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Foreign Direct Investment and Inclusive Green Growth in Africa: Energy Efficiency Contingencies and Thresholds

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Foreign Direct Investment and Inclusive Green Growth in Africa: Energy Efficiency Contingencies and Thresholds

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Abstract

Despite the growing number of empirical studies on foreign direct investment (FDI) and energy efficiency (EE) as they relate to green growth, there remains an empirical research gap with respect to whether EE can engender positive synergy with FDI to foster inclusive green growth (IGG) in Africa. Also, little has been done to show the IGG gains from improving EE in both the short and long terms. Thus, this paper aims to investigate whether there exists a relevant synergy between EE and FDI in fostering IGG in Africa by using macrodata for 23 countries from 2000 to 2020. According to our findings, which are based on dynamic GMM estimator, FDI hampers IGG in Africa, while EE fosters IGG. Notably, in the presence of EE, the environmental-quality-deterioration effect of FDI is reduced. Additional evidence by way of threshold analysis indicates that improving EE in Africa generates positive sustainable development gains in both the short and long terms. This study suggests that a country’s drive to attract FDI needs to be accompanied by appropriate policy options to promote energy efficiency.

Keywords: Africa; Energy efficiency; FDI; Inclusive Green Growth; Greenhouse Gases; Environmental Sustainability

***JEL Codes**: F2; F21; O11; O44; O55; Q01; Q43; Q56*

1. Introduction

Economic growth which is green and inclusive is central to sustainable development, and global attention to this effect is captured in the United Nations' Agenda 2030 dubbed '*The Future We Want*', which seeks to ease pressure on global resources while achieving and sustaining growth that is both greener and more inclusive (Zhao & Yang, 2017; Tenaw & Beyene, 2021; Gu, et al., 2021; Fay, 2012). Hence, the rise of the concept of inclusive green growth (IGG), which stresses the complete harmonization of three core elements: environment, economy, and society (Sun et al., 2020; Ofori et al., 2022a; World Bank, 2012). The harmonization of these three spheres fosters socioeconomic sustainability (SES) and environmental sustainability (EVS).

With respect to SES, empirical evidence reveals that foreign direct investment (FDI) can generate durable and equitable wealth through technological transfer, innovation, industrialisation, forward and backward linkages, macroeconomic stability, employment, and poverty alleviation (Asongu & Odhiambo, 2020a; Opoku et al., 2019; Ofori & Asongu, 2021; Ofori et al., 2022b, Ibrahim et al., 2021; Sakyi & Egyir, 2017). Additionally, FDI has the potential to foster equitable income growth and distribution through economic complexity by way of enhancing private-sector competition, global value participation, and foreign exchange (Anetor et al., 2020; Fauzel et al., 2015; Ucal, 2014; Krugman & Obstfeld, 2009).

From an EVS perspective, FDI inflows can support the continent's quest for clean growth and environmentally-friendly innovations as well as efforts aimed at promoting the efficiency of the continent's energy systems (Iyke, 2015; Apergis & Payne, 2010; Shiu & Lam, 2004; Stern, 2000). For instance, the spillover effect of the technical know-how characteristic of FDI can aid African countries to build the competence and capacity to foster environmental quality (Popp, 2009). With regard to infrastructure, FDI can support EVS through the manufacture and distribution of renewable energy equipment as well as water and waste management, solid waste management, hazardous-waste management, and recycling (UNCTAD, 2010). Furthermore, FDI has the power to enable services that promote environmental quality of life through carbon capture, air pollution control, soil and water remediation, and noise abatement (Levinson & Taylor, 2008).

Notwithstanding these favourable effects of FDI on environmental quality, some studies have also shown that it harms the environment of host countries. For example, across both the developing and developed countries, evidence shows that FDI accelerates carbon emissions (Rafindadi, 2018; Bokpin, 2017; Doytch & Uctum; 2016; Shahbaz et al., 2015;

Ren et al., 2014; Pao & Tsai, 2011). In fact, fresh evidence is also emerging that the harmful effect of FDI on the environment goes beyond CO_2 emissions to include the emission of air pollutants and acidifying gasses (Opoku & Boachie, 2020; Cole et al., 2011). It is on the basis of these dark sides of FDI and the call that Africa's green energy mix has to rise in the next decade to address possible social and environmental setbacks that we pay attention to energy efficiency (UNCTAD, 2021; IEA, 2021; IPCC, 2018). In highly informal and low-income settings like Africa, energy efficiency (hereafter, EE) could play a major role in achieving Agenda 2050 (IPCC, 2022; IEA et al., 2020).[1]

More precisely, energy efficiency (EE) can drive EVS by playing a salient role in protecting the environment through reductions in energy intensity and stress on natural asset bases (Arouri et al., 2021; Akram et al., 2020; Lin & Abudu, 2020). Moreover, aside from its much-emphasised role in supporting the fight against climate change through reductions in carbon emissions and the achievement of net-zero emissions in the broader perspective by 2050 (UNFCCC, 2015), EE can also support environmentally-friendly practices and innovations, hence indirectly contributing to improving the environmental quality of life and reducing pollution-related mortality (IEA, 2021; WEF, 2021; OECD, 2017; GGKP, 2013).

The core motivation for conducting this study is that although prior studies have examined the unconditional effects of EE or FDI on both social and environmental progress (see e.g., Agradi et al., 2022; Adom et al., 2021; Dauda et al. 2021; Ohene-Asare et al. 2020; Opoku & Boachie, 2020; Akram et al., 2020; Lin & Abudu, 2020), the question of whether EE can engender positive synergy with FDI to foster IGG is a blind spot in the scholarly literature. Also, despite Africa's drive towards green energy and EE, there is a lack of empirical studies examining the IGG-related gains as a result of improving EE in both the short term and long term. This study seeks to fill these gaps in extant scholarship.

Specifically, this study examines whether there exists a relevant synergy between EE and FDI in fostering IGG in Africa. Furthermore, our study investigates whether improving EE in Africa generates positive sustainable development gains in the short and long terms. Addressing these issues is particularly important to policymakers in Africa, as it will provide new empirical evidence on the importance of EE in fostering IGG, including the multiple short- and long-term gains generated by EE. Our results, which are based on instrumental variable regression and macrodata for 23 countries for the period 2000 to 2020 has generated major findings. The study finds that FDI hampers IGG in Africa, while EE fosters IGG.

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[1] This is the 2050 global net-zero emissions target.

Notably, in the presence of EE, the environmental-quality-deterioration effect of FDI is reduced. Additional evidence by way of threshold analysis indicates that improving EE in Africa generates positive sustainable development gains in both the short and long terms.

The rest of the paper is structured as follows: Section 2 offers a brief review of the literature, while Section 3 presents the data and methodology. Section 4 discusses the findings, and Section 5 provides some concluding remarks.

2. Brief review of literature

2.1 Theoretical perspectives: FDI and IGG relationship

We draw on the theoretical contributions of the new endogenous growth theories (Romer, 1986; Lucas, 1990) and the modernisation theory to explain the nexus between FDI and SES. With regards to the former, FDI is regarded as a driving force of sustainable economic growth through the expansion of recipient countries' productive capacity, global value chain participation, R&D activities, transfer of technology, ideas, managerial skills and job creation (Romer, 1990; Grossman & Helpman, 1991; Barro & Sala-i-Martin, 1995). The main tenet supporting the direct link between FDI and SES is that multinational corporations (often FDI giants) enter host countries with contemporary technologies, patents, trade secrets, brands and management strategies that spur economic growth (Dunning, 1993). On the contrary, the modernisation theory suggests that an FDI-driven economy can be harmful to shared growth for developing countries (see Kuznet, 1955). This view is buttressed by Feenstra and Hanson's (1997) North-South model. According to Feenstra and Hanson (1997), FDI can trigger inequality outcomes in developing countries due to resource-driven comparative advantage. Other critics (Ravallion, 2018; Pavcnik, 2017; Krugman, 2008; IMF, 2007) argue that FDI can discourage shared economic prosperity in host countries by intensifying income inequality through labour redundancy due to rent-seeking, intense competition with its attendant collapse of domestic firms, capital flight and macroeconomic instability (Alvaredo et al., 2013; Ndikumana & Sarr, 2019).

In the remit of FDI-EVS, there is strong division between two opposing theories regarding the link between capital flows and environmental progress. These are the pollution halo hypothesis (PH) and pollution haven hypothesis (PHH). The PH is the notion that FDI inflows to developing countries helps in the transfer of environmentally-friendly technologies and green practices that reduce carbon emissions and hence foster EVS (Zarsky, 1999). This is based on the argument that multinational corporations (MNCs) possess sophisticated production, pollution-control technologies, and practices which they transfer to their affiliates in developing countries (Gallagher & Zarsky, 2007; Demena & Afesorgbor 2020)**.** The opposing view, PHH, is the idea that FDI hampers EVS by increasing pollution in the weak regulated developing countries. The rationale behind this proposition is that, the fierce competition among developing nations for foreign investors may result in the lowering of environmental standards (for e.g., abatement costs) for foreign investors. This ultimately triggers the relocation of pollution-intensive firms in advanced countries to developing countries (Zugravu-Soilita, 2015; Golub et al., 2011). It follows that, environmental pollution in the host countries increases as these MNCs expand production activities (Copeland & Taylor, 2004; Grossman & Krueger, 1993; Zarsky, 1999). Accordingly, we capture our first hypothesis as:

Hypothesis 1: Foreign direct investment hampers inclusive green growth in Africa

2.2 Empirical perspectives: FDI and IGG relationship

Empirical evidence on the FDI-SES relationship is fast growing albeit mixed results. On the one hand, a strand of the literature finds that FDI enhances inclusive growth. For instance, Opoku et al. (2019) used the system GMM to show that FDI fosters growth in 38 African countries for period 1960–2014. Similarly, in a study stretching over 1988-2013, Mamingi and Martin (2018) find that FDI enhances income growth in 34 countries between. Lee et al. (2020) also utilised the panel smooth transition regression method for 37 countries over the period 2001-2015. The empirical results indicate that FDI reduces income inequality. Adams & Opoku (2015) also show that in the presence of a strong credit market, business and labour market regulations, FDI is remarkable for spurring economic growth in sub-Sharan Africa.

The other side of the empirical contributions reveals a negative effect of FDI on SES. For instance, Agbloyor et al. (2014) find that FDI does not promote economic growth in 14 African countries. In a similar contribution by Adams and Klobodu (2017), which was based on macrodata for 21 SSA countries for the period 1984 to 2013, the authors find that FDI heightens income inequality in both the short run and long run. Interrogating the FDI-income inequality in the case of 20 major remittance-receiving developing countries, Song et al. (2021) find evidence from the dynamic ordinary least squares technique that FDI hinders SES by widening the income disparity gap. Likewise, Fang et al. (2020) used the fixed effects and fully modified ordinary least square techniques and find FDI to exacerbate income inequality in 71 developing countries from 1995 to 2015. The income inequality-inducing effect of FDI has also been reported in the Commonwealth of Independent States by Khan and Nawaz (2019) who employed the system GMM and macrodata spanning 1990-2016. The FDI-SES relationship has, somewhat, been summarised in a meta-analysis by Huang et al. (2020). The analysis which was based on 543 empirical works from 1995-2019 showed that FDI (i) increases income inequality in low-income economies, (ii) has no effect in the middle-income countries, and (iii) reduces inequality for the high-income countries.

From the EVS perspective, the literature shows evidence of the PH especially in developing countries. For instance, a study by Solarin and Al-Mulali (2018) reveals EVS-enhancing effect of FDI in 20 developed and developing countries. Ben Jebli et al. (2019) shows that for the period 1995-2010, FDI inflows to Central and Southern America reduces CO_2 emissions. Likewise, Zakaria and Bibi’s (2019) study which was based on 5 South Asian countries and the fixed effect estimator shows that FDI reduces carbon footprint. It is a result that has been confirmed in the case of 22 SSA countries for the period 1995 to 2014 by Opoku et al. (2021).

Several studies also provide validating evidence for the PHH. In developed countries, for instance, Shahbaz et al. (2019) used the autoregressive distributive lag (ARDL) approach to show that FDI increased CO_2 emissions in the United States from 1965 to 2016. In France, Shahbaz et al. (2018) employed the Bootstrapping ARDL method on macrodata stretching from 1955-2016 and find FDI to increase carbon emission. A recent study by De Pascale et al. (2020) in which the pooled least squares, fixed effects and random effects estimators were used, show that FDI hampers environmental progress (proxied by CO_2 and greenhouse gas emission) in 36 OECD countries.

Opoku and Boachie (2020) used the pooled mean group method in 36 African countries from 1980 to 2014 and revealed that FDI has a detrimental effect on environmental quality. Similarly, using the fixed and random effects estimation techniques, Sapkota and Bastola (2017) find FDI to increase environmental pollution in 14 Latin American countries from 1980 to 2010. Sarkodie and Strezov (2019) also validate the PHH in China, India, Iran, Indonesia and South Africa by reporting a positive link between FDI and CO_2 emission from 1982 to 2016. Additionally, Shahbaz et al. (2015) find evidence of a strong positive relationship between FDI and environmental degradation (CO2 emissions) in 99 heterogenous high-, middle-, and low-income countries.

2.3 Theoretical perspectives: energy efficiency (EE) and IGG relationship

From the EVS perspective, the ecological modernization theory highlights that EE minimises energy-driven environmental pollution through green innovation and eco-friendly practices (Gouldson & Murphy, 1997; Murphy & Gouldson, 2000; Bovenberg & Smulders, 1995). On the other hand, the rebound effect predicts that while improvement in EE would reduce cost of energy consumption, it provides the means for economic agents to engage in economic activities that are energy-intensive (Jevons, 1865). Notably, Brookes (1979) and Khazzoom et al. (1990) contend that this backfire effect can be a major concern in developing countries where precariousness and the reliance on solid and fossil fuels are high.

Also, from the SES dimension of IGG, we rely on the new endogenous growth theories (Romer, 1990; Romer, 1994) and the Porter and van der Linde (1995) hypothesis to conceptualise the link between EE-SES. The former implicitly positions EE as an important driver of shared growth through firm innovativeness, efficiency and productivity. Along the same line of argument is the Porter and Van der Line hypothesis, which suggests that, EE can foster sustainable growth through firm performance. This arises as EE lowers energy costs, which means extra resources to invest in other growth-enhancing inputs. In support of this assertion is the argument by Deichmann and Zhang (2013) who argue that strict compliance to energy conservation policies such as EE can spur inclusive growth. Similarly, as proffered by Rajbhandari and Zhang (2018), energy-related innovations like EE creates new demand and increase market share, consequently stimulating durable growth, employment and poverty alleviation. Contrariwise, conservative views based on the endogenous growth theories postulate that EE could be a drawback to economic growth. Dercon (2012) enhances this view by emphasising that EE enhancement is more of a hazard than economic growth enhancer in developing countries. Particularly, in milieus like Africa, where a tremendous amount of production and consumption of energy is required to meet developmental goals, strict adherence to EE could be inimical to sustainable development. On the basis of the foregoing theoretical linkages, we specify our second hypothesis as,

Hypothesis 2: Energy efficiency fosters inclusive green growth in Africa

2.4 Empirical perspectives: energy efficiency (EE) and IGG relationship

From the SES domain of IGG, there is a growing body of empirical works showing that EE enhances inclusive growth through increased economic growth and job creation. For example, in panel of 51 African countries spanning 1991-2017, Adom et al. (2021) find that EE fosters economic growth. In a related study by Bayar and Gavriletea (2019) for the period

1992 to 2014, it is evident that EE promotes economic growth in emerging economies. Similarly, Bataille and Melton (2017) establish a positive link between EE improvements and GDP, employment, and welfare in Canada for the period 2002-2012. A similar outcome is reported by Cantore et al. (2016) who examined the relationship between EE and economic performance based on a dataset for 29 developing countries. Despite these results, empirical contributions (see e.g., Pan et al., 2019; Mahmood & Kanwal, 2017) report a negative relationship between of EE and economic development**.**

Empirical evidence concerning the EE-EVS nexus is also not without controversy. For example, Akram et al. (2020) report a negative relationship between EE and CO_2 emissions in developing countries, suggesting that improvement in EE promotes the environmental quality of life. In a comprehensive study by Marques et al. (2019) and Rajbhandaria and Zhang (2018), it is reported that EE improvement yields remarkable environmental quality gains without compromising socioeconomic progress. Examining the EE-EVS relationship in 36 countries for the period 1971-2009, Özbuğday and Erbas (2015) find that EE promotes environmental progress by reducing carbon emissions in the long run. Tajudeen and Banerjee (2018) also provide evidence in the case of 30 OECD countries to suggest that sustainable energy practices like EE contribute to EVS by reducing carbon intensity.

Conversely, Ponce and Khan (2021) in their study which covered the period 1995 to 2019, report that EE is not potent enough for reducing CO2 emissions in 9 advanced countries. Their finding is corroborated by Marques et al. (2019) who show strong evidence of CO_2 emission-inducing effect of EE in the case of 36 middle-income and high-income countries. This result is further bolstered by Lei et al. (2022) who used the non-linear ARDL to investigate the effects of EE on CO_2 emission in China for the period 1991 to 2019.

Taking cues from the empirical insights on the harmful effects of FDI on both SES and EVS, we argue that EE could count by propelling FDI to contribute to IGG. Our argument is based on the growth-enhancing and climate change-mitigation effects of FDI (IPCC, 2022; IEA, 2021; IEA & World Bank, 2017). In this regard, we formulate our third hypothesis as:

Hypothesis 3: FDI interacts with energy efficiency to induce inclusive green growth

2.5. Analytical framework

Drawing on recent work on green growth (Acosta et al. 2019; OECD, 2017; GGKP, 2013) and IGG (Ofori et al. 2022a), we developed an *IGG-Framework* tailored to our study (Figure 1). We constructed an IGG framework that captures the core ingredients for IGG (i.e., social progress and environmental sustainability). Notably, our IGG-framework points to the intimate link between social progress (which is achieved by improving access to education, water, and sanitation, and equitable distributions of income), environmental sustainability (attained by improving the environmental quality of life, protecting natural asset bases, creating green economic opportunities, and developing efficient resource production schemes), and IGG.

