# Effect of Internet usage on economic growth in Ghana and moderating role of government effectiveness

Diana Domekakpier Aawaar and Anselm Komla Abotsi
*Department of Economics Education, University of Education Winneba, Winneba, Ghana*

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## Abstract

**Purpose** – Internet usage, a major component of technology, has been recognised to positively impact economic growth. The economic growth in Ghana is estimated to decline in the post-COVID, era with its associated devastating effects on the citizenry. This study, therefore, seeks to find how Internet usage affects economic growth in Ghana and the moderating role of government effectiveness.

**Design/methodology/approach** – Quarterly time series data which covered the year 2000 to 2020 was deployed. The study used the autoregressive distributed lag (ARDL) method.

**Findings** – The results show that Internet usage and government effectiveness are positively associated with economic growth in both the short and long run. However, in the presence of the interactive term between Internet usage and government effectiveness, Internet usage is positively related to economic growth in the short run but negative in the long run. Nonetheless, with the moderating role of government effectiveness through quality policy formulation and its effective implementation, the overall marginal effect of Internet usage turns out to be positive on economic growth in the long run.

**Social implications** – The study therefore recommends that the government of Ghana formulate and implement appropriate Internet and information and communication technologies policies to enhance economic growth and alleviate unemployment and poverty.

**Originality/value** – Previous empirical studies on the effect of Internet usage on economic growth deployed cross-country data for the analysis, which makes it difficult to outline country-specific effects of internet usage on economic growth. Additionally, the literature on the effects of Internet usage on economic growth in the Ghanaian context and the moderating role of government effectiveness is not well-established.

**Keywords** Internet usage, Economic growth, Government effectiveness

**Paper type** Research paper

## Introduction

Technological advancement has been identified as the primary driver of employment and economic growth. Internet usage is a major component of technology that enhances growth and prosperity within the globe and is even considered by some as a fundamental human right (Isaac, Abdullah, Ramayah, Mutahar, & Alrajawy, 2018). The Internet offers enormous opportunities for development in developing countries (Deloitte, 2014). The Internet can transform the very nature of an economy and support economic development by enhancing the speed and quality information flow, which culminates in reduced transaction cost, improved human resource qualification and specification and enhanced access to financial capital services such as mobile banking. The Internet also facilitates entrepreneurship and business expansion such as access to new markets, enhanced innovation and adoption of new organisational models and business strategies (Deloitte, 2014). These benefits derived from the use of the Internet especially in the financial sector of the economy are essential ingredients for economic growth and development. Economic growth provides employment opportunities

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either directly or indirectly even if the growth is due to a high degree of technology or mechanization and hence reduces poverty. Literature abounds on the employment-GDP relationship (referred to as Okun's Law) and the employment elasticity of growth (Kapsos, 2005; Piacentini and Pini, 2000; Seyfried, 2006). Economic growth in Ghana especially during post COVID-19 era is not encouraging to say the least which has resulted in high unemployment and poverty among the Ghanaian citizenry. Due to the worsening macroeconomic imbalances in Ghana such as high public debt estimated at 91% of GDP, depreciating local currency and high inflation, the economic growth in Ghana is estimated to decline to an average of 2.4% in 2023–24 from 5.4% in 2021 to 3.3% in 2022 (African Development Bank, 2023). The unemployment rate which has increased from 11.9% in 2015 to 13.4% in 2021 together with the rising cost of living has impacted negatively on the standard of living of Ghanaians (African Development Bank, 2023). Though the poverty rate declined from 11% in 2021 to 10% in 2022, the 10% is still high and therefore worrying. To reduce unemployment and poverty in Ghana, there is a need to grow the economy to absorb the increasing number of unemployed. In support of this, the Sustainable Development Goal (SDG) 8 encourages the international community to "promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all". This can be achieved through the promotion of essential economic variables such as diversification, technological upgrading and innovation to sustain per capita economic growth and productivity (United Nations, 2017). One major component of technology that has been found to enhances growth in recent times is the use of the Internet.

Cognizance of the fact that Internet usage has a positive and significant impact on economic growth, many researchers fascinated by this have drawn their attention to studying the impact of the Internet on economic growth at various levels across the world (Maurseth, 2018). The use of the Internet and Information and Communication Technologies (ICT) in general are being more recognized as having a direct influence on economic growth. To ascertain the contributions of Internet usage to economic growth, some theoretical and empirical studies have been conducted by researchers. While some empirical studies confirmed that the Internet plays a positive and significant role both in developed countries (Inklaar, O'Mahony, & Timmer, 2005; Röller & Waverman, 2001) and developing countries (Choi & Yi, 2009; Meijers, 2014; Salahuddin & Alam, 2013), some did not (Maurseth, 2018). Using cross-country panel data from 1990 through 2000, Choi and Yi (2009) found Internet usage to stimulate economic growth, nonetheless, Maurseth (2018) extended the period from 1990 to 2015 and found a negative and significant effect of the Internet on economic growth. This notwithstanding, empirically, there is overwhelming evidence that Internet usage has a favourable influence on economic growth (Choi and Hoon Yi, 2009; Meijers, 2014; Salahuddin & Alam, 2013; Tufail, 2015). However, there is insufficient empirical evidence to determine the precise association between Internet usage and economic growth in Ghana (Atsu, Agyei, Phanuel, & Adjei-Mensah, 2014; Quarshie & Ami-Narh, 2012; Siaw, Jiang, Twumasi, & Agbenyo, 2020). Some available data indicate a fast-growing usage of the Internet in Ghana (World Bank Group, 2022), yet Internet infrastructure, connectivity and accessibility appear to be lacking in some areas of the country which is similar in some poor nations (Jonas & Lin, 2023) and hence the need to address it.

Empirical literature indicates that enhanced effectiveness of government will result in high economic growth (Duho, Amankwa, & Musah-Surugu, 2020). The potential benefits of Internet and ICT-related technology to a country may be dependent on the extent of the effectiveness of the government in the formulation and implementation of Internet and ICT-related policies. Government effectiveness refers to the quality of policy formulation and implementation and how credible the government is committed to such policies (Kaufmann, Kraay, & Mastruzzi, 2008). Despite the positive influence of government effectiveness on economic growth, unfortunately, the moderating role of government effectiveness has not been considered in any of these studies on the use of the Internet and economic growth. In Ghana, the number of individuals using the Internet expressed as a percentage of the

population increased from 23% in 2015 to almost 38% in 2017 and further increased to 45% and 68% in 2019 and 2021, respectively (World Bank, 2023). Therefore, with quality formulation and implementation of Internet and ICT-related policies, Internet usage is expected to influence economic growth positively.

