economic growth for 13 Eurasia countries from 1992 to 2007, find a bi-directional causality. Kristjanpoller et al. (2018), applying wavelet analysis to 74 developing and emerging nations from 1972 to 2014, also confirm the feedback hypothesis. Similar results confirming the *feedback hypothesis* can be found in the following studies (Yildirim et al., 2012; Omri and Kahouli, 2014; Saidi and Mbarek, 2015; Saidi et al., 2017). In this scenario, implementing policies that result in using less energy could hurt economic growth. Nevertheless, it is instructive to note that some researchers have argued that adopting energy efficiency policies may not adversely impact economic growth under this hypothesis (Cantore et al., 2016; Lin and Zhou, 2022).

The *neutrality hypothesis* suggests no causal relationship exists between energy use and economic growth. Empirical investigations into this hypothesis show some evidence supporting the hypothesis. For example, Jobert and Karanfi (2007), using data between 1960 and 2003 and applying cointegration and Granger causality tests, did not find evidence supporting a long-term link between energy use and income in Turkey. Also, Menegaki (2011), using the dynamic error correction for 27 European countries from 1997 to 2007, found no correlation between REC and economic growth. Bulut and Menegaki (2020) employed panel cointegration and causality approaches for the top 10 solar-installed energy capacity countries over the period 1999–2015 and found no causation between solar (i.e., REC) energy and GDP. Further, evidence documented by Narayan and Doytch (2017) and Umurzakov et al. (2020) supports the energy consumption-economic growth neutrality hypothesis.

The empirical studies discussed have applied varied econometric methodologies focusing on different countries, regions, and periods and adopting different proxy variables. Given that the policy implications depend on the relationship established, the choice of proxies is a significant matter. For instance, studies examining the link between energy and economic growth rely extensively on traditional measures of economic growth, such as GDP or GNP, which only focus on national income (Apergis and Payne, 2009; Ozturk, 2010; Akadiri and Ajmi, 2020; Dogan et al., 2020; Kouton, 2021). As important as they are, results derived from such proxies do not reflect societal equity. This is reinforced by Ali and Son (2007) and Oluseye and Gabriel (2017), who confirm widening inequality despite a consistent increase in GDP per capita. Hence, using economic growth proxies in energy-growth studies that go beyond higher production enables a better alignment between policy interventions and general welfare. Therefore, this paper uses a broad-based inclusive growth measure that emphasises equitable growth.

In addition, several extant studies have primarily focused on aggregated energy consumption. Recent studies argue for the need to disaggregate energy consumption (i.e., REC and NREC) and observe their unique effects on economic growth (Kahia et al., 2017). This is important to achieve sustainable and reliable energy consumption in an environmentally sustainable manner (Bowen and Kuralbayeva, 2015; World Bank, 2018). Thus, this paper examines the disaggregated effect

Table 1
Variable definition.

Variable	Symbol	Definition	Source	Empirical Papers that Used the Variables
Inclusive growth	IG	Inclusive growth index calculated based on the PCA approach	Authors	Ofori and Asongu (2021b, 2024); Iddrisu et al. (2023c)
Energy consumption				
Total energy	TEC	Log of total energy consumption	EIA	
Renewable energy	REC	Log of renewable energy consumption	EIA	Kouton (2021)
Non-renewable energy	NREC	Log of non-renewable energy consumption	EIA	Ibrahim et al. (2021)
Foreign Direct Investment	FDI	Net foreign direct investment inflow (% GDP)	WDI	Ofori and Asongu (2021b, 2024); Iddrisu et al. (2023c)
Interaction term:	$EC \times FDI$		Authors	
Domestic Capital	GCF	Gross fixed capital formation	WDI	Adams et al. (2016)
Trade openness	TO	Trade (% of GDP)	WDI	Adams et al. (2016)
Inflation	CPI	Inflation	WDI	Ofori and Asongu (2021a); Adams et al. (2016)
Population	POP	Population growth (%annual)	WDI	Adams et al. (2016)
Control of corruption	CC	Control of corruption	WDI	Iddrisu et al. (2023c)
Oil rent	OR	Oil rents are the difference between the value of crude oil production at regional prices and total costs of production	WDI	Ofori and Grechyna (2021)

Notes: EIA denotes Energy Information Agency; WDI is World Development Indicators. This table features the variables used, the data sources, and how they are measured.

of energy consumption on inclusive growth.

2.3. FDI and economic growth

The empirical literature examining FDI and growth report findings support the positive impact of FDI on economic growth, thus confirming the theories. For instance Agbloyor et al. (2014), applying the GMM method and using data between 1960 and 2014, found that FDI boosts economic growth in 38 African countries. Also, Appiah et al. (2019), using PMG on selected African nations, show that FDI net inflows favourably affect economic growth. Further, Iheonu et al. (2017) and Ofori and Asongu (2021a) document a positive and significant impact of FDI on growth in SSA countries. UNCTAD (2014) also shows that FDI can enhance growth by increasing innovation, private sector competition and efficient use of resources to bring about economic sustainability. Nevertheless, several papers also show that FDI may dampen or negatively impact economic growth (e.g., Saltz, 1992; Anyanwu and Yameogo, 2015; Edrees, 2015; Kotey and Abor, 2019).

A thread of studies also shows that FDI and economic growth affect each other. For example, Amri (2016) and Abdouli and Hammami (2017a, 2017b) found a bi-directional relation between FDI and output per capita in 75 developed and emerging countries. Kaulihowa and Adjasi (2018) used PMG to analyse the effect of FDI on income inequality in 16 African nations from 1980 to 2013. The paper documents a U-shaped effect, suggesting a non-linear link. Also, the connection between FDI and growth may be conditional. For example, Ofori and Asongu (2024) find that FDI has little impact on growth in countries with weak governance. Further, Bello et al. (2022) find that ICT threshold levels in SSA limit the favourable impact of FDI on growth. Also, Kusumawati (2018) found that quality institutions help FDI boost growth in Indonesia.

Generally, research on energy consumption, FDI, and inclusive growth in SSA remains sparse. To the best of our knowledge, little or no study has examined the disaggregated effects of energy consumption (REC and NREC) on inclusive growth in SSA. More importantly, whether REC and NREC complementing FDI can foster inclusive growth in SSA remains unanswered. This paper fills these gaps.

3. Material and methods

3.1. Material

The sample analysed in this paper includes 32 SSA countries from 1995 to 2019 due to data availability. The data is sourced from the

Table 2
Variable used to construct inclusive growth index.

