# ADDIS ABABA UNIVERSITY

# SCHOOL OF GRADUATE STUDIES

## DETERMINANTS OF INTERNET PENETRATION IN DEVELOPING COUNTRIES: EVIDENCE FROM SUB-SAHARAN AFRICA

BY

DEGENET SHIFERAW

July, 2015

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Degenet Shiferaw

A thesis Submitted to the school of graduate studies of Addis Ababa University in Partial Fulfillment of the Requirements for the Degree of Master of Science in Economics (Economic Policy Analysis)

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***Abstract***

*Internet use, especially in developing countries, has expanded rapidly in recent years. Even in light of this, penetration rates differ markedly between developed and developing countries and across developing countries.*

*To identify the determinants of Internet penetration in low income countries of SSA, the study examines panel data for 25 SSA countries over the year 2009-2013 periods using Arellano and Bover (1995) dynamic panel data estimation technique. The study find evidence indicating that network externalities, GDP percapita, mobile cellular subscription, ICT goods import from developed countries, and urbanization are associated with high internet penetration rates. Estimates from Arellano Bover (1995) reveal that the main factor responsible for low rates of internet penetration is unemployment.*

*Hence, policy measures geared towards improving the countries investment in telecommunication sector, expanding productive employment should be given due emphasis if the economy is to benefit from internet use.*

***Key words****: Internet penetration, Dynamic Panel data, and SSA*

**Acknowledgement**

First of all, I would like to express my deepest gratitude to my advisor, Dr. Assefa Admassie, for his invaluable comments, encouragement, dedication, wonderful patience and Fatherly approach**.** Dr Assefa is a person which we youngsters could learn a lot from his strong research experience. My special thanks also goes to my Professors in Economics of AAU starting from undergraduate class.

My gratitude also goes to Internet society stuffs (at Geneva especially for Dr Micle kende and Dr Dawit Bekele) for their support in initiating this new area of study for sub Saharan Africa. A big sought should also goes to Addis Ababa University and African Economic Research Consortium (AERC) for the financial support in my two years of study.

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Thank you all!!!

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## List of Acronyms

| | |
|---|---|
| DSL | Digital Subscriber Line |
| GDP | Gross Domestic Product |
| GLS | Generalized Least Square |
| GMM | Generalized Method of Moments |
| GNI | Gross National Income |
| HDI | Human Development Index |
| ICT | Information Communication Technology |
| IDI | ICT Development Indicators |
| ISDN | Integrated Service Digital Network |
| ITU | International Telecommunications Union |
| LDC | Least Developed Countries |
| MDG | Millennium Development Goals |
| OECD | Organization for Economic Cooperation and Development |
| OLS | Ordinary Least Square |
| PPP | Purchasing Power Parity |
| SSA | Sub Saharan Africa |
| UN | United Nation |
| UNCTAD | United Nations Conference on Trade and Development |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| USD | United States Dollar |
| WB | World Bank |
| WDI | World Development Indicators |
| WSIS | World Summit on the Information Society |
| WWW | World Wide Web |

# CHAPTER ONE: INTRODUCTION

## 1.1 General Background

The diffusion of Information and Communication Technologies (ICTs) has been identified by international policy-makers and scholars as an important driver of economic development. At macro level, high penetration of technology benefits a country both by improving the quality of available human capital, increasing demand for technological goods and improving the collaboration in policy making through research and development. At micro level, households with access to new technologies gain several advantages, such as obtaining a better access to information and knowledge, improving communication efficiency, and gaining technological skills which are increasingly important in the job-market (Fairlie, 2006). Focusing on developing countries, ICT diffusion can also play a major role in poverty reduction, through better diffusion of information, more effective promotion of social programs and improved governance and political participation.

In this decade, information and communication technology (ICT), through its component the internet has been seen as a powerful tool for assisting poor countries to achieve further development (Sahay and Argerou, 2002). For instance, the world development report (2011) stated that, this new technology greatly facilitates the acquisition and absorption of knowledge, offering developing countries unprecedented opportunities to enhance educational system, improve policy formation and execution, and widen the range of opportunities for business and the poor (World Bank; 2011).

The internet is considered to be today's largest network that supports many new advanced services and a key to progress in communications and in the exchange of

knowledge, goods, services and technologies. The reason why the internet seems all powerful can be explained by two unique characteristics that no other previously existing information and communication mechanisms possess according to Jackson et al (2004). First, the internet is the largest information resources in the world. Second, it provides people with access to an interactive mechanism to directly communicate with each other. In fact the use of internet increases the social knowledge network, communication efficiency, decreases transaction cost and allows developing countries to "leap frog" from traditional methods of increasing productivity and hence considered as a key to human development causing massive innovation in the world (Steinmueller, 2003).

Internet enables people's mentality change, delivers culture and services and creates business opportunities for entrepreneurs. These benefits are not only for the users, but also for the whole community, and have huge local and global impact in regions where internet is used. Hence, access to internet in a country is not a privilege; rather it is a tool for achieving economic development and poverty reduction.

According to ITU (2014), although the number of internet users worldwide reaches almost 3 billion (40% of the world population had access to an internet by the end of 2014), diffusion rates across countries vary tremendously. In fact by the end of 2014, 78% of the total household in developed countries had internet access, whereas only 32% of households in developing countries had internet access (ITU, 2014).These disparities in technology diffusion may have important economic consequences because technology use may increase knowledge diffusion through improving communication efficiency (Jovanovic and Rob,1989),improve political engagement (Narris,2001) and by far it increases productivity (Brynjolfsson and Hitt,2003). The report further indicated that

there are many rural and urban areas in the world that are unconnected. The ITU statistics in 2006 indicates that Europe and North America which represent a mere 17.5% of the world population, house close to 50% of worldwide internet users. To make matters worse, the "digital divide" is steadily increasing.

In accordance with the Millennium Development Goals (MDGs), the 2003 phase of the World Summit on the Information Society (WSIS) held in Geneva agreed on a Declaration of Principles and a Plan of Action, setting ten targets and several action lines to be achieved by 2015. The targets put forward under the Plan of Action aim, *inter alia*, to improve ICT connectivity in villages, schools, scientific and research institutions, libraries, museums, post offices, national archives and government agencies, as well as adapting primary and secondary school curricula to meet the challenges of the information society; support the development of multilingualism on the Internet; and ensure access to ICTs for more than half of world's inhabitants. The Final WSIS Targets Review carried out by the Partnership on Measuring ICT for Development (2014) found that "while ICTs have grown tremendously and an increasing number of people are joining the globa l information society, major differences in ICT uptake and use persist." An analysis of the IDI over the WSIS period confirms this finding. According to ITU (2014) report, A comparison of IDI values of the 147 economies shows that the global IDI value has almost doubled from 2.52 in 2002 to 4.88 in 2013,

Underlining the considerable growth in ICT networks over the past decade, tremendous increases in ICT access and use were recorded in both in developed and developing countries. In absolute terms, the IDI increased most in developed countries, but, given their lower starting value, developing countries saw a higher relative growth in IDI from

2002 to 2013 (111 per cent). However, there was already a significant difference in terms of ICT development between developed and developing countries in 2002, and this divide is even more pronounced in 2013(ITU report on ICT measurement,2014).

The depth and pace of internet penetration are measurable and comparable across nations. Hence, given that the internet has revolutionized communication and information and even impacts the cultural economic and political development of a country, it is important to try to understand what the primary key factors that determine internet penetration.

To the best of our knowledge, there is no recent systematic econometric analysis on the determinants of internet penetration using current data focusing on countries especially for sub-Saharan Africa (low income countries).

### 1.2 Statement of the Problem

Sub Saharan Africa is one of the poorest region in which among the 33 poorest countries in the world, 28 are found in the region. The Economic performance of the region is poorer than any region in the world. The average annual growth rate of real GDP per capita was only 0.4 in the period 2008-2009, at the end of 2009 the region showed a global recovery, the GDP growth has increased to 4.2 percent in 2010 and further increased to 5.6 percent in 2012 (UNCTAD, WDI, 2013).However despite some progress made in the past, it has been far from meeting to bring sustainable development and eradicate poverty in the region, which remains the overarching goal of development policy in Africa.

Technology use should have been, therefore one of a very essential requirements to get rid of poverty to defuse knowledge and enhance production, access for the internet could

therefore be one of the key tools for achieving economic development and poverty reduction because Internet use increases knowledge diffusion through improving communication efficiency (Jovanovic andRob,1989),improve political engagement (Narris,2001), increases productivity (Brynjolfsson and Hitt,2003).Nevertheless, internet use in Africa is still at its lower stage used by 25 % of households in contrast to developed nations where 78 % of the households had an access for the Internet (ITU Report on Internet usage, 2014).On this issue, Castells (2006) argues that "differences in Internet access among countries and regions in the world are so considerable that they actually modify the meaning of the digital divide, and the kind of issue to be considered'.

ICTs where internet is one component continue to be an important factor in the development, effectiveness, and efficiency of both human and economic advancement. This is evident in the information sharing and network building that engulf most sectors (education, health, agriculture, financial markets etc.). Institutions and other business mediums continue to elevate towards more integrated and productive business environments ( Nacasius U. Ujah,2010).A higher level of investment on internet in the developing world will enhance growth and development which will also have many effects. A higher level of Internet users` percentage, and the increase in the percentage of Internet users would imply, on one hand, more clients and profits for companies and, on the other hand, new means for Policy makers to collaborate with the achievement of development goals.

The determinants of Internet diffusion in developing countries to economic advancement has been stressed in the policy arena although the research is scant. For developed economies, the literature is fairly well developed, while the implications for developing

countries are yet to be fully explored. To the extent that the pace of economic growth is dependent on new technologies and hence Internet, which is a means to transfer knowledge, it would be important to examine the factors that determine the uptake of Internet. Estimates from ITU in 2013 indicated that Internet penetration rates for developing countries have increased seven-fold since their 1999 levels.The surge in Internet trends is not specific to developing countries as technology use rates are considerably higher now than they were just a few years ago for almost every country in the world.