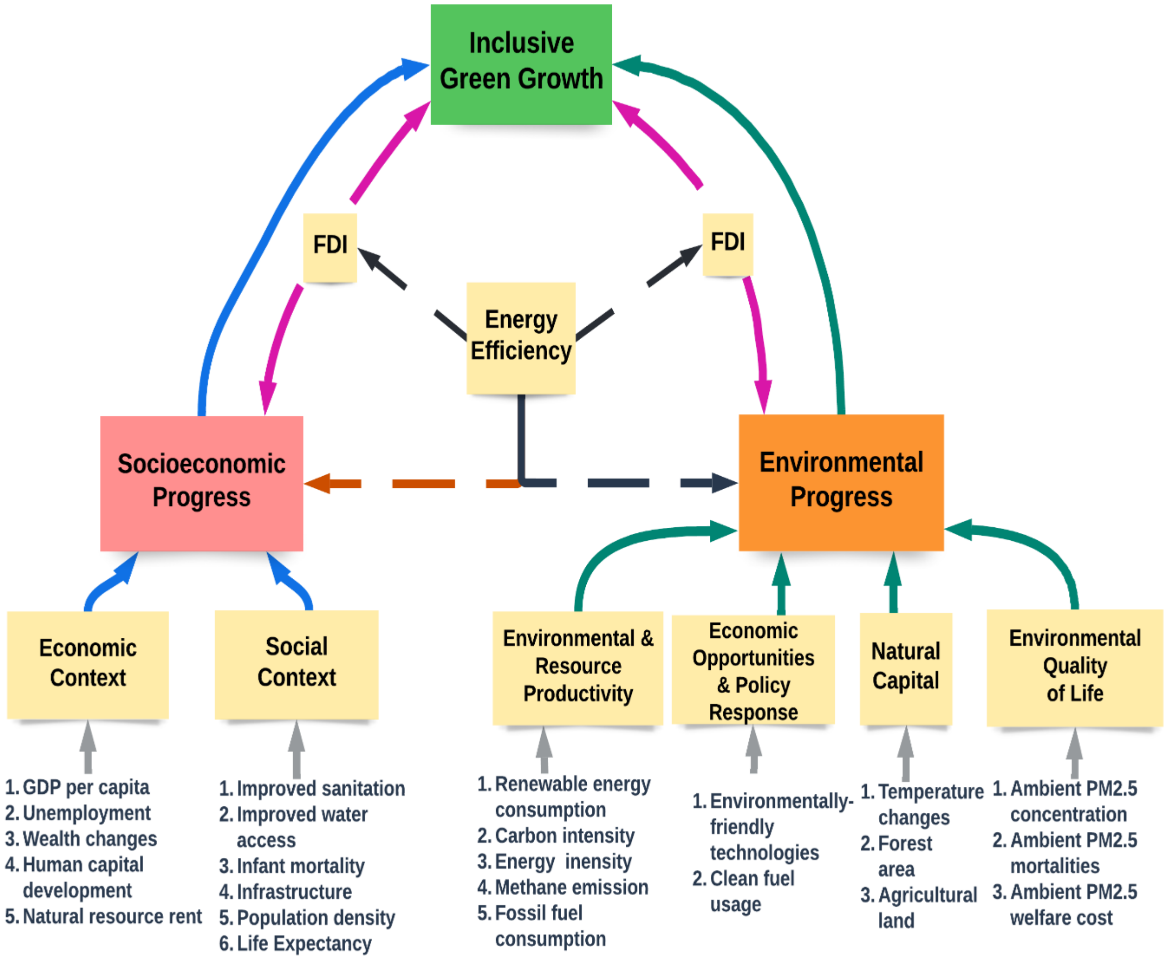

Figure 1: Analytical framework for Inclusive Green Growth
Source: Authors' design

Our SES-EVS-IGG framework suggests that while in principle, both SES and EVS are pillars for multidimensional sustainability, there are possible feedback effects of IGG for both social and environmental progress. Also, growth which is 'dirty' and/ or 'porous' can hinder sustainable development through the deterioration of biodiversity, ecosystems, and peaceful coexistence. The direct linkages between EVS, SES and IGG in the broader perspective can be traced to the Rio+20 development agenda, which identified capital flows as a key channel for realising UN Agenda 2030 (UNCED, 2012). On the one hand, our IGG framework suggests that FDI can contribute to the IGG efforts in developing countries. This can manifest in various forms – from durable job creation, foreign exchange, and private sector efficiency and competitiveness, to economic growth and poverty alleviation (Suehrer, 2019; OECD, 2016). On the other hand, FDI can foster IGG through renewable energy investments and the acceleration of green technologies diffusion and technological ‘leapfrogging’ in developing countries (UNCTAD, 2022; Golub et al., 2011; Zarsky, 1999). This is implicitly captured in the Green Solow growth model, which identifies eco-friendly capital flows as giant channels for engineering green growth through the diffusion of pollution abatement technologies (Brock & Taylor, 2010).

Additionally, in line with the call by the United Nations to identify and enhance, where they exist, positive synergies among the SDGs, we incorporated EE into our IGG framework. Indeed, among all other SDG-enhancing modules, sustainable energy stands out. This is evident in a recent International Energy Agency (IEA) report (2021), which indicates that the global energy sector alone currently accounts for three-quarters of greenhouse gas emissions. Achieving the ambitious net-zero emissions target by 2050 and thus maintain long-term global temperatures within 1.5˚C, highlights the need to address the energy sector’s inefficiencies and emissions. Particularly in Africa where the renewable energy potential is high but the continent’s high reliance on solid and fossil fuels is high (IEA & World Bank, 2017), sustainable energy policies like EE can be a game-changer. In such settings, EE can enhance IGG, considering its huge implications for sustainable production, consumption, mobility, and the new economy.

3. Data and Methodology

3.1. Data

Our empirical analysis is based on a balanced panel of 23 countries over the period 2000 – 2020.[2] The main dependent variable in this study is IGG, and is generated following the

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[2] The African countries investigated are: Algeria; Angola; Benin; Botswana; Cameroon; Democratic Republic of Congo; Republic of Congo; Cote d'Ivoire; Ethiopia; Gabon; Ghana; Kenya; Mauritius; Mozambique; Namibia; Niger; Nigeria; Senegal; Seychelles; South Africa; Tanzania; Togo; and Tunisia.

dimensional reduction technique, principal component analysis. Following previous studies (see e.g., Ofori & Asongu, 2022; Tchamyou et al., 2019; Del Carpio et al., 2017; Jolliffe, 2002), we generate our IGG series using the dimensional reduction technique of principal component analysis (PCA). To show the importance of the energy efficiency-FDI linkage for socioeconomic and environmental sustainability (i.e., at the disaggregated level of IGG), we capture the former by inclusive growth and the latter by greenhouse gas emissions. Following Anand et al. (2013), we generate inclusive growth based on the utilitarian social welfare function in which we integrate income growth (i.e., GDP per capita) and income distribution (i.e., Gini index) in a unified manner.[3] As Anand et al. (2013) point out, this measure of shared prosperity is comprehensive, since it takes into account both the absolute definition (proxied by GDP per capita) and relative definition of shared growth (proxied by the Gini index). For environmental progress, we opt for a broader measure for greenhouse gas emissions, as environmental sustainability goes beyond CO_2 emissions and includes other pollutants.

The main independent variable in this study is FDI, which is defined as the net inflow of direct investment by foreigners as a percentage of GDP. As mentioned earlier, the IGG-inducing effect of FDI can be analysed through the lenses of the endogenous growth theory as well as the PH and PHH (Sarkodie et al., 2020; Golub et al., 2011). This is, however, not without controversy, as the PHH and the growth-destabilising effect of globalisation also suggest that FDI can drag down IGG (Tawiah et al., 2021; Khan et al., 2020). The moderator in this study is EE, and this is generated by following the stochastic frontier approach (SFA) of Kumbhakar et al. (2014).

In a multiple regression analysis of this kind, it is worth noting that some IGG covariates are also controlled for on the grounds of econometric prudence. Generally, the essence of these control variables in the conditioning information set is to: (i) capture the implications of institutions for social and environmental sustainability; (ii) take into account the role of resource allocation; and (iii) mitigate possible omitted variable bias. First, following previous studies (e.g., Holley & Lecavalier, 2017, Atkinson & Klausen, 2011; Acemoglu, & Robinson, 2010; Kaufmann et al., 2010), we pay attention to the power of institutions in providing mechanisms or structures for levelling the playing field for social progress. To this end, we capture institutions by regulatory quality, which is sourced from the World Bank's World Governance Indicators (World Bank, 2022). On the environmental

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[3] Recent empirical studies have used this approach (see, e.g., Obeng et al., 2022; Ofori &Asongu, 2021).

front, sound regulatory quality also matters, both for environmental protection and conservation as well as ensuring that both local and foreign investors commit to environmental laws.

Second, we keep tabs on financial development, considering the growing empirical evidence that it can foster IGG in developing countries. For instance, regarding SES, there is a growing consensus that financial development aids poor and vulnerable households to access resources that are essential for investment, growth, poverty alleviation, and inequality reduction (De Haan et al., 2021; Peprah et al., 2019; Asongu & Odhiambo, 2018; Tchamyou et al., 2019). Though Yang et al. (2021) report contrary effects, empirical evidence in Weber (2014) and Shahbaz et al. (2013) also suggest that the relevance of financial development for environmental sustainability goes beyond green finance, innovation, and low greenhouse gas emissions to encompass the provision of resources to address precariousness and stress on the environment. Our financial development series were taken from the IMF's Financial Development Index Database (Svirydzenka, 2016).

Third, we include remittances in the light of Sustainable Development Goals (SDGs) 8 and 10, which suggest that external financing can enhance shared income growth and distribution.[4] Specifically, some scholars contend that remittances (either monetary or non-monetary) can spur economic growth and poverty alleviation by providing recipient households with the resources to mitigate consumption needs and material poverty (Acheampong et al., 2021, Chowdhury, 2016; Song et al., 2020). Also, remittances can contribute to decreases in income inequality by promoting private sector productivity, job creation, and human capital development by boosting investment in health and education (Kumar & Patel, 2021; Akobeng, 2021; World Bank, 2018; Williams, 2016). Although concerns have been raised that remittances can heighten income inequality through the polarisation of resources (Prokhorova, 2017; Anyanwu, 2011) and environmental degradation, as related to the remittance-led emission hypothesis (Usman & Jahanger, 2021; Khan et al., 2020), some studies argue that remittances can support improvement in environmental quality through the adoption and increased use of clean fuels and green technology (Wang et al. 2021; Ahmad et al., 2019). Finally, we consider vulnerable employment due to the high levels of informality in Africa. Despite the contribution of the informal sector to growth and poverty alleviation in developing countries, increasing

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[4] The United Nations' Agenda 2030 identifies migration and migration-related financial flows as potential drivers of sustained, inclusive, and sustainable economic growth, with Targets 8.8, 10.7, and 10.c reserved explicitly for creating congenial environments for migrants and reductions in the cost of sending remittances.

vulnerability to unemployment is likely to have a more negative influence on the incomes of the poor, and by extension, reduce inclusive growth (Fosu, 2015; Anand et al., 2013). There is also the concern that high levels of vulnerable employment can increase reliance on the environment for subsistence and non-clean energy (Mutz et al., 2017; Eakin & Luers, 2006). A summary of the description and sources of the variables is provided in Table 1.

Table 1: Description of variables and data sources

Variables	Symbol	Descriptions	Sources
Dependent variable			
Inclusive green growth	*igg*	Sustainable development indicators generated using the PCA	Authors
Inclusive growth	*ingrow*	Income growth and distribution approach of Anand et al. (2013)	Authors
Greenhouse gas emissions	*ghgas*	Total greenhouse gas emissions (thousand metric tons of CO_2 equivalent excluding Land-Use Change and Forestry)	WDI
Control variables			
Vulnerable employment	*vul*	Contributing family workers and own-account workers as a percentage of total employment	WDI
Financial development	*findev*	International Monetary Fund's Financial development index	FINDEX
Remittances	*remit*	Personal remittances received (% of GDP)	WDI
Regulatory quality	*regu*	Captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.	WGI
Variable of interest			
Foreign direct investment	*fdi*	Net inflow of foreign direct investment (%GDP)	WDI
Moderating variable			
Energy efficiency	*ee*	Energy efficiency index generated following the stochastic frontier approach (SFA) of Kumbhakar et al. (2014)	Authors

Note: WDI is World Development Indicators; Findex is IMF's Financial Development Index; GCIP is Global Consumption and Income Project; WGI is World Government Indicators; KOF is KOF; Globalisation Index and AIKP is Africa Infrastructure Knowledge Program.

3.2. Estimation of Energy efficiency (EE)

Our key independent variable, EE, like IGG is not directly accessible in databases for the relevant period, and is therefore generated. The procedure for this is covered in this section. It is worth noting that since EE is computed from a given energy demand function, we first present the econometric models for energy demand before delving into the model for EE. With regard to EE particularly, though we recognise that techniques such as Data Envelopment Analysis (DEA) have been employed for generating EE scores, we opt for that of Stochastic Frontier Analysis (SFA) on the grounds of econometric prudence. Adom et al. (2022) and Mutz et al. (2017) argue that the SFA is more powerful in handling data outliers, measurement errors, and omitted variable bias when compared to the DEA, and importantly, unlike the non-parametric DEA, SFA is designed to split EE scores into persistent and transient components (Agradi et al., 2022, Kumbhakar et al., 2014, Filippini & Hunt, 2011). We find this decomposition to be key in this study, as it provides the basis to inform us whether long-term or short-term EE investments are worthwhile.

That said, we follow the functional approach of Adom et al. (2021), and specify a single conditional energy demand model, as shown in Equation (1), where energy consumption is driven primarily by price and income. To capture the elasticity of energy demand with regard to the aforementioned factors, we adopt a Cobb-Douglas energy demand function as seen in Equation (2), which is then linearised by way of a logarithmic transformation to obtain Equation (3). In line with the extant literature on energy demand[5] (Adom, 2019; Adom et al., 2018, Zhang & Adom, 2018; Filippini & Hunt, 2011), we modify Equation (3) to obtain Equation (4), where we control for variables such as industrialisation, trade openness, urbanisation, and human capital.

$$e_{it}^{ED} = f(p_{it}, g_{it}, Z_{it}, \emptyset)e^{v_{it} - u_{it}}, \tag{1}$$

where $\emptyset_p < 0$ and $\emptyset_h > 0$

$$e_{it}^{ED} = f(p_{it}, g_{it}, Z_{it}, \emptyset) = Ap_{it}^{\emptyset_p} g_{it}^{\emptyset_g} z_{it}^{\emptyset_{z_i}} \tag{2}$$

$$lne_{it}^{ED} = \delta_0 + \emptyset_p lnp_{it} + \emptyset_g lng_{it} + \emptyset_{z_i} lnZ_{it} + \varepsilon_{it}, \tag{3}$$

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[5] See Table A.1 in Appendix A for the description and summary statistics of the energy demand variables.

$$lne_{it}^{ED} = \delta_0 + \emptyset_p lnp_{it} + \emptyset_g lng_{it} + \emptyset_k lnurban_{it} + \emptyset_{z_1} lnind_{it} + \emptyset_{z_2} lntrade_{it} + \emptyset_{z_3} lnhc_{it} + \varepsilon_{it}, \quad (4)$$

where $\boldsymbol{e_{it}^{DD}}$ is energy demand, $\boldsymbol{g_{it}}$ is the level of income proxying the standard of living, $\boldsymbol{p_{it}}$ is the price of energy proxied by crude oil prices, and other energy demand drivers ($\boldsymbol{Z_{it}}$), and '$\boldsymbol{e}$' is the Euler's mathematical constant. Also, $\emptyset_p$ and $\emptyset_g$ denote the price and income elasticity of energy and income, respectively. Additionally, δ_0 is the energy demand intercept and ε_{it} is the error term, which is decomposed into an inefficiency term (u_{it}) and an idiosyncratic noise term (v_{it}). It is worth noting that while our inefficiency term (u_{it}) is assumed to be half-normally distributed, v_{it} follows a normal distribution. Consequently, we introduce u_{it} as a constraint to the benchmark energy frontier in Equation (4) to obtain Equation (5). We then follow Adom et al. (2021) and Greene (2005) by taking the exponential u_{it} to obtain our energy efficiency scores, as seen in Equation (6).

$$lne_{it}^{ED} = \delta_0 + \emptyset_p lnp_{it} + \emptyset_g lng_{it} + \emptyset_k lnurban_{it} + \emptyset_{z_1} lnind_{it} + \emptyset_{z_2} lntrade_{it} + \emptyset_{z_3} lnhc_{it} + \varepsilon_{it} - u_{it}, \quad (5)$$

$$ef_{it} = \exp(-u_{it}) \quad (6),$$

where $0 \leq ef_{it} \leq 1$.

As mentioned earlier, a key contribution of this study arises from its examination of whether short-term or long-term energy policies are worthwhile. Specifically, high and persistent energy inefficiency vis-à-vis transient energy inefficiency means that energy inefficiency will persist over a long period if policymakers do not address the structural impediments involved with energy production (see Kumbhakar, 2014). On the other hand, a very high transient energy inefficiency relative to persistent energy inefficiency also means that the current inefficiencies characterising a country's energy production are temporary or shock-driven, and as such are not a concern for long-term energy supply. To this end, we follow the approach of Kumbhakar et al. (2014) by decomposing our total inefficiency scores ($-u_{it}$) into persistent (α_i) and transient (π_{it}) efficiency scores while accounting for unobserved country-specific heterogeneities (ω_i) in Equation (7). It follows that Equation (6) can be modified to obtain Equation (8), which simultaneously yields our energy demand elasticities and the attendant efficiency and inefficiency scores.

$$u_{it} = u_i + \omega_i + \pi_{it} \tag{7}$$

$$lne_{it}^{ED} = \delta_0 + \emptyset_p lnp_{it} + \emptyset_g lng_{it} + \emptyset_k lnurban_{it} + \emptyset_{z_1} lnind_{it} + \emptyset_{z_2} lntrade_{it} + \emptyset_{z_3} lnhc_{it} + \varepsilon_{it} - u_i - \omega_i - \pi_{it}, \tag{8}$$

According to Kumbhakar et al. (2014), the estimation procedure involved in generating the efficiency scores (ef_{it}) follows four key steps. The first step is to estimate our energy demand frontier either by applying a random-effect or fixed-effect estimator. Per the Hausman test statistics provided in Table A.2 in the Appendix A, we find the random-effect estimator appropriate for the estimation. The next two steps, in respective terms, involve the estimation of the transient energy efficiency ($exp(-\pi_{it})$) and persistent energy efficiency component ($exp(-\alpha_i)$) by using the stochastic frontier residuals. As a final step, we take the product of the transient and persistent EE components to obtain our final EE scores.

Nonetheless, as Schmidt and Sickles (1984) note, the estimation of EE via the stochastic frontier approach follows the adoption of either a cost-type or production-type function, which is decided on based upon a test of skewness. In this regard, Schmidt and Sickles (1984) posit that a production-type stochastic frontier should be adopted if there are negatively skewed residuals, whereas a cost-type stochastic frontier should be preferred if the residuals are positively skewed. Based on the results in Table 2, the study adopts a production-type stochastic frontier for the estimation.

Table 2: Test of skewness of energy demand function

Skewness	Kurtosis	Pr(Skewness)	Pr(Kurtosis)	Joint Chi-square test
-0.6772	2.4490	0.0000	0.0012	33.15 ***

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

3.3. Theoretical and empirical model specifications

The empirical model specifications in this study draw on the argument that both EE and FDI can foster inclusive green growth through SES and EVS (Akram et al., 2020; Cantore et al., 2016; Howarth, 1997; Grossman & Krueger, 1991). That said, we proceed with the presentation of our empirical models following the functional form specification espoused by Opoku and Boachie (2020) where we model inclusive green growth, as seen in Equation (1).

$$igg = f(fdi, ee, V), \tag{8}$$

where $\boldsymbol{igg}$ is inclusive green growth, our indicator for sustainable development, which is endogenously determined by foreign direct investment ($\boldsymbol{fdi}$), energy efficiency ($\boldsymbol{ee}$), and other IGG determinants ($\boldsymbol{V}$) (i.e., regulatory quality ($\boldsymbol{regu}$); vulnerable employment ($\boldsymbol{vul}$); remittances ($\boldsymbol{remit}$); and financial development ($\boldsymbol{findev}$)). We now turn attention to the specification of the environmental sustainability (EVS) dichotomy of sustainable development by following the functional form from Akram et al. (2020)[6], as in Equation (9):

$$evs = f(fdi, ee, V), \tag{9}$$

where $\boldsymbol{evs}$ is environmental sustainability, proxied by greenhouse gas emission, $\boldsymbol{fdi}$ is foreign direct investment, $\boldsymbol{ee}$ is energy efficiency, and $\boldsymbol{V}$ is a vector of our control variables. Finally, following the theoretical model adopted by Cantore et al. (2016) and Howarth (1997), we specify a functional form in Equation (10), where social progress is directly related to energy efficiency, foreign direct investment, and our set of control variables.

$$ses = f(fdi, ee, Z), \tag{10}$$

where $\boldsymbol{ses}$ is the socioeconomic sustainability, $\boldsymbol{fdi}$ is foreign direct investment, $\boldsymbol{ee}$ is energy efficiency, and $\boldsymbol{V}$ is a vector of our control variables.

