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Research article

Unlocking Africa's potential: The transformative power of foreign direct investment for sustainable development

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A R T I C L E I N F O

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A B S T R A C T

In the context of developing economies, Foreign Direct Investment (FDI) has long been acknowledged for its potential to stimulate economic growth. However, with the evolving understanding of development encompassing not only economic prosperity but also environmental and social well-being, the impact of FDI on sustainable development has become a subject of increasing importance and complexity. To shed light on this multifaceted relationship, our study empirically investigates the causal link between FDI and sustainable development in a panel of 48 African economies spanning the period from 1990 to 2020. We employ a robust measure of sustainable development, Adjusted Net Savings (ANS), as well as an innovative Sustainable Economic Growth (SEG) index that encompasses the three core pillars of sustainable development. FDI is measured both as FDI net inflow as a percentage of GDP and as the stock of FDI as a proportion of GDP for robustness testing. Our analytical approach utilizes the GMM-PVAR model. Our findings reveal a noteworthy unidirectional negative causality running from foreign direct investment to sustainable development across African economies. Intriguingly, the magnitude of this adverse impact is more pronounced in low-income nations, while a favorable causal effect of FDI on sustainable development is observed in high-income countries within the region. Importantly, these results hold true across various measures of sustainable development and different metrics of foreign direct investment. As a result, our study offers valuable insights for policymakers in Africa and beyond. Recognizing the nuanced impact of FDI on sustainable development, we propose tailored policy recommendations that take into account the income level of countries to maximize the benefits of foreign investment while mitigating potential adverse effects. Moreover, we advocate for ongoing research and policy innovation to further align FDI with the broader goals of sustainable development on the African continent.

1. Introduction

Foreign Direct Investment (FDI) has long been recognized as a potent driver of economic growth in contemporary society [1,2].

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However, in today's world, where sustainable development has emerged as a paramount global priority, the influence of FDI on this broader agenda remains an area of uncertainty and debate among scholars and policymakers [3,4]. Sustainable development represents a multifaceted socioeconomic and environmental path designed to safeguard the well-being of the present generation without jeopardizing the prospects of future generations [5–7]. Achieving sustainable development necessitates substantial investment and capital, which poses a significant hurdle for many developing nations.

Africa, in particular, a continent predominantly comprised of developing countries, faces unique challenges in its pursuit of sustainable development. These include low savings rates, inadequate domestic capital, and a host of socio-economic development issues [8,9]. In this context, FDI emerges as a promising avenue for advancing sustainable development in the region. According to UNCTAD's [10] World Investment Report, substantial FDI inflows are imperative for developing countries to make significant strides toward sustainable development. In essence, while both public and private sectors have critical roles to play in financing the 2030 Agenda for Sustainable Development, FDI stands out as a primary external capital source, particularly beneficial for developing nations in their pursuit of sustainable development [9,10].

FDI has the potential to stimulate socio-economic progress by augmenting domestic capital, job creation, and income generation [11–14]. Moreover, it can contribute to environmental quality improvement by facilitating the transfer and adoption of green technology and innovation [15–17]. Consequently, governments in African countries have prioritized FDI as a significant funding source for sustainable development, evident in their adoption of liberal and market-oriented policies and initiatives such as the African Continental Free Trade Area (AfCFTA) agreement, aimed at attracting FDI. As a result, FDI inflows into the region reached $48 billion in 2018, marking a 13% increase over the previous year, despite the global decline in FDI [18,19].

However, it's crucial not to lose sight of the fact that while FDI presents substantial opportunities for development and improved welfare in developing nations, it may also carry inherent risks that could impede the sustainable development trajectory of host countries. There is a body of literature suggesting that FDI might inadvertently hinder socio-economic progress [20–26] by exacerbating inequality, displacing local investment, draining foreign exchange reserves, and potentially degrading environmental quality [16,27–29], through the transfer and adoption of outdated or less environmentally friendly technologies. Given this dual nature of FDI's impact, this study seeks to empirically explore the causal relationship between foreign direct investment and sustainable development in Africa. This investigation is crucial, as a comprehensive analysis that systematically examines this intricate nexus remains scarce. To this end, we employ the GMM-PVAR model and analyze a balanced panel of forty-eight African countries spanning the years 1990–2020. Through this rigorous analysis, we aim to shed light on the nuanced and multifaceted interplay between sustainable development and foreign direct investment on the African continent.

Sustainable development represents a multifaceted socioeconomic and environmental path designed to safeguard the well-being of the present generation without jeopardizing the prospects of future generations [6,7,30]. To gauge sustainable development in our study, we employ two key indicators, namely; Adjusted Net Saving (ANS) and sustainable economic growth (SEG).

Adjusted Net Saving serves as a crucial proxy for measuring sustainable development from an economic perspective [31–34]. This metric reflects the net change in a country's wealth, accounting not only for traditional economic factors like investment and consumption but also for natural resource depletion and environmental degradation. In essence, ANS provides a holistic measure that captures the economic, environmental, and social dimensions of sustainable development. In addition, following the recommendation of Curran [35], we constructed the Sustainable Economic Growth index (SEG) as an alternate measure of sustainable development. This index is designed to encompass the three main cornerstones of sustainable development: economic, environmental, and social dimensions. It offers a comprehensive view of development, acknowledging that true sustainability transcends economic growth alone. Our examination of the relationship between FDI and sustainable development utilizes these two robust indicators to provide a comprehensive assessment of development dynamics.

Additionally, in our empirical analysis, we measure Foreign Direct Investment using two metrics: FDI net inflow as a percentage of GDP and the stock of FDI as a ratio of GDP. This approach enhances the robustness of our investigation by considering different aspects of FDI. Furthermore, as part of our study's empirical explorations, we conduct subsample analysis to examine how the relationship between sustainable development and foreign direct investment behaves across countries at different stages of development. This approach allows us to account for variations in economic, environmental, and social factors that may influence this relationship in diverse contexts. The results from the GMM-PVAR model unearth a unidirectional negative causality from foreign direct investment to sustainable development in African economies. The results disclose further that the magnitude of the adverse impact of FDI on sustainable development in the region is more pronounced in the low-income nations. Nonetheless, a favorable causal effect of FDI on sustainable development is found in the high-income countries in the area. The study's conclusions are robust even in estimating different measures of sustainable development and foreign direct investment.

Consequently, the findings of the present study make an immense contribution to the literature by uncovering the uncharted link between foreign direct investment and actual economic development, which differs from conventional measure of economic development, gross domestic product per capita (GDP per capita) that does not capture the trade-offs that may exist between the three pillars of sustainable development. Thus, while previous research examines the leading role of FDI in either economic growth, social progress, or environmental degradation, there is a vacuum in the literature discussing the effect of FDI on all three pillars of sustainability simultaneously to ensure comprehensive sustainable development. Furthermore, following the recommendation of [35] consistent with Joseph Stiglitz's Beyond GDP, the study constructed additional comprehensive and contemporary indicators aside from the adjusted net saving to offer fresh evidence on the potential connection between FDI and sustainable development. The index constructed is also inclusive enough to capture all the multidimensional aspects of sustainable development to assess the full impact of foreign direct investment on development without losing track of any trade-offs to ensure the robustness of the study conclusions. Moreover, by examining the causal link at different national income brackets, the study will add to our knowledge of how FDI might influence sustainable development based on economic disparities.

The rest of the paper is organized as follows: section 2 discusses the related papers, followed by the research design, which encompasses the sample and data sources, measurement of critical variables, empirical models, and estimation techniques. Section 4 discusses the results and interpretations thereof, and the last section offers the conclusions and deduced policy suggestions.

2. Literature review

The concept of sustainable development is a multifaceted concept that cuts across diverse issues and, results in various definitions [33,36]. However, despite the myriad interpretations and perspectives, there is a remarkable convergence and agreement among scholars and practitioners on the key three pillars that universally underpin the concept of sustainable development [33,36]. These pillars, namely the economic, social, and environmental dimensions, provide a comprehensive framework for understanding and promoting an inclusive approach to development that meets the needs of the present without compromising the ability of future generations to meet their own needs [37–41].

The economic dimension of sustainable development recognizes the importance of fostering long-term economic growth and prosperity while ensuring the equitable distribution of resources and opportunities. It emphasizes the need for sustainable economic systems that generate employment, stimulate innovation, and promote fair trade, without depleting natural resources or compromising the well-being of future generations [42–46,69]. Moreover, the social dimension of sustainable development highlights the significance of social equity, justice, and inclusivity [45,46]. It acknowledges the importance of enhancing human well-being, protecting human rights, reducing inequality, and ensuring access to education, healthcare, and basic services for all individuals [42,43,47]. The environmental dimension of sustainable development focuses on the imperative of protecting and conserving the natural environment and its resources [44,47–49]. It acknowledges the interdependence between human activities and the ecosystems that support life on Earth. This pillar emphasizes the need to minimize environmental degradation, address climate change, promote biodiversity conservation, and adopt sustainable resource management practices.

In essence, the role of an economic agent in sustainable development cannot be assessed in isolation from the other pillars of sustainable development. It is crucial to recognize that actions or interventions focused solely on economic development may have trade-off effects on the other pillars, leading to negative impacts despite positive outcomes in one aspect. This interdependence and potential trade-offs among the pillars of sustainable development necessitate a comprehensive and integrated approach. However, despite the growing literature on the role of FDI on the disaggregated pillars of sustainable development, there is a lack of comprehensive research that examines the impact of foreign direct investment (FDI) on all three pillars of sustainability (economic, social, and environmental) concurrently, aiming to ensure holistic sustainable development [50,51]. Therefore, the literature review covers the relationship between FDI and the three disaggregated dimensions of sustainable development.

FDI's function, relevance, and influence at the local, national, and global levels have been hotly contested in economic research over the last few decades. The influence of FDI on economic growth has been studied extensively, albeit with inconsistent findings though majority of the study posit positive outcome on economic growth. Thus, FDI is often seen as the long-term reagent of economic growth in developing countries [12,14,23,30,52,53]. For instance Ref. [52], explored the functions of private entities in the accumulation of funds for development in the African region. Employing the ordered-probit model on 44 African nations, the authors revealed that foreign investors or FDI favorably influence growth in the selected African economies. They argue that FDI spurs development through the improvement of green technology, core infrastructure, and shared technological expertise [53]. establish a direct positive association between foreign direct investment and economic development in a sample of eight Southern African nations. Also, Dinh et al. [7] employing a variety of empirical models on a group of emerging nations, emphasized that FDI exerts a favorable influence on growth in both the short and long-term. More recently, Arthur et al. [23], in examining the theory of the FDI-led growth hypothesis, documented that FDI spurs growth in the region of Ghana. Consistent with this outcome [54], found evidence of a favorable positive effect of FDI on the economic growth of Kenya. According to the authors, FDI inflows create new employment and provide access to contemporary technology, resulting in a favorable export and balance of payments.

In constract to the positive outcome of FDI on economic growth, some studies evidence adverse effect of FDI on the growth of local economies. FDI may cause detrimental ramifications such as crowding out local investment and the creation of unfair business practices between overseas and local firms [14,22,54–56]. The literature likewise yields varied results regarding the effect of FDI on social progression. While some studies argue for a positive relationship, other studies posit a negative relationship [26]. found a positive relationship between FDI and income inequalities in Africa. Using the estimator of the pooled mean group on sixteen African countries between the period 1980 and 2013, the authors claim that inbound FDI does not certainly reduce inequalities although it may spur economic growth. Similarly, the empirical study of [57] on Botswana between 1980 and 2014 revealed that FDI exacerbates the poverty gap in the country. More recently [25], also confirm an adverse effect of FDI on poverty reduction in twenty-nine Sub--Saharan African nations in their study. The authors postulated that the desired amount of FDI to relieve poverty in the nations captured in the study or the African region had not been attained.