Many of the empirical studies on the effect of Internet usage on the growth of small- and medium-sized enterprises, economic growth and development were focused on developing countries and deployed cross-country data for analysis over the years (Choi & Yi, 2009; Elgin, 2013; Guerriero, 2015; Hinson & Adjasi, 2009; Maurseth, 2018). However, cross-country studies on the effect of Internet usage on economic growth conducted using different econometric models and, on a panel, -bases make it difficult to outline country-specific effects of Internet usage and its implication on economic growth. Literature on the effects of digitalization, Internet usage and telecommunication development on economic growth in the Ghanaian context has not well been established. Therefore, this study seeks to find the effect of Internet usage on economic growth in Ghana and the moderating role of government effectiveness. This study contributes to the literature by finding the effect of Internet usage on economic growth in Ghana and the moderating role of government effectiveness.

This is followed by a review of previous literature on Internet development and usage in Ghana, government policies on ICT in Ghana, endogenous growth theory and empirical literature. The rest of the paper presents data and methodology, a discussion of results and a conclusion.

## Literature review

The importance of economic growth in the reduction of unemployment cannot be overemphasized especially in the post-COVID-19 era. In the contemporary world, the growth of many economies is driven by a high degree of technology as has been indicated by the United Nations (2017) that the sustainability of per capita economic growth and productivity is enhanced by technological upgrading and innovation. One of the major components of technology that enhances growth and prosperity within the globe is the use of the Internet. The Internet refers to a global area network connecting systems of computers all over the world. It comprises numerous high-bandwidth data lines connected to major Internet hubs that distribute data to other locations such as web servers and Internet Service Providers. The Internet has a mechanism for information dissemination due to its global broadcasting capability and thus serves as a medium for collaboration and interaction between individuals or groups and their computers for communication with others irrespective of their geographical location (Kleinrock, 2008).

## Internet development and usage in Ghana

In 1995, Ghana achieved full Internet connectivity and has since become one of the fastest-growing countries in terms of Internet infrastructure development. Internet connectivity in Ghana is a collaboration among several organizations including the Ministry of Transport and Communication of Ghana, Network Computer System, British Telecom, Ghana Telecom and Unix to Unix Network among others (Quaynor, Tevie, & Bulley, 1997). The National Telecommunications Policy (NTP) of Ghana was unveiled in 2005. One of the specific goals of the NTP is to enhance universal access to telephone, Internet and multimedia services by 2010 as well as national penetration of universal telecommunications services. The use of the Internet has become the primary source of information and communication among the people living in Ghana. Globally, the increase in Internet connectivity has boosted businesses, especially in the private sector culminating in economic growth. In Ghana, the Internet is used enormously for so many purposes such as education, business and entertainment among others with the youth having the greatest Internet usage (Frimpong & Vaccari, 2015). In Ghana, there was a steady growth between 1995 and 2001 with increased growth from 2001 to 2013.

This was followed by a sharp increase from 2013 to 2014 but decreased in 2015. From 2017 to 2019 the country again experienced a constant growth in Internet penetration. As of January 2022, approximately 23.05 million people representing approximately 68.2% of the Ghanaian population were estimated to have access to the Internet according to the World Bank Group's World Development Indicators (WDI) 2022 (World Bank Group, 2022). The emergence of the Internet has fundamentally changed the way people work, play and communicate in Ghana.

**Government policies on ICT in Ghana**

Governments worldwide have recognized the crucial role that ICTs can play in facilitating and accelerating socio-economic development and economic growth. Several countries have in place relevant policies and strategic plans that will enable them to transform their economies into information and knowledge-based economies. The government of Ghana over the years has developed key ICT policies to drive the growth and development of ICT in all sectors of the economy placing much emphasis on the role of ICT in contributing to the economy.

The Ghanaian parliament developed and passed the National ICT Development Policy (ICT4D) in 2013. The aim of the National ICT Development Policy (ICT4D) was to enhance the transformation of the Ghanaian economy into an information-rich knowledge-based economy by developing, deploying, exploiting and utilizing technology to support various activities within the economy. This is one of the key policies under the medium-term development plan as captured in the Ghana Poverty Strategy Paper I and II and the Education Strategy Plan 2003–2015. The policy has 14 priority areas such as promoting legal, regulatory and institutional frameworks, developing research and development, scientific and industrial research capacity and promoting ICTs in education among others (Republic of Ghana, 2003). One of the 14 pillars of the ICT4D policy is the e-government policy captured as "Facilitating Government Administration and Service delivery". E-government is defined as using ICT and the Internet to improve the access to and delivery of all government services and operations to the benefit of citizens, businesses and all stakeholders (Srivastava & Teo, 2010). The E-government policy aims at modernizing the operation of services by deploying ICT to help reduce administration costs and promote efficiency and effectiveness in service delivery. The establishment of an institutional framework is paramount in ensuring the successful implementation of the E-government policy (Mensah, 2016). The expectation is that policies that seek to incorporate the use of the Internet and ICT in the various activities within the Ghanaian economy will enhance productivity and economic growth.

**Endogenous growth theory and Internet usage**

Though the neoclassical growth theory considers technology as a major determinant in maximizing productivity, nonetheless it is assumed to be exogenously determined which is supposed to augment labour productivity and increase the output capacities of labour (Solow, 1956; Swan, 1956). The neoclassical growth theory postulates that countries will converge to the same balanced growth path assuming that technology is proportionately accessible by all countries. The convergence property in the Solow model is because of the key assumption of diminishing returns to reproducible capital. Again, in neoclassical growth theory, the Solow residual (total factor productivity), has been widely criticised, especially by endogenous and new growth theorists. The Solow residual represents the portion of output that cannot be explained by the inputs used in the production process. The obvious divergence between countries could be explained by the level of technology a country can operate at. The endogenous growth theories emerged around the 1980s as a result of the limitations of neoclassical growth theory in explaining the convergence property. Frankel (1962) with the AK model, opined that if a portion of the capital employed in the production process is used for innovative capital that contributes to technological progress, aggregate production functions

can also exhibit increasing returns to scale. The Frankel endogenous AK model assumes that the savings rate increases in fixed proportions.

Romer (1986) endogenized the drivers of economic growth to develop a fully specified long-run economic growth model with a savings rate assumed to be endogenously generated by an intertemporal utility maximization which is supported by technology (Chirwa & Odhiambo, 2018). The endogenous growth theories postulate that technology is endogenous since it relies on investment decisions in research and development and diffusion (Bassanini & Scarpetta, 2001).

Romer (1990) transformed Cobb Douglas's production function to specify a model in which final goods are produced in a perfectly competitive market.

$$Y = H_Y^{\alpha} L^{\beta} \sum_{i=1}^{\infty} x_i^{1-\alpha-\beta} \tag{1}$$

Where $0 < \alpha, \beta < 1, 0 < \alpha + \beta < 1$, $H_Y$ is human capital used to produce the final output, $L$ is labour and $x_i$ is the input of intermediate goods.