Variable	Variable Definition	Source
Clean energy	Access to clean fuels and technologies for cooking (% of population)	WDI
Electricity	Access to electricity (% of population)	WDI
Mobile cellular	Mobile cellular subscriptions (per 100 people)	WDI
Contributing worker	Contributing family workers, total (% of total employment)	WDI
Employment	Employment to population ratio, 15+, total (% modelled ILO)	WDI
Immunisation	Immunisation, DPT (% of children ages 12–23 months)	WDI
Mortality rate	Mortality rate under 5 (per 1000 live births)	WDI
Health expenditure	Government expenditure on health (% total government expenses)	WDI
Underweight	Prevalence of underweight, weight for age (% of children under 5)	WDI
Education	Primary education, duration (years)	WDI
Women in parliament	The proportion of seats held by women in national parliaments (%)	WDI
Pupil-teacher ratio	Pupil-teacher ratio, primary	WDI
Equality in primary	School enrolment, primary (gross), gender parity index (GPI)	WDI
Equality in secondary	School enrolment, secondary (gross), gender parity index (GPI)	WDI
Portable water	People using at least basic drinking water services (% of population)	WDI
Primary education	Number of years required to complete primary education	WDI
Sanitation	People using at least basic sanitation services (% of population)	WDI
GDP per capita	GDP per capita (% annual growth)	WDI

Note: WDI represents World Development Indicators. This table shows the variables used to construct our inclusive growth index.

World Bank [Development Indicators (WDI)] and the Energy Information Agency (EIA), as shown in Table 1. Our dependent variable is inclusive growth, proxied with an inclusive growth index using the PCA approach. We follow the ADB inclusive growth framework, using 18 variables to create the inclusive growth index used in this paper (see Table 2). Since the 18 variables are each measured differently, the paper normalised the individual variables before using them to construct the index. Panel normalisation minimises the effect of outliers on the results (Gygli et al., 2019). The index is then normalised to a scale of 0%–100%, followed by an appropriateness test.²

The main independent variables of interest are energy consumption and FDI. Energy consumption was measured with a log of a country's

Table 3
Descriptive statistics.

Variables	Mean	Std. Dev.	Min	Max
Inclusive Growth	41.047	17.076	0.000	100
Total energy consumption	31.734	1.532	28.034	36.284
Renewable energy consumption	29.76	1.771	21.993	32.683
Non-renewable energy consumption	31.454	1.55	28.02	36.27
Foreign Direct Investment	3.411	5.144	-11.199	39.828
Domestic Capital	21.188	9.222	22.786	81.021
Trade Openness	66.928	31.604	20.723	192.537
Inflation	9.226	31.668	-9.616	513.907
Population	2.491	0.827	-0.402	5.078
Control of corruption	-0.642	0.567	-1.555	1.245
Oil rent	3.823	10.201	0.000	57.513

Note: This table captures the statistical information on the variables used for the study.

Sources: STATA Version 17, 2024

total primary energy consumption (quadrillion British thermal units (Btu)). The paper disaggregates total energy consumption into REC and NREC to inform policy discussions on which form of energy promotes inclusive growth, as shown in Table 1. On the other hand, FDI is measured as a percentage of GDP and is obtained from WDI (see Table 1).

Following the extant literature (Adegboye et al. 2020a, 2020b; Ofori and Asongu, 2021a, 2024; Iddrisu et al. 2023a, 2023b), SSA characteristics and availability of data, the paper also includes several control variables in the estimated models. These are domestic capital, trade openness, inflation, population, control of corruption and oil rent (see Table 2). Domestic capital and inflation are proxied by gross capital formation (% GDP) and consumer prices (% annual), respectively. Trade

openness, proxied by net trade (% GDP), captures trade liberalisation, whilst population growth shows the growth level of the population in percentage annually. While control of corruption measures how well corruption has been managed, oil rent denotes the difference between the value of crude oil production at regional prices and total production costs.

We discussed some preliminary results including descriptive statistics, correlation matrix and multicollinearity test. Table 3 presents the results of the descriptive statistics, however we only provided a discussion of the main variables of interest. The results in Table 2 reveal that our index has an average value of 41.047%. This indicates that inclusive growth in the SSA sample is low. At the country level, South Africa is detected to have the highest inclusive growth (89.8), whereas Niger (21.7) is characterised by low inclusive growth (see Fig. 1(a)).

Also, Table 3 shows that FDI flows to the sample countries has a mean value of 3.411% and a minimum of -11.199%, which shows that SSA still has very low inflows of FDI. This indicates that, on average, the FDI inflow to these countries is relatively low, with some countries experiencing negative FDI, particularly in the Sub-Saharan Africa region. On a country level, Mozambique (11.8% of GDP) and Congo Republic (10% of GDP) are seen to have the greater inflow of FDI, whilst Comoros (0.459%) and Burundi (0.461% of GDP) attracted the least inflow of FDI (see Fig. 1).

According to Table 3, total energy consumption has an average value of 31.734%, which signifies that on average, about 31.734% of the available energy is being used. In other words, around one-third of the total energy available is being consumed. The country-level data shows South Africa (36.2) has the highest total energy consumption, whereas Comoros (28.5) consumes the lowest energy (see Fig. 2(a)). Disaggregating energy consumption into REC and NREC, the averages are reported to be 29.76 and 31.45, respectively. Also, South Africa

