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Does Import of Information and Communications Technology (ICT) Goods Foster Sustainable Economic Development in Sub-Saharan Africa? The Role of Governance Quality

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Abstract

This paper examines the relationship between sustainable economic development and the import of information and communications technology (ICT) goods (MICTG) across 32 Sub-Saharan African (SSA) countries between 2000 and 2020, contributing to the broader discourse on achieving Sustainable Development Goals within the region. Utilizing a computed Sustainable Economic Development Index (SEDI), we assess the role of governance quality, categorized into political, institutional, and economic dimensions, in moderating the impact of ICT goods imports on sustainable economic development outcomes. Fixed-effects and instrumental variables two-stage least squares estimation results reveal that MICTG exerts a significantly negative influence on sustainable economic development, while governance quality across all dimensions positively influences SEDI. Our findings highlight the pivotal role of institutions in mitigating the adverse effects of ICT imports, although improvements in governance frameworks may not yield immediate positive development outcomes. Policy implications suggest the urgent need for SSA countries to strengthen institutional governance to create an environment where ICT imports can foster sustainable growth.

Categories: Innovation Economics, Sustainable Economic Development, Trade and economic development
Keywords: import of ict goods, sdgs, sub-saharan africa, fixed-effects, iv-2sls
JEL Classifications: Q01, F19, F63, G30

Introduction

The motivation for this study, which investigates the nexus between sustainable economic development and the importation of information and communications technology (ICT) goods in Africa, is driven by three principal factors. First, the 2024 Sustainable Development Report underscores a growing disparity in Sustainable Development Goal (SDG) progress, noting that "the gap between the world average SDG Index score and that of poor countries ... is larger in 2023 than it was in 2015" [1]. Second, 14 Sub-Saharan African countries are identified as having significant potential for science, technology, and innovation (STI) strategies aimed at advancing the SDGs, backed by political stability and established STI frameworks [2]. Third, significant gaps remain in the existing literature regarding this relationship and governance quality's role.

The SDGs (Figure *1*) have been adopted as universal targets to be achieved by 2030[3]. Yet, their realization at the national level demands clear benchmarks, public engagement, strategic goal-setting, and practical implementation mechanisms. Research on this subject has yielded varied results, with scholars suggesting that country-specific approaches to SDG actions are shaped by unique circumstances and external factors [4]. Nonetheless, collaboration remains crucial for balancing economic growth with ecological constraints, fostering equitable and sustainable development [5,6]. Improved governance and strategic partnerships are also essential to enhance economic growth [7]. The relationship between social and environmental SDGs and economic growth presents mixed findings. While some studies suggest that social and environmental goals may negatively correlate with short-term economic growth [8], they are also shown to positively influence economic objectives, promoting entrepreneurship and competitiveness [9]. This suggests that although sustainability initiatives may initially slow growth, they contribute to long-term economic resilience. Furthermore, pursuing sustainable socio-economic development is inherently tied to environmental sustainability, emphasizing the need for coordinated innovation and the involvement of diverse stakeholders to ensure balanced progress [10]. Effective environmental policies, such as urban environmental management and developing a circular economy, are vital for advancing sustainable development [11]. These findings highlight the interconnected nature of sustainable development's economic, social, and environmental dimensions, necessitating a comprehensive approach to achieving the SDGs by 2030. This study adopts the systems approach first introduced by Barbier [12], which identifies three critical systems for development: economic, environmental, and social. Given that the Africa SDG Index and Dashboards Report 2020 identifies SDG 13 (Climate Action) as the only goal where most African nations are on track [13], the focus here will be on the economic aspect of sustainable development.

The rapid growth of the digital economy has sparked significant scholarly debate regarding the role of ICT as a driver of innovation and technological advancement, particularly its impact on sustainable development. Numerous studies have demonstrated that ICT accessibility, investment, and development have a positive influence on various aspects of sustainable development, including performance outcomes [14], innovation [15], energy sustainability [16], the digital economy [17], and overall economic growth[18], while also enhancing sustainability more broadly [19]. Furthermore, advancements in digital trade have been found to contribute positively to achieving the SDGs, particularly in the social and environmental dimensions [20]. This underscores the need to further examine ICT's role in advancing the SDGs. The Africa SDG Index and Dashboards Report [21] reveal regional disparities, with Northern Africa leading in SDG progress while Central Africa lags. Daniels et al. [2] also highlight these uneven advancements, particularly in Sub-Saharan Africa (SSA), underscoring the need for further research in this region. Notably, the literature lacks studies specifically addressing the effects of ICT goods imports on achieving the SDGs. This study seeks to fill this gap in several ways. First, it analyzes SSA's progress toward the SDGs, focusing on economic sustainability. Second, it controls for potential bidirectional causality between ICT goods imports and sustainable economic development, empirically assessing the impact of ICT imports on financial sustainability. Third, it examines the role of governance in shaping this relationship.

FIGURE 1: The 17 Sustainable Development Goals

Source: https://sdgs.un.org/goals

The rest of the paper is organized as follows. The research method includes the theoretical framework, literature review, methodology, and data. The results are then presented, followed by a discussion. Finally, the conclusion is provided.

Research Method

Theoretical framework

Sustainable Economic Development

Barbier [12] suggests that "sustainable economic development" is indirectly related to aggregate economic growth, typically at the national level. However, he emphasizes that for development to be truly sustainable, it must also encompass both social and ecological dimensions. Barbier advocates for adopting a "systems approach" (Figure *2*), which conceptualizes sustainability as the intersection of three interrelated systems: economic, social, and environmental. This study adopts this framework, focusing on the economic dimension of sustainability.