Accumulation of capital is measured as the part of total output not consumed. It is also assumed that $\eta$ units of products ($x_i$) is used to produce a unit of capital goods (intermediate goods). The production of intermediate is constrained by $A$ (the number of designs) as indicated in Equation (2).

$$\dot{K}(t) = Y(t) - C(t) \tag{2}$$

Where $K = \eta \sum_{i=1}^{\infty} x_i = \eta \sum_{i=1}^{A} x_i$

A general equilibrium solution can be derived in the following form to examine the dynamic characteristics of the model.

$$Y(H_Y, L, x) = H_Y^{\alpha} L^{\beta} \int_0^{\infty} x_i^{1-\alpha-\beta} di$$

$$= H_Y^{\alpha} L^{\beta} A \overline{x}^{1-\alpha-\beta}$$

$$= H_Y^{\alpha} L^{\beta} A \left(\frac{K}{\eta A}\right)^{1-\alpha-\beta}$$

$$Y(H_Y, L, x) = (H_Y A)^{\alpha} (LA)^{\beta} (K)^{1-\alpha-\beta} (\eta)^{\alpha+\beta-1}$$

The technology is developed by the existing technology level of present human capital as presented in Equation (3).

$$\dot{A_T} = \delta H_A A_T \tag{3}$$

$A_T$ represent technological level, $H_A$ is the Human capital employed in research and $\delta$ is the productivity coefficient. The general equilibrium solution can be presented in Equation (4).

$$g = \frac{\delta H - \gamma\rho}{\sigma\gamma + 1} \tag{4}$$

Where $g$ is the economic growth rate, $\gamma = \frac{\alpha}{(1-\alpha-\beta)(\alpha+\beta)}$ and $H = H_A + H_Y$

From these general equilibrium solutions, the following implications can be derived. Based on the production and technology functions, the growth rate $g$ can be derived (Equation (5)).

$$g = \delta H_A = \delta H - \frac{\alpha}{(1-\alpha-\beta)(\alpha+\beta)} r \quad (5)$$

Where r represents interest rate. Equation (5) shows that economic growth is determined by human capital ($H_A$) from which the technological-development-oriented growth exhibiting increasing return to scale can be achieved (see Lee & Yu, 2002 for further discussion on this issue). In the literature, technological innovation and stimulating demand have been indicated as the new driving force for future economic growth (Chatterjee & Sahasranamam, 2018; Mbanyele & Wang, 2022). A major component of technology that enhances growth is the use of the Internet (Isaac *et al.*, 2018). The Internet enhances economic growth by improving communication and connectivity, enabling global trade and reducing costs. E-commerce and digital markets allow businesses to reach wider audiences, while access to information and education improves workforce skills and competitiveness. Internet usage fosters innovation and entrepreneurship, driving digital startups and technological advancements. Productivity and automation increase efficiency and financial inclusion empowers unbanked populations through digital banking. E-governance enhances public services, while the digital economy creates jobs in IT and freelancing. The Internet also supports smart agriculture and industry growth, optimizing operations and attracting investment by making economies more data-driven and globally connected.

**Moderating the role of government effectiveness**

The influence of Internet usage on economic growth, however, may not be uniform across countries, since other country-specific factors, such as the quality of governance, particularly government effectiveness play a role. Government effectiveness reflects the quality of public services, quality civil service and independence from political pressures, quality of policy formulation and implementation and credibility of the government's commitment to policies according to the World Bank. Government effectiveness can moderate the effect of Internet usage on economic growth through good policies that ensure effective government investment in digital infrastructure (broadband access, connectivity in rural areas, etc.) to enable Internet usage to reach more people and businesses and enhance higher returns on Internet usage. Governments that ensure stable, transparent and efficient regulatory environments attract more digital innovation and entrepreneurship. Effective governments also invest in human capital through education and digital literacy to ensure people know how to use the Internet productively. Effective governance ensures cybersecurity, data protection and trust since without trust in online platforms, people and firms won't engage in e-commerce or digital finance. Finally, an effective government uses the Internet for efficient service delivery such as e-government, online tax filing and digital health records among others which saves costs and boosts productivity.

**Empirical literature**

Empirical studies indicate positive and significant impacts of Internet and ICT usage on productivity, economic development and growth. Bakari (2021) found that the Internet has a positive effect on innovation and economic growth, in the long run, using 76 developed and developing countries for the period 1995 to 2016 and a Panel autoregressive distributed lag (ARDL) Model. Rosnawintang, Tajuddin, Adam, Pasrun, and Saidi (2021) examined the effect of the Internet on economic growth in ASEAN-5 countries (Indonesia, Malaysia, the Philippines, Singapore, and Thailand). The study used the panel ARDL model with annual time series for the period from 1995 to 2018 and concluded that the Internet positively affects economic growth in the long run. Billon, Crespo, and Lera-Lopez (2018) investigated the impact of Internet use on economic growth for a panel data set of 94 countries between 1995 and 2010 and obtained a positive and significant impact of Internet use on economic growth.

Tripathi and Inani (2016) examined the long-run and short-run relationship between Internet usage and economic growth for 42 sub-Saharan African countries using the ARDL model for the period 1998 to 2014. The study results indicate that Internet usage has a positive and significant impact on economic growth in the long run but is negative in the short run. The study by Cheng, Chien, and Lee (2021) deployed data from 59 countries between 1995 and 2010 and found that the Internet enhances economic growth in high-income countries, however, the impact of the Internet in middle and low-income countries is unclear. Deploying various methodologies, the major conclusions of empirical studies on Internet and economic growth (Bahrini & Qaffas, 2019; Donou-Adonsou, Lim, & Mathey, 2016; Haini, 2019; Koyuncu, Yilmaz, & Yildirim, 2017; Li, 2019; Myovella, Karacuka, & Haucap, 2020; Rangkakulnuwat & Dunyo, 2018; Salahuddin & Gow, 2017) indicate a positive and significant impacts of Internet and ICT usage on productivity, economic development and growth.

On the contrary, studies elsewhere show that Internet usage has a negative and significant effect on economic growth (Bakari, Tiba, & Mohamed, 2020; Maurseth, 2018). However, it is argued that the extent of government effectiveness in the formulation and implementation of Internet and ICT-related policies will determine the potential benefits that the country will get from the use of Internet and ICT technology. Alam, Kitenge, and Bizuayehu (2017) employed a System Generalized Method of Moments technique to investigate the impact of government effectiveness on the economic growth of a panel of 81 countries. The finding of the study indicates a significant positive effect of government effectiveness on economic growth. Other empirical studies have also revealed that government effectiveness has a significantly positive effect on economic growth (Afolabi, 2019; Güney, 2017). Despite the positive influence of government effectiveness on economic growth, unfortunately, none of these studies on the Internet and economic growth considered the moderating role of government effectiveness.

The fact that the economic growth in Ghana is estimated to decline to an average of 2.4% in 2023–24 (African Development Bank, 2023) with its devastating effect (unemployment, poverty, etc.) on the citizenry of the country, there is a need to grow the economy to ameliorate these threats. The results of most empirical studies on the Internet and economic growth indicate a positive and significant impact of Internet and ICT usage on productivity, economic development and growth. Though in Ghana, the number of individuals using the Internet expressed as a percentage of the population has increased to 68% in 2021 (World Bank, 2023), the effects of digitalization, Internet usage and telecommunication development on economic growth in the Ghanaian context has not well been established. Therefore, this study seeks to find the effect of Internet usage on economic growth in Ghana and the moderating role of government effectiveness, since with quality formulation and implementation of Internet and ICT-related policies, Internet usage is expected to influence economic growth positively.