We now turn to specification of our empirical models. We begin by specifying three baseline models, as seen in Equations 11–13, where we focus on the direct effects of the control variables on inclusive green growth, environmental sustainability, and socioeconomic sustainability.

$$igg_{it} = \alpha_0 + \delta_1 igg_{it-1} + \delta_2 regu_{it} + \delta_3 vul_{it} + \delta_4 remit_{it} + \delta_5 findev_{it} + \mu_i + \mu_t + \epsilon_{it} \tag{11}$$

$$ghgas_{it} = \tau_0 + \omega_1 ghgas_{it-1} + \omega_2 regu_{it} + \omega_3 vul_{it} + \omega_4 remit_{it} + \omega_5 findev_{it} + \mu_i + \mu_t + \epsilon_{it} \tag{12}$$

$$ingrow_{it} = \not{g}_0 + \beta_1 ingrow_{it-1} + \beta_2 regu_{it} + \beta_3 vul_{it} + \beta_4 remit_{it} + \beta_5 findev_{it} + +\mu_i + \mu_t + \epsilon_{it}, \tag{13}$$

where $\boldsymbol{ghgas}$ denotes greenhouse gas emissions (i.e., the outcome variable for environmental sustainability), $\boldsymbol{ingrow}$ is inclusive growth (i.e., the dependent variable for

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[6] Unlike Akram et al. (2020), who used CO_2 emission as dependent variable, we use greenhouse gas emission as the outcome variable.

social progress), and all other symbols remain as earlier defined. Next, to capture the direct and indirect effects of our variable of interest—FDI—through our moderating variable—EE—on IGG, we modify Equations 11–13 into a standard panel specification as shown in Equations 14–16, respectively:

$$igg_{it} = \alpha_0 + \delta_1 igg_{it-1} + \delta_2 regu_{it} + \delta_3 vul_{it} + \delta_4 remit_{it} + \delta_5 findev_{it} + \delta_6 fdi_{it} + \delta_7 ee_{it} + \delta_8 (ee_{it} \times fdi_{it}) + \mu_i + \mu_t + \epsilon_{it} \qquad (14)$$

$$ghgas_{it} = \tau_0 + \delta_1 ghgas_{it-1} + \delta_2 regu_{it} + \delta_3 vul_{it} + \delta_4 remit_{it} + \delta_5 findev_{it} + \delta_6 fdi_{it} + + \delta_7 ee_{it} + \delta_8 (ee_{it} \times fdi_{it}) + \mu_i + \mu_t + \epsilon_{it} \qquad (15)$$

$$ingrow_{it} = \not{g}_0 + \beta_1 ingrow_{it-1} + \beta_2 regu_{it} + \beta_3 vul_{it} + \beta_4 remit_{it} + \beta_5 findev_{it} + \beta_6 fdi_{it} + \beta_7 ee_{it} + \beta_8 (ee_{it} \times fdi_{it}) + \mu_i + \mu_t + \epsilon_{it} \qquad (16)$$

In estimating Equations 14-16, we opt for the instrumental variable regression (i.e., system GMM) approach of Blundell and Bond (1998). Various reasons account for our choice. First, according to these authors, the technique is appropriate when the number of countries under consideration (i.e., 23), is greater than the study period (i.e., N>T). Second, the approach is consistent with dynamic specifications, which is imperative for addressing the issue of misspecification in growth models of this kind by capturing the initial level of growth (Baltagi, 2008). We take this into account in this study by introducing the first lag of inclusive green growth to capture the initial level of sustainable development. However, doing so raises a potential reverse-causality endogeneity concern (Roberts & Whited, 2013; Baum et al., 2003). This arises since $\boldsymbol{igg_{it-1}}$ depends on $\boldsymbol{\epsilon_{it-1}}$, which also depends on the country-specific impact $\boldsymbol{\mu_i}$. According to Roodman (2009), this endogeneity arises in the first difference estimation, as the GMM estimator sweeps away the country-specific effects, leading to a correlation between the lag of inclusive green growth and the error terms.

To address the aforementioned econometric concerns, Arellano and Bond (1991) and Wooldridge (2010) propose that the difference lagged outcome variable and the other endogenous covariates are instrumented with their past values. This means estimating Equations 14 - 16 via the first-difference GMM estimator, which is also not without limitations. More precisely, as Ahn and Schmidt (1995) argue, the first-difference GMM estimator does not account for the possible information contained in the level relationship and the relationships between the level and the first differences. This suffices since, in the presence of strong endogeneity, the level variables become weak instruments for their first differences.

To mitigate the limitation of the first-difference estimator, Blundell and Bond (1998) suggest the system GMM estimator, which estimates the level and first-difference regressions as a system. In this regard, we follow Blundell and Bond’s (1998) approach by constructing the level equation with the lagged first-differenced covariates and that of the first-differenced estimation with the lagged level variables. Researchers contend that the system GMM estimation technique yields asymptotically consistent and reliable estimates (i.e., lower bias and standard errors) compared to the first-difference GMM (Windmeijer, 2005; Bond et al., 2001). Additionally, we follow Roodman (2009) by merging the instruments to take care of possible overfitting of the endogenous variables, which if unresolved can result in wrong coefficients and confidence intervals. Doing so addresses instrument proliferation[7], which can be a source of overfitting (Mehrhoff, 2009). Several recent empirical studies (see, e.g., Chen et al., 2018; Sung et al., 2018; Ofori et al., 2022c) have used the Blundell and Bond (1998) system-GMM estimator for evidenced-based recommendations.

That said, we transform Equation (14) into Equations (17) and (18) to capture the level and first-difference specifications of inclusive green growth[8], which encapsulates the dynamic system estimation method[9]:

$$igg_{it} = \alpha_0 + \delta_1 igg_{it-1} + \delta_2 fdi_{it} + \delta_4 ee_{it} + \textstyle\sum_1^4 \theta_k V_{kit-\tau} + \mathcal{J}_i + \mu_t + \varepsilon_{it} \qquad (17)$$

$$igg_{it} - igg_{it-\tau} = \delta_1\left(igg_{it-\tau} - igg_{it-2\tau}\right) + \delta_2\left(fdi_{it} - fdi_{it-\tau}\right) + \delta_3(ee_{it} - ee_{it-\tau}) + \textstyle\sum_1^4 \theta_k (V_{kit-\tau} + V_{kit-2\tau}) + (\mu_t - \mu_{it-\tau}) + (\varepsilon_{it} - \varepsilon_{it-\tau}) \qquad (18)$$

Next, to capture the hypothesised joint effect of FDI and EE on inclusive green growth, Equation (18) is modified to obtain Equation (19):

$$igg_{it} - igg_{it-\tau} = \delta_1\left(igg_{it-\tau} - igg_{it-2\tau}\right) + \delta_2\left(fdi_{it} - fdi_{it-\tau}\right) + \delta_3(ee_{it} - ee_{it-\tau}) + \delta_4\left(ee \times fdi_{it} - ee \times fdi_{it-\tau}\right) + \textstyle\sum_1^4 \theta_k (V_{kit-\tau} + V_{kit-2\tau}) + (\mu_t - \mu_{it-\tau}) + (\varepsilon_{it} - \varepsilon_{it-\tau}) \qquad (19)$$

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[7] A case where a single instrument is created for each time period and lag available, and the number of instruments exceeds the sample size.

[8] For brevity, we point out that both social and environmental progress follow similar specifications.

[9] Note that for brevity, V_k is used to denote our control variables.

Similarly, we specify the dynamic GMM models for environmental sustainability and socioeconomic sustainability, respectively, as shown in Equations 20 and 21.

$$ghgas_{it} - ghgas_{it-\tau} = \omega_1(ghgas_{it-\tau} - ghgas_{it-2\tau}) + \omega_2(fdi_{it} - fdi_{it-\tau}) + \omega_3(ee_{it} - ee_{it-\tau}) + \omega_4(ee \times fdi_{it} - ee \times fdi_{it-\tau}) + \sum_1^4 \theta_k(V_{kit-\tau} + V_{kit-2\tau}) + (\mu_t - \mu_{it-\tau}) + (\varepsilon_{it} - \varepsilon_{it-\tau}) \qquad (20)$$

$$ingrow_{it} - ingrow_{it-\tau} = \beta_1(ingrow_{it-\tau} - ingrow_{it-2\tau}) + \beta_2(fdi_{it} - fdi_{it-\tau}) + \beta_3(ee_{it} - ee_{it-\tau}) + \beta_4(ee \times fdi_{it} - ee \times fdi_{it-\tau}) + \sum_1^4 \theta_k(V_{kit-\tau} + V_{kit-2\tau}) + (\mu_t - \mu_{it-\tau}) + (\varepsilon_{it} - \varepsilon_{it-\tau}) \qquad (21)$$

The attendant net effects from the interactions between FDI and EE on IGG are captured in Equation (20) as:

$$\frac{\partial(igg_{it})}{\partial(fdi_{it})} = \delta_2 + \delta_4\overline{(ee_{it})} \qquad (22)$$

$$\frac{\partial(ghgas_{it})}{\partial(fdi_{it})} = \omega_1 + \omega_3\overline{(ee_{it})} \qquad (23)$$

$$\frac{\partial(ingrow_{it})}{\partial(fdi_{it})} = \delta_2 + \beta_4\overline{(ee_{it})} \qquad (24)$$

where $\overline{\boldsymbol{ee}}$ is the mean value of energy efficiency, $\boldsymbol{igg_{it} - igg_{it-\tau}}$ is the initial inclusive green growth in country $\boldsymbol{i}$ at time $\boldsymbol{t}$, $\boldsymbol{vul}$ is vulnerable employment, $\boldsymbol{regu}$ is regulatory quality, $\boldsymbol{remit}$ is remittances, and $\boldsymbol{findev}$ is financial development. Additionally, $(\boldsymbol{ee_{it}} \times \boldsymbol{fdi_{it}})$ is the interaction term for energy efficiency and foreign direct investment, $\boldsymbol{\mu_i}$ represents the country-specific effects, and $\boldsymbol{\epsilon_{it}}$ is the idiosyncratic error term.

It is worth noting, however, that the effectiveness of the GMM technique in yielding robust estimates depends on some post-estimation tests, which we take into account. First, we evaluate the validity of the instruments based on Hansen's test of over-identification. The test is premised on the null hypothesis of no correlation between the set of identified instruments and the residuals (Hansen, 1982). Additional post-estimation tests are evaluated regarding whether: (i) there is evidence of second-order serial correlation in the residuals or not; (ii) the interaction terms are significant; and (iii) the estimated models are jointly significant.

3.4 Computation of inclusive green growth index

In this section, we provide more information on how our outcome variable, IGG, was generated. It is imperative, therefore, to begin by paying attention to the variables that have been identified in the extant scholarship as salient drivers of social and environmental progress. In this regard, we take cues from the OECD (2019, 2017), World Bank (2012), Hickel and Kallis (2020) by selecting 24 variables that cut across the SES and EVS dichotomy. For brevity, we introduce Table 3, which shows the definition and sources of the 24 variables used in computing our IGG.

In this study, we capture socioeconomic progress (SES) by paying attention to income growth, income distribution, and equity in the access to social overhead capital. In view of this, we capture the economic aspect of SES by 5 key variables, namely, income growth, income inequality, unemployment, changes in wealth, and human capital income. The essence of income growth, which we proxy by GDP per capita, for SES is anchored in both the neoclassical and contemporary theories which suggests that sustained periods of economic expansion is required to create opportunities for the masses (Solow, 1956; Brocks & Taylor, 2010). In other words, economic growth is essential for generating sustainable socioeconomic opportunities that can result in poverty alleviation and inequalities in wealth (UN, 2015; Sachs, 2012).

Closely linked with economic growth is the level of income disparity in societies, which we proxy by the Gini index. The relevance of income distribution for SES is based on the argument that economic growth that address glaring disparities in incomes is imperative for shared prosperity and social cohesion (Anand et al., 2013; World Bank, 2012; Ofori et al., 2022d, 2021). This is precisely why we consider unemployment and wealth stability for SES. We pay attention to these two variables per the argument that, durable employment opportunities provide concrete grounds for poverty alleviation, a high and stable standard of living, and the surest way of arming economic agents to withstand socioeconomic shocks (Berg & Ostry, 2011; Ali & Son, 2007). To achieve SES, it is necessary to make investments that equip the people with entrepreneurial and employable skills, so that they can contribute to economic development (World Bank, 2020; Ofori et al., 2022e). This brings to the fore the importance of human capital development, which signifies years of quality education and returns to such investments.

Table 3: Definition of Variables in Inclusive Green Growth (IGG) Index

Variable	Symbol	Variable description	Data source
A. Socioeconomic sustainability			
(i) Social context			
Sanitation	*sanit*	Population with access to improved sanitation, % total population	GGKP Data
Population density	*pop*	Population density, inhabitants per km2	OECD Statistics
Potable water	*powat*	Population with access to improved drinking water sources, % total population	GGKP Data
Infant mortality	*infmort*	Mortality rate, infant (per 1,000 live births)	WDI Data
Life expectancy	*lifexp*	Life expectancy at birth, total (years)	OECD Statistics
Transport infrastructure	*trans*	Composite index for road, air, maritime, and railway transport infrastructure	AIKP
(ii) Economic context			
Changes in wealth	*cwea*	Changes in wealth per capita (US$)	GGKP Data
Income growth	*incgro*	GDP per capita, PPP (constant 2017 international $)	GGKP Data
Income inequality	*ineq*	Gini index (0=Lowest; 1=Highest)	GGKP Data
Human capital index	*hci*	Human capital index, based on years of schooling and returns to education	PWT
Unemployment	*unemp*	Unemployment, total (% of total labour force)	GGKP Data
B. Environmental sustainability			
(i) Natural capital			
Agricultural land	*agric*	Agricultural land (% of land area)	GGKP Data
Forest cover	*forest*	Forest area (% of land area)	OECD Statistics
Temperature changes	*temp*	Annual surface temperature, change since 1951-1980	OECD Statistics
(ii) Environmental quality of life			
Exposure to ambient PM.2.5	*amb*	Mean population exposure to PM2.5	OECD Statistics
Ambient PM.2.5 mortalities	*ambmort*	Mortality from exposure to ambient PM2.5	OECD Statistics
Ambient PM.2.5 welfare cost	*ambcost*	Welfare costs of premature mortalities from exposure to ambient PM2.5, GDP equivalent	OECD Statistics
(ii) Environmental & resource productivity			
Methane emission	*metha*	Agricultural methane emissions (thousand metric tons of CO_2 equivalent)	GGKP Data
Natural resources rent	*natres*	Total natural resources rents (% of GDP)	GGKP Data
Renewable energy	*renener*	Renewable energy consumption (% of total final energy consumption)	WDI Data
Carbon intensity	*carint*	CO_2 intensity level, primary energy	WDI Data
Fossil fuel consumption	*fosiful*	Fossil fuel energy consumption (% of total)	OECD Statistics
(iv) Economic opportunities & policy response			
Clean fuel usage	*cleanfuel*	Access to clean fuels and technologies for cooking (% of population)	WDI Data
Environmentally friendly technologies	*envtech*	Development of environment-related technologies, % all technologies	OECD Statistics

NB: WDI is World Development Indicators; PWT is Penn World Tables; GGKP is Green Growth Knowledge Program; AIKP is Africa Infrastructure Knowledge Program; OECD is The Organisation for Economic Co-operation and Development.

Source: Authors' construct, 2022

The computation of our IGG scores will not be complete if we turn a blind eye on social protection and inclusion. In this study, we note that, equity in quality healthcare delivery, access to potable water, and good sanitation are crucial for SES. Indeed, broadening access to these SES indicators can improve well-being, productivity and life expectancy (Asian Development Bank, 2013; Ofori et al., 2022e). For example, access to potable water and good sanitation is required for reducing the prevalence of sanitation-related diseases (e.g., malaria, diarrhoea, cholera, hepatitis and typhoid) and mortalities among infants. Additionally, we consider transport infrastructure and population growth. Our attention on transport infrastructure is against the backdrop that it facilitates access to information and shared access to jobs, education, and healthcare. Also, we incorporate population in the computation of our IGG per the argument that population density has implications for quality accommodation, congestion, and the sustainability of social amenities.

Besides, the global discourse since the Brundtland commission report and the ensuing Rio+20 and Paris Agreement suggests that an analysis of sustainable development is incomplete without attention to environmental sustainability (EVS). In this study, we follow Acosta et al. (2019) and the OECD (2017) by paying attention to four key dimensions of EVS, namely, the environmental quality of life, environmental and resource productivity, natural asset base, and economic opportunities and policy response. First, information gleaned from WHO (2022) and UNFCCC (2015) suggests that the drive towards IGG requires that economies grow in a manner that improves the environmental quality of life. This requires that air pollution (i.e., exposure to ambient PM2.5), premature mortalities arising from air pollution and public spending on environmental degradation be reduced to the barest minimum. It is in the remit of this that we consider the implication of environmental and resource productivity, which essentially denotes energy consumption, natural resource depletion (i.e., natural resources rent), greenhouse gas emissions (methane and CO_2 emissions) in the EVS. We note that promoting EVS will require judicious use of natural capital, and a shift from solid and fossil fuels to sustainable energy sources that reduces carbon intensity (IEA & World Bank, 2017).

Nonetheless, lags in the capacity and resources for engineering sustainable environmental productivity, especially in developing countries, has amplified the call for enhanced economic opportunities and policy response (IEA, 2021). Key among such modules is the development of environmentally-friendly technologies and support for the adoption of clean technologies for cooking, especially in marginalised societies, for human prosperity and well-being (IPCC, 2022). This also feeds into our attention on natural asset base in the calculation of IGG index. This is because achieving the Agenda 2050 and EVS in the broader perspective will also rest on (i) protecting agricultural land for subsistence, (ii) conserving forests for the protection of ecosystems and life, and (iii) pursuing sustainable production and consumption to keep the increase in global temperatures within the 1.5°C bracket.

With all that said, we delve into the econometric procedure employed for generating the IGG series. Generally, we do this to ensure that our 24 IGG variables form a sufficient sample for dimensional reduction (i.e., PCA). In this regard, we follow prior studies (e.g., Onat et al., 2019; Lamichhane et al., 2021; Ofori and Asongu, 2021), by testing whether: (1) our sample is adequate, (2) there is strong correlation among the variables, and (3) the pairwise intercorrelations between the IGG variables are strong enough.

4. Empirical results and discussion

4.1. Summary statistics and overview of key variables

Table 4 presents the summary statistics. The pairwise correlations between these variables are also presented in Table A.3 in Appendix A. From Table 4, our socioeconomic sustainability component of IGG, as indicated by inclusive growth, averaged US$898.11 over the study period. This is lower than the average GDP per capita value of US$5996.05 for the same period. This suggests that growth in Africa has not been inclusive. Furthermore, the data show an average FDI value of 3.725, and as we show in the in-country developments in Figure A.1 in Appendix B, account for a significant percentage of the overall GDP of African countries.

Table 4: Summary statistics, 2000 – 2020

Variables	N	Mean	Std. Dev.	Min	Max
IGG	180	0.0001	1.000	-1.424	1.783
Inclusive growth	483	898.111	1475.857	48.457	13934.86
Greenhouse gas emission	437	10.481	1.190	8.366	13.171
GDP per capita	483	5996.051	4955.111	630.702	22870.29
FDI	460	3.725	5.487	-6.370	39.760
Regulatory quality	437	-0.462	0.582	-1.684	1.127
Vulnerable employment	460	61.312	26.931	8.830	94.40
Remittances	469	2.224	2.707	0.000	10.822
Financial development	460	0.180	0.134	0.029	0.646
Energy efficiency	483	0.550	0.213	0.124	0.984

Note: N is Observations; Std. Dev. = Standard Deviation

While in general, Africa's growth is non-inclusive, the concern is glaring in countries such as Algeria, Angola, Botswana, Mauritius, Namibia, Gabon, South Africa, and Tunisia (Figure 2). As illustrated in Figure 2, although these countries have achieved remarkable growth rates (see GDP per capita), unemployment and income inequality in these countries are high, culminating in overall non-inclusive growth.