Other research, in contrast to the adverse influence of FDI on social progression, claims that FDI exerts a favorable influence on the host country's social progression. That is, for instance, FDI help reduces or has a negative impact on poverty and income inequality. According to Ref. [58], FDI facilitated a reduction in the state-level income inequality in Mexico between the years 1990 and 2000. Similarly, the study of [59] conducted with 153 sampled countries (from both developed and developing nations) came to a similar conclusion indicating that FDI decreases income disparities in nations with a higher degree of democracy [60]. also found a similar conclusion of FDI reducing poverty lines in some selected Sub-Saharan African nations between the period of 1990–2010. Moreover [61], concurs in his study on thirty-eight Sub-Saharan African nations, by establishing that though FDI doesn't exert any substantial impact on income inequality, FDI coupled with a modest amount of democracy can help to alleviate inequality.

Regarding the effect of FDI on ecological quality, the empirical evidence also posits inconclusive results where one class of studies reflects the favorable influence of FDI on the environment, while others support the deleterious impact of FDI on the environment [62]. The study of [17] in the Asian region indicate that foreign direct investment has a substantial beneficial effect on environmental quality through lowering pollutant levels. Duodu et al. [16], found a similar outcome of FDI on environmental pollution in Africa using the Compact With Africa initiative (CWA) [63]. found a favorable influence of the FDI-environment nexus, indicating that FDI reduces pollution concentration via the use of cleaner and more efficient technology. A similar conclusion was documented by Ref. [62]. He argued, based on his empirical findings, that foreign companies are more environmentally conscious than their local counterparts because they employ superior management methods and innovative technology that are environmentally friendly.

However [18], found that FDI has a destructive effect on the quality of the environment in the MENA economies through increasing economic expansion [64]. established that the economic growth of Pakistan is attained on the wings of diminishing environmental quality [65]. also arrived at a similar conclusion finding a negative influence of FDI on the ecological health of some selected African countries. Similarly [28], on thirty-six African nations over the period of 1980–2014, confirmed the "pollution haven theory" in the region upon examining FDI-environment nexus. Besides, the study by Ref. [66] on twenty-one nations indicate that FDI reduces the emission in wealthier nations while upsurging pollution in middle-income class nations in the short term. Moreover [16], consistent with the environmental Kuznets hypothesis, found that FDI improves the health of twenty-three Sub-Saharan countries in the long term, though, in the short-term, it weakens environmental health.

In sum, it is evident from the literature review that there isn't an unanimity on the social, environmental, and economic influence of foreign direct investment on the host economy. These studies suggest that the impact of FDI on sustainable development should not be assessed in isolation of the other pillars, as FDI can have trade-offs that adversely affect the other pillars of sustainable development. Therefore, it is expedient to examine the effect of FDI on sustainable development by adopting an integrated or comprehensive approach, which can enable stakeholders to strive for sustainable development that optimizes positive impacts across all pillars and minimizes potential trade-offs. Hence, the current study tolls this path by adopting a comprehensive measure of sustainable development to adequately investigate the role of FDI in sustainable economic development of the African region.

3. Methodology

3.1. Sample and data

The original sample of this study comprises annual country-level information about FDI and sustainable development in all 54 African nations over the period 1990–2020. However, owing to the dearth of information on the key variables for all nations, our sample and analysis were reduced to 48 countries. The FDI net inflow as a percentage of GDP time series data is based on the Word Development Indicators reported by the Word Bank. Moreover, for the robustness test, the stock of FDI as a proportion of GDP reported by the United Nations Conference on Trade and Development (UNCTAD) was utilized. Regarding sustainable development (SD), we utilized Word Bank's Adjusted Net Savings (ANS) (World Development Indicators) as seen in Table 1.

In our comprehensive study, we further incorporate a set of relevant proxies to account for the institutional and policy influence that have been widely reiterated in various studies to influence this intricate connection between Foreign Direct Investment (FDI) and sustainable development [67].Thus, along with FDI, which is an economic factor, the institutional factor - Institutional quality(IQI), and the policy factors -Trade Openness (TO) and Financial Freedom (Finfreed) were considered. The inclusion of these variables, drawn from recent economic growth literature, is imperative as they interact with FDI and are intricately tied to equitable distribution of economic benefits, regulatory quality, and overall sustainable development outcomes.

Table 1
Variable measurement.

Name of variable	Description	Source
Dependent variables		
Foreign Direct Investment (FDI)	FDI inflows (% of GDP) Stock FDI as ratio of GDP	UNCTAD
Independent Variables		
Adjusted Net Savings (ANS)	Net change in a country's wealth	World Development Indicators
Sustainable Economic Growth (SEG)	Alternate measure of sustainable development comprising social, economic and environmental pillars	Researchers own Construct using data from World Development Indicators
Control variables		
Institutional Quality (IQI)	The effectiveness, transparency, and reliability of a country's legal and governance systems	World Development Indicators
Trade openness (TO)	Trade % of GDP	World Development Indicators
Financial freedom (FinFreed)	Gauge the level of economic liberty and the ability of individuals and businesses to make economic choices.	Heritage Foundation (2020)
Real exchange rate (REEx)	Real effective exchange rate index	World Development Indicators
Gross capital formation (GCF)	Gross capital formation (% of GDP)	World Development Indicators
GDP per capita (GDPC)	GDP per capita	World Development Indicators

For example, trade openness, reflecting a country's engagement in international trade, is a vital force in the global economy. Economies embracing open trade not only attract higher levels of Foreign Direct Investment (FDI) by expanding market access but also play a pivotal role in fostering sustainable development. This is achieved through the dual impact of promoting economic growth and enhancing resource efficiency, making trade openness a strategic driver for economic prosperity and environmental responsibility [68–71,113]. Similarly, institutional quality, a variable with both positive and negative signals, may not only reflect good governance but also poor governance, potentially influencing various dimensions of sustainable development [16,29]. The foundation for a favorable business environment lies in institutional quality, a key player influencing both Foreign Direct Investment (FDI) and sustainable development [114–117]. Strong institutions, characterized by transparent legal frameworks, efficient governance structures, and adherence to the rule of law, are recognized as pivotal factors in drawing in FDI [118,119]. Moreover, institutional quality plays a crucial role in ensuring the sustainable use of foreign investments, guaranteeing fair distribution of benefits and minimizing negative social and environmental consequences. Essentially, robust institutions act as drivers for attracting investments and contribute to a sustainable and equitable development trajectory [120].

Additionally, the significance of financial freedom, indicative of a nation's openness in the financial sector and regulatory framework, stands out as a pivotal factor influencing the interactions between Foreign Direct Investment (FDI) and sustainable development [32,123]. Empirical evidence suggests that nations characterized by elevated levels of financial freedom tend to attract higher FDI inflows, driven by the appeal of well-regulated and efficiently functioning financial markets to investors [121,122]. Moreover, financial freedom is intricately linked to sustainable development by promoting inclusive economic growth. Notably, countries with robust financial freedom mechanisms are better positioned to allocate financial resources to initiatives that align with environmentally responsible practices [125] further emphasizing the multifaceted role of financial freedom in shaping the dynamics of FDI and contributing to sustainable development.

These variables are also intricately connected with specific Sustainable Development Goals (SDGs) outlined by the United Nations. Drawing insights from the research of [3,16,21,29,71,89], these variables play pivotal roles in advancing targeted SDGs. Trade openness contributes significantly to the realization of industry, innovation, and infrastructure (SDG 9) [123], while also facilitating partnerships essential for the attainment of overarching SDGs (SDG 17). Lastly, the quality of institutions and governance is intrinsically linked to the establishment of strong institutions and the promotion of justice (SDG 16). While financial freedom itself is not a specific SDG, it underpins many of the goals and targets within the SDGs. It is a fundamental enabler of economic growth, poverty reduction, and sustainable development, making it a critical component of the broader agenda to achieve the SDGs [124]. It is somehow related to SDG 1, 8 and 9. These variables collectively contribute substantially to addressing multifaceted aspects of sustainable development, encompassing economic, social, and environmental dimensions as outlined in the SDGs.

To calculate or estimate sustainable development, the gauge of a suitable indicator that incorporates the economic, social, and ecological components via a transdisciplinary method is required. In line with this theoretical and pragmatic analytical prerequisite, the study adopted the Adjusted Net Saving, which has been argued for and utilized in the literature to be a good indicator for measuring sustainable development from an economic perspective [32,34,71–73, 111]. Adjusted Net Savings (ANS), expressed as a proportion of Gross National Income (GNI), is established on the concept or notion of "Wealth accounts" and "Green National Accounts" [74]. According to Ref. [79], ANS encompasses produced capital, natural capital, and human capital and revises conventional net savings to deduce a proxy for the absolute level of aggregate savings appropriate for sustainable development. By implication, to derive ANS, spending on school education is added to the gross national savings to show investment in human resources on the one hand. Depletion of natural resources and costs of pollution and emissions are deducted, on the other hand, to reflect the downgrading of environmental goodies and damage of human resources and tangible assets, respectively.

In other words, ANS is estimated mathematically by adjusting the Gross National Savings (GNS) in the succeeding ways: first, subtracting capital depreciation (CD) to obtain national net savings; second, adding present public Educational Expenditure (EE) to capture human capital worth creation, third, subtract deterioration of various natural resources (DNR), such as afforests, oil, minerals, to account for the decrease in natural goods and fourth, less pollution damage (PD), in particular, damage and expenditure incurred from urban carbon emissions and air pollution. Lastly, the outcome indicator is divided by gross national income (GNI) to obtain the adjusted net saving [76]. The ANS calculation process is statistically presented as seen in equation (1) below:

$$\mathbf{ANS} = \frac{GNS - GD + EE - \sum DNR - PD}{GNI} \tag{1}$$

3.2. Empirical model and estimation technique

To realize the primary objective of examining the causal link between foreign direct investment and sustainable development, the generalized method of moment panel vector autoregressive model (GMM-PVAR), which is an advanced econometric model, was deployed owing to its inherent advantages. First and foremost, the GMM-PVAR builds an endogenous framework and treats all the variables in an unobstructed way [77]. This helps to explore and capture the full dynamic endogenous connections among variables. Second, the GMM-PVAR also offers a better grasp of the source of heterogeneities by accounting for cross-sectional dynamic heterogeneities, which increases coherence and measurement of consistency. Additionally, the GMM-PVAR helps to capture the time variations in the coefficient and the variance of the shocks. Thus, the GMM-PVAR through the granger causality test help establishes the interlink path of causality between variables of interest. Furthermore, utilizing the Impulse Response Functions (IRFs), the dynamic periods of associations amogn sustainable development and its factors can be assessed.