## Data and methodology

### *Data*

The variables used in this study are based on secondary data collected from WDI World Governance Indicators (WGI), Federal Reserve Economic Data and International Telecommunication Union (ITU) database. Quarterly time series data which covered the year 2000 to 2020 was employed. The variables of the study such as real GDP per capita were sourced from the Federal Reserve Economic Database and inflation data was sourced from the Bank of Ghana. Also, variables namely financial development (FD), capital and the Total Labour Force (TLF) were sourced from WDI, and government effectiveness was sourced from WGI. Data on Internet usage was also sourced from the ITU database. Though the period covered is relevant for the study as it captures the period in which Internet usage was enormous in Ghana, it is also important to note that data on Internet usage from the ITU website was not available before the year 2000 which necessitated the choice of period (2000 to 2020) for the study.

*Estimation procedures and model specification*

The study adopted the endogenous growth model of Romer (1986). The theory suggests that growth is primarily determined by a country's internal innovation and population size. The endogenous growth model endogenized technology. Therefore, technological advancement leads to economic improvement. The model further assumes that government and institutions play a major role in the growth of an economy through incentives that influence the innovativeness of entrepreneurs. An increase in Internet usage is expected to have a positive effect on the economy's innovative capabilities through knowledge spillover, dissemination of cheaper information that can facilitate the adoption of new technologies developed by others, the development of innovative mechanisms and business strategies that promote growth. The focus of this study therefore is on the role of Internet usage in contributing to economic growth in the Ghanaian economy. The functional form of the aggregate production function is presented in Equation (6).

$$Y_t = f(K_t, L_t, A_t) \tag{6}$$

Where $Y_t$ indicates productivity, $K_t$ is the level of capital, $L_t$ is labour and $A_t$ is level of technology.

The study, therefore, followed the production function in the form of the empirical model presented in Equation (6). RGDPPC is real gross domestic product per capita, INTERNET refers to number of Internet users as a percentage of the population aged 15 to 74, GOV_EFFECT is the government effectiveness, INTERNET *GOV_EFFECT is the interactive term between number of Internet users as a percentage of the population aged 15 to 74 and government effectiveness, GFCF refers to Gross Fixed Capital Formation, TLF is the Total Labour Force, INF is inflation and FD refers to financial development. The focus on Internet usage within the 15 to 74 age group is because this age group forms the economically active population of the country. Two models were estimated both for the short run and long run to find the effect of Internet usage on economic growth in Ghana and the moderating role of government effectiveness. The first model (Equation (7)) included Internet usage and government effectiveness without the interactive term in the estimation and the second model (Equation (8)) included Internet usage, government effectiveness and the interactive term in the estimation.

$$LnRGDPPC_t = \beta_0 + \beta_1 INTERNET_t + \beta_2 GOV\_EFFECT_t + \beta_3 LnGFCF_t + \beta_4 LnTLF_t + \beta_5 FD_t + \beta_6 INF_t + \varepsilon_t \tag{7}$$

$$LnRGDPPC_t = \beta_0 + \beta_1 INTERNET_t + \beta_2 GOV\_EFFECT_t + \beta_3 INTERNET*GOV\_EFFECT_t + \beta_4 LnGFCF_t + \beta_5 LnTLF_t + \beta_6 FD_t + \beta_7 INF_t + \varepsilon_t \tag{8}$$

For the convenience of parameter estimation, some variables such as RGDPPC, TLF and GFCF have undergone a logarithmic transformation. The βs are the coefficients to be estimated and $\varepsilon_t$ is the error term.

RGDPPC measures the value of goods and services produced by a country within a specific period adjusted for inflation. RGDPPC is used as the dependent variable in the study and as a measure of economic growth. Internet usage is measured as the number of Internet users as a percentage of the population aged 15 to 74 and it is expected to have a positive effect on the growth of the economy. Government effectiveness encompasses the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies (Kaufmann *et al.*, 2008). It entails sound policy formulation, appropriate implementation and generally citizen-centric policies that bring about peace and prosperity

in the country. It is expected that an effective government will regulate the use of technology such that it will be able to affect the growth of the economy positively. The Consumer Price Index (CPI) representing inflation is a measure of price changes in a basket of consumer goods and services, or a bundle of regularly purchased products and services by a household. An increase in consumer commodity prices may create a drop in demand for products and services in the economy, which may discourage investors from investing in the economy, resulting in weaker investment and economic growth. As a result, the CPI coefficient is predicted to be negative. GFCF is used as a proxy for capital stock (K) in the study. GFCF is referred to as the total value added to fixed assets by domestic enterprises, fewer disposals of fixed assets during the year, including additions to the value of non-produced assets such as discoveries of mineral deposits, plants, machinery and equipment purchases, and the construction of infrastructure and commercial and industrial buildings. In most countries, GFCF is more often than not considered the engine of growth due to the additions it makes to capital. An increase in the level of capital formation will improve the economy's productivity potential and hence economic growth. The quantity and quality of labour that individuals supply is an important factors in determining the economy's level of production and rate of growth. It is therefore expected that an increase in the labour force should have a positive effect on the growth of the economy. FD is measured by the total amount of credit allocated to the private sector as a percentage of GDP. It is expected that the level of FD will have a positive effect on the level of economic growth.

The Augmented Dickey-Fuller (ADF), KPSS and Phillips-Perron (PP) unit root test approaches were used to test for the stationarity of the variables deployed in this study. In dealing with variables that are integrated of a different order, I(0), I(1), or a combination of both, the ARDL method or the Bounds testing approach by Pesaran, Shin, and Smith (1999) is preferable. ARDL method is relatively more efficient when dealing with small and finite sample data sizes and robust when there is a single long-run relationship between the underlying variables (Nkoro & Uko, 2016; Obeng & Abotsi, 2024). The study therefore deployed the ARDL method. The ARDL bounds test uses an Ordinary Least Squares approach to test for the existence of a long-run relationship among the variables by conducting an *F*-test for the joint significance of the coefficients of the lagged levels of the variables. Since the Akaike Information Criterion (AIC) does not require any subjective threshold setting, the study used this approach to choose the lag length. The Error Correction Model (ECM) was used to estimate the short-run dynamic parameters with the associated long-run estimates. The evidence of short-run causal effect by the explanatory variables is represented by the *F*-statistic while the *t*-statistic of the coefficient of the lagged error-correction term denotes the long-run causal relationship (Narayan & Smyth, 2006; Obeng & Abotsi, 2024; Odhiambo, 2009). The long-run and short-run parameters are estimated concurrently using the models presented in Equations (9) and (10).