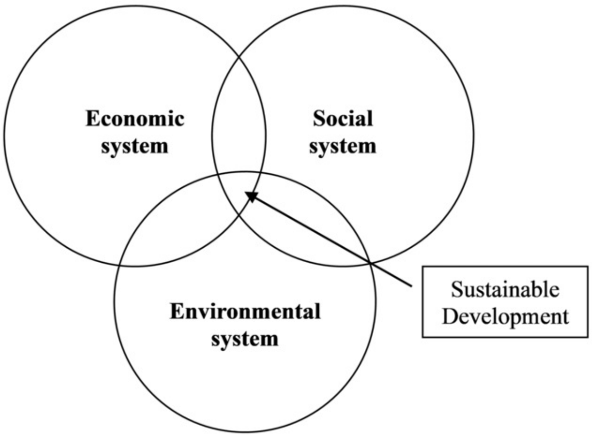

FIGURE 2: The system approach to sustainability

Source: Barbier and Burgess et al. [22]

ICT Goods Imports and Sustainable Development

The impact of ICT goods imports on sustainable development can be understood through two critical economic theories. First, the “international trade theory” [23] emphasizes the advantages of trade in goods and services, including its contributions to sustainable development [24]. For example, Jiahao et al. [25] find that simplifying trade procedures effectively promotes sustainable economic growth in SSA. Similarly, Sarwar et al. [26] show that increased trade openness and other related factors help reduce carbon emissions. In the context of digital trade, Jiang and Usman [27] identify a significant negative relationship between digital trade and carbon emissions, underscoring its role in advancing carbon neutrality in heavily polluted economies. Anukoonwattaka et al. [20] also highlight a positive relationship between digital trade growth and progress toward SDG targets, particularly in the social and environmental dimensions, further supporting the need to evaluate ICT's impact on economic sustainability. Second, Rogers’ “diffusion of innovations theory” [28] offers insights into how new technologies, such as ICT, are adopted and spread across societies and economies. This theory provides a valuable framework for understanding the potential of ICT to drive economic and social transformation when effectively integrated [19]. For instance, the growing number of mobile phone users in SSA illustrates how ICT diffusion can accelerate progress toward the SDGs by improving access to information [15], enhancing education [29], and healthcare [14], and promoting environmentally sustainable practices [30]. As a result, the increased presence of ICT goods in an economy is expected to influence sustainability outcomes positively.

The discussion above demonstrates the potential effects of ICT goods imports on sustainable economic development. However, a literature review suggests that ICT and sustainable development form a dynamic and interdependent system. Sustainable development plays a pivotal role in shaping ICT by prioritizing balanced economic, social, and environmental progress. The transition to a sustainable economic model necessitates technological innovation and an emphasis on knowledge-based industries, driving the growth of ICT sectors. For instance, Onofrei and Cigu [31] stress the importance of regional strategies and partnerships aligned with sustainability goals, fostering entrepreneurship and innovation, which are closely linked to ICT advancements. Similarly, the shift toward a knowledge-based economy, as observed in the Gulf Cooperation Council countries [32], highlights how sustainable development frameworks encourage the growth of engineering and technological sectors. The demand for environmentally friendly industrial processes, as noted by Prysyazhnyuk and Mikhel [10], also fosters the development of ICT tools that monitor and mitigate environmental impacts. D’Adamo et al. [33] further illustrate the role of digital transformation in achieving sustainability goals, emphasizing how sustainable development drives the integration of digital solutions to enhance business environments and economic growth. In conclusion, sustainable development not only fosters ICT innovation but also ensures that technological progress aligns with broader economic, social, and environmental goals. Therefore, the import of ICT goods is closely tied to sustainable economic development.

Governance Quality and Sustainable Development

The work of McGuire and Olson[34] provides significant insights into how various governance structures, from autocratic to democratic systems, influence economic performance. Similarly, Stojanović et al. [35] emphasize the theory of "good governance," suggesting that its impact on sustainable development differs based on the chosen indicators and the specific group of countries under consideration. Recent studies confirm that governance plays a crucial role in shaping economic growth across Africa [36], as well as in advancing SDGs by affecting the efficacy and scope of policy initiatives. For example, Atukunda et al. [37] identify weak governance and state fragility as major obstacles to achieving SDG 2 (Zero Hunger) in Africa, underscoring the importance of strengthening governance to address food insecurity and promote sustainable development. Furthermore, the effectiveness of governance is vital for overcoming political and economic challenges related to implementing climate-smart agriculture in Eastern Africa, as it influences how nations balance food security and climate objectives while advancing the SDGs [38]. Inefficiencies arising from poor governance, such as land mismanagement, further delay progress toward sustainable development [39]. Therefore, governance quality has a direct impact on sustainable economic development.

Moreover, governance quality moderates the relationship between ICT imports and sustainable development. Strong governance-characterized by transparency, accountability, and robust regulatory frameworks-ensures that ICT adoption aligns with broader sustainability goals. For example, Africa's digital transformation efforts are more successful in countries with better governance, where supportive regulatory environments and multilateral cooperation foster sustainable development [40]. In sectors like energy consumption and climate action, governance elements such as accountability and the rule of law enhance the positive impact of ICT on sustainability outcomes [41]. Conversely, weak governance can lead to resource misallocation, reduced transparency, and hindered progress toward sustainability. Technological advancements in ICT, such as blockchain and artificial intelligence, further affect the governance-sustainable development relationship by promoting transparency, efficiency, and environmental sustainability [42]. However, if governance frameworks fail to adapt to rapid technological changes, they may struggle to fully leverage ICT's potential for sustainable development [43]. Therefore, governance is pivotal in shaping how ICT imports contribute to sustainable economic development.

Building on this foundation, the present study examines the effect of ICT goods imports on sustainable economic development in SSA, with a particular focus on the moderating role of governance quality in this relationship.

Literature Review of Sustainable Development in Africa

The review begins by examining the existing literature on sustainable economic development in SSA with a focus on ICT-related research. The findings from current studies on how ICT factors influence sustainable economic growth in the region present mixed outcomes. Onginjo and Mei [44] stress the importance of ICT infrastructure in advancing both social and economic sustainability, noting that a robust ICT framework can serve as a catalyst for broader development initiatives. In contrast, Dzator et al. [45] provide a more complex view, arguing that while mobile phone penetration can reduce poverty, internet and broadband access may increase poverty if not accompanied by policies on income redistribution and improved credit access. This highlights the need for holistic ICT policies that integrate broader economic strategies to ensure sustainable development. Adejumo et al. [46] further affirm the positive impact of technology-driven growth, particularly through mobile networks and ICT advancements, in transforming key socio-economic indicators like poverty and unemployment. Guzikova and Bitchoga [47] explore the role of mobile technology in fostering economic growth, finding a positive relationship between mobile subscriptions and revenue generation and emphasizing the transformative potential of 5G technology for economic performance. Together, these studies indicate that ICT-related variables are critical to achieving economic sustainability in SSA. However, there remains a gap in the literature regarding the specific role of ICT goods imports in driving sustainable economic development.

