

The Role of Modern Technology in Promoting Human Development in Emerging Economies

Research Paper

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Abstract: **Research Purpose:** Human development spurs progress toward the Sustainable Development Goals (SDGs) by enabling the capabilities, productivity, and resilience needed to meet economic, social, and environmental targets. Promoting human development facilitates achieving SDGs. Giving attention to factors that spurred human development in the right direction propagates education, health, and economic prosperity and, as such, achieves SDGs. Hence, the determinants of human development are central to SDGs. This study examines the relationship between information and communication technology (ICT) and access to electricity on human development in selected emerging economies.

Design/ Methodology/ Approach: Following the modernisation theory, the relationship between ICT, access to electricity and human development is assessed within an econometric second-generation panel unit root test, cross-sectional dependence test, slope heterogeneity, a panel-corrected standard error model, a Dumitrescu and Hurlin causality test, and a threshold model between 2000 and 2022.

Findings: The findings reveal the crucial importance of ICT and access to electricity on human development in emerging economies. ICT spur human development and suggests that it remains one of the key drivers in the transitory economies, as they support human development in education, health, and social protection and, as such, improves quality of life. Meanwhile, the ICT-human development nexus could break down when access to electricity is not commensurate with ICT. The finding shows that access to electricity has a direct and significant impact on human development in emerging economies. In addition, there is unidirectional causality from ICT to human development and from access to electricity to human development. Within the threshold regression, the result reveals that ICT and access to electricity spur human development at lower and upper regimes. The policy implication is that when access to electricity is not commensurate with ICT, heavy reliance on ICT can create vulnerabilities when systems fail or when communities cannot adapt without digital solutions and as such, it may have a negative impact on human development. The study recommends that ICT penetration and usage should be encouraged since small improvements in ICT access can produce significant gains in human development. Also, energy policies and electrification programs should be strengthened as a foundation for sustainable improvements in human well-being.

Originality/ Value/Practical Implications: The study stressed that the criticality of access to electricity and ICT is central to human development in emerging economies.

Keywords: Human Development • ICT • Access to Electricity • Emerging Economies

JEL codes: I3; O35; Q43

Introduction

Human development spurs progress toward the Sustainable Development Goals (SDGs) by enabling the capabilities, productivity, and resilience needed to meet economic, social, and environmental targets. Promoting

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human development facilitates achieving SDGs. The SDGs seek to address urgent global challenges towards human well-being, as adopted by the United Nations in 2015 (UN, 2015). Meanwhile, the engagement with the planet and Earth exploration by the people creates some of the global challenges that the SDGs were intended to address. Human actions such as outdoor air pollution from fossil-fuel combustion, industry, and transport (Lelieveld et al., 2015), e-waste, emissions, misinformation, surveillance, and cybercrime (Vishwakarma et al., 2022), large dams, and global CO₂ emissions (IEA, 2023; Zarfl et al., 2015) have created an urgent need to address global challenges. Hence, the crucial importance of SDGs is central to human development.

From theoretical perspectives to empirical evidence, giving attention to factors that spurred human development in the right direction propagates education, health, and economic prosperity (Barua, 2021; UNDP, 2024) and, as such, achieves SDGs (Moyer & Bohl, 2019). To be specific, information and communication technology (ICT) has been documented to spur education, health, and economic prosperity across many spectrums (Badri et al., 2019; Ježić et al., 2022; Karaman Aksentijević et al., 2021). First, ICT provides platforms for distance learning, online resources, and virtual classrooms that expand educational opportunities (UNESCO, 2021). Secondly, ICT support the delivery of healthcare through tools such as remote medical consultations, digital patient record systems, and mobile health platforms (WHO, 2019). Thirdly, ICT fosters entrepreneurship, access to markets, and innovation. It enables small businesses to connect with global markets and enhances productivity through automation and digital tools (World Bank Group, 2016). In this case, ICT spur human development and, as such, achieve SDGs. Meanwhile, Electricity spurs ICT (Asongu & Le Roux, 2017). In emerging economies, electricity facilitates ICT, and as such creates potential for human development across many sectors (Aker & Mbiti, 2010). In sub-Saharan Africa (SSA), unreliable electricity dampens digital technology adoption between households and firms (Foster & Rana, 2020). Within the foregoing, electricity determines ICT penetration across many sectors. Addressing the electricity access bridge rural-urban gap and supporting inclusive human development (IEA, 2023). Likewise, ICT and access to electricity are not mutually exclusive in many economies and, as such, could spur human development towards achieving sustainable development and integrated infrastructure and social development programs (World Bank, 2022). Furthermore, in many emerging economies, concurrent denial and unreliable electricity supply dampen ICT adoption and, by extension, human development (IEA, 2023). As the year 2030 draws closer, the need to attain clean energy, one of the core objectives of Sustainable Development Goal (SDG) 7, has become increasingly critical. Despite global progress, an estimated 685 million people remain without electricity (IEA, 2023). These populations, who are often among the most disadvantaged, are concentrated in some of the world's least developed regions, particularly in parts of Sub-Saharan Africa, as well as in countries such as Haiti and Papua New Guinea (IEA, 2023; World Bank Group, 2024). Ensuring that the universal electrification target is achieved is essential, not only for expanding energy access but also for fostering meaningful improvements in human development for these vulnerable communities. Studying access to electricity alongside ICT provides a more realistic picture of their combined impact. Within the foregoing, this research aims to assess the role of ICT and access to electricity on human development in emerging economies.