$$\begin{aligned}\Delta ln\, RGDPPC_t = {} & \beta_0 + \sum_{i=1}^{k} \alpha_i \Delta ln\, RGDPPC_{t-i} + \sum_{i=0}^{k} \beta_i \Delta INTERNET_{(t-i)j} \\ & + \sum_{i=0}^{k} \gamma_i \Delta lnGFCF_{t-i} + \sum_{i=0}^{k} \delta_i ln\, \Delta TLF_{t-i} + \sum_{i=0}^{k} \lambda_i \Delta FD_{t-i} \\ & + \sum_{i=0}^{k} \lambda_i \Delta INF_{t-i} + \sum_{i=0}^{k} \varphi_i \Delta GOV\_EFFECT_{t-i} + +\theta_1 ln\, RGDPPC_{t-1} \\ & + \theta_2 INTERNET_{(t-i)} + \theta_3 lnGFCF_{t-i} + \theta_4 ln\, \Delta TLF_{t-i} + \theta_5 FD_{t-i} \\ & + \theta_6 INF_{t-i} + \theta_7 GOVT\_EFFECT_{t-1} + \varepsilon_t \end{aligned} \tag{9}$$

$$\Delta ln\, RGDPPC_t = \beta_0 + \sum_{i=1}^{k} \alpha_i \Delta ln\, RGDPPC_{t-i} + \sum_{i=0}^{k} \delta_{2i} GOV\_EFFECT_{(t-i)} * INTERNET_{(t-i)} + \sum_{i=0}^{k} \beta_i \Delta INTERNET_{(t-i)j} + \sum_{i=0}^{k} \gamma_i \Delta lnGFCF_{t-i} + \sum_{i=0}^{k} \delta_i ln\, \Delta TLF_{t-i} + \sum_{i=0}^{k} \lambda_i \Delta FD_{t-i} + \sum_{i=0}^{k} \lambda_i \Delta INF_{t-i} + \sum_{i=0}^{k} \varphi_i \Delta GOV\_EFFECT_{t-i} + +\theta_1 ln\, RGDPPC_{t-1} + \theta_2 INTERNET_{(t-i)} + \theta_3 INTERNET_{(t-i)} * \theta_7 GOVT\_EFFECT_{t-1} + \theta_4 lnGFCF_{t-i} + \theta_5 ln\, \Delta TLF_{t-i} + \theta_6 FD_{t-i} + \theta_7 INF_{t-i} + \theta_8 GOVT\_EFFECT_{t-1} + \varepsilon_t \quad (10)$$

The short-run coefficients for an ARDL are estimated using the difference equations as indicated in Equations (11) and (12).

$$\Delta ln\, RGDPPC_t = \beta_3 + \sum_{i=1}^{k} \alpha_{3i} \Delta lnRGDPPC_{t-i} + \sum_{i=0}^{k} \beta_{3i} \Delta INTERNET_{t-i} + \sum_{i=0}^{k} \delta_{3i} \Delta GOV\_EFFECT_{(t-i)j} + \sum_{i=0}^{k} \lambda_{3i} \Delta INF_{t-i} + \sum_{i=0}^{k} \varphi_{3i} \Delta lnGFCF_{t-i} + \sum_{i=0}^{k} \varphi_{3i} \Delta FD_{t-i} + \sum_{i=0}^{k} \phi_{3i} \Delta lnTLF_{t-i} + \gamma\, ECT_{t-i} + \varepsilon_{3t} \quad (11)$$

$$\Delta ln\, RGDPPC_t = \beta_3 + \sum_{i=1}^{k} \alpha_{3i} \Delta lnRGDPPC_{t-i} + \sum_{i=0}^{k} \beta_{3i} \Delta INTERNET_{t-i} + \sum_{i=0}^{k} \delta_{3i} \Delta GOV\_EFFECT_{(t-i)j} + \sum_{i=0}^{k} \delta_{3i} \Delta GOV\_EFFECT_{(t-i)j} * \Delta INTERNET_{(t-i)j} + \sum_{i=0}^{k} \lambda_{3i} \Delta INF_{t-i} + \sum_{i=0}^{k} \varphi_{3i} \Delta lnGFCF_{t-i} + \sum_{i=0}^{k} \varphi_{3i} \Delta FD_{t-i} + \sum_{i=0}^{k} \phi_{3i} \Delta lnTLF_{t-i} + \gamma\, ECT_{t-i} + \varepsilon_{3t} \quad (12)$$

where $\gamma$ is the speed of adjustment to long-run equilibrium following a shock to the system and $ECT_{t-1}$ is the error correction term residuals obtained from the cointegration equation model. The cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUMSQ) were applied to test the stability of the parameters of the model.

## Discussion of results

The study computed the descriptive statistics of the variables included in the study as presented in Table 1. It can be observed from the table that all the variables used in the study have positive average values (means). It can also be observed that all the variables in the study are positively skewed indicating that all the values of the variables are less than their means. The average Internet usage per 100 indicates that about 15.2 out of 100 persons between the ages of 15 to 74 use the Internet in a quarter. A minimum of about 0.15 persons out of 100 persons between the ages 15 to 74 use the Internet while a maximum of about 62.01 persons use the Internet per 100 persons within the ages 15 to 74 in Ghana indicating a wide range. The rate of Internet usage in Ghana indicates a low documented subscription to the Internet. It can also be observed that RGDPPC recorded a minimum value of GHC 45983.00 and a maximum value of GHC58017.00 over the period covered. Its average and standard deviation are 51570.11 and 3238.06. Government effectiveness has a minimum and maximum rate of 29.33 and 49.27 respectively. Its mean and standard deviation are 39.89 and 5.13. The minimum and maximum values for labour are 8277620.00 and 13364617 respectively implying a very wide range.

## Unit root test results

The results of the test for the stationarity of the time series data under the study using the ADF, Phillips-Perron (PP) and KPSS unit root test approach are presented in Table A1 in Appendix. The unit root results from the ADF, PP and KPSS test show that all the variables are either integrated at level, levels with constant, or at first difference. Since the same variables are integrated of order zero I(0) or one I(1), the ARDL is deemed an appropriate approach and suitable or can be retained to test the existence of the long-run equilibrium impact of Internet usage, government effectiveness and the interaction term of Internet usage and government effectiveness on economic growth since it allows the estimation of variables with mixed order of integration thus I (0) or I(1) or different combination order of stationary I (0) or I (1). This approach captures both short-run and long-run dynamics with the error correction term.