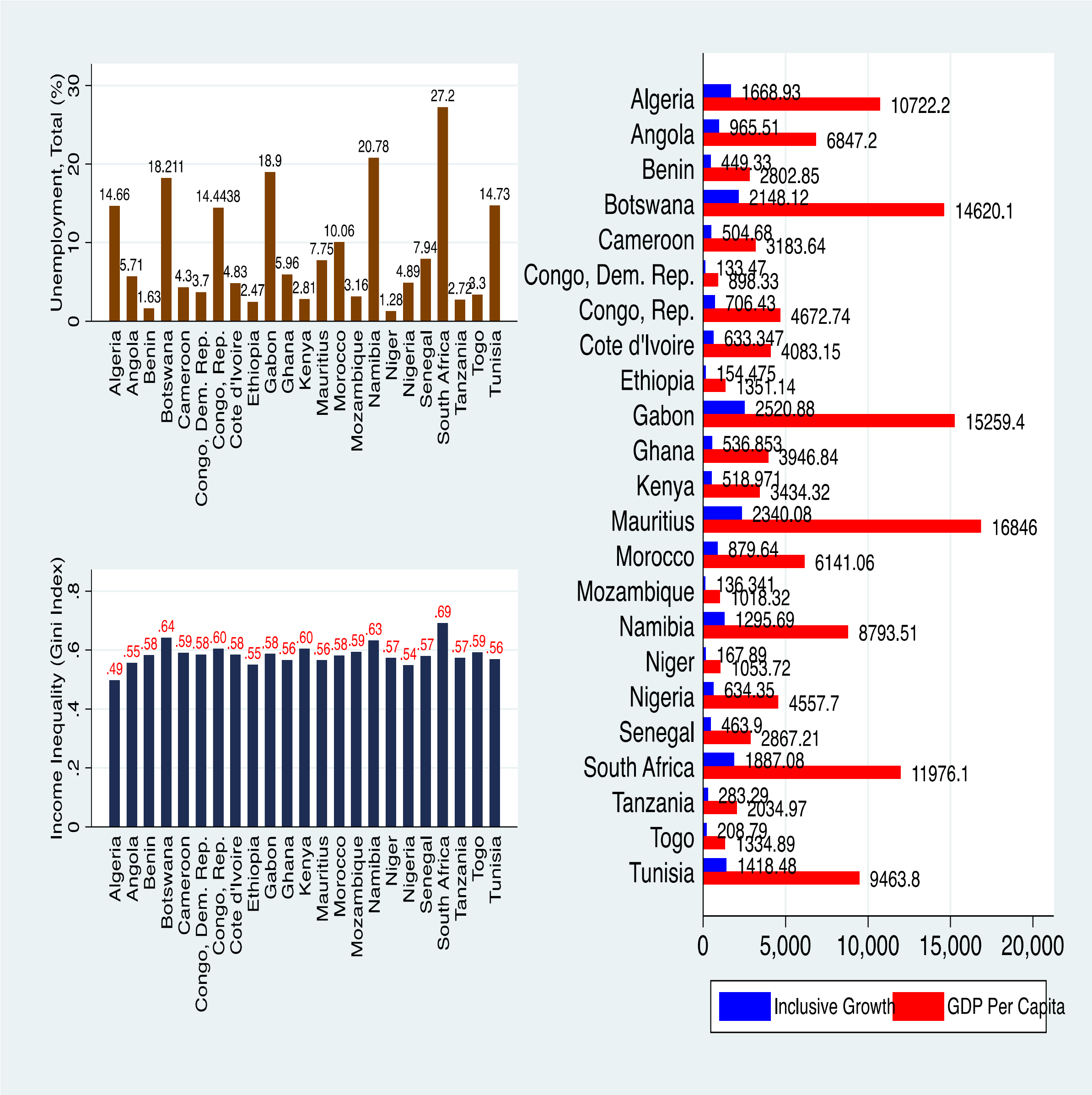

Figure 2: In-country Socioeconomic Sustainability Indicators in Africa, 2000 – 2020

Regarding the environmental perspective, as presented in Figure 3, concerns about the viability of Africa to achieve sustainable development are evident considering the high fossil fuel consumption, carbon emissions, and PM2.5 concentrations in the sample countries. Clearly, Figure 3 shows that while PM2.5 concentrations are high in countries such as Cameroon, Niger, Nigeria, Gabon, and Congo, CO_2 emissions are high in South Africa, Algeria, Gabon, Angola, and Tunisia. These developments feed directly into their high air pollution-related mortalities, and indirectly, into the high infant mortality and moderate life expectancy in Africa (see Figure A.2 in Appendix B). On a continent where the adoption and use of clean fuels and green technologies are significantly low (as shown in Figure 3), FDI and energy efficiency can prove crucial in achieving IGG.

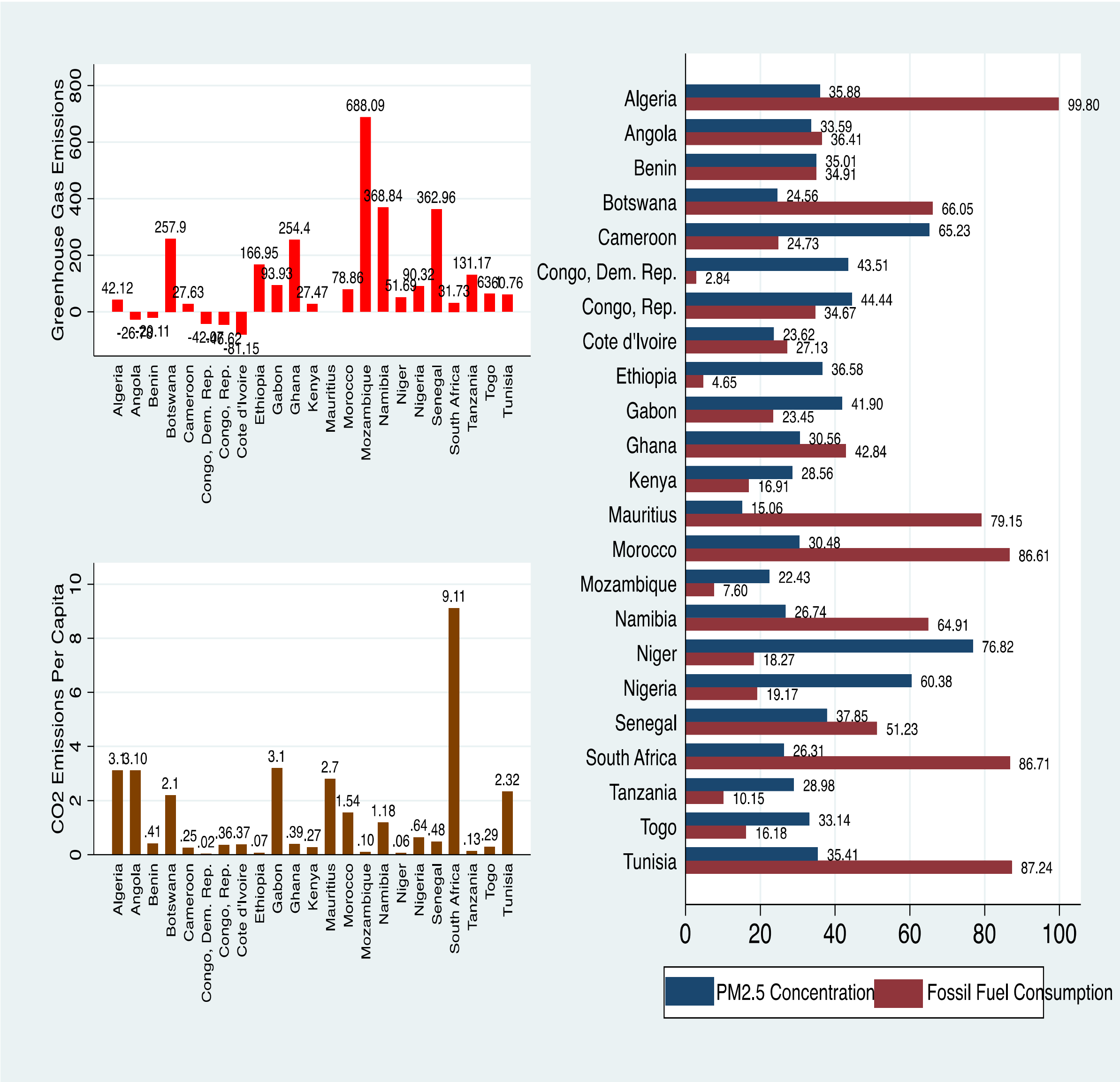

Figure 3: In-country Environmental Sustainability Indicators in Africa, 2000 – 2020

4.2. Energy efficiency: estimation of persistent, transient and total scores

In this section, we present our results for EE, which are generated based on Equation (6). It is imperative to point out that we follow the approach of Adom et al. (2021) by first presenting the results on the determinants of energy demand in Africa. As reported in Table 5, we find that covariates such as urbanisation, crude oil price, industrialisation, and human capital are significant determinants of energy demand in Africa. Regarding specifics, while industrialisation and human capital are positive drivers of energy demand, as found by Agradi et al. (2022), crude oil price and urbanisation reflect otherwise (Adom et al., 2021). Overall, our energy demand model is econometrically sound considering the F-statistic of 209, which is statistically significant at 1%.

Table 5: Determinants of energy demand, 2000 – 2020

Variable	Coefficient	Standard error	t-value
Trade openness	-0.0343	0.0244	-1.40
Urbanization	-0.439***	0.0973	-4.52
Economic growth	0.0641	0.0411	1.56
Crude oil price	-0.0273**	0.0112	-2.45
Industrialisation	0.0713**	0.0328	2.17
Human capital	0.654***	0.159	4.11
t	-0.0051**	0.0020	-2.51
Constant	13.116***	3.287	-0.15
Observations	451	–	–
Countries	23	–	–
F-stats[P-value]	205.9***[0.000]	–	–

Note: (Dependent variable: energy consumptions (all sectors), OECD data

Next, we pay attention to the results for EE. These results, as reported in Table 6, indicate that the level of EE in Africa is moderate at 0.550. Interestingly, the results suggest that Africa’s energy efficiency is temporary rather than long-term. This is reflected by the high average transient EE score of 0.963 compared to the persistent EE score of 0.570. Comparatively, while our moderately high EE results corroborate those of Ohene-Asare et al. (2020), they contradict those of Adom et al. (2021).

Table 6: Energy efficiency estimates

Energy efficiency (EE)	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Transient EE ($-\tau_{it}$)	483	0.963	0.040	0.797	0.992
Persistent EE ($-\mathcal{U}_i$)	483	0.570	0.215	0.125	0.997
Overall EE ($-\tau_{it} - \mathcal{U}_i$)	483	0.550	0.213	0.124	0.984

Source: Authors’ construct, 2022

4.3. Inclusive green growth scores for African countries

In this section, we present results from our PCA. In all, we find evidence that our sample is statistically adequate for PCA analysis. Table 7 shows the summary statistics for our sample. First, we find evidence of a strong correlation between our IGG variables (Table A.4). Second, considering the Bartlett Chi-square (X^2) statistic of 6891.67, which is statistically significant at 1 per cent, we conclude that that there are strong intercorrelations between the IGG variables. Finally, with a Kaiser–Meyer–Olkin (KMO) test statistic of 0.7435, we satisfy the PCA condition of sample adequacy.

Table 7: Summary statistics of IGG variables, 2000 – 2020

Variables	N	Mean	Std. Dev.	Minimum	Maximum
Clean fuel usage	391	33.708	34.727	0.340	99.100
Agricultural land	437	44.888	19.502	8.022	80.888
Life expectancy	460	60.322	7.848	46.267	76.880
Forest cover	483	30.889	23.621	0.663	91.978
Fossil fuel consumption	345	40.944	30.138	1.640	99.978
Economic growth	483	5996.051	4955.111	630.702	22870.29
Renewable energy	437	56.944	30.394	0.059	98.343
Exposure to Ambient PM.2.5	299	6.661	2.365	1.130	15.200
Unemployment	483	8.772	7.392	0.320	33.29
Sanitation	423	30.846	24.102	2.000	93.200
Potable water	368	73.000	17.158	28.900	99.900
Wealth changes	287	-94.743	620.182	-3281.8	1867.6
Temperature changes	483	1.007	0.420	-0.562	2.291
Population density	483	78.127	121.545	2.180	626.486
Carbon intensity	444	0.150	0.126	0.024	0.738
Ambient PM.2.5 mortalities	460	283.848	162.144	47.066	742.247
Ambient PM.2.5 welfare cost	460	3.187	1.909	0.474	8.621
Transport infrastructure	414	8.746	8.774	1.255	37.649
Income inequality	327	46.213	8.622	32.900	66.900
Human capital index	460	1.869	0.455	1.118	2.939
Methane emission	437	11414.7	13434.02	20.000	68350
Natural resources rent	460	11.726	12.439	0.001	58.65
Eco-friendly technologies	393	10.806	16.667	0.000	100.00
Infant mortality	460	52.18	24.283	12.500	121.200

Note: N = Observations; Std. Dev denotes Standard Deviation.

With all these requirements satisfied, we now present the results for our IGG index. It is worth noting that since the 24 variables are measured on different scales, we first normalise all the variables before generating the indices for each country. Following previous studies (Asongu and Odhiambo, 2020b; Ofori and Asongu, 2021), we generate our IGG index based on the first 6 principal components, which cumulatively account for 79.9 per cent variation in the dataset (see Table 8). As we show in Figure 4, these 6 components meet the Kaiser rule of at least 1.[10]

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[10] The attendant eigenvectors of all the principal components are disclosed in Table A.5 in Appendix A

Table 8: Principal components and eigenvalues for inclusive green growth

Component	Eigenvalue	Difference	Proportion	Cumulative	KMO Statistic
Comp 1	**10.051**	**7.532**	**0.419**	**0.419**	**0.826**
Comp 2	**2.519**	**0.370**	**0.105**	**0.524**	**0.363**
Comp 3	**2.149**	**0.113**	**0.089**	**0.613**	**0.744**
Comp 4	**2.036**	**0.659**	**0.085**	**0.698**	**0.579**
Comp 5	**1.376**	**0.320**	**0.057**	**0.755**	**0.800**
Comp 6	**1.057**	**0.146**	**0.044**	**0.799**	**0.831**
Comp 7	0.911	0.055	0.038	0.837	0.776
Comp 8	0.855	0.228	0.036	0.873	0.684
Comp 9	0.627	0.071	0.026	0.899	0.844
Comp 10	0.556	0.105	0.023	0.922	0.742
Comp 11	0.451	0.096	0.019	0.941	0.876
Comp 12	0.355	0.062	0.015	0.956	0.610
Comp 13	0.293	0.071	0.012	0.968	0.850
Comp 14	0.222	0.016	0.009	0.977	0.296
Comp 15	0.206	0.086	0.009	0.986	0.708
Comp 16	0.120	0.054	0.005	0.991	0.758
Comp 17	0.066	0.019	0.003	0.994	0.821
Comp 18	0.047	0.005	0.002	0.996	0.655
Comp 19	0.042	0.015	0.002	0.997	0.391
Comp 20	0.028	0.010	0.001	0.999	0.746
Comp 21	0.017	0.006	0.001	0.999	0.669
Comp 22	0.011	0.008	0.001	1.000	0.558
Comp 23	0.004	0.002	0.000	1.000	0.569
Comp 24	0.002	0.000	0.000	1.000	0.749
Overall	–	–	–	–	**0.720**

Note: KMO is Kaiser-Meyer-Olkin; Comp is Principal Component.
Source: Authors' computation

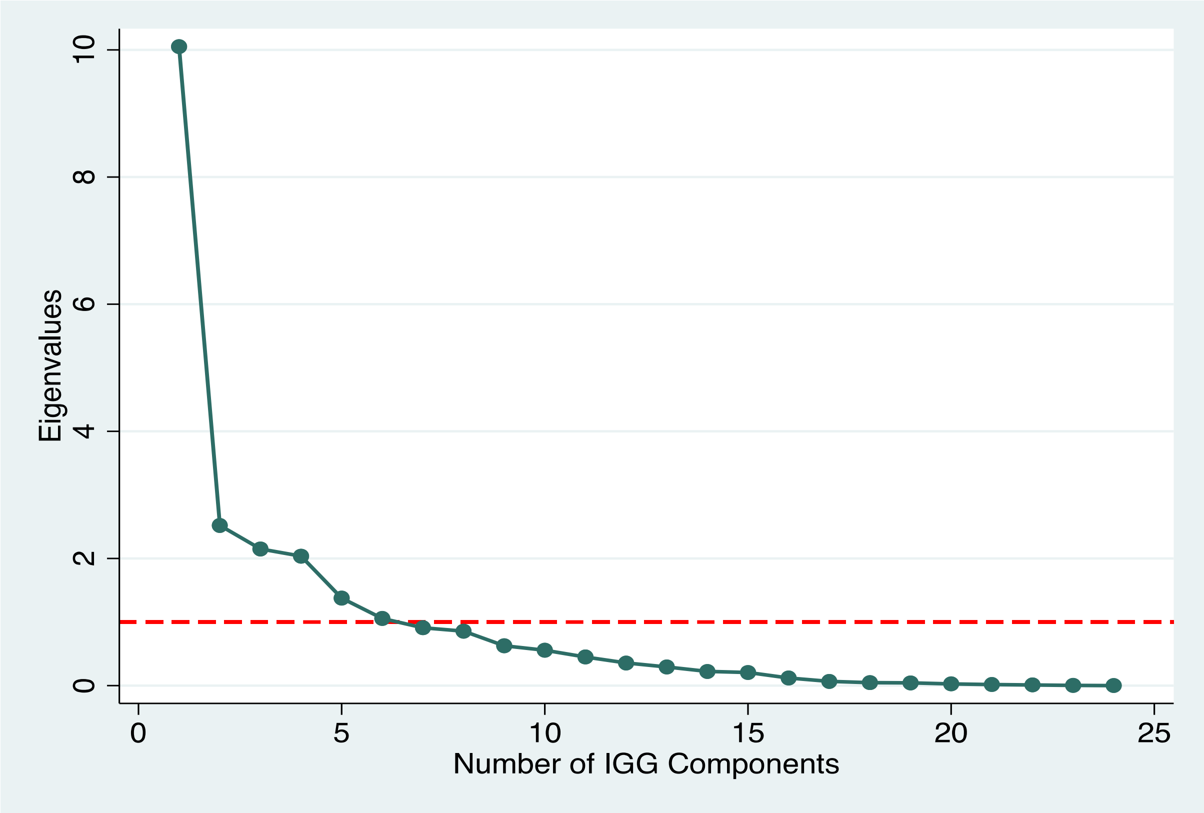

Figure 4: Scree plot of IGG Components

With our IGG series generated, it is imperative to show how the sampled countries compare to each other over the study period. We do this by focusing on Figure 5, which gives a clearer picture of whether a country's growth trajectory is both inclusive and green or otherwise. To allow for cross-country comparison, we follow the approach of Kaufmann et al. (2010) by transforming our IGG index into the standard deviation [+2.5, -2.5]. This also means that while a country could be worse off from the perspective of social progress, it may still have strong environmental performance, culminating in an overall positive IGG.

In contrast, a negative IGG could also mean a reverse of the above or that a country is performing poorly in both the environmental and social progress dimensions of sustainable development. As Figure 3 illustrates, of the 23 countries considered in this study, only 9 have a growth trajectory that is inclusive and green. These countries are Algeria, Botswana, Mauritius, Morocco, Namibia, Senegal, South Africa, Tanzania, and Tunisia, and per the 2022 Climate Change Report[11] and 2021 Sustainable Development Report[12], their positive IGG values are more reflective of environmental performance than social progress. Additionally, Figure 5 shows that in Africa, lags in inclusive growth and environmental

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[11] Pörtner et al. (2022)

[12] See Sachs et al. (2021)

sustainability are conspicuous in countries such as the Democratic Republic of Congo, Ethiopia, Kenya, Niger, Nigeria, and Togo.

