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# Productive use of the Internet to accelerate income per capita growth in Sub-Saharan Africa

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**Abstract:** This paper investigates the potential link between internet use and income per capita growth in Sub-Saharan Africa (SSA). Despite greater internet access throughout the region, many countries still fail to achieve the anticipated economic growth. This research explores whether and how internet usage affects real income per capita growth and identifies the conditions that cause this effect to manifest. A simultaneous equation model (SEM) and the three-stage least squares (3SLS) method analyzed data from 27 Sub-Saharan African countries between 2008 and 2019 to understand the relationship between internet use and income growth. The model incorporated equations for internet demand and supply to examine the impact of price, infrastructure quality, education levels, and governance efficiency. Research revealed that internet usage slightly decreases income per capita growth in a statistically meaningful way. The unexpected outcome likely arises from poor internet access, high costs, insufficient infrastructure, and limited digital skills in several nations. Strong institutions and low inflation rates support income growth. Internet demand faces major restrictions due to high costs, while expanded electricity access supports the growth of the Internet supply. This study concludes that simply increasing internet access alone will not lead to improved income growth. To achieve higher productivity from internet use, SSA countries must develop superior infrastructure and affordable services while building strong institutions and investing in digital skills training. The region stands to benefit as these improvements unlock the internet's full potential as a driving force.

**Keywords –** Income per capita, Internet use, Simultaneous equation modelling, Sub-Saharan Africa, Three-stage least squares

## 1. INTRODUCTION

The internet has grown at an unprecedented pace around the world during recent decades, reshaping economic operations as well as communication and service provision. Stakeholders in Sub-Saharan Africa (SSA) consider the internet essential for enhancing productivity levels, driving innovation, generating employment opportunities, and connecting to international markets (Donou-Adonsou, 2019; Hjort & Poulsen, 2019). Development agencies, together with the government, have allocated major resources to extend digital infrastructure throughout the area. The anticipated gains in income per capita across regions remain unevenly achieved. Digital technology benefits have been realized by some SSA countries, but others remain challenged by inadequate infrastructure and high internet costs combined with limited digital skills, which limit effective internet usage (Bahia et al., 2023; Awad & Albaity, 2022).

This paper seeks to examine whether internet use contributes meaningfully to real GDP per capita growth in SSA. The central objective is to determine the direction, size, and significance of the relationship between internet usage and income growth across countries in the region. More specifically, it investigates whether increased internet penetration enhances productivity and economic performance, and under what enabling conditions such effects are likely to materialize.

The core problem addressed in this study is that while internet access is growing, its impact on income growth in SSA remains uncertain and, in some cases, counterintuitive. Some studies report positive associations between ICT development and GDP growth, particularly in countries that have invested in education and complementary infrastructure (Albiman & Sulong, 2017; Asongu & Odhiambo, 2020). Others find negligible or even negative effects, especially in contexts where internet access is low or not used productively (Bakari & Tiba, 2020). In addition, methodological issues such as endogeneity and reverse causality, where income growth itself spurs greater internet use, complicate causal inference (Evans, 2019).

Theoretical perspectives such as the Solow growth model, endogenous growth theory, and Schumpeterian innovation theory have been applied to explain the potential impact of digital technology on economic development. While the Solow model treats technological change as external, endogenous growth theory emphasizes that innovation, which includes internet adoption, is a product of deliberate investment and learning within the economy (Romer, 1990). Schumpeterian theory further highlights the role of entrepreneurship and creative destruction that has been enabled by new technologies (Aghion & Howitt, 1992).

Although several empirical studies suggest that internet use can foster income growth, few of those studies accounted for its potential feedback loop with economic growth. This paper addresses this gap using a simultaneous equation model (SEM), which allows us to estimate the causal relationship between internet usage and GDP per capita growth while accounting for demand- and supply-side interactions. By doing so, the study contributes to a more profound understanding of how to harness the internet for inclusive and sustainable growth in Sub-Saharan Africa.

## 2. LITERATURE SURVEY

### 2.1. Theoretical survey

Several economic theories gave an explanation of how internet use contributes to growth, with neoclassical, innovation, and endogenous growth theories being the most influential. The neoclassical model sees internet use as an external technological advancement that enhances productivity, but it struggles to explain sustained growth from digital technologies due to its assumption of diminishing returns and external tech progress (Solow, 1956). In contrast, endogenous growth theory sees technology and innovation, like internet use, as results of investments in education, research, and infrastructure, making it better for understanding long-term growth driven by digital advancements. The innovation theory, grounded in Schumpeter's concept of creative destruction, highlights the internet's role in reducing barriers for new firms and fostering economic transformation through technological advancements, despite its potential to ignore infrastructure and institutional requirements (Aghion & Howitt, 1992). Because of its ability to integrate the roles of human capital, innovation, and internal drivers of growth, endogenous growth theory is the preferred framework for this paper.

### 2.2. Methodological survey

Researchers have extensively studied the relationship between internet use and economic growth, often within the broader context of ICT and development. In the Sub-Saharan African context, the independent variable of interest is usually related to internet penetration or access. The dependent variable is typically income growth, most often measured as the growth rate of GDP per capita (or occasionally the log-level of GDP per capita for long-run effects). Control variables are drawn from standard growth regression frameworks, including physical capital investment, human capital (school enrollment rates), labor force growth, openness to trade, and institutional quality (Albiman & Sulong, 2016; Abdulqadir & Asongu, 2022; Bakari & Tiba, 2020; Choi & Yi, 2009). For instance, a study by Abdulqadir & Asongu (2022) looks at factors like private sector credit, trade openness, government quality, and tariff rates, along with internet access, to understand growth in 42 African countries.

An important nuance in recent literature is the possibility of non-linear effects: several studies have tested whether a minimum level of internet penetration is needed before it significantly contributes to growth. Albiman and Sulong (2016) found threshold levels (4–5% penetration) for ICT's effect on African growth, and similarly, Abdullahi and Asongu (2022) identified a significant threshold at about 3.55% internet access; below that, internet expansion had a minimal effect on GDP growth, but above it, the effect became significant. This pattern reflects the idea that network effects and complementary infrastructure must reach a critical mass for the internet to substantially boost economic productivity. Some studies also differentiate between types of ICT. Chavula (2013) showed that in the 1990s–2000s, fixed telephone and mobile phone penetration had measurable impacts on African per capita income growth, whereas internet usage at the time did not (likely because it was very low). By the 2010s, however, internet access had grown enough that studies (Evans, 2019) started finding positive links between the internet and broad development indices. This literature thus tracks an evolving set of variables as technology advances, but generally focuses on ICT access metrics vs. macroeconomic performance indicators.