## Results from bounds tests

Given that the series is of mixed order of integration, cointegration of the series is a necessary condition for the existence of a long-run relationship among the variables of interest. Autoregressive distributed lag (ARDL) model developed by Pesaran, Yongcheol, and Richard (2001) and Pesaran *et al.* (1999) was used to test the existence of long-run equilibrium relationships between the variables within the framework of the bounds-testing approach to

**Table 1.** Summary statistics of the variables

| | RGDPPC | INTERNET | GOV_ EFFECT | TLF | INF | FD | GFCF |
|---|---|---|---|---|---|---|---|
| Mean | 51570.11 | 15.20 | 39.70 | 10,713,024 | 15.54 | 14.84 | 2.23E+10 |
| Median | 51507.50 | 8.25 | 38.80 | 10,697,599 | 13.75 | 14.39 | 5.66E+09 |
| Maximum | 58017.00 | 62.01 | 49.27 | 13,364,617 | 41.95 | 18.07 | 6.92E+10 |
| Minimum | 45983.00 | 0.154 | 29.33 | 8,277,620 | 7.60 | 11.09 | 6.27E+08 |
| Std. Dev. | 3238.06 | 16.59 | 5.13 | 1,510,539 | 7.45 | 2.02 | 2.46E+10 |
| Skewness | 0.15 | 1.20 | 0.16 | 0.09 | 1.73 | 0.10 | 0.72 |
| Kurtosis | 2.26 | 3.55 | 1.81 | 1.83 | 5.85 | 1.60 | 1.81 |
| Jarque-Bera | 2.25 | 21.37 | 5.31 | 4.75 | 70.53 | 7.04 | 11.86 |
| Probability | 0.32 | 0.002 | 0.070 | 0.093 | 0.000 | 0.030 | 0.003 |
| Observations | 84 | 84 | 84 | 84 | 84 | 84 | 84 |

**Note(s):** Std. Dev. represents Standard Deviation while Sum Sq. Dev. represents the Sum of Squared Deviation
**Source(s):** Computed by authors using EViews 10.0 package

cointegration. The null hypothesis of no cointegration is rejected at all the significance levels. This implies that there exists a long-run relationship among the variables included in the two models. The result of the bounds test for cointegration is presented in Tables 2 and 3.

The calculated F-statistic reported shows that, there is a long-run relationship between economic growth and its explanatory variables since in the two models the F-statistic values (7.0281 and 4.9435) are higher than the top critical bound values (2.94 and 3.13 respectively) at 10% significance level and (3.99 and 4.26 respectively) at a 1% significance level. The lag length selection (4) in both models was based on the Akaike selection criteria (AIC).

**Estimated results of the long-run relationship**

Given the results of the cointegration analysis, the ARDL framework was employed in estimating the long-run relationships among the variables as shown in Tables 4 and 5. The results for the first model estimated (including Internet usage and government effectiveness without the interactive term) are presented in Table 4. The results for the second model estimated (including Internet usage, government effectiveness and the interactive term) are presented in Table 5. The sign of the coefficients of the long-run estimates (either positive or negative) indicates either an increase or decrease of the dependent variable with a magnitude

**Table 2.** The bounds test for cointegration (interactive term excluded)

| Test statistic | SIC lag length | Value | Signif. | I(0) | I(1) |
|---|---|---|---|---|---|
| *F*-statistic | 4 | 7.0281 | 10% | 1.99 | 2.94 |
| K | | 6 | 5% | 2.27 | 3.28 |
| | | | 1% | 2.88 | 3.99 |

**Source(s):** Computed by authors using EViews 10.0

**Table 3.** The bounds test for cointegration (interactive term included)

| Test statistic | SIC lag length | Value | Signif. | I(0) | I(1) |
|---|---|---|---|---|---|
| *F*-statistic | 4 | 4.9435 | 10% | 2.03 | 3.13 |
| K | | 7 | 5% | 2.32 | 3.5 |
| | | | 1% | 2.96 | 4.26 |

**Source(s):** Computed by authors using EViews 10.0

**Table 4.** Results of ARDL estimation in the long run (interactive term excluded)

| Dependent variable: LNRGDPPC | | Selected model: ARDL (4, 2, 4, 4, 2, 2, 4, 3) | | |
|---|---|---|---|---|
| Variable | Coefficient | Std. error | *t*-statistic | Prob. |
| INTERNET | 0.0011 | 0.0004 | 2.2801 | 0.0258** |
| G0V_EFFECT | 0.0031 | 0.0005 | 6.0118 | 0.0000*** |
| LNTLF | 0.0386 | 0.1133 | 0.3409 | 0.7342 |
| LNGFCF | 0.0376 | 0.0076 | 4.9532 | 0.0000*** |
| FD | −0.0064 | 0.0015 | −4.1234 | 0.0001*** |
| INF | −0.0008 | 0.0004 | −2.1931 | 0.0318** |
| C | 9.2552 | 1.6606 | 5.5730 | 0.0000*** |

**Note(s):** ***, ** and * denote significance at 1, 5 and 10%, respectively
**Source(s):** Computed by the authors using E-views 9.0

**Table 5.** Results of ARDL estimation in the long run (interactive term included)

| Dependent variable: LNRGDPPC | | Selected model: ARDL (4, 2, 4, 4, 2, 2, 4 and 3) | | |
|---|---|---|---|---|
| Variable | Coefficient | Std. error | *t*-statistic | Prob. |
| INTERNET | −0.0068 | 0.0030 | −2.3712 | 0.0218** |
| G0V_EFFECT | 0.0027 | 0.0006 | 4.4890 | 0.0000*** |
| LNTLF | 0.2158 | 0.0777 | 2.7789 | 0.0078** |
| LNGFCF | 0.0355 | 0.0051 | 6.9002 | 0.0000*** |
| INTERNET*GOV_EFFECT | 0.0002 | 0.0008 | 2.4134 | 0.0197** |
| FD | 0.0124 | 0.0015 | 8.1836 | 0.0000*** |
| INF | −0.0001 | 0.0004 | −0.1320 | 0.8955 |
| C | 6.5884 | 1.1576 | 5.6913 | 0.0000*** |

**Note(s):** ***, ** and * denote significance at 1, 5 and 10%, respectively
**Source(s):** Computed by the authors using E-views 9.0

determined by the corresponding coefficient in the long run. Thus, all positive coefficients indicate a positive effect on the dependent variables and vice versa. In Table 4, the coefficient of Internet usage is positive and statistically significant at a 5% level implying that Internet usage in the long run exerts a positive impact on economic growth. The coefficient of Internet usage (0.0011) implies that a percent increase in Internet usage will cause economic growth to increase by approximately 0.11%. This result is consistent with the findings of earlier studies (Bahrini & Qaffas, 2019; Bakari, 2021; Cheng *et al.*, 2021; Haini, 2019; Koyuncu *et al.*, 2017; Li, 2019; Rangkakulnuwat & Dunyo, 2018; Rosnawintang, Tajuddin, Adam, Pasrun, & Saidi, 2021). The results for government effectiveness also show that government effectiveness is positive and statistically significant at a 1% level. The positive coefficient of 0.0031 indicates that a unit increase in government effectiveness leads to a 0.31% increase in economic growth in the long run. The positive coefficient of government effectiveness implies that the efficient and effective commitment to formulating and implementing policies fosters economic growth. This finding is consistent with earlier studies (Afolabi, 2019; Alam *et al.*, 2017; Güney, 2017). The estimated elasticity coefficient of capital (i.e. LNGFCF) in relation to economic growth showed that the variable is positive and statistically significant at 5% in the estimated model. Consistent with earlier studies (Osei, Aglobitse, & Bentum–Ennin, 2017), a percentage increase in capital leads to an increase in economic growth by 0.04%. The study results also show that the coefficient of FD is −0.0064 and is statistically significant at a 1% level implying that FD is negatively related to economic growth in the long run. An increase in FD will lead to a 0.64% decrease in economic growth. The coefficient of inflation is negative and statistically insignificant. The negative coefficient of inflation suggests that there is an inverse relationship between inflation and economic growth. As prices rise in an economy, growth is likely to slow down. This negative effect of inflation on economic growth is similar to the findings of Ahiakpor (2014) who also showed a negative relationship between inflation and economic growth. The total labour force (LNTLF) is found not to be statistically significant.