A few studies have focused on the topic, although technology use in developing countries is a fast moving target. One of the empirical studies was conducted by Hargittai (1999). It focuses on the Internet penetration in 18 countries, using OLS regression for a cross-section of countries. The main finding of the paper is the importance of wealth and market competition for Internet diffusion. Susmita Dasgupta et al.(2001) conducted an empirical study of Internet diffusion based on data for 44 countries. They use data for growth in Internet penetration from 1990 to 1997 in a cross-section of countries and estimate a model using OLS. They found that wealth is not statistically significant (on the contrary of the previous paper) and their significant factors are size of urban population and index of competition policy. However there are a number of differences between the two papers. The former deals with OECD countries only whereas the latter with both developed and developing countries. Secondly, the time periods differ. Third, the first paper is based on levels and the second one on growth data.

Sampsa Kiiski and Matti Pohjola studied Internet penetration by using three frameworks. First, with only 23 OECD countries. They used OLS cross-country estimation based on

growth between 1995 and 2000. Second, they added 37 developing countries. They provide both cross-country and panel data estimation. Third, they used a simultaneous equation framework by considering an equation for GDP and access cost (proxied by telephone access cost) in addition to an Internet diffusion equation. The wealth level is found to be significant for Internet diffusion; internet access costs have negative impact in OECD countries whereas they have no impact for a larger set of countries. However, in the simultaneous equation model they found a negative impact for OECD countries. Education appears to be significant for the larger set of countries but not for OECD countries.

Menzie D. Chinn and Robert W. Fairlie studied the Internet penetration in 1999-2001 in 161 countries. They conducted a similar study for 2002-2004 . They use panel data random effect estimation, i.e. GLS estimation. They found wealth is important for Internet penetration. Also important is the rule of law. Somewhat surprisingly, the share of urban population has a negative impact for the earlier periods.

The studies mentioned above are interesting by themselves but they often have contradictory results. The limitation of the previous studies is that they used static estimators despite the fact that the process is clearly dynamic. This leads to the omitted variable bias. Furthermore, previous studies focused on OECD countries only or on OECD and developing countries in one sample or a sample of developing countries which includes lower middle and lower income countries. However, since the nature of technology diffusion (including Internet) in developing countries is suggested to be different, it is worth considering developing countries in a separate sample.

To fill the gaps of the previous studies, first, the study will use a data set for low income countries only since the pattern of Internet diffusion is different for developing and developed nations due to difference in economic status. Hence I will do an empirical study of internet use focused in low income countries of sub Saharan Africa which includes a set of variables for economic, infrastructure, institutional and the impact of network effects.

Second most of the papers mentioned used static estimators despite the fact that the process is clearly dynamic. This leads to the omitted variable bias. To avoid it, the lag of the Internet diffusion has to be included into the model. The study then uses a dynamic estimator. The endogeneity of some repressors may also be an issue and needs to be solved before concluding about the consistency of the estimates.

Furthermore, it is not only the generation of new technology but also, and perhaps even to a higher extent, its diffusion throught the economy which affects productivity growth at the micro and hence at macro level. Pilat and Lee (2001), for example, show that to capture the benefits of "Information and communication Technologies"(ICT) it is not necessary to dispose of an ICT producing sector. Timely diffusion of new technology or, from the firm's point of view, its adoption is a key element to securing economic growth. It is thus not surprising that technology policy stresses the importance of the capacity to absorb and successfully apply technological knowledge. From this perspective, understanding the factors determining technology adoption, the internet becomes highly relevant also from the policy point of view.

### 1.3 Objective of the study

The overarching objective of this study is to identify the major factors that determine internet penetration in sub Saharan African countries. The specific objectives of the study are:

- To measure the effect of socio-economic factors that determines internet penetration in sub-Saharan Africa.
- To examine the effect of public administration on Internet use in sub Saharan Africa countries.
- Based on the above to come up with policy recommendation.

### 1.4 SIGNIFICANCE OF THE STUDY

The significance of the study rests on its expected outcome in terms of probing into new information regarding the main determinants of Internet usage. The results of the study will be useful in the information they provide to formulate practical policies for promoting internet deployment. Moreover, higher number of internet users in a country is a sign of higher sharing of information, which is important for the development of a country where today Information plays its main role in adopting new technologies. Hence, the out puts of the study will serve as an input for policy makers to design effective strategies and policies that can promote the usage of internet in the country, and to have a better understanding of the socio-economic factors that affect Internet penetration in the country. The research will also contribute to the literature by providing the estimates of network effects on Internet penetration, and an analysis of the determinants of Internet Penetration over the past few years for the 25 countries in sub Saharan Africa.

### 1.5 Scope and limitation of the study

Lack of data for the basic determinants of internet use has led us to select only 25 countries out of 48 SSA countries. This means a loss of degrees of freedom that makes some of the coefficients insignificant. On the other hand, it makes the Hansen test of over identifying restriction weak forcing us to use only the first appropriate lags of the covariate as instrument and to reject the difference GMM estimation. Moreover, the data for cost of internet subscription is not available for SSA countries .As a result inflation is used as a proxy measure of cost of using internet in SSA since most of the goods to use internet services is imported one hence it is plausible to assume that if a country is inflationary then it could hamper the use of internet.

### 1.6 Organization of the thesis

The rest of the chapters are organized as follows. The second chapter reviews the theoretical and empirical literature on internet penetration. The third chapter specifies the theoretical and econometric model while the fourth chapter consists of descriptive and econometric data analysis. The last chapter provides conclusions and policy implications.

# CHAPTER TWO: LITERATURE REVIEW

## 2.1 Basic Concept and Evolution of Internet

ICT (information and communications technology - or technologies) is an umbrella term that includes any communication device or application, encompassing: radio, television, cellular phones, computer and network, hardware and software, satellite systems and so on, as well as the various services and applications associated with them, such as video conferencing and distance learning. Internet which is one of the components of ICT is a means of connecting a computer to any other computer, or computer to any electronic device, or any other electronic devices interconnected each other via dedicated routers and servers to share information, audio, video and other outputs .Internet can also be defined as a world-wide computer network that can be accessed via a computer, mobile telephone, PDA, games machine, digital TV, etc. The Internet access service can be provided through a fixed (wired) or mobile network: analogue dial-up modem via standard telephone line, ISDN (Integrated Services Digital Network), DSL (Digital Subscriber Line) or ADSL, Cable modem, High speed leased lines, Fiber, Power line, Satellite broadband network, WiMAX, Fixed CDMA, Mobile broadband network (3G, e.g. UMTS) via a handset or card, Integrated SIM card in a computer, or USB modem. http://www.business.com/definiton/internet (accessed Oct 26,2014).

The evolution of the Internet is part and a continuation of the development of ideologies that evolved in the West after World War II. These ideologies have focused on technology and science to enhance "large scale industrialization, militarization, and national political power". The development of such tenets was a

reaction to the fear on the part of the main Western powers to lose their political and economic edge in the aftermath of the War and as a result of the national liberation movements across the "Third World." It was also part of the staging of the Cold War between the two emergent superpowers, the United States and the Soviet Union Shahidullah,( 2008).

The historical era that gave birth to the Internet witnessed similar technological advances, such as space shuttles, nuclear power, computers, and satellite television, which all originate in political and economic interests (Nicholas, 2003; Bromley, 1998). The Internet itself was developed in the late 1960s to provide "a secure and survivable communication network for organizations engaged in defense-related research". In its evolution over the following two decades, the Internet remained under the control of a few politicians and scientists assembled mostly in North America and Europe. In this initial phase, the new medium served primarily as a new channel of communication and information sharing, particularly among different academic communities, featuring many aspects of earlier communication media and adding to them interconnectivity, interactivity, and efficiency(Internet Society, 2006) .

In the early 1990s the Internet was commercialized under corporate economic pressures. The previously "regulated" environment of the internet became completely uncontrollable with the development of spam and virus traffic. Interestingly, however, because of its "uncontrollable" nature, the Internet fits within and supports the free market system within which most Western corporations operate. Corporations aimed at harnessing the Internet to create "an infinitely expanding cyber

market" (Scolve, 1998). The technology industries (computers, electronics, cables, microprocessors, etc.) were first to capitalize on the new medium through supporting the spread of the Internet, the computer industry was inducing a new culture of technological consumerism, which automatically necessitates "an endless series of upgrades" to satisfy the industry's desire to increase its share of the market (Bowers, 1998, cited in Shahidullah, 2008).

The commercialization of the Internet has allowed the corporate to shift emphasis from producing and controlling material goods to controlling information. Information became "something produced, exchanged, and used within the framework of a market economy". This shift to an information-based economy has necessitated new information-based domains and new markets. This explains the intense competition among major technology industries to extend their control over universities, schools, libraries and other public spheres. The ensuing information revolution has generated a dynamic economic sector, incorporating web-based companies, virtual universities, cyber-stores, and so on. Even industries that do not rely heavily on information have utilized the Internet to propagate their merchandize, attract more clientele, reduce secretarial labor, and gain more profit through online sale activities. Commercial undertakings have become a characteristic feature of the World Wide Web in particular, shaping its design, tone, content, language, and usage (Agre, 2003).

The economic boom introduced by the Internet in terms of flow of money, job creation and increased efficiency has given Western industries and business a competition advantage in the regional and global marketplace. In fact, the Internet has

helped renew Western economic hegemony through controlling the information capital, the lifeblood of the new information-based industries. These advantages have prompted the technology industries to internationalize the new medium, extending its reach to more than 3 billion international users (ITU, 2014 report). This technological explosion did not happen by chance, especially if we consider the huge profits that the electronic corporate giants (Google, Yahoo, EBay, Amazon, etc.) have reaped from online business. According to the Silicon Valley Investment Indicators (2006), the net profit of each of the top ten electronic companies was above $ 1 billion in 2005. The internationalization of the Internet not only helped Western corporations extend their marketplace worldwide but also facilitated the world's shift to a more open and global society. Because international business and economy is controlled by the same countries and forces that nurtured the Internet culture, the adoption of the Internet and other network technologies became not only an option, but a must dictated by "international standards" in business, communication, and global labor.

Technology corporations have taken a proactive role in the diffusion of the Internet in developing countries. These corporations have offered various incentives and initiated several projects in Africa, Asia and Latin America to ensure their "connectivity" to the Internet and to the rest of the world. Examples of these projects include Information and Communications Technologies for Development in the Middle East and North Africa, Science and Technology program in developing countries, and ICT R&D Grants Program for Asia and the Pacific Region. Computer companies were bringing the network technologies into developing countries "in their own self-

interest rather than as philanthropy because today's poor countries are potential growth markets of tomorrow" (Bu-Hulaiga, 2001).