Numerous factors have been identified as essential for achieving the SDGs, including human development (Hamad et al., 2023; Moses et al., 2022; Moyer & Bohl, 2019; Tu et al., 2023). Policymakers, governments, and researchers need to give more attention to solutions to the root cause of the challenges. Within the foregoing, this study raises critical questions to assess the crucial importance of human development in emerging economies: 1) What is the moderating effect of access to electricity on the relationship between ICT and human development in emerging economies? and 2) what is the threshold level of ICT and access to electricity on human development in emerging economies? This study aimed to provide answers to these questions in order to advance the frontier of knowledge on the root causes of global challenges and the attainment of SDG targets.

Literature review

From modernisation to human development, the provision of electricity and ICT have created channels through which sustainable development could be achieved. Following modernisation theory, there is a progressive link between modernisation and human development (Rostow, 1960). Modernisation facilitates the provision of electricity and ICT, which are key instruments in the process of sustainable development of an economy. The transition from conventional to modern provision systematically stimulates human development in education, health, and social protection and, as such, improves quality of life (Badri et al., 2019; Ježić et al., 2022; Karaman Aksentijević et al., 2021; Moyer & Bohl, 2019; UNESCO, 2021; WHO, 2019; World Bank Group, 2016). In emerging economies, the

provision of electricity and ICT is a modern process that indicates signs of structural transformation and progress toward human development, ultimately leading to sustainable development. Over the years, extant studies have documented a direct nexus between modernisation via ICT and human development (Foster & Rana, 2020; IEA, 2023; Pradhan et al., 2018; World Bank, 2022), while others have established an inverse link (Acemoglu & Restrepo, 2020; Zuboff, 2023) with little or no attention on the provision of electricity and ICT. One of the reasons for the divergence in these studies could be the provision of electricity, since electricity spurs ICT (Asongu & Le Roux, 2017), particularly in the emerging economies. Besides, ICT and access to electricity are mutually inclusive in many economies and, as such, could spur human development towards achieving sustainable development.

The provision of electricity is fundamental towards the attainment of SDGs, and it is broadly recognised as a cornerstone of human development (Fuso Nerini et al., 2018). Studies have revealed the benefits towards the provision of electricity across many phenomena, including economic activities (Qi et al., 2023), health improvements (Nguea, 2024), and educational outcomes (Casati et al., 2023; Sharma et al., 2019). Nonetheless, the link between the provision of electricity and human development is not always straightforward. Some research highlights that electrification's contribution to human development may have limits (Aklin et al., 2017; Bahan & Dramani, 2020). In certain cases, access to electricity has even been associated with new forms of inequality among certain groups (Fernández-Baldor et al., 2014; Nguea, 2024; Sarkodie & Adams, 2020). The negative or non-positive findings are not uniform across contexts but vary by geography. For instance, Acheampong et al. (2021) reported an adverse effect of electricity inclusivity on human development index (HDI) in parts of Latin Caribbean America, while Bahan and Dramani (2020) documented reduced social well-being linked to electricity consumption in a sub-Saharan Africa (SSA) country. Although these findings represent a minority view compared to the broader consensus, they remain significant. This divergence underscores the need to examine more deeply the role of access to electricity in consistently delivering positive human development outcomes.