## 2.3. Empirical survey

Research shows that internet expansion contributes to economic growth and higher incomes by boosting productivity and creating new market opportunities. In advanced economies, studies like Koutroumpis (2019) find that broadband internet significantly increases GDP by improving efficiency, though gains may have declined over time as these economies became more saturated with technology. In contrast, Bahrini and Qaffas (2019) show that while internet use benefits both rich and poor countries, the growth effects are larger in developing nations, supporting the idea that poorer countries can leapfrog using digital technologies. Their study also emphasizes that mobile and broadband internet now matter more for growth than older technologies like fixed-line phones. However, issues like reverse causality remain. At the individual level, Choi (2023) reports that internet access had a positive effect on the search and hire rate, with more searchers finding a job more quickly and improving their wages and unemployment rates.

Research from developing countries in Asia and Latin America has linked increased internet access to greater income, lower poverty, and faster growth, more so in developing countries than in developed ones. In middle-income Asian countries, for example, Pradhan et al. (2023) showed that better internet infrastructure contributes to growth and innovation, as well as driving a virtuous cycle of more growth leading to more ICT investment. However, their estimation cannot completely address the endogeneity issue. Haini (2019) found that internet usage and improved human capital significantly contributed to growth in ASEAN countries between 1999 and 2014. Using more advanced techniques, Haini (2022) reconfirmed this hypothesis, showing that tourism and internet access have a separate and joint positive effect on growth. Despite the sample being restricted to ASEAN, the results are still relevant for SSA. Internet use in Latin America was linked to faster GDP growth in countries that adopted it quickly (for example, Chile), when compared to other Latin American countries (Oyelaran-Oyeyinka & Lal, 2016). Bahrini and Qaffas (2019) also showed that the positive impact of internet use is larger in low- and lower-middle-income countries than in high-income countries. Overall, the results suggest that internet access can enable developing economies to "leapfrog" access to new markets and knowledge while bypassing decades of investment in traditional infrastructure.

At the micro level, the impact is also clear. In India, affordable mobile internet helped rural entrepreneurs increase their income by using WhatsApp and Facebook to reach out to more customers (World Bank, 2016). In Indonesia, villages with early 3G access saw higher household income and spending due to easier job searching and online business opportunities (Galperin & Viecens, 2017). These cases show how internet access reduces information gaps. Still, these studies often use methods that may not perfectly isolate internet effects, and their results may vary—for example, where literacy is low, internet access alone might not boost income. Another key finding is that human capital matters. Countries that have better education systems tend to gain more from internet access. Donou-Adonsou (2019) showed that in SSA, telecom infrastructure improves growth only where education access is stronger. So, without an educated workforce, the internet's impact is limited. This finding also explains why some Latin American countries didn't benefit much from ICT until they made reforms to improve the education system, as well as the business environment.

Internet usage in SSA is increasingly recognized as a key contributor to income and economic growth, although the evidence is still relatively scarce compared to other regions. Hjort and Poulsen (2019) show robust causal evidence that the installation of submarine cables was associated with higher-skilled employment and higher incomes due to increased service-sector jobs in the connected regions. Donou-Adonsou (2019) finds that the internet's economic impact is greater in countries with better educational systems, highlighting that both human capital and internet infrastructure are key to boosting growth. Nevertheless, the benefits of the internet are not evenly distributed, with rural and landlocked regions often lagging due to weaker infrastructure or educational systems.

Empirical research at various levels of aggregation supports the conclusions above. At the regional level, Albiman and Sulong (2017) and Abdulqadir and Asongu (2022) found a positive association between the internet and growth in SSA, especially in low-middle-income countries, and Odhiambo (2022) also observed a positive relationship between ICT and growth. The firm-level evidence provided by Esaku and Krugell (2019) supports that internet-using firms are more productive and profitable, and case studies from Nigeria and Kenya illustrate internet-enabled entrepreneurship by youth. However, self-selection bias and endogeneity continue to pose challenges in establishing causality, although the researchers attempted to control them using more sophisticated econometric methods. The study by Bahia et al. (2023) concludes that increasing mobile internet availability leads to lower poverty and higher employment, providing real-world support for the positive effects of the internet. However, the Internet may not always be beneficial; Bakari and Tiba (2020) found that the growth in the North African region's short-term GDP decreased with an increase in internet usage, which they attribute to "a nonproductive usage of the Internet".

### 2.4. Summary of literature and gaps

While there is a general consensus that the internet causes increased income and GDP, its causal effect is more challenging to measure due to endogeneity (causes and effects may be correlated). Since economic growth increases internet access, it is difficult to disentangle these two factors. Evans (2019) discovers a two-way causal relationship between internet usage and GDP in Africa. Recently developed econometric tools, such as system GMM (Wamboye et al., 2015), have attempted to control those endogeneities; however, these may not eliminate the problem completely. The early literature also assumes a simple linear effect of the internet, while more recent literature has suggested a nonlinear effect of the internet that is sensitive to thresholds, both in terms of the percentage of the population with internet access and other factors, such as human capital. Solomon and van Klyton (2020) show that in regions where the primary school enrollment is already very high, the growth effect of the internet comes into effect. For other developing regions, such as Sub-Saharan Africa, the internet allows for job creation, increased productivity, and the creation of new sectors, such as mobile banking and e-commerce (Hjort & Poulsen, 2019). However, the effect is also heterogeneous, favoring skilled workers and urban areas. Selection bias and measurement errors persist. All these gaps call for more research in this area.

## 3. PROBLEM STATEMENT

Despite the growing internet access in Sub-Saharan Africa, its effect on income growth remains unclear and uneven across countries. While some studies link internet usage to higher GDP per capita, especially where education and infrastructure are strong, others find limited or even negative effects where usage is low or unproductive (Albiman & Sulong, 2017; Bakari & Tiba, 2020). Methodological challenges like endogeneity and reverse causality further complicate the understanding of this relationship (Evans, 2019). This study seeks to clarify whether and under what conditions internet use meaningfully contributes to income growth in the region.