Interestingly, the dissemination of the Internet in developing countries was associated with promises of economic development opportunities, positive social change, and political participation chances for disenfranchised groups (Wheeler, 2004). It was argued that the Internet and related network technologies support economic growth, contribute to human resource advancement, and make possible leapfrogging over certain development constraints. Moreover, they empower individuals in the exercise of their right to receive, produce, and circulate information and ideas beyond national borders. Further, they facilitate intercultural communication where differences of race, ethnicity, and class disappear. In fact, industrial and corporate forces were often behind this technological idealization (Watson, 1998; Noble, 1998; De Castell et al, 2002). Such images have been propagated throughout the globe mainly for industrial and corporate profit.

### 2.2 General overview of Internet penetration

In this decade, information and communication technology (ICT), through its component the internet has been seen as a powerful tool for assisting poor countries to achieve further development (Sahay and Argerou, 2012). For instance, the world development report (2011) stated that, this new technology greatly facilitates the acquisition and absorption of knowledge, offering developing countries unprecedented opportunities to enhance educational system, improve policy

formation and execution, and widen the range of opportunities for business and the poor (World Bank; 2011).

The internet is considered to be today's largest network that supports many new advanced services and a key to progress in communications and in the exchange of information, Knowledge through E-learning, goods, services and technologies. The reason why the internet seems all powerful can be explained by two unique characteristics that no other previously existing information and communication mechanisms possess according to Jackson et al (2004). First, the internet is the largest information resources in the world. Second, it provides people with access to an interactive mechanism to directly communicate with each other. In fact the use of internet increase the social knowledge network, communication efficiency, decrease transaction cost and allow developing countries to "leap frog" traditional methods of increasing productivity because better access to Internet in the developing countries will, for example, enhance education opportunities through e-learning, improve the business environment for industries who could sell or advertise their products on the web, reduce drastically the communication costs etc. All these factors can also contribute to economic growth and hence considered as key to human development causing massive innovation in the world (Steinmueller, 2003).

Internet enables people's mentality change, delivers culture and services and creates business opportunities for entrepreneurs. These benefits are not only for the users, but also for the whole community, and have huge local and global impact in regions where internet is used. Hence, access to internet in a country is not a privilege; rather it is a tool for achieving economic development and poverty reduction.

According to ITU (2014), although the number of internet users worldwide reaches over 3 billion, diffusion rates across countries vary markedly. In fact by the end of 2012, 78% of the total household in developed countries had internet access, whereas only 32% of households in developing countries had internet access (ITU, 2014) .The report further indicates that Europe and North America which represent a mere 17.5% of the world population, house close to 50% of worldwide internet users. To make matters worse, the "digital divide" is steadily increasing.

These disparities in technology diffusion may have important economic consequences because technology use may increase knowledge diffusion through improving communication efficiency (Jovanovic and Rob,1989),improve political engagement(Narris,2001) and by far it increases productivity(Brynjolfsson and Hitt,2003). It is further indicated that there are many rural and urban areas in the world that are unconnected.

In accordance with the Millennium Development Goals (MDGs), the 2003 phase of the World Summit on the Information Society (WSIS) held in Geneva agreed on a Declaration of Principles and a Plan of Action, setting ten targets and several action lines to be achieved by 2015. The targets put forward under the Plan of Action aim, inter alia, to improve ICT connectivity in villages, schools, scientific and research institutions, libraries, museums, post offices, national archives and government agencies, as well as adapting primary and secondary school curricula to meet the challenges of the information society; support the development of multilingualism on the Internet; and ensure access to ICTs for more than half of world's inhabitants. The Final WSIS Targets Review carried out by the Partnership on Measuring ICT for

Development (2014) found that "while ICTs have grown tremendously and an increasing number of people are joining the global information society, major differences in ICT uptake and use persist." An analysis of the IDI over the WSIS period confirms this finding according to the review by partnership on measuring ICT. A comparison of IDI values of the 147 economies for which data were available for 2002 and 2013 shows that the global IDI value has almost doubled from 2.52 in 2002 to 4.88 in 2013, underlining the considerable growth in ICT networks over the past decade. Tremendous increases in ICT access and use were recorded in both developed and developing countries. In absolute terms, the IDI increased most in developed countries, but, given their lower starting value, developing countries saw a higher relative growth in IDI from 2002 to 2013 (111 per cent). However, there was already a significant difference in terms of ICT development between developed and developing countries in 2002, and this divide is even more pronounced in 2013(ITU report on ICT measurement,2014).

### 2.3 Theories of Internet Diffusion and Innovations

A deeper and richer understanding of the multifaceted and complex process of diffusion and adoption of internet requires an integration of theories from diverse perspectives (Kallol, 2007).Theoretical and practical evidence suggests that political and government policy play important roles in the diffusion of modern ICT and hence the internet. Diffusion theories that relate diffusion pattern with political structure in a country argue that a technology is not equally compatible with all types of political structures. These theories, for instance, predict that authoritarian government have relatively less favorable attitudes towards developing interpersonal means of

communications such as telephone and the internet (e.g Groth and Hunt 1985; kshetri, 2001; kshetri and Dholakia2001 ), postulate that Marxist government allocate relatively smaller proportions of resources for the development of interpersonal communication means.

Since diffusion of innovation requires an understanding of "people, hardware, software, communication network and data resources that collects transforms and disseminates information" (O'Brien 1996), theories from information system are well suited for explaining such aspects of the diffusion and adoption phenomena.

Diffusion and adoption of ICT's entail decision at various levels (individual, organization, national, international) about allocation of scarce resources (Andrews 2002). Economic theories help explain how individuals, organizations and governments make decisions regarding the allocation of resources in ICT investment. Basic demand and supply theories are helpful in explaining the varied distribution patterns of the internet across countries. For instance, income can be expected to be positively associated with the demand for modern ICT products (Gatignon and Robertson 1985: Rogers 1983).

Geography and geopolitics are important aspects of international business in general (As-Saber, Liesch ad Dowling 2000) and global diffusion of internet in particular. Geopolitical theories help in answering questions such as, "why are things located where they are? How do different places related to each other? How have geographic patterns and relationships changed over time?" (Baewald 1996, P.23, Cited in IJEDICT,2008,Vol.4).

Geopolitical variables include population (Cohen 1963) as well as characteristics of population such as skills, educational qualifications, productivity and the cost of labor (AS-Saber, Liesch and Baerwal 2000). Literacy rate and English language skills are other geopolitical factors likely to influence the diffusion of innovations. Such skills are associated with the availability of information and the proficiency required to use a new technology or the inter-relatedness among users and producers of the technology (Cassiolato and Batised, 1996).

Geopolitical variables such as geographical distance between adopting units influence the level of terrestrial barriers and hence the diffusion of the internet (Gatignon and Robertson 1985). Origination of the internet in the US is one of the major factors responsible for the disproportionately higher number of internet users is North America. Furthermore, high band width backbones were created first in North America, followed by Europe, and data traffic to other regions was constrained by low band width connectivity (Roberton, 2000).

## 2.4 Theoretical foundation on Factors Impacting the Diffusion of Internet

### 2.4.1 Economic factors

Economic factors have a huge influence in the adaptation of new technologies by a country and its citizens. A country's overall economic strength will affect internet diffusion in that the necessary resources are more likely to be present, and capital required for the expansion of the technology is more available, in richer countries (Hargittai 1999).

Economic factors such as income level, economic growth level, economic growth rate, inflation, availability and price structure of ICT products and services, and bandwidth and supporting infrastructure influence the diffusion of the internet (Kshetri, 2001).The economic growth level of a nation (usually measured by GDP per capita) is critical to most ICT diffusions. High income, high education, and human resources play an important role in high economic and ICT growth (Bagchiet al. 2004: Barro 1991).

The development of internet infrastructures is closely associated with access to venture capital investment in today's globalized economy. Venture capital investment is typically associated with high technology industries, such as biotechnology and ICT (Information and Communication Technology). The geographical factors shaping the location of the internet industry include external economies, the ability to create and commercialize new knowledge, and the availability of skilled labor (Zook 2002).

The venture capitalists invest their money in well-urbanized, economically prosperous regions so that they can earn profit, which creates a snowball effect for developed countries. As a result they develop and prosper more. On the other hand, countries that are poor are destined to be poorer. The difference keeps on widening everyday between the information rich and information poor. After all, the strongest factors that shape the location of demand for internet services are the density of human settlement and the location of industry (Greenstein,2004).

Wealthier nations tend to have a greater demand for and supply of new technologies because they can afford more (Milner 2003). Wealthier countries also tend to adopt innovations earlier, as their consumers can afford the greater economic sacrifice associated with investment in new and initially more expensive innovation (Dekime et al, 1994: Hovav and Schuff 2005) furthermore, countries whose people are better off economically tend to have higher internet penetration (Elie 1998, Gruber and Verbove 2001). In general when it comes to adopting new technologies, richer countries have well-developed market economies and well-established legal systems and as a result are able and willing to invest more in research and development and hence innovation. It is therefore, expected that the level of economic growth (GDP per capital) will related to internet diffusion.

Inflation plays a negative role in economic growth since the competitiveness of the country in terms of hard currency will be low and consequently may play a negative role in ICT growth (Davis and Kanago 1998).

### 2.4.2 Telecommunication and technology infrastructure

The internet is a fairly advanced technology in that it requires a well-functioning telecommunication network to be present in order to operate. At the beginning of the internet era, the presence of a traditional telephone line per computer was necessary in order to be able to connect the internet via modem. However, over the last few years, innovation has paved the way for a much faster internet via broad band, which depending on the technology, requires only a single phone line for an entire network of computers (all types of DSL) or even none at all (cable, satellite, fiber optics),

(Dholakia, 2003) while such technologies are readily available in most developed countries their availability in developing countries is rare. For instance, 50 percent of the worldwide bandwidth capacity is in North America compared to 3 percent in the Middle East and Africa (Frontline net 2001 cited in Kallol, 2007). Lower bandwidth results in longer time to transfer data and hence low relative advantages of internet use. Moreover, the lack of intraregional infrastructure in developing nations of Asia, Africa and Latin America means that even Internet communications with neighboring countries have to be routed through the US or other industrialized countries in Europe, further increasing the costs. When high bandwidth is available it becomes a driver of rapid internet diffusion (Frontline, net 2001 cited in Kallol, 2007).