The review then turns to key factors influencing the non-economic dimensions of sustainable development in Africa. Kunkel and Matthess [48] point out that ICT policies in SSA and East Asia often focus on the indirect environmental benefits of ICT, such as improved energy efficiency and resource management, while underestimating direct negative effects like increased electricity consumption. This underscores the need for a more balanced approach to integrating ICT into environmentally sustainable industrial practices. Chindengwike [49] and Slimani et al. [50,51] highlight the crucial role of external financial assistance, such as grants, in supporting sustainable development efforts, emphasizing their importance in achieving sustainability goals. While international capital flows, including foreign direct investment (FDI) and remittances, positively impact economic and social sustainability, they pose challenges to environmental sustainability. The studies argue that the effective diffusion of ICT, combined with strong governance, can amplify the positive effects of international capital while minimizing its environmental drawbacks, promoting a more balanced approach to sustainable development. Despite the emphasis on governance in advancing sustainability goals through ICT and financial support, these studies do not address the specific role governance quality plays in the relationship between ICT goods imports and sustainable economic development.

Research hypothesis

Building on the theoretical foundation and the identified gaps in the literature, we propose a conceptual model (Figure *3*) to evaluate the relationship between ICT goods imports and sustainable economic development in SSA. Additionally, the model examines how governance quality influences this relationship. The following hypotheses are formulated:

H1: ICT goods imports directly and positively impact sustainable economic development in SSA.

H2: Governance quality directly and positively influences sustainable economic development in SSA.

H3: Governance quality moderates the relationship between ICT goods imports and sustainable economic development in SSA, potentially mitigating its negative effects.

H4: Sustainable economic development fosters increased imports of ICT goods in SSA.

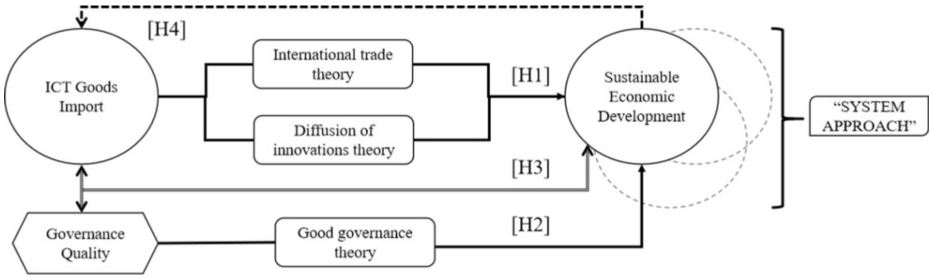

FIGURE 3: Conceptual model of the study

Source: Authors

Data and variable selections

To empirically test the hypotheses outlined in the previous section, we draw on a panel dataset comprising 32 Sub-Saharan African countries (listed in Appendix Table *11*) from 2000 to 2020. The choice of countries and time frame is primarily dictated by data availability, ensuring consistency and coverage for key variables related to ICT goods imports, governance quality, and sustainable economic development.

Dependent Variables

A suitable index for the sustainable economic development variable is essential for developing a robust assessment framework to evaluate progress. In alignment with the 2030 Agenda for Sustainable Development and its 17 SDGs (Figure *1*), and building upon the works of Costanza et al.[52], Barbier and Burgess [53], and Dhahri et al. [54], as well as Slimani et al. [51], we have identified several indicators relevant to sustainable economic development (Table *1*). Subsequently, we construct a composite index consolidating these indicators to measure progress toward sustainable economic development goals effectively.

Goals	Names	Targets	Indices	Signs
n.1	No Poverty	End poverty in all its forms, everywhere	Poverty headcount ratio at $1.90 a day (2011 purchasing power parity) (of population)	-
n.2	Zero Hunger	End hunger, achieve food security and improved nutrition, and promote sustainable agriculture	Prevalence of undernourishment (% of population)	-
n.3	Good Health and Well-being	Ensure healthy lives and promote well-being for all at all ages	Delivery under the care of skilled medical staff (% of total)	+
n.6	Clean Water and Sanitation	Ensure available and sustainable management of water and sanitation for all	People using at least basic drinking water services (% of population)	+
n.7	Affordable and Clean Energy	Ensure access to affordable, reliable, sustainable, and modern energy for all	Access to clean fuels and technologies for cooking (% of population)	+
n.8	Good Jobs and Economic Growth	Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all	GDP per capita growth (annual %)	+
n.9	Industry, Innovation and Infrastructure	Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation	Manufacturing, value added (% of GDP)	+

TABLE 1: Sustainable economic development goal indicators

GDP: gross domestic product

The unique composite indicator is built based on the entropy weighting method as utilized in various literature [55,56]. It leverages the principles of information entropy to quantify the uncertainty and dispersion of each indicator. By analyzing how much information each indicator contributes, the entropy value assigns weights objectively, thus mitigating subjectivity and avoiding the overlap of information among indicators [57]. The improved version of the entropy method further enhances accuracy by standardizing raw data, which addresses extreme or negative values that could distort measurements. This refinement ensures that the composite indicator reflects a more precise and credible assessment of the evaluated variables, making the entropy method a highly reliable tool in research for integrating diverse data sources into a cohesive evaluation framework [58]. The specific steps are as follows:

Step 1: Indicators standardization - we use the two equations below to standardize the chosen indicators above:

$$X_{t,i,j} = 1 - \frac{x'_{t,i,j} - x'_{i_{\min},j}}{x'_{i_{\max},j} - x'_{i_{\min},j}} \quad \text{.... (1)}$$

$$X_{t,i,j} = \frac{x'_{t,i,j} - x'_{i_{\min},j}}{x'_{i_{\max},j} - x'_{i_{\min},j}} \quad \text{.... (2)}$$

where $X_{t,i,j}$ is the standardized value for goal j measured for country i in year t. $x_{i'\_\max,j}$ and $x_{i'\_\min,j}$ are the maximum and minimum values for the observed goal j measured for country i in the whole period considered. Equation (1) is used for goals 1 and 2 because a higher value of their observation indicates negative progress toward the sustainable economic development goal.

