UNIVERSITY OF EDUCATION, WINNEBA

EFFECTS OF INTERNET USAGE ON ECONOMIC GROWTH IN GHANA

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DECLARATION

Student's Declaration

I, DIANA DOMEKAKPIER AAWAAR, declares that with the exception of quotations and references contained in published works which have all been identified and acknowledged is entirely my own original work and it has not been submitted, either in part or whole for another degree elsewhere.

SIGNATURE: …….

DATE: …….…….

Supervisor's Declaration

I hereby declare that the preparation and presentation of the thesis was supervised in accordance with the guidelines for supervision of thesis as laid down by the University of Education, Winneba.

NAME OF SUPERVISOR: Prof. Anselm Komla Abotsi PhD

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DATE: …….…….

DEDICATION

To Mr. and Mrs. Aawaar, Doris, Dorcas, Douglas and Ann-Marie

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Abstract

The study examines the impact of internet usage on economic growth highlighting the challenges faced by developing nations. While some data suggested that connectivity in Ghana was rising quickly, infrastructure, connectivity, and accessibility seem to be deficient in specific areas or throughout some developing countries. This current study applied autoregressive distributed lag model (ARDL) to examine the effect of internet usage on economic growth in Ghana. It also examined the effect of government effectiveness on economic growth in Ghana. Quarterly data spanning a period from 2000 to 2020 was employed in the study. The study reveals that internet usage positively impacts short-term economic growth. However, in the long-run internet usage has a detrimental influence on economic growth. Government effectiveness has a significant positive relationship with economic growth both in the long and short run. The composite effect of internet usage and government effectiveness is positive and significant, affecting Ghana's economic growth in both short and long terms. Based on the findings, the study recommends governmental agencies support in improving internet infrastructure thus by directing more resources to investing in infrastructure with the intention that it can target the vast majority of the population to ensure more accessibility of the use of the internet to boost productivity. The study also recommends that policies and programs that ensure policy formulation, implementation and credibility of governments' commitment to such policies are fundamental for long-term sustainability of the economy.

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ABREVIATIONS

AIC	Akaike Information Criteria
AME	Arab and Middle East
ARDL	Auto Regressive Distributed Lag
ARPANET	Advance Research Project Agency Network
ASEAN	Association of South-East Asian Nations
BBN	Bolt, Beranek and Newman
CRM	Customer Relationship Management
CPI	Consumer Price Index
CUSUM	Cumulative Sum of Recursive Residuals
CUSUMSQ	Cumulative Sum of Squares of recursive residuals
EU	East Europe
ERP	Enterprise Resource Planning
ECM	Error Correction Model
FE-IGLS	Fixed Effect- Iterated Generalized Least Square
FDI	Foreign Direct Investment
FNC	Federal Networking Council
GDP	Gross Domestic Product
GH	Ghana
GH.COM	Ghana Dot Com
GMM	Generalized Methods of Moments
GSMA	Global System for Mobile Communications

GSS	Ghana Statistical Service
HQ	Hannan-Quinn criterion
ICT4AD	Information and Communication Technology for Accelerated Growth
IQI	Institutional Quality Index
IPTO	Information Processing Techniques Officer
IPR	Intellectual Property Rights
ICT	Information, Communication and Technology
IMP	Interface Message Processor
TCP/IP	Transmission Control Protocol/Internet Protocol
UNDP	United Nations Development Programme
KPSS	Kwiatkowsky, Phillips, Schmidt and Shin
WEF	World Economic Forum
LM	Lagrange Multiplier
MDGs	Millennium Development Goals
MENA	Middle East and North Africa
MIT	Massachusetts Institute of Technology
NCS	Network Computer System
NRI	Network Readiness Index
NTP	National Telecommunications Policy
ITU	International Telecommunications Union.
WD	World Bank
ISP	Internet Service Providers
GMM	Generalized Method of Moments

OECD	Organization for Economic Cooperation and Development
OLS	Ordinary Least Square
PU	Perceived Usefulness
R&D	Research and Development
SBIC	Schwarz Bayesian Information Criterion
SGMM	System Generalist Method of Moment
SIC	Swartz Information Criterion
SRI	Stanford Research Institute
SSA	Sub-Saharan Africa
SEE	South East Europe
TAM	Technology Acceptance Model
TRA	Theory of Reasoned Action
UCLA	University of California, Los Angeles
UUNET	Unix to Unix Network
2SLS	Two Stage Least Square
VAR	Vector Autoregressive (VAR)
VECM	Vector Error Correction Model
WGIs	Worldwide Governance Indicators

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Technology advancement has been identified as the primary driver of employment and economic growth. Economic growth can be defined as an increase in gross domestic product per capita (Nuhuman, 2017). Economic growth is also known as an increase in national per capita income (Todaro & Smith, 2015). Todaro and Smith (2015) define economic growth as an increase in the amount of goods and services produced by a country. Haller (2012) defines economic growth as the process of increasing national economies, macroeconomic indicators, most notably GDP per capita, in an ascendant but not necessarily linear direction, with a positive effect on the economic-social sector.

Robert (1956) considered that the amount of capital and labor as well as the technological possibilities to which a country has access determines its economic growth. The surge in innovations for information and communication technologies and particularly the increasing expansion of internet and its access is modifying every single human activity (Alemna & Sam, 2006). Hence the internet has been identified as the primary transformer for economic activities in all sectors in recent times (Lijevern & Karlsson, 2017). The internet has become a vital technological instrument for enhancing economic growth within the globe; as it is perceived to be one of the fundamental human rights (Isaac et al., 2018).

The internet offers enormous opportunities for development in developing countries (Deloitte, 2014). Internet can transform the very nature of an economy and support economic development by enhancing speed and quality information flow resulting in reduced transaction cost, improves

human resource qualification and specification and enhances access to financial capital services such as mobile banking. The internet also facilitates entrepreneurship and business expansion: access to new markets, enhances innovation, adoption of new organizational models and business strategies (Deloitte, 2014). Venturini (2007) pointed out that the increasing rates of productivity in many developed countries in the 1990s is as a result of the exceptional increase in the utilization of internet and ICT capital. Yousefi (2011) however maintains that as of the years 1995 to 2000, Australia and the United States of America had the highest share of ICT capital investment.

According to the World Bank, nearly half of today's population lives in areas with internet access, but only one out of every seven people in least developed countries has access to it (Frempong & Atubra, 2001). However, one critical factor that influences the availability of internet access within a country is the infrastructure that it must rely on. One issue with internet accessibility is its high cost particularly in Africa (Chukwuma et al. 2002). While developed countries have full access to technology such as fixed line, cellular, and satellites, developing countries have a limited range of options (Chukwuma et al., 2002). Another factor is the availability of inadequate infrastructure in developing countries which is seen as the main barrier to accessing the internet (Frempong & Atubra, 2001).

According to Global System for Mobile Communications (GSMA, 2016) nearly 85 percent of Europeans and nearly 79 percent of Americans had a mobile subscription in 2015, while only 43 percent of the population in Sub-Saharan Africa did.

In responds to global changes in the ICT sector, Ghana among other African states reformed its ICT industry and developed legal regulatory systems to aid in the growth of the ICT sector (Alemna & Sam, 2006). In view of this the government of Ghana since 1990 relaxed its

restrictions in the telecommunication sector in order to allow the private sector to participate in providing services to improve and boost customer accessibility, increase coverage and also initiate value-added services (Frempong & Atubra, 2001).

Following Kenya, Ghana became the second country in Sub-Saharan Africa to gain complete internet access in August 1995 (Alemna & Sam, 2006). Ghana formulated the ICT for Accelerated Development Policy of 2003 and the National Telecommunications Policy of 2005, which aims to help the country transition to an information society (Frempong, 2012). The fundamental goal of the Information and Communication Technology for Accelerated Growth (ICT4AD) initiative is to create the required motivation and methods for the country's socioeconomic development to reach its maximum potential.

Ghana aspired to become a middle-income country with an information-rich, knowledge-based, technology-driven economy and society, which necessitated the development, deployment, and exploitation of information and communication technology (ICT) as a commercial sector and as a facilitator of other sectors (Quarshie & Ami-Narh, 2012).

Ghana has been rated as a medium human-developed country in recent editions of the UN Development Programme's (UNDP) Human Development Report. Ghana was ranked 133 out of 191 countries in the UNDP Human Development Index for the year 2021 (UNDP, 2022). The World Economic Forum established a Network Readiness Index (NRI) to quantify the possibility of a country being able to use ICT to drive economic growth, owing to ICT's growing importance in accelerating economic development (WEF). The WEF's NRI structure had undergone several minor changes between 2012 and 2002 to better match the rapid speed of development in the technology environment.

In 2021, Ghana's score in the NRI was 38.89 and was ranked 103 out of 131 economies. Regarding technology component Ghana scored 34.65, 30.83 in the component for people, Governance 49.54 and 40.5 in the impact component (Network Readiness Index, 2022).

The internet and ICT have an impact on economic growth and company value, as well as enhancing innovation through diffusion processes, use behaviors, and commercial success (Hector, Salvador, & Emigdio, 2016). ICT adoption has significantly increased resource allocation efficiency, drastically decreased production costs, and boosted demand and investment across all economic sectors (Pradhan, Arvin, & Norman, 2015).

The increase in production per person and per unit of time in a country is commonly used to quantify economic growth. Production is mostly responsible for the growth in output. The internet's use improves the production process' capability, and its most essential method for encouraging economic growth is its impact on production factors and sectors (Li, 2019). Dimelisa and Papaioannou (2010) attributed the previous decades' new information economy to increased ICT diffusion, faster productivity gains, and increased growth.

Institutional economics emphasizes the critical significance of institutions in economic performance, in addition to the impact of the internet on economic growth. North (1990) defines institutions as "the rules of the game in a society or, more formally, as the humanly devised constraints that shape human interaction." North's definition of institutions points out three important features of institutions. These characteristics indicate that they are (1) "humanly devised," as opposed to other potential fundamental causes, such as geographic factors, which are beyond human control; (2) that they are "game rules," imposing "constraints" on human behavior; and (3) that their primary effect will be through incentives (North, 1981).

In both industrialized and emerging nations, the theoretical and applied questions of the link between institutions and economic growth have been carefully addressed. Institutions, according to North and Thomas (1973), influence economic growth through altering property rights, incentive structures, and transaction costs. Rodrik (2000) highlighted how diverse non-market institutions play a crucial role in the creation of full and dependent markets. Institutions contributes to growth and development by lowering the risk of doing business, allowing resources to be directed toward innovation rather than property rights or exploitative rents. "Institutions are the rules of the game in a society, the humanly constructed limits that influence human interaction," writes North (1990). They shape human trade incentives, whether political, social, or economic.

Institutional quality is a measure which indicates the quality of governance and institutions in a country. Institutions are multifaceted. Commercial and non-commercial organizations such as the World Economic Forum (WEF), Global Integrity, Freedom House, Fraser Institute (FI) (Gwartney & Lawson, 2008), Heritage Foundation (Miller et al. 2009), and Marshall et al. (2002) have developed a variety of indicators to measure institutional quality across countries. The World Bank equally provides six indicators of institutional quality which includes political stability, voice and accountability, government effectiveness, regulatory quality, rule of law, and control of corruption.

Government effectiveness is a concept that is relevant in the public policy space. Public policy is a means by which governments implement their political visions to deliver desired changes. Effectiveness measures the quality of output and how well policy achieves desired objectives (Kim and Voorhees, 2011; Osborne and Gaebler, 1992). Measuring effectiveness entails the use of the opinions of stakeholders, which makes it a relative concept to assess.

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 which brings about peace and prosperity in the country. Effective government has been proved as helpful in boosting businesses and economic activities (Levi, 2006). Hence, effectiveness is a key performance indicator of interest for improving the status of their citizens, therefore if policies on ICT formulated and implemented by the government are effective it will be able to affect the growth of the economy positively. The effectiveness of government is an issue of concern for governments and the populace and as a result be considered a major factor of growth and poverty reduction in society. Government effective have an impact on both physical and human capital investment, as well as production in an organization (North 1990). To achieve a high level of production per worker, the social infrastructure must support productive activities and foster capital accumulation, skill training, creativity, and technology transfer (Hall & Jones 1999).

ICT boosts economic growth through three ways, according to theory. The first channel of ICT-induced growth is through its promotion of innovation and knowledge transfer from developed to developing countries; the second channel is through improving the quality of firm and household decision-making, resulting in increased resource allocation efficiency; and the third channel is through ICT penetration, which lowers production costs and stimulates demand and investment, improving productivity and growth rates (Khuong, 2011). Empirically, there is overwhelming evidence that internet usage has a favorable influence on economic growth (Choi&Yi, 2009; Meah, 2012; Meijers, 2014; Salahuddin & Alam, 2013; Tufail, 2015). As a result, the internet and ICT in general are being more recognized as having a direct influence on economic growth.

However, there is insufficient empirical evidence to determine the precise association with Ghana (Quarshie & Ami-Narh, 2012; Siaw, et al. 2020; Atsu, et al. 2014).

It is critical to examine the effect of internet usage and the role government effectiveness as an indicator of institutional quality play in the transfer of the benefit of internet usage to economic growth, given the importance of the internet and the incentive function of government effectiveness in economic growth.

1.2 Problem Statement

The development and expansion of internet access worldwide has contributed in a lot of ways to economic growth and consequently development (Haftu, 2019). Internet has grown to become accessible to users globally at an astonishing rate allowing people to access information, obtain knowledge, and wisdom on a far larger scale, breadth, and speed than previously through Internet usage (Bahrini & Qaffas, 2019).

Increased internet access has been demonstrated to promote economic growth, productivity, and employment, as well as raise consumer surplus and company efficiency (OECD, 2012). Some available data indicates a fast-growing rate of connectivity in Ghana and many other developing countries (WIS, 2018; ITU, 2013).

The ability of the Ghanaian population to afford or access internet related devices is fundamental to having a significant positive effect on economic growth. Some available data indicated a fast-growing connectivity in Ghana, yet infrastructure, connectivity, and accessibility appear to be lacking either in some parts or the whole of some poor nations such as Ghana (Jonas & Lin, 2023). In as much as internet usage is a necessary condition for economic growth, its access and

usage in terms of connectivity, infrastructure and government involvement is a fundamental problem in developing economies like Ghana hence the need to address it.

Cognizance of the fact that internet usage has a positive significant impact on economic growth, many researchers fascinated by this have drawn their attention to studying the impact of internet on economic growth at various levels (firms, national and cross-country levels) across the world (Maurseth, 2018). To ascertain the contributions of internet usage to economic growth, some theoretical and empirical researches have been conducted. Some theories revealed that technology plays a critical role in contributing to economic growth. For empirical studies, whiles some confirmed that internet plays a positive and significant role both in developed countries (Inklaar et al., 2005; Roller & Waverman, 2001) and developing countries (Meah, 2012; Salahuddin & Alam, 2013; Meijers, 2014; Choi & Yi, 2009), some do not (Maurseth, 2018). Nevertheless, these studies have added to the empirical evidence that there may be some relation of interest between internet and economic growth as envisaged.

Furthermore, many of the empirical studies focusing on developing countries adopted mixed econometric methodologies and relied on cross-country data to analyze the effects of internet on economic growth over the years (Guerriero, 2015; Elgin, 2013; Hinson & Adjasi, 2009). Cross-country studies (with Ghana included) conducted using different econometrics models and on a panel-bases makes it difficult to outline country-specific efforts on the effects of internet usage and its implication on economic growth.

Additionally, literature on the effects of digitalization, internet and telecommunication development and usage on economic growth in the Ghanaian context is not well-established and therefore does not give a clear picture of the relationship that exist between internet usage and economic growth. For instance, a study of the relationship between growth and internet usage in

Ghana using a qualitative approach suggests that there is inadequate evidence in testing the cause-and-effect hypothesis as the subjective judgment of the researcher is always manifested in the study findings (Schonfeld & Mazzola, 2013; Quarshie & Ami-Narh, 2012). Therefore, conducting a study to seek the use of quantitative models in estimating the relationship between internet usage and economic development is very key.

As a result of the foregoing, the current study aims to add to literature by looking at effects of internet usage on economic growth in Ghana and the effectiveness of government in contributing to the increase in internet usage to drive growth in Ghana using a quantitative method that is free of researcher's judgments, as well as co-integration (ARDL), which has the tendency to estimate the model's short- and long-run parameters at the same time.

1.3 Objectives of the Study

The study seeks to assess the effect of internet usage on economic growth in Ghana. Specifically, the study seeks to;

i. determine the effect of internet usage on economic growth in Ghana.
ii. determine the effect of government effectiveness on economic growth in Ghana.
iii. determine the interactive effect of government effectiveness and internet usage on economic growth in Ghana.

1.4 Hypothesis

The study shall test the following hypothesis using appropriate quantitative and statistical approaches. Three hypotheses are set to enable the study achieve its specific objectives:

1. H_0: Internet usage have no effect on economic growth in Ghana.

   H_1: Internet usage does have an effect on economic growth in Ghana

2. H_0: Government effectiveness have no effect economic growth in Ghana

   H_1: Government effective does have an effect on economic growth in Ghana.

3. H_0: The interaction of government effectiveness and internet usage does not have a significant effect on economic growth

   H_1: The interaction of internet usage and government effectiveness has a significant effect on economic growth.

1.5 Significance of the Study

Even though there have been some studies, although few, conducted on internet usage in Ghana, yet there remains a knowledge gap on the issue of the effect of internet usage on economic growth. There are no studies that directly focus on the relationship between internet usage and economic growth in Ghana Most of the studies cut across Europe, America and Asia; with very little attention given to individual countries in Sub-Saharan Africa (Pradhan et al., 2013). This study is positioned to be one of its kind that empirically quantify the long-run and short-term effect of the internet on economic growth in Ghana and hence contributes by adding to existing literature by looking at the effective role of government in contributing to the increase in internet usage to drive growth in Ghana. This study also emphasized on the impact of internet usage on economic growth as part of advocacy push to persuade policy makers. The results from the study also serve as a guide to making appropriate ICT sector reforms and evaluating their effectiveness to achieve economic growth.

1.6 Scope of the Study

The study is concentrated on the usage of internet in Ghana. Using quarterly data from 2000:1 to 2020:1, thus a total of eighty-four (84) observations, the study aims to investigate the impact of internet usage on economic growth in Ghana via measurement. In this study, the research uses a quantitative approach and descriptive statistics. The Auto-Regressive Distributed Lagged (ARDL) Model, also known as the bounds testing approach to co-integration, was developed by Pesaran & Pesaran (1997); Pesaran, Shin, & Smith (2001) to assess the short-run and long-run relationship between variables hence is employed to examine the short run and long-run relationship between internet usage and economic growth, the effect of institutional quality on economic growth as well as the effect of the interaction of internet usage and government effectiveness on economic growth in Ghana. The Auto-Regressive Distributed Lagged (ARDL) Model is used since it allows for the study of both short and long-term relationships between variables.

1.7 Organization of the Study

The research is divided into five chapters. The background of the study, the statement of the problem, the research objectives, the hypothesis to be tested, the research objectives, the significance of the study, the scope of the study, and the organization of the study will all be included in the first chapter, which will serve as the introduction. The second chapter covers the literature review that includes both theoretical and empirical evidence from other writers' work that is related to the topic. The study's methodology will also be presented in the third chapter. It comprises the study's variables, the model definition, data sources, and data analysis. The fourth chapter will go through the data analysis and the outcomes. Finally, in chapter five, a summary of the study's findings and conclusions will be presented. Recommendations for policymaking

will also be discussed, as well as the limitations that will be discovered during the research. This chapter will also include suggestions for additional research.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction.

This chapter essentially presents a review of relevant literature on the impact of internet usage on Ghanaian economic growth. This entails reading both theoretical and empirical literature. The theoretical review includes a definition of the internet as well as brief discussions on its evolution, development in Ghana, the trend of internet penetration in Ghana, the technology acceptance model, economic growth, and the state of Ghana's economy. Economic growth theories are also discussed, including the Harrod-Dormar growth model, the neoclassical growth model, and the Endogenous growth model. Following that, previous empirical findings on the effect of internet usage on economic growth are reviewed. The final section is a chapter summary.

2.2 The Concept of Internet

The internet is a global area network that connects computer systems all over the world. It is made up of numerous high-bandwidth data lines that form the body of the internet. These high-bandwidth lines connect to major internet hubs, which distribute data to other locations such as web servers and Internet Service Providers (ISP). To connect to the internet, one must have access to an Internet Service Provider. The Internet Service Provider acts as a bridge between internet users and the internet by providing broadband Internet access via cable, DSL, or fiber (Christenson, 2015).