### 2.4.3 Human development

Economic development growth theory states that industrial countries differ from developing countries by much more than their level of capital or even their human capital (Hoff and Stiglitz 2000). The inclusion of the term human capital in economic developmental growth theory is the recognition that people are important and essential elements of national development and growth (Welch 1970, cited in Hoff and Stiglitz 2000 ). Growth theorists have also suggested that the accumulation of human capital as an indicator of human development index (HDI) which is necessary to sustain long term growth (Hoff and Stiglitz 2000).

### 2.4.4 Educational standard and literacy rates

The population's level of education is relevant to the internet connectivity. In the case of the internet's global spread, countries with better educated population will be more

likely to show higher rates of internet diffusion than nations with less educated citizens (Hargittai 1999).

The World Wide Web and e-mail are currently entirely text based implying that literacy is required in order to be able to actually use the internet. Academic institutions play an essential role in adopting new technology. Indeed, schools are among the first institutions to heavily make use of the internet, and in doing so introduced young people to this new form of media (Robert farilie, 2006). Today, research and other important aspects of education rely on the use of the internet; hence, one can argue that education also promotes the adoption of the internet in this sense.

Literacy and education may not be enough to guarantee an "enjoyable" internet experience since internet tends to favor the English speaking population because most of the software and interfaces used in the internet are in English. Also, a large proportion of the WWW content is in English language. For instance, a survey conducted in 1998 found that about 85% of the text on the WWW were in English (Nunberg 2000), which decreased to about 80% in 1999 (Nua Internet Surveys 2000 cited (Nikhilesh, 2003) which further decreased to 50 percent in 2003 (Phaninpra, 2009). These numbers are so high because many nonnative English speakers choose to publish their websites in English in order to attract more surfers to their site.

### 2.4.5 Geopolitical factors

Many scholars suggest that the nation's institutional environment has a direct effect on internet connectivity. The institutional legal environment in a country is also

relevant to the internet's spread because national policies can enhance or hold back diffusion of technology, depending on their approach to regulating mechanisms, privatization, and free competition (Hargittai 1999).

National institutions can take measures to influence an innovation as well as diffusion of new technologies. Political support strongly influences the diffusion pattern of the internet. Investments in modern ICTs alone will not bridge the digital divide in the absence of political support (Koss 2001). Internet diffusion in several countries, especially the developing ones, has been hampered by political factors such as authoritarian government concern about the flow of information on the internet, tariff/non-tariff barriers to ICT products, and unfavorable regulatory environments that negatively influence the telecom markets (Kshetri, 2001). The internet has been described as "the greatest democratizer the world has ever seen" (Pitroda 1993, P.66, cited in Kshetri, 2001). It is thus, incompatible with most of the authoritarian regimes.

Tariff and non-tariff barriers and regulations in telecom markets are hindering e-commerce development in some developing markets. Many developing countries tend to treat ICT products as Luxury items and impose import duty, value added tax, sales tax, etc, making these products expensive and unobtainable (Koss 2000).

A politically non free and unstable country is likely to hinder the usage of new media in general. This is particularly true when it comes to the internet, where anti-government websites are only click away and typically hard to censor. Thus, it is reasonable to assume that countries that are less free will have lower penetration rates, partly due to the problems that the internet creates for their government (luis,

2005). In fact, Buchner (1988) demonstrates that communist countries tend to have fewer telephone lines per capita than their counterparts, and that this difference is indeed primarily due to the regime itself. It would therefore, not be surprising to see this phenomenon also apply to the internet and this could be captured by the quality of public administration in such a way that more liberal economy have high quality of administration in the development of new technology while non-free economy has low quality of administration (Kshetri, 2001).

ICT policies play vital roles in facilitating ICT developments, promoting investment in the ICT industry that will in turn boost the nation's economy .Favorable ICT policies ensure that ICT products are affordable and accessible and it will also able to address issues on ethical and moral conducts, copyright and cyber crimes. Good ICT policies offer certain conveniences such as ensuring the development of information infrastructure, information transfer in a nation, proper information planning development, low cost of access, efficiency in the provision of telecommunication network, to mention but a few. ICT policies can contribute to increasing the development rate in developing countries because they serve as development infrastructure facilitators. The rapid growth in the field of ICT and the growth of the information services sector have radically changed the world. These changes have given birth to a new society. According to Dzidonu (2002), if developing countries are to achieve rapid and radical social and economic transformation in the new information age, to be dominated by information and knowledge-based economies, they will need to implement comprehensive ICT-led socio-economic development policies, strategies and plans.

### 2.4.6 Innovation variables

A nation's innovativeness may play a positive role in internet or other ICT diffusion, where innovativeness may best be measured by a country's research and development (R&D).Schuff (2005) found that early adopters of a new technology are firms that spend more on R&D,an increase in R&D activities will promote an increase in the number of researchers, number of scientific articles and number of patents which further increase the diffusion of internet and new technologies (Hovan and Schuff, 2005).

### 2.4.7 Environmental Variables

Environmental factors refer to the atmosphere in which the market place operates in and includes such considerations as heterogeneity levels such as the level of urbanization

### 2.4.8 Level of urbanization

Urbanization defined as urban density or percentage of residents living in urban areas may be viewed as a factor impacting ICT and hence Internet diffusion since urban centers is typically wealthier and tends to be more innovative (Gatignon et al. 1989).

It is generally acknowledged that urban environments play a vital role in education, culture, and productivity. Consumers living in the country's major metropolitan areas tend to be more cosmopolitan (Hanner 1990), and because metropolises also tend to have a denser retail infrastructure, it is easier for consumers to acquire a new product.

## 2.5 Global Diffusion of the Internet

Starting with just a few countries in 1990, the number of countries connected to the internet crossed 198 countries today (ITU, 2014). The diffusion pattern of the internet, however, varies widely across the world. The ITU report on Internet (2014) revealed that only 32% of the developing world population had access to internet whereas 78% of the developed world population had access to the internet. Country wise China, US and India took the top three In terms of the number of Internet users while Marshal Islands and Niue took the lowest internet users in the world.

North America, where the internet originated has over 279 million users accounting for 10% of the world's users but only 4.4% of the world's population. Asia pacific, with over 60% of the world's, is experiencing the most rapid growth n recent years, where china for instance having 45.8% penetration rate according to ITU statistics in 2014.

### 2.5.1 Fixed (wired)-broadband and mobile-broadband markets

Infrastructure deployment providing access to broadband Internet continues to be a priority for telecommunication service providers and governments in most countries. This is reflected in the continuous growth in the number of mobile- and fixed-broadband subscriptions worldwide. In 2014, fixed-broadband subscriptions reach a total of 711 million globally, corresponding to a penetration rate of almost 10 per cent , as against 220 million and 3.4 per cent in 2005. Distinct patterns can be observed, between developed and developing regions. In most developed countries, fixed-

broadband penetration has already reached relatively mature levels, with a penetration of 27.5.

In developing countries, fixed-broadband penetration growth rates have dropped from 18 per cent in 2011 to 6 per cent in 2014, reaching an overall (low) penetration rate of 6 per cent by end 2014, and less than 1 per cent in LDCs. This slowdown in/low growth of fixed-broadband subscriptions, despite low penetration, coincides with a strong growth in mobile-broadband subscriptions in the developing world (ITU report, 2013).

A closer look at different regions shows that the Asian States and CIS are the regions with double-digit fixed-broadband penetration growth rates, whereas the Americas(north and south) region displays the lowest growth in fixed broadband, estimated at 2.5 per cent and reaching a penetration rate of around 17 per cent by end 2014. Asia and the Pacific stands out as a region registering relatively low fixed-broadband penetration (7.7 per cent) and a sharp decline in the growth of fixed broadband over the past four years (ITU report,2013). Europe's fixed-broadband penetration is much higher compared with other regions and almost three times as high as the global average: 27.7 per cent and 9.8 per cent, respectively. The Arab States region stands out with a low fixed-broadband penetration of 3.1 per cent by end 2014, the second lowest among all regions next to Africa and considerably below the global average of almost 10 per cent. As compared with other key ICT indicators, the region performs lower next to Africa.

Mobile broadband remains the fastest growing market segment, with continuous double-digit growth rates in 2014 and an estimated global penetration of 32 per cent – four times the penetration rate recorded just five years earlier (ITU report, 2014). Nevertheless, the divide between developed and developing countries remains huge: mobile-broadband penetration reaches 84 per cent in the former compared with 21 per cent in the latter. .

A closer look at the different mobile technologies and their market shares highlights the shift from lower-speed to higher-speed technologies over the past 15 years. In developed countries, 3G subscriptions overtook 2G subscriptions in 2010 and 3G growth is flattening. In developing countries, the large majority of subscriptions are still 2G.4G services came onto the market only recently and 4G subscriptions still account for only a small market share, in both developed and developing countries.

The data on fixed- and mobile-broadband uptake confirm what has been observed on the ground. In developed countries, fixed-broadband infrastructure and services were available much earlier than in most developing countries, and before fast mobile-broadband services and smartphones entered the market. This has contributed to the higher uptake of fixed broadband in developed countries. In developing countries, by contrast, on account of the limited fixed-broadband infrastructure and the lack of affordable fixed-broadband service offerings, mobile-broadband services are increasingly becoming an alternative to fixed broadband, and indeed the preferred choice of consumers. Furthermore, the mobile market has benefited from a more liberal regulatory approach than the fixed market, further contributing to its successful growth (ITU, 2014).

It should be noted that the numbers of fixed- and mobile-broadband subscriptions are, strictly speaking, not comparable. Fixed-broadband connections are mostly shared connections and deployed to a (physical) building (belonging to, for example, households, cybercafés, businesses or other public and private organizations). Mobile-broadband subscriptions are not bound by physical connections and usually refer to individuals, and – in the same way as with mobile-cellular subscriptions – there is a certain amount of double counting involved, for example when people use multiple devices (e.g. smartphone, tablet) and SIM cards.

### 2.5.2 Households with Internet access `in the World

Household access to the Internet is the ultimate way of guaranteeing an inclusive information society in which all people, irrespective of age, gender, employment status, etc. or possible level of disability, can access the Internet within the privacy and proximity of their own home. Household access is also mostly shared access, whereby all family members can use the same service and share the subscription fees.