The contributions of ICT to human development are not without harm. To be more specific, studies have shown a negative effect of ICT on human development in many economies. ICT expansion can deepen inequalities between those with access and those without. Poor infrastructure, low digital literacy, and affordability issues exclude marginalised groups, worsening inequality in education, health, and economic opportunities (Zuboff, 2023). Acemoglu and Restrepo (2020) show that digitalisation disproportionately affects workers in the routine and manufacturing sectors. Heavy reliance on ICT can create vulnerabilities when systems fail or when communities cannot adapt without digital solutions (Avgerou, 2010). ICT infrastructure and electronic waste (e-waste) pose serious environmental challenges. The inconclusive evidence on the ICT and human development literature can therefore be explained by countries being interlinked and, as such, failures to model spillover, leading to biased results. In addition, ICT could dampen human development due to imported decadence from various virtual and online engagements, leading to both positive and negative responses to human development. Meanwhile, in low-income settings characterised by poor infrastructure and unreliable access to electricity, ICT may have been underutilised to have both positive and negative responses on human development. In an economy operating below a threshold level of ICT penetration and complementary infrastructure, the benefits may become more invisible and unsustainable (Asongu & Le Roux, 2017; Pradhan et al., 2018).

Put differently, the provision of electricity alleviates energy poverty (Ekengoue et al., 2025), advances human development (MacGinley et al., 2025), and increases economic opportunities for gender balance (Asaleye et al., 2025). Access to electricity is one of the key modernisation factors as it supports human development, efficient service delivery, and improved quality of life. Meanwhile, ICTs are fundamentally dependent on electricity for their operation. At the most basic level, ICT infrastructure, such as mobile phones, computers, data centres, and internet networks, requires a reliable source of energy to function (World Bank, 2020). Without electricity, the hardware and supporting infrastructure for ICT cannot be powered, which makes access to modern digital services nearly impossible (IEA, 2023). This study intends to provide answers to the determinants of human development in order to advance the frontier of knowledge on the root cause of the global challenges and attainment of SDGs targets.

Research methodology

The criticality of access to electricity on the link between ICT and human development in selected emerging economies between 2000 and 2022 is anchored in the modernisation theory. World Bank and United Nations Development Program (UNDP, 2024) reports are the data sources. Following the modernisation theory, the study

adopts Fuso Nerini et al. (2018) because access to electricity is not just an infrastructural input but a marker of a society's transition from traditional to modern structures. Within the preliminary techniques of analysis, the study utilised a cross-sectional dependence test, a panel unit root test, slope heterogeneity, a Panel-Corrected Standard Error (PCSE) model, Discroll & Kraay (D&K) model, a Dumitrescu and Hurlin causality test, and a threshold model. These were done to establish unbiased baselines and robust models in assessing the role of access to electricity on the link between ICT and human development. Within the preliminary procedure and the baseline model, the functional relationship is presented in equation 1. Figure 1 offers a clear visual summary of the methodological framework adopted in this study; Therefore, the study's functional form can be written as:

$$HD = f(ICT, ELEC, GOV, \text{ and } GFCF) \quad (1)$$

Where HD is the human development, while ICT, ELEC, GOV and GFCF measure information and communication technology, access to electricity, government expenditure, and gross fixed capital formation, respectively. To avoid omitted variable bias, control variables of GOV and GFCF are included in the model. For the model specification, equation one is further simplified to show the interactive role of access to electricity and ICT on human development in emerging economies, as presented within the empirical equations and is formed as an empirical model as follows:

$$HD_{it} = \alpha_1 + \beta_1 ICT_{it} + \beta_2 ELEC_{it} + \beta_3 (ICT * ELEC)_{it} + \beta_4 GOV_{it} + \beta_5 GFCF_{it} + \varepsilon_{it} \quad (2)$$

Where the variables remain as defined with unbiased estimates, although ε represents a stochastic term; i and t represent 15 selected emerging economies, such as Brazil, Chile, China, Colombia, Egypt, India, Indonesia, Korea, Malaysia, Mexico, Peru, Philippines, South Africa, Thailand, Turkey, and 23 time periods. The selected economies were based on MSCI classification and data availability. Within the four components, the measure for ICT is generated to have comprehensive and robust coverage of the provision of ICT in an economy. Within the foregoing, the preliminary techniques of analysis, the study applied a panel-corrected standard error model and a Dumitrescu and Hurlin causality test in order to obtain asymptotically efficient, consistent estimates in selected emerging economies. Furthermore, this study employs Hansen's (2000) panel threshold estimation technique to investigate whether ICT and access to electricity exert nonlinear effects on human development in emerging economies. The approach is well-suited for detecting threshold values and accounting for regime-dependent relationships within a regression framework. Hence, the model is specified in Equation 3.