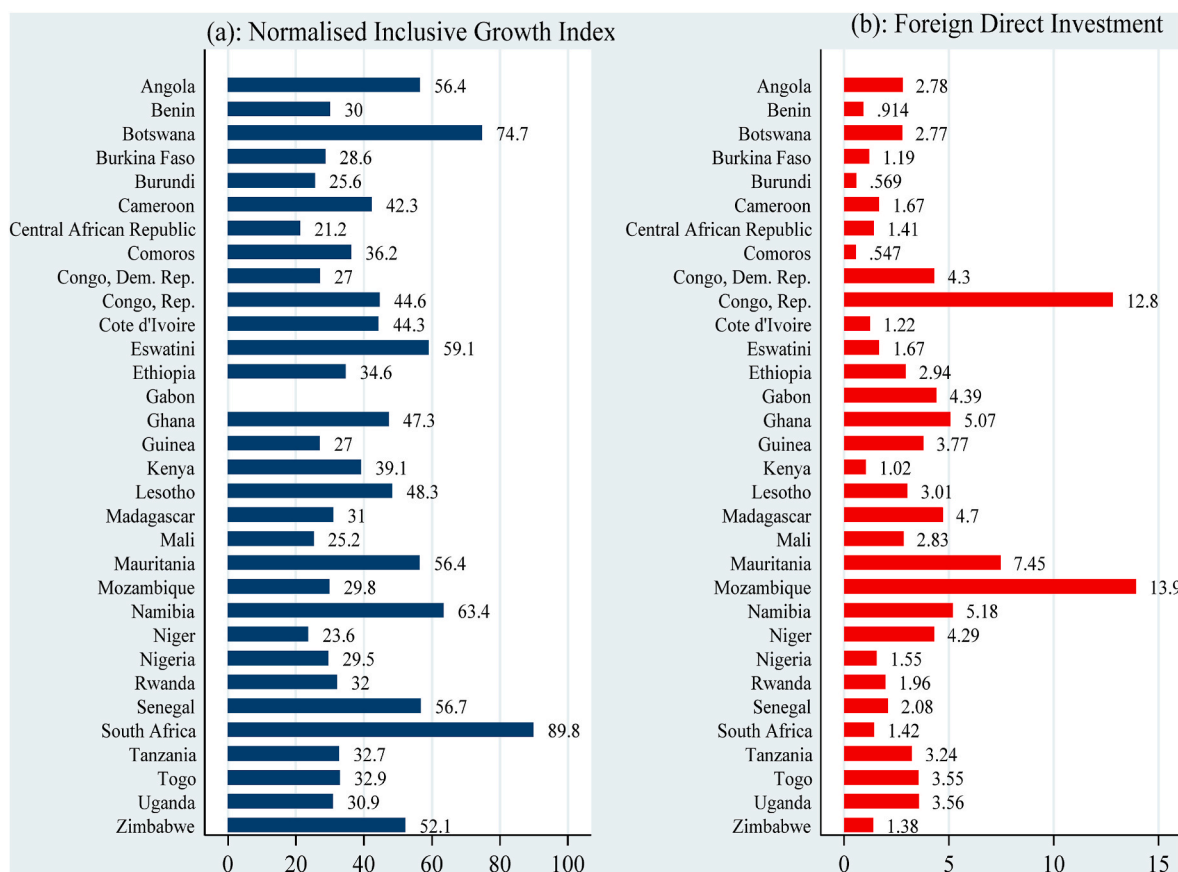


Fig. 1. In-country inclusive growth and FDI, 2000–2019.
Source: STATA Version 17, 2024.

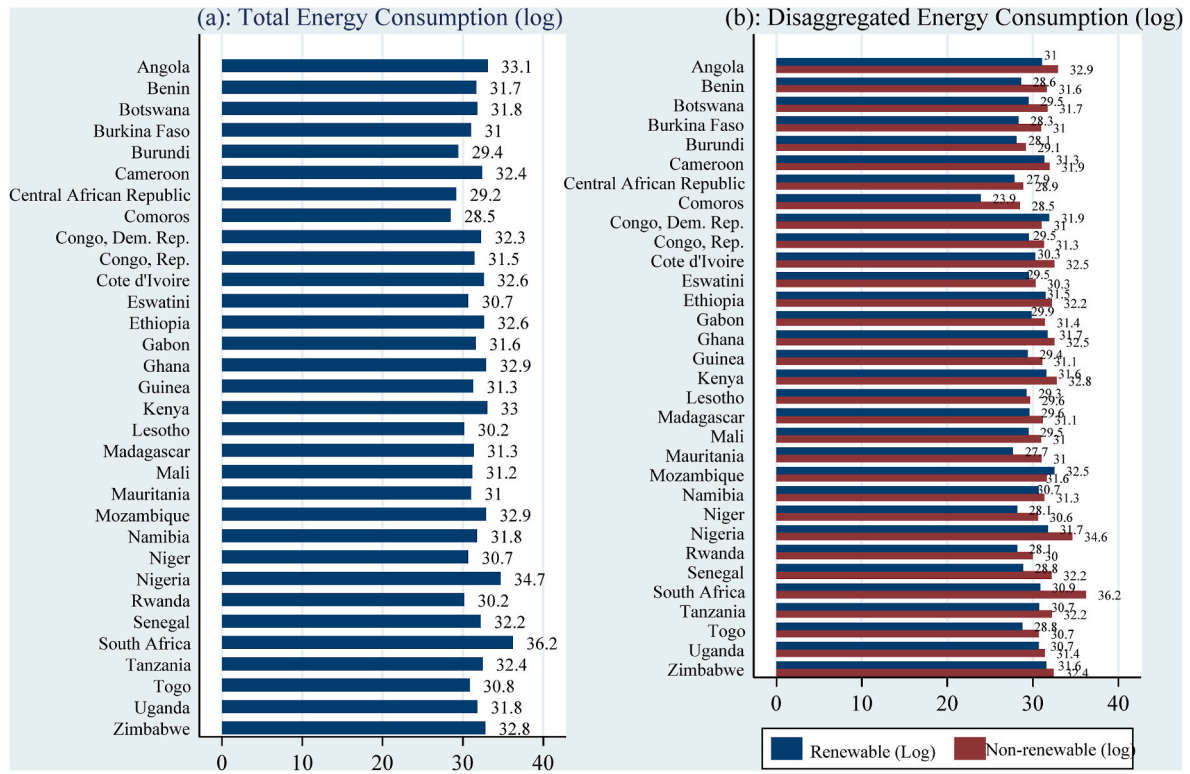


Fig. 2. In-country Energy Consumption, 2000–2019. Source: STATA Version 17, 2024.

consumes more non-renewables, with a share of 36.2%, whereas Mozambique leads in REC at 32.5% (see Fig. 2(b)).

Table 4 presents the Pearson correlation for all variables included in the empirical analysis. The table shows that all the variables significantly affect inclusive growth. Also, apart from the high correlations between total and disaggregated energy, all correlations are below 0.5. Nevertheless, we do not include both variables in the same estimated model, so it does not present multicollinearity problems. Notwithstanding that, a multicollinearity test was conducted using the Variance Inflation Factor (VIF) to ensure that no high correlation would affect our regression output. The findings, reported in Table 4 reveal the absence of multicollinearity, as indicated by individual VIFs below 5, and the average VIF below 10, aligning with the rule of thumb.

3.2. Method

3.2.1. Empirical model

Drawing upon neo-classical theory and some empirical studies (Adegboye et al. 2020a, 2020b; Ofori and Asongu, 2021a, 2024; Iddrisu et al. 2023a, 2023b) as our foundation, we delineate our empirical model, initiating with the estimation of equation (1). This enables us to explore the direct influence of energy consumption and FDI on the promotion of inclusive growth. Equation (2) on the other side captures the non-linear relationship between FDI and inclusive growth. We delve into examining the interactive effect of energy consumption and FDI on inclusive growth which is specified in equation (3).

$$IG_{it} = a + \beta_0 IG_{it} + \beta_1 EC_{it} + \beta_2 FDI_{it} + \beta_3 GCF_{it} + \beta_4 TO_{it} + \beta_5 CPI_{it} + \beta_6 POP + \beta_7 CC + \beta_8 OR + \varepsilon_{it} \quad (1)$$

$$IG_{it} = a + \beta_0 IG_{it} + \beta_1 FDI_{it} + \beta_2 FDI_{it}^2 + \beta_3 GCF_{it} + \beta_4 TO_{it} + \beta_5 CPI_{it} + \beta_6 POP + \beta_7 CC + \beta_8 OR + \varepsilon_{it} \quad (2)$$

$$IG_{it} = c + \forall_0 IG_{it} + \forall_1 EC_{it} + \forall_2 FDI_{it} + \forall_3 GCF_{it} + \forall_4 TO_{it} + \forall_5 CPI_{it} + \forall_6 POP + \forall_7 CC + \forall_8 OR + \forall_9 (EC \times FDI)_{it} + \varepsilon_{it} \quad (3)$$

From equations (1)–(3), IGI_{it} is the index for the inclusive growth of the country i at time t . EC_{it} represents the energy consumption of country i at time t , which captures REC and $NREC$. FDI denotes net foreign direct investment as a percentage of gross domestic product. GCF , TO , CPI , POP , CC and OR represent gross fixed capital formation as a percentage of gross domestic product, trade as a percentage of gross domestic product, annual inflation growth rate, annual population growth rate, estimate of control of corruption and oil rent (the difference between the value of crude oil production at regional prices and total cost of production), respectively. In the equations, i is the country-specific dimension and t is the time period. The error term, ε_{it} , is decomposed into $k_i + m_t + e_{it}$, where; k_i represents the country-fixed effect, m_t represents the time-fixed effect and e_{it} represents the error term that varies over entity and time. The interaction variable, $(EC \times FDI)$, equation (3) specifies the interaction between energy consumption and FDI. Here, we emphasise that although both EC and FDI could directly affect inclusive growth positively, their interaction could bring higher effects.