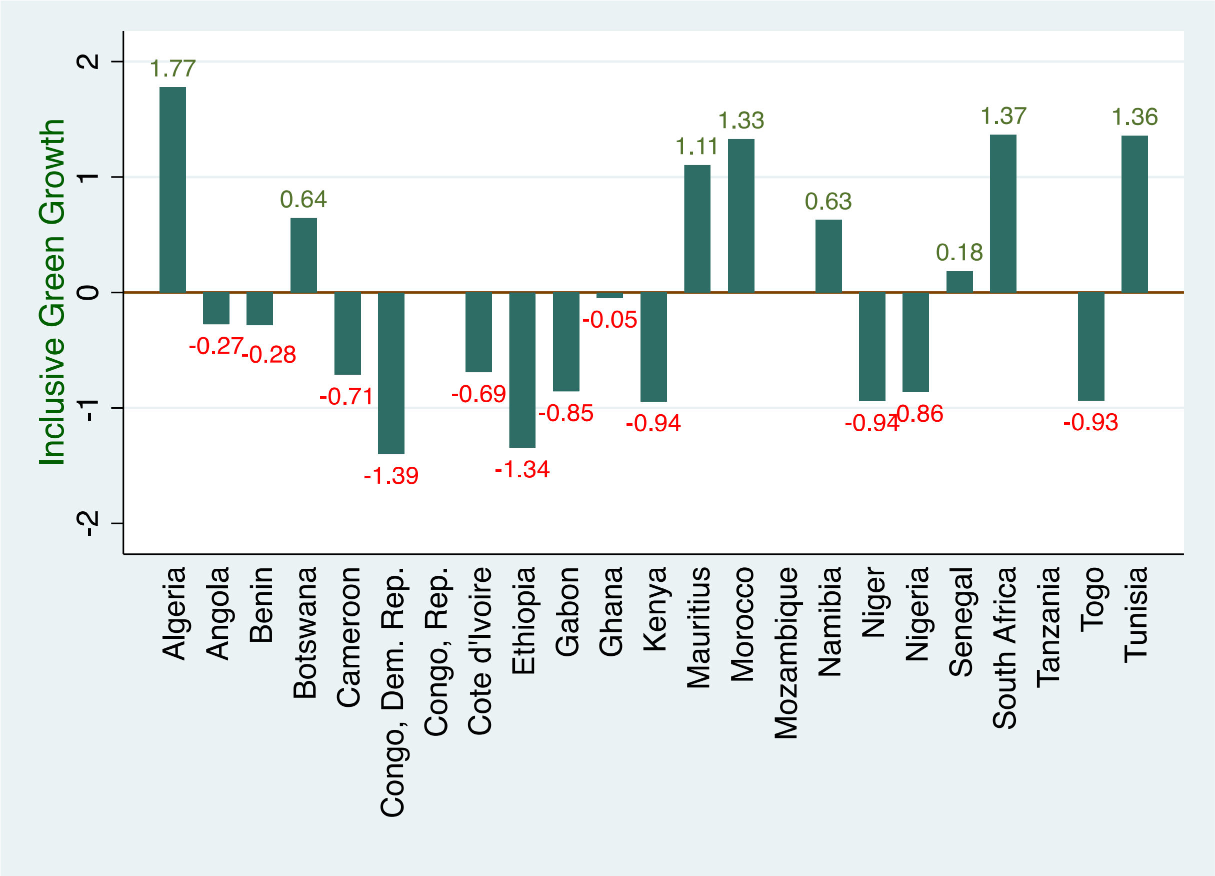

Figure 5: In-country Inclusive Green Growth in Africa, 2000 – 2020

4.4. Results for the effect of EE and FDI on inclusive green growth in Africa

Table 9 shows the results for the effects of FDI and EE on IGG in Africa. Unconditionally, we find that FDI is negative regardless of the type of model specification. The study finds that FDI stifles IGG, and suggest that a 1% increase in FDI retards IGG by 0.02%. Consistent with previous studies (e.g., Haug & Ucal, 2019; Salahuddin et al., 2018; Beradovic, 2009), our results show evidence of the downside of cross-border capital and financial flows, which takes the form of high-income inequality and environmental degradation. This supports the observations by some studies (Ofori & Asongu, 2022, Bokpin, 2017; Cornia & Martorano, 2012) that FDI inflow to Africa is mainly concentrated in capital-intensive extractive industries and services that generate limited durable employment opportunities for the population. Moreover, consistent with the PHH and Africa's weak environmental standards, the negative effect of FDI on IGG is not surprising (see, e.g., Inglesi-Lotz & Ajmi, 2021; Sarkodie et al., 2020; Sarkodie & Strezov, 2019).

Table 9: Results for the effects of FDI and energy efficiency on sustainable development (Dependent variable: inclusive green growth)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Inclusive green growth (-1)	1.0221***	0.9679***	1.0067***	0.9883***	1.0178***	1.1348***	1.1043***
	(0.0333)	(0.0278)	(0.0265)	(0.0355)	(0.0502)	(0.0670)	(0.0667)
FDI	-0.0022	-0.0064**	-0.0003	-0.0022	-0.0026	-0.0013	-0.0223**
	(0.0017)	(0.0023)	(0.0025)	(0.0022)	(0.0018)	(0.0026)	(0.0090)
Regulatory quality		0.3536***	0.0267	0.1216**	0.1484*	0.1861***	0.1453*
		(0.1069)	(0.0913)	(0.0525)	(0.0779)	(0.0641)	(0.0735)
Vulnerable employment			0.0005	0.0006	0.0027	0.0007	0.0046*
			(0.0007)	(0.0011)	(0.0022)	(0.0031)	(0.0023)
Remittances				0.0039	-0.0004	0.0001	-0.0037
				(0.0032)	(0.0059)	(0.0056)	(0.0066)
Financial development					0.2842	-0.0955	0.2897*
					(0.1838)	(0.2795)	(0.1533)
Energy efficiency (EE)						0.6521**	
						(0.2991)	
FDI x EE							0.0399**
							(0.0173)
Constant	0.0205**	0.1678***	-0.0139	0.0059	-0.1381	-0.2810*	-0.2489*
	(0.0090)	(0.0345)	(0.0513)	(0.0720)	(0.1177)	(0.1490)	(0.1251)
Net effects	na	na	na	na	na	na	-0.0013
Joint Significance Test Statistic	na	na	na	na	na	na	5.35**
Joint Significance Test (P value)	na	na	na	na	na	na	0.0321
Observations	160	160	160	159	159	159	159
Countries	20	20	20	20	20	20	20
Instruments	15	19	23	23	23	23	23
Wald Statistic	604.3***	715.6***	991.8***	983.1***	6036***	1461***	2543***
Wald P-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hansen P-Value	0.601	0.379	0.614	0.725	0.786	0.609	0.679
AR(1)	0.006	0.006	0.004	0.011	0.012	0.012	0.009
AR(2)	0.498	0.100	0.495	0.444	0.417	0.330	0.463

Standard errors in parenthesis: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

In Column 6 of Table 9, we find strong evidence that energy efficiency induces IGG. Specifically, for every 1% increase in EE, IGG increases by 0.65%. This result provides empirical evidence regarding the importance of SDG 7 (i.e., fostering affordable, reliable and clean energy) in the context of Africa. Our results suggest that EE can induce IGG possibly through reduced household and business energy costs, freeing up additional resources to get additional factors of production. This has the potential to generate multiple growth gains and improve living standards while enhancing energy conservation and environmental quality of life (Tawiah et al., 2021; Adom et al., 2021; Prindle, 2000). Additionally, the positive effect of EE on IGG is in line with prior studies (see e.g., Yang & Lu, 2015; Javid & Khan, 2020; IEA, 2020) that contend that in highly informal settings like those in Africa, there is extensive room for EE to support reductions in indoor pollution, stresses on the physical environment, and environmentally-related mortality.

Considering the expected rebound of FDI inflow to Africa from 2022 due to the implementation of the African Continental Free Trade Area (AfCFTA), EE can possibly form relevant synergies with FDI to promote IGG. We analyse this possibility by paying attention to the FDI-EE interaction term in Column 7. We report a net effect of -0.001, which is calculated based on Equation (22) by taking into consideration the unconditional effect of FDI (-0.0223), the effect of the interaction between FDI and EE (0.0399), and the mean value of EE (0.550).

$$\frac{\partial(igg_{it})}{\partial(fdi_{it})} = -0.0223 + (0.0399 \times 0.550) = -0.0013$$

The novelty of this finding is that EE significantly nullifies (dampens) the IGG-reducing effect of FDI. Put differently, in the presence of EE, the environmental-quality-deterioration effect of FDI is reduced. Our result makes economic sense, based on several factors. First, foreign-based Energy Service Companies (ESCOs) are strongly concerned about national government energy efficiency policies and energy prices of recipient countries (Yang & Yu, 2015). Second, FDIs impose a higher energy premium on the host country via the scale effect, since more capital implies more energy required to run the capital equipment and machinery (Shahbaz et al., 2019). As Yang and Yu (2015) note, where there is a strong national government policy initiative for energy efficiency investment, there is a market for ESCO businesses. In contrast, if a market has fossil energy subsidies, it can deter ESCOs.

Therefore, with the African continent being endowed with abundant renewable energy sources, EE project developers who foresee future government policy efforts can redirect investment to energy-efficient technologies, which can yield IGG benefits in the long run.

For our control variables, we report a significant positive effect of regulatory quality on IGG. The magnitude of the coefficient indicates that for every 1-point increase in regulatory quality, sustainable development is enhanced by 0.14% (Column 7). This result implies that sound regulatory regimes are paramount for realizing IGG in Africa. For instance, effective regulatory quality will emphasize a shift from dirty growth while favouring green FDI and sustainable production and consumption practices. This aligns with Bokpin (2017) argument that in the presence of weak institutions, economic agents may adopt technologies that primarily serve their interests at the expense of environmental quality. Also, we find that vulnerable employment is IGG-enhancing, albeit only statistically significant in Column 8, where we see a modest effect of 0.004%. The result is not surprising, as Africa's informal sector, which is dominated by own-account enterprises and informal employer enterprises, is a key contributor to growth and employment, with producers turning to the adoption of subsidised clean fuels such as liquefied petroleum gas (ILO, 2020). Also, Column 8 of Table 9 shows a favourable effect of financial development (0.28) on IGG. This result corroborates the argument of De Haan et al. (2021) and Shahbaz et al. (2013) that the relevance of financial development goes beyond resource allocation and investment for social progress to include green finance and innovations that reduce pressure on the environment.

The reliability of our results is seen in their robustness to different types of model specifications and several post-estimation tests. On the evidence of the Hansen p-values, it is clear that our instrumental variable regressions are free from instrument proliferation. In other words, the instruments used are valid for addressing the endogeneity concerns. Also important, as the AR(2) statistics indicate, is the absence of second-order serial correlation in the residuals. Finally, the significance of the tests for the interaction term and overall model show that the results are appropriate.

4.5. Effects of FDI and EE on socioeconomic sustainability (Inclusive growth)

Table 10 shows the effects of EE and FDI on the socioeconomic sphere of IGG. The results are based on Equation (21), where inclusive growth, generated via the Jolliffe (2002) approach, is used as the outcome variable. Consistent with Ofori and Asongu (2022), we provide evidence (Column 7) that FDI fosters inclusive growth in Africa. This result provides optimism regarding the achievement of Aspiration 1 of the African Union's Agenda 2063, especially as FDI inflows to Africa are projected to increase from 2022 (UNCTAD, 2021).[13] Consistent with its effect on IGG, we find that the effect of EE on inclusive growth is positive and significant. Specifically, we reveal a marginal effect of 2.31% for every 1% improvement in EE. Thus, we provide empirical support for SDG 8.3 in that EE can lead to job creation, entrepreneurship, and poverty reduction either directly or indirectly by reducing economic agents' expenditures on energy (see IEA, 2019; Bell et al., 2011).

Regarding the second objective of this study, we examine the net effect of EE-FDI interaction on inclusive growth. The results, as reported in Column 7, show that the EE-FDI interaction is significant at 1%, hence supporting our hypothesis that EE can propel FDI to yield a remarkable shared growth effect. The corresponding net effect, which is based on Equation 24, is 0.327, and is calculated as follows:

$$\frac{\partial(ingrow_{it})}{\partial(fdi_{it})} = 0.1659 + (0.2930 \times 0.55) = 0.327,$$

where 0.1659 is the direct effect of FDI on inclusive growth, 0.2930 denotes the conditional effect of FDI on inclusive growth, and 0.55 is the mean value of EE, as shown in the summary statistics (Table 2).

This result is sound both from the political and socioeconomic perspectives, as: (i) the energy component of the cost structure in the production process is a critical determinant of the growth and sustainability of firms, and (ii) foreign investors consider the availability, reliability, and affordability of energy when appraising the direction for investment. Additionally, following the implementation of the AfCFTA and the anticipated rise in FDI in Africa from 2022, our results regarding the significant synergy between EE and FDI suggest the plausibility of the greater equitable income growth and distribution effect via poverty reduction, macroeconomic stability, job creation, and access to a variety of goods and services, in line with enhanced industrial bases, forward and backward linkages, and increased global value chains.

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[13] Aspiration 1 of the African Union's Agenda 2063 focuses on a "prosperous Africa based on inclusive growth and sustainable development".

Table 10: Results for the effects of FDI and EE on socioeconomic sustainability (Dependent variable: Inclusive growth)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Inclusive growth (-1)	0.8163***	0.8590***	0.8622***	0.8347***	0.8735***	0.7877***	0.8793***
	(0.0031)	(0.0207)	(0.0128)	(0.0214)	(0.0338)	(0.0413)	(0.0501)
FDI	0.0002	-0.0009	0.0077***	-0.0166***	-0.0189***	-0.0241***	0.1659***
	(0.0005)	(0.0013)	(0.0020)	(0.0057)	(0.0039)	(0.0063)	(0.0411)
Regulatory quality		-0.3682***	0.2071**	0.0109	-0.0423	0.0665	-0.1304
		(0.0795)	(0.0764)	(0.0698)	(0.1121)	(0.1477)	(0.0902)
Vulnerable employment			-0.0038***	-0.0047**	-0.0031	0.0070*	0.0053**
			(0.0011)	(0.0021)	(0.0034)	(0.0038)	(0.0023)
Remittances				-0.0191*	-0.0030	0.0160	-0.0048
				(0.0108)	(0.0121)	(0.0099)	(0.0190)
Financial development					0.7194**	0.2218	1.0129
					(0.3325)	(0.5657)	(0.6688)
Energy efficiency (EE)						2.3076**	
						(0.9350)	
FDI x EE							0.2930***
							(0.0867)
Constant	1.0339***	0.6040***	1.0467***	1.3061***	0.8042**	2.0593***	0.0795
	(0.0232)	(0.1687)	(0.0529)	(0.0829)	(0.3191)	(0.6877)	(0.5677)
Net effects	na	na	na	na	na	na	0.327
Joint Significance Test Statistic	na	na	na	na	na	na	11.41***
Joint Significance Test (P value)	na	na	na	na	na	na	0.0027
Observations	437	414	414	405	405	405	405
Countries	23	23	23	23	23	23	23
Instruments	25	28	23	23	23	23	23
Wald Statistic	194314	197011	1.880e+06	960261	597095	8188	144413
Wald P-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hansen P-Value	0.421	0.597	0.659	0.619	0.609	0.601	0.672
AR(1)	0.005	0.009	0.009	0.011	0.012	0.012	0.011
AR(2)	0.250	0.244	0.297	0.284	0.277	0.284	0.241

*Standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$*

We focus on the effects of our control variables on inclusive growth. The lag of inclusive growth is remarkably noticeable across all specifications, signifying that shared growth momentum gathered in previous years induces current inclusive growth efforts. Furthermore, the results in Column 2 show that regulatory quality has a positive and statistically significant effect on inclusive growth (i.e., 0.207). This result is in line with Ofori and Asongu (2022), who contend that in highly informal settings like Africa, the effectiveness of policymakers in formulating sound policies and regulations can promote economic freedom and shared income growth and distribution. Also, similar to Gyamfi et al. (2013), we find that vulnerable employment is harmful to shared growth in Africa. Arguably, this is because individuals in precarious jobs lack social protection and a consistent inflow of earnings that help them to manage socioeconomic shocks effectively. Additionally, we find that remittances are deleterious to inclusive growth in Africa (Column 2), albeit with a weak effect (i.e., 0.019). This finding reinforces the notion that remittances have little impact on shared growth, as they are often spent on consumables (Giuliano & Ruiz-Arranz, 2009).

Regarding financial development, we reveal a significant positive effect, with the size of the coefficient indicating that a 1% improvement in access, depth, and efficiency Africa's financial systems enhances inclusive growth by a remarkable 0.71% (Column 5). Our finding follows Tchamyou et al. (2019) argument that a well-developed financial system can foster inclusive growth by offering financial products and services to households and firms, which can go a long way to support innovation, private sector growth, economic growth, and reductions in income inequality.

4.6. Effects of FDI and energy efficiency on environmental sustainability

As shown in Table 11, we find evidence to support the pollution haven hypothesis in SSA, since greenhouse gas emissions (GHGs) are directly related to FDI. Specifically, we note that a 1% increase in FDI inflow worsens environmental sustainability by 0.12% (Column 6). This finding supports empirical studies that have highlighted the importance of monitoring FDI-driven economic growth (Tawiah et al., 2021; Dauda et al. 2021; Sarkodie & Strezov, 2019).

Furthermore, EE was also found to have no statistically significant effect on EVS, suggesting that Africa’s current level of energy efficiency is not effective for reducing greenhouse gas emissions.

Table 11: Results for the effects of FDI and EE on environmental sustainability (Dependent variable: Greenhouse gas emissions)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Greenhouse gas emissions (-1)	0.3757***	0.3978***	0.4430***	0.2641***	0.0917*	0.1421***	0.1346***
	(0.0310)	(0.0586)	(0.0181)	(0.0295)	(0.0478)	(0.0396)	(0.0415)
FDI	0.0814***	0.0939***	0.0578***	0.0753***	0.1056***	0.1243***	0.0297
	(0.0065)	(0.0090)	(0.0057)	(0.0111)	(0.0188)	(0.0250)	(0.1361)
Regulatory quality		-2.3787***	-0.2169	-1.5764***	-1.6868***	-2.3816***	-1.8695***
		(0.2500)	(0.1973)	(0.5029)	(0.4292)	(0.6621)	(0.5971)
Vulnerable employment			0.0165***	0.0111*	0.0109	0.0035	0.0089
			(0.0044)	(0.0059)	(0.0179)	(0.0253)	(0.0202)
Remittances				-0.0693**	0.0211	-0.0749	0.0122
				(0.0306)	(0.0540)	(0.0673)	(0.0540)
Financial development					2.0862	0.1623	0.4259
					(2.5976)	(4.1721)	(3.4778)
Energy efficiency						3.2666	
						(2.4916)	
FDI x Energy efficiency							0.1975
							(0.1808)
Constant	0.4223***	-0.7632**	-0.6788*	-0.8611	-1.3783	-2.6245	-1.0651
	(0.1256)	(0.2695)	(0.3486)	(0.6370)	(1.4588)	(2.1695)	(1.6392)
Net effect	na	na	na	na	na	na	na
Joint Significance Test Statistic	na	na	na	na	na	na	na
Joint Significance Test (P-value)	na	na	na	na	na	na	na
Observations	259	237	237	231	231	231	231
Countries	22	22	22	22	22	22	22
Instruments	18	21	22	22	22	22	22
Wald Statistic	3282***	838***	3112***	1405***	186.1***	269.6***	98.17***
Wald P-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hansen P-Value	0.204	0.390	0.591	0.692	0.618	0.675	0.620
AR(1)	0.046	0.054	0.055	0.056	0.068	0.042	0.054
AR(2)	0.840	0.100	0.100	0.104	0.156	0.114	0.132

*Standard errors in parenthesis; *** $p<0.01$, ** $p<0.05$, * $p<0.1$*

Also, the EE-FDI interaction term is positive but statistically insignificant, suggesting that, in the presence of low EE, FDI could hamper environmental progress. For our controls, we find that regulatory quality and remittances play a crucial role in advancing the course of ensuring environmental quality. The estimated negative coefficients of both variables indicate a decline in GHGs by 2.3% and 0.069% from a 1% improvement in regulatory quality and remittances, respectively. This finding is in line with that of Adekunle (2021), who asserts that strong institutions are the only way to foster environmental sustainability, through myriad green policy design and implementation. Conversely, we find that informal economic activities inhibit environmental sustainability. Therefore, if the activities in the informal sector pollute the environment, then we might argue that the absence of government regulation permits this sector to pollute more than the formal sector (see, e.g., Swain et al., 2020).

4.7. Further discussion and threshold estimates

We have established that FDI inflows to Africa hinder sustainable development. At the disaggregated level, however, we find that this negative effect stems from the strong negative effect of FDI on environmental progress (greenhouse gas emission) relative to the weak favourable effect on socioeconomic sustainability (inclusive growth). In this regard, the study confirms both the pollution haven hypothesis and the conventional wisdom around FDI-induced growth. Furthermore, we find that EE is key to the realisation of IGG. Though EE is not statistically significant in reducing greenhouse gas emissions, we find strong evidence to show that EE is effective in enhancing social progress, which cumulatively feeds into the overall IGG-enhancing effect of EE.