The Federal Networking Council (FNC) passed a resolution defining the term internet in 1995, after consulting with the leaders of the Internet and Intellectual Property Rights (IPR)

Communities. Because the FNC was established by the White House's National Science and Technology Council, their definition of the internet may be considered somewhat official. As a result, the Federal Networking Council (FNC) defined the internet as a global information system capable of supporting communications via the Transmission Control Protocol/Internet Protocol (TCP/IP) suite or its subsequent extensions/follow-ons, as well as other IP compatible protocols. The Federal Networking Council (FNC) also refers to the internet as a global information system that provides, uses, or makes available high-level services layered on the communications and related infrastructure described herein, either publicly or privately (Leiner et al. 2009)

2.3 History of Internet

The internet is a global broadcasting capability, a mechanism for information dissemination, and a medium for collaboration and interaction between individuals and their computers that is not limited by geography (Kleinrock, 2008). Kahn et al (1997) noted that the history of the internet revolves around four different aspects. These four distinct aspects are technological evolution, operations and management, social issues, and commercialization.

Prior research on packet switching and the Advance Research Project Agency Network sparked the technological evolution (Leiner et al. 2009). Currently, research is being conducted to broaden the scope of the infrastructure in terms of scale, performance, and functionality. The social aspect of internet evolution is concerned with the large community of internet users who collaborate to create and evolve the technology. The commercialization aspect results in a highly effective transformation of the research results into a widely deployed and accessible information infrastructure. The origins of the global internet can be traced back to the 1960s and the US-based ARPANET (Towela & Biru, 2015).

The ARPANET project began in 1962 in response to the launch of the Soviet Union's Sputnik, the first man-made object to orbit the Earth on October 4, 1957. One of the Advance Research Project Agency was the Information Processing Techniques Officer (IPTO). It was very successful in funding early-stage computer science research. It made advances in networking (creating the internet), packet satellite networking, packet radio networking, digital signal processing, time sharing, and hypertext, among other areas (Kleinrock, 2008).

Dr. J.C.R. Licklider of the Massachusetts Institute of Technology (MIT) was hired as the head of the computer research program in October 1962, not long after imagining a network of computers linked globally through which people could communicate with one another and obtain data and programs from any location (Leiner et al, 2009). While at the Advance Research Project Agency (ARPA), Dr. J.C.R. Licklider persuaded his successors of the importance of networking concepts.

Leonard Kleinrock, then at the Massachusetts Institute of Technology, published the first paper and book on packet switching theory in July 1961 and 1964, respectively (MIT). In their article, Leiner et al. (2009) stated that Kleinrock persuaded Robert to consider the possibility of communicating using packets rather than circuits. The ability to communicate using packets was a significant step toward computer networking. Another critical step was to get the computers to communicate with one another. In 1965, Robert collaborated with Thomas Merrill to determine this. He connected the TX-2 computer in Massachusetts to the Q-32 computer in California using a low-speed dial-up telephone line, allowing for the first time the construction of long-distance electronic networks. The findings of Roberts' investigation confirmed Kleinrock's case for packet switching. That is, many people in different locations could use a specific computer system to

effectively collaborate, run programs, and retrieve data, which the circuit switch telephone system could not do.

According to Kleinrock (2008), Robert developed the concept of a computer network in 1966 and then published his plan paper on ARPANET in 1967. He learned about other works on packet switching by Donald Davies from the United Kingdom and Roger Scantlebury of NPL, Paul Barran from RAND, and Leonard Kleinrock from Massachusetts Institute of Technology at the conference center where he published his paper on the ARPANET. He claimed that the packet switching research conducted by Paul Baran of RAND, Leonard Kleinrock of MIT, and Roger Scantlebury of NPL was done independently.

After being mentioned in a number of other papers on packet switching, Robert organized a meeting with a number of ARPANET's main researchers. The team discussed Wesley Clark's suggestion that separate computers work together to share a network and offload networking functions from a main computer system. As a result, they created the Interface Message Processor (IMP) for the separate computer, which is nearly identical across the network.

In their article, Kahn et al. (1997) stated that in 1969, a Massachusetts firm- Bolt, Beranek and Newman (BBN) - was awarded a contract to build a working network that would allow researchers to access each other's computers as well as numerous resources on each computer. Frank Heart was the BBN team's project manager at the time. At BBN, Bob Kahn was in charge of system design. It is noted in the article that, the University of California, Los Angeles (UCLA) became the first location to host the Interface Message Processor (IMP) in September 1969, eight months after the contract was awarded to BBN. This was due to Klenrock's Network Measurement Center at UCLA, where he conducted his early research on the development of packet switching theory. His early works focused heavily on analysis, design, and measurement.

Stanford Research Institute received the ARPANET's second node (SRI). One month later, after SRI was connected to the ARPANET, the first host-to-host message was sent from Kleinrock's laboratory to SRI.

ARPANET was extended to the University of California, Santa Barbara, and the University of Utah. ARPANET's final two nodes, which were deployed to the University of California, Santa Barbara and the University of Utah, integrated projects that used imagining. Kleinrock (2008) stated in his article that Glen Culler and Burton Fried of the University of California, Santa Barbara investigated techniques for using storage displays that would deal with the problem of refresh over the internet to reveal mathematical functions. Robert Taylor and Ivan Sutherland at the University of Utah investigated 3-D representations over the internet.

After connecting the ARPANET to four locations, the University of California, Los Angeles held a press conference on July 3, 1969, announcing the ARPANET's impending implementation. The internet was launched two months after the press conference (Kahn et al. 1997).

As a result, the original ARPANET evolved into the Internet. The Internet was founded on the concept of multiple independent networks of varying design, beginning with the ARPANET as the first packet switching network and soon expanding to include packet satellite networks, ground-based packet radio networks, and other networks. The Internet as we know it now is built on a fundamental technical concept known as open architecture networking (Leiner et al. 2009).

2.4 Development of Internet in Ghana

Ghana achieved full internet connectivity in 1995 and has since been one of the fastest-growing countries in terms of internet infrastructure, with this digitization trend expected to continue. Ghanaians use the internet extensively. As a result, the internet has become the primary source of

information and communication. As of January 2022, approximately 23.05 million people, or roughly 68.2 percent of the Ghanaians population were estimated to have Internet access to the internet according to the World Bank Group's World Development Indicators 2022 (World Bank, 2022).

Collaboration among several organizations, including Network Computer System (NCS), Unix to Unix Network (UUNET) Pipex International, the Ministry of Transport and Communication of Ghana, British Telecom, and Ghana Telecom, resulted in Ghana's full internet connectivity. Dr. Nii Quaynor and his strong technical team at NCS, which included William Tevie, Joseph Annan, Andy Bulley, and others, worked tirelessly to connect Ghana (Quaynor, 1997).

Ghana unveiled a National Telecommunications Policy (NTP) in 2005, with one of its specific policy goals being universal access to telephone, Internet, and multimedia services by 2010; and national penetration of universal telecommunications services. Based on this, the telecommunications sector embarked on a privatization program.

Network Computer System, Internet Ghana, and Africa Online are the three full Internet Service Providers (ISPs) in Ghana, each with their own independent internal Internet links. Network Computer Systems (NCS) is the country's first and largest Internet Service Provider, as well as the first to set up a global Internet gateway with full connectivity in Ghana. It transmitted data at 384 Kbit/s via the F1 Intelsat earth station. NCS was founded in 1988 and provides consulting, network installation and maintenance, and training services (Addy-Nayo, 2001).

InternetGhana is a Ghanaian firm that offers Internet services. InternetGhana, founded in June 1996, operates a full digital Internet link, connecting to the world-renowned Internet MCI's

Super High Bandwidth Internet Backbone in New York. InternetGhana operated at 128 Kbps and has a presence in Kumasi in addition to Accra (Quaynor, 1997).

Africa Online Ghana is a subsidiary of Africa Online and the largest provider of Internet communications services in Africa. It provided Internet users with an equal distribution of technical expertise and breadth of service unrivalled on the continent to thousands of successful individuals and businesses. Africa on-line's headquarters were in Nairobi, Kenya, and the company had operations in Kenya, Côte d'Ivoire, Ghana, Tanzania, Uganda, and Zimbabwe (Christenson, 2015).

The Ministry of Transport and Communication has given NCS permission to offer value-added e-mail and other services to Ghanaian subscribers. NCS registered the GH.COM domain in 1993 and sought a service provider to serve it. Pipex accepted the request and collaborated with NCS to establish a commercial service in Ghana (Quaynor, 1997).

According to Addy-Nayo (2001) the initial method of connection was by dial-up IP to Pipex performed on a regular basis, using a DEC station 5000 model 25 with Morningstar PPP software. With the growth of the global Internet, it became critical that Ghana's network be expanded. One of the primary constraints to network expansion was a lack of adequate or sufficient DELs, making it impossible for NCS to obtain dial-in lines for subscribers.

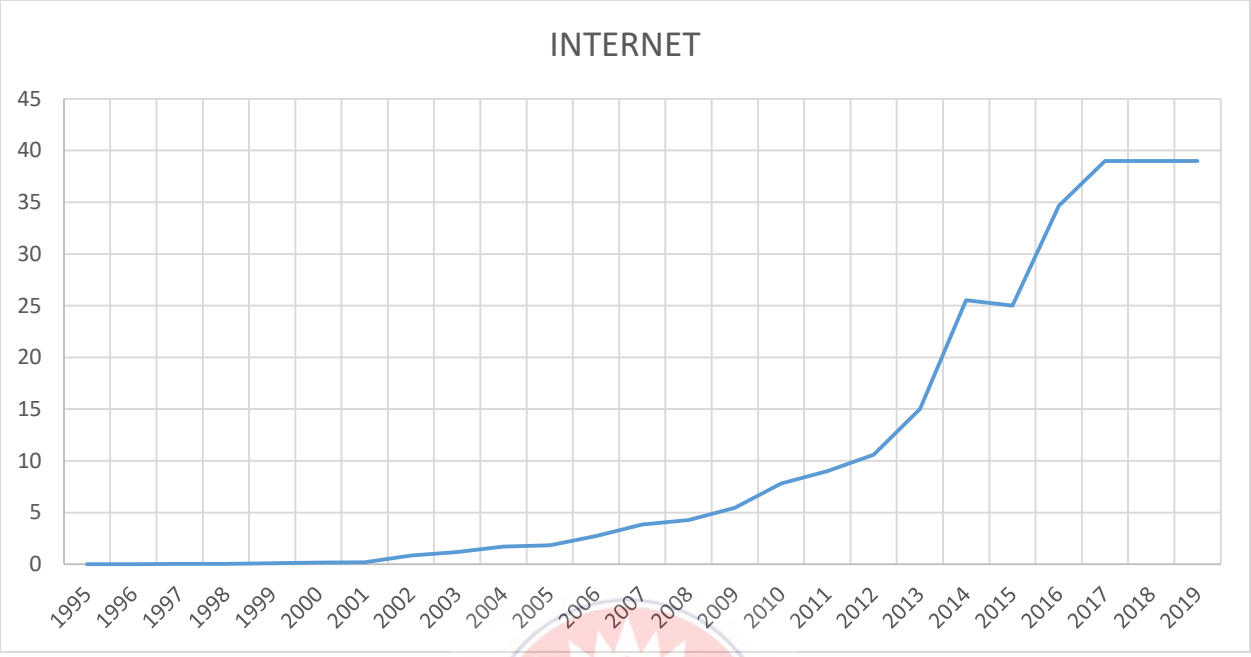
However, Ghana Telecom has been expanding the national telephone network since the beginning of October 1994. This expansion resulted in the addition of 15,000 lines to Accra exchanges via the second telecom project. This made available additional dial-in lines to subscribers. NCS applied for the top-level domain GH, and its approval in January 1995 thus put further pressure for improvement and expansion of the network (Addy-Nayo, 2001).

2.5 Trend of Internet Growth in Ghana

The emergence of the Internet has fundamentally changed the way we work, play and communicate. Today, Internet technology being Internet-based communication and phone services are growing faster than landline communications (Towela et al., 2015). Over the previous years, increased in internet connectivity globally is said to have boosted businesses, especially in the private sector contributing to the economic growth. In Ghana, internet is used enormously for so many purposes such as education, businesses, and entertainment among others. By far, the youth have the greatest internet usage (Frimpong & Vaccari, 2015).

Ghana has experienced tremendous increase in internet growth since it was fully connected. According to the 2010 Ghana Census, only 47.8 percent of Ghanaians own a mobile phone while 63.4 percent of urban dwellers own phones, only 29.6 percent of rural dwellers does. In respect to Internet usage, the Census found that the difference between urban and rural users is even more pronounced. While 12.7 percent of urban dwellers used the Internet in 2010, only 2.1 percent of rural dwellers did (Frimpong & Vaccari, 2015).

The figure below indicates the trend of internet usage.



Source: Author, 2023

Figure 1 Trend of Internet penetration in Ghana

The figure above indicates the trend of the internet penetration from 1995 to 2019. From 1995-2001 indicates a steady growth and from 2001 to 2013 indicates a continuous increase. There was a sharp increase from 2013 to 2014 in internet penetration growth but became constant from 2014 to 2015 and again a rise from 2015 to the year 2017. From 2017 to 2019 the country again experienced a constant growth in internet penetration.

2.6 Technology Acceptance Model

Several theoretical models have been developed and applied to investigate the adoption of technology. The most influential and widely model considered by researchers to describe the acceptance and usage of a particular technology by individuals and or firms, studying the influence of human factors in the adoption of new technologies is the Technology Acceptance Model (TAM) (Silva, 2015).

The technology acceptance model developed by Davies (1989) was originally derived from the Theory of Reasoned Action (TRA) (Fishbein, Martin & Ajzen, 1975). The Theory of Reasoned Action assumes that attitude and behavioral intention of an individual guides or even dictates an individual's behavior. Intention is considered the main determinant of a person's readiness to perform a given behavior, and it is considered to be the immediate antecedent of behavior (Ajzen & Fishbein, 1980; Leach et al., 1994).

Davis (1989), added psychological factors to the TRA factors to produced TAM. The addition of the psychological factor made it the major factor that differentiated TAM from TRA.

The model is originally designed to predict users' acceptance of Information Technology and usage in an organizational context. The Technology Acceptance Model outlined two basic factors thus; Perceived usefulness (PU) and Perceive ease-of-use as factors that influence an individual's decision in accepting and using a particular technology (Davis, 1989).

Perceived usefulness is referred to as the extent to which an individual is of the opinion that adopting a given innovation system would enhance his/her job performance. This implies that, in accepting and using a particular technology, individuals have a positive behavioral response that is supposed to benefit and improves their productivity for a particular job (Luo et al. 2006)

Perceived ease-of-use is the degree to which a potential users of a given technology expect that the particular system would be effort free. With this, it is assumed that the usage of a particular innovative technology would be effortless. This construct further indicates that, when a technology is easier to use human behavior would respond faster towards that particular technology (Luo et al. 2006).

Aside perceive ease of use and perceived usefulness of a given technology outlined by Davis, (1989) as factors that determines an individual's intention to technology acceptance and usage, the Technology Acceptance theory equally consider external factors that also serve as continuous usage of that technology (Silva, 2005). The introduction of a new technology therefore influences the individual's life in response to the introduction of that particular technology.

2.7 Government Policies on ICT in Ghana.

Governments world-wide have recognized the crucial role that ICTs can play in facilitating and accelerating socio-economic development. A number of countries have in place relevant policies and strategic plans that will enable them transform their economies into information and knowledge-based economies. Ghana like other developing countries is equally placed to take advantage of these technologies to facilitate her socioeconomic development hence the use of internet technology to provide various services to the public. 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. It placed much emphasis on the role of ICT in contributing to the economy. Some of the public ICT policies in Ghana includes;

ICT4 Development.

The National ICT Development policy (ICT4D) was developed and passed by parliament in 2013. It was among the key policies under the medium-term development plan captured in the Ghana Poverty Strategy Paper I & II and the Education Strategy Plan 2003 -2015. The National ICT Development policy (ICT4D) statement aimed at realizing the vision of transforming the Ghanaian economy into an information-rich knowledge-based economy through the development, deployment, exploitation and utilization of technology to support various activities within the economy. The ICT policy is set out to have four year rolling plan and has between 15

to 20 years operational life span. The policy has 14 priority areas such as promoting legal, regulatory and institutional frameworks, developing research and development, scientific and industrial research capacity, promoting ICTs in education among others (Republic of Ghana, 2003).

The Ghana Poverty Reduction Strategy plan (GPRS I & II) and the Education Strategic plan 2003-2015 suggest the use of ICT as a means of reaching out to the poor and vulnerable in Ghana. The government believes that Ghana being an underdeveloped nation will need to use ICT to aide its socio-economic process as well as implementing policies and programs aimed at developing the ICT sector.

E-Government.

Hernon et al., (2002) defined e-government as the use of technology, particularly the internet to enhance the access to and delivery of government information and services to citizens, government employees, businesses and other agencies. E-government is defined as "The use of ICT and internet to enhance the access to and delivery of all facets of government services and operations for the benefits of its stakeholder groups, including citizens, businesses, and the government itself" (Srivastava and Teo, 2010)

The e-government policy (2005) is one of the 14 pillars of the ICT4D policy which is captured as “Facilitating Government Administration and Service delivery. One of its objectives is to modernize the operation of services through the deployment of ICT to facilitate the reduction of administration cost and enhance their efficiency and effectiveness in service delivery through the establishment of institutional framework to ensure its successful implementation (Mensah, 2016)

The development of e-government was part of the third piece of the e-Ghana project which was initiated by the Ministry of Communication with collaboration from Bank of Ghana. The project sought to support specific efforts to carry out the government's ICT-led development agenda, focusing on, among other things, efficiency of the National Information technology Agency which is the ICT implementation wing of the government of Ghana (Mensah, 2016).

All the three arms under the e-government project are expected to be linked electronically at all levels to enable them interact with and serve citizens and the private sector. An e-government infrastructure network is established with the aim of standardizing connectivity between agencies and allowing them utilize higher bandwidths. This is to facilitate the exchange of information and also create an enabling environment for interaction and coordination of work among agencies, departments, citizens and private businesses to improve productivity. The development of the Ghana e-government implementation strategy in 2005 was therefore to ensure that the objectives of the ICT4D were achieved (Srivastava and Teo, 2010).

2.8 Economic Growth

Economic growth is the sustained increase in the capacity to satisfy the demand for goods and services resulting from increased production scale and innovation in product and processes. Alina (2012) looked at economic growth both in its limited as well as its wider sense. Economic growth is analyzed in its limited sense as an increase in the national income per capita and its analysis especially in quantitative terms focus on the functional relation between the endogenous variables while in a wider sense it involves the increase of the Gross domestic product, Gross National Product and National income.

Based on the above, Alina (2012) defined economic growth as the process of increasing the sizes of national economies, the macro-economic indicators especially the Gross Domestic Product per

capita, in an ascendant but not necessarily linear direction, with positive effects on the economic-social sector. An expansion in the production of goods and services will bring about an increase in the number of job opportunities, a reduction in the unemployment rate, a rise in income as well as increase in the standard of living of the populace resulting in a higher economic growth. Economic growth can be positive, zero or negative. An economy records a positive economic growth when the annual average rhythms of the macro-indicators are higher than the average rhythms of growth of the population. The desired economic growth countries therefore aimed at attaining is a positive economic growth. Economic growth is subject to economic fluctuations which could lead to economic recession. Economic growth is determined by the resources available to a nation in the form of labour, energy, materials and capital and the productive way in which these resources are used.

According to Akutson et al. (2018), economic growth is the continual process of enhancing the economy's efficiency and, as a result, growing national income. Higher rates of rise in per capita production and total factor productivity, especially labor productivity, are associated with increasing an economy's productive capacity and hence national wealth. They said that growth is meaningful when it is substantially faster than population expansion because it must result in an increase in human welfare. They also mentioned that calculating a country's growth rate using its real Gross Domestic Product (GDP) has been shown to be an effective means of determining how an economy has expanded over the course of a year.

A gain in national per capita income is referred to as economic growth (Todaro and Smith, 2015). Economic growth is assessed by the increase in the number of products and services produced in a country, according to Todaro and Smith (2015).

Motley (2016), explains why using growth rate instead of GDP is important: "Economic growth rate helps to know the changes in economic activity in a country as opposed to GDP, which measures the value of all final goods and services produced by labor and property in a well-defined geographical area."