**Table 1:** Variable measurements

| *Variable* | *Measurement* |
|---|---|
| GDPG | Measured as real GDP per capita growth using national-accounts growth rates and expressed it in real constant terms (million 2011 dollars) |
| INET | Internet usage per capita, computed by dividing the population size by internet users and multiply the quotient by 100 |
| FBB | Fixed broadband subscriptions per capita, which comes from dividing the fixed broadband customer total by the population and multiplying this quotient by 100 |
| K | Physical capital stock which is measured in real constant terms using investment data from 2011 dollars for structures and equipment |
| L | Labour force, which includes people aged 15-64 |
| ED | Human capital assessed through the human capital index developed by Feenstra et al. (2015) |
| T | Innovation, captured by the number of scientific journal articles |
| INST | Institutional quality, represented by the index of five equally weighted factors computed using principal component analysis |
| OPEN | Economic openness index combines total imports and exports as a GDP percentage |
| INF | Inflation rates measured by annual consumer price changes, which demonstrate macroeconomic balance |
| PRICE | Fixed broadband monthly service charges to measure internet costs |
| URB | An urbanization metric measured by urban population percentages |
| GOV | General government final consumption expenditure as a percentage of GDP |
| ELEC | Percentage of population with access to electricity |
| FDI | Net FDI inflows percentage of GDP |

***Source:*** WDI, ITU, Peen world Table 10.0

**Table 2:** Summary statistics

| | N | Std. Dev. | Mean | Median | Min | Max | Skewness | Kurtosis |
|---|---|---|---|---|---|---|---|---|
| RGDPPCG | 324 | 3.042 | 1.979 | 2.044 | -15.891 | 11.3 | -.885 | 6.848 |
| INET | 315 | 14.767 | 15.647 | 10 | .45 | 69.697 | 1.339 | 4.168 |
| FBB | 315 | 2.794 | 0.909 | .174 | .002 | 23.699 | 5.653 | 37.404 |
| CN | 324 | 777113.12 | 402101.432 | 122494 | 16434 | 4243349 | 3.147 | 12.427 |
| LBR | 324 | 13485196 | 11169696.068 | 7300000 | 340887 | 67000000 | 2.306 | 8.275 |
| ED | 324 | .578 | 1.873 | 2 | 1 | 3 | .009 | 2.867 |
| SCTJ | 324 | 2063.102 | 754.297 | 158.515 | 3.94 | 14999.2 | 4.516 | 24.51 |
| INST | 324 | 1 | 0.000 | -.124 | -2.055 | 2.614 | .641 | 3.2 |
| OPEN | 309 | 28.549 | 67.821 | 60.627 | 15.282 | 161.127 | .913 | 3.468 |
| INF | 324 | 7.91 | 6.986 | 5.344 | -16.86 | 63.292 | 2.82 | 16.199 |
| INETPR | 322 | 280.165 | 107.419 | 35.393 | .35 | 3152.63 | 7.5 | 71.605 |
| URBG | 324 | 1.275 | 3.853 | 4.075 | -.151 | 5.993 | -1.183 | 4.469 |
| GOVEXP | 322 | 7.004 | 16.085 | 14.595 | 5.588 | 43.482 | 1.611 | 5.941 |
| ELEC | 324 | 21.964 | 42.891 | 40.15 | 6 | 100 | .667 | 2.973 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| FDI | 324 | 4.984 | 3.645 | 2.597 | -11.192 | 38.943 | 3.118 | 18.984 |

***Source:*** Author's computation

**Table 3:** Matrix of correlations

| Variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) INET | 1.00 | | | | | | | | | | | | | |
| (2) FBB | 0.52 | 1.00 | | | | | | | | | | | | |
| (3) CN | 0.29 | -0.03 | 1.00 | | | | | | | | | | | |
| (4) LBR | 0.02 | -0.16 | 0.72 | 1.00 | | | | | | | | | | |
| (5) ED | 0.50 | 0.38 | 0.18 | -0.13 | 1.00 | | | | | | | | | |
| (6) SCTJ | 0.44 | 0.05 | 0.74 | 0.47 | 0.33 | 1.00 | | | | | | | | |
| (7) INST | 0.40 | 0.51 | -0.14 | -0.35 | 0.48 | 0.09 | 1.00 | | | | | | | |
| (8) OPEN | 0.19 | 0.25 | -0.16 | -0.48 | 0.18 | -0.15 | 0.44 | 1.00 | | | | | | |
| (9) INF | -0.07 | -0.13 | 0.20 | 0.29 | -0.04 | 0.03 | -0.28 | -0.20 | 1.00 | | | | | |
| (10) INETPR | -0.26 | -0.11 | -0.08 | 0.07 | -0.20 | -0.09 | -0.07 | -0.15 | 0.17 | 1.00 | | | | |
| (11) URBG | -0.58 | -0.60 | -0.01 | 0.31 | -0.49 | -0.19 | -0.50 | -0.35 | 0.11 | 0.12 | 1.00 | | | |
| (12) GOVEXP | 0.19 | 0.01 | -0.08 | -0.22 | 0.08 | 0.00 | 0.38 | 0.72 | -0.22 | -0.05 | -0.23 | 1.00 | | |
| (13) ELEC | 0.74 | 0.56 | 0.31 | 0.01 | 0.54 | 0.40 | 0.40 | 0.18 | -0.03 | -0.29 | -0.65 | -0.01 | 1.00 | |
| (14) FDI | -0.22 | -0.05 | -0.17 | -0.08 | -0.19 | -0.13 | 0.01 | 0.22 | -0.03 | -0.02 | 0.12 | 0.07 | -0.21 | 1.00 |

***Source:*** Author's computation

**Table 4:** Rank test results

| *Test statistic* | *Rank of matrix* | *Chi-square* | *p-value* |
|---|---|---|---|
| Kleibergen-Paap | 25.98 | 13 | 0.0171 |
| Cragg-Donald | 26.00 | 13 | 0.0170 |
| Cragg-Donald (auto & hetero) | 22.71 | 13 | 0.0451 |