According to contemporary literature on interactive regressions (Adegboye et al. 2020a, 2020b; Iddrisu et al. 2022, 2023a, 2023b, 2023c, 2024; Iddrisu, 2024a, 2024b; Ofori and Asongu, 2024), to capture the value of the joint effect, the net effect must obtain by partially differentiating the dependent variable concerning the main variable of interest. Therefore, to obtain the net effect of energy consumption, we partially differentiate equation (3) with respect to energy consumption, which gives rise to equation (4).

$$\frac{\partial IG_{it}}{\partial Energy_{it}} = \forall_1 + \forall_9 \overline{FDI}_{it}, \quad (4)$$

where, \overline{FDI}_{it} denotes the mean of FDI , ∂ is the difference operator, IG_{it} is

Table 4
Correlation matrix and variance inflation factor.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	VIF ₁	VIF ₂	VIF ₃	VIF ₄
(1) IG	1.000														
(2) TC	0.461	1.000										1.840	1.760		
(3) REC	0.183***	0.768***	1.000											1.890	
(4) NREC	0.496***	0.980***	0.664***	1.000											1.760
(5) FDI	0.021	0.072*	0.141***	0.042	1.000										1.630
(6) GCF	0.216***	0.116***	0.050	0.148***	0.391***	1.000									1.450
(7) TO	0.357***	-0.041	0.111***	-0.066*	0.331***	0.287***	1.000								1.270
(8) cpi	-0.061	0.063	0.132***	0.020	0.045	-0.034	0.028	1.000							1.300
(9) pop	-0.454***	0.013	0.051	0.017	0.107***	0.199***	-0.350***	0.050	1.000						1.040
(10) cc	0.490***	0.010	-0.112***	0.037	-0.027	0.117***	0.215***	-0.109***	-0.402***	1.000					1.480
(11) oil	0.101**	0.127***	0.106***	0.147***	0.169***	0.284***	0.346***	0.130***	0.299***	-0.298***	1.000				1.480
Mean VIF												1.450	1.760	1.480	1.760

Notes: IGI index is inclusive growth index, REC is log of renewable energy, NREC is log of non-renewable energy, FDI is foreign direct investment, TO is trade openness; GDP is GDP per persons employed; *p < 0.10, **p < 0.05, ***p < 0.01; VIF denote variance inflation factor; VIF₁ is when renewable was main variable of interest whereas VIF₂ is when non-renewable was main variable of interest.

Source: STATA, Version 17, 2024.

the normalised inclusive growth index and $Energy_{it}$ is energy consumption.

We proceed to examine the threshold or turning point of FDI on inclusive growth. To determine the turning point, from equation (2) the increase or decrease in net FDI depends on the exact signs of β_1 and β_2 such that if $\beta_1 < 0, \beta_2 > 0$, then a U-shaped relationship exists, and the turning point of this curve is given by $\hat{\tau} = 0.5 \frac{\hat{\beta}_1}{\hat{\beta}_2}$. Furthermore, if $\beta_1 > 0, \beta_2 < 0$ then an inverse U-shaped relationship exists, and the turning point of this curve is computed as $\hat{\tau} = 0.5 \frac{\hat{\beta}_1}{\hat{\beta}_2}$.

3.2.2. Estimation techniques

The paper uses the two-stage system GMM (2SGMM) approach suggested by [Blundell and Bond \(1998\)](#) to estimate equations (1)–(3) due to concerns of endogeneity and the complex relationship between variables in a 32-country dataset over 25 time periods. The primary concern arises from endogeneity caused by including the lag of the dependent variable in both equations, creating a loop between variables. This endogeneity is amplified in first-difference estimations, affecting the reliability of the estimators. [Arellano and Bond \(1991\)](#) propose instrumenting endogenous variables to mitigate this issue, advocating for the system GMM estimator over the first-difference GMM. This approach is supported by some literature ([Bond et al., 2001](#); [Windmeijer, 2005](#)) and updated by [Roodman \(2009\)](#). The study follows suit, employing [Roodman \(2009\)](#) approach by instrumenting level and first-difference equations with lagged variables differently, addressing concerns of bias and unreliable standard errors. To prevent instrument overuse, a 2SGMM is adopted as recommended by [Roodman \(2009\)](#). The issue of endogeneity was addressed by utilising several instruments, including year dummies (2000–2019), lags of REC, NREC, FDI, GDP, and trade openness. The validity of these instruments is confirmed by the Hansen test. A statistically significant Hansen test would indicate that the instruments are inappropriate, while a non-significant result suggests their validity. The Hansen test results are presented in [Tables 5 and 6](#).

While the 2SGMM technique is effective in dealing with the problem of endogeneity, it is less effective in dealing with cross-sectional dependence ([De Hoyos and Sarafidis, 2006](#); [Mamba, 2021](#)). We therefore proceed to test for the presence of cross-sectional dependence in our data as shown in Table A.3 of the Appendix. The results in Table A.3 confirm that the variables exhibit the presence of cross-sectional dependence within the SSA, except for population growth and control of corruption. Consequently, we re-estimated our empirical models using the Driscoll-Kraay robustness regression model, which effectively addresses the presence of cross-sectional dependence ([Iheonu, 2019](#); [Sarkodie and Strezov, 2019](#); [Shah et al., 2021](#)).

4. Empirical results and discussions

This section starts with the presentation and discussion of the 2SGMM results, which are shown in [Tables 5 and 6](#). Thereafter, we present and discuss the results of the fixed-effect model utilising Driscoll-Kraay standard errors, as shown in [Tables 7 and 8](#), to serve as robustness checks.

¹ This is the energy-growth hypothesis.

² A Chi-square (X^2) statistic of 11941.612 and a p-value significant at 1% from the Bartlett (see Table A.1) test shows that our variables used to generate the index are interrelated. KMO statistic of 0.849 (see Table A.1) signifies the adequacy of our variables. Results in Table A.2 suggest that at least there are eigenvalues greater than 1.

Table 5
2SGMM results for energy consumption, FDI and inclusive growth.