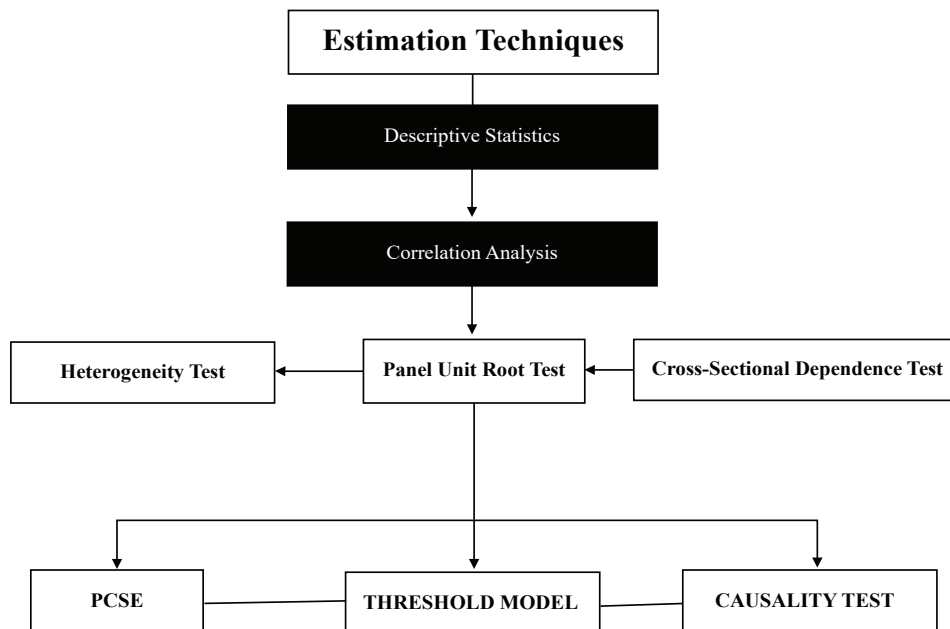


Figure 1. Estimation Techniques (Source: Created by the authors).

$$HD_{it} = \begin{cases} \alpha_i + \beta_1 X_{it} + \theta_1 q_{it} + \varepsilon_{it} & q_{it} < \gamma \\ \alpha_i + \beta_2 X_{it} + \theta_2 q_{it} + \varepsilon_{it} & q_{it} \geq \gamma \end{cases} \quad (3)$$

Where the variables remain as defined.

Research results

To establish the determinants of human development within the role of ICT and access to electricity in emerging economies, Tables 2, 3 and 4 present the results of the preliminary analysis. The results of cross-sectional dependence presented in Table 1 show that all variables (HD, ICT, ELEC, GOV, and GFCF) show cross-sectional dependence among emerging economies. Also, the results in Table 2 show that all variables are stationary at level $I(0)$ except GOV, which is stationary at first difference $I(1)$ across cross-sectional Im, Pesaran and Shin (CIPS) and cross-sectional augmented Dickey-Fuller (CADF). Furthermore, the slope homogeneity results in Table 3 indicate significant heterogeneity in the coefficients for both models of human development. This suggests that the impact of the independent variables, such as ICT, ELEC, GOV and GFCF, differs markedly across the sampled emerging economies.

To address cross-sectional dependence among emerging economies, the PCSE and D&K techniques were adopted across four models (I-IV), with results presented in Table 4. The results show that ICT have a positive and significant impact on human development across models I and III. This reveals that ICT spur human development among emerging economies. This suggests that ICT is one of the key drivers in the transitory economies, as they support human development in education, health, and social protection and, as such, improve quality of life. This is not unexpected due to existing documents submission that ICT spurred human development in the right direction, propagates education, health, and economic prosperity (Barua, 2021; UNDP, 2024) and, as such, achieves SDGs (Moyer & Bohl, 2019). To be more specific, increasing ICT provides platforms for distance learning, online resources, and virtual classrooms that expand educational opportunities (UNESCO, 2021). It supports the delivery of healthcare through tools such as remote medical consultations, digital patient record systems, and

Table 1. Cross-Sectional Dependence (Source: Created by the authors).