***Source:*** Author's computation

**Table 5a:** The effect of internet use on income per capita (income growth equation)

| | 3SLS | SUR | 2SLS | 3SLS1 | 3SLS2 | 3SLS3 |
|---|---|---|---|---|---|---|
| | $drgdppcg$ | $drgdppcg$ | $drgdppcg$ | $drgdppcg$ | $drgdppcg$ | $drgdppcg$ |
| $rgdppcg\_1$ | -0.717***(-13.2) | -0.717***(-13.2) | -0.715***(-12.6) | -0.717***(-13.3) | -0.718***(-13.2) | -0.717***(-13.2) |
| $rgdppcg\_2$ | 0.172*** (3.17) | 0.172*** (3.17) | 0.171*** (3.03) | 0.171*** (3.17) | 0.169*** (3.12) | 0.172*** (3.17) |
| $inet$ | -0.048** (-2.57) | -0.048** (-2.57) | -0.045** (-2.32) | -0.041* (-1.82) | -0.036 (-1.40) | -0.048** (-2.57) |
| $lnk$ | -0.056 (-0.24) | -0.056 (-0.24) | -0.058 (-0.23) | -0.074 (-0.31) | -0.085 (-0.35) | -0.056 (-0.24) |
| $lnlbr$ | 0.218 (0.65) | 0.218 (0.65) | 0.214 (0.61) | 0.255 (0.75) | 0.272 (0.79) | 0.218 (0.65) |
| $lned$ | 0.234 (0.42) | 0.234 (0.42) | 0.206 (0.35) | 0.296 (0.49) | 0.354 (0.56) | 0.234 (0.42) |
| $lnsctj$ | 0.088 (0.39) | 0.088 (0.39) | 0.093 (0.40) | 0.073 (0.32) | 0.0625 (0.27) | 0.088 (0.39) |
| $inst$ | 0.842*** (3.29) | 0.842*** (3.29) | 0.822*** (3.07) | 0.920*** (3.47) | 0.904*** (3.35) | 0.842*** (3.29) |
| $lnopen$ | 0.019 (0.03) | 0.019 (0.03) | -0.001 (-0.00) | 0.073 (0.13) | 0.054 (0.09) | 0.019 (0.03) |
| $inf$ | -0.0649* (-1.93) | -0.065* (-1.93) | -0.065* (-1.85 | -0.066* (-1.90) | -0.065* (-1.85) | -0.065* (-1.93) |
| $inet\_ed$ | | | | 0.011 (0.24) | 0.021 (0.37) | |
| $inet\_inst$ | | | | -0.013 (-1.00) | -0.012 (-0.93) | |
| $inet\_c2$ | | | | | -0.0001 (-0.31) | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Constant | 538.1 (0.42) | 538.1 (0.42) | 559.9 (0.42) | 592.0 (0.47) | 557.5 (0.44) | 538.1 (0.42) |
| Dummy_T | Yes | Yes | Yes | Yes | Yes | - |
| *N* | 235 | 235 | 235 | 235 | 235 | 235 |
| $R^2$ | 0.521 | 0.521 | 0.521 | 0.524 | 0.524 | 0.521 |

*t* statistics in parentheses, * p<0.1, ** p<0.05, *** p<0.01
***Source:*** Author's computations

**Table 5b:** The effect of internet use on income per capita (internet demand equation)

| | 3SLS | SUR | 2SLS | 3SLS1 | 3SLS2 | 3SLS3 |
|---|---|---|---|---|---|---|
| | *dinet* | *dinet* | *dinet* | *dinet* | *dinet* | *dinet* |
| *inet_1* | 0.229*** (3.58) | 0.229*** (3.58) | 0.232*** (3.46) | 0.229*** (3.59) | 0.229*** (3.58) | 0.229*** (3.58) |
| *inet_2* | -0.326***(-4.83) | -0.326***(-4.83) | -0.333***(-4.68) | -0.326***(-4.82) | -0.326** (-4.83) | -0.326***(-4.83) |
| *rgdppcg* | 0.004 (0.06) | 0.004 (0.06) | 0.045 (0.59) | 0.007 (0.10) | 0.007 (0.09) | 0.004 (0.06) |
| *fbb* | -0.216** (-2.51) | -0.216** (-2.51) | -0.202** (-2.25) | -0.219** (-2.54) | -0.219** (-2.54) | -0.216** (-2.51) |
| *lnprice* | -0.938***(-4.39) | -0.938***(-4.39) | -0.967***(-4.31) | -0.940***(-4.40) | -0.940***(-4.40) | -0.938***(-4.39) |
| *lned* | 0.774 (1.21) | 0.774 (1.21) | 0.782 (1.16) | 0.773 (1.21) | 0.772 (1.21) | 0.774 (1.21) |
| *urbg* | -0.834***(-3.58) | -0.834***(-3.58) | -0.864***(-3.53) | -0.836***(-3.59) | -0.837***(-3.60) | -0.834***(-3.58) |
| *lngov* | 0.313 (0.58) | 0.313 (0.58) | 0.349 (0.63) | 0.314 (0.59) | 0.313 (0.58) | 0.313 (0.58) |
| *inst* | 0.108 (0.36) | 0.108 (0.36) | 0.030 (0.10) | 0.107 (0.36) | 0.108 (0.36) | 0.108 (0.36) |
| Constant | 41.53 (0.03) | 41.53 (0.03) | 3.593 (0.00) | 40.08 (0.03) | 39.61 (0.02) | 41.53 (0.03) |
| Dummy_T | Yes | Yes | Yes | Yes | Yes | - |
| *N* | 235 | 235 | 235 | 235 | 235 | 235 |
| $R^2$ | 0.521 | 0.521 | 0.521 | 0.524 | 0.524 | 0.521 |

*t* statistics in parentheses, * p<0.1, ** p<0.05, *** p<0.01
***Source:*** Author's computations

**Table 5c:** The effect of internet use on income per capita (internet supply equation)

| | 3SLS | SUR | 2SLS | 3SLS1 | 3SLS2 | 3SLS3 |
|---|---|---|---|---|---|---|
| | *dfbb* | *dfbb* | *dfbb* | *dfbb* | *dfbb* | *dfbb* |
| *fbb_1* | 0.220*** (3.45) | 0.220*** (3.45) | 0.202*** (3.02) | 0.220*** (3.45) | 0.220*** (3.45) | 0.220*** (3.45) |
| *fbb_2* | -0.119* (-1.66) | -0.119* (-1.66) | -0.100 (-1.33) | -0.119* (-1.66) | -0.119* (-1.66) | -0.119* (-1.66) |
| *rgdppcg* | 0.007 (0.95) | 0.007 (0.95) | 0.007 (0.90) | 0.007 (0.94) | 0.007 (0.94) | 0.007 (0.95) |
| *inet* | -0.006** (-2.16) | -0.006** (-2.16) | -0.005 (-1.55) | -0.006** (-2.16) | -0.006** (-2.16) | -0.006** (-2.16) |
| *elec* | 0.004** (2.36) | 0.004** (2.36) | 0.004** (2.07) | 0.004** (2.36) | 0.004** (2.36) | 0.004** (2.36) |
| *lngov* | 0.029 (0.54) | 0.029 (0.54) | 0.020 (0.36) | 0.029 (0.54) | 0.0285 (0.54) | 0.029 (0.54) |
| *inst* | 0.027 (0.98) | 0.027 (0.98) | 0.021 (0.72) | 0.027 (0.98) | 0.0272 (0.97) | 0.027 (0.98) |
| *fdi* | 0.001 (0.32) | 0.001 (0.32) | 0.001 (0.26) | 0.001 (0.32) | 0.001 (0.32) | 0.001 (0.32) |

| Constant | -49.37 (-0.31) | -49.37 (-0.31) | -39.55 (-0.24) | -49.37 (-0.31) | -49.37 (-0.31) | -49.37 (-0.31) |
|---|---|---|---|---|---|---|
| Dummy_T | Yes | Yes | Yes | Yes | Yes | - |
| *N* | 235 | 235 | 235 | 235 | 235 | 235 |
| $R^2$ | 0.521 | 0.521 | 0.521 | 0.524 | 0.524 | 0.521 |