VARIABLES	(1)	(2)	(3)	(4)	(5)
	IG	IG	IG	IG	IG
L.IG	0.6424*** (0.0711)	0.7176*** (0.0511)	0.6812*** (0.0813)	0.9043*** (0.0397)	0.8994*** (0.0288)
TC	4.5544*** (1.4781)				
REC		1.8935** (0.7551)			
NREC			6.6587*** (1.4213)		
FDI				-0.9422*** (0.1981)	-0.6625** (0.2438)
FDI ²					0.0173*** (0.0060)
GCF	0.0615 (0.1087)	0.3248** (0.1383)	-0.4121*** (0.1023)	0.2530*** (0.0706)	0.1757** (0.0680)
TO	-0.1676*** (0.0509)	-0.2165*** (0.0606)	-0.0152 (0.0203)	-0.0027 (0.0497)	-0.0061 (0.0113)
CPI	-0.1280*** (0.0322)	-0.1168*** (0.0345)	-0.0622* (0.0311)	-0.0477* (0.0278)	-0.0384 (0.0263)
POP	-3.4774 (3.0187)	-7.7551** (3.0744)	2.8042 (2.9755)	-1.8032 (2.2079)	-2.7801** (1.3313)
CC	-1.9323 (4.3538)	-3.6162 (4.0664)	2.1207 (1.9455)	-2.1349 (4.7598)	-2.5261 (1.6691)
OR	0.9437** (0.4072)	1.2418*** (0.3657)	0.4562* (0.2605)	0.2539*** (0.0819)	0.3200** (0.1316)
Constant	-115.0112** (47.6493)	-22.7829 (23.2598)	-195.2811*** (46.3841)	5.1933 (7.9805)	8.1421** (3.2348)
Observations	532	532	532	532	532
Number of id	31	31	31	31	31
Instruments	25	25	23	26	24
Wald Statistic	346.1	1212	238.2	7954	4167
Wald P-value	0	0	0	0	0
Hansen P-Value	0.203	0.200	0.505	0.217	0.301
Sargan P-Value	0.0573	0.145	0.0175	0.0592	9.35e-09
AR(1)	0.0203	0.0109	0.0318	0.00663	0.00599
AR(2)	0.267	0.603	0.316	0.467	0.0664

Note: The standard errors are in parentheses and brackets display the probability; *, **, *** means 10%, 5%, 1% critical level. L.IG, TC, REC, NREC, FDI, FDI², GCF, TO, CPI, POP, CC and OR represent inclusive growth lag, total energy consumption, renewable energy consumption, non-renewable energy consumption, foreign direct investment and its square, domestic capital, trade openness, inflation, population, corruption control and oil rent respectively.

Source: STATA Version 17, 2024.

4.1. 2SGMM results for energy consumption and FDI on inclusive growth nexus

Tables 5 and 6 present 2SGMM findings on energy consumption, FDI, and inclusive growth. Both tables reveal a significant positive effect of lagged inclusive growth on current inclusive growth, implying present policies for inclusivity enhance future outcomes. This validates a pre-requisite for a 2SGMM estimation. Endogeneity correction instruments are valid, indicated by statistically insignificant p-values in the Hansen test. Autocorrelation at order 2 is observed in the results. These findings underscore the importance of policy interventions for fostering inclusive growth and the effectiveness of the applied methodological approach in addressing endogeneity.

Starting with the direct effect of energy consumption, Table 5 shows that energy consumption promotes inclusive growth in SSA. The reported positive and significant coefficient of 4.55 for total energy consumption implies that a unit increase in energy consumption promotes inclusive growth by 4.55 units, ceteris paribus (see column 1 of Table 5). By implication, energy consumption can promote inclusive growth by providing essential resources and opportunities across various sectors, thereby, reducing disparities and enabling broader participation in economic, social, and educational activities. This result confirms the assertion of the President of Senegal and chairperson of the African Union, who argued that energy consumption can promote economic growth and development, hence, the need to develop and exploit energy potentials in Africa. The positive relationship between energy consumption and inclusive growth in the region aligns with the objectives of

SDG 7 of the UN's Agenda 2030) and Africa Union's Agenda 2050, emphasising the importance of reliable, accessible and affordable energy sources and their impact on development. The empirical findings suggest that access to reliable and affordable energy can foster shared growth through private sector growth, industrialisation, and employment. Empirically, our result is consistent with results reported in other studies (see Adams et al., 2016).

The paper disaggregates energy consumption into REC and NREC to observe their impact on inclusive growth in Africa. The results in Table 5 (columns 2 and 3) reveal that both energy consumption promotes inclusive growth in Africa, although NREC (coefficient; 6.6587) showed a more significant impact on inclusive growth than REC (coefficient; 1.8935). This can be attributed to the fact that NREC, like coal or conventional fossil fuels, are cheaper in the short term than REC, which often requires substantial upfront investments in infrastructure (Jinapor et al., 2023). For instance, in the initial phases of renewable energy utilisation, its primary adoption tends to concentrate more within urban regions than in rural or remote areas (see Bhattacharya et al., 2016). Also, in SSA, a significant section of the population depends on NREC, such as kerosene, petrol, diesel, firewood and charcoal (without afforestation) due to low sources of income, inadequate knowledge or skill level in renewable energy. Furthermore, REC is linked to challenges in variable generation and storage (Alam et al., 2020; Bhuiyan et al., 2022), which could have minimal effect on inclusive growth in the short term. This is particularly relevant for many SSA countries, where technological capabilities to manage the variability and storage of renewable energy remain limited (Bishoge et al., 2020).

Table 6
2SGMM results for the moderation role of FDI on energy consumption-inclusive growth nexus.

	(1)	(2)	(3)
Lag of inclusive growth	0.5582*** (0.1523)	0.6457*** (0.0916)	0.5676*** (0.0743)
Total energy consumption	6.9117** (3.1679)		
Renewable energy consumption		3.4563** (1.5150)	
Non-renewable energy consumption			9.2631*** (1.1813)
Foreign direct investment	-23.8046** (9.8239)	-13.8268*** (4.6357)	24.9186*** (8.0170)
Domestic capital	-0.1526 (0.1193)	0.2184 (0.1474)	-0.2344*** (0.0472)
Trade openness	0.0502 (0.0429)	-0.0272 (0.0485)	-0.0546* (0.0311)
Inflation	-0.1274** (0.0521)	-0.1279*** (0.0395)	-0.0411 (0.0269)
Population growth	7.8847** (3.4934)	-0.1429 (2.8432)	0.2490 (1.9891)
Control of corruption	-2.3950 (4.8599)	-3.7877 (5.9875)	1.9842 (2.6253)
Oil rent	0.6870** (0.3194)	0.8643*** (0.2955)	-0.2448** (0.1065)
TC × FDI	0.7256** (0.3046)		
REC × FDI		0.4439*** (0.1529)	
NREC × FDI			-0.7896*** (0.2542)
Constant	-223.4284** (101.2241)	-94.5062** (44.9939)	-263.8533*** (36.0001)
Observations	532	532	532
Number of ID	31	31	31
Instruments	24	24	29
F-Statistic	285.8***	184.1***	3570***
Hansen P-Value	0.380	0.154	0.167
Sargan P-Value	0.903	0.406	0.256
AR(1)	0.0510	0.0143	0.00414
AR(2)	0.897	0.714	0.323
Net effects	9.3867***	4.9706***	6.5956***
Joint significant effect	10.23***	10.56***	22.09***

Note: The standard errors are in parentheses and brackets display the probability; *, **, *** means 10%, 5%, 1% critical level respectively. TC × FDI is the interaction between total energy consumption and FDI, REC × FDI is the interaction between renewable energy consumption and FDI; NREC × FDI is the interaction between non-renewable energy consumption and FDI.
Source: STATA Version 17, 2024.