Variable	CD-test	p-value	corr	abs(corr)
HD	47.840	0.000	0.973	0.973
ICT	44.020	0.000	0.896	0.896
ELEC	43.540	0.000	0.886	0.886
GOV	14.620	0.000	0.298	0.451
GFCF	9.930	0.000	0.202	0.382

Table 2. Panel Unit Root Test (Source: Created by the authors).

Variable	CIPS		CADF	
	Level $I(0)$	First Difference $I(1)$	Level $I(0)$	First Difference $I(1)$
HD	-2.621***	-	-2.435***	-
ICT	-2.249**	-	-2.551***	-
ELEC	-2.588***	-	-2.522**	-
GOV	-1.689	-3.163***	-1.988	-2.341**
GFCF	-2.376***	-	-2.488***	-

Table 3. Slope heterogeneity (Source: Created by the authors).

Model	Statistics	Value	P-Value
HD = f(ICT, GOV, GFCF)	Delta	12.065	0.000
	Adj. Delta	13.638	0.000
HD = f(ICT, ELEC, ICT*ELEC, GOV, GFCF)	Delta	12.716	0.000
	Adj. Delta	15.245	0.000

Table 4. Model on Human Development (Source: Created by the authors).

Dep: HD	PCSE Model		D&K Model	
	Model I	Model II	Model III	Model IV
ICT	0.0041*** (0.0003)	-0.0074*** (0.015)	0.00222*** (0.0003)	-0.0034** (0.0014)
ELEC	-	0.0015*** (0.0004)	-	0.0018*** (0.0004)
ICT*ELECT	-	0.0001*** (0.00002)	-	0.00005*** (0.00002)
GOV	-0.00006 (0.0007)	0.0004 (0.0007)	0.0044** (0.0016)	0.0028 (0.0016)
GFCF	-0.0006* (0.0003)	-0.0013*** (0.0003)	0.0007 (0.0009)	0.0009 (0.0008)
Constant	0.6136*** (0.0129)	0.5118*** (0.0323)	0.5791*** (0.0256)	0.4392*** (0.0453)
R-squared	0.6384	0.7372	0.6122	0.6547
Wald Chi / F-stat	2777.35***	496.64***	40.25***	191.28***

mobile health platforms (WHO, 2019) and also fosters entrepreneurship, access to markets, and innovation. The growing ICT in emerging economies indicates growing human development. Meanwhile, the criticality of access to electricity in emerging economies could break down the flow of the ICT-human development nexus, as documented in Table 4 models II and IV. The results in models II and IV show that ICT harms human development in emerging economies. This reveals access to electricity as one of the determinants of ICT on human development in emerging economies. First, when access to electricity is not commensurate with ICT, heavy reliance on ICT can create vulnerabilities when systems fail or when communities cannot adapt without digital solutions and as such, it may hurt human development. Second, access to electricity with a poor ICT network could bring about low digital literacy and frustration in education, health and social protection and as such, dampen human development. Lastly, ICT infrastructure and electronic waste (e-waste) could pose serious environmental challenges and, as such, dampen human development in emerging economies.

Further, the result reveals a direct and significant effect of access to electricity on human development in emerging economies. This implies that an increase in access to electricity leads to a rise in human development among emerging economies. This suggests that the provision of electricity in an economy could facilitate human development across various phenomena such as health, education and gross national income (GNI) as identified by UNDP (2024) and subsequently drive attainment of SDGs. The positive nexus between access to electricity and human development in emerging economies is not unexpected because electrification supports multiple dimensions of development, including economic activities (Qi et al., 2023), health improvements (Nguea, 2024), and educational outcomes (Casati et al., 2023; Sharma et al., 2019). In addition, access to electricity is the backbone of ICT. The interaction of access to electricity and ICT in emerging economies has a direct and significant effect on human development. This is not surprising because weak electricity access limits the adoption of ICT for education, healthcare, and business activities, undermining its potential for human development.