*t* statistics in parentheses, * p<0.1, ** p<0.05, *** p<0.01
***Source:*** Author's Computations

**Table 6:** Diagnostic tests

| *Test* | *3SLS* | *SUR* | *2SLS* | *3SLS1* | *3SLS2* | *3SLS3* |
|---|---|---|---|---|---|---|
| Harvey LM Test | 1.495 (0.684) | 1.495 (0.684) | 0.927 (0.819) | 1.479 (0.687) | 1.479 (0.687) | 1.886 (0.597) |
| Breusch-Pagan LM | 5.621 (0.132) | 5.621 (0.132) | 5.621 (0.132) | 5.560 (0.135) | 5.576 (0.1342) | 6.508 (0.089) |
| Likelihood Ratio Lr | 5.732 (0.125) | 5.732 (0.125) | 5.732 (0.125) | 5.665 (0.1291) | 5.683 (0.1281) | 6.610 (0.085) |
| Hansen J | 31.319 (0.089) | 31.319 (0.089) | | 33.890 (0.067) | 35.507 (0.061) | 25.896 (0.018) |
| Wald test | 397.24 (0.000) | 397.24 (0.000) | 40.18 (0.000) | 398.47 (0.000) | 397.67 (0.000) | 428.68 (0.000) |
| Pesaran, Xie (2021) | -1.28 (0.201) | -1.28 (0.201) | -1.90 (0.058) | -2.08 (0.037) | -1.99 (0.046) | 1.37 (0.170) |
| Hausman | 0.46 (1.000) | | | | | |

***Source:*** Author's Computations

# 4. RESEARCH METHODOLOGY

## 4.1. Theoretical framework

Developing a theoretical framework for studying internet usage's effect on GDP per capita growth in Sub-Saharan Africa requires embedding the potential internet effect into an endogenous growth model framework. According to the Solow growth model, economic expansion relies on capital accumulation alongside labor and technological advancements. The Modified Solow Growth Model enhances flexibility by including human capital and technological factors, also, occasionally institutional elements, which help in explaining the economic growth in developing areas such as sub-Saharan Africa.

The basic Solow model is represented by the equation:

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha} \quad (1)$$

Where: $Y_t$ is output (GDP) at the time $t$, Total factor productivity (TFP) is represented by $A_t$ and reflects technological advances within the economy, $K_t$Is the capital stock, $L_t$ is labor (human capital or population), and $\alpha It$ is the output elasticity of the capital.

The Modified Solow Model demonstrates TFP ($A_t$) Growth through simultaneous technological advancements and increases in human capital. We can view internet usage as a factor that boosts technological advancement. Internet utilization enhances economic growth through its positive impact on Total Factor Productivity. The research found that the hypothesis is that internet usage will boost productivity levels, which will lead to increased GDP per capita growth in sub-Saharan Africa. Economic growth receives multiple influences from internet use through:

- **i)** Knowledge transfer and innovation: Through internet access, individuals can obtain new information and technological advancements, which can result in productivity improvements across multiple sectors such as agriculture, manufacturing and services.
- **ii)** Human capital development: Internet access can also enable online education and skills growth, which in turn builds the human capital that is considered essential for economic progress.

**iii)** Market access: Through the internet, businesses can gain entry into the worldwide markets, which can lead to better trade prospects, as well as stimulate competition and innovations.

We can extend the TFP term ($A_t$) Within the Solow model framework to integrate effects from internet usage. The relationship is captured as:

$$A_t = A_0 e^{\gamma . I_t} \quad (2)$$

Where: The initial technological progress level is represented by $A_0$, the parameter $\gamma$Measures how Total Factor Productivity responds to internet usage, and the $I_t A$ Metric measures how deeply internet use affects economic activities by indicating the percentage of people who use the internet.

By integrating internet use into the Solow framework, we achieve a modified production function.

$$Y_t = A_0 e^{\gamma . I_t} K_t^{\alpha} L_t^{1-\alpha} \quad (3)$$

The formula demonstrates how internet access leads to increased total factor productivity ($A_t$) Which results in higher output ($Y_t$).

Internet use directly contributes to human capital development. Equally, access to better information and educational resources enables people to develop skills that assist to in boosting their productivity at work. Our analysis presents a link between labor qualities (human capital), which improves as internet penetration increases.

$$L_t = L_0 e^{\emptyset . I_t} \quad (4)$$

Where: $L_0$ is the initial labor force, and the $\phi$ A variable measures human capital's sensitivity level to internet usage. The internet functions as a resource that improves labor quality over time, which leads to increased output.

This study examines how internet usage affects economic growth through its impact on human capital development. The economic output equation incorporates the combined effects of internet use on both TFP and human capital.

$$Y_t = A_0 e^{\gamma . I_t} K_t^{\alpha} (L_0 e^{\emptyset . I_t})^{1-\alpha} \quad (5)$$

The application of logarithms to both sides of the equation simplifies interpretation and growth rate analysis.

$$ln(Y_t) = ln(A_0) + \gamma I_t + \alpha ln(K_t) + (1-\alpha) ln(L_0) + (1-\alpha)\emptyset . I_t \quad (6)$$

The model allows us to analyze internet usage effects on GDP per capita growth by studying parameters, $\gamma$ and $\phi$, which represents internet use influences on total factor productivity, and the human capital, respectively.

## 4.2. Empirical model

Considering (6) above, the elasticities of technology, capital, labor, and human capital are typical of production functions. However, the internet use elasticity estimates a one-way causal link from internet use to GDP per capita. This may produce misleading results due to anticipated endogeneity problems. First, reverse causality such that internet use may depend on economic growth. Individuals earning highly easily buy computers and smartphones, as well as use the internet. Moreover, a nation's level of growth determines its state's engagement with the telecom sector. This creates confusion about the sectoral regulatory and policy effect with the Internet use effect. For example, while responding to the COVID-19 pandemic, several governments in different countries came up with recovery plans, which required making high-speed internet available to (Amaglobeli et al., 2023).

The researchers conducted an empirical study to assess how internet usage influences GDP per capita growth across sub-Saharan Africa. A regression model was used to derive the coefficients $\gamma$ and $\phi$, which measures the influence of internet use variations on economic output and labor productivity. We isolated the internet's effect by controlling for additional factors including, capital accumulation, educational levels, infrastructure development, and governance quality.