Step 2: Indicators normalization - because the entropy weighting method involves logarithms, and we have 0 values after standardization, therefore, we shift the value by adding one unit to all standardized indicators to avoid undefined values:

$$X'_{t,i,j} = X_{t,i,j} + 1 \quad \text{.... (3)}$$

Step 3: Computing the proportion value for each indicator observed - we calculate the proportion of each indicator relative to the sum of the indicator across countries for each year (n = 32 countries * 21 years: the number of the observed values for j^{th} goal indicators for each country i at time j):

$$P_{t,i,j} = \frac{X'_{t,i,j}}{\sum_{t=1}^{n} X'_{t,i,j}} \quad ....(4)$$

Step 4: Computing the information entropy value for each indicator:

$$e_{t,i,j} = \frac{\sum_{t=1}^{n} P_{t,i,j} \times \ln(P_{t,i,j})}{\ln(n)} \quad .... (5)$$

Step 5: Computing the redundancy of each j^{th} goal indicator:

$$d_{t,i,j} = 1 - e_{t,i,j} \quad .... (6)$$

Step 6: Weighting for each indicator (we have k = 7 indicators: goal 1, goal 2, goal 3, goal 6, goal 7, goal 8, goal 9):

$$W_{t,i,j} = \frac{d_{t,i,j}}{\sum_{j=1}^{k} d_{t,i,j}} \quad .... (7)$$

Step 7: Building the composite index using the weight and the following equation:

$$SEDI_{t,i} = \sum_{j=1}^{k} W_{t,i,j} \times X'_{t,i,j} \quad .... (8)$$

where, $\mathrm{SEDI}_{t,i,j}$ is the sustainable economic development index (SEDI) for country i in year t. $W_{t,i,j}$ is the calculated weight for indicator j and $X'_{t,i,j}$ is the normalized observation of indicator for each country, each year. Table *2* shows the result of the above calculation. We can see that the indicator assigned to Goal 7 contributes the most to all of the indicators included in our SEDI.

Goals	Names	Targets	Weights
n.7	Affordable and Clean Energy	Ensure access to affordable, reliable, sustainable, and modern energy for all	0.257
n.1	No Poverty	End poverty in all its forms everywhere	0.180
n.9	Industry, Innovation and Infrastructure	Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation	0.155
n.6	Clean Water and Sanitation	Ensure available and sustainable management of water and sanitation for all	0.154
n.3	Good Health and Well-Being	Ensure healthy lives and promote well-being for all at all ages	0.132
n.2	Zero Hunger	End hunger, achieve food security and improved nutrition and promote sustainable agriculture	0.100
n.8	Good Jobs and Economic Growth	Promote sustained, inclusive, and sustainable economic growth, full and productive employment and decent work for all	0.021

TABLE 2: Results of the entropy weighting method

Independent Variables

Several critical factors identified in the literature review support the choice of "ICT goods imports (% of total goods imports)" (*MICTG*) as a key explanatory variable for sustainable economic development. The "M" in the acronym refers to Imports, indicating that the data pertains to the importation of ICT goods into a country, as opposed to exports. This convention is widely used to standardize the classification of trade data across countries and organizations.

ICT goods, defined as products primarily intended to facilitate information processing and communication through electronic means (including transmission and display [59]), encompass computers, telecommunications equipment, and electronic components, all of which are essential for the dissemination of technology. Additionally, the importation of these goods plays a crucial role in transitioning to a knowledge-based economy, a fundamental aspect of achieving long-term economic sustainability. As illustrated in Figure *4*, the average value of ICT goods imports in the sample countries significantly surpasses that of exports, a trend that is not unexpected given the limited capacity of domestic industries in SSA to produce these products. To the best of our knowledge, this article represents the first effort to investigate the role of ICT goods imports in promoting sustainable economic development within the context of SSA.

The second core independent variable is governance quality, which we define using the framework proposed by Kaufmann et al. [60], who describe governance as "the traditions and institutions by which authority in a country is exercised." Following the works of Asongu and Nwachukwu [61], Omri et al. [62], and Asongu and Odhiambo [63], we employ three proxies for governance quality: political governance (PG), which include political stability, absence of violence or terrorism, and voice and accountability, reflecting how authorities are selected and replaced; institutional governance (IG), which encompasses the rule of law and control of corruption, indicating the regulation of interactions between the state and citizens; and economic governance (EG), which covers regulatory quality and government effectiveness, highlighting how policies are formulated and implemented. Unlike existing literature, we assign equal weight to each indicator within the governance quality proxies, as the values of each observation are already standardized, and the quality of each proxy is determined by the indicators it comprises.

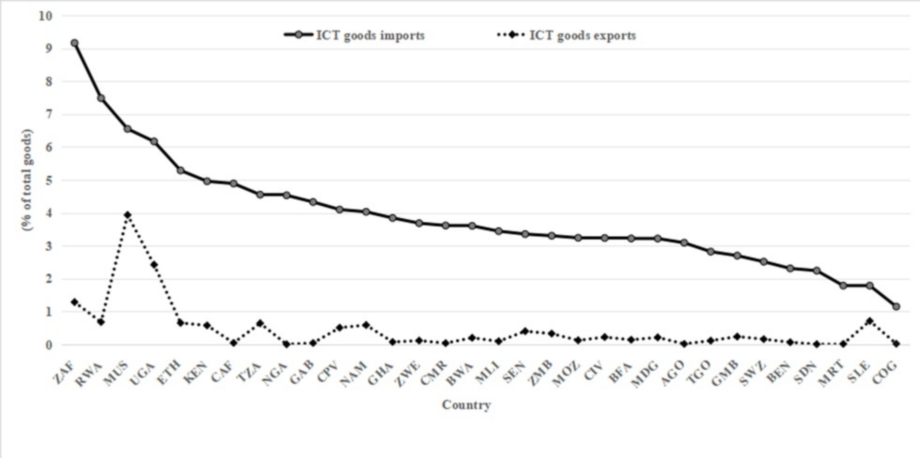

FIGURE 4: ICT goods import and export as % of total goods (average value of 2000-2020)

Source: World Bank Development Indicator

Control Variables

To appraise the relationship between the import of ICT goods and sustainable economic development and to correct variable omission bias, we introduce into our basic model five variables that have been identified as important determinants of sustainable development. According to the existing literature, we introduce population growth [64,65], FDI [50,51,66], logistic performance index [67], unemployment rate, and natural resources rents (to account for the social and environmental part of the system, respectively, as seen in Figure *2*). Table *3* indicates the definitions and sources of the selected variables above.