We then cast the net a bit wider in line with SDG 7, where we find that EE interacts with FDI to foster IGG, SES, and EVS, though statistical significance for the latter proved elusive. Crucially, we find that EE mitigates the harmful effect of FDI on IGG. This interactive effect is noticeable in the case of social progress. These encouraging developments relate to some key findings from this study, which are based on threshold analysis. The essence of our threshold analysis is to estimate sustainable development gains of improving Africa’s current EE level of 0.550 (Table 2). Specifically, the relevance of our threshold analysis is conveyed in the following question, i.e., given the current regulatory standards, what are the possible sustainable development gains of improving EE from 0.6 to 0.9 if there is a 1% increase in FDI inflow to Africa? It is important to emphasise that these thresholds are calculated based on Equations 22 and 23 by taking into consideration our pathway estimates presented in Column 7 of Tables 8 and 9 (i.e., results with IGG and SES as dependent variables). Table 12 presents some of the findings for informing policy.

Table 12: Energy efficiency thresholds and inclusive green growth net effects

	Net Effects		
Thresholds	**IGG**	**SES**	**EVS**
0.6	0.0016	0.3417	na
0.7	0.0056	0.3710	na
0.8	0.0096	0.4003	na
0.9	0.0136	0.4296	na

Note: IGG is Inclusive Green Growth, SES is Socioeconomic Sustainability; EVS is Environmental Sustainability; EE is Energy Efficiency; and na is Not Applicable.

For IGG, the results provide optimism for African governments and their development partners on the possible sustainable development gains of channelling resources into improvements of EE. This optimism is based on evidence that by improving EE in the short term (i.e., from the current 0.550 to 0.6), the harmful effects of FDI on IGG are reversed completely, yielding a positive net effect (i.e., 0.0016). In the long term, we report greater IGG dividends of 0.0096 and 0.0136 for EE levels of 0.8 and 0.9, respectively. Regarding social progress, the results are even striking both in the short term through to the long term, suggesting that improving EE in Africa can be a gamechanger for equitable income growth and distribution.

4.8 Theoretical contribution of the study

Our study offers theoretical insights that enhance our understanding of how capital flows and sustainable energy policies feed into inclusive green growth. Our unique IGG framework highlights the complexity of IGG, and is based on a combination of various concepts, including socio-economic progress, environmental progress, and energy efficiency. By combining these concepts to understand the concept of IGG, we equally provide theoretical insights linked to several theories, including the ecological modernization theory and new endogenous growth theories. Notably, no single theory can effectively capture the complexities of IGG. Our *IGG framework* can be utilized by scholars towards theory development, as we have provided the groundwork. Moreover, our IGG framework suggests that policymakers should prudently consider the synergistic effect of foreign direct investment and energy efficiency in their efforts towards achieving a growth trajectory that is both socially progressive and environmentally sustainable.

5. Conclusion and policy implications

This paper uses macrodata for 23 countries from 2000–2020 in addition to the dynamic system GMM estimator to examine whether there exists a relevant synergy between EE and FDI in fostering IGG in Africa. This study is a major departure from previous studies, as it examines whether EE can engender a positive synergy with FDI to foster IGG, including examining the IGG gains from improving EE in the short and long terms. The main findings drawn from the empirical analysis include that unconditionally, FDI hampers IGG in Africa, and also that EE fosters IGG in Africa. In the presence of EE, the environmental-quality-deterioration effect of FDI is reduced. Notably, the threshold analysis indicates that improving EE in Africa generates positive sustainable development gains both in the short term and long term.

Our study contributes to Africa's drive towards sustainable development on multiple fronts. First, we respond to the call by the United Nations and other international actors to identify areas where there exist positive synergies among the SDGs to inform targeted policy actions aimed at fostering shared prosperity. Our study aligns with Sachs (2012), as it shows that the private sector plays a key role in achieving sustainable development. Specifically, we show that FDI, which is explicitly linked with SDG 8 (Decent work and economic growth), SDG 9 (industry, innovation and infrastructure) and SDG 12 (Responsible production and consumption), hinder sustainable development in Africa. Nonetheless, our evidence suggests that it is a concern that is not beyond African leaders and their development partners. We show that repacking FDI for sustainable development in Africa requires sustainable energy measures like EE, which is closely linked with SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action). Moreover, in a period where African leaders are putting in place measures to lure foreign investors into their folds in line with the AfCFTA, our study suggests that turning a blind eye on complementary policies such as EE presents major drawback to both social and environmental sustainability.

Our findings have policy implications. First, EE can be seen as one solution to the negative effects of FDIs in Africa. Therefore, efforts made by African countries to attract FDI should also be accompanied by appropriate policy options aimed at ensuring energy efficiency, as doing so will contribute to addressing the problem of environmental degradation. African governments could adopt policies which encourage investment in EE, and such policies should not just be restricted to foreign companies, but should also target local firms as well as households.

Second, the finding that FDI negatively affects IGG highlights the need for African governments to identify the negative elements of FDI, and that once these adverse elements are identified, measures should be undertaken to address them, as doing so would contribute to fostering IGG, which is vital for people’s economic and social wellbeing. African leaders should therefore prioritise environmentally sustainable FDI and investments in the areas of recycling and environmentally-friendly technologies.

The limitations of this study are twofold. First, the study does take into account the main sources of FDI inflow to Africa (e.g., FDI inflow from the EU, OECD or China). Second, we do not disaggregate FDI into various sectors, for example, FDI inflow to the mining, aviation, or the manufacturing sectors. The study calls for further research, particularly country-specific studies that would provide more country-specific policies that are more tailored to the initial development conditions of the respective countries. This future research direction is based on the premise that while evidence-based cross-country analysis of this nature is relevant for common policy harmonisation, country-oriented policies should be informed by the relevant time-series empirical strategies.

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References:

Acemoglu, D., & Robinson, J. A. (2010). Why is Africa poor? *Economic history of developing regions*, *25*(1), 21-50.

Acheampong, A. O., Appiah-Otoo, I., Dzator, J., & Agyemang, K. K. (2021). Remittances, financial development and poverty reduction in Sub-Saharan Africa: Implications for post-COVID-19 macroeconomic policies. *Journal of Policy Modeling*, *43*(6), 1365-1387.

Acosta, L. A., K. Hartman, R. J. Mamiit, N.M. Puyo, and O. Anastasia. (2019). *Summary Report: Green Growth Index Concept, Methods and Applications. Green Growth Performance Measurement (GGPM) Program*, Global Green Growth Institute, Seoul, Republic of Korea.

Adams, S., & Klobodu, E. K. M. (2017). Capital flows and the distribution of income in sub-Saharan Africa. *Economic Analysis and Policy*, *55*, 169-178.

Adams, S., & Opoku, E. E. O. (2015). Foreign direct investment, regulations and growth in sub-Saharan Africa. *Economic Analysis and Policy*, *47*, 48-56.

Adekunle, I. A. (2021). On the search for environmental sustainability in Africa: the role of governance. *Environmental Science and Pollution Research*, *28*(12), 14607-14620.

Adom, P. K. (2019). An evaluation of energy efficiency performances in Africa under heterogeneous technologies. *Journal of Cleaner Production*, *209*, 1170-1181.

Adom, P. K., Agradi, M., & Vezzulli, A. (2021). Energy efficiency-economic growth nexus: What is the role of income inequality? *Journal of Cleaner Production*, *310*, 127382.

Adom, P. K., Amakye, K., Abrokwa, K. K., & Quaidoo, C. (2018). Estimate of transient and persistent energy efficiency in Africa: A stochastic frontier approach. *Energy Conversion and Management*, *166*, 556-568.

Agbloyor, E. K., Abor, J. Y., Adjasi, C. K. D., & Yawson, A. (2014). Private capital flows and economic growth in Africa: The role of domestic financial markets. *Journal of International Financial Markets, Institutions and Money*, *30*, 137-152.

Agradi, M., Adom, P. K., & Vezzulli, A. (2022). Towards sustainability: Does energy efficiency reduce unemployment in African societies? *Sustainable Cities and Society*, 103683.

Ahmad, M., Ul Haq, Z., Khan, Z., Khattak, S. I., Ur Rahman, Z., & Khan, S. (2019). Does the inflow of remittances cause environmental degradation? Empirical evidence from China. *Economic research-Ekonomska istraživanja*, *32*(1), 2099-2121.

Ahn, S. C., & Schmidt, P. (1995). Efficient estimation of models for dynamic panel data. *Journal of Econometrics*, *68*(1), 5-27.

Ali, I., & Son, H. H. (2007). Measuring Inclusive Growth. Asian Development Review, Vol. 24 (1), pp. 11-31.

Akram, R., Chen, F., Khalid, F., Ye, Z., & Majeed, M. T. (2020). Heterogeneous effects of energy efficiency and renewable energy on carbon emissions: evidence from developing countries. *Journal of Cleaner Production*, *247*, 119122.

Akobeng, E. (2021). Harnessing remittances for the poor: the role of institutions. *Journal of Economic Policy Reform*, 1-17.

Anand, R., Mishra, M. S., & Peiris, M. S. J. (2013). *Inclusive growth: Measurement and*

Determinants. International Monetary Fund.

Anetor, F. O., Esho, E., & Verhoef, G. (2020). The impact of foreign direct investment, foreign aid and trade on poverty reduction: Evidence from Sub-Saharan African countries. *Cogent Economics & Finance*, *8*(1), 1737347.

Apergis, N., & Payne, J. E. (2010). Renewable energy consumption and economic growth: evidence from a panel of OECD countries. *Energy policy*, *38*(1), 656-660

Arellano, M., & Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The Review of Economic Studies*, 58(2), 277-297

Arouri, M., El Ghoul, S., & Gomes, M. (2021). Greenwashing and product market competition. *Finance Research Letters*, 101927.

Asongu, S. A., & Odhiambo, N. M. (2020a). Foreign direct investment, information technology and economic growth dynamics in Sub-Saharan Africa. *Telecommunications Policy*, *44*(1), 101838.

Asian Development Bank. (2013). Framework of inclusive growth indicators: Key indicators for Asia and the Pacific. Mandaluyong City, Philippines: *Asian Development Bank.*

Asongu, S. A., & Odhiambo, N. M. (2020b). Inequality thresholds, governance and gender economic inclusion in sub-Saharan Africa. *International Review of Applied Economics*, 34(1), 94-114

Asongu, S. A., & Odhiambo, N. M. (2018). ICT, financial access and gender inclusion in the formal economic sector: evidence from Africa. *African Finance Journal*, *20*(2), 45-65.

Atkinson, R., & Klausen, J. E. (2011). Understanding sustainability policy: governance, knowledge and the search for integration. *Journal of Environmental Policy & Planning*, *13*(3), 231-251.

Anyanwu, J. C. (2011). International remittances and income inequality in Africa. *Review of Economic and Business Studies*, *4*(1), 117-148.

Baltagi, B. H. (2008). Forecasting with panel data. *Journal of Forecasting*, *27*(2), 153-173.

Bataille, C., & Melton, N. (2017). Energy efficiency and economic growth: A retrospective CGE analysis for Canada from 2002 to 2012. *Energy Economics*, *64*, 118-130.

Baum, C. F., Schaffer, M. E., & Stillman, S. (2003). Instrumental variables and GMM: Estimation and testing. *The Stata Journal*, *3*(1), 1-31.

Bayar, Y., & Gavriletea, M. D. (2019). Energy efficiency, renewable energy, economic growth: evidence from emerging market economies. *Quality & Quantity*, *53*(4), 2221-2234.

Bell, C. J., Nadel, S., & Hayes, S. (2011). On-bill financing for energy efficiency. improvements. *A review of current program challenges, opportunities and bets practices*.

Ben Jebli, M., Ben Youssef, S., & Apergis, N. (2019). The dynamic linkage between renewable energy, tourism, CO2 emissions, economic growth, foreign direct investment, and trade. *Latin American Economic Review*, *28*(1), 1-19.

Beradovic M (2009). The role of FDI and openness of trade in economic growth: a study of Africa and Asia. Unpublished Bachelor Thesis Submitted to Jonkopin International Business School, Jonkopin University.

Berg, A. G., & Ostry, J. D. (2011). Equality and Efficiency: Is there a trade-off between the two or do they go hand in hand? *Finance & Development*, *48*(003).

Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of econometrics*, *87*(1), 115-143.

Bokpin, G. A. (2017). Foreign direct investment and environmental sustainability in Africa: The role of institutions and governance. *Research in International Business and Finance*, *39*, 239-247.

Bond, S. R., Hoeffler, A., & Temple, J. R. (2001). GMM estimation of empirical growth models. *Available at SSRN 290522*.

Bovenberg, A. L., & Smulders, S. (1995). Environmental quality and pollution-augmenting technological change in a two-sector endogenous growth model. *Journal of Public Economics*, *57*(3), 369-391.

Brock, W. A., & Taylor, M. S. (2010). The green Solow model. *Journal of Economic Growth*, *15*(2), 127-153.

Brookes, L. (1979). A Low Energy Strategy for the UK by G Leach et al: a Review and Reply. *Atom*, *269*(3–8).

Cantore, N., Calì, M., & te Velde, D. W. (2016). Does energy efficiency improve technological change and economic growth in developing countries? *Energy Policy*, *92*, 279-285.

Chen, H., Hao, Y., Li, J., & Song, X. (2018). The impact of environmental regulation, shadow economy, and corruption on environmental quality: Theory and empirical evidence from China. *Journal of Cleaner production*, *195*, 200-214.

Chowdhury, M. (2016). Financial development, remittances and economic growth: Evidence using a dynamic panel estimation. *Margin: The Journal of Applied Economic Research*, *10*(1), 35-54.

Cole, M. A., Elliott, R. J., & Zhang, J. (2011). Growth, foreign direct investment, and the environment: evidence from Chinese cities. *Journal of Regional Science*, *51*(1), 121-138.

Cornia, G. A., & Martorano, B. (2012). *Development policies and income inequality in selected developing regions, 1980–2010* (No. 210). United Nations Conference on Trade and Development.

Dauda, L., Long, X., Mensah, C. N., Salman, M., Boamah, K. B., Ampon-Wireko, S., & Dogbe, C. S. K. (2021). Innovation, trade openness and CO2 emissions in selected countries in Africa. *Journal of Cleaner Production*, *281*, 125143.

Del Carpio, X. V., Gruen, C., & Levin, V. (2017). Measuring the Quality of Jobs in Turkey. World Bank, Washington, DC

De Haan, J., Pleninger, R., & Sturm, J. E. (2021). Does financial development reduce the poverty gap? *Social Indicators Research*, 1-27.

Demena, B. A., & Afesorgbor, S. K. (2020). The effect of FDI on environmental emissions: Evidence from a meta-analysis. *Energy Policy*, *138*, 111192.

Deichmann, U., & Zhang, F. (2013). *Growing green: the economic benefits of climate action*. World Bank Publications.

De Pascale, G., Sardaro, R., Faccilongo, N., & Contò, F. (2020). What is the influence of FDI and international people flows on environment and growth in OECD countries? A panel study. *Environmental Impact Assessment Review, 84*, 106434.

Dercon, S. (2012). Is Green Growth Good for the Poor? *Policy Research Working Paper 6231, The World Bank.*

Doytch, N., & Uctum, M. (2016). Globalization and the environmental impact of sectoral FDI. *Economic Systems*, *40*(4), 582-594.

Dunning, J. (1993). *Multinational Enterprises and the Global Economy*. Addison-Wesley, Wokingham.

Eakin, H., & Luers, A. L. (2006). Assessing the vulnerability of social-environmental systems. *Annual Review of Environment and Resources, 31*, 365-394.

Fauzel, S., Seetanah, B., & Sannasee, R. V. (2015). Productivity spillovers of FDI in the manufacturing sector of Mauritius. Evidence from a dynamic framework. *The Journal of Developing Areas*, 295-316.

Fay, M. (2012). *Inclusive green growth: The pathway to sustainable development*. World Bank Publications.

Feenstra, R. C., & Hanson, G. H. (1997). Foreign direct investment and relative wages: Evidence from Mexico's maquiladoras. *Journal of International Economics*, *42*(3-4), 371-393.

Filippini, M., & Hunt, L. C. (2011). Energy demand and energy efficiency in the OECD countries: a stochastic demand frontier approach. *The Energy Journal*, *32*(2).

Fosu, A. K. (2015). Growth, inequality and poverty in Sub-Saharan Africa: recent progress in a global context. *Oxford Development Studies*, *43*(1), 44-59.

Gallagher, K. P., & Zarsky, L. (2007). *The enclave economy: foreign investment and sustainable development in Mexico's Silicon Valley*. MIT Press.

Giuliano, P., & Ruiz-Arranz, M. (2009). Remittances, financial development, and growth. *Journal of Development Economics*, *90*(1), 144-152.

Golub, S. S., Kauffmann, C., & Yeres, P. (2011). Defining and measuring green FDI: an exploratory review of existing work and evidence.

Gouldson, A., & Murphy, J. (1997). Ecological modernisation: restructuring industrial economies. *Political Quarterly*, *68*(B), 74-86.

Greene, W. (2005). Reconsidering heterogeneity in panel data estimators of the stochastic frontier model. *Journal of Econometrics*, *126*(2), 269-303.

Green Growth Knowledge Platform (GGKP) (2013). Moving towards a Common Approach on Green Growth Indicators. *Global Green Growth Institute*, OECD, UNEP and The World Bank.

Grossman, G. M., & Krueger, A. B. (1991). Environmental impacts of a North American free trade agreement.

Gu, K., Dong, F., Sun, H., & Zhou, Y. (2021). How economic policy uncertainty processes impact on inclusive green growth in emerging industrialized countries: A case study of China. *Journal of Cleaner Production*, *322*, 128963.

Hansen, L. P. (1982). Large sample properties of generalized method of moments estimators. *Econometrica: Journal of the Econometric Society*, 1029-1054.

Haug, A. A., & Ucal, M. (2019). The role of trade and FDI for CO2 emissions in Turkey:

Nonlinear relationships. *Energy Economics*, *81*, 297-307

Huang, K., Sim, N., & Zhao, H. (2020). Does FDI actually affect income inequality? Insights from 25 years of research. *Journal of Economic Surveys, 34*(3), 630-659.

Hickel, J., & Kallis, G. (2020). Is green growth possible? *New political economy*, *25*(4), 469-486.

Holley, C., & Lecavalier, E. (2017). Energy governance, energy security and environmental sustainability: A case study from Hong Kong. *Energy Policy*, *108,* 379-389.

Howarth, R. B. (1997). Energy efficiency and economic growth. *Contemporary Economic Policy*, *15*(4), 1-9.

Ibrahim, M., Koomson, I., Aluko, O. A., & Opoku, E. E. O. (2021). Re–examining Bhagwati hypothesis: the case of some selected countries in Sub-Saharan Africa. *Transnational Corporations Review*, 13(3), 334-345.

IEA, International Energy Agency (2021). *World Energy Outlook.* IEA. Paris.

IEA, International Energy Agency (2020). *World Energy Outlook.* IEA. Paris. R

IEA, International Energy Agency (2019). *Africa Energy Outlook: World Energy Outlook Special Report.* IEA. Paris.

IEA (International Energy Agency) & World Bank)2017). Sustainable Energy for All: Global Tracking Framework 2017—Progress toward Sustainable Energy (Summary). World Bank, Washington, DC.

IMF. (2007). Globalization and Inequality. World Economic Outlook: 31- 65.

ILO, (2020). COVID-19 Cruelly Highlights Inequalities and Threatens to Deepen Them. ILO Newsroom.

Inglesi-Lotz, R., & Ajmi, A. N. (2021). The impact of electricity prices and supply on attracting FDI to South Africa. *Environmental Science and Pollution Research*, *28*(22), 28444-28455.

IPCC (2022): *Climate Change 2022: Impacts, Adaptation, and Vulnerability.* Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. In Press.

IPCC (2018). *Global Warming of 1.5°C*. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.

Iyke, B. N. (2015). Electricity consumption and economic growth in Nigeria: A revisit of the energy-growth debate. *Energy Economics*, *51*, 166-176.

Javid, M., & Khan, M. (2020). Energy efficiency and underlying carbon emission trends. *Environmental Science and Pollution Research*, *27*(3), 3224-3236.

Jevons, W. S. (1865). The Coal Question. London: MacMillan

Jolliffe, I. T. (2002). Principal components in regression analysis. *Principal component analysis*, 167-198.

Kaufman, D., Kraay, A., & Mastruzzi, M. (2010). The Worldwide Governance Indicators: Methodology and Analysis. *World Bank Policy Research Paper*, (5430).