The latest ITU data show that by end 2014, almost 44 per cent of the world's households have Internet access at home, up from 40 per cent one year earlier and 30 per cent four years earlier. Household Internet access is growing steadily, and strongly, at 9 per cent over the past year. Global growth is mostly driven by developing countries, where household Internet access is growing at 14 per cent as compared with around 4 per cent in developed countries. By end 2014, 78 per cent of households in developed countries have Internet access, compared with 32 per cent in developing countries and 5 per cent in LDCs. In absolute terms, the number of

households with Internet access in developing countries surpassed those in developed countries in 2013, and doubled between 2010 and 2014(ITU,2014).

A comparison across regions reveals huge differences: while 78 per cent of households in Europe have Internet access and numbers are approaching saturation rates (with 2.4 per cent growth in 2014), **only 11 per cent of households in Africa have internet access**.

The Asia and the Pacific region boast the highest number of households with Internet access in absolute terms, with close to 350 million estimated by end 2014, i.e. almost as many as in the Americas and Europe combined. However, the large majority of them are in China and India. If we take out these, the two largest countries, the number of households with Internet access in the region amounts to (only) 109 billion. Penetration rates in the Asia and the Pacific region are well below the global average and some two-thirds of the household in the region are not yet connected to the Internet (ITU, 2014).Largest countries, the number of households with Internet access in the region amounts to (only) 109 billion. Penetration rates in the Asia and the Pacific region are well below the global average and some two-thirds of the household in the region are not yet connected to the Internet (ITU, 2014).

As is the case with other indicators, there is a significant urban-rural divide when it comes to household Internet access. In countries where data are available, rural household access falls far below urban household access, with differences ranging from 4 per cent (meaning that household Internet penetration in urban areas is 4 per cent higher than in rural areas) in highly developed countries such as Japan and the

Republic of Korea to 35 per cent in developing countries such as Colombia and Morocco. In Guatemala, urban households are 12 times more likely to be connected to the Internet than rural households (Partnership, 2014)

## 2.6 Empirical Literature Review

### 2.6.1 Empirical Literature on ICT and internet penetration in the world

The literature contains a lot of studies on other information and communication technologies penetration. One of these largely cited was conducted by Francesco Caselli and Wilbur John Coleman (1990). They consider a sample of 89 countries (both developed and developing) from 1970 to 1990. They restricted their data on 5-year gaps (i.e. 1970, 1975, etc.) because of limited data accessibility so that finally the panel includes only 6 observations per country. The estimation was made with GLS panel data random effect estimator. They found wealth is important for ICT penetration. The estimation however does not include the lagged dependent variable. In some estimation the number of observations is very small.

Caselli and Coleman (2001) examine a cross-country dataset encompassing up to 89 countries over the years 1970-1990, focusing on the ratio of computer imports to worker, as a proxy measure for the investment in ICTs. In attempting to explain the variation in this variable, they rely on a large set of variables, including income per worker, investment per worker, the sectoral shares of agriculture, the sectoral shares of manufacturing, human capital, imports and exports from and to the OECD. They also include an institutional variable, in this case an index of property rights.

Openness to imports from OECD countries, the level of educational attainment are two notable variables with statistical significance.

There exist some studies on Internet penetration. One of the empirical studies was conducted by (Hargittai, 1999, Cited in Xidingchen ,2007). It focuses on the Internet penetration in 18 OECD countries, using OLS regression for a cross-section of countries. The main finding of the paper is the importance of wealth and market competition for Internet diffusion. SusmitaDasgupta et al. (2001) conducted an empirical study of Internet diffusion based on data for 44 OECD and developing countries. They use data for growth in Internet penetration from 1990 to 1997 in a cross-section of countries and estimate a model using OLS. They found that wealth is not statistically significant (on the contrary of the previous paper i.e in contrary to Hargittai, 1999 finding ) and their significant factors are size of urban population and index of competition policy. However there are a number of differences between the two papers. The former deals with OECD countries only whereas the latter with both developed and developing countries. Secondly, the time periods differ. Third, the first paper is based on levels and the second one on growth data. The differences mentioned above suggest that comparison of the results should be made with a lot of care.

SampsaKiiski and MattiPohjola (2002) studied Internet penetration by using three frameworks. First, with only 23 OECD countries. They used OLS cross-country estimation based on growth between 1995 and 2000. Second, they added 37 developing countries. They provide both cross-country and panel data estimation. Third, they used a simultaneous equation framework by considering an equation for

GDP and access cost (proxied by telephone access cost) in addition to an Internet diffusion equation. In accordance to the previous studies, the wealth level is found to be significant for Internet diffusion. Internet access costs have negative impact in OECD countries whereas they have no impact for a larger set of countries. However, in the simultaneous equation model they found a negative impact for OECD countries. Education appears to be significant for the larger set of countries but not for OECD countries. Menzie D. Chinn and Robert W. Fairlie (2006) studied the Internet penetration in 1999-2001 in 161 countries. They conducted a similar study for 2002-2004. They use panel data random effect estimation, i.e. GLS estimation. They found wealth is important for Internet penetration. Also important is the rule of law. Somewhat surprisingly, the share of urban population has a negative impact for the earlier periods.

Pohjola (2003) studies observed investment in information and communication technology in 49 countries from 1993 to 2000. He regresses ICTs investment per capita on income per capita, the relative price of ICT equipment, human capital measures, the share of agriculture and openness to international trade. He finds that a positive impact of human capital and a negative impact of agriculture share in GDP on ICT diffusion. Chinn and Fairlie (2007) examine a panel of 161 countries over the 1999-2001 periods on internet penetration and find that the global digital divide is mainly accounted for by income differentials.

Similar but more extensive research was conducted by SanjeevDewan et al. (2001). They use different measures of IT penetration - the usual measures in per capita terms. On top of this, they consider three generations of IT - mainframes, PCs and

Internet. The time period is 1985- 2001 which is much larger than in the previous papers. The paper compares the three generations of IT and concludes that Internet penetration has different dynamics compared to the two other IT considered, as the set of statistically significant regressors are different. For the Internet penetration, if per capita measures are used, phone line cost (usually considered as a proxy for Internet access cost) has a negative impact; wealth has a positive impact as well as years of schooling. When per-GDP measures are used, phone line density appears to have a positive impact, Internet access cost has a negative impact as before, wealth is no more significant, years of schooling still have a positive impact and trade in goods as share of GDP appears to have a positive impact.

All the previous studies focused on OECD countries only or on OECD and developing countries in one sample. However, since the nature of technology diffusion (including Internet) in developing countries is suggested to be different, it is worth considering developing countries in a separate sample. One such study was conducted by Scott Wallsten (2003). The paper focuses on regulation and institutional issues of Internet adoption in the developing countries. It found like almost all other papers a positive effect of wealth. The empirical approach is a cross-section estimate of panel data.

### 2.6.2 Empirical Literature in Africa

The issue of policy to promote Internet access in developing countries has attracted the attention of scholars in recent years. WorldBank (2007) emphasizes that issues requiring immediate attention for the use of the Internet include pricing structures,

monopoly control of Internet access, and licensing charges for content. Additionally, World Bank suggests the policies should be directed at liberalization of telecommunications networks and Internet service provision, as well as lower tariffs on computer and telecommunications equipment.

Afullo (2000) studied the information infrastructure in Africa and contends that the issues influencing Internet penetration include infrastructure, pricing, policies, literacy, income, and education. He reports that the vast majorities of Internet hosts are in developed nations and argues that wealth and education are major factors affecting Internet diffusion. He also suggests that Internet accessibility in Africa can be remedied ‘‘through liberalization, unrestricted market access, eradication of under-investment and inefficiency through privatization and private sector involvement, and tariff reform’’.

Adams (1997) discusses some challenges to universal access in Africa, which include the deteriorating rural infrastructure, low education level, statist nature of telecommunications operations, and hierarchical government institutions. He states his concern that high prices set by existing local ISPs in Africa may deter the academic and research community from accessing global resources (cited in Trevor R. Roycroft, Siriwan Anantho,2003).

Jensen (2000) discusses the development of Internet content among African countries. Among the increasing numbers of organizations having a web site with basic descriptive and contact information, ‘‘many are hosted by international development agency sites, and very few actually used the web for their .He notes that

this phenomenon results from a small number of local people having access to the Internet, limited skills to create web pages, and high costs of local web-hosting services.

Ngwainmbi (2000) discusses the problems of information technology in Africans' daily life. He states that the computer is out of reach for the majority of African people because of its high initial cost. The high cost of maintenance also limits the use of computers. He finds that the major impediments to the implementation of information technology in most African countries include obsolete and dilapidated telecommunications infrastructures, high costs of links to Internet backbones, shortages of technical staff, and limited availability of electricity. He also notes that some African governments may view the Internet as a threat to African culture, or even national security, thus resulting in the restriction of public accessibility.

In the study of information transfer to African nations, Edoho and Udo (2000) argue that poverty is a major challenge that restrains African countries from utilizing information technology. Many countries have low per capita income and declining standards of living, therefore policymakers are concentrating their efforts to meet the basic needs of the poor people. They also argue that the absence of infrastructure makes it extremely difficult for the African region to receive and utilize information technology. Electricity breakdowns cause prolonged power outages that disrupt business operation and increase costs. In Africa, the infrastructure is concentrated in the urban areas and accesses to telephones are limited to a few elite. Poverty contributes to inter-ethnic strife and civil wars devastating the region, policy makers

are more concerned with investing in internal security, rather than in information technology.

Chisenga (2000) finds factors affecting the Internet connectivity in the region include the slow development of telecommunications infrastructure, high cost of telecommunications, and high telecommunications tariffs in most countries. Smith (2000) conducted a case study on bringing Internet access to a sparsely populated and remote province in South Africa. He indicates that underdeveloped infrastructure is the main problem in African remote rural areas, in which the majority of homes and businesses do not have telephones. Only three out of 71 schools in the areas Smith studied had electricity and none had telephones.

Roycroft and Anantho (2003) found that regarding the expansion of Internet accessibility on the African continent, the most significant factors were: the level of economic development, the country's Anglophone heritage, the capacity of available Internet bandwidth, the density of Internet servers (an indirect measurement of both content quantity and locally-offered services), and the intensity of competition among network access providers.

In their research, Oyelaran-Oyeyinka and Lal (2005) indicated that the rate of Internet use in Sub-Saharan countries increased with: the country's rate of computer ownership, density of landline connections, and the number of Internet hosts. In addition, per capita income has a positive influence on Internet implementation, by means of stimulating telecommunications infrastructure investment.