Variables	Names (codes)	Definitions	Sources
Dependent	Sustainable Economic Development Index (SEDI)	Based on [68]: higher value indicates progress toward sustainable economic development goals	WDI, Entropy
Independent	ICT goods imports (MICTG)	Share of ICT goods as a percentage of total imports trade (%)	UNCTAD
	Political governance (PG), Institutional governance (IG), and Economic governance (EG)	Based on [59]: measured on a scale of -2.5 to 2.5, with values close to 2.5 indicating better governance outcomes and vice versa	WGI
Controls	Population growth (POPG)	Population growth rate (annual %)	WDI
	Foreign direct investment (FDI)	FDI, net inflows (% of GDP)	WDI
	Logistic performance index (LPI)	Quality of Trade and Transport Related Infrastructure (1=Very Low to 5=Very High)	WDI
	Unemployment (UNEMP)	Total unemployment (% of the total labour force) (modelled ILO estimate)	WDI
	Natural resources rents (NAT)	Total natural resources rents (% of GDP)	WDI

TABLE 3: Variables definitions and sources

Source: Authors

UNCTAD: United Nations Conference on Trade and Development; WDI: World Development Indicators; ILO: International Labour Organization

Methodology

To analyze the effect of ICT goods imports on sustainable economic development, we will use Equation (4) as the main econometric model:

$$SEDI_{it} = \alpha_0 + \alpha_1 \text{MICTG}_{it} + \alpha_2 \text{GQ}_{it} + \alpha_3 \text{CONTROLS}_{it} + \gamma_i + \mu_t + \epsilon_{it} \quad ...(9)$$

where $SEDI_{it}$ represents the sustainable economic development index for the country i during period t. The term $MICTG_{it}$ indicates the share of ICT goods as a percentage of total import trade, while GQ_{it} reflects governance quality. The vector $CONTROLS_{it}$ comprises the aforementioned control variables. To control for unobservable heterogeneity among countries and to account for global business cycles, we incorporate country-fixed effects denoted by γ_i, and period-fixed effects represented by μ_t. Additionally, ε_{it} signifies the error term. We employ the fixed effect model to estimate our benchmark regression efficiently. This estimator allows us to consider the time-fixed effect and the country-fixed effect, and it also helps us reduce the risk of omitting important variables [69]. However, the robustness of the estimation needs to be further addressed to account for different sources of endogeneity. We will discuss this issue in the section below.

Results

Preliminary analysis

The descriptive statistic of the chosen variables is shown in Table *4*. We have a strongly balanced dataset. The negative mean value for the governance quality proxies (PG, IG, and EG) indicates poor governance quality in the region on average, with PG showing the worst performance. The negative minimum value for FDI net inflow means a divestment, which happened in some of the countries in our sample due to significant withdrawal from some investors, and as a result, the continent experienced a 10% drop in inflows in 2019.

Variables	Obs	Mean	Std.Dev.	Min	Max
SEDI	672	1.423	.146	1.199	1.899
MICTG	672	3.892	2.065	.006	12.774
PG	672	-.459	.723	-2.195	1.014
IG	672	-.51	.612	-1.7	.975
EG	672	-.588	.56	-1.817	1.174
POPG	672	2.433	.831	-.077	5.785
FDI	672	3.664	5.271	-18.918	39.811
LPI	672	2.274	.3	1.27	3.79
UNEMP	672	8.682	6.983	.6	28.24
NAT	672	10.46	10.433	.002	59.684

TABLE 4: Descriptive statistics

Source: Authors

In Figure 5, we provide a scattergram to visualize the relationships between core independent variables (import of ICT goods: MICTG and the three governance quality indices: PG, IG, and EG) and the dependent variable (SEDI). The figure shows the SEDI and the import of ICT goods are negatively correlated, while governance quality indices are positively correlated with the SEDI. We further analyze these correlations in the section below by estimating the model introduced above. First, we can rewrite the baseline model of this analysis after incorporating the regressors chosen in the above section, as follows:

$$SEDI_{it} = \alpha_0 + \alpha_1 \mathrm{MICTG}_{it} + \alpha_2 \mathrm{GQ}_{it} + \alpha_3 \mathrm{POPG}_{it} + \alpha_4 \mathrm{FDI}_{it} + \alpha_5 \mathrm{LPI}_{it} + \alpha_6 \mathrm{UNEMP}_{it} + \alpha_7 \mathrm{NAT}_{it} + \gamma_i + \mu_t + \epsilon_{it}$$

.... (10)