Table 5 also reveals that FDI has a non-linear relationship with inclusive growth. It can be detected from the table that while FDI has a significant and negative effect on inclusive growth, its squared term promotes inclusive growth (see column 5 of Table 5). This could imply that FDI might not significantly contribute to inclusive growth at low levels due to various challenges, such as a lack of a sufficiently large manufacturing sector, an infrastructure base in the host country and governance issues (Kang and Martinez-Vazquez, 2022). However, it is shown that as FDI increases beyond a certain threshold, its positive impacts become more pronounced, leading to a squared or amplified effect on inclusive growth, especially when coupled with policies that ensure equitable distribution and address social and economic disparities. Specifically, the turning point, $\hat{\tau} = 0.5 \frac{\hat{\beta}_1}{\hat{\beta}_2}$, is 19.15 percent, which implies that the impact of FDI on IG falls to 19.15 percent, beyond which it rises. The non-linear relationship could also signify that the inflow of FDI to SSA may not be adequate to spur inclusive growth, considering the current economic and social needs. Therefore, there is a need to implement diverse policies to attract more FDI to SSA to a point where it will start to enhance shared growth and prosperity. This aligns with empirical studies suggesting that while a certain level of FDI is coming

into SSA, it falls short, considering the continent’s growth trajectory and developmental requirements (Adegboye and Okorie, 2023; Shittu et al., 2023). Our findings could also imply that FDI flowing into SSA is channelled into the service and extractive sectors where fewer jobs are generated annually for the masses; therefore, when proper policies are implemented later, the spillover effect can be efficiently and sufficiently allocated. Empirically, our findings do not support some studies (Anand et al., 2013; Ofori and Asongu, 2021a, 2024; Iddrisu et al., 2023c) who argue that the initial levels of FDI are an essential determinant of inclusive growth.

Evidence of the joint effect of energy consumption and FDI on inclusive growth in SSA is provided in Table 6. The reported results suggest that FDI matters for the moderating effect of energy consumption towards attaining an inclusive growth agenda. To identify the magnitude of this effect, we compute the net effect of energy consumption on inclusive growth as specified in equation (4) which is presented in Table 6 as the net effect. To verify the statistical significance of this magnitude, we extended our analysis to examine the joint significant effect. Our findings indicate that energy consumption and FDI, together, have a significant collective influence on fostering inclusive growth in Africa (see Table 6). The results in Table 6 show that the coefficient (9.3867 unit) of the net effect of energy consumption implies that for SSA governments to obtain benefits from energy consumption, they must promote and attract more FDIs into their economies. Also, the development of the energy sector is both capital and technology-intensive, requiring the support of foreign investors who can bring in the needed capital and technological know-how. Therefore, benefits from FDI via technological spillover, energy-saving and clean energy technologies can induce inclusive growth in SSA. This also means that, in settings like SSA where lags in meeting the growing energy demand are apparent, FDI can also play a key role by providing the needed investment in the areas of generation capacity and energy management, which are essential for persistent energy supply, productivity and social inclusion. This, in effect, can fuel equitable income growth and distribution by reducing the cost of production, job creation and improvement in household consumption by reducing the share of income spent on energy.

Although FDI forms synergy with non-renewable energy consumption (net effect: 6.5956) to promote inclusive growth, we note with interest that the interaction between FDI and REC (net effect: 4.9706) in promoting inclusive growth is remarkable and very much heightened compared to their distinct effects, revealing the critical role that FDI can potentially play to enhance REC towards realising inclusive and sustainable growth in SSA economies in line with the united nations sustainable development goals (United Nations, 2015; IRENA, 2021).

Focusing on the control variables, the results in the Tables show that each variable (except proxy for corruption) impacts inclusive growth to some extent. However, Table 5 illustrates varying degrees of impact among these control variables. For instance, the study reveals that domestic capital promotes inclusion, except in the NREC model. Increased levels of inclusive growth are associated with higher domestic capital, consistent with growth theory (Solow, 1956; Stern, 2019), which suggests that domestic capital is an important determinant of growth. The results also indicate that trade openness negatively influences inclusive growth. Trade openness in Africa, reliant on raw commodity exports, amplifies vulnerability to global market shifts. While favouring specific sectors, it exacerbates inequalities, limiting inclusive growth by leaving some regions or industries behind. Our empirical do not support some empirical studies (Adom et al., 2019; Opoku et al., 2019).

According to Table 5, inflation disrupts inclusive growth by creating economic uncertainty, impeding businesses’ ability to strategies and invest. This deters foreign investment, lowers consumer confidence, and hampers economic stability, impacting long-term growth opportunities. Table 5 shows that population growth constrains inclusive growth by burdening resources and infrastructure, resulting in difficulties in delivering vital services such as healthcare, education, and sanitation.

Table 7
Driscoll-Kraay results of direct effects of energy consumption and FDI on inclusive growth.

VARIABLES	(1)	(2)	(3)	(4)	(5)
	IG	IG	IG	IG	IG
TC	11.93*** (0.075)				
REC		5.686*** (0.397)			
NREC			10.25*** (0.239)		
FDI				-0.109*** (0.0409)	-0.122*** (0.104)
FDI ²					0.0252*** (0.00478)
GCF	0.0607 (0.0235)	0.0607** (0.0235)	-0.201*** (0.0543)	0.302*** (0.0561)	0.302*** (0.0565)
TO	-0.0755*** (0.0177)	-0.0962*** (0.0183)	-0.0709 (0.0218)	-0.110 (0.0261)	-0.111 (0.0243)
CPI	-0.0236*** (0.00155)	-0.0221*** (0.00195)	-0.0326** (0.00333)	-0.0414** (0.00515)	-0.0414 (0.00514)
POP	-0.240 (0.420)	-0.764** (0.419)	-0.402 (0.718)	-0.972 (0.676)	-0.969*** (0.647)
CC	-0.222 (0.543)	-0.306 (0.731)	0.0361 (0.819)	-2.482 (0.715)	-2.499 (0.758)
OR	0.235** (0.0674)	0.233*** (0.0669)	0.105** (0.0480)	0.0955*** (0.0686)	0.0939*** (0.0681)
Constant	-337.5** (30.38)	-278.9** (28.81)	-128.4*** (30.84)	38.24** (4.692)	38.24*** (4.747)
R-squared	0.5660	0.5420	0.0238	0.2054	0.2055
Observations	557	557	557	557	557
Number of groups	31	31	31	31	31

The robust standard errors are in parentheses, and brackets display the probability: *, **, *** means 10%, 5%, and 1% critical level, respectively. TC, REC, NREC, FDI, FDI¹, GCF, TO, CPI, CC, and OR represent total energy consumption, renewable energy consumption, non-renewable energy consumption, foreign direct investment and its square, domestic capital, trade openness, inflation, population, corruption control, and oil rent, respectively.
Source: STATA Version 17, 2024.