Lepenies (2016), also postulate that growth is determined by the pace of change in GDP over a specific period of time. It is expressed as percentage and price is adjusted, denoting that an attempt is made to exclude the effect of inflation. He referred to GDP as all goods produced and services provided domestically, considering that these goods and services produced are not used as inputs for the manufacture of other goods and services.

2.9 The Economy of Ghana

Ghana, officially known as the Republic of Ghana, is a democratic country. It is a West African country with a population of approximately 31.70 million people in as at January 2021(GSS, 2021). It is bounded on the west by Côte d'Ivoire, on the east by Togo, on the north by Burkina Faso, and on the south by the Atlantic Ocean. In 1957, Ghana became the first black African country to gain independence from British colonial rule. Ghana's main economic sectors are the agricultural sector, the industrial sector, and the service sector. These sectors drive the country's economic growth. The service sector is regarded as the most important component of the economy, accounting for about 55 percent of GDP and employing 43.7 percent of the workforce (World Bank, 2021).

Ghana's economic growth pattern has varied significantly by sector, as evidenced by shifts in the sectoral distribution of national output away from agriculture and toward the two other sectors. The shift in sectoral dominance from agriculture to services has resulted in relatively stronger growth in services and industry. Estimates from the World Development Indicators showed a

growth rate of 8.4 percent for agriculture in 2017, compared to 16.7 percent for industry and 4.3 percent for services.

The share of industry increased from 24.3 percent in 2016 to 30 percent in 2021. The strong evidence of industry contribution to growth and the industry sector has emerged largely owing to improved growth performance in the mining and construction sub-sectors (GSS, 2021). With the start of commercial oil production in 2011, the industrial growth rate reached a high of 41.6 percent, increasing the sector's share from 21.7 percent in 2006 to 30 percent in 2021(World Bank, 2021).

The agricultural sector was regarded as the backbone of the Ghanaian economy, and the shift from agricultural dominance to services in real GDP may be viewed as a structural transformation of the economy. The structural transformation of economic arrangements can be viewed as an increasing ability of the economy and society to respond efficiently and effectively to changing and increasing pressures to improve people's welfare. This is a procedure in which sectors other than agriculture account for the relative increase in employment and output of the economy. This is due to a net resource transfer from agriculture to other sectors of the economy over a specific time period (GSS, 2018).

2.10 Economic Growth Models

The importance of studying economic growth and investigating its causes seems obvious and this for a long time has drawn the attention of researchers (Griffiths, 2002). Investigating into the causes of economic growth in an economy has led to the emergence of three economic growth theories namely; Harrod-Dormar growth theory, the neoclassical growth theory and endogenous growth theory.

2.10.1 Harrod-Dormar Growth Model

Harrod (1939), first version of economic growth was first published in "An Essay in Dynamic Theory''. Three growth concepts were outlined; the actual rate of growth, natural rate of growth and warranted (Required) rate of growth. Actual growth is the real rate increase in a country's GDP per year. Natural rate of growth as that rate of growth of output which is required to fully employ the entire growing labor force. Warranted (Required) rate of growth is the rate of growth where an economy neither produces more or less than the right amount needed by the economy (Eltis, 1987; Hagemann, 2009).

Harrod's model pointed out two kinds of problems that could arise with growth rates. The first was that rate of saving and growth of the labor force are outlined as determinants of actual growth and natural growth respectively. The model assumes a fixed wage rate as well as a constant return to scale in the aggregate production function and for that matter the natural rate of growth of production must be equivalent to the rate of labor growth. There was no necessary reason for actual growth to equal natural growth and therefore the economy had no inherent likelihood to reach full employment. These assumptions are the basis for the identification of this first problem outlined by the model (Blume & Sargent., 2015).

The second issue raised by Harrod's approach was that of insecure growth. If corporations modified their investment based on their expectations for future demand, and the projected demand materialized, justified growth would equal actual growth. If the actual rate of growth in the economy exceeds the authorized pace of growth for any reason. The real incremental capital per unit of incremental production will be lower than the targeted incremental capital per unit of incremental output in this circumstance. An unforeseen shortage in inventory stock or an excess demand for equipment will result from a shortfall in real capital compared to budgeted capital.

Both scenarios will result in inflation, and the firm's response will be to increase the pace of planned investment. It indicates that whenever the real rate of production growth exceeds the justified rate of growth, the businesses' reaction mechanism will cause the actual rate of growth to exceed the warranted rate of growth, causing greater disequilibrium in the long term. This will push the economy even further away from its equilibrium growth path, putting it on the verge of a boom. If the actual growth rate in the economy is lower than the justified growth rate, the opposite is true. Growth would be slowed as a result of this.

According to the aforementioned research, Harrod's equilibrium growth route is fully unstable. As a result, the equilibrium growth is described as Knife-Edge Stable (Blume & Sargent., 2015).

This conclusion drawn here again was the result of two unrealistic assumptions made by Harrod:

(1) Companies naïvely base their investment plans only on anticipated output, and

(2) Investment is instantaneous.

In spite of these limitations, Harrod did get economists to start thinking about the causes of growth as carefully as they had thought about other issues, and that is his greatest contribution to the field (Blume & Sargent., 2015).

Adhikari (2018) stated Harrod's equilibrium analysis was based on three assumptions:

(i) Saving is proportional to national income. $S_t = sY$

(ii) Investment, the demand for saving, is proportional to the growth of national income,

$$I_t = g(Y_{t-1} - Y_t)$$

(iii) Saving equals investment, the demand for saving equals the supply of saving,

$S_t = I_t$

From this, one derives the 'fundamental equation',

$\frac{Y_{t+1}-Y_t}{Y_t} = \rho_w = \frac{s}{g}$,

Where;

ρ_w is the 'warranted' growth rate. Put differently, national income follows the first-order difference equation $Y_t = \left[\frac{g}{(g-s)}\right] Y_{t-1}$ with $1 > g > s > 0$. Domar (1946), arrived at the same result using different model (Blume et al. 2015).

Domar (1946), developed a model based on a question that seeks to know the rate of increase in investment which would equalize the increase in income and the increase in productive capacity, so as to maintain full employment. He postulated that a country will be in a steady state when its productive capacity is equivalent to its national income. This will be based on the capital the country has accumulated. Domar (1946), forged a link between aggregate supply and aggregate demand through investment to which steady state could be obtained in a close economy setting without taking into consideration the possibility of having external economies as well as diseconomies.

This approach was adopted based on the general theory of equilibrium. The model is based on the dual character of investment: investment increases productive capacity, and two, investment generated income. The two sides of investment provide solution for steady growth (Blume & Sargent., 2015). From the demand side, investment can be represented as

$Y_d = \frac{I}{d}$ …….. (1)

Where

Y_d = level of effective demand at full employment (demand side)

I = net investment, which implies change in stock of real capital, i.e. ΔK

d = marginal propensity to save

From the demand side the level of effective demand is directly related to the level of investment but inversely related to the marginal propensity to save. That is an increase in investment will lead to an increase in effective demand and vice versa whiles an increase in the marginal propensity to save will lead to a decrease in the level of effect demand and vice versa (Blume & Sargent., 2015). The supply side of investment can be represented by an equation as

$Y_s = \sigma k$…… (2)

Where

Y_s represents supply of output

σ Represents productive capacity of capital and

k represents the amount of real capital.

A change in the supply of any of these will result in a corresponding change in the supply of output.

In equilibrium, the demand and supply should balance. Hence

$$Y_d = Y_s$$

Or

$$I/_d = \sigma k$$

By cross multiplication

$I = d\sigma k$ ..... (3)

Steady growth is possible when investment is equivalent to saving income ratio, capital stock and capital productivity. Equation (3) therefore explains the condition for steady state. For this to be maintained, an adjustment or increment to the demand and supply conditions presented above should be made. The demand function in its adjusted form can be stated as

$\Delta Y_d = \Delta I/d$ ..... (4)

Adjustment is made only to the level of effective demand and investment because they are variables. Increment is not shown in d because it is assumed to be a constant.

The supply equation in its increment or adjusted form is presented as

$\Delta Y_s = \sigma \Delta K$ ..... (5)

The equation indicates that a change in the supply of output (ΔY_s) would be equal to the product of the productivity of capital (σ) and change in real capital (ΔK). Change in capital is expressed as net investment. Hence ΔK is represented investment (I).

Substituting I in place of ΔK in equation (5) gives the equation below as

$\Delta Y_s = \sigma$I ..... (6)

The steady state condition is maintained when equation (4) is equal to equation (6). Hence in equilibrium

$$\Delta Y_d = \Delta Y_s$$

Or $\Delta I/d = \sigma$I ..... (7)

Here

Y_d = Level of national income or level of effective demand at full employment (demand side)

Y_s = Level of productive capacity or supply at full employment level (supply side)

K = real capital

I = net investment, which implies change in stock of real capital, i.e. ΔK

d = marginal propensity to save, which is the reciprocal of multiplier i.e., (mpλ=1/multiplier)

σ = productivity of capital

By cross-multiplying , we obtain

$\Delta I/I = \sigma d$ ..... (8)

This explains that, explains that the growth-rate of net investment $\Delta I/I$ should therefore be equal to the product of marginal propensity to save (d) and productivity of capital (σ). This equality must be maintained to ensure stable and steady growth in the Dormar (1946) model.

Harrod-Dormar growth Theory is the integration of Harrod (1939) and Domar (1946) growth models based on the experience of capitalist economies. This model was developed independently by English economist Roy F. Harrod in 1939 and American economist Evsey Domar in 1946 (Zhai, 2018).

The Harrod-Domar model is a neo-classical economic growth model that supports the opinion that economic growth rate is dependent on the function of the saving and investment rate (Dragoi, 2019). Harrod–Domar model put emphasis squarely on the productivity of capital and savings rate (Adhikari, 2018). It implies that boosting savings rate (hence investment) and making capital more productive will enable an economy achieve economic growth.

The model is widely adopted by many development economists in the explanation of economic growth rates as well as estimating the level of foreign aid required to reach some target rate of growth (Zhai, 2018).

There were a number of criticisms of the model; one being that there was no reason for the actual growth to equal natural growth and that an economy had no tendency to full employment. This is based on the assumption of wages (relative price of labour) being fixed. Labour and capital are assumed to be used in equal proportion. The criticisms of the Harrod-Dormar growth model led to the development of the Solow growth model.

2.10.2 Neoclassical Growth Theory

The neoclassical growth theory is an economic theory introduced by Robert Solow and Trevor Swan in (1956). They built their model based on the exogenous growth model where they outlined three factors thus labor (population growth), capital accumulation (savings) and technological progress as determinants of economic growth.

Technology in the Solow model is considered to be the major determinant in maximizing productivity and is assumed to be exogenously determined. It is thought to augment labor productivity and increase the output capacities of labour. The model assumes that countries will converge to the same balance growth path on condition that technology is proportionately accessibly by all countries as well as free movement of labor and capital regardless their initial output per capital (Dragoslava, Slobodan & Gorica., 2016).

The Solow-Swan model used production function that expresses the correlation between inputs and output. The standard production function employed in neoclassical growth models takes the following form

$$Y = Ae^{ut}K^{\alpha}L^{1-\alpha}$$

Where;

Y is gross domestic product,

K is the stock of human and physical capital,

L is unskilled labor,

A is the technological progress, also known as the Total Factor Productivity.

The labour input as well as the level of technology is presumed to be constant. It is believed that the Technology factor in the Solow model makes labor more efficient and for this reason technology is referred to as labor-augmenting.

e^{ut} represents the exogenous rate at which that technology evolves (Solow, 1956).

α indicates the percentage increase in gross domestic product resulting from a 1 percent increase in capital.

Empirically, α is usually obtained from the share of capital in the national income accounts of individual countries. This assumes that capital is paid its private marginal product and that it confers no external economies. As long as α is less than 1, this formulation displays diminishing returns to capital and labor.

The Solow model also has its central equation to be $\dot{k} = sk^{\alpha} - (\dot{n} + g + \delta)k$

From the equation

K represents the rate at which capital per unit of effective labor change

S represents the saving rate

δ is the capital depreciation rate and

n and g are the growth rate of labor L(t) and technology A(t) respectively

The inference drawn from the equation is that the factors of production employed in the Solow's production function increase at a constant rate leading the economy to a steady state. When an economy is said to be a steady state which is assumed to be solely influenced by technological progress, growth in standard of living is sustained. Nonetheless the saving rate has a permanent change in the level of capital per worker as well as output per worker. This implies that only technological progress has a permanent effect on growth whiles all other changes have level effect.

Despite Solow's contribution on analyzing economic growth, the model has been criticized based on their convergence predictions. The neoclassical growth theory states that all countries should converge to a steady state if they have equal distribution of technology. This implies that poor countries with low capital to labor ratio will turn to have high growth rate as a result of high marginal products of capital than rich countries with high capital to labor ratio resulting in what is termed as absolute convergence.

Contrary to this, to a large extent, countries continue to differ in growth rate and GDP level. In addition to this, different countries turn to have different levels of technology since new technology is not readily available in all countries at the same time. For these reasons countries do not eventually converge to the same balance growth path. Barro (1991), work takes to the opinion of conditional convergence where countries differ in technology and hence resulting in the difference in steady state growth levels among them.

Savings which is the fraction of the total output saved for investment in the neoclassical growth model and is considered a vital factor in explaining the differences in the balance growth among countries is treated as exogenous. Technology is also treated as exogenously given (Zhao, 2019). This criticisms about the neoclassical growth theory led to the evolution of the endogenous growth theory which takes into account technological progress in contributing to economic growth.

2.10.3 Endogenous Growth Theory.

The endogenous growth theory emerged around the 1980s as a result of the neoclassical growth theory. It first started with authors such as Romer (1986), Romer (1990), Lucas (1988) and Rebelo (1991) who developed models by non-decreasing return to a broad class of goods including human capital.

Endogenous growth theory outlined human capital, innovation, and technology as determinants of economic growth. The theory postulate that when human capital of an economy is enhanced it will lead to economic growth when new forms of technology as well as efficient and effective means of production are developed. The new growth theories postulate that technology is endogenous because it relies on the decision to invest in research and development and diffusion (Bassanini & Scarpetta, 2001).

Contrary to the neoclassical growth theory, pioneers of endogenous growth such as Romer (1986), Robert Lucas (1988), Sergio Rebelo (1991) and Ortigueira and Santos (1997) omitted, technological change in their models. They attribute indefinite investment in human capital which had a spillover effect on the economy and reduces the diminishing return to capital accumulation to growth. The endogenous growth theory assumes that economic growth is generated from within a system as a result of internal processes.

Endogenous growth theory is expressed in a simple equation form as $Y = AK$,

Where

A represents any factor that influences technology,

K represents both human and physical capital. The model assumes increasing returns to capital, a characteristic that can be achieved by implementing policies that offsets any tendency to diminishing returns.

An alternative to obtaining an equation like $Y = AK$ is to propose that increased quality and or variety of machinery or intermediate inputs offsets the predisposition to diminishing returns. Investment in either human capital or physical capital by an individual or a firm respectively, brings about an increase in productivity that exceeds the private gain.

The endogenous growth model maintained, that an increase in the investment rate in physical and human capital could possibly lead to sustained growth if strong external economies were generated by investment itself so that savings (investment) in the Solow model becomes unity.

2.11 Empirical Literature Review

The empirical review focused on materials that link the influence of internet usage on economic development. The major conclusions of these research were varied, while some indicated positive impacts, others indicated a detrimental effects of internet usage on economic growth. As part of the literature review under this, the following papers were reviewed:

Kaminer & Braunstein (1998) examined the impact of internet usage on scholarly productivity. The main method for gathering data for the analysis of Internet usage was done using questionnaires. Their study utilized computer logs to measure Internet use. The researchers

compared a traditional publication (productivity) model with a new model that contained internet-use variables using a sample of natural scientists at a major research university and found that adding measures of Internet use improves the explanatory power of the traditional model of scholarly productivity. Their measures were derived from a principal components analysis that identified two principal components which captured a number of common forms of Internet use.

Goss (2001) evaluated the influence of internet usage on US productivity development from 1997 to 1999 utilizing pooled time series and cross-section data in a production system. The findings revealed that job-related internet usage had a favorable and statistically significant influence on productivity growth, averaging 0.25 percent every year. The findings also revealed that the internet's capacity to boost productivity varies depending on the industry's information technology capability. According to the study, businesses that do not utilize information technology intensively contribute 0.52 annual to productivity growth, but firms that use information technology intensively contribute less than 0.04 annual to productivity growth.

Hannula and Lonnqvist (2002) examined how the internet affects productivity. The researchers used 762 articles from EBSCO1 article database search made on May 11th 2001 with the entries internet and productivity. The key finding of the researchers is that the use of the Internet may or may not increase productivity, depending on the way it is used. From the managerial perspective, the study shows that there are also many other reasons for using the Internet, such as improved customer service or competitive pressure. However, a better customer service means better value for a customer and this usually means better productivity for a firm. To conclude, it seems evident that successful investments in internet technology should lead to better productivity and

the greatest productivity improvements are attainable when the Internet is used to create entirely new business models.

Bajak (2006) investigated the link between various internet application usage and research output. The study employed ANOVA, a simple variance analysis, and a more complex binomial hurdle model to analyze a survey of over 1,400 scientists from five academic disciplines (astronomy, chemistry, computer science, economics, and psychology) from seven European countries conducted between April and July 2003. (Denmark, Germany, Ireland, Italy, the Netherlands, Switzerland and the UK). The researcher's findings revealed a favorable association between internet use for personal communication, information retrieval, and dissemination, and research productivity. He indicated that he was not able to examine the relationship between internet and other pre-internet tools which equally perform the same function and for that matter the results should be interpreted with caution.

Sooryamoorthy & Shrum (2007), examined the relationships among electronic communication, collaboration, and productivity in South Africa, a country that has undergone remarkable change in the sphere of science and technology. These researchers carried out a survey on 275 scientists in selected research institutes and universities in the province of KwaZulu-Natal to address the questions as to whether greater use of the Internet is associated with international collaboration and as to whether collaboration and Internet use is associated with publication in national and foreign journals. The findings of Sooryamoorthy & Shrum (2007), indicated that Internet use, as measured by time spent on email, is positively associated with collaboration. The results of the empirical studies also shows that collaboration is not generally related to publication productivity. The findings again indicated that there is little evidence that South African academics benefit from international collaboration. While scientists who use email intensively

are slightly more productive, this is not the case for foreign productivity in the case of academic scientists.

Nurmilaakso (2009) examined the influence of information and communication technology (ICT) on worker productivity using cross-sectional data from 1955 European enterprises in 2005. The results of the linear regression analysis shows that, Internet access, standardized data exchange with trading partners, enterprise resource planning (ERP) system, and customer relationship management (CRM) system all contribute significantly to increased labor productivity, whereas a website on the Internet and a supply chain management system do not. Internet access has a significant effect on labor productivity whiles website on the Internet has an insignificant effect on labor productivity.

Choi and Yi (2009) conducted research on the effect of the internet on economic growth using cross-country panel data for the period 1991 to 2000 for 207 countries. Using fixed effects they found evidence that the internet plays positive and significant role in economic growth after consumption ratio, investment ratio and inflation were used as control variables in the growth equation.

Meah (2012) looked at the influence of the internet on Bangladesh's economic growth. Panel data from the World Bank for 244 countries, excluding Ghana, was used to conduct the experiment, which revealed that an increase in the number of internet users has a favorable influence on economic growth within the country. The results indicated that Internet usage has positive impact on economic growth. Findings from the study indicated that internet usage influences economic growth in Bangladesh. From the panel regression test, the results indicated that, internet user's takes on a negative coefficient for South Asian countries. The reasons for contradictory results may be as a result of biased approach or misspecification error. From the

study, it is indicated that, Bangladesh has the ability to grow at a faster pace if the country enacts policies to stimulate Internet expansion and that sectors in Bangladesh such as e -commerce, e government telecommunications, and infrastructure stands to benefit from Internet expansion. The use of internet from their study gives a mixed result, hence the current study focusing on Ghana uses ARDL.

Quarshie (2012) examined the growth and usage of internet in Ghana. A survey was carried out to assess the number of years and the purpose for which the various working folks in the country use the internet. A questionnaire was developed and administered to about 200 people in the government, private agencies and others from small and medium enterprises. The researcher extracted and evaluated 160 survey results using SPSS. Findings from the study indicated that 45.6% of the Ghanaian folks use internet frequently for educational purpose, 33.75% frequently use it for news; and only 6.35% frequently use the internet for commerce.