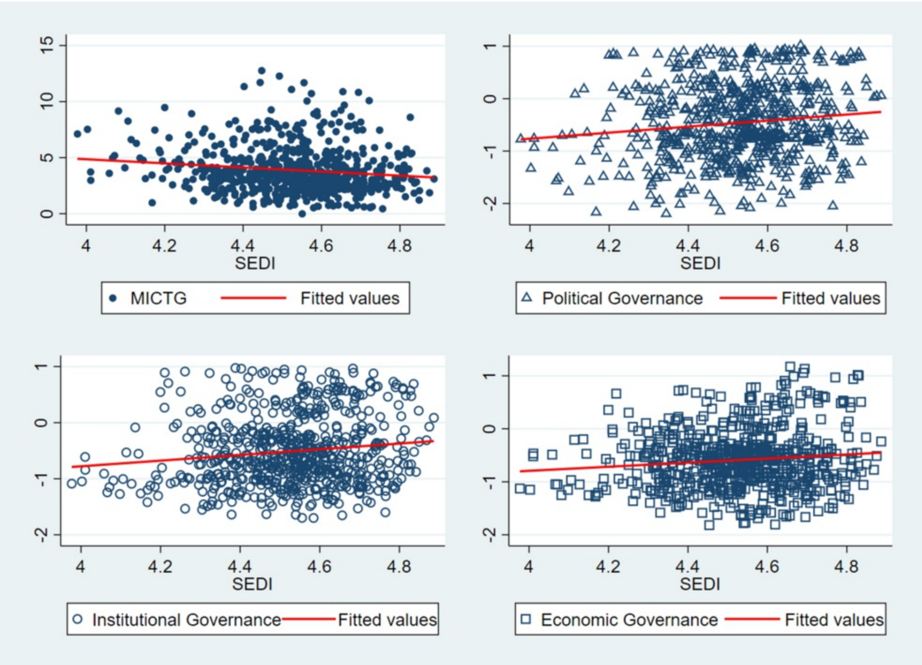

FIGURE 5: Core dependent and independent variables scatter plot

Source: Authors

Baseline result

Before conducting our regression analysis, we first run a Pearson correlation matrix to identify multicollinearity in our independent variables. This step is essential to avoid unreliable regression estimates. As seen in Appendix Table *12*, our independent variables' coefficients are all below 0.5 except for the three governance quality indices (we will add them to the model separately since they are highly correlated), a common threshold for severe multicollinearity.

To examine the impact of ICT goods imports on sustainable economic development, we begin by estimating the model using fixed-effect estimation. The benchmark results, outlined in Equation (10), are presented in Table *5*. The findings in columns 1-4 indicate a negative and statistically significant relationship at the 1% level across all specifications, suggesting that the import of ICT goods negatively affects progress toward sustainable economic development in the Sub-Saharan African countries analyzed. Specifically, the results show that an increase in ICT goods imports (MICTG) reduces SEDI, with a one-standard-deviation increase in MICTG (3.892) corresponding to a decrease in SEDI of approximately 0.089 units, holding other factors constant. This relationship remains consistent across columns 2-4, lending support to the decline of hypothesis H1. A potential explanation for this finding could be that the use of ICT goods in SSA is not yet fully aligned with sustainable economic development objectives, and as a result, their increased importation may impede progress in this area. This conclusion is contrary to the findings of Khan et al. [19], who observed a positive impact of ICT on sustainability. Moreover, all three governance quality indices exhibit positive and significant coefficients, demonstrating that governance quality in the sample countries contributes to progress in sustainable economic development. Among the governance indicators, IG has the most pronounced effect, surpassing both PG and EG in magnitude. This observation aligns with recent literature on the subject [36].

	(1)	(2)	(3)	(4)
Variables	SEDI	SEDI	SEDI	SEDI
MICTG	-0.023***	-0.024***	-0.023***	-0.025***
	(0.004)	(0.004)	(0.004)	(0.004)
PG		0.105***		
		(0.020)		
IG			0.154***	
			(0.030)	
EG				0.067**
				(0.029)
POPG		-0.005	-0.009	-0.012
		(0.014)	(0.014)	(0.014)
FDI		0.001	0.000	-0.000
		(0.001)	(0.001)	(0.001)
LPI		0.028	0.035	0.032
		(0.040)	(0.040)	(0.041)
UNEMP		-0.004	-0.002	-0.002
		(0.004)	(0.003)	(0.004)
NAT		-0.001	-0.002	-0.002
		(0.001)	(0.001)	(0.001)
cons	4.628***	4.672***	4.688***	4.670***
	(0.028)	(0.108)	(0.108)	(0.110)
N	672	672	672	672
r2	0.335	0.368	0.367	0.347
country_effect	Yes	Yes	Yes	Yes
year_effect	Yes	Yes	Yes	Yes

TABLE 5: Fixed-effect estimation result

Standard errors in parentheses. ***p < 0.01, **p < 0.05, and *p < 0.1.

Source: Authors

Endogeneity issues

In our study, we address two main sources of endogeneity to check the reliability of our estimation result. Namely, the reverse causality issue between SEDI and MICTG, as well as the unobserved variables that may affect SEDI, was not included in our model. First, this issue is in line with our hypothesis H4. To check the existence of reverse causality, we use the Granger causality test [70], a commonly useful method for a panel dataset [69]. Moreover, Weber and Lopez [71] argue that one should not use this tool to analyze non-stationary variables. Therefore, we first test to see if our variables of interest are unit-rooted. We adopt the second generation of testing method for the panel dataset, called the cross-sectional Im-Pesaran-Shin (CIPS) unit root test [72]. The CIPS statistic is the average of the individual cross-sectionally augmented Dickey-Fuller test statistics across all cross-sectional units (i.e., it averages the test statistics from each unit's regression). Table *6* indicates that the CIPS statistics are lower (more negative) than any critical value; thus, we can reject the null hypothesis and conclude that both SEDI and MICTG are adequate for the Granger causality test, which in turn validates our H4, indicating the existence of a reverse causality bias.

CIPS					Granger causality		
Null hypothesis:	Statistic	Critical value			Null hypothesis:	F-statistic	P-value
SEDI is homogeneous non-stationary	-3.076	-2.08 (10%)	-2.16 (5%)	-2.30 (1%)	MICTG does not Granger-cause SEDI	11.6764	0.000
MICTG is homogeneous non-stationary	-3.109				SEDI does not Granger-cause MICTG	14.9240	0.000

TABLE 6: Results of the CIPS and Granger causality tests

Source: Authors

To address this issue, we re-estimate the effect of MICTG on SEDI using instrumental variables two-stage least squares (IV-2SLS). This method can isolate the effect of MICTG on SEDI [73]. The choice of instruments is based on previous literature, which uses the lagged values of the endogenous variable [74,75]; they argued that this choice usually satisfies the exogenous condition. Therefore, we choose the two- and three-year lagged value of MICTG as instruments; the validity of this choice is tested after the estimation. The result is reported in Table *7*. First of all, from columns (1) to (4), regarding the Kleibergen and Paap (2006) statistic, we can reject the null hypothesis that the equation is under-identified, i.e., the model is identified. Next, the weak instrument test can be used as a diagnostic for whether a particular endogenous regressor is "weakly identified" [76]. Given the Cragg-Donald Wald F-statistic from columns (1) to (4), our instruments are valid because we can reject the Stock-Yogo [77] weak ID test null hypothesis, where the F statistics are all greater than the 10% critical values. Last but not least, the failure to reject the null for the Hansen J statistic [78] indicates that the instruments are valid, i.e., uncorrelated with the error term. The IV-2SLS estimation result indicates that our model can pass the endogeneity test in general by indicating a similar result to the baseline estimation above. However, the robustness of our estimation is still tested in the section below.