Khan, S. A. R., Yu, Z., Belhadi, A., & Mardani, A. (2020). Investigating the effects of renewable energy on international trade and environmental quality. *Journal of Environmental Management*, *272,* 111089.

Khan, I., & Nawaz, Z. (2019). Trade, FDI and income inequality: empirical evidence from CIS. *International Journal of Development Issues*.

Khazzoom, J. D., Shelby, M., & Wolcott, R. (1990). The conflict between energy conservation and environmental policy in the US transportation sector. *Energy Policy*, *18*(5), 456-458.

Krugman, P. R., & Obstfeld, M. (2009). *International economics: Theory and policy*. Pearson Education.

Krugman, P. (2008). The international finance multiplier, mimeo, Princeton University.

Kumar, N. N., & Patel, A. (2021). Income thresholds in the remittances-growth association? a case study of Fiji. *Applied Economics Letters*, 1-9.

Kumbhakar, S. C., Lien, G., & Hardaker, J. B. (2014). Technical efficiency in competing panel data models: a study of Norwegian grain farming. *Journal of Productivity Analysis*, *41*(2), 321-337.

Lamichhane, S., Eğilmez, G., Gedik, R., Bhutta, M. K. S., & Erenay, B. (2021). Benchmarking OECD countries' sustainable development performance: A goal-specific principal component analysis approach. *Journal of Cleaner Production*, *287*, 125040.

Lee, C. C., Lee, C. C., & Cheng, C. Y. (2022). The impact of FDI on income inequality: Evidence from the perspective of financial development. *International Journal of Finance & Economics*, *27*(1), 137-157.

Lei, W., Xie, Y., Hafeez, M., & Ullah, S. (2022). Assessing the dynamic linkage between energy efficiency, renewable energy consumption, and CO2 emissions in China. *Environmental Science and Pollution Research*, *29*(13), 19540-19552.

Levinson, A., & Taylor, M. S. (2008). Unmasking the Pollution Haven Effect. *International Economic Review*, *49*(1): 223-254.

Lin, B., & Abudu, H. (2020). Can energy conservation and substitution mitigate CO2 emissions in electricity generation? Evidence from Middle East and North Africa. *Journal of Environmental Management*, *275*, 111222.

Lucas, R. E. (1990). Why doesn't capital flow from rich to poor countries? *The American Economic Review*, *80*(2), 92-96.

Mahmood, T., & Kanwal, F. (2017). Long Run Relationship between Energy Efficiency and Economic Growth in Pakistan: Time Series Data Analysis. *Forman Journal of Economic Studies*, *13*.

Mamingi, N., & Martin, K. (2018). Foreign direct investment and growth in developing countries: Evidence from the countries of the Organisation of Eastern Caribbean States. *CEPAL Review*.

Marques, A. C., Fuinhas, J. A., & Tomás, C. (2019). Energy efficiency and sustainable growth in industrial sectors in European Union countries: A nonlinear ARDL approach. *Journal of Cleaner Production*, *239*, 118045.

Murphy J, & Gouldson A. (2000). Environmental policy and industrial innovation: integrating environment and economy through ecological modernisation. *Geoforum* 31: 33–44

Mutz, R., Bornmann, L., & Daniel, H. D. (2017). Are there any frontiers of research performance? Efficiency measurement of funded research projects with the Bayesian stochastic frontier analysis for count data. *Journal of Informetrics*, *11*(3), 613-628.

Ndikumana, L., & Sarr, M. (2019). Capital flight, foreign direct investment and natural resources in Africa. *Resources Policy*, *63*, 101427.

Obeng, C. K., Mwinlaaru, P. Y., & Ofori, I. K. (2022). Global value chain participation and inclusive growth in Sub-Saharan Africa. In *The Palgrave Handbook of Africa's Economic Sectors* (pp. 815-840). Palgrave Macmillan, Cham.

OECD (2019). OECD Work on Green Growth 2019-20. https://issuu.com/oecd.publishing/docs/gg_brochure_2019_web

OECD (2017). Green Growth Indicators 2017. OECD Green Growth Studies, OECD Publishing, Paris, https://doi.org/10.1787/9789264268586-en.

OECD (2016). The Governance of Inclusive Growth: An Overview of Country Initiatives, OECD Publishing, Paris

Ofori, I. K., Gbolonyo, E. Y., & Ojong, N. (2022a). Towards Inclusive Green Growth in Africa: Critical energy efficiency synergies and governance thresholds. *Journal of Cleaner Production*, *369*, 132917.

Ofori, I. K., Dossou, T., Asongu, S., & Armah, M. K. (2022b). Bridging Africa's Income Inequality Gap: How Relevant Is China's Outward FDI to Africa? *Economic Systems*, Forthcoming. http://dx.doi.org/10.2139/ssrn.3993613

Ofori, I. K., Gbolonyo, E. Y., Dossou, T. A. M., & Nkrumah, R. K. (2022c). Remittances and income inequality in Africa: Financial development thresholds for economic policy. *Research in Globalization*, *4*, 100084.

Ofori, I. K., Armah, M. K., & Asmah, E. E. (2022). Towards the reversal of poverty and income inequality setbacks due to COVID-19: The role of globalisation and resource allocation. *International Review of Applied Economics*, 1-28.

Ofori, I. K., Cantah, W. G., Afful Jr, B., & Hossain, S. (2022). Towards shared prosperity in sub-Saharan Africa: How does the effect of economic integration compare to social equity policies? *African Development Review*, *34*(1), 97-113.

Ofori, I. K., & Asongu, S. (2022). Repackaging FDI for Inclusive Growth: Nullifying Effects and Policy Relevant Thresholds of Governance. *European Xtramile Centre of African Studies*, WP/22/003. https://dx.doi.org/10.2139/ssrn.3999095

Ofori, I. K., Armah, M. K., Taale, F., & Ofori, P. E. (2021). Addressing the severity and intensity of poverty in Sub-Saharan Africa: How relevant is the ICT and financial development pathway? *Heliyon*, 7(10), e08156.

Ofori, I. K., & Asongu, S. A. (2021). ICT diffusion, foreign direct investment and inclusive growth in Sub-Saharan Africa. *Telematics and Informatics*, *65*, 101718.

Ohene-Asare, K., Tetteh, E. N., & Asuah, E. L. (2020). Total factor energy efficiency and economic development in Africa. *Energy Efficiency*, *13*(6), 1177-1194

Onat, N. C., Kucukvar, M., & Afshar, S. (2019). Eco-efficiency of electric vehicles in the United States: A life cycle assessment based principal component analysis. *Journal of Cleaner Production*, *212*, 515-526.

Opoku, E. E. O., & Boachie, M. K. (2020). The environmental impact of industrialization and foreign direct investment. *Energy Policy*, *137*, 111178

Opoku, E. E. O., Ibrahim, M., & Sare, Y. A. (2019). Foreign direct investment, sectoral effects and economic growth in Africa. *International Economic Journal*, *33*(3), 473-492.

Opoku, E. E. O., Adams, S., & Aluko, O. A. (2021). The foreign direct investment-environment nexus: does emission disaggregation matter? *Energy Reports*, *7*, 778-787.

Özbuğday, F. C., & Erbas, B. C. (2015). How effective are energy efficiency and renewable energy in curbing CO2 emissions in the long run? A heterogeneous panel data analysis. *Energy*, *82*, 734-745.

Pan, X., Ai, B., Li, C., Pan, X., & Yan, Y. (2019). Dynamic relationship among environmental regulation, technological innovation and energy efficiency based on large scale provincial panel data in China. *Technological Forecasting and Social Change*, *144*, 428-435.

Pao, H. T., & Tsai, C. M. (2011). Multivariate Granger causality between CO2 emissions, energy consumption, FDI (foreign direct investment) and GDP (gross domestic product): evidence from a panel of BRIC (Brazil, Russian Federation, India, and China) countries. *Energy*, *36*(1), 685-693.

Pavcnik, N. (2017). *The impact of trade on inequality in developing countries* (No. w23878). National Bureau of Economic Research.

Peprah, J. A., Kwesi Ofori, I., & Asomani, A. N. (2019). Financial development, remittances and economic growth: A threshold analysis. *Cogent Economics & Finance*, *7*(1), 1625107.

Ponce, P., & Khan, S. A. R. (2021). A causal link between renewable energy, energy efficiency, property rights, and CO2 emissions in developed countries: a road map for environmental sustainability. *Environmental Science and Pollution Research*, *28*(28), 37804-37817.

Popp, D. (2009). Policies for the development and transfer of eco-innovations: Lessons from the literature.

Porter, M. E., & Van der Linde, C. (1995). Toward a new conception of the environment-competitiveness relationship. *Journal of Economic Perspectives*, *9*(4), 97-118.

Pörtner, H. O., Roberts, D. C., Adams, H., Adler, C., Aldunce, P., Ali, E., ... & Birkmann, J. (2022). Climate change 2022: Impacts, adaptation and vulnerability. *IPCC Sixth Assessment Report*.

Prokhorova, A. (2017). Remittances in North and Central Asian Countries: Enhancing Development Potential. *Asia-Pacific Population Journal*, 32(2), 9-59.

Rajbhandari, A., & Zhang, F. (2018). Does energy efficiency promote economic growth? Evidence from a multicountry and multisectoral panel dataset. *Energy Economics*, *69*, 128-139.

Ravallion, M. (2018). Inequality and globalization: A review essay. *Journal of Economic Literature*, *56*(2), 620-42.

Ren, S., Yuan, B., Ma, X., & Chen, X. (2014). International trade, FDI (foreign direct investment) and embodied CO2 emissions: a case study of Chinas industrial sectors. *China Economic Review*, *28*, 123-134.

Roberts, M. R., & Whited, T. M. (2013). Endogeneity in empirical corporate finance1. In *Handbook of the Economics of Finance* (Vol. 2, pp. 493-572). Elsevier.

Romer, P. M. (1990). Endogenous technological change. *Journal of Political Economy*, *98*(5, Part 2), S71-S102.

Romer, P. M. (1986). Increasing returns and long-run growth. *Journal of Political Economy*, *94*(5), 1002-1037.

Romer, P. M. (1994). The origins of endogenous growth. *Journal of Economic Perspectives*, *8*(1), 3-22.

Roodman, D. (2009). How to do xtabond2: An introduction to difference and system GMM in Stata. *The Stata Journal*, *9*(1), 86-136.

Sachs, J. D. (2012). From millennium development goals to sustainable development goals. *The lancet*, *379*(9832), 2206-2211.

Sachs, J., Kroll, C., Lafortune, G., Fuller, G., & Woelm, F. (2021). *Sustainable development report 2021*. Cambridge University Press.

Salahuddin, M., Alam, K., Ozturk, I., & Sohag, K. (2018). The effects of electricity consumption, economic growth, financial development and foreign direct investment on CO_2 emissions in Kuwait. *Renewable and Sustainable Energy Reviews, 81*, 2002-2010.

Sapkota, P., & Bastola, U. (2017). Foreign direct investment, income, and environmental pollution in developing countries: Panel data analysis of Latin America. *Energy Economics*, *64*, 206-212.

Sarkodie, S. A., Adams, S., & Leirvik, T. (2020). Foreign direct investment and renewable energy in climate change mitigation: does governance matter? *Journal of Cleaner Production*, *263*, 121262.

Sarkodie, S. A., & Strezov, V. (2019). Effect of foreign direct investments, economic development and energy consumption on greenhouse gas emissions in developing countries. *Science of the Total Environment*, *646*, 862-871.

Schmidt, P., & Sickles, R. C. (1984). Production frontiers and panel data. *Journal of Business & Economic Statistics*, *2*(4), 367-374.

Shahbaz, M., Gozgor, G., Adom, P. K., & Hammoudeh, S. (2019). The technical decomposition of carbon emissions and the concerns about FDI and trade openness effects in the United States. *International Economics*, *159*, 56-73

Shahbaz, M., Hye, Q. M. A., Tiwari, A. K., & Leitão, N. C. (2013). Economic growth, energy consumption, financial development, international trade and CO2 emissions in Indonesia. *Renewable and Sustainable Energy Reviews*, *25*, 109-121

Shahbaz, M., Nasreen, S., Abbas, F., & Anis, O. (2015). Does foreign direct investment impede environmental quality in high- middle-and low-income countries? *Energy Economics*, *51*, 275-287.

Shahbaz, M., Nasir, M. A., & Roubaud, D. (2018). Environmental degradation in France: the effects of FDI, financial development, and energy innovations. *Energy Economics*, *74*, 843-857.

Shiu, A., & Lam, P. L. (2004). Electricity consumption and economic growth in China. *Energy Policy*, *32*(1), 47-54.

Song, M., Zhu, S., Wang, J., & Zhao, J. (2020). Share green growth: Regional evaluation of green output performance in China. *International Journal of Production Economics*, *219*, 152-163.

Solarin, S. A., & Al-Mulali, U. (2018). Influence of foreign direct investment on indicators of environmental degradation. *Environmental Science and Pollution Research*, *25*(25), 24845-24859.

Solow, R. M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics, 70*(1), 65-94.

Song, Y., Paramati, S. R., Ummalla, M., Zakari, A., & Kummitha, H. R. (2021). The effect of remittances and FDI inflows on income distribution in developing economies. *Economic Analysis and Policy*, *72*, 255-267.

Stern, D. I. (2000). A multivariate cointegration analysis of the role of energy in the US macroeconomy. *Energy economics*, *22*(2), 267-283.

Suehrer, J. (2019). The future of FDI: achieving the sustainable development goals 2030 through impact investment. *Global policy, 10*(3), 413-415.

Sun, Y., Ding, W., Yang, Z., Yang, G., & Du, J. (2020). Measuring China's regional inclusive green growth. *Science of the Total Environment*, *713*, 136367

Sung, B., Song, W. Y., & Park, S. D. (2018). How foreign direct investment affects CO2 emission levels in the Chinese manufacturing industry: evidence from panel data. *Economic Systems*, *42*(2), 320-331.

Svirydzenka, K. (2016). *Introducing a new broad-based index of financial development*. International Monetary Fund.

Swain, R. B., Kambhampati, U. S., & Karimu, A. (2020). Regulation, governance and the role of the informal sector in influencing environmental quality? *Ecological Economics*, *173*, 106649.

Tchamyou, V. S., Asongu, S. A., & Odhiambo, N. M. (2019). The role of ICT in modulating the effect of education and lifelong learning on income inequality and economic growth in Africa. *African Development Review*, *31*(3), 261-274.

Tawiah, V., Zakari, A., & Adedoyin, F. F. (2021). Determinants of green growth in developed and developing countries. *Environmental Science and Pollution Research*, *28*(29), 39227-39242.

Tenaw, D., & Beyene, A. D. (2021). Environmental sustainability and economic development in sub-Saharan Africa: A modified EKC hypothesis. *Renewable and Sustainable Energy Reviews*, *143*, 110897.

Ucal, M. Ş. (2014). Panel data analysis of foreign direct investment and poverty from the perspective of developing countries. *Procedia-Social and Behavioural Sciences, 109,* 1101-1105.

United Nations (2015) Resolution adopted by the General Assembly on 25 September 2015, Transforming our world: the 2030 Agenda for Sustainable Development. https://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E

UNCED (United Nations Conference on Environment and Development) (2012). The future we want. Rio+20 United Nations Conference on Sustainable Development, Rio de Janeiro, 19 June 2012. https://sustainabledevelopment.un.org/rio20

UNFCCC (2015). Press Release: Rising Number of Initiatives by Cities and Better Land Management Show Pathways Towards Carbon Neutral Future. (Bonn. http://www.newsroom.unfccc.int/media/1605/pr20141506_sb40_close.pdf.

UNCTAD. (2021). *Global foreign direct investment fell by 42% in 2020, outlook remains* *weak*. Geneva. https://unctad.org/news/global-foreign-direct-investment-fell-42-2020-outlook-remains-weak

UNCTAD (2010). World Investment Report 2010: Investing in a Low-Carbon Economy. New York and Geneva. https://unctad.org/system/files/official-document/wir2010_en.pdf

Usman, M., & Jahanger, A. (2021). Heterogeneous effects of remittances and institutional quality in reducing environmental deficit in the presence of EKC hypothesis: a global study with the application of panel quantile regression. *Environmental Science and Pollution Research*, *28*(28), 37292-37310.

Wang, Z., Zaman, S., & Rasool, S. F. (2021). Impact of remittances on carbon emission: fresh evidence from a panel of five remittance-receiving countries. *Environmental Science and Pollution Research*, *28*(37), 52418-52430.

Weber, O. (2014). The financial sector's impact on sustainable development. *Journal of Sustainable Finance & Investment*, *4*(1), 1-8.

Windmeijer, F. (2005). A finite sample correction for the variance of linear efficient two-step GMM estimators. *Journal of Econometrics*, *126*(1), 25-51.

World Bank (2020). *Poverty and shared prosperity 2020: Reversals of fortunes (October).* The World Bank

World Bank. (2018). Migration and Remittances: Recent Developments and Outlook. Washington DC: World Bank.

World Bank. (2012). *Inclusive Green Growth: The Pathway to Sustainable Development*. Washington, DC. World Bank.

World Economic Forum (2021). Net Zero Carbon Cities: An Integrated Approach. Insight Report.

World Health Organisation (WHO) (2022). The Global Health Observatory. Air pollution data portal. https://www.who.int/data/gho/data/themes/air-pollution

Yang, B., Jahanger, A., Usman, M., & Khan, M. A. (2021). The dynamic linkage between globalization, financial development, energy utilization, and environmental sustainability in GCC countries. *Environmental Science and Pollution Research*, *28*(13), 16568-16588.

Yang, M., & Yu, X. (2015). *Energy efficiency: Benefits for environment and society* (pp. 11-42). Berlin: Springer.

Zakaria, M., & Bibi, S. (2019). Financial development and environment in South Asia: the role of institutional quality. *Environmental Science and Pollution Research*, *26*(8), 7926-7937.

Zarsky, L. (1999). Havens, halos and spaghetti: untangling the evidence about foreign direct investment and the environment. *Foreign direct Investment and the Environment*, *13*(8), 47-74.

Zhang, L., & Adom, P. K. (2018). Energy Efficiency Transitions in China: How persistent are the movements to/from the frontier? *The Energy Journal*, *39*(6).

Zhao, T., & Yang, Z. (2017). Towards green growth and management: Relative efficiency and gaps of Chinese cities. *Renewable and Sustainable Energy Reviews*, *80*, 481-494.

Appendix A

Table A.1: Description and summary statistics of energy demand variables

Variables	**Description**	**N**	**Mean**	**Std. Dev.**	**Minimum**	**Maximum**
Economic growth	Annual growth rate of GDP at market prices (%)	483	4.177	3.795	-14.868	15.329
Urbanization	The proportion of total population living in urban areas (%)	483	47.107	17.097	14.74	90.092
Trade openness	The sum of export and import expressed as a percentage of GDP (%)	467	71.919	27.245	20.723	156.862
Industrialisation	The value additionn of mining, manufacturing, construction, electricity, water, and gas to overall GDP (%)	480	29.029	12.905	9.435	72.153
Human capital	Composite index based on years of schooling and returns to education	460	1.869	0.455	1.118	2.939
Crude oil prices	The average BRENT crude oil price (annual)	483	63.512	28.196	24.44	111.67

Note: N is observation; Std. Dev. is Standard.