Huaroto (2012) used the first differences approach to investigate the impact of internet use on productivity using a sample of Peruvian microbusiness owners' data from 2007 to 2010. According to the findings of their research, using the internet increases corporate efficiency.

Elgin (2012) used a panel data sample of 152 nations from 1999 to 2007 to investigate if the expansion of the internet benefited or encouraged the shadow economy. The findings of panel and cross-section estimations show that the relationship between internet usage and shadow economy size is substantially influenced by GDP per capita.

Similarly, Meijers (2012) equally employed Generalized Methods of Moments and Vector Autoregressive (VAR) model and adopted a panel data from 1990 to 2008 for 162 countries in examining the relationship and causality between internet use and economic growth as well as international trade. Their result also found a positive relationship between internet use and

economic growth but its positive significance disappeared when fully specified growth model was used. A Granger causality analysis between internet use, international trade and per capita GDP does not lead to strong conclusions in all cases. The current study uses ARDL because of its ability to capture both the short run and long run effect at a go

Salahuddin and Alam (2013) used yearly time series data for Australia from 1985 to 2012 to evaluate the growth impacts of internet usage, financial development, and trade openness. To evaluate the long-run and causative link between internet usage, financial development, and economic growth, the researchers used the ARDL limits test for co-integration and the Granger causality test. According to the findings of the ARDL estimates, internet usage and financial development have long-run positive and significant influence on economic growth, but their short-run effects are negligible. The unidirectional causal relationship between internet usage and growth and financial development is confirmed by a multivariate Granger causality test. The use of the internet, in turn, causes financial development. Though the current study also uses time series data for Ghana, it evaluates the effect of internet usage as well as the effect of government effectiveness on economic growth in Ghana.

Pradhan et al. (2013) look into the links between the internet, economic growth, government spending, and inflation. They discovered that internet, economic growth, government expenditure, and inflation appeared to be co-integrated using panel data from 34 OECD nations from 1990 to 2010. Furthermore, there was bidirectional causation between the internet and economic growth, as well as between inflation and economic growth and inflation and the internet. Economic development, government spending, and inflation, according to the research, are the long-term causes of the internet. The evidence of a bidirectional causal link between internet and growth in OECD nations supports the importance of the internet. Furthermore, the

necessity of economic growth for the continuous development and usage of the internet in the economy is reinforced by these findings. The current study focuses on internet usage and economic growth.

Again Pradhan et al. (2013) investigated the link between information technology communication infrastructure and economic growth in 34 OECD countries using Granger causality test. Based on the VECM, the results suggested that telecommunication infrastructure does not cause economic growth. This means that there is unidirectional causality flow from economic growth to telecommunication infrastructure both in the short-run and in the long-run. However, there was no any causality flow from telecommunications to that of economic growth. Panel co-integration analysis equally indicated that telecommunication infrastructure and economic growth are co-integrated in the long-run. The study recommended that for policymakers to promote information technology communication infrastructure, the attention should be on long run policies on sustainable economic growth. It also recommended that more resources should be directed to investing in telecommunication infrastructure with the intention that it can target the vast majority of the population and all sectors of the economy and also telecommunication infrastructure should be used effectively for the promotion and diffusion of e-government, e-commerce and e-learning in order to increase effective administration, transparency and public participation.

Chavula (2013) looked at the influence of information technology communication penetration on Africans' per capita income growth and how that affects their living standards. To examine the economic impact of telecommunications development in Africa, the study used the Barro (1991), endogenous growth model on a cross-section of 49 African nations from 1990 to 2007. Overall, the findings show that telephone main lines and mobile telephony have a statistically significant

influence on people's living standards in Africa, however Internet use has no meaningful impact on economic growth. This implies that, despite the widespread availability of fixed telephone lines and mobile phones across the continent, people and businesses fail to optimize the use of internet technology in conducting their enterprises.

However, when the 49 countries studied are divided into three groups based on the 2008 World Bank classification criteria of upper-middle, upper-low, and low-income countries, fixed telephony, mobile telephony, and Internet usage all have a significant impact on growth in upper and middle income countries, while only mobile telephone penetration has a significant impact on growth in both upper and low income countries. Among the country groupings, the cell phone has the greatest impact on growth. The current study uses time series since it gives a country-specific efforts, and effects of internet usage and its implication on economic growth.

Gholizadeh et al. (2014) also examined the relationship among publication, gross domestic product (GDP) and internet usage and also the publication productivity among the elite universities in Asian countries and also the ten top universities around the world from the year 1993 to 2012. The researchers employed one-way ANOVA and multiple regression analysis to investigate the impact of economic growth and internet usage on publication productivity respectively. The results showed that the rate of publication growth was 1.9, 20.9, and 65.5 % in top universities in the world, ASEAN countries and Malaysia, respectively. The results also indicated that there is a positive and significant correlation between GDP and the number of internet users given the number of publications in ASEAN and Malaysian universities. Internet usage had much more influence in comparison with the GDP in predicting the number of publications among these groups except for top Ten Malaysian Universities from 2003 to 2012. Publication dominates in top ten Malaysian and ASEAN universities are promising.

Rizwana and Tufail (2015) empirically evaluated the influence of internet technology on economic growth in Southern Asia, with a specific focus on Pakistan. They used an annual time series data set that spanned the years 1995 to 2013. In their model estimations, they employed a panel ARDL technique. Capital and labor have a favorable influence on economic growth, according to the research. Their research also showed that internet use has a long-term favorable influence on economic growth. The current study uses high frequency data (quarterly data) that spanned the year 2000 to 2020. This period covered will give a clear picture of the current situation of the effect of internet usage on the economic growth of Ghana.

Ficawoyi et al. (2016) conducted a study on Technological Progress and economic growth using panel data of 47 Sub-Saharan African countries from 1993 to 2012. They adopted instrumental variable Generalized Methods of Moments (GMM) in their estimations. Economic variables in the study included government expenditure, inflation, investment, trade and telecommunication. The findings of the study indicated a positive effect of internet usage on economic growth using the fixed effect, two stage least square (2SLS) and IV-GMM. All control variables mentioned in the study except trade variable coefficients are statistically significant whiles that of investment has positive effect. The number of mobile phone used to measure technological progress is significant with fixed effect estimation. The study indicated that all the control variables are statistically significant while investment although positive using 2SLS and IV-GMM still proved insignificant. The current study uses the proportion of individuals using internet as a measure for internet usage as it is a better measure as compared to the number of mobile phone used. The number of mobile phone used does not necessary mean the usage of internet by a person and hence does not make it a good measure for internet usage.

Tripathi and Inani (2016) used a panel autoregressive distributed lag (ARDL) model to look at the long-run and short-run link between internet usage and economic growth for 42 Sub-Saharan African nations from 1998 to 2014. The results of the experiment suggest that internet usage and economic growth are linked and have a long-term association. The findings show that internet usage has a long-term beneficial and considerable influence on economic growth. However, in the near term, internet usage has a detrimental influence on economic development. The study concluded that there was strong evidence that internet usage had a long-term positive impact on economic growth in Sub-Saharan African nations. As a result, the researchers suggested that politicians support the use of the internet in diverse areas, such as health, education, and agriculture, in order to investigate the internet's potential as a strategic tool in these fields. As their result confirms that internet usage has a detrimental influence on economic growth in the short run whiles having positive influence on economic growth in Sub-Saharan nations in the long-run, this current study also uses ARDL but focuses on a single country; Ghana.

Koyuncu et al. (2017) also look at the macro-level effects of the internet on various indicators of productivity. The researchers adopted an annual panel data for 162 countries from the year 2000 to 2013 as well as thirteen productive indicators. The researchers identified a positive correlation between internet penetration and productivity. Their finding is found to be statistically significant and valid for all thirteen different productivity indicators. The researchers indicated that the results suggest that internet penetration increases productivity controlling for other factors that may contribute to productivity.

Gosavi (2017) also investigated the influence of internet use on productivity and sales development in Indian female-owned businesses. He studied the over ten thousand Indian businesses that use the internet using data from the World Bank's Enterprise Survey program for

2014. The findings revealed that while female-owned businesses in India are more likely to use the internet than male-owned businesses, this does not mean they are more or less likely to boost productivity and/or sales growth.

Harb (2017) evaluated the impact of the Internet penetration rate and investment in the telecom sector on economic growth in the Arab and Middle East (AME) region. The study employed annual panel data from 1995 to 2014 years period for 93 countries. Their results indicated that the Internet has been a significant growth determinant in the AME region, particularly in high-income AME countries; Internet penetration in middle-income AME countries seems to be hovering below the growth impact rate. It was discovered that Telecom investments did not affect growth in the AME region, thus focusing the general-purpose technology nature of such investments and the adjustment period needed before the investment in telecom to bear fruits.

Salahuddin and Gow (2017) using a combination of panel and time series data for the period 1990 to 2012 equally examined the effect of internet on economic growth of Southern African countries. They found that in the long-run the Pooled Mean Group employed in their estimations indicated a positive significant relationship between internet usage and economic growth in the Southern African countries. Similarly in the long-run, their results for the effect of internet on financial development and trade openness turns to be positive and significant. In the short-run, the relationship between the variables turn to be insignificant. Salahuddin and Gow (2017), again carried out Panel Vector Error Correction Model granger causality test to test the link between the variable internet, financial development and trade openness and economic growth. Whilst the results indicated internet usage to granger cause economic growth, economic growth, financial development and trade openness turn to have no causal link. A unidirectional causal link running from internet usage to financial development was observed. They concluded that internet usage

will have an increasing effect on economic growth in the future based on results from the variance decomposition analysis forecast. The current study uses ECM since the VECM used by Salahuddin and Gow is appropriate for multi cointegrating equation.

In addition, Rangkakulnuwat1 and Dunyo (2018) equally conducted a research to examine the effect of internet on economic growth in African. They employed panel data for 19 African countries from 2003 to 2014. The Fixed Effect- Iterated Generalized Least Square (FE-IGLS) estimation was applied to correct for serial correlation and heteroskedasticity problems. Based on Levin – Lin – Chu panel unit root test they found that the residuals of the model are stationary. Their findings indicated that an input elasticity would depends on the level of other inputs. The internet usage itself cannot boost outputs in the 19 African countries, but can raise outputs when internet usage is adopted with capital and technology other than internet. Their findings also showed that increasing in labour deteriorate the elasticity of output with respect to human capital in longer life expectance and with respect to technology other than internet. Capital enhanced the output elasticity with respect to internet usage but it eroded the output elasticity with respect to technology. The results again indicated that human capital investment related to longer life expectancy would deteriorate output through decreasing in labour elasticity. Technology other than internet equally deteriorate the elasticity of output in relation to labour but rather enhances the elasticity of internet usage. Nonetheless human capital investment in secondary education would equally not increase output.

Choi and Yi (2018) conducted research to see how the Internet affects the link between R&D spending and economic development. The panel data study is based on data from 105 nations from 1994 to 2014. In its model estimates, the study used pooled OLS, fixed-effects, random-effects, and panel GMM, and the estimated coefficients of the R&D and Internet interaction

factors were positive and significant. The Internet has a favorable influence on R&D spending on economic growth, and the effect of the Internet on economic growth is favorably increased as R&D expenditure grows.

Maurseth (2018) reexamined the study conducted by Choi and Yi on the effect of internet on economic growth. He equally adopted a cross-country panel data for 171 countries from 1990 to 2015 using fixed effects estimations. His results confirmed the findings of Choi and Yi for the 1990 to 2000 year period that was employed in the study. The coefficients for the share of internet users are positive and significant indicating the positive and significant role of internet usage on economic growth. However the results proved otherwise when the researcher extended the period of study from 1990 to 2000 to 1990 to 2015 in all the regions of their study. The coefficients for the share of internet users are negative and significant.

Saidi and Mongi (2018) used VECM models to evaluate the short-term causation and long-run link of education, research and development, and information technology on economic growth in high-income nations. The researchers used panel root test and panel co-integration to detect the relationship between the dependent variable, gross domestic product (GDP), and independent variables, education, research and development, mobile cellular telephone, and internet users, using a panel data set from 1990 to 2015. The granger causality test revealed a one-way relationship between education and mobile cellular phone usage, internet users and mobile cellular phone usage, and research and development, as well as education and research and development. The study's findings also revealed that there is a bidirectional causation between internet users and economic growth, between research and development and economic growth, and between education, internet users, and mobile cellular telephones in the short term. Furthermore, the study's findings revealed that there is a bidirectional association between

education, internet users, and mobile phone users. Furthermore, the empirical findings revealed the existence of a unidirectional relationship between internet users and economic growth and research and development, as well as a unidirectional relationship between mobile cellular phones and economic growth and research and development, in the long run. The current study uses ECM since the VECM used by Mongi is appropriate for multi cointegrating equation.

Li (2019) used data from 65 nations in the Belt and Road Region between 1996 and 2014 to quantify the impact of the Internet on GDP using the dynamic panel data technique, especially the spatial panel data analysis method. Their findings also revealed that the internet has a positive and statistically significant impact on economic growth, and that these impacts amplify as the Internet evolves. They came to the conclusion that capital, labor force, technology, industrial structure, international commerce, and economic level are key predictors of the Internet's impact on economic growth in the Belt and Road countries.

Haini (2019) examines the effects of Internet penetration and human capital on economic growth. The study employed a panel dataset of 10 Association of South-East Asian Nations (ASEAN) economies from the period of 1999 to 2014 to examine how internet penetration and human capital collaborate to affect economic growth using a trans-log production function model. The estimated results of the study conducted indicated that internet penetration and human capital formation is positive and significantly affect economic growth thereby providing support for the absorptive ability of human capital. The study therefore recommends that the ASEAN economies should enact policies that encourage human capital formation and as well support the development of the communication technology sector to promote affordability and accessibility of the internet.

Furthermore, Bahrini and Qaffas (2019) applied a panel Generalized Method of Moment (GMM) growth model over the period 2007–2016 to examine the impact of information and communication technology (ICT) on the economic growth of selected developing countries in the Middle East and North Africa (MENA) region and the Sub-Saharan Africa (SSA) region. According to their estimates, Internet usage, mobile phone adoption, and broadband adoption were the key drivers of economic development in MENA and SSA emerging nations from 2007 to 2016. Policymakers should approve policies that allow the development of financial sectors, provide a more convenient regulatory and institutional environment, increase economy openness, prioritize the allocation of resources to the development of ICT infrastructure, and curb the negative effects of inflation and government consumption to benefit from the ICT drivers of economic growth, according to the researchers. The current study uses ARDL because of its ability to capture both the short run and long run effect at a go.

Li et al. (2020) investigated how the development of the internet affects China's Green Total Factor productivity. The study employed the threshold regression model and fixed-effect model to empirically analyze the influence intensity and internal mechanism of green total factor productivity in places affected by Internet development in China from 2009 to 2017.

The empirical findings revealed that there is a digital gap in China's regions. Many elements, including Internet growth, human capital, urbanization, energy efficiency, and foreign dependency, all have a beneficial impact on China's green total factor productivity, according to the findings.

Hsieh and Goel (2020) focus on the type and magnitude of the influence of Internet usage or penetration on labor productivity development in OECD nations. The researchers used panel data from 28 OECD nations, including the United States, from 2001 to 2016. The study used a basic

model that incorporates Internet usage as a component that increases labor quality, rather than the standard labor-augmented production function method. Data on production, capital, and labor comes from official OECD publications, whereas data on the penetration ratio, a proxy for Internet usage, comes from an internet source. The parameter estimates for Internet usage in all of the models are positive, despite the lack of statistical evidence. A descriptive study for the United States, based on a unique historical survey data set that isolates Internet usage at home from use at work, reveals that increasing Internet use at work reduces productivity growth. The current study uses time series since it gives a country-specific effort, and effects of internet usage and its implication on economic growth.

Sayef et al. (2020) evaluated the influence of internet use and innovation on economic growth in the Tunisian economy, using the exogenous and endogenous theories as well as the key Schumpeterian contribution. Over the years 1985 to 2018, they used the ARDL bounds testing approach. In the near run, their empirical findings show that innovation has no major impact on economic growth. Their research also shown that the internet promotes economic growth. However, their empirical findings revealed that, in the long run, innovation and the usage of the internet had a detrimental influence on economic growth.

Their findings revealed that the internet and economic growth have a long-term favorable influence on innovation. The findings again revealed that economic expansion had a detrimental influence on internet usage. However, the findings show that innovation has a large beneficial influence on internet usage.

According to the experts, Tunisian authorities should prioritize innovation and the potential of internet use in order to modernize, diversify, and strengthen the economy by creating new employment and identifying new markets, strategic partners, and possibilities.

2.11.1 Government effectiveness and Economic Growth.

The impact of institutional quality on economic growth on less developed countries is important especially with the quest to transform their institutions to market economy. For this reason, several studies have been carried out to ascertain the effect of the quality of these governance in contributing to the growth of their economies.

Quibria (2006) examined the relationship between government effectiveness and economic growth for 28 developing Asian countries for the period between 1999 and 2003 using regression. The study employed a panel data and based on the VECM, the results suggested that there was no positive effect of government effectiveness on economic growth. However, it was concluded that economic growth had a positive effect on government effectiveness. The current study uses ECM since the VECM used by Quibria is appropriate for multi cointegrating equation.

Tanjung (2020) applied static and dynamic GMM to analyze the impact of Public wellness, competitiveness and government effectiveness along with Literacy rate and Population growth on quality of education using panel data. The period of 25 years for 10 Asian countries. The results show that, public wellness, Government effectiveness, literacy rate and population growth significantly impact the quality of education leading to development human capital and consequently growth in Asian Countries.

Alam et al. (2017) analyzed the effect of government effectiveness on economic growth for 81 countries from the period 1996 and 2011. The study employed the Panel GMM technique in analyzing the model. The results from the study revealed that government effectiveness has a significantly positive effect on economic growth. In addition, according to the results, governance is highly important for reaching the development goals. While the relationship

between government effectiveness and economic growth was estimated to be positive in the study, it was also stated that different results could be obtained according to different country groups.

Afolabi (2019) researched the relationship government effectiveness, regulatory quality, governance and institutional development for West African countries using the system GMM approach. The study covered the period 2002 to 2016. The results from the study shows that, government effectiveness is positively related to development.

Güney (2017) applied the system generalized methods of moments (GMM) to examine the effect of government effectiveness on economic growth for 78 developing countries in the years between 1996 and 2015 as employed by Kurtz and Schrank (2007) and Alam et al. (2017) in their study. According to their estimates government effectiveness has a positive significant effect on economic growth whiles increase population rate negatively affect economic growth. In addition, the effect of government effectiveness on economic growth is stronger than trade openness, inflation, capital and labour variables. The current study uses ARDL because of its ability to capture both the short run and long run effect at a go

Using the Granger causality test, Huang and Ho (2017) examined the relationship between governance and economic growth for 12 Asian nations between 1996 and 2014. The study found that, with the exception of Indonesia and Thailand, strong governance promotes economic growth. It is important to extend and promote the policies for increasing governance quality.

Kurtz and Schrank (2007) analyzed the relationship between government effectiveness and economic growth for 164 countries in the period between 1996 and 2004. It was concluded that economic growth had a positive effect on government effectiveness. However, the study also revealed that government effectiveness had no effect on economic growth.

Sule (2020) investigated how institutional quality through contract intensive money and effective governance affects the economic growth in Nigeria. The study adopted Johansen Cointegration and Ordinary Least Square (OLS) and was applied to an annual time series data covering the period 1979 to 2018 to investigate the relationship between institutional quality and economic growth in Nigeria. The results found a positive and significant relationship between economic growth and effective governance.

2.12 Summary

The chapter reviewed the theoretical and empirical literature relevant to the study. The theoretical literature reviewed covers economic growth theories including Harrod-Dormar growth model, the neoclassical growth theory and the endogenous growth model whiles the empirical review considered empirical works on internet usage and economic growth.

From the literature reviewed above, the contribution of internet usage to economic growth has drawn the attention of researchers and happenings in recent times have indicated that economies and almost all sectors of human living will depend more on the internet of things than it has ever. The role of internet in shaping how economies grow cannot be over emphasized.

Most of the studies reviewed have analyzed the effect of internet usage on economic growth by employing the panel cross country approach (Maurseth, 2018; Bahrini and Qaffas 2019; Haini, 2019, Twumasi and Agbenyo, 2020). The findings of these studies produce a panel aggregated results which does not give country specific results. This current study therefore turns to examine the effect of internet usage on economic growth in Ghana which has characteristics specific variables and which gives characteristics specific results using high frequency data.