A typical empirical specification looks like:

$$\Delta ln Y_{it} = \beta_0 + \beta_1 Internet\ Use + \beta_2 Control\ Variables + \epsilon_{it} \quad (7)$$

The growth rate of GDP per capita is represented by $\Delta ln(Y_{it})$ while $Internet\ Use_{it}$ measures internet use for the country $i$ at time $t$.

According to the Modified Solow growth model analysis, internet use promotes GDP per capita growth in sub-Saharan Africa through enhancements in total factor productivity and human capital. The parameters $\gamma$ and $\phi$ measure how technological progress and human capital accumulation respond to increasing internet penetration. The framework enables a complete evaluation of internet use as an essential factor for regional economic growth.

Estimates from equation (7) show that internet usage seems to cause GDP per capita to rise, but this ignores the possibility that the two might influence each other, which could lead to wrong conclusions, indicating that economic growth might encourage more internet use. Wealthier people can buy devices and internet access more easily, increasing usage; however, a country's level of economic development affects how much the government gets involved in telecom, making it difficult to tell apart the effects of policies from the real impact of internet usage. The distinction was clear during COVID-19 when many governments used stimulus packages to improve high-speed internet access (Amaglobeli et al., 2023). Wealthier individuals can afford devices and internet access, speeding up usage, while a country's economic development stage influences the government's involvement in telecom, making it challenging to separate policy effects from the actual internet usage impact. This trend was evident during COVID-19 when many governments used stimulus packages to expand high-speed internet (Amaglobeli et al., 2023). To address these complexities, we used a Simultaneous Equation Model (SEM) based on Meijers (2014), adding institutional quality and human capital to his original control variables. By creating separate equations for internet demand and supply, we analyzed how GDP affects internet use and vice versa. Internet demand was influenced by factors like price, GDP per capita, education, and urbanization, while supply depended on GDP per capita, demand, electricity, government spending, institutions, and foreign direct investment, treating internet usage as an endogenous factor.

The econometric model is specified as follows:

$$GDPG_{it} = \alpha_0 + \alpha_1 INET_{it} + \alpha_2 K_{it} + \alpha_3 L_{it} + \alpha_4 ED_{it} + \alpha_5 T_{it} + \alpha_6 INST_{it} + \alpha_7 OPEN_{it} + \alpha_8 INF_{it} + d_i + v_i + \xi 1_{it} \quad (8.1)$$

$$INET_{it} = \beta_0 + \beta_1 GDPG_{it} + \beta_2 FBB_{it} + \beta_3 PRICE_{it} + \beta_4 ED_{it} + \beta_5 URB_{it} + \beta_6 GOV_{it} + \beta_7 INST_{it} + d_i + v_i + \xi 2_{it} \quad (8.2)$$

$$FBB_{it} = \gamma_0 + \gamma_1 GDPG_{it} + \gamma_2 INET_{it} + \gamma_3 ELEC_{it} + \gamma_4 GOV_{it} + \gamma_5 INST_{it} + \gamma_6 FDI_{it} + d_i + v_i + \xi 3_{it} \quad (8.3)$$

## 4.3. Data sources

The data collection covered 27 SSA countries such as Angola, Benin, Botswana, Burkina Faso, Cameroon, Cote d'Ivoire, Eswatini, Ethiopia, Ghana, Kenya, Lesotho, Madagascar, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, South Africa, Sudan, Tanzania, Togo, Uganda, and Zambia. From the World Development indicators (WDI) database, the researchers, were able to gather real GDP per capita growth along with labor force data and innovation statistics, as well as trade openness figures together with inflation rates and government expenditure details, and measurements of access to electricity and foreign direct investment. The researchers also acquired the institutional quality data from the Worldwide Governance Indicators (WGI) and obtained capital stock and human capital information from Peen wWorld Table 10.0, while internet per capita, along with fixed broadband and internet price statistics, were sourced from the ITU database. The data spans from 2008 to 2019 because these years offered available data.

## 4.4. Estimation procedure

The researchers applied a SEM approach in this analysis. The following steps were followed in the implementation of the approach. First, descriptive statistics were computed to gain knowledge of the underlying characteristics of the variables. The researchers then conducted an identification test to gauge whether the structural coefficients are estimable. Thereafter, the researchers ran a 3SLS regression to generate coefficients. Finally, the researchers ran a diagnostic, testing whether model assumptions hold, is paramount. Such major assumptions under consideration are the proper specification of the equations, instrument validity, and dealing with the issue of endogeneity. Violating any of these could lead to inefficient, inconsistent, and biased parameter estimates. Therefore, to verify the appropriateness of the results, the researchers conducted a serial correlation, heteroscedasticity, over-identification or validity of instruments, joint significance, and cross-sectional dependence tests.

## 5. DATA ANALYSIS AND DISCUSSIONS

This subsection presents estimates of the researchers' analysis. The presentation begins with the results of the descriptive statistics, followed by model identification results, 3SLS results, and finally diagnostic test results.

### 5.1. Descriptive statistics

Table 2 shows key descriptive statistics for all variables, highlighting large differences in economic and development indicators across Sub-Saharan Africa. The average real GDP per capita growth rate is 1.979%, but skewness and kurtosis values reveal that many countries grow below average, with a few experiencing extreme outcomes, like Botswana's -15.891% in 2009 and Ghana's 11.3% in 2011. Internet usage, broadband access, and innovation indicators are highly right-skewed with high kurtosis, showing that only a few countries have high levels, while most lag behind. Variables like total consumption, labor force, trade openness, inflation, internet price, and foreign direct investment also show uneven distributions, with some countries dominating the data. Education is more normally distributed, while institutional quality and electricity access are only slightly skewed. Urban growth is left-skewed, and government spending varies across countries. These distribution patterns show important differences in development in the region and highlight the need for econometric models that can handle variations and outliers in panel data analysis.

The researchers' examination for multicollinearity showed that all variables were acceptable since their correlation coefficients remained below 0.8 according to Gujarati's (2003) recommendations. As such, there was a retention of all the variables. The analysis showed that multicollinearity was not a concern because the regression coefficients remained low (see Table 3).