In Table 5, the long-run results reveal that the estimated coefficients for the long-run relationship among the variables have a positive effect on economic growth except for inflation and Internet usage. In addition, except for inflation, all other variables are significant in the long run. The coefficient (−0.0068) of Internet usage implies that with the inclusion of the interactive term between Internet usage and government effectiveness in the model, a percentage rise in Internet usage will cause economic growth to reduce by approximately 0.68%. This negative impact of Internet usage on economic growth found in this study, in the long run, occurs because of the moderating role of government effectiveness. The interactive term is the moderating variable that affects the strength or direction of the relationship between Internet usage and economic growth. Therefore the change in sign of the coefficient of Internet usage from positive to negative may be a result of the moderating variable (the interactive

term) suppressing the irrelevant variance, thereby revealing the "true" relationship. Good government effectiveness can enhance the positive impact of Internet usage on economic growth, while bad government effectiveness or lack of effective regulation can weaken this positive impact, or even turn it negative. In addition, the inefficiencies that are linked with prolonged use of the Internet for personal unproductive gains such as spending productive time having fun on social media, and watching movies even during working hours, among others rather than for productive purposes may contribute to the negative impact. This result is inconsistent with the results in Table 4 and earlier findings (Bahrini & Qaffas, 2019; Haini, 2019; Koyuncu *et al.*, 2017; Rangkakulnuwat & Dunyo, 2018; Salahuddin & Gow, 2017) which indicate a positive and significant impact of Internet and ICT usage on economic growth, this results confirm the evidence from earlier studies that Internet usage has a negative relationship with economic growth (Bakari *et al.*, 2020; Maurseth, 2018). However, with the interaction term, the composite effect of Internet usage and the moderating role of government effectiveness turns out to have a positive impact on economic growth in the long run. The marginal effect, $\left[\left(\frac{dy}{dx} = \beta_1 + \beta_3 * \overline{\text{GOV\_EFFECT}}\right) = -0.0068 + 0.0002 * (39.70) = 0.00114\right]$ indicate that with the effectiveness and efficiency of government in the formulation and implementation of appropriate Internet and ICT policies, Internet and ICT usage will enhance economic growth in Ghana.

The results also show that government effectiveness is positive and significantly associated with economic growth. The size of the coefficient (0.0027) implies that conditioned on the interactive term between Internet usage and government effectiveness and other factors included in the model, a percentage rise in government effectiveness will cause economic growth to increase by approximately 0.27%. The positive sign of the government effectiveness coefficient indicates the effective and efficient commitment of the government in the formulation of appropriate policies and the implementation of these policies enhances economic growth which is consistent with earlier findings (Afolabi, 2019; Alam *et al.*, 2017; Güney, 2017). Similarly, a unit increase in the TLF will increase economic growth by approximately 0.22% in the long run, all other things being equal. This shows that more able and willing personnel within the labour force is necessary for achieving higher growth in the economy. The finding is consistent with earlier studies like Shahid (2014) which also found a positive relationship between labour force and economic growth in the long run.

**Estimated results of the short-run relationship**

The ECM captures the short-run dynamics of the system and its coefficient by measuring the speed of adjustment to equilibrium in the event of shocks to the system. The estimated coefficient of the ECM is approximately −0.3211 and −0.77 in the two models respectively (Tables 6 and 7). This shows that about 32 or 77% of the disequilibrium in the previous year following shocks to the system converges back to the long-run equilibrium in the current year. The results from the short-run estimates (Tables 6 and 7) indicate that Internet usage and government effectiveness are both positive and statistically significant. A percentage increase in Internet usage in the short run will result in an increase in economic growth by 0.29 or 2.25% in Tables 6 and 7 respectively. Similarly, a percentage increase in Government effectiveness in the short run will result in an increase in economic growth by 0.47 or 0.65% in Tables 6 and 7 respectively. The results (Table 7) indicate that the interactive term between Internet usage and Government effectiveness is positive and statistically significant in the short run. This implies that the commitment of the government to efficiently and effectively formulate and implement Internet and ICT-related policies would enhance economic growth. For the short-run results (Table 7), except for inflation, all the variables are positive and significant. The short-run effect of Internet usage like the long-run results, is positively and significantly related to economic

**Table 6.** Results of ARDL estimation in the short-run (interactive term excluded)

| Dependent variable: LNRGDPPC | | Selected model: ARDL (1,3, 3, 4, 2, 4 and 1) | | |
|---|---|---|---|---|
| Variable | Coefficient | Std. error | *t*-statistic | Prob. |
| C | 4.6015 | 0.7565 | 6.0827 | 0.0000*** |
| D(INTERNET) | 0.0029 | 0.0004 | 7.1907 | 0.0000*** |
| D(GOV_EFFECT) | 0.0047 | 0.0010 | 4.5648 | 0.0000*** |
| D(LNTLF) | 14.7336 | 1.6234 | 9.0756 | 0.0000*** |
| D(LNGFCF) | 0.0081 | 0.01796 | 0.4545 | 0.6512 |
| D(FD) | −0.0023 | 0.0019 | −1.2026 | 0.2343 |
| D(INF) | −0.0012 | 0.0002 | −4.4568 | 0.0000*** |
| CointEq(-1)* | −0.3211 | 0.0522 | −6.1442 | 0.0000*** |
| *R*-squared | 0.8664 | | | |
| Adjusted *R*-squared | 0.8270 | | | |
| *F*-statistic | 21.9919 [0.00] | | | |
| Sum squares resid. | 0.0021 | | | |
| AIC | −7.1946 | | | |
| SIC | −6.6289 | | | |
| DW-statistic | 2.2370 | | | |

**Note(s):** *** and ** denote significance at 1 and 5%, respectively
**Source(s):** Computed by author using EViews 10.0