Following the empirical procedure of [77–79], a five-step econometric technique was employed. Firstly, some preliminary assessments were performed utilizing the first- and second-generation panel stationarity tests coupled with the cross-sectional dependence to determine the nature of the data and the most suitable estimation approach to adopt. This is because the unit root and cross-sectional dependence can potentially alter the genuine parameter values of estimated models if overlooked. Secondly, the suitable optimum lag order was selected using jointly the Hannan and Quinn information criterion (HQIC), Akaike's information criterion (AIC), and the Bayesian information criteria (BIC) to prevent misspecification of the projected model. An unsuitable chosen lag length will alter the model's degrees of freedom leading to prejudiced results, especially a long lag order in the case of a small size sample. Hence, the optimal lag lengths that result in residuals. that are closest to the white noise process were selected. Thirdly, the empirical model utilized in estimating the nexus among sustainable development, foreign direct investment and other institutional and policy variables is then expressed in equation (2) below.

$$K_{it} = \mu_i + \Phi(I)K_{it-1} + V_i + \theta_t + \varepsilon_{it} \tag{2}$$

where "i" denote country-specific units while "t" denotes time periods. K_{it} is the vectors of endogenous variables, which are FDI, ANS, IQI, TO and Finfreed.The lag operator of the endogenous variables is given as $\Phi(I)$, V_i and θ_t are the individual and time-specific effect, respectively, while the stochastic error term is given as ε_{it}. Ordinary Least Squares (OLS) and a fixed effect would have been used to estimate equation (2). Nevertheless, including the lag of the explained variable into the structure equation would interact with the panel fixed effect, leading to biased and inconsistent parameter estimations [82]. contends that employing lagged instruments and first differencing are the best tactics for eliminating the individual fixed effect and producing consistent results in this regard. Thus, to estimate the aforementioned equation, this study used the system generalized method of moment (GMM) of [81], specifically in this framework where the N is large than T. The generalized method of the moment of [81] unlike the GMM approach of [82], employs the difference of lag of the dependent variable as instruments for equations in levels and also integrates the lagged levels of the dependent variable as instruments for equations in first differences [79,83]. Thus, to remove the time-fixed and country-specific effects from Eq. (2), we estimate the first difference technique in Eq. (3) outlined below. Δ in equation (3) denotes the first difference or the forward orthogonal transformation.

$$\Delta K_{it} = \Delta\mu_i + \Phi(I)\Delta K_{it-1} + \Delta V_i + \Delta\theta_t + \Delta\varepsilon_{it} \tag{3}$$

Fourthly, diagnostic tests were performed to ensure the stability and robustness of the GMM-Panel VAR results since an unstable GMM-Panel VAR model fundamentally nullifies the impulse response and variance forecast decomposition outcomes. Hence, the roots of the companion matrix stability graph were deployed to certify the stability of the estimated model. Lastly, the impulse-response functions (IRF) and variance forecast error-decompositions (accounting-innovation-function) were estimated upon ensuring the stability of the GMM-Panel VAR model following the classic technique of [84,85]. The IRF defines the responsiveness of one variable within a framework to structural innovation in another variable while all other shocks stay constant [77]. Unlike the IRF, variance forecast-error decomposition also determines the proportion of movement in an endogenous variable due to its own shock and all other known shocks [86]. Hence, the orthogonalized IRF and variance decomposition were deployed in our model to offer a clearer understanding of the dynamic relationships between the elements under consideration since the PVAR parameters in the reduced state cannot be described as causal linkages unless parameter estimations constraints-identification are implemented [79]. The technical road map of our estimation process is presented in Fig. 1.

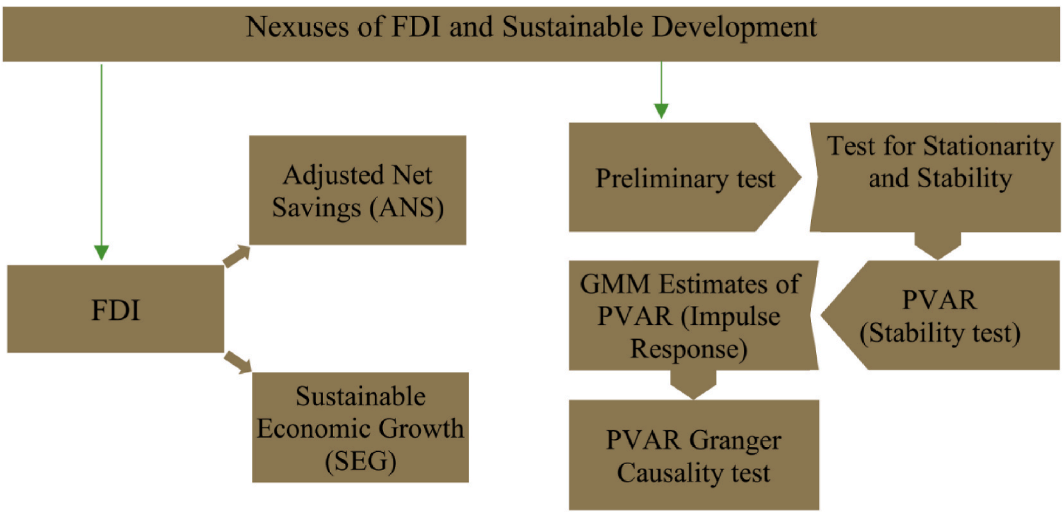


Fig. 1. Technical roadmap.

4. Empirical results and discussion

4.1. Descriptive statistics

Table 2 reports the summary statistics for country-year observations of the main variables of interest in this section. All variables are winsorized at the first and ninety-fifth percentile level to curb any possible irregularities (outliers) in the observations.

A cursory view at Table 2 reveals that ANS seems to be the most volatile between the two variables when its overall mean and standard deviation are directly compared. Comparing the between and within standard deviation values shows that unlike the FDI, the between standard deviation values tend to be significantly larger than the within values indicating higher data disparities across countries. The main dependent variable, adjusted net savings (ANS), has a mean value of 5.597 and a standard deviation of 12.339 indicating substantial sustainable development variation across the study region. The evident wide differences in ANS can be chiefly attributed to the enormous variations in human development, ecological footprint (pollution), and economic advancement in the African region. Dr. Congo with the lowest ANS value of −77.607 in the year 1996 signposts that the nation was on relatively worse sustainable development grounds whereas Zimbabwe with the highest ANS value of 55.685 for 1994 signposts the nation was in a better situation than other countries.

The main independent variable of interest, FDI, has an average value of 3.863 with a minimum value of −34.211 and a maximum value of 161.824. The standard deviation of 7.621 indicates a high degree of dispersion across nations which are attributed chiefly to the varying enabling host influencing factors for inbound FDI. The lowest value of inbound FDI among all the nations is ascribed to Mauritania in the year 2020 whereas the nation with the greatest inflow of FDI value is Equatorial Guinea in the year 1996. Thus, some nations in the African regions attract more FDI than others in the region. IQI is an index created by combining six components of the global governance indicator (42): voice and accountability, political stability and lack of violence/terrorism, regulatory quality, government effectiveness, rule of law, and corruption control, using the PCA technique. Because the index is normalised after creation, it ranges from 0 to 1. All other variables are also volatile and show a wider range.

4.2. Unit root and cross-sectional dependence tests

To satisfy the standard condition of variable stationarity for estimating the GMM-PVAR, three panel unit root (stationary) test were deployed simultaneously to ensure the variables do not enter the model in an explosive form. As such, the Augmented Dickey- Fuller (ADF) panel unit root test, Pesaran– Shin (IPS) unit root test and the Phillips- Perron (PP) unit root test being the first-generation panel unit root tests were first utilized to determine the integrating properties of the variables under investigation. Table 3[A-D] contains the first-generation stationary test results where panel A presents the ADF stationary test, panel B displays the IPS stationary test and Panel

Table 2
Summary statistics.

Variable		Mean	Std. dev.	Min	Max	Observations
FDI	overall	3.863	7.621	−34.211	161.824	N = 1200
	between		3.524	0.454	19.451	n = 48
	within		6.776	−34.966	146.236	T = 25
FDIbop (in billion)	overall	0.664	1.462	−7.397	11.578	N = 1200
	between		0.963	−0.098	4.338	n = 48
	within		1.109	−6.635	10.790	T = 25
ANS	overall	5.597	12.339	−77.607	54.368	N = 1200
	between		9.742	−27.789	26.087	n = 48
	within		7.698	−57.776	67.789	T = 25
SEG	overall	1995.035	3824.197	3.955	36633.680	N = 1196
	between		3533.769	4.678	15713.840	n = 48
	within		1572.855	−7413.177	25049.280	T = 24.917
IQI	overall	0.494	0.163	0	1	N = 1200
	between		0.153	0.181	0.880	n = 48
	within		0.061	0.232	0.778	T = 25
TO	overall	72.217	39.838	−0.873	347.997	N = 1200
	between		33.614	28.298	170.333	n = 48
	within		21.905	−46.363	266.832	T = 25
FinFreed	overall	41.575	15.512	10	70	N = 1200
	between		12.671	17.200	70	n = 48
	within		9.126	5.575	72.775	T = 25
GDPC	overall	2301.102	2757.377	233.033	16747.360	N = 1058
	between		2656.031	299.681	13085.930	n = 43
	within		772.209	−5214.626	7999.594	T = 24.605
GCF	overall	21.984	9.564	−3.946	60.156	N = 931
	between		21.984	9.564	−3.946	n = 40
	within		6.881	−4.174	65.675	T = 23.275
REEx	overall	101.901	22.097	53.710	273.009	N = 425
	between		9.361	81.963	115.350	n = 17
	within		20.140	56.658	260.470	T = 25

Table 3
[A-D]:First generation Panel Unit Root and Cross-sectional Dependence test.

Panel A: Augmented Dickey-Fuller (ADF) stationary test				
Variables	No trend		Trend	
	Statistic	**Prob.**	**Statistic**	**Prob.**
ANS	196.147	0.0000	186.499	0.0000
dANS	416.021	0.0000	291.391	0.0000
FDI	192.761	0.0000	136.815	0.0040
dFDI	490.582	0.0000	351.311	0.0000
IQ	130.603	0.0109	125.819	0.0222
dIQ	281.218	0.0000	196.634	0.0000
TO	85.565	0.7684	119.705	0.0511
dTO	352.391	0.0000	276.283	0.0000
FinFreed	155.145	0.0001	141.871	0.0000
dFinFreed	365.267	0.0000	275.633	0.0000
Panel B: Im-Pesaran-Shin (IPS) Stationary test				
ANS	−6.0672	0.0000	−5.5546	0.0000
dANS	−30.2600	0.0000	−26.8503	0.0000
FDI	−11.939	0.0000	−11.687	0.0000
dFDI	−37.1150	0.0000	−31.821	0.0000
IQ	−3.8847	0.0000	−2.2066	0.0137
dIQ	−24.797	0.0000	−22.8350	0.0000
TO	−0.9990	0.1589	−1.9305	0.0268
dTO	−25.1088	0.0000	−22.1576	0.0000
FinFreed	−5.0957	0.0000	−2.8415	0.0022
dFinFreed	−26.3929	0.0000	−23.2131	0.0000
Panel C: Phillips-Perron (PP) Stationary test				
ANS	222.0678	0.0000	194.7914	0.0000
dANS	1492.561	0.0000	1286.390	0.0000
FDI	391.4334	0.0000	387.0717	0.0000
dFDI	2031.181	0.0000	1797.807	0.0000
IQ	144.4038	0.0010	142.2698	0.0015
dIQ	1008.640	0.0000	851.473	0.0000
TO	104.9458	0.2500	116.1285	0.0794
dTO	1015.152	0.0000	847.859	0.0000
FinFreed	509.4126	0.0000	498.2917	0.0000
dFinFreed	1113.838	0.0000	932.8277	0.0000
Panel D: Cross-sectional Dependence test:Pesaran (2004) CD test				
dANS	1.80		0.071	
dFDI	0.77		0.439	
dIQ	6.05		0.000	
dTO	13.45		0.000	
dFinFreed	1.62		0.104	

C displays the PP stationary test. Panel D of Table 3[A-D] also shows the results for [87] cross-sectional dependence test.

The results from the various first-generation stationary tests utilized posit that some variable are not stationary at level. Therefore, we examine the unit root of their first difference and find that all variables are stationary because all of the test statistics are significant. The null hypothesis indicating the existence of unit root in the variables under consideration is rejected at one percent level of significance. However, the results from the cross-sectional dependence test indicates that the variables exhibit cross-sectional dependence, which is a drawback to the first-generation unit root test. Thus, an advanced empirical technique that control for cross-sectional

Table 4
Second generation Pesaran (2007) Panel Unit Root test.