It is also observed that studies that considered Ghana are done with data spanning relatively shorter periods and low frequency data due to unavailability of data. Some of the literature

reviewed above indicated the use of fixed-line telephone and mobile cellular subscriptions (Bahrini & Qaffas, 2019; Ficawoyi & Mathey, 2016) as a measure of internet usage. However, the mere usage of a fixed telephone line does not guarantee that a subscriber will have access to the internet.

This current study extended the time period of the data using high frequency data and also build upon studies that have already existed by adding other variables that determines growth. The study used the number of internet users per 100 people within the ages 15 to 74 thus the proportion of the individuals within the country's population that uses the internet as a measure for internet usage. Again, this current study employed the Auto-Regressive Distributed Lagged (ARDL) Model otherwise known as the bounds testing approach to co-integration developed by (Pesaran & Pesaran, 1997; Pesaran, et al. 2001) to assess the effect of internet usage and economic growth, the effect of government effectiveness on economic growth in Ghana as well as the effect of the interaction of internet usage and government effectiveness economic growth in Ghana.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter delineates the methods employed in the study and the specific procedures used to identify, select, process and analyze information on the effect of internet usage on Ghana's economic growth. This section gives attention to the study design, data and variables. It elaborates in detail the theoretical and empirical model specification, sources of data, the tools employed for the conduct of data analysis, estimation technique for the study and definition and measurements of variables in the model.

3.2 Research Philosophy

Research philosophy refers to the set of beliefs, assumptions and principles that underlie the way researchers approach their investigations. A researcher is an impartial analyst who works independent and dissociates himself from personal ideas. The main types of research philosophy that researchers follow in conducting research are the interpretivism, pragmatism and positivism.

Interpretivism Philosophy starts from the premise that people create their own meanings and interpretations of reality and that the world is subjective. According to them, research should prioritize comprehending people's subjective experiences, be context-sensitive, and value-laden (Antwi & Hamza, 2015).

Pragmatism Philosophy starts with the assumption that the world is a dynamic and complex system that cannot be fully comprehended by either positivist or interpretivist methods by themselves. Pragmatists hold that research should be problem-oriented and that the selection of

research methodologies should be made based on the methods' actual relevance to solving challenges in the real world.

Positivism implies that the researcher's environment and congenial events of interest are objective, unrelated and external thus positivists believe that the reality is objectively given and measurable using properties independent of the researcher (Antwi & Hamza, 2015). This study therefore follows a positivist philosophy in its estimation.

3.3 Research Design

The research design maps out how the main questions in the study are addressed (Saunder et al. 2009). There are several research designs that researchers employ to conduct research. Th main research design employed by researchers includes descriptive research design, experimental research design, diagnostics research design, correlation research design and exploratory research design. Exploratory research is a technique used to examine a phenomenon that has not previously been researched or adequately explained. Its major goal is to describe where to look for a limited amount of information. This current study looks at explaining the relationship between internet usage and Ghana's economic growth, using exploratory research design. Effects of internet usage on economic growth has receive little attention in literature and hence this current study adopted explanatory research design framework to examine effects of internet usage on economic growth in Ghana.

3.4 RESEARCH APPROACH

Research approach refers to the systematic and structured procedures employed by a researcher in conducting research. The quantitative research approach was adopted to analyze the

relationship between internet usage and economic growth. The quantitative research approach was used to address the research hypotheses of the study.

3.4 Model Specification

3.4.1 Theoretical model

Endogenous growth theories represent the production and dissemination of ideas and information as the key drivers of economic growth, according to Romer's (1986, 1990) endogenous growth model (Romer 1990; Zilibotti et al., 1999). The theory assumes that government and institutions play a role in the growth of the economy through incentives which increases the innovativeness of entrepreneurs and investments. As a result, the massive increase in Internet usage may have an impact on the economy's innovative capabilities through knowledge spillover, the dissemination of cheaper information that can facilitate the adoption of new technologies developed by others, the development of innovative and mechanisms, and business strategies that promote growth. The quality of institutions therefore also plays a major part in the model.

The study adopted aggregate production function in the form.

$$Y_t = f(K_t, L_t, A_t) \quad \text{..... (1)}$$

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

In the framework of the endogenous growth theory, growth can be internalized through increase in level of technology. Hence A which denotes total factor productivity (TFP), thus how much output can be produced from the influence of technology, TFP therefore measures efficiency of productivity (VanBeveren, 2010).

We assume that for internet to have a desired effect on the growth of the economy, government institutions should play a greater role in the facilitation process, hence we interact the innovation variable (internet) with the institution's variable (government effectiveness).

3.4.2 Empirical Model

The purpose of the study is to examine the effect of internet usage on economic growth in Ghana. We base our econometric model on the assumptions of the endogenous growth models of Romer (1956) as used by Choi and Yi (2009) and adapted by Salahuddin et. al., (2013). They stated the empirical model and made internet usage as a function of economic growth as indicated below,

$Y_t = f(K_t, L_t, A_t)$ ……………………………………………………………………..... (2)

Where;

A = f (INF, INTERNET, GOVT_EFFECT, INTERNET*GOVT_EFFECT, FD)

Base on the above, the model to be estimated is

$$LnRGDPPC_T = \beta_0 + \beta_1 INTERNET_t + \beta_2 GOV\_EFFECT_t + \beta_3 INTERNET * GOV\_EFFECT_t + \beta_4 LnGFCF_t + \beta_5 LnTLF_t + \beta_6 FD_t + \beta_7 INF_t + \mathcal{E}_t$$

Where β are the coefficients and $\mathcal{E}_t$ is the error term. RGDPPC is real gross domestic product per capita, measuring economic growth, INF is inflation, $INTERNET$ is internet usage, FD is financial development, GFCF is Gross fixed capital formation, TLF is total labor force, GOV_EFFECT is Government effectiveness, INTERNET*GOV_EFFECT represents the interaction of internet usage and government effectiveness.

3.5 Justification and Measurement of Variables Economic Growth

Real Gross Domestic Product Per Capita

Real gross domestic product per capita measures the value of goods and services produced by a country within a specific period of time adjusted for inflation. Real gross domestic product per capita is used as the dependent variable in the study and as a measure for economic growth. The study used real GDP as a measure for economic growth because this estimation makes an attempt to exclude the effect of inflation on the regular prices of goods and services produced. Real GDP per capita have been used severally by literature as a measure of economic growth. Data for Real GDP per capita is sourced from the Federal Reserved Economic database.

Internet Usage

The internet is defined as a World-wide pubic network that grant access to a number of communication services. This includes the World-wide Web, data files, email, news and entertainment. Internet users refer to those who use the internet from any location including work in the country. Internet access may be through a computer, Internet-enabled mobile phone. Internet usage is measured as the number of internet users as a percentage of the population aged 15 to 74.

The indicator is derived by dividing the number of Internet users by total population and multiplying by 100. Data for the usage of internet in Ghana is sourced from the International Telecommunication Union (ITU) website. The databases are rated credible sources for data related to internet and ICT. It is expected that a growth in the usage of the internet will have a positive effect on the growth of the economy due to its spillover behavior.

Government effectiveness

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 which brings about peace and prosperity in the country. The index chosen to measure the quality of government comes from the World Governance Indicators data of the World Bank. The measurement for the variable government effectiveness ranges from 0 to 100. The higher the score, the higher the effectiveness of governance. It is quite elementary at this point that the hypothesis in this case consists in affirming that quality of government affects growth in a positive direction, therefore the estimated coefficient is expected to be positive. 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.

Inflation Rate

Inflation is defined as a steady rise in the overall price level or the pace at which the prices of products and services rise on a regular basis. Inflation has an impact on income distribution. The Consumer Price Index (CPI) 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. A rapid rise in the general price level of commodities creates uncertainty about the future outcome of project investment in an economy. This is because increased 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. The consumer price index (CPI) is utilized as a proxy for inflation in this study since it is the most generally used indicator of inflation. Data for inflation is sourced from the World Development Indicators database.

Capital

Gross fixed capital formation is used as a proxy for capital stock (K) in the study. Gross fixed capital formation is referred to as the total value added to fixed assets by domestic enterprises, less 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 (Baafi, 2010; Barro, 1996). In most countries Gross fixed capital formation is more often than not considered as the engine of growth due to the additions it makes to capital. It is seen as a major factor in determining aggregate output. An increase in the level of capital formation will improve the economy's productivity potential and hence economic growth, all other things being equal. It contributes to economic growth not only through the additions it makes to capital but also it offers many potential advantages as both a source of financial capital and a source of skills and technology transfer (Amoako-Gyampah & Acquaah, 2008). The size of capital determines the productive capacity of the economy. It is important to emphasize that high rate of capital formation through investment results in high economic growth (Cole, 2003). Hence, the coefficient of capital is expected to be positive. Data for Capital is sourced from the World Development Indicators database.

Labour Force

Labour stand for the human factor employed in the production of goods and services in an economy. Labor force comprises people ages 15 and older who supply labor for the production of goods and services during a specified period. It includes people who are currently employed and people who are unemployed but seeking work as well as first-time job-seekers. The quantity and quality of labour that individuals supply is an important factor in determining the economy's

level of production and rate of growth. This study used total labor force as a measure for labour. It is expected that increased labor in the economy will imply that firms will always have a ready market for labour input to expand their scale of operations and output. It is therefore expected that an increase in the labour force should have a positive effect on the growth of the economy. The data is sourced from the WDI database.

Financial Development

These variable measures the level of financial sector development in the economy. Various studies have used various measures of financial development to proxy for the level of financial development, including the amount of M2 per GDP, total credit allocated to the private sector among others. For this study, financial development 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 financial development will have a positive effect on the level of economic growth.

3.6 Sources of Data

Based on the nature of the current study, the study made use of secondary data. Secondary data is a data that has already been gathered and can be accessed by researchers. Quarterly data which covered the period 2000 to 2020 is employed thus covering 84 period. The variables of the study such as real GDP per capita was sourced from Federal Reserve Economic Database, inflation data was sourced from Bank of Ghana. Also, variables namely financial development, capital, total labour force was sourced from World Development Indicators (WDI), government effective was source from World Governance Indicator (WGI). Data on internet usage is also sourced from the International Telecommunication Union (ITU) database. Data for internet usage starts from 1995, however the study uses data beginning the year 2000 when mobile phone and computer penetration started becoming significant in Ghana. This period covered is relevant for

the study as it captures the period which internet usage was enormous in Ghana as well as the availability of data. The choice of sources of data is relevant as the integrity of the database and the procedure used in the collection of the data is important.

3.7 Estimation Procedures

The long-run and the short-run relationship between internet usage and economic growth as well as that of the government effectiveness and economic growth were tested using the Autoregressive Distributed Lag (ARDL) model approach to cointegration and error correction model. The testing approach includes;

1. Using the Augmented Dickey–Fuller (ADF) and the Phillip-Perron (PP) tests to first determine the data's time series properties by carrying out the unit roots test to determine whether or not the variables are stationary.
2. This follows the Autoregressive Distributed Lag (ARDL) approach otherwise known as the bounds testing approach to cointegration test to verify the presence of long-run relationship among the variables.
3. Thirdly, the ARDL approach was used to test for short run and long run relationship between internet usage and economic growth
4. Thirdly, the stability and diagnostic test statistics of the ARDL model is then examined to ensure the reliability and the goodness of fit of the model.

3.8 Unit Root Test

Stationarity test is a statistical procedure employed to determine the stationarity of a series. Macroeconomic data sets are generally or usually found to be non-stationary. In other words, the levels of time series data are not stationary but its difference is. Difference stationary processes are said to be integrated process of order *d*, or *I*(d), where *d r*epresents the number of times the

process is being differenced in order to become stationary. It is therefore very necessary to test for the statistical properties of variables when working with time series data, this is because time series data are often found to have unit root. Time series data are either non-stationary or stationary. A time series is non-stationary if its mean, variance and autocovariances are not constant overtime or independent of time. However, a time series is stationary when its mean, variance and autocovariances are independent of time. This implies that the presence of a unit root indicates that a time series under consideration is non-stationary while the absence of it implies that the time series is stationary. Time series data exhibits features such as trends, seasonal and non-seasonal cycles, pulses and steps, and outliers. A regression analysis that employs time series data can reveal the pattern of relationships among variables of interest. Understanding the pattern will help in proper redressed which will in turn aid to avoid spurious regression (Chang, 1979).

Basically, the reason for performing stationarity test is to establish that the integration of the variables of interest is by no means in a higher order to cause spurious results. Spurious results occur when the results obtained from the regression indicates a high and significant relationship among variables when no relationship actually exist. A series with unit root have no tendency to return to long-run deterministic path and the variance of the series is time dependent. A series with unit root suffers permanent effects from random shocks, thus, follow a random walk. To a larger extend, the Augmented Dickey-Fuller Test, Phillips-Perron test and Kwiatkowsky, Phillips, Schmidt and Shin (KPSS) test are the most commonly used approaches employed for investigating the stationarity of a time series data though other techniques such as graphical or formalized test can equally be adopted. For the formalized tests, the null hypothesis asserts that there is a unit root as opposed to the option of series stationarity, which could include a non-zero

mean term, a deterministic linear trend, and possibly seasonal dummy variables. In each case, the lag-length is chosen using the Akaike Information Criteria (AIC) and Swartz Information Criterion (SIC) for both the ADF and PP test. The sensitivity of ADF tests to lag selection renders the PP test an important additional tool for making inferences about unit roots. The KPSS is the third kind of test which take a quite different perspective at the unit root testing problem. It checks a stationarity null hypothesis against an alternative of a unit root. The differences in these tests are how autocorrelation in the residuals is corrected. Except for this, they are similar.

The stationarity test carried out indicated that the variables employed for this study are integrated of different order hence the adoption of the ARDL modelling technique in this study.

The basic formulation of the ADF is expressed as follows:

$$Y_t = \mu + \alpha Y_{t-1} + \gamma t + \varepsilon_t \quad \ldots\ldots (9)$$

Subtracting Y_{t-1} from both sides gives:

$$\Delta Y_t = \mu + (\alpha - 1) Y_{t-1} + \gamma t + \varepsilon_t \quad \ldots\ldots (10)$$

Representing $(\alpha - 1)$ by ρ gives the equation below:

$$\Delta Y_t = \mu + \rho Y_{t-1} + \gamma t + \varepsilon_t \quad \ldots\ldots (11)$$

The *t*-test on the estimated coefficient of Y_{t-1} that is ρ provides the DF test for the presence of a unit-root. The Augmented Dickey Fuller (ADF) test is a modification of the DF test that requires adding lagged values of the dependent variables to the above-mentioned equation (11). It's designed to ensure that the estimating equation's error process is residually uncorrelated, as well as to account for the possibility that Yt is characterized by a higher order autoregressive process.

Although the DF methodology is often used for stationarity tests, it suffers from a restrictive assumption that the error processes are independent and identically distributed (i.i.d). Hence, letting (α−1) to be equal to ρ as well as correcting for serial correlation by adding lagged first differenced to equation (11) yields the ADF test of the following form below:

$$\Delta Y_t = \mu + \rho Y_{t-1} + \gamma t + \sum_{i=1}^{\rho} \beta_i Y_{t-1} + \varepsilon_t \quad \text{..... (12)}$$

Philips-Perron (PP) Test

Phillips-Perron (1988) proposed a modification of the ADF test technique by non-parametrically correcting any heteroscedasticity and serial autocorrelation in the residuals. This indicates that it is used to check for robustness of the results derived from the ADF test. The PP test specifically takes care of any deviation so as not to achieve white noise in the model estimated. It is used in time series analysis to test the null hypothesis that a time series is integrated of order 1. It builds on the Dickey-Fuller test of the null hypothesis ρ = 1

$\Delta RGDPPC_t = (\rho - 1)\ RGDPPC_{t-1} + \varepsilon_t$

Where Δ represents the first difference operator. The Phillip-Perron test also addresses the issues that the process generating data for $RGDPPC_t$ might have a higher order of autocorrelation than it is admitted in the test equation making $RGDPPC_{t-1}$ endogenous and thus making the Dickey-Fuller test invalid.

Both the ADF and PP methodology test the null hypothesis, (H_0): series contains unit root (series are non-stationary) as against the alternative hypothesis (H_1): series has no unit root (series are stationary). Thus,

$H_0: \beta = 0\ or\ \rho = 0$ (Where $\beta = \rho - 1$)

$H_0: \beta \neq 0 \; or \; \rho \neq 0$

To draw conclusions on the test, the calculated PP statistics is compared to the critical values from Fuller's table. The null hypothesis (H_0) cannot be rejected when the results obtained for the test statistic is lesser than the critical value and the conclusion drawn will be that the series are not integrated of order zero. The p-value of the test can also be compared to the level of significance for drawing a conclusion. A variable is integrated of order zero I(0) if it is stationary without differencing, and integrated of order one if it is stationary only after the first difference. This was done to ensure reliable results of the test for stationarity due to the inherent individual weaknesses of the techniques. The PP test was selected over the ADF because it solves the problem of serial correlation, structural breaks and heteroscedasticity which is normally not corrected by the ADF.

3.9 Autoregressive Distributed Lag (Bounds Test) Approach to Cointegration

The Autoregressive Distributed Lag (ARDL) co-integration strategy will be used to estimate the model. The ARDL is best suited for data that are integrated of different orders (Pesaran, et al. 2001). It also makes it possible to derive error correction models (ECM) using linear transformation of the variables.

An autoregressive distributed lag (ARDL) model is an ordinary least square (OLS) based model which is applied to time series that are non-stationary as well as variables that are integrated of different order. This implies that being a least square based model, it can be employed in the estimation of both dependent and independent variables using lags. Hence to practically examine the long-run and short-run correlation between variable of interest, this study used the autoregressive distributed lag co-integration procedure developed by (Pesaran, et al. (2001).

This study employed the autoregressive distributed lag modelling technique as a result of the following considerations: First and foremost, the ARDL technique is statistically more significant than the Johansen and Juselius co-integration procedure in identifying the co-integration relation in small samples data sizes, like the one in this study (Pesaran & Shin, 1999).

Secondly, the study adopted the ARDL technique because it allows the exploration of the correlation between variables in the short and long run. Thirdly, the data generating process in the model is been captured by a sufficient number of lags in a general to specific modeling framework (Shrestha & Bhatta, 2018). Again, because there is typically a lag between an economic action and a result, the ARDL approach allows for appropriate lags to fit the data generation process or the model.

In addition to the above, the ARDL procedure does not necessarily require that the variables employed be pretested for stationarity as compared with other techniques such as the Johansen approach. ARDL is used whether the variables in the model are strictly I(0), strictly I(1), or mutually co-integrated. In the presence of the I(2) series, however, the process will fail.

Unlike the traditional co-integration such as Johansen (1988) and Johansen and Juselius (1990) that may show problems of endogeneity in their models, the ARDL technique has the ability to differentiate between the dependent and independent variables in its model and for that matter portions where the model regressors are endogenous, the bound testing procedure for most parts in the long run gives unbiased estimates and *t*-statistics (Narayan, 2005). The ARDL approach therefore has the ability to eradicate the endogeneity problem on the estimated coefficients that may arise due to the presence of autocorrelation. Lastly, the ARDL model can estimate long and short-term co-integration relations at the same time, providing accurate estimations for the study (Pesaran, et al. 2001).

Using the ARDL approach to co-integration, analyzing the long run relationship between variables entails two stages. The first step is to check for the existence of a long-run relationship between all variables. Once the long-run relationship is determined or established the long-run and short-run models are estimated. Using the ARDL co-integration procedure we first estimate the long run co-integration to analyze the long run relationship as

$$\Delta lnRGDPPC_t = \beta_0 + \sum_{i=1}^{k} \alpha_i \Delta lnRGDPPC_{t-i} + \sum_{i=0}^{k} \delta_{2i} GOV\_EFFECT_{(t-i)} * INTERNET_{(t-i)} + \sum_{i=0}^{k} \beta_i \Delta INTERNET_{(t-i)j} + \sum_{i=0}^{k} \gamma_i \Delta lnGFCF_{t-i} + \sum_{i=0}^{k} \delta_i ln\Delta TLF_{t-i} + \sum_{i=0}^{k} \lambda_i \Delta FD_{t-i} + \sum_{i=0}^{k} \lambda_i \Delta INF_{t-i} + \sum_{i=0}^{k} \varphi_i \Delta GOV\_EFFECT_{t-i} + +\theta_1 lnRGDPPC_{t-1} + \theta_2 INTERNET_{(t-i)} + \theta_3 INTERNET_{(t-i)} * \theta_7 GOVT\_EFFECT_{t-1} + \theta_4 lnGFCF_{t-i} + \theta_5 ln\Delta TLF_{t-i} + \theta_6 FD_{t-i} + \theta_7 INF_{t-i} + \theta_8 GOVT\_EFFECT_{t-1} + \varepsilon_t \ldots\ldots (4)$$

Where:

RGDPPC is used as a measure for economic growth, INF is inflation, $INTERNET$ is internet usage, FD is financial development, GFCF is gross fixed capital formation used as proxy for Capital, TLF is Total labour force, GOVT_EFFECT is government effectiveness, INTERNET*GOV_EFFECT represents the interaction of internet usage and government effectiveness, ln represents the natural logarithms, Δ represents the difference equation, θ_i represents the long-run coefficients, ε_t represents the error term.