### 5.2. Model identification

It is crucial to compare the number of variables not contained in the equation but everywhere else in the model $(K - M)$ and the right-hand variables less one $(G - 1)$, when implementing the order condition. The equation is identified if $(K - M) >= (G - 1)$. In the researcher's case, $K$ is 17, the total number of endogenous variables $(G)$ is 3, thus $G - 1 = 2$. Given that the GDP equation has $(M = 10)$, demand equation has $(M = 9)$, and supply equation has $(M = 8$The researchers concluded that $(K - M) > (G - 1)$For all equations, thus they are over-identified. The researcher's also tested for the rank condition using Kleibergen-Paap, and Cragg-Donald Langrange Multiplier tests. Results of the test displayed in Table 4 show rejection of the null hypothesis of the under-identified instrument matrix $(H_0: rank = 2)$ while accepting an alternative hypothesis of the identified instrument matrix $(H_1: rank \geq 3)$. This means that the model is likely well identified because the instrument matrix has enough independent instruments to estimate the parameters of all three endogenous variables (see Table 4).

### 5.3. Presentation and interpretation of empirical findings

This study looks at how using the internet affects the growth of real GDP per capita (RGDPPCG) in Sub-Saharan Africa (SSA) by using a three-equation model analyzed with Three-Stage Least Squares (3SLS). The three endogenous equations are (1) a Growth Equation (RGDPPCG), (2) an Internet Demand Equation (INET), and (3) an Internet Supply Equation (FBB). The 3SLS estimator takes into account how growth and internet variables affect each other, giving reliable estimates by using tools and considering errors that are related across the equations. To ensure accuracy, we also look at results from Seemingly Unrelated Regressions (SUR) and Two-Stage Least Squares (2SLS), and we use different versions of the 3SLS method (called 3SLS1, 3SLS2, and 3SLS3) to see how sensitive the results are (see Table 5 (a, b, and c)). Next, we explain the results for each equation, looking at how the key variables behave, their size, and their importance, and then we compare the models and what this means for policymakers.

The three-stage least squares (3SLS) results for the real GDP per capita growth (RGDPPCG) equation indicate that internet use (INET) has a negative and statistically meaningful effect on growth. The coefficient on INET is about –0.0481 and is significant at the 5% level. This implies that a 1% increase in internet usage (as a share of population) is associated with roughly a 0.05 percentage point decline in annual RGDP per capita growth, holding other factors constant. While small in absolute value, over time, such an effect could cumulatively slow growth. This counterintuitive result contrasts with much of the global literature (which often finds positive effects) and thus deserves careful interpretation. One possible explanation is that many SSA countries are still below a critical threshold of internet penetration needed to realize growth benefits. Empirical studies suggest that internet and mobile penetration rates need to reach roughly 5% before contributing positively to growth (Albiman & Sulong, 2016).

In SSA's context, where average internet penetration has historically been low, initial increases in internet use may yield minimal or even negative short-term growth impacts. This could occur if early internet adoption is used more for consumption and social networking than productive business activities, or if it diverts limited resources away from other investments without immediate payoff. Additionally, weak complementary infrastructure (e.g., unreliable electricity, limited broadband capacity) and skill gaps can dampen the productivity gains from internet use. When digital technologies "perform below expectations due to poor infrastructural equipment," their contribution to GDP growth can be negligible or negative (Awad & Albaity, 2022). In other words, without adequate network quality and user skills, internet access might not translate into economic output gains, and during periods of network downtime or misuse, the value from internet subscriptions "diminishes" for the economy (Awad & Albaity, 2022). Importantly, the effect of internet use remains robustly negative and significant across all model variants, underscoring its role as a key growth driver in Sub-Saharan Africa.

Institutional quality (INST) enters with a strongly positive and significant coefficient (approximately 0.84), aligned with expectations that better governance fosters growth. The positive point estimate suggests that improvements in political stability, government effectiveness, rule of law, and related governance metrics tend to coincide with higher growth. Inflation (INF) has a significant negative effect on growth (coefficient around –0.07), indicating that higher consumer price inflation undermines real income growth. Even a moderate increase in inflation (for example, 5 percentage points) is associated with a few tenths of a percent lower annual GDP per capita growth, everything else remaining equal, underscoring the importance of maintaining price stability for growth. Other covariates, such as capital, labor, education, and openness, are statistically insignificant. These controls were included to avoid omitted variable bias, but their lack of significance suggests that over the 2008–2019 period, cross-country differences in them did not translate into measurable short-run growth divergences after controlling for other factors.

In the Internet demand equation (Table 5b), past values of internet use are key drivers. The first lag (inet_1) has a significant positive effect (0.229), while the second lag (inet_2) is significantly negative (–0.326), suggesting a correction process or diminishing marginal adoption. Surprisingly, fixed broadband subscriptions (fbb) have a significant negative effect (–0.216), contrary to prior expectations, potentially reflecting substitution effects with mobile internet or measurement issues. The price of internet service (lnprice) is significantly negative (–0.938), confirming affordability as a major constraint to uptake. Additionally, urbanization (urbg) shows a strongly negative and significant coefficient (–0.834), which may reflect unanticipated patterns of usage.

In the Internet supply equation (Table 5c), past broadband levels strongly predict current supply: fbb_1 = 0.220 and fbb_2 = –0.119, again showing inertia and correction. Internet use (inet) negatively affects broadband supply (–0.00606), suggesting that rapid increases in demand may temporarily outpace infrastructure expansion. Electricity access (elec) is positive and significant (0.00347), reinforcing the infrastructure's role in enabling broadband growth.

To see how reliable the main growth equation results are, two different methods, seemingly unrelated regression (SUR) and two-stage least squares (2SLS), were used, and both gave results very similar to the original 3SLS model. The SUR method examines each equation individually but allows for related errors, leading to nearly the same coefficients and significance levels, including an internet use effect of -0.0481, which matches the 3SLS estimate. This shows that the connection of errors between equations does not affect the results. This evidence indicates that the correlation of errors between equations does not change the results. In the same way, the 2SLS method, which addresses potential issues in the growth equation by using instrumental variables, also supported the findings, showing the internet use effect at around -0.0453 and still significant. Other key variables, like inflation, also showed similar effects across all methods. In general, the results from both SUR and 2SLS support the primary conclusion: there is a negative and statistically significant effect of internet usage on per capita GDP growth, which is robust across methods.

The researchers used three variations of the 3SLS model, 3SLS1, 3SLS2, and 3SLS3, to test sensitivity, and they all confirmed the results. In 3SLS1, the researchers added the interaction terms between internet use and education, and between internet use and institutional quality. However, these were not significant. The negative effect of internet use on growth remained strong, indicating that it does not depend on levels of education or governance. In 3SLS2, the researchers included a squared internet term to test for non-linearity but found no strong evidence of diminishing returns; the main internet effect stayed negative, though slightly weaker. In 3SLS3, the researchers removed year dummies to see if global trends were driving results, but the key coefficients remained nearly the same, confirming that the internet's effect reflects real cross-country differences, not just common time shocks. Overall, these sensitivity checks show that the negative impact of internet use on growth is robust across different model setups.