Variables	No trend		Trend	
	Statistic	Prob.	Statistic	Prob.
ANS	−1.070	0.142	−1.240	0.108
dANS	−13.906	0.000	−10.454	0.000
FDI	−2.754	0.003	−0.741	0.229
dFDI	−13.828	0.000	−10.329	0.000
IQ	−1.489	0.068	0.309	0.621
dIQ	−10.054	0.000	−7.862	0.000
TO	2.237	0.987	−1.503	0.066
dTO	−11.911	0.000	−8.458	0.000
FinFreed	1.615	0.947	5.366	1.000
dFinFreed	−5.121	0.000	−3.203	0.000

The null hypothesis is that the variable follows a unit root process.

dependence should be deploy since the assumption of cross-sectional independence of the conventional first-generation panel unit root tests could not be met. To circumvent this limitation of the first-generation stationary test, the study deployed the second-generation stationary test which incorporates the cross-sectional interdependence among variables to determine if the variables are still stable or not. Therefore, the [88] cross-sectional augmented Dickey-Fuller panel unit root test which contains heterogeneous auto-regressive parameters across sections was used, Similar to Ref. [89].

The results of the second-generation panel stationary test utilizing the [88] stationary tested is reported in Table 4 below. The findings of [88] second generation panel stationary test determine that all variables are not stationary at level but are stationary at their first difference even in the presence of cross-sectional dependence. Hence, were utilized first differentiation data of all variables in the GMM-PVAR implementation [34,77,78].

4.3. Lag optimal length selection

Given that inappropriate lag order will cause bias results either via under-specification or over-parameterization [90], the study proceeded to estimate the optimal suitable lag using [91] three model selection criteria. Based on the result of the optimal lag offered in Table 5, the second-order lag is selected as the optimal lag for the PVAR model. Though the BIC, AIC, and HQIC is the smallest at lag 1, the first-order panel VAR model reject Hansen's overidentification constraint at the 5% confidence level, suggesting probable model misspecification. Moreover, the overall coefficient of determination is also highest at lag 2. Therefore, we choose the second-order panel VAR model.

4.4. Evidence from the GMM-PVAR estimation

Having satisfied the model's prerequisite specifications, we estimated the second-order lag PVAR model based on equations (2) and (3) through the GMM technique since the ordinary least squares estimator would produce biased parameters or coefficients in a dynamic model due to several issues such as lagged dependent variables, and endogeneity of independent variables [92]. Furthermore, following [78,79] the forward orthogonal transformation was used to transform the fixed effects since it is correlated with the regressors owing to the presence of the lag-dependent variable [93].

The results of the estimation of the GMM-PVAR model is reported in Table 6. Because the study's primary goal is to reveal the dynamics of FDI and sustainable development, we primarily interpret how it impacts the inclusive development. In addition, we discover and confer some intriguing and unique discoveries similar to Ref. [112].

Results show that FDI has a significant negative influence on sustainable development, while sustainable development exerts a positive but statistically insignificant impact on foreign direct investment. The implication is that FDI contributes to the unsustainable path of African countries either directly or indirectly through its externalities. The empirical evidence supports the hypothesis that all other things being held constant, foreign direct investment has a substantial negative impact on sustainable development. The empirical evidence is also in line with related separate studies on Africa, such as [25,26,28] wherein FDI was found to dent possible sustainability paths by worsening the income inequality, widening the poverty gaps, and destroying the quality of the environment respectively. However, the result is also inconsistent with other related studies, such as [53,60], wherein FDI is found to foster sustainable development by bridging the inequality gaps in Sub-Saharan African. The contradictions between prior and current studies may be related to variances in the metrics of sustainable development utilized by the different studies. This is because, unlike the multidimensional metrics of sustainable development deployed by this current study, the single-dimensional metrics of sustainable development cannot simultaneously capture the possible effects or trade-off of FDI on all three main pillars constituting sustainable development.

The results in Table 6 indicate specifically that the first lag of ANS is positively correlated, with both the current ANS and FDI respectively, implying that the past realization of ANS respectively induces an increase in both the current levels of ANS and FDI. However, the results indicate that the initial value of FDI has a negative and positive impact on the current levels of ANS and FDI, respectively. It suggests that an increase in the initial values of FDI induces an increase in the current level of FDI whiles it costs an increase in the current level of ANS.

The direction and significance of the estimated parameter of FDI indicate that foreign direct investment substantially influences a host country's level of sustainable development. Specifically, the direction of the FDI estimates, in general, seems to confirm the logical argument that the beneficial impact of FDI on the host country's sustainable development level is not given. Still, it depends on the host country's conditions, where in this case, African countries since FDI can also adversely affect the host economy simultaneously. The likely explanation to the result is that Africa countries choose not to implement stronger socio-environmental constraints for fear of losing points in the race to attract FDI from other countries. Consequently, the probable gains of FDI inflows are eroded off by its

Table 5
Optimal lag.

Lag	CD	J	J Pvalue	BIC	AIC	HQIC
1	0.7897944	120.7451	0.0774257	−555.4122*	−79.25494 *	−261.506*
2	0.8115717*	91.64365	0.1028771*	−415.4743	−28.865	−195.0447
3	0.5601187	63.85694	0.1200588	−274.2217	−36.14306	−127.2686

Note: * signifies suitable optimal lag order chosen by the criterion.

Table 6
GMM-Panel VAR estimation results.

Response to	Response of				
	$dANS_t$	$dFDI_t$	$dIQI_t$	dTO_t	$dFinFreed_t$
$dANS_{t-1}$	−0.321***	0.002	−0.009	−0.006	−0.016
	(0.050)	(0.048)	(0.013)	(0.017)	(0.022)
$dANS_{t-2}$	−0.126***	0.033	0.006	0.009	0.010
	(0.034)	(0.034)	(0.014)	(0.013)	(0.35)
$dFDI_{t-1}$	−0.0335	−0.280***	0.024***	0.024	−0.008
	(0.0253)	(0.069)	(0.008)	(0.021)	(0.017)
$dFDI_{t-1}$	−0.097***	−0.025	0.004	0.030	0.050***
	(0.028)	(0.049)	(0.009)	(0.20)	(0.016)
$dIQI_{t-1}$	0.182**	−0.048	−0.128**	−0.0122	0.139**
	(0.083)	(0.087)	(0.054)	(0.042)	(0.065)
$dIQI_{t-2}$	0.0406	−0.037	0.071*	−0.029	0.094
	(0.0787)	(0.107)	(0.44)	(0.043)	(0.065)
dTO_{t-1}	−0.0076	0.057	−0.109***	−0.033	0.0219
	(0.0586)	(0.079)	(0.024)	(0.098)	(0.0325)
dTO_{t-1}	−0.0196	−0.156**	−0.006	−0.060	0.010
	0.0637	(0.062)	(0.0243)	(0.072)	(0.023)
$dFinFreed_{t-1}$	0.014	−0.0386	−0.005	−0.006	−0.023
	(0.037)	(0.041)	(0.0175)	(0.020)	(0.044)
$dFinFreed_{t-2}$	−0.0182	0.043	−0.009	0.002	−0.029
	(0.334)	(0.049)	(0.016)	(0.018)	(0.031)
Hansen's p value	(0.13)				
No. of panel	48				
Observations	864				

GMM estimates a two-variable VAR model; country-time and fixed effects are removed before estimation. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

simultaneous cost on the host society and environment leading to a fall in the sustainable development level of the countries [94,]. documents that SSA area has retarded growth in economic due to the region's comparatively weak economic institutions, which raise the danger of expropriation and rent-seeking.

In line, with heightened battle for FDI, polluting industries in advanced nations relocate to developing countries particularly African countries owing to the relatively tough laws and growing expense of pollution cut in advanced nations [95,96]. For instance, Kearsley and Riddel [96] explains in their study that the decrease in pollutants or emissions in many advanced economies are attributable in part to the relocation of polluting activities to developing regions which includes the Africa nations.

Additionally, the anecdotal evidence supports the argument, since developing economies have the lion's share of FDI inflows and world emissions simultaneously. According to the UNCTAD (2019) World Investment Report, foreign direct investment flows to developing economies have remained consistent and increased from 36 percent in 2016 to 47 percent in 2017 despite the fact that

Table 7
GMM- Panel VAR Granger causality results.

Causality	Chi-square	df	Probability	Decision
dANS ⇸ dFDI	0.982	2	0.612	Unidirectional
dFDI ⇸ dANS	12.264	2	0.002***	Causality
dANS ⇸ dIQI	0.827	2	0.661	Unidirectional
dIQI ⇸ dANS	4.762	2	0.092*	Causality
dANS ⇸ dTO	0.701	2	0.704	No Causality
dTO ⇸ dANS	0.111	2	0.946	
dANS ⇸ dFinFreed	1.143	2	0.565	No
dFinFreed ⇸ dANS	0.458	2	0.795	Causality
dIQI ⇸ dTO	0.473	2	0.790	Unidirectional
dTO ⇸ dIQI	20.339	2	0.000***	Causality
dIQI ⇸dFinFreed	5.529	2	0.063*	Unidirectional
dFinFreed ⇸ dIQI	0.432	2	0.806	Causality
dTO ⇸ dFinFreed	0.593	2	0.743	No
dFinFreed ⇸ dTO	0.123	2	0.940	Causality
dFinFreed ⇸ dFDI	2.170	2	0.338	Unidirectional
dFDI ⇸ dFinFreed	16.573	2	0.000***	Causality
dFDI ⇸ dIQI	9.706	2	0.008***	Unidirectional
dIQI⇸ dFDI	0.341	2	0.843	Causality
dFDI ⇸ dTO	2.231	2	0.328	Unidirectional
dTO⇸ dFDI	6.810	2	0.033**	Causality

Note: *, ** and *** denotes statistical significance at the 10%, 5% and 1% respectively level.

global FDI flows have been on a downward trend. Furthermore, the report indicates specifically that the African region witnessed a 11 percent upsurge in FDI inflows over the 2017 inflows. The continual boom of FDI into the African continent can be traced in part to the relatively weak regulations combined with inexpensive commodity availability in the region.

Once again, despite the recent movement of some investments towards the services and manufacturing [19], FDI to Sub-Saharan Africa has generally been directed toward oil and natural resources extraction [97,98,124], which are the major pollution intensive production industries and a probable reason behind the negative relationship between sustainable development and FDI. This is because, FDI steered towards resource exploitation and pollution-intensive production more often than not reduce sustainable development gains by generating negative externalities to the environment and society at large [33,98].

Results also infer that Institutional Quality (IQI) promotes sustainable development, while FDI contributes to good IQI, implying that IQI directly and indirectly upholds sustainable development. These results are consistent with (113). Interestingly, TO holds back FDI and thus contributes to sustainable development through the channel of FDI. This finding is obvious, as a higher TO may encourage the foreign firm to engage in international business through foreign trade instead of FDI.

4.5. *Evidence from the panel granger causality test*

Following these findings from the panel GMM-VAR estimations, we proceed to the panel VAR granger causality estimation to have a clearer view of the interrelationships between the variables. That is, to determine whether FDI granger causes sustainable development and vice versa. The null hypothesis demonstrates the absence of causality. Table 7 shows the findings of the panel VAR Granger causality test. The results indicate that sustainable development (ANS) does not granger cause foreign direct investment (FDI), as evident by the insignificant probability value. Thus, we fail to reject the null hypothesis indicating that FDI is not a granger caused by sustainable development. However, we reject the null hypothesis suggesting that sustainable development is not a granger caused by FDI at a one percent level of significance. Hence, according to Table 7, a unidirectional causal relationship flows from foreign direct investment to sustainable development. In other words, FDI exerts a significant causal impact on the sustainable development level of African countries. This outcome is consistent with [99] study on the Turkish economy, where a one-way causal relationship from FDI to sustainable development index was established. In addition, as evidenced by the significant probability value, IQI granger causes ANS, FDI granger causes IQI, and TO causes IQI and FDI. These findings imply that IQI causes ANS directly and also through the channel of FDI, and TO causes ANS indirectly through the channel of IQI and FDI.