	(1)	(2)	(3)	(4)
Variables	SEDI	SEDI	SEDI	SEDI
MICTG	-0.001	-0.012***	-0.013***	-0.013***
	(0.004)	(0.004)	(0.004)	(0.004)
PG		0.026***		
		(0.009)		
IG			0.026**	
			(0.010)	
EG				0.032***
				(0.011)
POPG		-0.021***	-0.021***	-0.020**
		(0.008)	(0.008)	(0.008)
FDI		-0.000	-0.000	-0.000
		(0.001)	(0.001)	(0.001)
LPI		0.092***	0.097***	0.093***
		(0.022)	(0.022)	(0.022)
UNEMP		-0.002**	-0.002**	-0.002**
		(0.001)	(0.001)	(0.001)
NAT		0.001	0.001	0.001
		(0.001)	(0.001)	(0.001)
cons	4.468***	4.374***	4.367***	4.384***
	(0.031)	(0.057)	(0.056)	(0.056)
N	576	576	576	576
r2	0.303	0.355	0.351	0.352
Kleibergen-Paap_rk_LM_statistic	125.65***	118.80***	113.36***	110.23***
Cragg-Donald Wald F statistic	431.256	247.794	251.616	252.339
Stock-Yogo weak ID test critical values (10%)	19.93	19.93	19.93	19.93
Hansen J statistic	1.772	1.075	1.086	1.047

TABLE 7: IV-2SLS estimation result

Standard errors in parentheses. ***p < 0.01, **p < 0.05, and *p < 0.1.

Source: Authors

Robustness check

To mitigate potential bias in the estimation results, several robustness tests were conducted to validate the baseline findings. First, considering the relatively large number of countries (32) and the shorter time span (21 years) in our dataset, the baseline estimation could potentially yield biased results. To address this concern, we applied the Driscoll-Kraay standard errors estimator, which is specifically designed to account for serial correlation, heteroskedasticity, and cross-sectional dependence-common issues in datasets where the number of cross-sectional units exceeds the number of periods (N > T) [79]. Additionally, to assess the sensitivity of our results, we used an alternative source for the independent variable, ICT goods imports as a percentage of total goods imports, by extracting data from the World Bank Development Indicators database. The results, as presented in Table 8, show consistency across both estimation methods and data sources, affirming the robustness of our findings. Consequently, we conclude that imports of ICT goods negatively impact SEDI in SSA. In the following section, we delve deeper into the role of governance quality within this relationship.

	Driscoll-Kraay estimation result			Fixed effect estimation result		
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	SEDI	SEDI	SEDI	SEDI	SEDI	SEDI
MICTG	-0.024***	-0.038***	-0.039***			
	(0.003)	(0.005)	(0.006)			
MICTG_wdi				-0.020***	-0.023***	-0.021***
				(0.006)	(0.006)	(0.006)
PG	0.105***			0.054		
	(0.018)			(0.057)		
IG		0.173***			0.198**	
		(0.027)			(0.091)	
EG			0.043			0.042
			(0.028)			(0.072)
Controls	YES	YES	YES	YES	YES	YES
cons	4.672***	4.715***	4.685***	4.557***	4.617***	4.568***
	(0.088)	(0.133)	(0.139)	(0.162)	(0.157)	(0.160)
N	672	672	672	672	672	672
r2				0.092	0.128	0.087

TABLE 8: Robustness check estimation results

Standard errors in parentheses. ***p < 0.01, **p < 0.05, and *p < 0.1.

Source: Authors

Discussion

Further analysis

In this section, we will analyze the role of governance quality in this relationship. As discussed in the research hypothesis, governance quality can also play a pivotal role in shaping the relationship between ICT and sustainable development. Therefore, we will introduce the interaction term of MICTG and the three different types of governance qualities (PG, IG, and EG) in the model to assess this role. This method is widely used for assessing the pivotal role of governance quality [80-83]. Thus, we can rewrite the baseline model of this analysis as follows:

$$\mathrm{SEDI}_{it} = \alpha_0 + \alpha_1 \mathrm{MICTG}_{it} + \alpha_2 \mathrm{GQ}_{it} + \alpha_k \left(\mathrm{GQ}_{it} \times \mathrm{MICTG}_{it}\right) + \alpha_3 \mathrm{POPG}_{it} + \alpha_4 \mathrm{FDI}_{it} + \alpha_5 \mathrm{LPI}_{it} + \alpha_6 \mathrm{UNEMP}_{it} + \alpha_7 \mathrm{NAT}_{it} + \gamma_i + \mu_t + \varepsilon_{it}$$

... (11)

where $GQ_{it} \times \mathrm{MICTG}_{it}$ is the interaction term between MICTG and the governance quality indicator. Based on Equation (11) and the estimation result in Table 9, we can conclude that only IG quality affects the nexus between SEDI and MICTG. We can calculate the net effect of IG quality in moderating the relationship between MICTG and SEDI and also the role of MICTG in moderating the relationship between IG and SEDI; we conclude in Table 10.

	(1)	(2)	(3)
Variables	SEDI	SEDI	SEDI
MICTG	-0.037***	-0.035***	-0.033***
	(0.004)	(0.005)	(0.007)
PG	0.033		
	(0.028)		
MICTG_PG	0.009*		
	(0.005)		
IG		0.131***	
		(0.041)	
MICTG_IG		0.010*	
		(0.006)	
EG			0.051
			(0.032)
MICTG_EG			-0.000
			(0.000)
Controls	YES	YES	YES
cons	4.690***	4.713***	4.690***
	(0.112)	(0.110)	(0.113)
N	672	672	672
r2	0.176	0.199	0.165

TABLE 9: Estimation results of the role of governance quality

Standard errors in parentheses. ***p < 0.01, **p < 0.05, and *p < 0.1.