In testing for the long-run co-integration relationship among the variables, the hypothesis below is stated:

$$H_0: \theta_1 = \theta_2 = \theta_3 = \theta_4 = \theta_5 = \theta_6 = \theta_7 = 0 \; (No\ co-integration)$$

$H_a: \theta_1 = \theta_2 = \theta_3 = \theta_4 = \theta_5 = \theta_6 = \theta_7 \neq 0 \ \ (co - integration\ exist)$

The ARDL procedure begins by estimating equation (4) using Ordinary Least Squares. By first equating the coefficients of the lagged level variables to zero, the resulting F-test (Wald test) is utilized to test for the presence of the long-run relationship among variables. For testing the co-integration relationship between variables, Pesaran, et al. (2001), gave two critical values, thus upper and lower limits. They stated that the upper critical value assumes that all variables are I(1), implying that the variables are co-integrating, whereas the lower critical value indicates that there is no co-integrating correlation between the variables, implying that all variables are I(0).

The null hypothesis of no co-integration will also be tested against the alternative using the *F* test, which has a non-standard distribution that depends on the number of regressors and whether the variables included in the model are purely *I(0), I(1)*, or mixed, and also whether the model has an intercept and/or trend. The null hypothesis is rejected if the F-statistics value is greater than the upper critical value, implying that the variables are co-integrated. However, if the F-statistics value is lesser than the lower critical value or lower level of the bound, it is unable to reject the null hypothesis, and hence no co-integration exists. The results are inconclusive if the values of the computed F-statistics fall between the lower and upper bounds of the critical values. Taking into consideration the sample size of this study which is small, the critical values reported by Narayan and Narayan (2005), which are based on a small sample size of between 30 and 80, will be used. The test uses asymptotic critical value bounds, which depend on whether the variables are *I*(0)*, I*(1), or mixed.

After evidence of co-integration between the variables is established, the below ARDL model is estimated to obtain the long-run and short-run coefficients. The long-run coefficients are estimated as below

$$lnRGDPPC_t = \beta_2 + \sum_{i=1}^{k} \alpha_{2i} lnRGDPPC_{t-i} + \sum_{i=0}^{k} \beta_{2i} internet_{t-i} + \sum_{i=0}^{k} \gamma_{2i} INF_{t-i} +$$

$$\sum_{i=0}^{k} \delta_{2i} GOV\_EFFECT_{(t-i)j} + \sum_{i=0}^{k} \delta_{2i} GOV\_EFFECT_{(t-i)j} * INTERNET_{(t-i)j} +$$

$$\sum_{i=0}^{k} \varphi_{2i} lnGFCF_{t-i} + \sum_{i=0}^{k} \lambda_{2i} FD_{t-i} + \sum_{i=0}^{k} \Phi_i lnTLF_{t-i} + \varepsilon_{2t} \ldots\ldots\ldots\ldots\ldots\ldots$$

The short run coefficients for an ARDL are estimated using the difference equations as indicated below;

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

The coefficients in the error correction equation indicates the short-run dynamics whiles γ is the speed of adjustment to long-run equilibrium following a shock to the system and ECT_{t-1} is the error correction term that is the residuals obtained from the cointegration equation lagged one period. The error correction term indicates the speed of adjustment to the long run equilibrium in the dynamic model. In other words, the error correction term shows how quick the variables converge to equilibrium when they are disturbed. It is expected to be statistically significant with a negative coefficient. The negative coefficient means that any shock that occurs in the short-run will be corrected in the long-run. The larger the coefficient of the error correction term in absolute terms the faster the convergence to equilibrium.

The AIC: Akaike Information criterion, SC: Schwarz Information Criterion is used in the study for determining the number of lags in the cointegration test.

3.10 Model Selection Criteria

Numerous researchers usually explore various statistical models or machine learning methods to aid in the selection of the appropriate models with respect to the lag order of the models for data observation in order to facilitate scientific discoveries or gain predictive power. Model selection is a key ingredient in data analysis for reliable and reproducible statistical inference or prediction, and thus central to scientific studies in fields such as economics. Model selection is therefore the task of selecting a statistical model from a model class, given a set of data (Wei et al., 2021).

A number of alternative criteria which are more economical in their use of regressors have been suggested but the most outstanding and widely used criteria include the Schwarz, Bayesian criterion (SBC) Akaike Information Criteria (AIC) of Akaike , and Hannan-Quinn criterion (HQ).

In this study, the competing models that are based on the appropriate lags are ranked according to the values of the AIC, SBC or HQ. The model is then selected based on the one with the lowest information criterion. The principle of parsimony is applied to select the most appropriate model in the situation where models competing have the same AIC, SBC and or HQ values. The principle prefers a model with fewer parameters to a complex one.

3.11 Model Diagnostic Checks

To ensure that the estimated model in a study is robust and unbiased, a number of post estimation tests is usually carried out to ascertain the robustness and goodness of fit of the model adopted for the study. Diagnostics and stability tests are often employed to determine the fitness of the model. The diagnostic test examines the serial correlation, functional form, normality and heteroscedasticity associated with the selected model. A serial correlation test is carried out to

ensure that the estimates obtained from the model are efficient. The study therefore employed the Lagrange Multiplier (LM) in testing for serial correlation in its model. It is adopted due to the following advantages. Firstly, the LM test could be used to test for higher order autoregressive (AR) errors, and is applicable whether or not there are lagged dependent variables. The LM also tests the null hypothesis of no serial correlation up to the chosen maximum lag length.

The structural stability test is also carried out using the Cumulative Sum (CUSUM) of recursive residuals and the Cumulative Sum of Squares (CUSUMSQ) of recursive residuals as suggested by Pesaran and Pesaran (1997) to determine whether the coefficients of the estimated model are stable over the period of the study. The CUSUM and CUSUMSQ statistics are updated recursively and plotted against the break points. If the plots of the CUSUM and CUSUMSQ statistics stay within the critical bounds of five percent level of significance, then we fail to reject the null hypothesis of stable coefficients in a given regression.

3.12 Data Analysis

The study employed both descriptive and quantitative analysis. Charts such as graphs and tables were employed to aid in the descriptive analysis. All estimations were carried out using Econometric views (E-views)10.

Stationarity tests were carried out on all variables employed in the study to ascertain their order of integration. The study further adopted the Autoregressive Distributed Lag (ARDL) approach to co-integration to obtain both the short and long run estimates of the main variables involved.

3.13 Summary

This chapter described the data and their sources used in the study. Quantitative estimations are used and quarterly data covering a period of 84 are employed. Data is sourced from WDI, WGI,

Federal Reserved Economic Data (FRED) and International Telecommunication Union database for the variables employed in the study. The variables of interest employed in the study includes Real Gross Domestic Product per capita (RGDPPC), INTERNET (Internet), inflation (INF), government effectiveness (GOV_EFFECT), Labour (TLF), financial development (FD) and gross fixed capital formation (GFCF) used as proxy for capital. Explanations of the various tests of stationarity that was adopted for this study were also shown.

To determine the short run and long run effect of internet usage and government effectiveness on the growth of the Ghanaian economy, the study used the ARDL long run and bounds testing approach to cointegration. It is thus expected that both variables will have a positive effect on the rate of growth of the economy.

CHAPTER FOUR

PRESENTATION AND ANALYSIS OF DATA

4.1 Introduction

This chapter presents a thorough analysis and discussion of the results of the study. The chapter is divided into three sections. Section one examines the time series properties of the data. It presents the descriptive statistics, unit root test and the bound test for cointegration. The second section presents and discusses the results of the estimated long run growth equation using the ARDL approach. The results of the Error Correction Model for the selected ARDL model were also presented and analyzed in the second section. The third section presents the stability tests and the tests of goodness of fit of the estimated model. All estimations were obtained with the help of Eviews 10 software packages.

4.2 Descriptive Statistics

The study computed the descriptive statistics of the variables included in the study as presented in Table 4.0. It can be observed from Table 4.0 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 within the age's 15 to 74 uses internet in a quarter. A minimum of about 0.15 persons out of 100 persons within the ages 15 to 74 uses internet whiles a maximum of about 62.01 persons use 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 real gross domestic product per capita (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 as 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. The average inflation rate for the period is 15.97% whilst it reported a maximum of 41.51% and a minimum of 7.14%. Financial development recorded a maximum rate of 18.07 and a minimum of 11.09 and on the average however, it reported a rate of 14.89 and a standard deviation of 2.03. The maximum and minimum values reported for Capital are 6.92 and 6.27 respectively. On average however it reported a rate of 2.23 and a standard deviation of 2.46

Table 4.1. Summary Statistics of the Variables

	RGDPPC	INTERNET	GOV_EFFECT	TLF	INF	FD	GFCF
Mean	51570.11	15.20	39.70	10713024	15.54	14.84	2.23E+10
Median	51507.50	8.25	38.80	10697599	13.75	14.39	5.66E+09
Maximum	58017.00	62.01	49.27	13364617	41.95	18.07	6.92E+10
Minimum	45983.00	0.154	29.33	8277620.	7.60	11.09	6.27E+08
Std. Dev.	3238.06	16.59	5.13	1510539.	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: Std. Dev. represents Standard Deviation while Sum Sq. Dev. represents Sum of Squared Deviation.

Source: Computed by author using EViews 10.0 Package

4.3 Results of Unit Root Test

Given that most macroeconomic time series such as inflation, government effectiveness, and financial development exhibit non-stationary over time, it was necessary that unit root test be done for the variables used in the study. Prior to estimating the long-run relationship effect of internet, government effectiveness as well as their combined effect on economic growth in Ghana, the stationarity status of all the variables in the model specified for the study were

determined using the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and KPSS unit root test approach. The three tests were applied to all the variables at levels and in first difference in order to formally establish their level of integration. The results of the unit root test based on the Augmented Dickey-Fuller (ADF) is presented in 4.2 respectively.

Table 4.2. Test For the Order of Integration (ADF) Results

Levels (Constant)			1st Difference (Constant)	
Var.	ADF-Statistic	Var.	ADF-Statistic	*OI*
LRGDPPC	-1.1838(0.6782)	D(LRGDPPC)	-11.3953(0.0001)***	*I*(1)
INTERNET	-0.4676(0.8908)	D(INTERNET)	-1.4431(0.5567)	
GOV_EFFECT	-1.7588(0.3981)	D(GOV_EFFECT)	-3.1170(0.0293)**	*I*(1)
LGFCF	-1.0025(0.7492)	D(LGFCF)	-3.6021(0.0077)**	*I*(1)
LTLF	-1.8591(0.3498)	D(LTLF)	-0.2197(0.9306)	
FD	-2.1211(0.2371)	D(FD)	-3.8282(0.0590)**	*I*(1)
INF	-3.1201(0.0291)**	D(INF)	-8.6617(0.0000)***	*I*(0)

Note: D denotes first difference. *** and ** represent significance at the 1% and 5% levels respectively. Numbers in brackets are P-Values. *OI* represents the order of integration.

Source: computed by author using E-views 10.0 Package

As shown in table 4.2, all the variables are non-stationary at levels except inflation rate. This is because the p-values of their ADF statistic are not statistically significant at all the conventional level of significance with the exception of inflation rate, which is significant at 5 percent. However, at first difference, real GDP per capita, government effectiveness, gross fixed capital formation, financial development and inflation rate are all stationary at 1 percent and 5 percent significant levels. On the contrary, internet usage and total labour force are still non stationary because their p-values are not significant at any of the conventional levels of significance. As a result, the study further employed the PP test of unit root to further ascertain the level of integration for these variables.

Table 4.3. Test For the Order of Integration (Phillips Perron) Results

Levels (Constant)		1st Difference (Constant)		
Var.	PP-Statistic	Var.	PP-Statistic	*OI*
LRGDPPC	-0.9675(0.7615)	D(LRGDPPC)	-11.991(0.0001)***	*I*(1)
INTERNET	1.1627(0.9977)	D(INTERNET)	-4.3854(0.0006)***	*I*(1)
GOV_EFFECT	-1.7928(0.3817)	D(GOV_EFFECT)	-3.9575(0.0026)**	*I*(1)
LGFCF	-1.4230(0.5673)	D(LGFCF)	-3.7092(0.0056)**	*I*(1)
LTLF	-2.9988(0.0391)**	D(LTLF)	1.2572(0.9983)	*I*(0)
FD	-1.7045(0.4253)	D(FD)	-4.5338(0.0004)***	*I*(1)
INF	-2.7805(0.0654)**	D(INF)	-6.4200(0.0000)***	*I*(0)

Note: D denotes first difference. *** and ** represent significance at the 1% and 5% levels respectively. Numbers in brackets are P-Values. *OI* represents the order of integration.

Source: computed by author using E-views 10.0 Package

From table 4.3, it can be noticed that at levels and with constant, all the variables failed to reject the null hypothesis of unit root at any of the error levels except total labour force and inflation. Thus, apart from total labour force and inflation which where stationary at levels at 5 percent significance level, the rest of the variables (Real GDP per capita, internet, government effectiveness, gross fixed capital formation, interaction, financial development,) are non-stationary at levels. However, after the first differencing, Real GDP per capita, internet, government effectiveness, gross fixed capital formation, interaction, and financial development achieved stationarity, and the null hypothesis that they pose unit root is rejected at 1 percent and 5 percent significance levels. This gives further indication that as total labour force and inflation are integrated of order zero (I(0)), real GDP per capita, internet, government effectiveness, gross fixed capital formation, interaction, and financial development are integrated of order one, (I(1)) hence a mixed order of integration among the variables under study. Since none of the variables were integrated of order two (I(2)), and confirming a case of a mixed order of integration, it is justifiable to apply the ARDL methodology to test for the existence of the long run equilibrium impact of internet, government effectiveness and the interaction term on economic growth.

Owing to the fact that both the ADF and the PP unit root tests are inconclusive on the order of integration of some of the variables particularly INTERNET, the study undertakes an additional unit root test. The study performs the Kwiatkowsky, Phillips, Schmidt and Shin (KPSS) test and the result is displayed in Table 4.4

Table 4.4. Test For the Order of Integration Kwiatkowsky, Phillips, Schmidt and Shin (KPSS) Results

Null Hypothesis: Variable is stationary				
Levels (Constant)			1st Difference (Constant)	
Var.	KPSS-Statistic	Var.	KPSS-Statistic	*OI*
LRGDPPC	1.1492***	D(LRGDPPC)	0.1856	*I*(1)
INTERNET	1.1767***	D(INTERNET)	0.3229	*I*(1)
GOV_EFFECT	0.9990***	D(GOV_EFFECT)	0.5221	
LGFCF	1.1261***	D(LGFCF)	0.1980	*I*(1)
LTLF	1.1535***	D(LTLF)	0.6160	
FD	0.8504***	D(FD)	0.1152	*I*(1)
INF	0.7340***	D(INF)	0.1500	*I*(1)

Critical value is 0.739000 at 1% significant level *** rejection of the Null hypothesis at 1%
Source: computed by author using E-views 10.0 Package

From Table 4.4, the study fails to reject the null hypothesis of stationarity of the first difference of all the variables because the calculated KPSS statistics for all the variables are less than the critical KPSS value of 0.73900 at 1% significant level. The study thus concludes that the variables are stationary at first difference using the KPSS test.

Table 4.5: Lag Length Selection Criterion

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-917.3232	NA	2.782171	23.72624	23.96795	23.82300
1	69.28823	1745.543	1.49e-10	0.069533	2.244956	0.940395
2	321.7887	394.9367	1.25e-12	-4.763813	3.654680	-3.118852
3	379.5014	78.43000	1.67e-12	-4.602599	1.440244	-2.183538
4	445.5668	76.22938*	2.07e-12	-4.655560*	0.320993*	-1.462399*
5	666.6938	209.7872	5.95e-14	-8.684457	1.225805	-4.717197
6	790.7371	92.23727	2.92e-14*	-10.22403	1.619945	-5.482667

Source: computed by author using E-views 10.0 Package

Table 4.5 above present lag selection criterion for the ARDL model of the study. The lag length selection was based on the Akaike selection criteria (AIC). From the table 4.4 it is evidence from both Akaike information criterion and Swartz Information Criterion (SIC) that the maximum time lag is four 4 based on the VAR approach. The study selects the lag length based on the AIC over FPE since the AIC is an improvement of FPE.

4.4 Results of Bound Test to Cointegration

Since the aim of this study is to examine the relationship between economic growth and internet usage and government effectiveness, it was essential to test for the existence of long-run equilibrium relationships between the variables within the framework of the bounds testing approach to cointegration. Thus, given that the series are 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. 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 model, when the equation is normalized on economic growth, thus, with economic growth being the dependent variable. The result of the bounds test for cointegration is presented in Table 4.6

Table 4.6: Results of Bound Test for Cointegration

Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	4.9435	10%	2.03	3.13
K	7	5%	2.32	3.5
		1%	2.96	4.26

Source: computed by author using E-views 10.0 Package

From Table 4.6, the calculated F-statistic reported shows that, there is a long-run relationship between economic growth and its explanatory variables as well as the interaction term. This is because the F-statistic value of 4.9435 is higher than the top critical bound values of 3.13 at 10 percent significance level and 4.26 at 1 percent significance level. This implies that the null hypothesis of no cointegration among the variables is rejected meaning that there exists a long run relationship between economic growth and its determinants. Given that there is existence of cointegration among the variables in the growth equation, the study therefore proceeds to estimate the long run coefficients and the short-run parameters of the model.

4.5 Results of the Long-run growth Model

Given the results of the cointegration analysis, the long run relationships among the variables were estimated using the ARDL framework. Thus, the study employed the ARDL framework in estimating the log-log model as expressed in the growth equation (3.3) to ascertain the long run relationship between economic growth and internet, government effectiveness and the interaction term. The results of the long run relationship between economic growth and its determinants

estimated by the ARDL approach are reported in Table 4.7. The coefficients of the variables represent the long run elasticities.

Table 4.7: Estimated Long-Run Model using the ARDL Approach.

Dependent variable: LNRGDPPC		Selected Model: ARDL (4, 2, 4, 4, 2, 2, 4, 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: ***, ** and * denote significance at 1%, 5% and 10% respectively

Source: computed by author using E-views 10.0 Package

From Table 4.7, the constant term is 6.5884 and is significant at 1 percent level. This implies that holding the influence of all the variables in the model constant, the positive and statistically significant constant term in Table 4.6 indicates that economic growth in Ghana will increase by approximately 6.6 percent due to the influence of all other variables that are not included in the model.

The results from table 4.7 further shows that the coefficient of internet usage assumed a negative sign and is also statistically significant at 5 percent error level. This implies that, all other things being equal, internet exerts a negative impact on economic growth in the long-run. The size of its coefficient (0.068) implies that, conditioned on the other factors included in the model, a percentage rise in internet usage will cause economic growth to reduce by approximately 0.068. The negative sign on the coefficient of internet can be attributed to inefficiencies that are linked with prolonged use of internet. Thus, as people become conversant with the use of internet over time, they tend to develop attitudes that influence them to use it for their personal gains rather

than for its intended purposes. What this implies is that, in the long term, when people are adequately abreast with internet, they tend to divert away from its productive benefits towards fraudulent and unproductive activities such as social media, watching of pornography and media gambling. This causes increased complexities in the production process through time and resource wasting, thereby reducing labour productivity which in effect decreases economic growth. This result is in line with the findings of Bakari & Tiba (2019) which also finds a negative relationship between internet usage and economic growth.