4.6. *Impulse response function analysis*

After the PVAR granger causality estimation, the authors proceed to perform the impulse-response function (IRF) and variance forecast error-decompositions upon ensuring the stability of the model [79]. This is imperative because an unstable GMM-Panel VAR model fundamentally nullifies the impulse response and variance forecast decomposition outcomes. Moreover, the orthogonalized IRF and variance decomposition were employed to analyze further the dynamic relationships between the elements under consideration since the PVAR parameters in the reduced state cannot be described as causal linkages unless parameter estimations constraints-identification are implemented [79]. The outcome of the stability test of the GMM-panel VAR model is offered in Fig. 2. The stability test results indicate that the modulus of eigenvalue values are less than one or fall within the unit circle, confirming that PVAR estimates meet the stability criterion, as seen in Fig. 2.

It should be noted that until identifying constraints on parameter estimations are implemented, the PVAR coefcients in reduced form cannot be described as causal links [79.]. To address this constraint, we conduct further analysis using the orthogonal IRF to explain the causal effect of sustainable development to the shock in FDI while all other shocks stay constant and vice versa [79.] Fig. 3 reports the findings from the impulse response function (IRF) and the 95% confidence interval band that was generated using 300 Monte Carlo simulations of the fitted form of the GMM panel VAR. The orthogonal IRF of the relevant variable over five years is shown by the solid lines in each graphic, while the shaded regions represent the 95 percent interval of confidence.

The first column of Fig. 3 shows the response of sustainable development, the second column displays the response of foreign direct

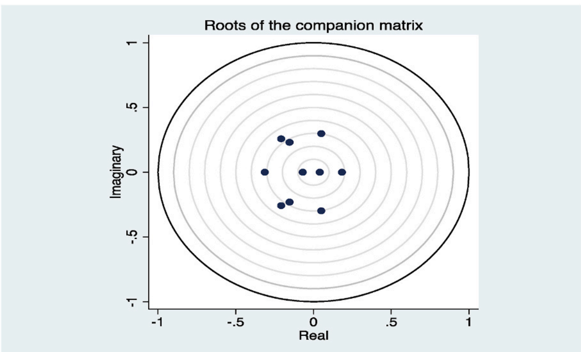


Fig. 2. Stability graph.

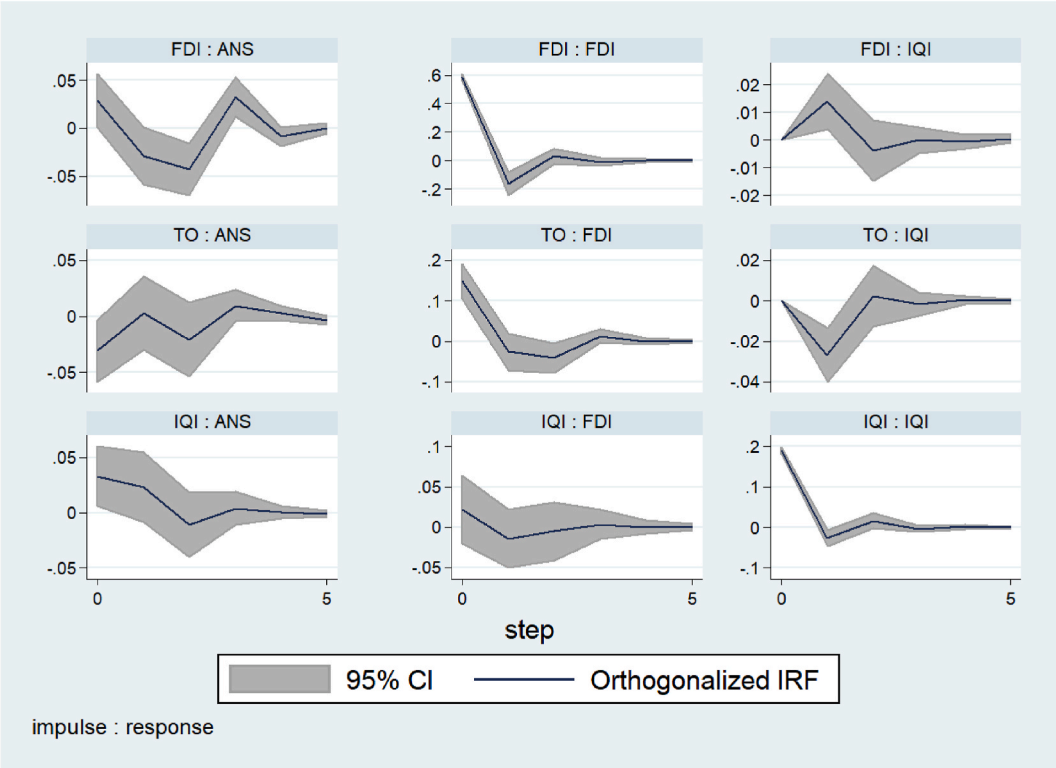


Fig. 3. Impulse response function graph.

investment, and the third column presents the response of Institutional quality, to the shock of FDI, IQI and TO. Fig. 3 reveals that sustainable development reacts negatively to a shock to foreign direct investment, confirming that FDI has a negative causal impact on the sustainable development of African countries. The results show that the effect of one standard deviation shock on the growth of FDI sharply decreases sustainable development up to 3 years, then slightly increases in the negative region and rises up to positive region in year 4 and eventually decreases gradually and divereses to zero in 5th year. The result is in line with the study of Acemoglu et al. (2001) on the SSA region, where they document that the African region has delayed economic growth owing to the high risk of expropriation and rent-seeking investment facilitated by the relatively weak economic institution in the area.

Thus, the adverse effect of FDI might be understood as an instant rise in economic activity due to the inflow of capital, which may raise environmental exposure due to the higher use of gas, oil, and other energy-consuming sources [28,29,65,100] and or worsening the inequality gap through increment of skill labor wages or employment as against unskilled labor [25,26].

The IRF graphs also show that IQI has a positive influence on ANS, which diverges to zero in the third period. This finding is consistent with the findings of (113). FDI supports good IQI and thereby, along with its direct effect, influences ANS indirectly through IQI. TO has a non-linear influence on FDI; it initially supports and then hurts FDI, thereby indirectly influencing sustainable development.

4.7. *Variance decomposition analysis*

Although the impulse response's function offers information on the influence of changes in one variable on another, it cannot determine the magnitude and degree of this effect. As such, we supplement the inquiry by finally performing the variance decomposition analysis to account for the collective impact of changes in the variables. Variance decomposition sends details about percentage differences in the dependent series induced not only by their shocks but also by shocks created by other variables. Table 8 [A-E] shows the findings of the ten periods of variance decomposition generated from the orthogonalized impulse response coefficient matrices.

Panel A of Table 8 [A-E] shows the percentage response of sustainable development to the shock of itself, FDI, IQI, TO and Finfreed respectively. In contrast, panel B shows the percentage response of foreign direct investment to the shock of itself and sustainable development, IQI, TO and Finfreed respectively. Similarly, panel C, D and E show the response of IQI, TO and Finfreed respectively. The result mainly shows that the bulk of the variations in sustainable development and foreign direct investment are explained by themselves by approximately 73% and 93%, respectively. Nevertheless, foreign direct investment (FDI) inflow approximately explains 26% of the variance in sustainable development (ANS), whereas sustainable development explains negligibly 0.04% of the variations in foreign direct investment. The significant magnitude of the impact of FDI on sustainable development reaffirms the findings from the

Table 8
[A-E]:Error Variance Decomposition results.

Forecast Horizon	Impulse Variable				
	dANS	dFDI	dIQI	dTO	dFinFreed
Panel A	Response on dANS				
2	0.7703	0.2196	0.0082	0.0047	0.0019
4	0.7295	0.2604	0.0087	0.0072	0.0023
6	0.7266	0.2633	0.0087	0.0073	0.0023
8	0.7260	0.2639	0.0087	0.0073	0.002
10	0.7257	0.2642	0.0087	0.0073	0.0023
Panel B	Response on dFDI				
2	0.0004	0.9392	0.0017	0.0579	0.0009
4	0.0006	0.9332	0.0018	0.0621	0.0020
6	0.0006	0.9332	0.0018	0.0621	0.0020
8	0.0006	0.9332	0.0018	0.0621	0.0020
10	0.0006	0.9332	0.0018	0.0621	0.0020
Panel C	Response on dIQI				
2	0.0051	0.0004	0.9752	0.00043	0.00043
4	0.0054	0.0011	0.9739	0.0011	0.0011
6	0.0054	0.0011	0.9739	0.0011	0.0011
8	0.0054	0.0011	0.9739	0.0011	0.0011
10	0.0054	0.0011	0.9739	0.0011	0.0011
Panel D	Response on dTO				
2	0.0025	0.0000	0.0067	0.9906	0.0000
4	0.0052	0.0003	0.0071	0.9871	0.0000
6	0.0052	0.0003	0.0071	0.9871	0.0000
8	0.0052	0.0003	0.0071	0.9871	0.0000
10	0.0052	0.0003	0.0071	0.9871	0.0000
Panel E	Response on dFinFreed				
2	0.0002	0.0004	0.0083	0.0003	0.9906
4	0.0106	0.000	0.0101	0.0007	0.9777
6	0.0106	0.0007	0.0100	0.0008	0.9776
8	0.0106	0.0007	0.0101	0.0008	0.9776
10	0.0106	0.0007	0.0101	0.0008	0.9776

GMM-panel VAR estimate and granger causality test results, which posit a significant causal negative effect of FDI on the sustainable development of African countries. Other variables explain a very small percentage of variations of ANS and FDI.

4.8. Robustness test

In particular, one may argue that our study results are driven by the variables' choice of measurement or description. As such, to ensure the study results' robustness, we conducted three main sensitivity tests by deploying alternate variable measurements for both sustainable development and foreign direct investment and including additional variables in the main model.

In contrast to the baseline estimation, first, an alternate measure of sustainable development, the sustainable economic growth index (SEG), was constructed and utilized purposely to test if the specification of the variable sustainable development drives the study's outcomes.Following the recommendation of [35], the study developed the sustainable economic growth (SEG) index which also touches the three main corner pillars of sustainable development. The constructed SEG index, in line with the assertion of [35], integrates economic efficiency (Gross domestic product per person), inefficiency of the society (proportion of unemployment) and ecological inefficiency (emission of carbon dioxide per person). In consistent with the proposition of [35] the SEG index was computed by dividing the economic inefficiency by the societal inefficiency and then by ecological inefficiency. This is expressed mathematical in equation (4) below.

$$SEG = \frac{GDP\ per\ person}{Percentage\ unemployment + \text{Carbon emission per person}} \tag{4}$$

Ceteris paribus, conferring to this proposed measure by Ref. [35], sustainability will improve in tandem with lower unemployment, lower carbon emissions, and higher GDP. The inverse of these will lead to a drop in the sustainable development of a country. The suitability of the proposed index by Ref. [35], lies in its derivation or computation, since it fits all the Bellagio Tenets [101] and takes into account the three corner pillars of sustainable development (economic, environmental, and social). The outcome of this estimation is outlined in panel A of Table 9[A-C]. Second, we deployed an alternate measure of foreign direct investment being the stock of foreign direct investment unlike the inflow of foreign direct investment utilized in the baseline estimation. Stock of FDI denotes cumulative investment in a host country over time, which fully depicts MNE structural presence than FDI flows alone [102,103]. The stock of FDI as a ratio of GDP reported by UNCTAD [19] was also utilized purposely to test if the specification of the FDI variable drives the study's outcomes. The results of this estimation are also given in panel B of Table 9[A-C].Third, we include additional three variables, GDP per capita (GDPC), gross capital formation (GCF) and real exchange rate (REEx) to our main model to test if the results are diven by choice

Table 9
[A-C]: Robustness test results.