Table A.2: Hausman test on Equation (8)

	Coefficients			
Variables	*Fixed effect (b)*	*Random effect (B)*	*Difference*	*Standard error*
Trade openness	-0.0209	-0.0343	0.0133	0.0000
Urbanisation	-0.312***	-0.439***	0.1273	0.0646
Economic growth	0.0867	0.0641	0.0226	0.0371
Crude oil price	0.0042	-0.0273**	0.0315	0.0126
Industrialisation	0.0494	0.0713**	-0.0218	0.0065
Human capital	0.680***	0.654***	0.0256	0.0476
t	-2.312***	-0.0051**	-2.3064	0.8885
t^2	0.0005***	0.0001	0.0004	0.0001

*Note: **t** is time in years; t^2 is time squared*
b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg
Test: Ho: difference in coefficients not systematic
Chi Statistic: 9.02; Chi(P-value): 0.2512
**** p<0.01, ** p<0.05, * p<0.1*

Table A.3: Pairwise correlation matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) Inclusive green growth	1									
(2) Inclusive growth	0.523^{***}	1								
(3) Greenhouse gases	0.216^{**}	0.0889	1							
(4) GDP per capita	0.615^{***}	0.765^{***}	0.201^{**}	1						
(5) Foreign direct investment	-0.0112	-0.128	0.250^{**}	0.00925	1					
(6) Regulatory quality	0.581^{***}	0.457^{***}	0.457^{***}	0.524^{***}	0.125	1				
(7) Vulnerable employment	-0.773^{***}	-0.728^{***}	-0.232^{**}	-0.903^{***}	-0.0524	-0.637^{***}	1			
(8) Remittances	0.116	-0.133	0.145	-0.277^{***}	0.0431	0.0115	0.175^{*}	1		
(9) Financial development	0.565^{***}	0.436^{***}	0.333^{***}	0.540^{***}	0.0633	0.673^{***}	-0.650^{***}	-0.0132	1	
(10) Energy efficiency	-0.736^{***}	-0.521^{***}	-0.304^{***}	-0.561^{***}	-0.144	-0.684^{***}	0.663^{***}	-0.0865	-0.385^{***}	1

$* p < 0.1, ** p < 0.05, *** p < 0.001$

Table A.4: Pairwise correlation matrix for IGG index variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
Cleanfuel (1)	1																							
agric (2)	0.127	1																						
enerint (3)	-0.504***	-0.236**	1																					
forest (4)	-0.151*	-0.439***	0.125	1																				
fosful 51)	0.866***	0.317***	-0.597***	-0.396***	1																			
gpc (6)	0.795***	0.0410	-0.499***	0.0456	0.667***	1																		
renener (7)	-0.840***	-0.325***	0.576***	0.398***	-0.991***	-0.657***	1																	
amb (8)	-0.290***	-0.0262	0.309***	0.205**	-0.213**	-0.458***	0.235**	1																
unemp (9)	0.631***	0.195**	-0.322***	-0.0673	0.647***	0.732***	-0.624***	-0.242**	1															
sanit (10)	0.630***	0.119	-0.437***	0.130	0.474***	0.717***	-0.482***	-0.376***	0.389***	1														
powat (11)	0.797***	0.227**	-0.726***	0.0297	0.782***	0.842***	-0.781***	-0.300***	0.656***	0.701***	1													
cwea (12)	0.164*	0.263***	-0.188*	-0.475***	0.412***	0.0983	-0.452***	-0.164*	0.230**	0.189*	0.227**	1												
temp (13)	0.143	0.0688	-0.0247	-0.249***	0.155*	-0.197**	-0.126	0.162*	-0.156*	-0.211**	-0.103	-0.0746	1											
pop (14)	0.223**	0.178*	-0.122	-0.115	0.175*	0.285***	-0.200**	-0.467***	-0.165*	0.384***	0.218**	-0.0003	-0.0054	1										
carint (15)	0.512***	0.468***	-0.104	-0.289***	0.647***	0.452***	-0.651***	-0.120	0.678***	0.308***	0.430***	0.177*	0.0286	0.0189	1									
ambmort (16)	0.862***	0.320***	-0.556***	-0.211**	0.820***	0.692***	-0.761***	-0.116	0.644***	0.436***	0.750***	0.102	0.178*	0.157*	0.540***	1								
ambcost (17)	0.852***	0.323***	-0.559***	-0.209**	0.811***	0.662***	-0.749***	-0.0986	0.629***	0.437***	0.741***	0.122	0.183*	0.136	0.523***	0.992***	1							
trans (18)	0.563***	0.141	-0.430***	-0.325***	0.646***	0.732***	-0.669***	-0.523***	0.513***	0.511***	0.648***	0.470***	-0.198**	0.558***	0.325***	0.500***	0.475***	1						
ineq (19)	-0.0129	0.340***	-0.210**	-0.0248	0.166*	0.267***	-0.187*	-0.0500	0.560***	0.253***	0.351***	0.398***	-0.421***	-0.290***	0.382***	0.0683	0.0780	0.303***	1					
hc (20)	0.525***	0.167*	-0.390***	-0.0021	0.515***	0.780***	-0.507***	-0.330***	0.648***	0.461***	0.674***	0.170*	-0.257***	0.233**	0.409***	0.625***	0.598***	0.665***	0.347***	1				
methane (21)	-0.403***	0.0402	0.538***	-0.105	-0.428***	-0.342***	0.442***	0.122	-0.277***	-0.206**	-0.595***	-0.0883	-0.0008	-0.0914	-0.117	-0.439***	-0.428***	-0.365***	-0.180*	-0.378***	1			
natres (22)	-0.0285	-0.453***	0.265***	0.527***	-0.277***	0.0348	0.290***	0.322***	-0.112	0.0344	-0.110	-0.459***	-0.0849	-0.272***	-0.240**	-0.210**	-0.209**	-0.378***	-0.253***	-0.209**	0.252***	1		
envtech (23)	0.118	-0.0487	0.0912	-0.0168	0.0656	0.0656	-0.0561	-0.0429	-0.002	0.0057	-0.0305	-0.009	0.0245	0.142	-0.003	0.0824	0.0809	0.0780	-0.189*	0.0642	0.107	0.00995	1	
infmort (24)	-0.760***	-0.164*	0.441***	0.372***	-0.766***	-0.674***	0.767***	0.507***	-0.578***	-0.353***	-0.628***	-0.337***	-0.0765	-0.283***	-0.425***	-0.695***	-0.680***	-0.675***	0.009	-0.699***	0.366***	0.367***	-0.126	1

* *p* < 0.1, ** *p* < 0.05, *** *p* < 0.001

Table A.5: Eigenvectors of IGG components

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6	Comp7	Comp8	Comp9	Comp10	Comp11	Comp12	Comp13	Comp14	Comp15	Comp16	Comp17	Comp18
cleanfuel	0.276	0.117	-0.227	0.033	0.080	-0.030	0.179	0.005	-0.014	0.040	-0.067	-0.180	0.109	0.220	0.045	-0.218	0.063	-0.059
agric	0.105	-0.358	0.090	0.136	0.058	0.579	-0.147	0.177	-0.130	-0.141	-0.021	-0.035	-0.407	0.342	0.113	-0.119	-0.080	0.110
enerint	-0.205	-0.034	0.016	0.022	0.471	-0.080	-0.037	-0.177	0.497	0.144	0.113	-0.199	0.052	0.399	-0.035	-0.212	0.267	-0.026
forest	-0.087	0.518	0.069	0.053	-0.085	0.104	-0.145	0.111	0.113	0.237	0.240	-0.312	-0.254	-0.210	0.488	0.064	0.038	-0.139
fosful	0.288	-0.094	-0.135	0.101	0.000	-0.081	0.168	0.077	0.076	0.055	-0.198	0.052	-0.075	-0.212	0.099	-0.026	0.001	-0.186
incgro	0.268	0.260	0.062	-0.076	0.140	0.004	0.054	-0.093	-0.058	-0.059	0.102	0.205	0.020	0.008	-0.024	-0.045	0.273	0.542
renener	-0.285	0.106	0.101	-0.075	0.004	0.088	-0.196	-0.086	-0.124	-0.113	0.229	-0.055	0.197	0.211	-0.060	0.120	-0.054	0.111
amb	-0.130	0.020	-0.139	0.457	-0.046	0.028	-0.039	0.364	0.512	-0.278	0.071	0.124	0.056	-0.241	-0.079	-0.278	-0.162	0.165
unemp	0.237	0.085	0.175	0.260	0.210	-0.146	-0.083	-0.206	-0.119	0.115	0.099	0.090	0.095	0.104	0.368	-0.110	-0.569	0.249
sanit	0.199	0.227	0.114	-0.146	0.056	0.298	0.372	0.233	-0.047	0.139	0.208	-0.297	0.232	-0.036	-0.440	-0.161	-0.302	-0.004
powat	0.282	0.175	0.042	0.036	-0.168	0.084	0.062	0.136	-0.032	0.033	0.010	0.067	-0.161	0.041	0.058	-0.178	0.510	0.178
cwea	0.115	-0.337	0.248	-0.032	-0.054	-0.350	0.362	0.296	0.161	-0.075	0.264	-0.299	-0.151	0.136	0.141	0.400	0.002	0.159
temp	-0.006	-0.203	-0.498	0.103	-0.112	0.028	0.104	-0.124	-0.077	0.339	0.664	0.279	-0.119	0.018	-0.064	0.013	0.003	-0.034
pop	0.091	-0.036	-0.093	-0.551	0.048	0.390	-0.052	0.059	0.361	0.063	-0.005	0.148	0.009	-0.015	0.201	0.084	-0.154	-0.102
carint	0.195	-0.132	0.055	0.269	0.341	0.198	-0.031	-0.185	0.153	0.433	-0.230	-0.043	-0.054	-0.271	-0.180	0.372	0.049	0.066
ambmort	0.271	0.031	-0.225	0.150	0.001	0.083	-0.166	-0.001	0.007	-0.215	0.044	-0.106	0.298	0.123	0.088	0.226	0.079	-0.013
ambcost	0.267	0.025	-0.225	0.162	-0.011	0.082	-0.148	0.028	-0.011	-0.225	0.065	-0.155	0.333	0.141	0.104	0.248	0.086	-0.277
trans	0.246	-0.043	0.155	-0.291	0.029	-0.125	0.034	0.011	0.275	-0.075	0.063	0.442	0.153	0.024	0.177	-0.029	-0.052	-0.080
ineq	0.097	-0.048	0.556	0.259	-0.038	0.030	-0.053	0.105	-0.077	0.157	0.184	0.261	0.141	0.092	-0.060	-0.147	0.167	-0.503
hc	0.236	0.138	0.155	-0.055	0.092	-0.051	-0.359	-0.133	0.129	-0.322	0.306	0.008	-0.298	-0.182	-0.405	0.213	-0.033	-0.048
methane	-0.158	-0.114	0.014	-0.021	0.551	0.156	0.293	-0.033	-0.266	-0.363	0.207	0.009	0.069	-0.413	0.252	-0.066	0.174	-0.108
natres	-0.104	0.442	-0.124	0.148	0.205	-0.013	0.363	0.049	-0.007	-0.163	-0.144	0.321	-0.347	0.358	-0.087	0.285	-0.141	-0.224
envtech	0.016	0.010	-0.172	-0.157	0.411	-0.274	-0.386	0.654	-0.250	0.218	-0.024	0.085	-0.011	0.025	-0.069	0.004	-0.003	0.009
infmort	-0.261	0.070	0.115	0.138	-0.073	0.259	0.089	0.232	0.037	0.148	-0.014	0.255	0.348	0.028	0.062	0.392	0.124	0.248

Variable	Comp19	Comp20	Comp21	Comp22	Comp23	Comp24
cleanfuel	-0.320	0.007	0.652	0.353	-0.103	0.005
agric	-0.199	-0.104	-0.122	0.066	-0.053	0.059
enerint	0.107	-0.240	-0.139	-0.076	-0.003	0.032
forest	-0.233	-0.028	-0.109	0.050	0.012	0.021
fosful	0.026	-0.384	-0.006	-0.256	0.054	0.690
incgro	-0.378	0.100	-0.030	-0.480	-0.069	0.019
renener	0.034	0.352	0.117	0.128	0.074	0.691
amb	-0.022	0.229	0.075	-0.017	-0.004	0.012
unemp	0.329	-0.082	0.077	-0.012	-0.041	-0.045
sanit	0.051	-0.075	-0.247	0.019	0.026	0.016
powat	0.617	0.127	-0.034	0.256	0.016	0.056
cwea	0.009	0.128	0.096	-0.057	0.023	-0.005
temp	-0.011	-0.004	-0.019	0.006	0.002	-0.002
pop	0.231	0.163	0.333	-0.284	0.065	-0.068
carint	-0.050	0.349	-0.022	0.180	0.006	0.039
ambmort	-0.035	-0.082	-0.103	0.011	0.745	-0.124
ambcost	0.095	0.135	-0.200	-0.167	-0.600	-0.030
trans	-0.264	0.028	-0.373	0.496	-0.053	0.086
ineq	-0.076	0.121	0.192	-0.231	0.123	-0.055
hc	0.066	-0.329	0.236	0.128	-0.088	-0.011
methane	0.071	0.005	0.048	0.085	0.019	-0.033
natres	0.053	0.105	-0.045	-0.030	0.062	-0.014
envtech	0.018	0.021	-0.012	0.001	0.006	-0.000
infmort	0.023	-0.494	0.182	0.127	-0.144	-0.032

Note: "Comp" denotes principal component

Appendix B

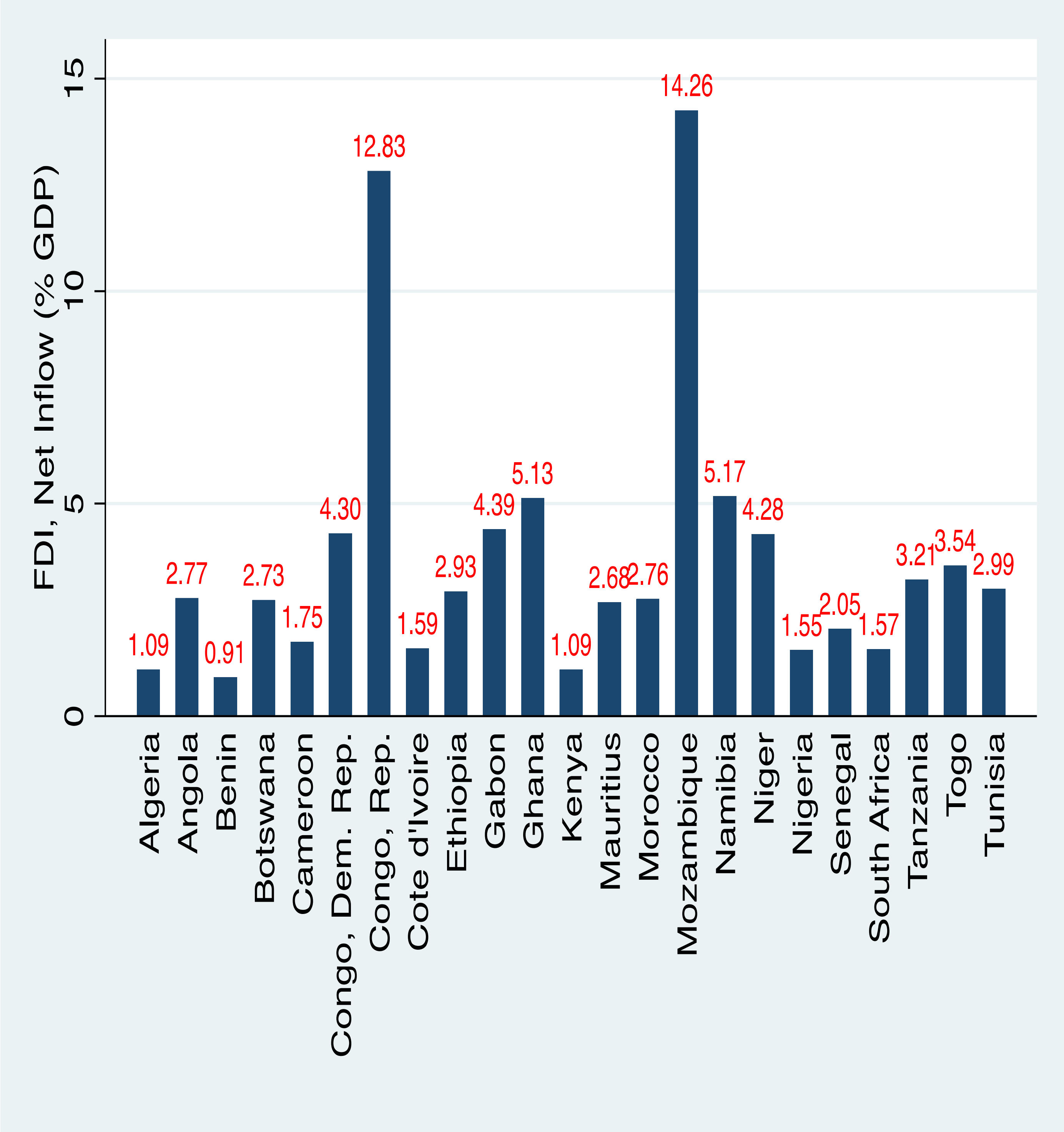

Figure A.1: In-Country FDI Inflows to Africa, 2000 – 2020

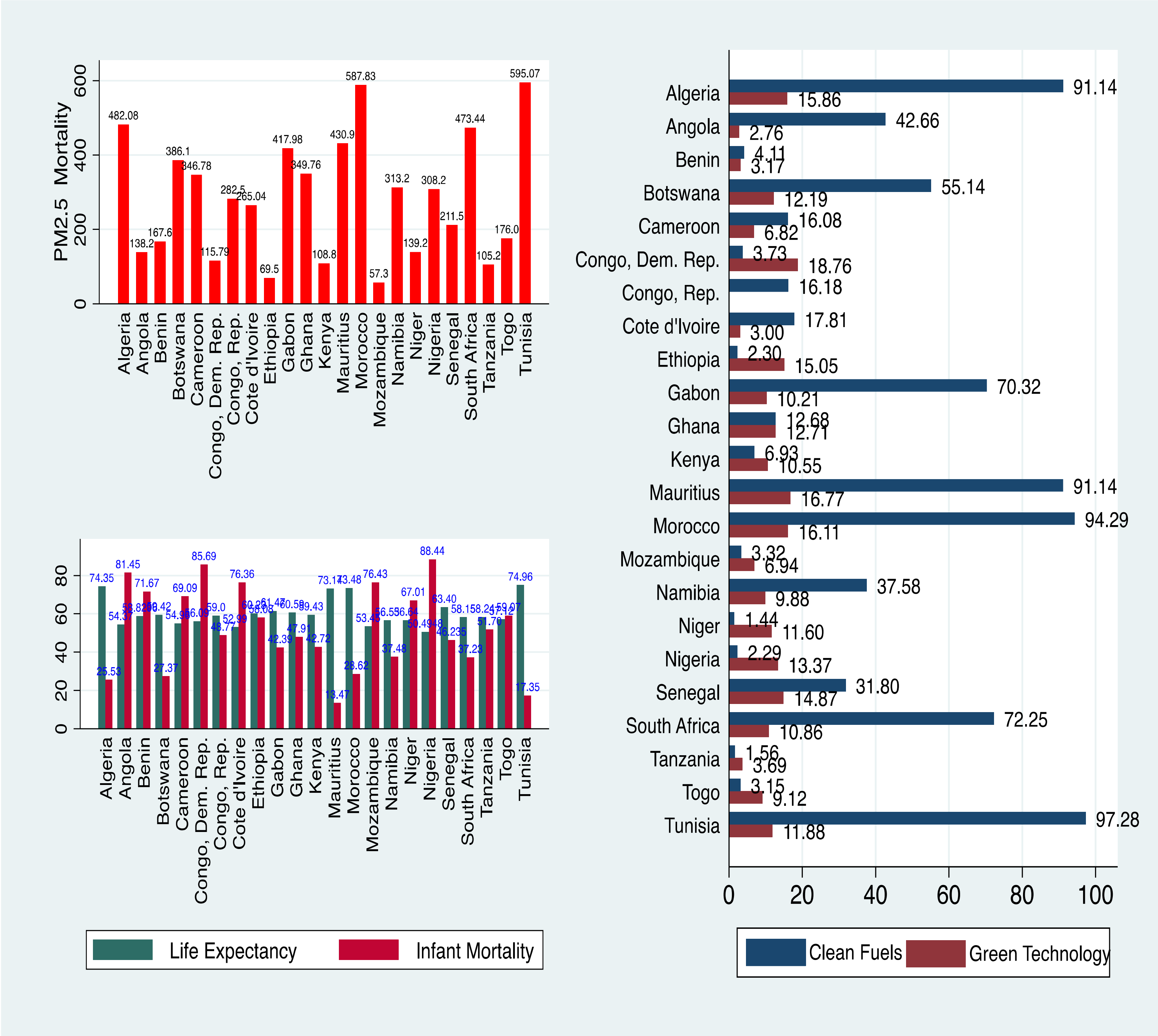

Figure A.2: In-Country Sustainable Development Indicators, 2000 – 2020