Source: Authors

Effect of MICTG on the IG and SEDI nexus	Effect of IG on the MICTG and SEDI nexus
$\partial SEDI/\partial MICTG = \alpha_1 + \alpha_k(IG)$	$\partial SEDI/\partial IG = \alpha_2 + \alpha_k(MICTG)$
$-0.035 + 0.01 \times -0.51 = -0.04$	$0.131 + 0.01 \times 3.892 = 0.17$

TABLE 10: The interaction term effect of IG and MICTG on SEDI

Source: Authors

The significant interaction term implies that the relationship between IG quality and SEDI is influenced by the level of ICT goods imports (MICTG) and also the effect of IG on the nexus between SEDI and MICTG, validating our hypothesis H3. Table 10, column 2, shows that at the mean level of ICT goods imports (3.892) (see Table 4), an increase in IG quality has a positive impact on SEDI, with a coefficient of approximately 0.17. Conversely, -0.04 indicates that at the mean level of IG quality (-0.51) (see Table 4), the effect of ICT goods imports on SEDI is negative, with a coefficient of -0.040. Thus, the interaction term shows that stronger institutions mitigate this negative effect. At the mean level of ICT goods imports, institutional quality has a positive and significant impact on sustainable economic development.

Conversely, at the mean level of institutional quality, ICT goods imports have a negative impact on development, though this adverse effect is lessened when institutional quality improves. Therefore, the overall impact of ICT goods imports on SEDI becomes more favorable as institutions strengthen. Since the threshold IG level (3.5) (calculated from the first column of Table *10*) exceeds the maximum observed value (2.5) (see Table *4*), it implies that within the range of institutional quality, the effect of ICT goods imports on SEDI will likely remain negative. However, the negative impact could lessen as institutional quality improves toward the higher end of the observed range (closer to 2.5). This suggests that while ICT goods imports alone may not directly enhance sustainable economic development in the current institutional environment, improvements in institutional quality can mitigate the negative impact.

This result indicates that focusing on improving institutional quality is crucial in SSA. Although it may not immediately turn the impact of ICT goods imports into positive development, it will gradually reduce the negative effects. Sustainable economic development benefits from ICT goods imports will only materialize when institutional reforms significantly elevate governance quality, pushing it closer to the upper bounds of the observed range.

Conclusions

This paper contributes to the ongoing discourse on how Sub-Saharan African countries can effectively achieve SDGs, particularly in the economic dimension of sustainable development. Given the slow progress of African nations in meeting the 2030 Agenda and recognizing the role of technology in accelerating this process, we analyze the relationship between sustainable economic development and ICT goods imports (MICTG) across 32 Sub-Saharan African countries from 2000 to 2020. Utilizing a computed SEDI. We also examine governance quality in three dimensions: political, institutional, and economic governance. Employing fixed effects and IV-2SLS estimations, we find that MICTG has a significantly negative impact on SEDI, while all three governance dimensions exert positive effects. Granger causality analysis suggests a bidirectional relationship between MICTG and SEDI. Furthermore, interaction terms reveal that improving IG can mitigate the negative effects of MICTG over time, facilitating sustainable development. From a policy perspective, strengthening IG is essential to creating an environment where ICT imports can contribute positively to sustainable economic development. A holistic approach addressing all governance dimensions-political, economic, and institutional-is necessary to harness technology's benefits for fully sustainable economic growth. Additionally, ICT policy should be aligned with governance reforms and human capital development to maximize technology's positive spillovers. Despite its contributions, the study has limitations. Potential omitted variables, such as cultural factors, may affect sustainable economic development, and the findings may not generalize beyond SSA. Future research could explore these dynamics in other regions and use advanced dynamic models to uncover long-term causal mechanisms. This study highlights the crucial role of governance in leveraging ICT imports for sustainable economic growth.

Appendices

Code – Name	Code – Name	Code – Name
AGO – Angola	GMB – Gambia	RWA – Rwanda
BEN – Benin	GHA – Ghana	SEN – Senegal
BWA – Botswana	CIV – Ivory Coast (Côte d'Ivoire)	SLE – Sierra Leone
BFA – Burkina Faso	KEN – Kenya	ZAF – South Africa
CPV – Cape Verde	MDG – Madagascar	SDN – Sudan
CMR – Cameroon	MLI – Mali	TZA – Tanzania
CAF – Central African Republic	MRT – Mauritania	TGO – Togo
COG – Congo (Republic of the Congo)	MUS – Mauritius	UGA – Uganda
SWZ – Eswatini (formerly Swaziland)	MOZ – Mozambique	ZMB – Zambia
ETH – Ethiopia	NAM – Namibia	ZWE – Zimbabwe
GAB – Gabon	NGA – Nigeria	

TABLE 11: The 32 Sub-Saharan African countries

Source: Authors

	SEDI	MICTG	PG	IG	EG	POPG	FDI	LPI	UNEMP	NAT
SEDI	1									
MICTG	-0.141***	1								
PG	0.127***	-0.005	1							
IG	0.132***	0.022	0.902***	1						
EG	0.110***	0.131***	0.787***	0.870***	1					
POPG	-0.145***	-0.306***	-0.196***	-0.253***	-0.370***	1				
FDI	-0.041	-0.160***	-0.090**	-0.089**	-0.106***	0.082**	1			
LPI	0.140***	0.480***	0.120***	0.132***	0.260***	-0.398***	-0.170***	1		
UNEMP	0.041	0.053	0.045	0.0280	0.162***	-0.408***	0.035	0.220***	1	
NAT	-0.164***	-0.171***	-0.201***	-0.319***	-0.282***	0.330***	0.204***	-0.350***	0.120***	1

TABLE 12: Variables correlation analysis

***p < 0.01, **p < 0.05, and *p < 0.1.

Source: Authors

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Tojo H. Rakotondrazaka

Acquisition, analysis, or interpretation of data: Tojo H. Rakotondrazaka, Lingli Xu

Drafting of the manuscript: Tojo H. Rakotondrazaka

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Disclosures

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