Panel A: Sustainable Economic Growth Index (SEG)					
Response to	Response of				
Variables	$dFDI_t$	$dIQI_t$	dTO_t	$dFinFreed_t$	$dSEG_t$
$dFDI_{t-1}$	−0.723***	0.015***	−0.001	−0.030**	−0.008***
	(0.069)	(0.005)	(0.011)	(0.012)	(0.003)
$dFDI_{t-2}$	−0.291***	0.010	0.007	0.003	−0.005
	(0.055)	(0.007)	(0.012)	(0.013)	(0.004)
$dIQI_{t-1}$	0.184**	−0.624***	0.075	0.257***	−0.005
	(0.090)	(0.051)	(0.046)	(0.063)	(0.019)
$dIQI_{t-2}$	0.108	−0.291***	0.037	0.139**	0.020
	(0.092)	(0.039)	(0.049)	(0.056)	(0.019)
dTO_{t-1}	0.012	−0.034	−0.470***	0.054*	−0.011
	(0.066)	(0.024)	(0.058)	(0.028)	(0.013)
dTO_{t-2}	−0.167**	−0.077***	−0.211***	0.035	0.001
	(0.079)	(0.018)	(0.045)	(0.030)	(0.012)
$dFinFreed_{t-1}$	−0.133***	−0.008	−0.052***	−0.589***	0.002
	(0.040)	(0.014)	(0.015)	(0.044)	(0.007)
$dFinFreed_{t-2}$	−0.053	−0.014	−0.037**	−0.292***	0.018*
	(0.043)	(0.014)	(0.015)	(0.039)	(0.010)
$dSEG_{t-1}$	0.025	−0.015**	−0.002	−0.014*	−0.832***
	(0.017)	(0.007)	(0.007)	(0.008)	(0.072)
$dSEG_{t-2}$	0.014	0.004	0.009	0.001	−0.469***
	(0.015)	(0.005)	(0.008)	(0.007)	(0.113)
Hansen's value	0.134				
No. of panel	48				
Observations	908				
Panel B: Stock of FDI as a percentage of GDP					
Response to	Response of				
Variables	$dFDI_t$	$dIQI_t$	dTO_t	$dFinFreed_t$	$dANS_t$
$dFDI_{t-1}$	−0.191**	−0.007	−0.002	0.034***	−0.030**
	(0.094)	(0.008)	(0.008)	(0.013)	(0.015)
$dFDI_{t-2}$	−0.121	−0.000	−0.003	0.025**	0.015
	(0.079)	(0.006)	(0.009)	(0.012)	(0.013)
$dIQI_{t-1}$	0.089	−0.132**	0.012	0.131**	0.134
	(0.099)	(0.054)	(0.043)	(0.066)	(0.083)
$dIQI_{t-2}$	−0.051	0.089**	0.007	0.095	−0.008
	(0.083)	(0.045)	(0.045)	(0.062)	(0.078)
dTO_{t-1}	0.177***	−0.063***	0.055	0.022	−0.016
	(0.061)	(0.022)	(0.126)	(0.036)	(0.060)
dTO_{t-2}	0.036	−0.010	0.020	−0.003	−0.034
	(0.055)	(0.024)	(0.081)	(0.026)	(0.064)
$dFinFreed_{t-1}$	0.036	−0.007	−0.018	−0.031	0.030
	(0.039)	(0.017)	(0.022)	(0.045)	(0.037)
$dFinFreed_{t-2}$	0.010	−0.022	−0.002	−0.021	−0.018
	(0.044)	(0.016)	(0.019)	(0.033)	(0.034)
$dANS_{t-1}$	0.001	−0.009	0.012	−0.022	−0.294***
	(0.040)	(0.014)	(0.019)	(0.024)	(0.051)
$dANS_{t-2}$	0.010	0.004	0.022	−0.002	−0.128***
	(0.031)	(0.015)	(0.015)	(0.035)	(0.035)
Hansen's value	0.224				
No. of panel	48				
Observations	864				
Panel C: With additional control variables					
Response to	Response of				
Variables					
	(1)	(2)	(3)	(4)	(5)
Variables	dFDI	dIQI	dTO	dFinFreed	dANS
$dFDI_{t-1}$	−0.229***	0.050***	0.035	0.045	−0.114*
	(0.080)	(0.016)	(0.023)	(0.032)	(0.064)
$dFDI_{t-2}$	0.033	−0.003	0.035	0.058**	−0.153***
	(0.057)	(0.015)	(0.022)	(0.026)	(0.052)
$dIQI_{t-1}$	0.242**	−0.008	−0.037	−0.103	0.221**
	(0.100)	(0.061)	(0.047)	(0.117)	(0.111)
$dIQI_{t-2}$	0.150	0.124**	0.001	−0.276**	−0.112
	(0.098)	(0.056)	(0.045)	(0.117)	(0.108)
dTO_{t-1}	−0.092	−0.120**	−0.007	−0.097	0.055
	(0.136)	(0.048)	(0.045)	(0.083)	(0.129)
dTO_{t-2}	−0.043	−0.104**	0.060	0.031	−0.021
	(0.146)	(0.043)	(0.056)	(0.076)	(0.097)

(continued on next page)

Table 9 (*continued*)

dFinFreed$_{t-1}$	−0.028	−0.073***	−0.009	−0.006	−0.021
	(0.044)	(0.025)	(0.020)	(0.051)	(0.042)
dFinFreed$_{t-2}$	0.072	−0.006	−0.004	−0.177***	0.097**
	(0.057)	(0.025)	(0.020)	(0.059)	(0.047)
dANS$_{t-1}$	0.047	−0.014	−0.019	−0.046*	−0.249***
	(0.054)	(0.015)	(0.016)	(0.027)	(0.061)
dANS$_{t-2}$	0.083**	−0.002	0.032*	−0.055	−0.089*
	(0.038)	(0.015)	(0.017)	(0.040)	(0.048)
dREEx	0.007*	−0.002	−0.005***	0.006*	0.011***
	(0.003)	(0.002)	(0.001)	(0.003)	(0.004)
dGCF	0.039***	−0.003	0.009***	−0.001	0.024***
	(0.008)	(0.002)	(0.003)	(0.004)	(0.007)
dGDPC	−0.001***	0.000**	−0.000***	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Hansen's value	0.24				
No. of panel	48				
Observations	250				

*, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively.

of control/additional variables. The outcome of these estimation is reported in panel C of Table 9[A-C].

The results from both panel A, B and C of Table 9[A-C] robustness tests are consistent with the main results, confirming that foreign direct investment has a significant negative influence on sustainable development, while sustainable development also exerts insignificant positive effect on foreign direct investment. By implication, multinational enterprises in Africa (MNE) contributes to the unsustainable path in the region either directly or indirectly through their externalities. The coherence of the direction and empirical significance of the parameters of the robustness test results certifies the robustness of the main GMM-panel VAR results of Table 6. Hence, the findings of the study are robust even to the estimation of different measures of sustainable development and foreign direct investment.

4.9. *Further analysis*

Upon confirming the robustness of the study results, the authors further conducted a subsample analysis to examine how the relationship between sustainable development and foreign direct investment will behave across countries at different stages of development. According to Ref. [104], the economic consequences of FDI do not accrue evenly across countries. In other words, the fundamental elements driving FDI activity are not consistent among nations at various phases of development [105]. Therefore, following the World Bank income group classification, we divide the whole sample into three categories, namely: low-income countries, middle-income countries, and high-income countries. The GMM-Panel VAR coupled with the granger causality test, impulse response function, and variance decomposition are rerun for the respective income grouping and reported in their separate tables below. The results of the GMM-panel VAR estimate for the respective income groups are offered in Table 10[A-C].

Panel A of the result in Table 10[A-C] indicates the relationship for the low-income group; Panel B displays that of the middle-income group, and Panel C signpost the high-income group. The results of the subsample income groupings are consistent with the results of the whole sample indicating that foreign direct investment exerts a significant negative impact on sustainable development. In contrast, sustainable development exerts a positive effect on foreign direct investment. Specifically, the income groupings estimation results indicate that the effect of FDI on sustainable development is negative and significant for low-income and middle-income but positive for high-income countries. However, the results of the high-income group should be considered or interpreted with caution due to the fear of small sample size bias. The difference in the results among the income group could be attributed to the fact that the high-income bracket countries have adequate absorptive capacities than the low and middle-income groups, enabling them to exploit FDI more efficiently. The use of somewhat sophisticated technology, ecological quality institutions, and improved domestic financial system in relatively high-income countries may have accounted for this relationship. This finding is consistent with [106], who document that nations with a higher sustainable development score have a higher income level.

Table 11[A-C] presents the causality analysis results across the various income groupings. Panel A of the result table indicates the relationship for the low-income group; Panel B displays that of the middle-income group, and Panel C signpost the high-income group. Consistent with the whole sample GMM-panel VAR granger causality test results, the high and middle income group subsample granger causality analysis reveals identical results suggesting a unidirectional causality flowing foreign direct investment to sustainable development across at 1 percent level of significance. However, a two-way causality can be assumed for the low-income countries, yet this outcome should be treated with caution owing to the fear of small sample size biasness.

We proceed to estimate the innovation accounting which comprise the impulse response function and the variance decomposition after establishing stability of the models for the respective income groups. Evidence from the stability graphs (Fig. 4[A-C]) affirm the stability of the estimates of the GMM-panel VAR across the panels as the modulus of eigenvalue values fall within the unit circle for all the panels. This suggests that inferences made from innovation accounting are identified and valid.

Panel A, B, and C of Fig. 5[A-C] below depict the impulse-response function for low-income, middle-income, and high-income countries, respectively. The results in Fig. 5[A-C] reveal that the effect of one standard deviation shock in the growth of FDI on sustainable development was negative, which appears briefly from the second year till the fourth year and then dissipates for the

Table 10
[A-C]:GMM-Panel VAR estimation results based on income groupings.

Panel A -Low-income countries

Response to	Response of				
Variables	$dFDI_t$	$dIQI_t$	dTO_t	$dFinFreed_t$	$dANS_t$
$dFDI_{t-1}$	−0.440***	−0.002	−0.068***	−0.010***	0.009
	(0.046)	(0.003)	(0.007)	(0.004)	(0.009)
$dFDI_{t-2}$	−0.221***	−0.018***	0.026**	−0.025***	−0.021***
	(0.031)	(0.005)	(0.010)	(0.005)	(0.006)
$dIQI_{t-1}$	−0.378***	−0.407***	−0.009	0.162***	0.354***
	(0.057)	(0.029)	(0.050)	(0.027)	(0.071)
$dIQI_{t-2}$	−0.513***	−0.029	−0.093	0.016	0.162**
	(0.054)	(0.020)	(0.066)	(0.029)	(0.075)
dTO_{t-1}	0.327***	−0.031***	0.271***	−0.046***	0.114***
	(0.021)	(0.006)	(0.051)	(0.011)	(0.023)
dTO_{t-2}	0.075***	−0.004	−0.155***	−0.019	−0.104***
	(0.025)	(0.011)	(0.032)	(0.020)	(0.022)
$dFinFreed_{t-1}$	0.166**	−0.045**	0.042**	−0.053*	−0.027
	(0.071)	(0.019)	(0.019)	(0.028)	(0.048)
$dFinFreed_{t-2}$	0.196***	−0.030***	−0.010	0.057**	−0.258***
	(0.046)	(0.011)	(0.018)	(0.022)	(0.042)
$dANS_{t-1}$	0.032	−0.066***	0.012	0.029**	−0.193***
	(0.032)	(0.010)	(0.016)	(0.011)	(0.038)
$dANS_{t-2}$	0.130***	0.004	−0.008	0.032***	−0.215***
	(0.021)	(0.009)	(0.015)	(0.011)	(0.022)
Hansen's value	0.447				
No. of panel	12				
Observations	180				