Also, government expenditure has a direct and significant effect on human development in emerging economies. This indicates that increases in government expenditure led to a rise in human development in emerging economies. This suggests that fiscal behaviour through government intervention may be used towards improving human development, particularly within critical sectors or critical infrastructure such as health, education, and social protection. Government intervention may serve as a bailout towards creating an enabling environment where the provision of electricity and ICT could be transmitted to development rather than recurrent expenses such as salaries and administrative costs. This finding aligns with the Keynesian perspective on the government's role in providing infrastructure to support the economy. Overall, this suggests that government spending can be a vital fiscal tool in attaining human development and achieving sustainable development goals. Furthermore, GFCF has a negative and significant impact on human development. This implies that an increase in gross fixed capital formation leads to a reduction in human development. This indicates that an increased investment in fixed assets does not necessarily translate into improved human development due to a large amount of inequality in sectoral investment. Besides, investment in fixed capital often takes time to yield tangible results. A negative short-term impact could reflect a lag

before investments begin to affect human development positively. In this study, increased investment may even disrupt service delivery temporarily due to ongoing construction or restructuring.

Furthermore, the direction of causality follows the Dumitrescu and Hurlin causality test. This test examines the causal relationships among the key variables of interest. The null hypothesis of no causality is rejected for each W-bar test statistic, as the associated p-values are significant at the 10%, 5%, and 1% levels. As reported in Table 5, the results indicate the presence of unidirectional causal relationships running from: (i) ICT to HD. This means that improvements in information and communication technology (ICT) contribute significantly to human development outcomes, but the reverse is not observed. In other words, as ICT expands through mobile penetration, internet access, and digital platforms, people experience better education, health, and income opportunities. However, higher levels of human development alone do not automatically drive ICT growth. The implication is that policymakers should prioritise ICT investments and digital inclusion strategies as a catalyst for improving living standards, reducing inequality, and expanding opportunities. (ii) ELEC to HD. This indicates that access to a reliable electricity supply enhances human development outcomes, but the reverse does not hold. Electricity is fundamental to running schools, hospitals, businesses, and households, which directly impacts education, healthcare, productivity, and overall quality of life. Yet, achieving higher levels of human development does not necessarily guarantee expanded electricity access without deliberate infrastructure investments. The implication is that energy policies and electrification programs should be strengthened as a foundation for sustainable improvements in human well-being. (iii) GFCF to HD. The growth in gross fixed capital formation, which reflects long-term investments in infrastructure, machinery, buildings, and technology, drives human development outcomes, but not vice versa. This shows that sustained capital accumulation improves access to essential services, job creation, and industrial productivity, which directly uplift human development indicators. However, better human development outcomes do not automatically lead to higher investment unless supported by economic policies. The implication is that governments must create an enabling environment for both public and private investments, as these investments are key drivers of long-term improvements in welfare. Meanwhile, bidirectional causality runs between human development and government expenditure. This suggests a two-way reinforcing relationship. On the one hand, higher government expenditure on health, education, infrastructure, and social services directly raises human development outcomes. On the other hand, improved human development (through a healthier, more educated, and more productive population) generates higher demand for public goods and strengthens government revenue bases, which in turn support higher expenditure. The implication is that a virtuous cycle exists: effective government spending enhances human development, and improved human development sustains government capacity to spend more productively. Based on the causality results, Figure 2 provides overall Granger causality. ICT, electricity access, and capital formation function as one-way drivers of human development, meaning they are foundational inputs that require deliberate investment. Meanwhile, government expenditure and human development reinforce each other in a feedback loop, suggesting that policy efficiency and human welfare improvements can be mutually sustaining.

From equation 3, the threshold value for human development in emerging economies is determined and presented in Table 6. The findings suggest that a nonlinearity exists in the model of human development in emerging economies, as indicated by a p-value of 0.000. This implies that the selected emerging economies should be divided into lower and upper regimes, defined by unbiased, efficient, and sufficient threshold values. Within the criticality of access to electricity on the link between ICT and human development in emerging economies, ICT spur human development at lower and upper regimes. This suggests that at the lower regime, where ICT penetration and usage are relatively low, even small improvements in ICT access can produce significant gains in human development.

Table 5. Granger Causality (Source: Created by the authors).