Furthermore, Table 4.7 reveals that in coherence with economic theory, government effectiveness is found to be positive and significantly associated with economic growth. However, the magnitude of the impact of government effectiveness on economic growth is lower compared to that of internet usage in the long run. Thus, at 1 percent significance level, a percentage rise in the effectiveness of government will lead to an increase in economic growth by approximately 0.0027 percent. This indicates the crucial role played by the government in enhancing growth in the economy, such that as the government works effectively towards political and economic stability, given that government activities are directed towards more productive sectors, and removing supply-side constraints by ensuring sustainable supply of energy, investing in productive infrastructure and other physical capital necessary to stimulate employment and output, the underground economy would be eliminated, productivity will increases and thus economic growth in general.

Additionally, from Table 4.7, the estimated elasticity coefficient of capital (i.e., LNGFCF) in relation to economic growth showed that the variable is positive and statistically significant at 1 percent in the estimated model. The coefficient of 0.0355 indicates that, all other things being equal, a one percent increase in the stock of capital in the economy will increase economic

growth by approximately 0.04 percent. Whereas the size of its effect (0.04 percent) seems to be smaller than both internet usage and government effectiveness, its positive and statistically significant impact on economic growth is extremely worthwhile. Thus, in an economy where a change in capital stock is relatively elastic, an increase in capital stock is necessary to increase economic growth. This finding is in line with the findings of Osei et al, 2017, who also finds a positive relationship between capital and economic growth in Ghana.

Similarly, the coefficient of total labour force is positive and statistically significant at 5 percent error level. The results from table 4.6 shows a coefficient of 0.2158 for total labour force which is an indication that as total labour force is increased in the economy, economic growth is induced to rise. The results indicates that, a percentage increase in total labour force will increase economic growth by approximately 0.22 percent in the long run, all other things being equal. The crucial effect of intensifying total labour force and its significant effect on improving economic growth is thus confirmed by the results in the sense that, more able and willing personnel within the labour force is necessary in achieving higher growth in the economy. This empirical finding is consistent with earlier studies like Biyase and Zwane (2011), and Shahid (2014) which also found a positive relationship between labour force and economic growth in the long run.

Furthermore, the interaction term turns out to exert a positive impact on economic growth in the long run. This positive relationship between the interaction term and economic growth is statistically significant at 5 percent level. Although, the interaction, which is the composite effect of government effectiveness and internet usage seems to be one of the most important determinants of economic growth in the long-run, its impact (in terms of the size of its coefficient) is relatively small, compared to the other determinants in the long run. The results indicates that other things being equal, a percentage point increase in the combined impact of

government effectiveness and internet usage (i.e., the interaction term) will cause economic growth to increase by just about 0.02 percent (thus, 100×0.0002) on the average, in the long run. This however gives a further indication that, in the long run, though there is a positive relationship, economic growth is less influenced by the combined impact of government effectiveness and internet usage as compared to their distinct respective impacts.

Also, from the results in Table 4.7, financial development is positively related to economic growth in the long run. The coefficient of financial development is 0.0124 and is statistically significant at 1 percent error level. What this means is that in the long run, all factors held constant, a percentage point increase in financial development will cause approximately 1.24 percent (thus, 100×0.0124) increase in economic growth. Financial development also showed up to be an important determinant of economic growth, with its average effect ranging above 1 percent. This gives further indication of the significant effect of financial development mainly through increased investment in the financial economy on economic growth.

Lastly, the impact of inflation is found to be negative but statistically insignificant. Irrespective of the insignificant relationship between inflation rate and economic growth, the inverse relationship between inflation and economic growth shows the damning implication of inflationary pressures on the growth of an economy. Thus, as general prices continue to rise in an economy, economic growth is likely to dwindle. This unswervingly negative effect of inflation rate on economic growth is consistent with the findings of Ahiakpor and Akapare (2014) and Ababio (2015) who also confirm the negative relationship between inflation rate and economic growth.

4.6 Results of the Short Run growth Model

With regards to short run estimates, Table 4.6 show the results of short run coefficients to help explain the relationship between economic growth and its determinants in Ghana. Engle and Granger (1987) argued that when variables are cointegrated, their dynamic relationship can be specified by an error correction representation in which an error correction term (ECT) computed from the long run equation must be incorporated in order to capture both the short run and long run relationships. The error correction term indicates the speed of adjustment to restore equilibrium in the dynamic model after a disturbance. Thus, the Error Correction Model (ECM) provides the means of reconciling the short run behaviour of an economic variable with its long-run behavior. 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 model uses the first difference of the variables to capture the short run changes. The estimated results are presented in Table 4.8.

Table 4.8: Estimated Short-Run Error Correction Model using the ARDL Approach

Dependent Variable: LNRGDPPC	Selected Model: ARDL (4, 2, 4, 4, 2, 2, 4, 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***

Note: *** and ** denote significance at 1% and 5% respectively.

Source: Computed by author using EViews 10.0

From Table 4.8, the short-run model show convergence to equilibrium in the long run, after a temporary shock. Theoretically, the dynamic stability of the path of economic growth requires that the coefficient on the error correction term be negative and statistically significant. This is confirmed in the short-run specification since the coefficients of the lagged ECM is both negative and highly significant at 1 percent level. From Table 4.8, the estimated coefficient of the ECM is approximately -0.77. This implies that about 77 percent of the disequilibrium in the previous year following shocks to the system converge back to the long run equilibrium in the current year. The coefficient is quite large, indicating that there is a greater rate of convergence toward equilibrium. By this finding, it is concluded that any disequilibrium within the growth dynamics of Ghana in the short run is swiftly adjusted and converged back to equilibrium in the long run.

Furthermore, as shown in Table 4.8, it can be noticed that unlike the long run results, internet is positively related to economic growth in the short run. The coefficient (0.0225) is statistically significant at 1 percent in the short run. However, the magnitude of the coefficient in the short-run is greater than that of the long-run. From Table 4.8, it is shown that in the short run, a percentage point increase in internet usage will cause economic growth to increase by about 2.25 percent (i.e., 100×0.0225), all other things being equal. Thus, in the short run, when internet usage is at its early stages, people are subjected to frequent trainings, workshops and conferences in relation to the proper use of it. This compels people to follow instructions and use internet for its intended purpose and in effect, result in economic growth in the short run.

Additionally, the short run results also indicate that the coefficient of government effectiveness maintained its positive sign as in the long run and is statistically significant at 1 percent error level. This is consistent with economic theory. Compared to the long run results, the magnitude

of the effect of government effectiveness on economic growth is slightly increased, thus, a percentage increase in government effectiveness will increase economic growth by approximately 0.65 percent (thus, 100×0.0065) in the short run, as against 0.27 percent in the long run. This indicates that even in the short run, government effectiveness still affects economic growth, such that effectiveness in government activity spurs the growth process in the Ghanaian economy.

Again, the coefficient (0.0481) of capital in the short run is positive and statistically significant at 5 percent. This finding is consistent with the long run results. The results in Table 4.8 shows that, in the short run, other things being equal, a 1 percent increase in capital stock in Ghana will cause the economy to grow at about 0.50 percent, which is quite bigger than the 0.40 percent growth in the long run. Thus, the positive and significant coefficient of capital in the short run suggest that adding to the capital stock of the country have contemporaneous effect on economic growth both in the short run and in the long run.

Similarly, the coefficient of labour force is positive (7.1667) and statistically significant at 1 percent significance level. This means that, all other things being equal, if labour force is increased by 1 percent, economic growth will increase by about 7.2 percent in the short run. The coefficient of labour force in the short run is quite large, suggesting that a slight percentage increase in labour force will lead to an extensive increase in economic growth, all things being equal. In general, the positive impact of labour force on economic growth both in the long run and in the short run supports existing growth theories which postulate that labour inputs impact positively on economic growth. It can, therefore, be concluded that labour force has a significantly positive influence on economic growth in Ghana.

Again, in conjunction with the long run estimates, the interaction term is found to significantly drive economic growth in the short-run as well. The size of the estimated coefficient (0.0003) of the interaction term, although relatively smaller as in the long run, is positive and statistically significant at 5 percent. The results suggest that, all other things being equal, a 1 percentage point increase in the composite effect of government effectiveness and internet will induce the economy to grow at approximately 0.03 percent (thus 100×0.0003) in the short run. Inferentially, the same positive impact of the interaction term on economic growth in the short run suggests that although the combined effect of government effectiveness and internet usage may be somewhat meagre, it is still instrumental in increasing economic growth in Ghana. Thus, government effectiveness and internet usage are collaboratively advantageous to economic growth both in the long run and in the short run, all other things being equal.

Again, the coefficient of financial development also maintained its positive sign and statistically significant at 1 percent significance level which is consistent with the long-run results. The result therefore implies that, if financial development goes up by 1 percent, economic growth accordingly will increase by approximately 0.67 (i.e., 100×0.0067) percent in the short-run. Thus, the short-run and long-run results indicate that financial development have been favourable for economic growth in Ghana over the period under study.

Lastly, consistent with the long run estimates, the short run coefficient of inflation rate assumed the expected negative sign as in the long run. That is, the short run coefficient of inflation rate portrays a negative relationship with economic growth. Again, this relationship is insignificant as in the long run. The coefficient also turned out to be 0.0001 indicating once again that all other things being equal, if inflation rate is increased by 1 percent, economic growth will decrease by about 0.01 percent (thus, 100×0.0001) in the short run. It can therefore be concluded that

inflation rate, (although not significant) if not suppressed has the propensity to reduce economic growth in the short run as it will in the long run.

4.7 Results of Model Diagnostic Tests

It is important to conduct parameter tests in order to avoid model misspecification which has the tendency of producing bias results. In this regard, the significance of the variables and other diagnostic and structural stability tests of the model were considered. Various diagnostic tests were eventually applied to examine the validity of the model. Table 4.9 summarizes the results of the model diagnostic tests.

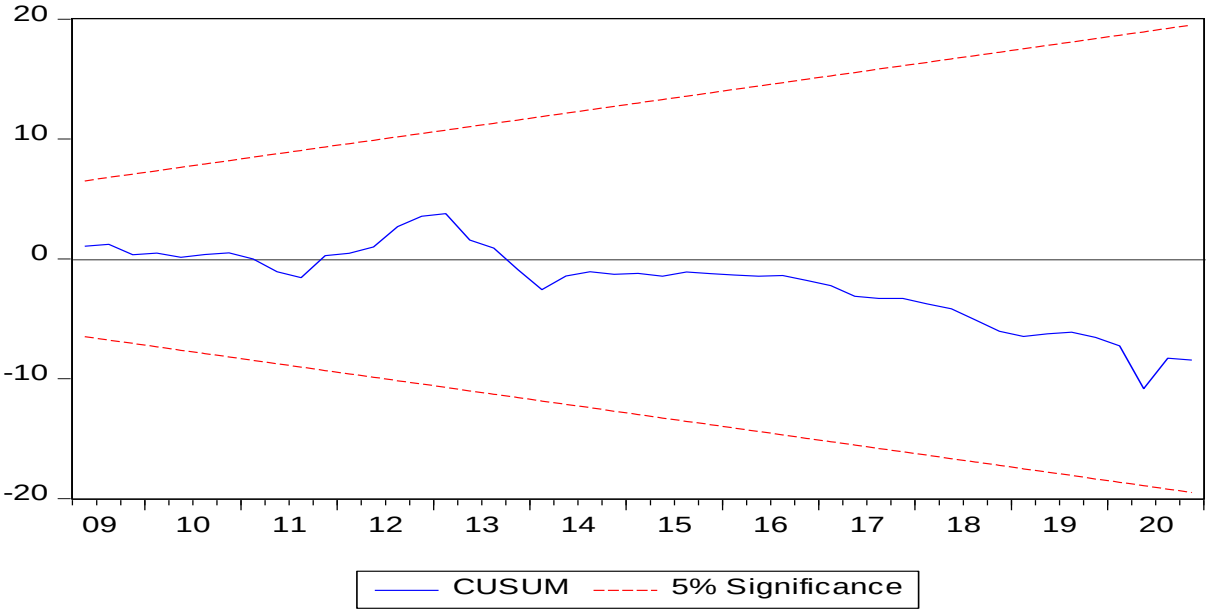
Table 4.9 Model Diagnostics and Goodness of Fit

Diagnostics			
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		
		F-statistic	**[Prob]**
Serial Correlation (LM Test)		1.7784	[0.1806]
Heteroscedasticity (ARCH)		1.1804	[0.2806]
Functional Form (RESET)		0.0390	[0.8443]
Normality		2.2007	[0.3330]

Sources: Computed by the author using E-views 10.0

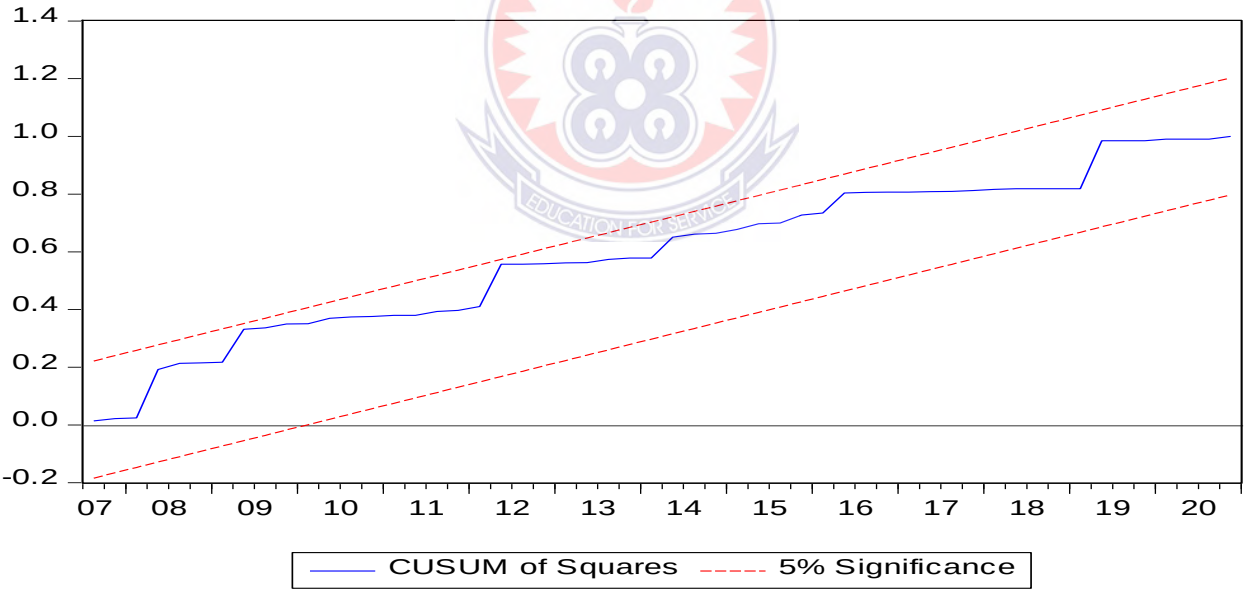
The results from Table 4.9 show that the overall regression is significant at the 1 percent level. Again, the adjusted R-squared value of approximately 0.86 indicate that about 86 percent of the variation in dependent variable (economic growth) can be accounted for by the changes in the independent variables. A DW statistic of 2.13 indicates that there is no strong serial correlation in the residuals. Moreover, an F- statistic value of approximately 20 suggests the joint significance of the determinants in the ECM. Also, the model passed the ARCH test for heteroscedasticity as well as the RESET test for correct specification of the model. Hence it can be concluded from the above analysis that the model has passed all the essential diagnostic tests. Therefore, the results presented in this study are unbiased and are valid for policy analysis.

Furthermore, the CUSUM and CUSUMSQ tests were done to show whether the regression equation is constant over time or not. The CUSUM and CUSUMSQ statistics are plotted against the critical bound of 5 percent significance level and the null hypothesis is that the coefficient vector is the same in every period and the alternative is simply that it is not. Thus, if the plot of these statistics remains within the critical bound of the 5 percent significance level, the null hypothesis that all coefficients in the model are stable cannot be rejected. The plots of CUSUM and CUSUMSQ tests are presented in figures 4.1 and 4.2 respectively.



Sources: Computed by the author using E-views 10.0

Figure 4.1. Plot of CUSUM at 5% significance level



Sources: Computed by the author using E-views 10.0

Figure 4.2. Plot of CUSUMSQ at 5% significance level

From figures 4.1 and 4.2, it can be concluded that all the coefficients of the estimated model are stable over the study period since they are within the 5 percent critical bounds.

4.8 Chapter Summary

This chapter presented the empirical results of the relationship between internet usage and economic growth, government effectiveness and economic growth as well as the combined effect of government effectiveness and internet usage on economic growth. The ADF and PP test for unit root revealed that the series had a mixed levels of integration hence the use of the ARDL model. Additionally, the cointegration test revealed a long run cointegrating relationship between internet usage, government effectiveness as well as the interaction term and economic growth.

Hypothesis one tested for the relationship between internet usage and economic growth in Ghana. The results revealed that the null hypothesis of no relationship between internet usage and economic growth is rejected at 1% and 5% in the short run and the long run respectively. Thus, the results indicated that internet usage is positively related to economic growth in the short run, yet the relationship is negative in the long run. Clearly, the results on hypothesis one suggests that internet usage drives economic growth only in the short run but the case is not so in the long run.

Hypothesis two also tested for the relationship between government effectiveness and economic growth. According to the results, the null hypothesis that there is no relationship between government effectiveness and economic growth is rejected at 1% in the short run and the long run. The results revealed that there is a positive relationship between government effectiveness and economic growth both in the short run and the long run. This finding gives further indication that government effectiveness is crucial in stimulating economic growth in Ghana.

Lastly, the study sought to ascertain the composite effect of government effectiveness and internet usage on economic growth. The results showed that the null hypothesis that there is no relationship between the interaction term and economic growth is rejected at 5% in the short run

and the long run. Hence it can be concluded that the positive combined impact of government effectiveness and internet usage on economic growth is significantly advantageous both in the short run and in the long run.

CHAPTER FIVE

SUMMARY CONCLUSION AND RECOMMENDATION

5.1 Introduction

The chapter outlines the summary, conclusions and recommendations of the study. The summary highlights an overview of the research problem, objectives, methodology and the findings of the study. The conclusion highlights the overall outcome pertaining to the findings of the study in respect to the stated hypotheses whiles the recommendations provides specific remedies to be implemented by agencies. The chapter further gives the limitations of the study and directions for future studies.

5.2 Summary

The study investigated the effect of internet usage on economic growth and the effects of government effectiveness on economic growth in Ghana using quarterly time series data from 2000 to 2020. Specifically, the study examined the effects internet usage on economic growth in Ghana, the effects of government effectiveness on economic growth in Ghana and interactive effects of government effectiveness and internet usage on economic growth in Ghana. The study employed explanatory research design and quantitative research approach. The study adopted was guided by the endogenous growth model and the AK model was adopted as theoretical model for the study. The study employed Auto Regressive Distributed Lag model to examine both the short run and long run effects of internet usage, government effectiveness, interaction of internet usage and government effectiveness, capital, total labour force, inflation and financial development on economic growth proxied by real GDP per capita. The ARDL approach to cointegration was used to examine the existence of long-run and short-run relationship among the study variables.

Based on the result of the cointegration test it was revealed that there exist a long run cointegrating relationship between internet usage, government effectiveness as well as the interaction term and economic growth. The study found there exist a significant negative relationship between internet usage and economic growth in the long run. It was however revealed that internet usage exerts a positive effect on economic growth only in the short run. The study again found there is a significant positive relationship between government effectiveness and economic growth both in the short run and the long run. This finding gives further indication that government effectiveness is crucial in stimulating economic growth in Ghana. Lastly, the study found that the interaction term (government effectiveness and internet usage) and economic growth are positively related. Hence it can be concluded that the positive combined impact of government effectiveness and internet usage on economic growth is significantly advantageous both in the short run and in the long run.

5.3 Conclusion

The study revealed that internet usage has a significant positive effect on economic growth in the short-run however, in the long-run its effect is negative. Government effectiveness has a significant positive effect both in the long-run and short run. The study further established that the interaction term thus internet usage and economic growth are equally related both in the long-run and short-run. The plausible explanation for this phenomenon could be that governance institutions are very vibrant to influence the effect of internet usage on the economy in the short run through formulations and implementations of ICT policies such as the ICT for Accelerated Development Policy of 2003 and the National Telecommunications Policy of 2005. Thus, effective government ensure the efficient functioning of various institutions and regulate how internet is used for effective growth of the economy

5.4 Policy Recommendations

The findings of the study can have important policy implications.