This strains government finances and restricts investments crucial for inclusive development. Table 5 reveals that oil rent can contribute to inclusive growth in Africa through diversification of oil revenue to different sectors, job creation, and equitable distribution of benefits across society.

4.2. Robustness checks using Driscoll-Kraay

This subsection provides an analysis and discussion of the empirical findings using Driscoll-Kraay methodology, which are presented in Tables 7 and 8. Given the presence of cross-sectional dependence in the data, we empirically assess whether this dependence could influence the results obtained from the 2SGMM model. The findings indicate that our study remains robust across different estimation techniques, as the presence of cross-sectional dependence did not alter the results of the 2SGMM model. This is evident from the Driscoll-Kraay regression outcomes, where the key variables of interest, such as energy consumption, FDI, and their interaction terms, align with the 2SGMM results. For example, Table 7 shows the static relationship between energy consumption and FDI on inclusive growth. The table demonstrates that energy consumption (including total, REC and NREC) has a statistically significant positive impact on inclusive growth in the SSA region, consistent with the 2SGMM results presented in Table 5.

Additionally, the findings in Table 7 provide strong evidence of the impact of FDI on enhancing inclusive growth. Similar to the results in Table 5, Table 7 demonstrates that FDI exhibits a threshold effect on inclusive growth, where FDI initially has a negative influence on inclusivity up to a certain point, after which it begins to positively affect inclusive growth. Table 8 is consistent with the findings in Table 6, showing a positive net effect of energy consumption on inclusive growth. This suggests that, in the presence of FDI, energy consumption—whether total, REC or NREC—has an even greater impact on inclusive growth.

5. Conclusion and policy implications

5.1. Conclusion

In line with seeking broader welfare and development objectives, as articulated in Sustainable Development Goals, this study investigates (1) the effect of energy consumption and FDI on inclusive growth, (2) the threshold effect of FDI on inclusive growth and (3) the joint effect of consumption and FDI on inclusive growth for 33 SSA countries spanning 2000 to 2019. To do this, the paper utilises the 2SGMM approach, keeping in mind the policy implications of the finding. This approach is more robust against misspecification and addresses endogeneity concerns. The results from this approach show a significant positive effect of lagged inclusive growth on current inclusive growth, implying prevailing policies for inclusivity enhance future outcomes. This validates a prerequisite for a 2SGMM estimation. The documented results also indicate that the endogeneity correction instruments are valid, as shown by the statistically insignificant p-values in the Hansen test. These underscore the importance of policy interventions for fostering inclusive growth and the effectiveness of the applied methodological approach in addressing endogeneity. The results also revealed that energy consumption broadly impacts inclusive growth positively. Disaggregating energy consumption into REC and NREC sources, the study finds both promote inclusive growth, with NREC having a more significant impact. There is also a non-linear relationship between FDI and inclusive growth, where FDI initially dampens but eventually promotes growth after a threshold. FDI synergises with energy consumption, enhancing inclusive growth, especially when high FDI levels increase energy consumption. Notably, FDI has a greater moderating effect on the NREC-inclusive growth nexus, due to SSA's abundance of non-renewable energy resources in commercial quantities compared to renewable resources.

Table 8
Driscoll-Kraay results for the moderation role of FDI on energy consumption-inclusive growth nexus.

VARIABLES	(1)	(2)	(3)
Total energy consumption	11.94*** (0.960)		
Renewable energy consumption		6.459*** (0.853)	
Non-renewable energy consumption			10.60*** (0.908)
Foreign direct investment	-0.877*** (0.867)	-0.631*** (0.736)	3.745*** (1.064)
Domestic capital	-0.0553 (0.0240)	0.180 (0.0338)	0.0791*** (0.0297)
Trade openness	0.0811 (0.0169)	0.0967 (0.0220)	-0.0979** (0.0190)
Inflation	-0.0242** (0.00165)	-0.0316*** (0.00499)	-0.0205 (0.00187)
Population growth	1.268*** (0.407)	-0.424 (0.495)	0.724 (0.409)
Control of corruption	-0.303 (0.564)	-1.863 (0.889)	0.0482 (0.754)
Oil rent	0.247*** (0.0658)	0.152*** (0.0518)	-0.226*** (0.0694)
TC × FDI	0.0253** (0.0271)		
REC × FDI		0.0161*** (0.0245)	
NREC × FDI			-0.118*** (0.0334)
Constant	-337.6*** (30.06)	-153.7*** (24.57)	-290.1*** (27.89)
R-squared	0.569	0.391	0.547
Observations	557	557	557
Number of groups	31	31	31
Net effect	12.026	6.514	10.198

Note: The standard errors are in parentheses and brackets display the probability; *, **, *** means 10%, 5%, 1% critical level. TC × FDI is the interaction between total energy consumption and FDI, REC × FDI is the interaction between renewable energy consumption and FDI; NREC × FDI is the interaction between non-renewable energy consumption and FDI.

Source: STATA Version 17, 2024.

5.2. Policy implications

This paper contributes to the policy discourse aimed at identifying channels crucial for promoting inclusive growth in SSA. To this end, we pay attention to SDG 1, 5, 7, 8 and 10 and Aspiration 1 of Africa's Agenda 2063 to examine pathways through which energy consumption and FDI can influence socioeconomic sustainability in SSA. Based on the empirical findings, several policy recommendations are made. Firstly, there is an urgent need for SSA's economies to prioritise energy sector investments and development to ignite economic activities, generate employment, and enhance living conditions towards attaining inclusive growth. To achieve this, SSA economies must build adequate regulatory frameworks, develop an attractive energy market and improve energy sector governance to incentivise private capital investment in energy sector-related projects. Also, aligning energy initiatives with sustainable development goals integrates social, economic, and environmental factors, while partnerships between governments, private sectors, and global organisations can pool resources for robust energy infrastructure in SSA. In addition, given that energy sector investments are capital intensive, the SSA government are encouraged to control, exploit and transform its mineral resources locally with an emphasis on value addition to generate the much-needed financial resources for investments in energy-related projects. African leaders and policymakers should collaborate with National Development Banks, international development partners and specialised organisations towards building a strong and resilient financial market to unlock much-needed capital for sustainable energy projects on the continent. These partnerships can

help leverage private sector capital to finance energy sector investments, especially in green energy. SSA countries must also develop the capacity to effectively utilise their domestic capital and gain greater access to global capital for energy sector investments.