Null Hypothesis	W-bar	Z-bar	Remarks
HD does not Granger-cause ICT	0.7223	-0.7604	UNIDIRECTIONAL
ICT does not Granger-cause HD	5.0886***	11.1971***	
HD does not Granger-cause ELEC	0.7622	-0.6513	UNIDIRECTIONAL
ELEC does not Granger-cause HD	5.0346***	11.0492***	
HD does not Granger-cause GOV	4.2969***	9.0289	BIDIRECTIONAL
GOV does not Granger-cause HD	1.9493***	2.5997*	
HD does not Granger-cause GFCF	1.5637	1.5436	UNIDIRECTIONAL
GFCF does not Granger-cause HD	2.5619***	4.2773***	

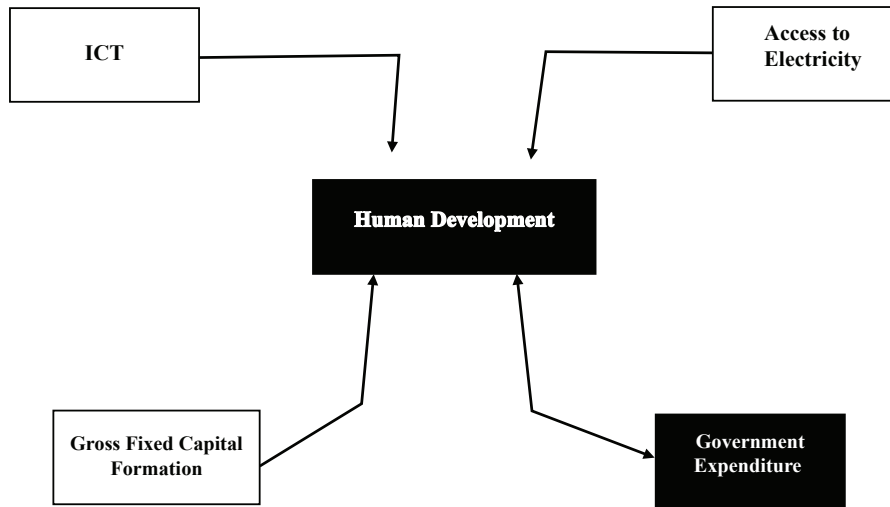


Figure 2. Granger Causality Framework (Source: Authors created).

Table 6. Threshold Model (Source: Created by the authors).

Dep: HD	Baseline Model		Robustness Model	
	Low (< 30.5133)	High (> 30.5133)	Low (< 28.7530)	High (> 28.7530)
ICT	0.0033*** (0.00023)	0.00022 (0.0002)	0.0027*** (0.0003)	0.0005** (0.0002)
ELEC	-	-	0.0013*** (0.0004)	0.0006* (0.0003)
GOV	0.0029*** (0.0011)	0.0073*** (0.001)	0.0014 (0.0011)	0.007*** (0.0011)
GFCF	-0.0013** (0.00063)	0.00066 (0.00051)	-0.0016** (0.0006)	0.0012** (0.0005)
Constant	0.6259*** (0.0179)		0.5445*** (0.0317)	
R-squared	0.7180		0.7366	
Threshold value	30.5133		28.7530	
Conf. Interval	(28.4665, 31.6081)		(27.1565, 29.7764)	
Linearity test/ p-value	0.0000		0.0000	

Basic access to mobile phones, internet connectivity, or digital financial services can improve access to education, healthcare, employment information, and government services. The implication is that in low-ICT environments, targeted ICT investments yield high marginal benefits for human development because they address pressing gaps in communication, information, and service delivery. Also, at the upper regime, where ICT penetration is already high, ICT continues to spur human development but in more sophisticated ways. ICT does not merely bridge gaps in access but enhances efficiency, innovation, and quality of life. The implication is that in high-ICT environments, the focus shifts from basic access to optimising ICT for innovation, equity, and sustainability in human development. The finding implies that ICT is a consistent driver of human development regardless of the stage of ICT adoption. At the lower regime, its role is transformative in bridging fundamental gaps, while at the upper regime, it strengthens and sustains advanced dimensions of development. Policymakers should therefore ensure that both basic access and advanced digital innovation are pursued depending on the level of ICT diffusion in society.