## 2.7 Economic conditions of sub-Saharan Africa

As a group, the Least Developed Countries (LDCs) to which most of SSA belongs, are identified by the United Nations (UN) as low-income countries, with low levels of human capital that are highly vulnerable to natural and man-made shocks. Out of the 49 countries in SSA, there are 33 LDCs (World Bank, 2013), putting the majority of SSA in this category .The 33 African LDCs differ widely in size and resource endowments; however, they share important common characteristics which distinguish them from other developing countries. Low levels of income, a low degree of industrialization and human capital development, high levels of export concentration, often in one or two primary commodity lines, and a high level of vulnerability to external shocks, are common features of these economies.

The extremely low levels of per capita income in SSA reflect the underdeveloped structures of these economies compared to other developing countries, and their meager stock of capital. On average, more than two-thirds of the population and labor force reside in the countryside and work in the agricultural sector. The vast majority of the population is either rural based or recent migrants to urban areas. African countries have a comparably weak physical and knowledge infrastructure base, exemplified by poor telecommunications and transport facilities. For example, the number of telephone lines per thousand people is about five, one-twentieth of the average for other developing countries (ITU,2013). The cost of local telephone calls is 100% higher than the average for the latter. In sum, the foregoing highlights three broad aspects of African economies, which have important implications for attenuating digital inequalities. First, the majority of Africa's population lives in

countries with very low per capita incomes and underdeveloped production structures. Secondly, extremely low levels of knowledge and physical infrastructure constrain the efficient use of productive resources in these countries. And thirdly, largely as a consequence of the first two characteristics, SSA countries and particularly the African LDCs are highly vulnerable to external shocks arising from the vagaries of nature or those arising from external economy-related factors. These factors have important implications for theory as well as policy for mitigating income and digital inequalities

# CHAPTER THREE: DATA AND METHEDOLOGY

## 3.1 The Data

It is not easy to determine the actual Internet penetration in sub-Saharan Africa. Internet subscriptions do not accurately reflect Internet use in the region because in general, an Internet subscription (fixed or mobile) is shared by several people. In addition, many people have access to the Internet through their jobs or at schools and colleges, especially at Public institutions and university level. In the face of this difficulty, the number of Internet users per hundred inhabitants is used in this study, as defined and used by the International Telecommunication Union (ITU) and World Bank (WB).

One important thing to note is that, for most technologies, the relevant measure of their diffusion is the ratio of actual users to potential users. Measuring potential users is problematic since it requires access to micro data, which is unavailable for most of the countries in the sample. However, as noted by Dasgupta et al. (2001), in the case of Internet, human capital requirements to use its basic applications (electronic mail and information search) are relatively low. Therefore, it seems reasonable to assume, as in this study is assumed, that the entire population is a potential user. The study uses World Bank Country Classification to study the determinants of internet use in low income countries in Sub Saharan-Africa.

The main dataset that this paper uses is from the World Bank database, from this dataset information on a set of 25 sub Saharan countries (Low income countries) for the period 2009-2013 is taken. As of July 2014, low-income economies are defined as

those with a GNI per capita, calculated using World Bank Atlas method, of $1686 or less in 2013.

## 3.2 The Model

### 3.2.1 Underlying Theoretical Background

To formalize the relationship between internet use and its determinants, the theory of utility maximization serves as a useful starting point. Individuals derive utility from consumption of various goods. Technological advances make available for consumers ever-more complex gadgets to consume. The rapid progress in microelectronics technology has facilitated the use of Internet at home, office and other areas (NSF, 2001). Individuals also engage in a variety of economically significant market and nonmarket activities. Examples for these activities include Personal care activities (home activities), paid/unpaid activities and engagement in leisure. As a result; individuals face the problem of consuming competing goods from various goods and engaging themselves in various activities, given their constraints. The finite nature of resources and time requires individuals to make choices among various activities and goods based on their perceived relative utilities.

Traditional economic theory deals with the labor/leisure choice by treating leisure as a part of a utility function, where utility is assumed to depend only on the consumption of a composite good and leisure time (Gronau, 1980). Blundell and Meghir (1986) extended Gronau's model by adding a set of taste shifter observable factors in the utility function. Based on these modifications, a utility function can be written as:

$U = f(X, T_i ; S)$ for i=1,2…..n ……(1)

This is a one-person, one-period model where X is consumption of a composite good, Ti is the time spent on the ith activity, and S ={R, F} denoting a vector of individual Characteristics (R), and other factors (F), such as geographic location, Economic variables and variables that are assumed to influence the individual's preferences (Kimmel and Connelly, 2007).

An individual maximizes this utility function subject to the following two interrelated constraints, known as budget and time constraints, respectively

$\sum_{k=1}^{m} X_k = A + w(T - \sum_{i=1}^{n} T_i)$ and $T = T_m + \sum_{i=1}^{n} T_i$ …….…….. (2)

Where Xk is the $K_{th}$ consumption good, A is nonlabor income; w is the fixed market wage rate, $T_m$ is market work time, and T is total time available. Maximizing (1) with respect to the constraints stated under (2) yields the optimal demand for consumption goods and for the various time allocations:

$X_K^* = f_k(W,A:S)$ and $T_i^* = f_i(W,A:S)$ for i=1,2,…….n …… (3)

This shows that the individual decides on the utility-maximizing level of consumption goods and determines how time Ti is used. Equation (3) also indicates that the optimal allocation of consumer goods and time for various activities depend on the price of time w and the set of taste shifter variables S(economic variables, demographic variables, infrastructure variables). Denoting all the factors that affect these optimal allocations by Z, equation (3) can be rewritten more compactly as:

$X_K^* = f_k(Z)$ and $T_i^* = f_i(Z)$

Let the optimal consumption goods in (3) $X_k^*$ be denoted by a vector specifying the consumption of various goods:

$X_k^* = (X_{i1}, X_{i2}, X_{i3}, X_{i4}, \ldots \ldots X_{ij} \ldots\ldots\ldots\ldots X_n)$

And let $X_{ij}$ be the consumption of internet use and hence denoted by $IU_{it}$ for individual i at time t. To estimate the impact of the explanatory variables described in equation (3) on the consumption of Internet use, the estimation version of the demand equation (3) can be written as:

$IU_{it} = \beta_0 + \beta_{it}^{`} Z + \varepsilon_{it}$ for i=1, 2, 3……..m ……4

t=1, 2,3……T

Estimation is carried out for internet use over the whole sample M in period T. Here Z denotes the vector of explanatory variables identified in equation (3) as potential determinants of internet use. These explanatory variables can be categorized into the following broad groups: economic variables demographic variables, infrastructure variables.

The focus of the present study is on national-level factors. The national-level factors responsible for internet diffusion in general have been investigated in the literature to some extent. It would be helpful to use an existing framework to assess the role of various factors in Internet use in a nation such as the Global Diffusion of the Internet (GDI) framework by Wolcott et al. (2001). This framework consists of variables used

to describe the state of the Internet within a country: connectivity infrastructure, level of urbanization, environmental variables such as level of competition and geographic dispersion. Many research results on Internet diffusion in a given nation are derived using this framework (Goodman et al. 1994; Press et al. 1997; Wolcott and Goodman 2003; Foster et al. 2004; Bernstein and Goodman 2005). However, some of the dimensions require experts to evaluate and rank each country for each individual characteristic, which can only be done through a detailed case study for each nation. The focus of this research is therefore identifying potential determinants of internet use consisting of different categories of factors that could be useful for studying Internet diffusion among nations. The model has only one dependent variable: the Internet users per 100 people.

The model described by Wolcott et al. (2001) takes the form;

$IU_{it}$=f (connectivity infrastructure, level of urbanization, environmental variables)

However the model described above is often criticized as lacking" a framework with standard theoretical underpinnings" (Odedokum, 1996 cited in Yabibal, 2006).

Hence based on the above framework the dependent variable (internet use) is a function of its own past lag, import of ICT goods and other conventional variables defined by Wolcott et al. (2001), hence our model takes the form;

$IU_{it}$=f ($IU_{it-1}$, GDP per capita, unemployment ,import of ICT goods, telephone mainlines, mobile cellular subscription, urbanization, Age dependency ratio, inflation, quality of public administration ,literacy rates).

**The dependent variable (Internet users per 100 people)**

The theoretical model is based on the framework developed by Wolcott et al. (2001) on the Global Diffusion of the Internet (GDI), Although It is not easy to determine the actual Internet penetration in sub-Saharan Africa. Internet subscriptions do not accurately reflect Internet use in the region because in general, an Internet subscription (fixed or mobile) is shared by several people. In addition, many people have access to the Internet through their jobs or at schools and colleges, especially at Public institutions and university level. In the face of this difficulty, the number of Internet users per hundred inhabitants is used in this study, as defined and used by the International Telecommunication Union (ITU) and World Bank (WB).

**Independent variables**

**GDP percapita**: a higher level of GDP per capita is naturally associated with higher purchasing power of goods and services and hence higher use of internet, this is a hypothesis that holds in general when it comes to adopting new technologies. Richer countries have well-developed market economies and well-established legal systems, and as a result are able and willing to invest more in research and development and innovation. Given that innovation relating to the Internet is taking place at an unprecedented pace, this should play a very important role.

**Infrastructure variables**: efficient, reliable and adequate infrastructure services increase information flow and decrease transaction costs. They also increase productivity and accelerate the pace of technology deployment. Hence Countries with more developed telecommunication and technology infrastructures are more likely to have higher internet penetration rates. The Internet is a fairly advanced technology in that it requires a well-functioning telecommunications network to be present in order to operate. At the beginning of the Internet era, the presence of a traditional telephone line per computer was necessary in order to be able to connect to the internet via modem. However, over the last years, information transmission technology has advanced dramatically. Innovation has paved the way for a much faster Internet, so-called broadband, which, depending on the technology, requires only a single phone line for an entire network of computers (all types of DSL), or even none at all (cable, satellite, fiber optics or mobile). While such technologies are readily available in most developed countries, their availability is extremely limited in less developed parts of the world. Hence, in this study infrastructure variable is captured by mobile cellular subscription and telephone lines per 100 peoples.

**Quality of public administration**: demonstrates the ability of the government to provide sound policies, regulation, government`s ability to reduce red tap and to promote technology use in a country. Among others this variable in this study include the average score of the country including(regulations concerning licensing arrangements, environmental and consumer safety and other related policies and regulations).The high score implies the government has good regulatory quality while lower score implies government has lower regulatory quality.