- Conscious efforts should be made by firms to invest in internet infrastructure. An investment in internet infrastructure will ensure that production processes of firms could be fully automated to speed up the process of production. Also, training of labor on use of internet will ensure that there can be a right mix of labor and capital to increase its productivity
- Ministry of Communication and digitalization should prioritize increasing internet usage to promote economic growth. This can be done through initiatives such as expanding broadband infrastructure.
- Education is an essential factor for the internet to foster economic growth. Hence National Commission for Civic Education and Ministry of Communication and Digitalization should focus on education and training to ensure that individuals have the skills necessary to take advantage of economic opportunities provided by the internet.
- Although the combined effect of internet usage and government efficiency is favorable, it would be wise for the government to reinforce policies already in place that are focused on internet use in order to further boost productivity.

5.5 Suggestions for Further Studies

- This study focuses on the effect of internet usage on economic growth in Ghana. The study considered ARDL bounds test co-integration in the analysis. Even though the study adopted an appropriate method in analyzing the effect of internet usage on economic growth, further studies could consider other methods such as VAR, Threshold analysis among others which could be used to analyze the effect of internet usage on economic

growth Since technology comes as a shock to an economy in order to make a more comprehensive analysis.

- The study employed the number of internet users per 100 people and government performance index as a measure for internet usage among other ways of measuring internet usage and government effectiveness respectively. The research suggest that other works could also look at other measures of internet as well as other measures of governance indicators (rule of law, political stability, control of corruption) to assess their effect on the growth of the economy. This will aid to check the robustness of the study with the various measurements of internet and government effectiveness.
- Studies could be conducted to look at the effect of internet usage of a particular sector of the economy and how it contributes to economic growth in Ghana. The current study focused on the whole economy. Further studies could thus, look at the effect of internet on specific sectors so as to determine how it specifically affects the sector and may further look at the transmission mechanisms from the sectors to the whole economy.

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Appendix

Descriptive Statistics

	RGDPPC	TLF	GFCF	Gov_effect	FD	INF	INTERNET
Mean	51432.17	10713024	2.23E+10	39.88684	14.89092	15.71531	13.51891
Median	51455.00	10697599	5.66E+09	39.01768	14.44086	13.91000	7.800000
Maximum	58017.00	13364617	6.92E+10	49.26829	18.07171	41.95000	58.00000
Minimum	45983.00	8277620.	6.27E+08	29.32692	11.09359	7.600000	0.153615
Std. Dev.	3190.515	1510539.	2.46E+10	5.127514	2.035858	7.522960	14.31989
Skewness	0.186428	0.091192	0.722909	0.092500	0.038691	1.681872	1.090453
Kurtosis	2.328839	1.827217	1.807328	1.823353	1.586082	5.657102	3.185537
Jarque-Bera	1.989489	4.754308	11.85589	4.788189	6.767387	62.01552	16.16885
Probability	0.369818	0.092814	0.002664	0.091255	0.033922	0.000000	0.000308
Sum	4166006.	8.68E+08	1.80E+12	3230.834	1206.164	1272.940	1095.032
Sum Sq. Dev.	8.14E+08	1.83E+14	4.85E+22	2103.312	331.5773	4527.594	16404.73
Observations	84	84	84	84	84	84	84

ADF Unit Root Test

UNIT ROOT TEST RESULTS TABLE (ADF)
Null Hypothesis: the variable has a unit root

	At Level							
		LRGDPPC	INTERNET	Gov_effect	FD	LNTLF	INF	LNGFCF
With Constant	t-Statistic	-1.1838	-0.4676	-1.7588	-2.1211	-1.8591	-3.1201	-1.0025
	Prob.	***0.6782***	***0.8908***	***0.3981***	***0.2371***	***0.3498***	***0.0291***	***0.7492***
		n0	n0	n0	n0	n0	**	n0
With Constant & Trend	t-Statistic	-3.2015	-1.9509	-2.9964	-1.7141	1.1471	-3.1517	-2.0503
	Prob.	***0.0913***	***0.6179***	***0.1399***	***0.7358***	***0.9999***	***0.1019***	***0.5651***
		*	n0	n0	n0	n0	n0	n0
Without Constant & Trend	t-Statistic	1.6525	-0.3764	-0.3828	-0.0784	-0.0178	-2.2236	1.9891
	Prob.	***0.9754***	***0.5455***	***0.5432***	***0.6535***	***0.6738***	***0.0261***	***0.9884***
		n0	n0	n0	n0	n0	**	n0
	At First Difference							
		d(LRGDPPC)	d(INTERNET)	d(Gov_effect)	d(FD)	d(LNTL)	d(INF)	d(LNGFCF)
With Constant	t-Statistic	-11.3953	-1.4431	-3.1170	-2.8282	-0.2197	-8.6617	-3.6021
	Prob.	***0.0001***	***0.5567***	***0.0293***	***0.0590***	***0.9306***	***0.0000***	***0.0077***
		***	n0	**	*	n0	***	***
With Constant & Trend	t-Statistic	-11.3207	-1.5650	-3.1172	-3.0677	-1.1192	-8.7400	-3.6372
	Prob.	***0.0000***	***0.7973***	***0.1096***	***0.1214***	***0.9188***	***0.0000***	***0.0327***
		***	n0	n0	n0	n0	***	**
Without Constant & Trend	t-Statistic	-11.0451	-0.6444	-3.1489	-2.8434	-1.1466	-8.5423	-2.8986
	Prob.	***0.0000***	***0.4348***	***0.0020***	***0.0050***	***0.2272***	***0.0000***	***0.0042***
		***	n0	***	***	n0	***	***

PP Unit Root Test

UNIT ROOT TEST TABLE (PP)

	At Level							
		LRGDPPC	INTERNET	Gov_effect	FD	LNTLF	INF	LNGFCF
With Constant	t-Statistic	-0.9675	1.1627	-1.7928	-1.7045	-2.9988	-2.7805	-1.4230
	Prob.	***0.7615***	***0.9977***	***0.3817***	***0.4253***	***0.0391***	***0.0654***	***0.5673***
		n0	n0	n0	n0	**	*	n0
With Constant & Trend	t-Statistic	-3.0667	-1.1916	-2.1392	-1.6223	1.1315	-3.6198	-1.3095
	Prob.	***0.1212***	***0.9054***	***0.5164***	***0.7758***	***0.9999***	***0.0341***	***0.8787***
		n0	n0	n0	n0	n0	**	n0
Without Constant &	t-Statistic	2.5080	2.2840	-0.9315	-0.3054	20.6579	-1.2578	4.1036

Trend								
	Prob.	***0.9969***	***0.9944***	***0.3102***	***0.5728***	***1.0000***	***0.1904***	***1.0000***
		n0	n0	n0	n0	n0	n0	n0
	At First Difference							
		d(LRGDPPC)	d(INTERNET)	d(Gov_effect)	d(FD)	d(LNTL)	d(INF)	d(LNGFCF)
With Constant	t-Statistic	-11.9912	-4.3854	-3.9575	-4.5338	1.2572	-6.4200	-3.7092
	Prob.	***0.0001***	***0.0006***	***0.0026***	***0.0004***	***0.9983***	***0.0000***	***0.0056***
		***	***	***	***	n0	***	***
With Constant & Trend	t-Statistic	-11.9041	-4.4760	-3.9293	-4.5537	0.0563	-6.3730	-3.7604
	Prob.	***0.0000***	***0.0030***	***0.0151***	***0.0023***	***0.9964***	***0.0000***	***0.0238***
		***	***	**	***	n0	***	**
Without Constant & Trend	t-Statistic	-11.1769	-4.1400	-3.9627	-4.5610	-1.0886	-6.4567	-2.8978
	Prob.	***0.0000***	***0.0001***	***0.0001***	***0.0000***	***0.2483***	***0.0000***	***0.0042***
		***	***	***	***	n0	***	***

Lag Order Selection Criteria

VAR Lag Order Selection Criteria
Endogenous variables: LRGDPPC INTERNETT Gov_effect INTERACT INF FD LNTLF LNGFCF
Exogenous variables: C
Date: 11/17/22 Time: 23:38
Sample: 2000Q1 2020Q4
Included observations: 78

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-917.3232	NA	2.782171	23.72624	23.96795	23.82300
1	69.28823	1745.543	1.49e-10	0.069533	2.244956	0.940395
2	321.7887	394.9367	1.25e-12	-4.763813	3.654680	-3.118852
3	379.5014	78.43000	1.67e-12	-4.602599	1.440244	-2.183538
4	445.5668	76.22938*	2.07e-12	-4.655560*	0.320993*	-1.462399*
5	666.6938	209.7872	5.95e-14	-8.684457	1.225805	-4.717197
6	790.7371	92.23727	2.92e-14*	-10.22403	1.619945	-5.482667

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Co-integration Test

F-Bounds Test			Null Hypothesis: No levels relationship	
Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	4.943503	10%	2.03	3.13
K	7	5%	2.32	3.5
		2.5%	2.6	3.84
		1%	2.96	4.26
Actual Sample Size	80		Finite Sample: n=80	
		10%	2.129	3.289
		5%	2.476	3.746
		1%	3.233	4.76

t-Bounds Test			Null Hypothesis: No levels relationship	
Test Statistic	Value	Signif.	I(0)	I(1)
t-statistic	-5.105243	10%	-2.57	-4.23
		5%	-2.86	-4.57
		2.5%	-3.13	-4.85
		1%	-3.43	-5.19

ARDL Output

Dependent Variable: LRGDPPCQ
Method: ARDL
Date: 11/13/22 Time: 10:29
Sample (adjusted): 2001Q1 2020Q4
Included observations: 80 after adjustments
Maximum dependent lags: 4 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (4 lags, automatic): INTERNETT GE33 LNTLFF LNGFCFLCC INTERACT FDD INFQ
Fixed regressors: C
Number of models evalulated: 312500
Selected Model: ARDL(4, 2, 4, 4, 2, 2, 4, 3)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LRGDPPCQ(-1)	0.424213	0.103727	4.089709	0.0002
LRGDPPCQ(-2)	0.133624	0.117909	1.133283	0.2628
LRGDPPCQ(-3)	0.000304	0.234410	0.001298	0.9990
LRGDPPCQ(-4)	-0.328658	0.165938	-1.980609	0.0535
INTERNETT	-0.007890	0.006056	-1.302858	0.1990
INTERNETT(-1)	0.025166	0.010570	2.380828	0.0214
INTERNETT(-2)	-0.022503	0.006665	-3.376509	0.0015
GE33	-0.000525	0.001943	-0.269917	0.7884
GE33(-1)	0.009067	0.003634	2.495127	0.0162
GE33(-2)	-0.007419	0.002856	-2.597546	0.0125
GE33(-3)	-0.001311	0.001950	-0.672527	0.5045
GE33(-4)	0.002253	0.001174	1.918889	0.0611
LNTLFF	16.60618	2.056245	8.075975	0.0000
LNTLFF(-1)	-38.54080	3.897827	-9.887766	0.0000
LNTLFF(-2)	24.20977	5.261478	4.601325	0.0000
LNTLFF(-3)	5.057804	5.404833	0.935793	0.3542
LNTLFF(-4)	-7.166677	3.217691	-2.227273	0.0308
LNGFCFLCC	0.048086	0.023656	2.032761	0.0477
LNGFCFLCC(-1)	-0.087163	0.037469	-2.326241	0.0244
LNGFCFLCC(-2)	0.066421	0.022168	2.996269	0.0044
INTERACT	0.000301	0.000178	1.688175	0.0980
INTERACT(-1)	-0.000907	0.000309	-2.932570	0.0052
INTERACT(-2)	0.000758	0.000193	3.928905	0.0003
FDD	-0.002917	0.002557	-1.140802	0.2597
FDD(-1)	-0.006601	0.004141	-1.594165	0.1176
FDD(-2)	0.002809	0.003949	0.711340	0.4804
FDD(-3)	0.003829	0.003610	1.060877	0.2942
FDD(-4)	-0.006657	0.002337	-2.847901	0.0065
INFQ	-0.000284	0.000310	-0.914511	0.3651
INFQ(-1)	-9.36E-05	0.000375	-0.249436	0.8041
INFQ(-2)	0.000705	0.000390	1.808898	0.0769
INFQ(-3)	-0.000367	0.000290	-1.266732	0.2115
C	5.076439	0.976351	5.199398	0.0000

R-squared	0.994385	Mean dependent var	10.85381
Adjusted R-squared	0.990561	S.D. dependent var	0.059886
S.E. of regression	0.005818	Akaike info criterion	-7.162593
Sum squared resid	0.001591	Schwarz criterion	-6.180007
Log likelihood	319.5037	Hannan-Quinn criter.	-6.768646
F-statistic	260.0906	Durbin-Watson stat	2.139872

Prob(F-statistic)	0.000000

*Note: p-values and any subsequent tests do not account for model selection.

Long Run Results

Levels Equation
Case 3: Unrestricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INTERNETT	-0.006784	0.002860	-2.371994	0.0218
GE33	0.002680	0.000597	4.488938	0.0000
LNTLFF	0.215800	0.077657	2.778899	0.0078
LNGFCFLCC	0.035489	0.005143	6.900232	0.0000
INTERACT	0.000197	8.16E-05	2.413969	0.0197
FDD	-0.012377	0.001512	-8.183631	0.0000
INFQ	-5.15E-05	0.000390	-0.132090	0.8955

EC = LRGDPPCQ - (-0.0068*INTERNETT + 0.0027*GE33 + 0.2158*LNTLFF + 0.0355*LNGFCFLCC + 0.0002*INTERACT -0.0124*FDD -0.0001*INFQ)

Short Run Results

ARDL Error Correction Regression
Dependent Variable: D(LRGDPPCQ)
Selected Model: ARDL(4, 2, 4, 4, 2, 2, 4, 3)
Case 3: Unrestricted Constant and No Trend
Date: 11/18/22 Time: 03:59
Sample: 2000Q1 2020Q4
Included observations: 80

ECM Regression
Case 3: Unrestricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.076447	0.750454	6.764501	0.0000
D(LRGDPPCQ(-1))	0.194729	0.101200	1.924194	0.0604
D(LRGDPPCQ(-2))	0.328353	0.113897	2.882887	0.0059
D(LRGDPPCQ(-3))	0.328658	0.141361	2.324950	0.0244
D(INTERNETT)	-0.007890	0.004732	-1.667483	0.1021
D(INTERNETT(-1))	0.022503	0.004986	4.513505	0.0000
D(GE33)	-0.000525	0.001611	-0.325699	0.7461
D(GE33(-1))	0.006477	0.001784	3.631479	0.0007
D(GE33(-2))	-0.000942	0.001140	-0.826621	0.4126
D(GE33(-3))	-0.002253	0.000930	-2.422238	0.0193
D(LNTLFF)	16.60614	1.553532	10.68928	0.0000
D(LNTLFF(-1))	-22.10082	2.481457	-8.906388	0.0000
D(LNTLFF(-2))	2.108828	2.908706	0.725006	0.4720
D(LNTLFF(-3))	7.166705	2.450687	2.924366	0.0053
D(LNGFCFLCC)	0.048086	0.018168	2.646733	0.0110
D(LNGFCFLCC(-1))	-0.066422	0.018477	-3.594792	0.0008
D(INTERACT)	0.000301	0.000139	2.159648	0.0359
D(INTERACT(-1))	-0.000758	0.000146	-5.205027	0.0000
D(FDD)	-0.002917	0.002024	-1.441259	0.1561
D(FDD(-1))	1.82E-05	0.002400	0.007602	0.9940
D(FDD(-2))	0.002827	0.002183	1.294955	0.2017
D(FDD(-3))	0.006657	0.002010	3.312411	0.0018
D(INFQ)	-0.000284	0.000216	-1.316302	0.1945
D(INFQ(-1))	-0.000338	0.000229	-1.475699	0.1467
D(INFQ(-2))	0.000367	0.000197	1.859090	0.0693
CointEq(-1)*	-0.770518	0.114307	-6.740783	0.0000

R-squared	0.902844	Mean dependent var	0.002472
Adjusted R-squared	0.857864	S.D. dependent var	0.014397
S.E. of regression	0.005428	Akaike info criterion	-7.337593
Sum squared resid	0.001591	Schwarz criterion	-6.563434
Log likelihood	319.5037	Hannan-Quinn criter.	-7.027210
F-statistic	20.07228	Durbin-Watson stat	2.139870
Prob(F-statistic)	0.000000		

* p-value incompatible with t-Bounds distribution.

Serial Correlation Test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.778485	Prob. F(2,45)	0.1806
Obs*R-squared	5.860284	Prob. Chi-Square(2)	0.0534

Breusch-Pagan-Godfrey Heretroskedasticity

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.864572	Prob. F(30,49)	0.6598
Obs*R-squared	27.68951	Prob. Chi-Square(30)	0.5869
Scaled explained SS	9.914589	Prob. Chi-Square(30)	0.9998

Ramsey RESET Test of Functional Form

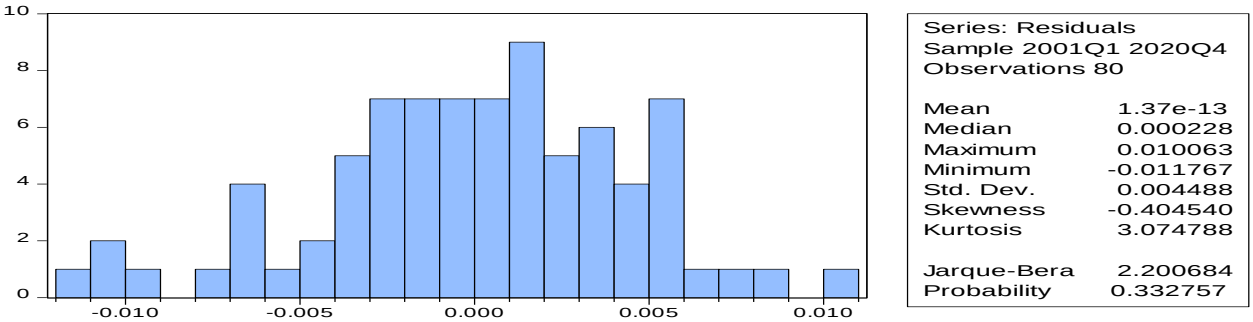
Ramsey RESET Test
Equation: EQ01
Specification: LRGDPPCQ LRGDPPCQ(-1) LRGDPPCQ(-2) LRGDPPCQ(-3) LRGDPPCQ(-4) INTERNETT INTERNETT(-1) INTERNETT(-2) GE33 GE33(-1) GE33(-2) GE33(-3) GE33(-4) LNTLFF LNTLFF(-1) LNTLFF(-2) LNTLFF(-3) LNTLFF(-4) LNGFCFLCC LNGFCFLCC(-1) LNGFCFLCC(-2) INTERACT INTERACT(-1) INTERACT(-2) FDD FDD(-1) FDD(-2) FDD(-3) FDD(-4) INFQ INFQ(-1) INFQ(-2) INFQ(-3) C
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	0.197731	46	0.8441
F-statistic	0.039097	(1, 46)	0.8441

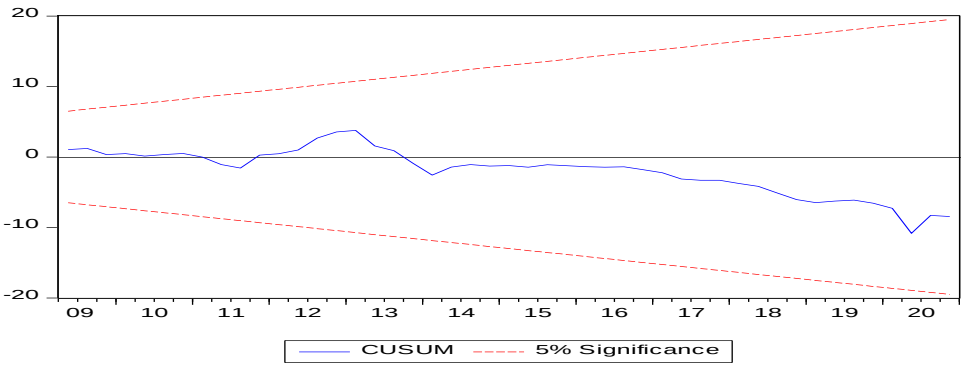
F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	1.35E-06	1	1.35E-06
Restricted SSR	0.001591	47	3.38E-05
Unrestricted SSR	0.001590	46	3.46E-05

Normality Test



CUSUM Test



CUSUM Square Test