Furthermore, the introduction of access to electricity in the human development model brings about innovation into the threshold model. First, access to electricity spurs human development at lower and upper regimes. At the lower regime, electricity access is limited, often characterised by low rural electrification, unreliable power supply, and restricted household or community coverage. In such settings, even modest improvements in access to electricity bring large and immediate benefits to human development. The implication is that in low-access contexts, expanding electricity supply addresses basic human needs and directly raises health, education, and income levels.

At the upper regime, where electricity access is already widespread and reliable, the impact of electricity on human development becomes more transformative and efficiency-driven rather than gap-filling. Hence, electricity supports industrialisation, digital economies, smart healthcare, advanced educational technologies, and sustainable urban living. The gains are less about initial access and more about leveraging electricity for higher productivity, innovation, and improved quality of life. The implication is that in high-access contexts, policy focus should shift toward ensuring reliability, affordability, sustainability, and efficient use of electricity to sustain long-term human development. Secondly, government expenditure remains insignificant at the lower and upper regimes. At the lower regime, where human development indicators and economic capacity are relatively weak, the insignificance of government expenditure implies that spending does not translate effectively into welfare improvements. The implication is that structural weaknesses and inefficiencies prevent expenditure from yielding meaningful development outcomes at the early stages. At the upper regime, where human development indicators are already relatively high, government expenditure may also remain insignificant. This suggests that additional spending does not generate substantial marginal improvements in human development. In other words, beyond a certain threshold, human development outcomes may depend more on the quality, efficiency, and targeting of spending rather than its size. The implication is that in advanced stages, human development outcomes are not automatically improved by increasing government expenditure but require smarter investments, innovation, and effective governance. Finally, gross fixed capital formation has a negative effect on human development at lower levels, while at upper regimes, gross fixed capital formation has a positive effect on human development in emerging economies. At the lower regime, where levels of economic development are still weak, gross fixed capital formation may negatively affect human development. This happens because resources devoted to building infrastructure, machinery, and industrial capacity can divert funds away from immediate social needs such as education, healthcare, and poverty alleviation. The implication is that at the early stages, heavy investment in physical capital may not benefit and could even harm human development if it comes at the expense of basic social spending or fails to reach the population effectively. At the upper regime, where economies are more developed, gross fixed capital formation positively influences human development. Investments in infrastructure, technology, and industrial capacity now complement improvements in education, health, and income, creating jobs and enhancing productivity. With stronger governance and better project execution, these investments translate into more accessible services, efficient economies, and improved quality of life. The implication is that at higher levels of development, physical capital accumulation becomes a driver of human development, reinforcing gains in welfare and sustaining long-term progress.

Conclusion

Human development is central to addressing Sustainable Development Goals (SDGs), and the SDGs seek to address urgent global challenges towards human well-being. This study examines the criticality of access to electricity on the link between ICT and human development in selected emerging economies between 2000 and 2022 within the modernisation theory across a battery of econometric techniques.

The findings reveal that ICT have a negative and significant impact on human development in emerging economies. This suggests the criticality of access to electricity in the relationship between ICT and human development in emerging economies. The policy implication is that when access to electricity is not commensurate with ICT, heavy reliance on ICT can create vulnerabilities when systems fail or when communities cannot adapt without digital solutions and as such, it may have a negative impact on human development. Second, access to electricity with a poor ICT network could bring about low digital literacy and frustration in education, health and social protection and as such, dampen human development. Lastly, ICT infrastructure and electronic waste (e-waste) could pose serious environmental challenges and, as such, dampen human development in emerging economies. It is recommended that, in addition to ICT, access to electricity should remain a key cornerstone of human development and a driver of progress across several Sustainable Development Goals (SDGs). Also, the interaction of access to electricity and ICT in emerging economies should lay a backbone towards achieving human development. Furthermore, ICT penetration and usage should be encouraged since small improvements in ICT access can produce significant gains in human development. Likewise, policymakers should prioritise ICT investments and digital inclusion strategies as a catalyst for improving living standards, reducing inequality, and expanding opportunities. Lastly, energy policies and electrification programs should be strengthened as a foundation for sustainable improvements in human well-being.

The study concluded that the criticality of access to electricity and ICT is central to human development in emerging economies. However, the study was carried out within a panel of selected emerging economies based on global integration of world sustainable development; further studies could examine the country-specific effect of ICT and electrification on human development. In addition, studies could find out how SDGs seek to address urgent global challenges towards human well-being.

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