**Inflation**: a price instability or high rate of inflation is a good signal for macroeconomic instability, the persistence of such situation implies the inability or unwillingness of the government and central bank to balance the budget and hence to reduce money supply which have an adverse effect on government consumption(G) and hence investment on technology adoption.

**Literacy rates:** higher educational standards and literacy rates are more likely to have higher technology use rates and hence higher internet penetration rates. There are many reasons why this hypothesis should hold, the most obvious being that the World Wide Web and e-mail are currently entirely text-based, implying that literacy is required in order to be able to actually use the Internet. Although there are some ongoing efforts to "vocalize" the Internet, such as Opera's text-to-speech.

Another, perhaps less apparent, reason supporting this hypothesis is that academic institutions play an essential role in adopting new technology. Indeed, schools were among the first institutions to heavily make use of the Internet, and in doing so introduced young people to this new form of media. Today, research and other important aspects of education rely on the use of the Internet; hence, one can argue that education also promotes the adoption of the Internet in this sense.

**Urbanization rates**: The urbanization rate in this study is calculated as number of peoples living in urban areas divided by total number of population in the country. Countries with a large percentage of their population living in urban areas are more likely to have higher internet penetration rates. In general; cities are better networked

than rural areas. This is mostly to practical and economic reasons. It is not only harder to build a communications network that spreads over vast territories, but it is also less interesting for firms from a profit-maximizing perspective, since firms want to target as many consumers as possible at the lowest cost possible. Therefore, it is plausible to assume that countries in which people tend to live in cities benefit from higher penetration rates. Studies such as Kay and Xiaoming (2004) and Crenshaw and Robison (2006) have found urban population to have a significant impact on Internet diffusion.

**Age dependency ratio (% of working-age population):** The rationale for using such variable is high dependency ratio can cause serious problems for a country on the productive part of the population also on internet use since they are economically inactive to pay for the cost of internet services .Hence, it is plausible to assume that the higher the dependency ratio in a country the lower the internet use in a country.

**ICT goods import (% of total goods import):** the rationale for using such variable is that ICT goods are an inputs for internet and countries under study in this research are sub Saharan countries which entirely depend on import of ICT good. Hence it is reasonable to assume higher import of ICT goods promotes internet use in sub Saharan countries under study.

### 3.3 Empirical Model

The research bases the estimation based on the model of the form

$$IU_{it} = \beta_1 GDPpc_{it} + \beta_2 CPIA\ qual_{it} + \beta_3 MOBIcell_{it} + \beta_4 AGEdep_{it} + \beta_5 ICTimp_{it}$$

$$+\beta_6 INF_{it} + \beta_7 UNEMP_{it} + \beta_8 URBAN_{it} + \beta_9 Liter_{it} + \beta_{10} TELline_{it} + \beta_{11} IU_{it-1} + \eta_i + u_{it} \quad \ldots\ldots 5$$

Where the error term $\varepsilon_{it}$ is

$\varepsilon_{it} = \eta_i + U_{it}$ and $\eta_i$ is the country effect of country i, $U_{it}$ is the idiosyncratic error

Table 3.1 Description of variables

| Variables | Description |
|---|---|
| $GDPpc_{it}$ | GDP per capita current international $ |
| $CPIA\ qual_{it}$ | CPIA quality of public administration rating (1=low to 6=high) |
| $MOBIcell_{it}$ | Mobile cellular subscription per 100 people |
| $AGEdep_{it}$ | Age dependency ratio (% of working-age population) |
| $ICTimp_{it}$ | ICT goods import(% of total goods import) |
| $INF_{it}$ | Inflation, GDP deflator (annual %) |

| | |
|---|---|
| | |
| $UNEMP_{it}$ | Unemployment, total (% of total labor force) (modeled ILO estimate) |
| $URBAN_{it}$ | Urban population(% of total population) |
| $Liter_{it}$ | literacy rate(Literacy rate, adult total (% of people ages 15 and above) |
| $TELline_{it}$ | Telephone lines (per 100 people) |
| $IU_{it-1}$ | Lagged internet users per 100 people |
| $\eta_i$ | the country effect of country i |
| $u_{it}$ | is the idiosyncratic error |

One would expect $\beta_1$ to be positive since a higher level of GDP percapita is naturally associated with higher purchasing power of goods and services and hence higher use of internet. The coefficient of quality of public administration is expected to be positive, since higher quality of public administration is an incentive for individuals to use internet services freely and for firms it indicates how easy it is to operate a business in internet services. The effect of the number of mobile cellular subscription is expected to be positive, since higher mobile cellular subscription indicates better infrastructure in telecommunication so as to use internet services,

mobile telephones also save on significant amounts of associated infrastructure(transmission towers replace overhead/underground cables) cost, but require the same amount of user time per unit of information communicated as fixed telephony, The rational for using such a proxy is the fact that the economic literature generally shows that a competitive and well regulated telecommunications sector is conducive to rapid growth in mobile cellular phone usage. The coefficient of age dependency ratio($\beta_4$) is expected to be negative because high dependency ratio can cause serious problems for a country on the productive part of the population so also on internet use since they are economically inactive to pay for the cost of internet services. The effect of urbanization on internet use is assumed to be positive because In general, cities are better networked than rural areas. This is mostly to practical and economic reasons. It is not only harder to build a communications network that spreads over vast territories, but it is also less interesting for firms from a profit-maximizing perspective, since firms want to target as many consumers as possible at the lowest cost possible, Therefore, it is plausible to assume that countries in which people tend to live in cities benefit from higher penetration rates .The coefficient of literacy rate($\beta_9$) is expected to be positive, there are many reasons why this hypothesis should hold, the most obvious being that the World Wide Web and e-mail are currently entirely text-based, implying that literacy is required in order to be able to actually use the Internet, today, research and other important aspects of education rely on the use of the Internet; hence, one can argue that education also promotes the adoption of the Internet in this sense. The coefficient of ICT goods import is expected to be positive because ICT goods and internet are complementary goods and countries

under study in this research are sub Saharan countries which entirely depend on import of ICT good. The coefficient $\beta_{11}$ measures the importance of network externalities in the diffusion of internet. In the absence of diffusion, $\beta_{11}$ is not significant. When $\beta_{11}$ is positive and smaller than 1, the diffusion model is accepted. Thus the number of users in the current period explains (in a percentage given by $\beta_{11}$ ) the number of Internet users the subsequent year.

Some of the repressors $X_{it}$ may be endogenous and we provide tests for that. Potentially, there may be endogeneity in GDP. But it may be rather predetermined than endogenous because the current level of technology development may influence future production within the country even if this effect can be assumed to be very small. And even if there is reverse causality, it is lagged in time.

### 3.4 Estimation Method

The analysis is made using panel data. Panel data analysis has several advantages over cross section and time series analyses (Baltagi, 2005). The main advantage of panel data is increased efficiency owing to pooling several time periods of data for each individual (cross section) which provides more degrees of freedom. Hence, estimators based on panel data are quite often more accurate than estimators from other sources (Cameron and Trived, 2005). Panel data enables one to control for unobserved individual heterogeneity (the country specific effects) which might be correlated with the regressors. It also provides the possibility of learning more about the dynamics of adjustment (Baltagi, 2005). Furthermore, the presence of panel data

reduces identification problems in the presence of endogenous regressors or measurement error and robustness to ommitted variables (verbeek, 2003).

As specified in the above section, owing to the dynamic nature of internet use,the lagged value of the dependent variable will be included in the model as an additional regressor. The dynamic panel data model which will be estimated in this study, therefore, has the following specification.

$$I_{it}=\alpha I_{it-1}+X_{it}\gamma+\eta_i + u_{it} \quad \ldots\ldots 6$$

The OLS estimation of the dynamic panel data model leads to inconsistent estimation of $\alpha$ and $\gamma$.Because first, OLS estimation requires that the individual country effect is uncorrelated with explanatory variables. But this is not the case if one looks at equation (7) below:

$$E(\eta_i)(I_{it-1})= E[\eta_i(\alpha I_{it-2} + X_{it-1\gamma} + \eta_i + u_{it-1})] \quad \ldots\ldots (7)$$

Since $E(\eta_i^2)$ is different from zero the regressor $IU_{it-1}$ is correlated with the individual (country) specific effects, $\eta_i$ and hence the composite error term $(,\eta_i + u_{it})$ irrespective of the way $\eta_i$ is treated.Second there is a possibility of endogeneity of a sub-set of $x_i$.

In such cases, standard panel estimators are all inconsistent (Cameron and Trivedi, 2005). In the OLS estimation of $IU_{it}$ on $IU_{it-1}$ and all regressors , the lagged dependent variable $IU_{it-1}$ is correlated with the individual (country) specific, $\eta_i$. As a

result, the error term violates the assumption necessary for the consistency of OLS. In the within estimation of $IU_{it} - IU_{it-1}$ on $IU_{it-1} - IU_{it-2}$and differenced regressors, the error term $u_{it} - u_{it-1}$ is correlated with the lagged dependent variable, $IU_{it-1} - IU_{it-2}$ by construction since $IU_{it}$ is correlated with $u_{it}$ from the equation (6)above and hence, $IU_{it-1}$ is correlated with $u_{it-1}$ hence, estimation of the within model gives inconsistent parameter estimates. The random effects estimator is also inconsistent. This is apparent from the fact that the random effects estimator is a linear combination of within and between estimators.

Anderson and Hsiao (1981) proposed the instrumental Variable Estimator in the first difference model to be consistent. They suggested first differencing the model to get rid of the $\eta_i$ and then using $\Delta IU_{it-2} = IU_{it-2} - IU_{it-3}$ or $I_{it-2}$ as an instrument for $\Delta IU_{it-1}$.This IV estimator leads to consistent but not necessarily efficient estimates of the parameter. Consistency of estimator is guaranteed given the assumption of no serial correlation in $u_{it}$ .Inefficiency of Anderson and Hsiao (1981) IV estimator arises from the fact it doesn't take into account the differenced structure on the residual disturbances, $\Delta u_{it}$ (Baltagi, 2005).

This paper capitalizes on the recommendation put forward by Arellano and Bond (1991) Generalized Method of Moments (GMM) procedure that exploit all the available moments conditions and hence, more efficient than the Anderson and Hsiao (1981) IV estimation and hence it addresses both the issues of omitted variable bias and endogneity. They argue that additional instruments can be made available by

utilizing the orthogonality conditions that exist between the lagged values of $IU_{it}$ and the disturbances $u_{it}$.