Secondly, although NREC shows a higher impact on inclusive growth than REC, policymakers should be mindful of the long-term environmental and social costs associated with NREC (Shaumya and Arulrajah, 2017; Jinapor et al., 2023; Masłowska, 2024), which can compromise the short-term economic benefits. Notably and more importantly, we reckon that the joint effect of FDI and REC turns to spike inclusive growth (from 1.89 to 4.9706) whilst that of NREC is somewhat reduced (from 6.6587 to 6.5956), reinforcing the potential role of FDI in stimulating REC to unearth the growth potential of SSA sustainably. Therefore, in light of the call to promote sustainable economic growth and the urgent need to ensure environmental sustainability, we strongly recommend that SSA governments prioritise sustainable energy transition and adopt policies to unlock the continent's vast renewable energy potential to reduce overreliance on non-renewable energy whilst putting in place mitigation measures from the unintended consequences of the energy transition. Various investment funds, such as the Africa Renewable Energy Fund and Clean Technology Fund, supported by governments and Development Finance Institutions, have profoundly impacted Africa's renewable energy landscape; hence, SSA governments should seize the opportunity to secure funding for renewable energy projects by collaborating with such organisations. Also, policymakers should ensure that existing power grids are upgraded and modernised to handle increasing shares of intermittent renewable energy generation, such as solar and wind power. This involves investing in grid flexibility, improving transmission and distribution infrastructure, and incorporating advanced technologies such as smart grids and energy storage systems. By doing so, power grids will be better equipped to manage the variability in renewable energy supply, maintain reliability, and ensure that renewable sources are efficiently integrated without causing disruptions. These measures can support sustainable energy transition and promote long-term energy security.

Thirdly, we found a non-linear relationship between FDI and inclusive growth, indicating that, initially, FDI may reduce inclusive growth, but ultimately, it promotes it in the long term. This underscores the need for continued and enhanced efforts to draw more FDI into SSA, which can eventually foster inclusive growth. Government policies are critical. Therefore, SSA should remain steadfast in implementing policies that provide a proper framework to attract FDI into SSA whilst leveraging existing policies such as SEs, AfCFTA, and NEPAD to attract more FDI. Specific policy measures must be implemented to improve the quality of public intuitions whilst ensuring political stability, which is critical as it helps reduce corruption and investment risk. Additionally, most SSA countries have weak infrastructure, such as unreliable power supply and transportation networks, which can impede foreign investors. Therefore, policymakers should invest and enhance infrastructure to reduce the cost of doing business for investors, which ultimately boosts FDI inflows into host countries (Kimiagari et al., 2015; Kimiagari et al., 2023). Developing and deepening financial markets can be instrumental in attracting foreign investors. In addition, SSA policymakers must ensure that their foreign investment policies are aligned with local content promotion and participation, which can help reduce supply costs, enhance skill acquisition, and ultimately promote a favourable and healthy working relationship between investors and local entrepreneurs. Finally, policies such as Government Consent and Support Agreements (GCSA), effective tariff administration and predictable fiscal stability agreements can help promote investments in SSA's energy sector.

Fourthly, since FDI moderates the nexus between energy consumption and inclusive growth, it is recommended that FDI be attracted, especially those that consume more energy. This is because the inflow of FDI leads to high energy consumption, which induces inclusive growth. This can be achieved when policymakers invest in infrastructure, particularly in the energy sector, to support renewable and non-

renewable energy projects, making the region more attractive to foreign investors. SSA countries have to incentivise the inflow of FDI towards clean energy investments to ensure sustainable development. This can be accomplished with appropriate and effective regulatory frameworks and fiscal policies, including tax cuts to foreign investments oriented towards renewable energy. Further policies such as carbon sinks, principles of polluter payment, and building capacity for project preparation, which are bankable and capable of attracting investments must be promoted. These policy interventions will certainly help attract foreign and local private investors to complement government efforts in energy investments, particularly in the area of renewable energy development. SSA countries can achieve this by strengthening governance frameworks, prioritising transparency and regulatory certainty, and promoting anti-corruption policies to enhance the investment climate of host countries to attract foreign investors. Additionally, promoting public-private partnerships (PPPs) can help address infrastructure deficits by harnessing private sector expertise and funding, particularly in renewable energy projects. Governments can also attract FDI by offering targeted tax incentives, subsidies, and other financial benefits for renewable energy investments. Lastly, stabilising macroeconomic conditions, mitigating political risks, and ensuring consistent policies can build investor confidence.

5.3. Future directions

The study leaves room for further research as this study focuses on selected SSA countries; hence, any future study can explore a specific country-level analysis. In addition, future research studies can focus on the various sub-components of renewable energy and their unique effect on inclusive growth when data becomes available.

Test A.1

Pre-Test for PCA

Kind of PCA test:	
Determinant of the correlation matrix	0.000
Kaiser-Meyer-Olkin Measure of Sampling (KMO)	0.849
Bartlett test of sphericity: Chi-square	11941.612
P-value	0.000

Source: STATA Version 17, 2024.

Table A.2

Principal components and eigenvalues (Inclusive growth index)

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	8.075	5.738	0.385	0.385
Comp2	2.337	0.513	0.111	0.496
Comp3	1.824	0.583	0.087	0.583
Comp4	1.241	0.074	0.059	0.642
Comp5	1.167	0.217	0.056	0.697
Comp6	0.950	0.166	0.045	0.743
Comp7	0.784	0.099	0.037	0.780
Comp8	0.685	0.113	0.033	0.813
Comp9	0.572	0.043	0.027	0.840
Comp10	0.529	0.056	0.025	0.865
Comp11	0.473	0.076	0.022	0.887
Comp12	0.397	0.057	0.019	0.906
Comp13	0.340	0.039	0.016	0.922
Comp14	0.301	0.039	0.014	0.937
Comp15	0.262	0.027	0.013	0.949
Comp16	0.235	0.026	0.011	0.961
Comp17	0.209	0.014	0.010	0.970
Comp18	0.195	0.029	0.009	0.980
Comp19	0.166	0.016	0.008	0.988
Comp20	0.149	0.038	0.007	0.995
Comp21	0.111	.	0.005	1.000

Source: STATA Version 17, 2024.

CRedit authorship contribution statement

John Abdulai Jinapor: Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Joshua Yindenaba Abor:** Supervision. **Michael Graham:** Supervision.

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We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property.

We confirm that the manuscript has been read and approved by all named authors and that all named authors have approved the order of authors listed in the manuscript.

Appendix

Table A.3
Cross-sectional dependence

Variable	Test statistic
IG	78.255**
TEC	68.549**
REC	35.720**
NREC	64.784**
FDI	4.850**
FDI2	1.899**
GCF	15.271**
TO	6.704**
CPI	20.332 **
POP	1.427
CC	-1.060
OR	4.684**

Note: *, ** and *** signify significance at 10%, 5% and 1%, respectively.

Source: STATA Version 17, 2024.

Data availability

Data will be made available on request.

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