The diagnostic tests indicate that the model is robust: The error variances seem to stay the same for all observations, as shown by the Breusch-Pagan LM Test and the Harvey LM Test, which found no signs of changing variances or patterns over time. Despite approaching the over-identification threshold, the Hansen J Test does not reject the null hypothesis, suggesting that the instruments employed are reliable and unrelated to the error terms. The Wald Test shows that the model's coefficients are important together, meaning the independent variables work well to explain the results. The Pesaran and Xie (2021) test shows that the residuals are independent across different units, meaning there is no sign of dependence between them (see Table 6).

### 5.4. Discussions

The results presented from the 3SLS estimation confirm and, in some cases, challenge established empirical findings on the relationship between internet use and economic development in Sub-Saharan Africa (SSA). Most importantly, the finding that internet use (inet) negatively affects GDP per capita growth goes against the common belief in research that says internet use usually helps growth by improving productivity, spreading knowledge, and encouraging innovation (Choi & Yi, 2009; Koutroumpis, 2009). This result may be interpreted through the lens of transitional dynamics and contextual constraints specific to SSA. As Cambini et al. (2024) argue, while internet use can promote innovation, it may initially disrupt traditional sectors, require complementary investments in human capital, and induce short-term adjustment costs. These factors may explain why the immediate net impact of internet expansion appears negative in the current model.

The clear and beneficial effect of institutional quality (inst) on economic growth, indicated by a high coefficient and strong statistical significance, backs up previous studies by Asongu and Odhiambo (2019), who highlighted that good governance enhances the effective use of digital technologies. Similarly, Jin and Jin (2014) noted that internet-based growth is significantly conditioned by institutional infrastructure, which shapes both public and private sector ICT adoption. Thus, the findings underscore the proposition that governance is not only a control variable but also a central enabling factor for digital dividends.

Inflation's negative effect on per capita growth is consistent with the macroeconomic instability-growth literature and complements the findings of Koutroumpis (2009) and Feenstra et al. (2015), who note that stable macroeconomic environments are prerequisites for ICT-induced growth to materialize. Although physical capital and labor didn't show a strong effect in this model, the way the regression is set up (with important past growth factors) indicates that the forces bringing growth together and time-related influences are important parts of SSA's growth patterns, which aligns with the extended Solow-type frameworks.

The internet demand equation highlights affordability and infrastructure access as key determinants of internet use, echoing conclusions by Byaro et al. (Byaro et al et al. 2023). The highly significant and negative coefficient on the price of internet services supports their argument that cost remains a critical barrier to digital inclusion in SSA. Furthermore, the negative coefficient on broadband availability (fbb) in the internet equation may reflect a substitution effect where mobile internet services are preferred over fixed broadband, or it may indicate measurement mismatches in infrastructure versus actual service access.

The supply-side equation (fbb) further validates the reciprocal nature of internet ecosystem development. That electricity access (elec) is a significant and positive predictor of broadband provision that affirms infrastructure interdependence, consistent with findings by Donou-Adonsou (2019), and Choi and Yi (2009), who observed that broadband growth in developing countries requires not just demand but foundational services like electricity and public investment. Additionally, the decrease in broadband supply due to increased internet use may suggest that the infrastructure is not keeping up with demand or that there are limitations on resources that slow down the ability to provide more broadband.

In general, the tests show that the 3SLS method is reliable, and the strong effects of institutions and inflation highlight the importance of comprehensive policy plans. Importantly, the evidence shows that just using the internet doesn't ensure growth; instead, its positive effects depend on the quality of institutions, how affordable it is, and the readiness of infrastructure, which aligns with the theories and studies that have been discussed above.

## 6. RESEARCH IMPLICATIONS

The findings suggest that instead of just focusing on increasing digital access, policies should be more strategic and aim to improve the basic conditions needed to effectively use digital technologies for inclusive development. SSA governments and development partners should prioritize integrated policies that link ICT investment with education, governance reforms, infrastructure development, and price regulation. In addition, expanding access to electricity and developing national broadband strategies tailored to country-specific needs could significantly improve the growth payoff from internet use.

## 7. CONTRIBUTIONS TO SCIENTIFIC COMMUNITY AND FUTURE RESEARCH

This study advances the scientific understanding of digital development and economic growth in Sub-Saharan Africa (SSA) through several key contributions. It employs a simultaneous equation model (SEM) estimated using Three-Stage Least Squares (3SLS) to address endogeneity and explore the complex, bidirectional relationship between internet use and real income growth per person. Unlike previous studies, this approach provides stronger causal insights. This paper's central finding challenges the often implicit assumption of an economic dividend of Internet use. It shows that, in the absence of an enabling environment in terms of infrastructure, institutions, and digital skills, internet use can be associated with a decline in short-term GDP per capita growth. This study also identified robust correlates of successfully leveraging digital technologies for inclusive economic gains, including high institutional quality, low inflation, access to affordable Internet, and electrification.

The researchers recommend several avenues for future research, building on this study's insights and acknowledging its limitations. As internet penetration in Africa is rapidly evolving, it is important to study its effects over a longer horizon. Future research can extend the period as data become available to see whether the effects on growth turn positive once countries pass certain thresholds of digital adoption. Monitoring the same countries over the next decade (into the late 2020s and beyond) would reveal if early negative growth impacts were temporary and if stronger positive effects (through innovation and new industries) eventually emerge. Studies could examine whether increased internet access is reducing or widening income inequality in SSA and how digital divides (rural-urban, gender, etc.) might be influencing equitable development. More work is needed on interaction effects—

investigating whether factors like education level, electricity access, or governance quality change the effectiveness of internet use.

## 8. CONCLUSION

This study concludes that while the literature stresses the internet's influence as positive, its relationship with economic growth appears more complex. The unexpected negative effect on short-term GDP per capita growth implies the possibility of experiencing growth pains or initial inefficiencies during the digitization process. One interpretation is that many SSA countries are still in an early phase of internet adoption, where usage might be skewed toward consumption or social uses rather than productive economic activity. It may also indicate that gains from internet use (productivity improvements, new businesses) take time to materialize, whereas some disruptive effects (competition for local firms, importation of digital services, or labor market upheavals) are felt more immediately.

This finding echoes the caution in the literature that the developmental effect of internet technology is not uniformly positive and can even be negative in the short term if the enabling environment is weak. Over the long term, however, theory and prior evidence imply that as digital penetration deepens and as societies adapt, the net effect is likely to turn positive.

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