Panel B- Middle-income countries

Response to	Response of				
Variables	$dFDI_t$	$dIQI_t$	dTO_t	$dFinFreed_t$	$dANS_t$
$dFDI_{t-1}$	−0.343***	0.002	0.111***	−0.034*	0.019
	(0.059)	(0.009)	(0.016)	(0.018)	(0.038)
$dFDI_{t-2}$	0.059	0.007	0.046***	0.055***	−0.118***
	(0.045)	(0.008)	(0.014)	(0.014)	(0.038)
$dIQI_{t-1}$	−0.064	−0.051	0.028	−0.034	0.258**
	(0.085)	(0.045)	(0.048)	(0.082)	(0.103)
$dIQI_{t-2}$	−0.045	0.064*	0.054	0.098	−0.025
	(0.100)	(0.036)	(0.049)	(0.075)	(0.101)
dTO_{t-1}	−0.155*	−0.053*	−0.156***	−0.072	−0.096
	(0.094)	(0.031)	(0.053)	(0.050)	(0.102)
dTO_{t-2}	−0.258***	−0.158***	−0.157***	0.005	−0.092
	(0.084)	(0.034)	(0.040)	(0.048)	(0.077)
$dFinFreed_{t-1}$	−0.108***	−0.024	−0.009	−0.081	−0.008
	(0.041)	(0.019)	(0.021)	(0.056)	(0.052)
$dFinFreed_{t-2}$	−0.014	−0.016	−0.013	−0.062	−0.049
	(0.057)	(0.022)	(0.023)	(0.038)	(0.045)
$dANS_{t-1}$	−0.035	0.005	−0.035**	−0.023	−0.335***
	(0.052)	(0.013)	(0.016)	(0.022)	(0.050)
$dANS_{t-2}$	−0.041	−0.008	0.010	−0.001	−0.065
	(0.043)	(0.015)	(0.017)	(0.028)	(0.043)
Hansen's value	0.244				
No. of panel	24				
Observations	408				

Panel C-High income countries

Response to	Response of				
Variables	$dFDI_t$	$dIQI_t$	dTO_t	$dFinFreed_t$	$dANS_t$
$dFDI_{t-1}$	0.155***	0.038***	0.007	−0.093***	−0.022
	(0.032)	(0.009)	(0.010)	(0.022)	(0.018)
$dFDI_{t-2}$	−0.028	−0.012	−0.007	0.128***	0.083***
	(0.034)	(0.010)	(0.012)	(0.019)	(0.018)
$dIQI_{t-1}$	−0.101	−0.074**	0.028	0.111*	0.220***
	(0.074)	(0.037)	(0.036)	(0.059)	(0.085)
$dIQI_{t-2}$	−0.370***	−0.033	−0.004	−0.243***	0.097
	(0.080)	(0.032)	(0.039)	(0.057)	(0.062)
dTO_{t-1}	−0.041	0.070	−0.004	0.270***	−0.234***
	(0.104)	(0.045)	(0.036)	(0.048)	(0.079)
dTO_{t-2}	0.335***	0.113***	0.341***	−0.270***	−0.278***
	(0.111)	(0.030)	(0.031)	(0.048)	(0.066)
$dFinFreed_{t-1}$	−0.106***	0.038**	−0.030	−0.088**	0.146***

(*continued on next page*)

Table 10 (*continued*)

	(0.031)	(0.018)	(0.020)	(0.038)	(0.030)
$dFinFreed_{t-2}$	−0.034	−0.007	0.001	−0.033	−0.050*
	(0.033)	(0.015)	(0.013)	(0.026)	(0.027)
$dANS_{t-1}$	−0.069*	0.017	−0.039**	−0.010	−0.223***
	(0.036)	(0.016)	(0.018)	(0.020)	(0.042)
$dANS_{t-2}$	−0.103***	0.055***	0.036**	−0.072***	−0.317***
	(0.027)	(0.018)	(0.017)	(0.017)	(0.038)
Hansen's value	0.383				
No. of panel	12				
Observations	192				

GMM estimates a two-variable VAR model; country-time and fixed effects are removed before estimation. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

middle-income countries. At the same time, it is negative and lasts until the third period before it starts diminishing for the low-income countries. Conversely, as shown in the bottom left plot of panel A and B respectively, unlike the middle-income countries, shocks in sustainable development appears not to have a substantial influence on foreign direct investment in low-income countries.

The adverse effect of FDI on sustainable development recognized across the low and middle-income countries is consistent with the whole sample results, which indicate that foreign direct investment has a mitigation effect on sustainable development. However, the differences in the extent of the impact on sustainable development between the low-income and middle-income countries, as mirrored by panels A and B, can be attributed to the inherent absorptive capacity in the respective income countries that enables them to exploit FDI more efficiently. Low-income countries, unlike middle-income countries, have relatively very limited fiscal revenue and poor public management institutions leading to insufficient and inefficient supply and use of public goods and hence, low sustainability gains [107,108]. This finding agrees with [106] who assert that greater sustainable development scores are associated with higher income levels. It is also consistent with Panayotou [109], who argues that strong institutions and effective policies are required to reduce environmental costs when income levels are low but speed up improvements when income levels are high.

Panel C of Fig. 5[A-C] shows the impulse response function for the sample restricted to high-income countries. This result should be interpreted with caution because of the limited sample size, which might suffer small sample size biases. Unlike the results reported from the low and middle-income countries, the effect of one standard deviation shock in the growth of FDI on sustainable development was instantaneously positive for high-income countries. The favorable or positive impact of FDI on sustainable development reaffirms the assertion that nations with higher sustainable development scores tend to have greater income levels [110]. It also suggests that high-income countries have far better absorptive capacity than low and middle-income countries, which enables them to exploit FDI more efficiently for utmost gain. Thus, the disparities in the effect of FDI on the various income categories might also be related to the variances in environmental regulatory enforcement and production methods employed across income levels. Whereas high-income nations may use energy-efficient industrial technologies and implement strong environmental restrictions, low-income and middle-income countries may loosen environmental laws to attract FDI.

In sum, these results are consistent with those of [104,105,110], who argue that the economic consequences of FDI do not accrue evenly across countries at a different level of development. Specifically, the subsample income group results consistent with the total sample indicate that foreign direct investment inflow exerts negative consequences on sustainable development in African nations. Nonetheless, FDI exerts a favorable effect on sustainable development in the high-income countries in the region. The conceivable explanation for the disparities in the impact of FDI on the different income groups might be attributable to variances in the absorptive capacity, such as the environmental regulatory enforcement and production methods employed across income levels. The outcome of the variance decomposition of the subsample income-level brackets affirms the robustness of these results.

Conclusively, we explore the variance decomposition analysis to assess the relative magnitude or percentage of either sustainable development or foreign direct investment in account for changes in each variable across the various income bracket. Panel A of Table 12 [A-B] if shows the percentage response of sustainable development to the shock of itself and foreign direct investment across the income level bracket. In contrast, panel B shows the percentage response of foreign direct investment to the shock of itself and sustainable development across the various income groups. The results from the error variance decomposition indicate that besides the bulk explanation of sustainable development by itself, foreign direct investment account approximately for 14%, 8%, and 6% variation in the sustainable development of the low-income, middle-income, and high-income countries, respectively, confirming the uneven economic consequences of FDI accruing to nations at varying developmental stages [104,105,110]. The results also emphatically confirm the differences in the magnitude of the negative impact of FDI on sustainable development between the low-income and middle-income groups envisaged in the impulse response function of Fig. 5[A-C]. Thus, consistent with the IRF analysis, FDI account for more variations in the sustainable development of low-income countries with 14% than the middle income with 8%. On the flip side, sustainable development explains slightly 0.01%, 0.4 %, and 3% of the variations in foreign direct investment for the low-income, middle-income, and high-income countries, respectively, while the significant variation in FDI is accounted for by itself across the income groups.

5. Conclusion

To investigate the causal relationship between sustainable development and foreign direct investment, we employ the GMM-PVAR

Table 11
[A-C]:Subsample GMM-Panel VAR Granger causality test.

Direction of causality	Chi-square statistics	Degree of freedom	Probability
Panel A -Low-income countries			
dANS → dFDI	40.776	2	0.000***
dFDI → dANS	14.259	2	0.001***
dANS → dIQI	51.286	2	0.000***
dIQI → dANS	28.843	2	0.000***
dANS → dTO	0.912	2	0.634
dTO → dANS	33.991	2	0.000***
dANS → dFinFreed	12.239	2	0.002***
dFinFreed → dANS	38.388	2	0.000***
dIQI → dTO	9.203	2	0.010*
dTO → dIQI	28.166	2	0.000***
dIQI →dFinFreed	48.974	2	0.000***
dFinFreed → dIQI	11.114	2	0.004***
dTO → dFinFreed	16.791	2	0.000***
dFinFreed → dTO	5.659	2	0.059*
dFinFreed → dFDI	20.089	2	0.000***
dFDI → dFinFreed	28.886	2	0.000***
dFDI → dIQI	19.412	2	0.000***
dIQI→ dFDI	90.090	2	0.000***
dFDI → dTO	96.709	2	0.000***
dTO→ dFDI	245.482	2	0.000***
Panel B- Middle-income countries			
dANS → dFDI	1.386	2	0.500
dFDI → dANS	33.159	2	0.000***
dANS → dIQI	0.500	2	0.779
dIQI → dANS	1.743	2	0.418
dANS → dTO	5.894	2	0.052*
dTO → dANS	11.815	2	0.000***
dANS → dFinFreed	0.049	2	0.976
dFinFreed → dANS	10.808	2	0.004***
dIQI → dTO	0.144	2	0.931
dTO → dIQI	11.329	2	0.003***
dIQI →dFinFreed	9.019	2	0.000***
dFinFreed → dIQI	0.711	2	0.701
dTO → dFinFreed	5.115	2	0.078*
dFinFreed → dTO	3.039	2	0.219
dFinFreed → dFDI	10.808	2	0.004***
dFDI → dFinFreed	7.540	2	0.023**
dFDI → dIQI	1.521	2	0.467
dIQI→ dFDI	0.695	2	706
dFDI → dTO	52.789	2	0.000***
dTO→ dFDI	20.445	2	0.000***
Panel C-High income countries			
dANS → dFDI	0.982	2	0.612
dFDI → dANS	12.264	2	0.002***
dANS → dIQI	0.827	2	0.661
dIQI → dANS	4.762	2	0.092*
dANS → dTO	0.701	2	0.704
dTO → dANS	0.111	2	0.946
dANS → dFinFreed	1.143	2	0.565
dFinFreed → dANS	0.458	2	0.795
dIQI → dTO	0.473	2	0.790
dTO → dIQI	20.339	2	0.000***
dIQI →dFinFreed	5.529	2	0.063*
dFinFreed → dIQI	0.432	2	0.806
dTO → dFinFreed	0.593	2	0.743
dFinFreed → dTO	0.123	2	0.940
dFinFreed → dFDI	2.170	2	0.338
dFDI → dFinFreed	16.573	2	0.000***
dFDI → dIQI	9.706	2	0.008***
dIQI→ dFDI	0.341	2	0.843
dFDI → dTO	2.231	2	0.328
dTO→ dFDI	6.810	2	0.033**

*, **, and *** denote 10%, 5%, and 1% levels of significance, respectively.

model for a balanced panel of forty-eight African countries from 1990 to 2020. Sustainable development was proxied by Adjusted Net Saving (ANS). In addition, following the recommendation of Curran (2017), the study constructed the sustainable economic growth (SEG) index, as an alternate measure of sustainable development that also touches the three main pillars of sustainable development.