**Table 7.** Results of ARDL estimation in the short-run (interactive term included)

| Dependent variable: LNRGDPPC | | Selected model: ARDL (4, 2, 4, 4, 2, 2, 4 and 3) | | |
|---|---|---|---|---|
| Variable | Coefficient | Std. error | *t*-statistic | Prob. |
| C | 5.0764 | 0.7505 | 6.7645 | 0.0000*** |
| D(INTERNET) | 0.0225 | 0.0050 | 4.5135 | 0.0000*** |
| D(GOV_EFFECT) | 0.0065 | 0.0018 | 3.6315 | 0.0007*** |
| D(LNTLF) | 7.1667 | 2.4501 | 2.9244 | 0.0053*** |
| D(LNGFCF) | 0.0481 | 0.0182 | 2.6467 | 0.0110** |
| D(INTERNET*GOV_EFFECT) | 0.0003 | 0.0001 | 2.1596 | 0.0359** |
| D(FD) | 0.0067 | 0.0020 | 3.3124 | 0.0018*** |
| D(INF) | −0.0001 | 0.0002 | −1.3163 | 0.1945 |
| CointEq(-1)* | −0.7705 | 0.1143 | −6.7408 | 0.0000*** |
| *R*-squared | 0.9028 | | | |
| Adjusted *R*-squared | 0.8578 | | | |
| *F*-statistic | 20.072 [0.000] | | | |
| Sum squares resid. | 0.0016 | | | |
| AIC | −7.3376 | | | |
| SIC | −6.5634 | | | |
| DW-statistic | 2.1399 | | | |

**Note(s):** *** and ** denote significance at 1 and 5%, respectively
**Source(s):** Computed by author using EViews 10.0

growth. Government effectiveness and the interactive term are still found to be positive and statistically significant in the short run. Although the combined effect of government effectiveness and Internet usage may be somewhat meager meagre in the short run, it is still instrumental in increasing economic growth in Ghana.

### Diagnostic tests of model

The results of the diagnostic tests of the ARDL model used in this study show that the R-square is 87% and 90% in the two models respectively which seems adequate for such a long period.

The f-statistic is 21.0 and 20.0, respectively (significant at a 1% level), which implies that the models are fine overall. Durbin-Watson statistics are 2.23 and 2.13, respectively, which shows that there is no strong serial correlation in the residuals (Tables 8 and 9). The normality test (Jarque-Bera) also reveals that model residuals are normally distributed while the LM test also shows that there is no serial correlation in the residuals. ARCH test indicates that there is no heteroscedasticity in the residuals (Tables 8 and 9). Hence it can be concluded from the above analysis that the model has passed all the essential diagnostic tests and thus the findings of the study can be relied on for policy formulation.

**Results of the Granger causality test**

Granger causality is useful in determining the direction of the relationships. From Table 10, there is no evidence to reject the null hypothesis that Internet usage does not Granger cause economic growth (the test statistics is 6.26293 with a *p*-value of 0.0030). However, the reverse is rejected at the 5% level of significance showing that economic growth does not Granger cause Internet usage (the test statistics is 2.90653 with a *p*-value of 0.0607). At a 5% level of significance, there is a unidirectional causality running from Internet usage to economic growth.

The stability of the parameters of the model carried out using CUSUM and Cumulative Sum of Squares Recursive Residuals (CUSUMSQ) is shown in Figures 1A and 2A in the Appendix. The coefficients of the estimated model are stable over the study period since they are within the 5% critical bounds.

**Table 8.** Diagnostic tests (interactive term excluded)

| Test | *F*-statistic | [Prob] |
|---|---|---|
| Serial correlation (LM test) | 0.9619 | [0.3887] |
| Heteroscedasticity (ARCH) | 1.1624 | [0.2843] |
| Functional form (RESET) | 0.0390 | [0.3302] |
| Normality | 2.3873 | [0.3031] |

**Source(s):** Computed by the author using E-views 10.0

**Table 9.** Diagnostic tests (interactive term included)

| Test | *F*-statistic | [Prob] |
|---|---|---|
| Serial correlation (LM test) | 1.7784 | [0.1806] |
| Heteroscedasticity (ARCH) | 1.1804 | [0.2806] |
| Functional form (RESET) | 0.9630 | [0.8443] |
| Normality | 2.2007 | [0.3330] |

**Source(s):** Computed by the author using E-views 10.0

**Table 10.** Pairwise Granger causality test

| Null hypothesis | Obs | *F*-statistic | Prob. |
|---|---|---|---|
| INTERNET does not Granger cause RGDPPC | 84 | 6.26293 | 0.0030 |
| RGDPPC does not Granger cause INTERNET | 84 | 2.90653 | 0.0607 |

**Source(s):** Computed by the author using E-views 10.0

## Conclusion and recommendation

This study aimed to find the effect of Internet usage on economic growth in Ghana and the moderating role of government effectiveness. The ARDL approach to cointegration was used to examine the existence of long-run and short-run relationships among the study variables. The results show that Internet usage is positive and statistically significant in the short and long run. The results also show that government effectiveness is positive and significantly associated with economic growth in the short and long run. The findings indicate that with the effectiveness and efficiency of the government in the formulation and implementation of appropriate Internet and ICT usage policies, economic growth in Ghana will be enhanced. However, in the presence of the interactive term between Internet usage and government effectiveness, Internet usage is positive and statistically related to economic growth in the short run but negative and statistically related to economic growth in the long run. Nonetheless, the overall marginal effect of Internet usage and government effectiveness turns out to have a positive impact on economic growth in the long run.

The association of an increase in Internet usage with a reduction in economic growth in the long run in Ghana in the presence of the moderating role of government effectiveness could be attributed to inefficiencies that are linked with prolonged use of the Internet for personal unproductive gains such as spending productive time having fun on social media while at work, and watching movies even during working hours among others rather than for productive purposes due to the possible lack of appropriate Internet and ICT-related policies. The finding also indicates that with the effectiveness and efficiency of the government in the formulation and implementation of appropriate Internet and ICT-related policies, Internet and ICT usage will enhance economic growth in Ghana in the long run. Therefore, in the formulation and implementation of Internet and ICT-related policies, it is recommended for the government to ensure that while expanding Internet and ICT infrastructure in various government institutions, workers are prohibited from using Internet services for unproductive activities in their offices. Furthermore, since Internet services play a crucial role in enhancing e-governance by improving accessibility, efficiency, transparency and citizen participation in government processes, it is recommended that the various government institutions in Ghana be encouraged through policy to incorporate the use of the Internet and ICT services in their daily official activities to ensure an efficient administrative system to increase productivity. Stakeholders including the private sector particularly telecom providers and employers play a crucial role in enhancing the growth of the digital economy hence the study also recommends that telecom providers should complement government efforts by building and expanding Internet access, especially to underserved or rural areas, offering affordable data and mobile plans to increase accessibility and inclusion, adopting modern technology and collaborating with governments to roll out national broadband plans or digital inclusion programmes.

The study relied on the number of Internet users as a percentage of the population aged from 15 to 74 but was unable to ascertain the activities of the Internet users due to data unavailability. This is the limitation of the study. It is recommended for further studies to explore the activities involved in the use of the Internet and ICT services in Ghana, especially the government institutions.

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**Supplementary material**
The supplementary material for this article can be found online.

**Corresponding author**
Anselm Komla Abotsi can be contacted at: aabotsi@uew.edu.gh, agrivetent@gmail.com