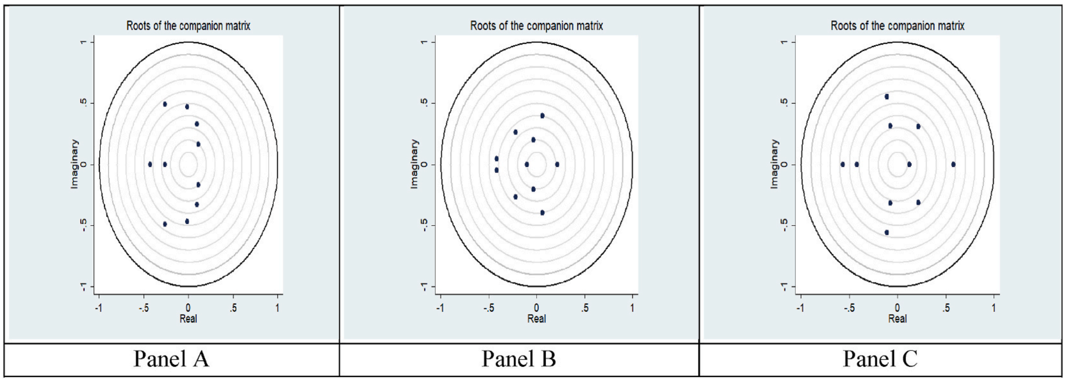


Fig. 4. [A-C]: Module stability for subsample income group analysis.

Foreign direct investment is measured with FDI net inflow as a percentage of GDP while the stock of FDI as a fraction of GDP was employed as an alternate measured for robustness test. As part of the study empirical explorations, subsample analysis was conducted to examine how the relationship between sustainable development and foreign direct investment will behave across countries at different stages of development.

The empirical findings from the GMM-PVAR uncovers that foreign direct investment have a significant negative influence on sustainable development, but sustainable development exerts an insignificant positive effect on foreign direct investment. In line with this outcome, the GMM-PVAR granger causality test established a unidirectional or one-way causality flowing from foreign direct investment to sustainable development. The robustness or sensitivity test submits that the study's findings are robust even to estimating different measures of sustainable development and foreign direct investment. Additionally, the subsample income group analysis submits consistent results with the total sample indicating that foreign direct investment exerts negative causal consequences on sustainable development in African nations; however, the magnitude of the adverse impact is pronounced in the low-income nations. Nevertheless, FDI exerts a favorable causal effect on sustainable development in the high-income countries in the region.

The study suggests some policy prescriptions for policymakers in Africa in light of the results. First and foremost, African governments and policymakers should prioritize high-quality or 'green' FDI in their pursuit to attract more foreign direct investment into their respective countries. Since the potential economic benefits of FDI may be ballast by potential socio-ecological costs, as FDI may occur concurrently with rising environmental degradation leading to unsustainable development. Thus, countries in Africa should be more selective or cautious in the sort of FDI entering their land to maximize the benefits of FDI for promoting SD while mitigating its negative externalities on the ticket of its growth-promoting tendency. Second, along with this, authorities in the African nations should also incorporate incentives for FDI inflows into cleaner areas of the economy to ensure long-term development. For instance, the government can establish tax-cut among other incentives for foreign investment geared toward these cleaner industries or sectors to accelerate the region's rate of attaining sustainable development. Lastly, nations in Africa at different development or income levels must plan differently to absorb the maximum gains of FDI for their respective lands to stimulate sustainable development since FDI has varying consequences on economics at varied ends of development. For instance, policymakers should design strong institutional policies and effective systems necessary to minimize the socio-environmental costs of FDI when income levels are low but to accelerate environmental improvement when income levels are high.

Despite the study's innovation and robustness, policymakers should take caution when applying the study recommendations since we mainly analyze the causal link between sustainable development and foreign direct investment in this study. Although, the study offered possible reasons underlying these interactions or findings, it would be more insightful to empirically exploit these underlying reasons such as the absorptive capacities of the host countries. Moreover, the study's focus on African nations may restrict the applicability of the findings to other regions. Therefore, we leave this for future research project that will be covered in other studies.

Data availability statement

The datasets used and/or analyzed during the current study are publicly available in different sources cited in the reference of the paper.

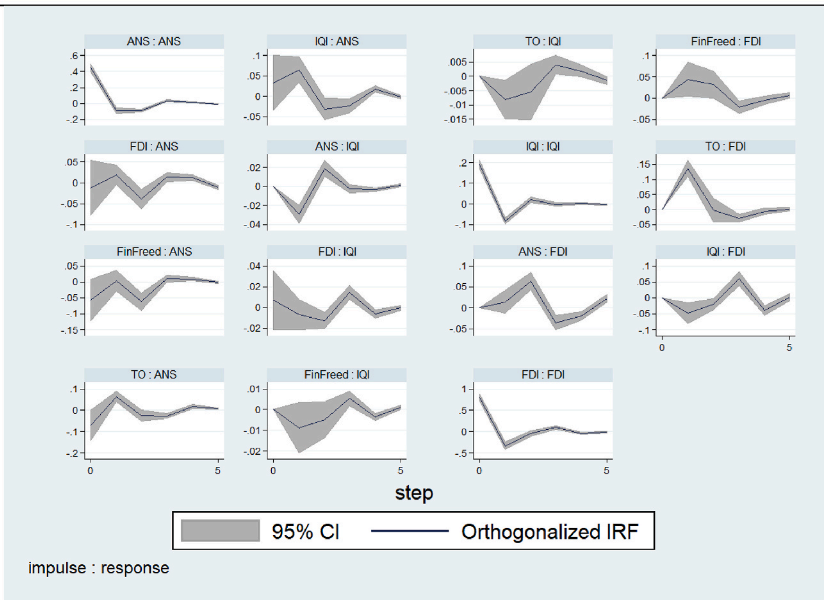
Ethics approval and consent to participate

Not applicable.

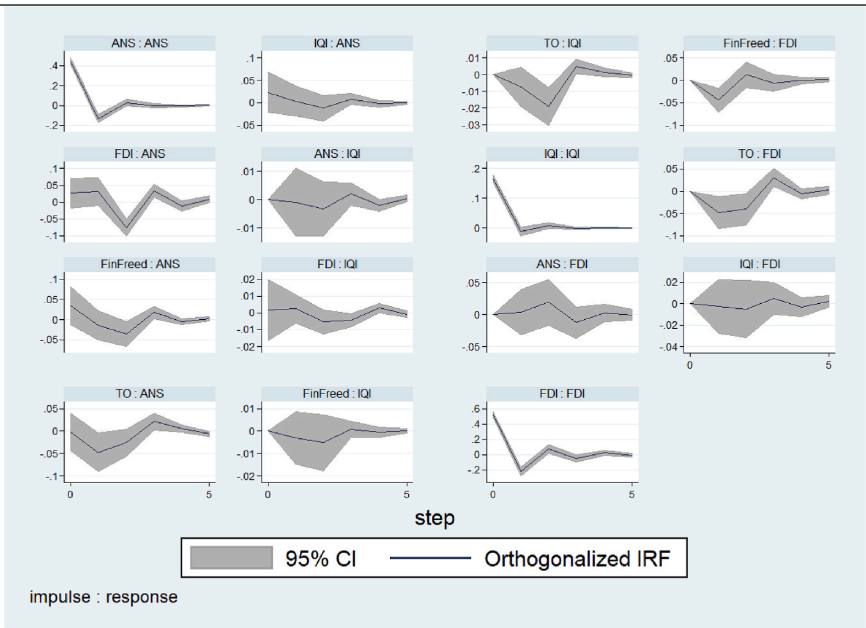
Conflicts of interest/competing interests

The authors declare that they do not have any competing interests.

Panel A -Low-income countries



Panel B- Middle-income countries



Panel C-High income countries

Fig. 5. [A-C]: Impulse response function for subsample analysis-income bracket.

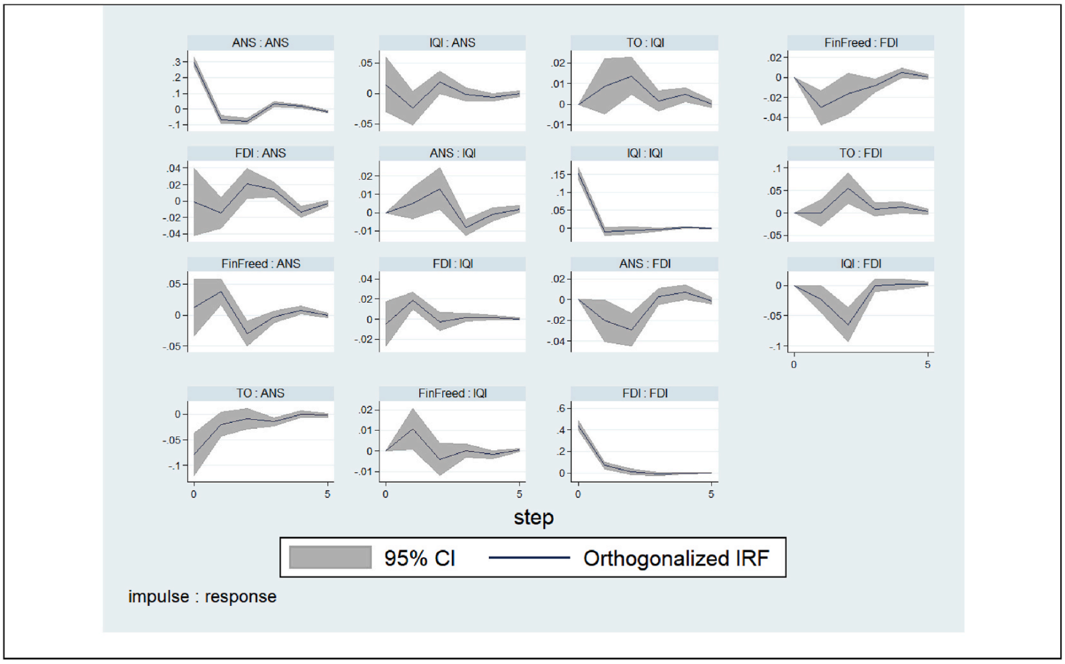


Fig. 5. (*continued*).

Table 12
[A-B]: Variance decomposition of the subsample income-level brackets.

Forecast Horizon	Low-Income Countries Impulse Variable		Middle-Income Countries Impulse Variable		High-Income Countries Impulse Variable	
	ANS	dFDI	ANS	dFDI	ANS	dFDI
Panel A	Response on ANS		Response on ANS		Response on ANS	
2	0.8814155	0.1185845	0.9642662	0.0357338	0.9413182	0.0586818
4	0.8696522	0.1303478	0.9197277	0.0802723	0.9397679	0.0602321
6	0.8677224	0.1322776	0.9178438	0.0821562	0.9375437	0.0624563
8	0.8671152	0.1328848	0.9176716	0.0823284	0.9370501	0.0629499
10	0.8568952	0.1431048	0.9165835	0.0834165	0.9361783	0.0638217
Panel B	Response on dFDI		Response on dFDI		Response on dFDI	
2	0.0001299	0.9998701	0.0030314	0.9969686	0.0296757	0.9703243
4	0.0001303	0.9998697	0.0037311	0.9962689	0.0304523	0.9695477
6	0.0001307	0.9998693	0.0039761	0.9960239	0.0312217	0.9687783
8	0.0001315	0.9998685	0.0041193	0.9958807	0.0338649	0.9661351
10	0.0001479	0.9998521	0.0043267	0.9956733	0.0342043	0.9657957

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Code availability

The codes used during the current study are available on reasonable request.

CRediT authorship contribution statement

Benedict Arthur: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Mallika Saha:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Francis Atta Sarpong:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation, Conceptualization. **Kumar Debasis Dutta:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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