To see how it works, take the first difference of equation (6).

$$IU_{it} - IU_{it-1} = \alpha(IU_{it-1} - IU_{it-2}) + \gamma'(X_{it} - X_{it-2}) + (u_{it} - u_{it-1}) \quad \ldots\ldots\ldots\ldots\ldots 8$$

As described earlier OLS cannot be used to estimate the above equation for two reasons .First, endogeneity of the explanatory variables is still unsolved. Second, the lagged dependent variable $IU_{it} - IU_{it-1}$ is now correlated with the new error term, $(u_{it} - u_{it-1})$ in contemporaneous terms in period $t - 1$.

In pure cross-section regressions, instrumental variables estimation does not control for the possible endogeneity of all explanatory variables .Hence, this approach can lead to inappropriate inferences,as many more variables may also be endogenous. Arellano and Bond (1991) suggest the use of internal instruments, defined as instruments based on past realizations of explanatory variables, so as to consider potential joint endogeneity of all other regressors as well.

Thus,under the assumption that (a) the error term u is not serially correlated, and (b) the explanatory variables are weakly exogeneious (uncorrelated with future realization of the error term),the GMM dynamic panel estimator developed by Arellano and Bond (1991) uses the following moment conditions.

$$E[IU_{it-s} \times (u_{it} - u_{it-1})] = 0 \ldots\ldots\ldots\ldots \text{for } s \geq 2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots 9$$

$$E[X_{it-s} \times (u_{it} - u_{it-1})] = 0 \ldots\ldots\ldots\ldots \text{ for } s \geq 2 \ldots\ldots\ldots\ldots\ldots\ldots 10$$

In this case,the lagged values of $IU_{it-2}, IU_{it-3}$ and longer lags (when observed) will be valid instruments in the first differenced equation. In general, by period T all lags prior to, say (T- 2) can be considered as instruments. Hence, if T is non-trivial we may need to limit the maximum lags of instruments to prevent the number of instruments from becoming too large i.e. the instrument proliferation.

Arellano and Bover (1995) and Blundell and Bond (1998), nonetheless, showed that lagged levels are often poor instruments for first differenced variables especially if the variables are close to a random walk ($\alpha$ is high) and if T is small. Hence, they proposed using lagged differences in addition to the lagged levels.

Specifically, they suggested using the conditions

$$E\,[IU_{it-s} - IU_{it-s-1} \times (\eta_i + u_{it})]=0 \quad \text{.....11}$$

$$E\,[(X_{it-s} - X_{it-s-1} \times (\eta_i + u_{it})]=0 \quad \text{..... 12}$$

for S < t-2 and where $\varepsilon_{it} = \eta_i + u_{it}$.This estimator which exploits additional moment conditions is more efficient than the Arellano and Bond (1991) estimator and called the system GMM estimator. This estimator has one-step and two-step variants. Although the two-step system GMM estimator is asymptotically more efficient, the reported two-step standard errors tend to be severally downward biased (Arellano and Bond, 1991),in other words the asymptotic standard errors from the two step GMM estimator have been found to have a downward bias(Blundell and Bond,1998).

The consistency of the GMM estimations depends heavy up on the condition E ($u_{it}\, u_{it-2}$) = 0. Hence, Arellano and Bond (1991) developed a test for the autocorrelation in the idiosyncratic errors, which, if present, can render invalid instruments. They propose a test of the hypothesis that there is no second order serial correlation for the disturbance of the first differenced equations. Here we test whether the differenced error term is second order serially correlated(by construction, the differenced error term is probably first order serially correlated even if the original error term is not but there should be no second order serial correlation to satisfy the additional moment condition(i.eE($\varepsilon_{it}\Delta IU_{it}$).Apart from the second order serial correlation test, there is a need to test for over identification restriction, i.e. the joint validity of the instruments used. To test for the joint validity of instruments Arellano and Bond (1991) suggested (Hansen) sargan test statistic which, under the null of over identification.

The sargan test is not robust to the heteroskedasticity and autocorrelation. Therefore, in one step robust estimation and all two step estimations the Hansen J statistic should be used. However, the Hansen test has its own pitfall as it can be weakened by instrument proliferation. Sargan (Hansen) statistic can also be used to test the validity of subsets of instruments via 'a difference-in-sargan' test, also known as a C statistic. If one performs estimation with and without a subset of suspect instruments, under the null of joint validity of the full instrument set, the difference in the two reported Sargan (Hansen) test statistics is itself asymptotically chi square distributed with degrees of freedom equal to the number of suspect instruments. The regression without the suspect instruments is called the unrestricted regression since it imposes

fewer moment conditions. The difference-in-Sargan test is of course only feasible if this unrestricted regression has enough instruments to be identified (Roodman, 2006)

In general, in this study taking the dynamic nature of the model into account, one-step system GMM of Arellano and Bover (1995) and Blundell and Bond (1998) would be used to estimate the model. Furthermore to favor identification of the estimates and to keep the rule of thumb(the rule of thumb is to keep the number of instruments less than or equal to the number of groups ) ,We have to chose the estimation technique that will provide the lower instrument numbers.A test of second order serial correlation would be made using the Arellano and Bond (1991) second order autocorrelation test procedure, Sargan (Hansen) test of the Arellano and Bond (1991) is used to test the joint validity of the instruments.

# CHAPTER FOUR: DATA ANALYSIS AND INTERPRETATION OF RESULTS

In this chapter both descriptive and econometrics methods will be employed to analyze and interpret the determinants of internet use in sub-Saharan Africa. In the first part, the average number of internet users in sub Saharan Africa will be compared with the rest of the world, in addition the characteristics of dependent and independent variables will be described. In the second part, the results of econometrics analysis will be presented.

## 4.1 DESCRIPTIVE DATA ANALYSIS

In this part of the chapter two things will be covered. First, average internet users in sub Saharan Africa will be overviewed with regard to the explanatory variables and hence compared with the rest of the world. Then summary statistics of variables will then be presented so as to assist in identifying any kind of unexplained regression outputs that might be encountered in the econometric analysis.

### 4.1.1 Cross-Country Differences in Internet Penetration Rates

Internet use has grown rapidly over the past years, the relatively high current rates of use, however, mask large disparities across regions of the world. The table below (table 4.1) reports internet penetration rates by region. In Europe, there are 68.7 internet users out of 100 people, whereas there are only 4.77 internet users out of 100

people in sub Saharan Africa, that is internet use in Europe is 14 times much higher than internet use in sub Saharan Africa .Internet use rates in Sub-Saharan African countries under study are strikingly low with only 4.77 internet users per 100 people. All other regions have higher penetration rates than sub Saharan Africa.

In the Americas (north and south), roughly one half of the population uses the Internet. In contrast, one half of one percent of the population uses the Internet in Sub-Saharan Africa. Internet use is higher in Europe and The Americas, and Asia & Pacific with 68.7,54.6 and 24.96 users per 100 people, but very low in sub Saharan Africa with lower than 5 peoples per 100 people using the internet

**Table 4. 1: Average number of internet users by Region**

| Region | Average number of Internet use per 100 people |
|---|---|
| The Americas | 54.6 |
| Europe | 68.7 |
| Asia & Pacific | 24.96 |
| Sub Saharan Africa | 4.77 |

Source: Own computation based on World Bank data (2013)

To examine cross country differences in internet use, average internet users are cross tabulated against each countries under study(see table 4.2). As can be seen from the table the number of average internet users per hundred people ranges from almost one person in Eritrea using the internet out of hundred peoples to almost 25 peoples out of 100 peoples in Kenya using the internet. Among the 25 countries under study in this paper only Ruanda, Gambia, Uganda, Zimbabwe and Kenya stood above the average with an average internet users 7.88, 10.82, 13.23, 14.83, and 24.62 respectively, all the rest stood below the average. Eritrea, Sierraleon, Burundi, Ethiopia, Niger, Chad, Congo dem.rep, Guinea, Madagascar stood at the lowest level of internet users with

roughly below 2 peoples out of 100 peoples using the internet in the region , that is the bottom of the distribution is mainly comprised of very poor countries in Sub-Saharan Africa. As can be seen from the table the average number of internet users in countries under study is 4.77(see table 4.2) which is far below than the developing countries average which is 24.04(see table 4.3), that is the developing world average number of internet users is almost 6 times higher than the sub Saharan countries average number of internet users under study. When we compare the average number of internet users of Eritrea, Sieraleon, Burundi, Ethiopia and Niger with the developing world average, the developing world average number of internet users is 24 times higher than those countries. Only Kenya has comparable internet users with the developing world average number of internet users, in contrast to Eritrea which have 24 times less than the developing world average.

**Table 4. 2: Average number of internet users by country**

| Countries | Average intrenet users per 100 people |
|---|---|
| Benin | 3.7 |
| Burkina Faso | 2.9 |
| Burundi | 1.1 |
| Central African Republic | 2.5 |
| Chad | 1.9 |
| Comoros | 5.31 |
| Congo, Dem. Rep. | 1.2 |
| Eritrea | 0.7 |
| Ethiopia | 1.1 |
| Gambia | 10.8 |
| Guinea | 1.2 |
| Guinea-Bissau | 2.6 |
| Kenya | 24.6 |
| Liberia | 2.8 |
| Madagascar | 1.8 |
| Malawi | 3.2 |
| Mali | 2.0 |
| Mozambique | 4.2 |
| Niger | 1.1 |
| Rwanda | 7.8 |
| Sierra Leone | 0.9 |
| Tanzania | 3.4 |
| Togo | 3.5 |
| Uganda | 13.2 |
| Zimbabwe | 14.8 |
| Total | 4.7 |

Source: Own computation based on World Bank data (2013)

**Table 4. 3: Average number of internet users by income status**

| Economies | Average number of internet users per 100 people |
|---|---|
| Developed | 69.86 |
| Developing | 24.04 |
| World | 32.18 |

Source: Own computation based on World Bank data (2013)

**A. Internet use with GDP precapita**

To examine the relationship between income per capita and internet usage, the average number of internet users per 100 people are cross tabulated against quantiles of GDP percapita(table 4.4), PPP (current international price).As can be seen from the table below the average number of internet users per 100 people vary with income per capita ,that is countries with GDP percapita below $1000 have almost 2 peoples using the internet out of hundred people. In contrast countries with GDP per capita above $ 2000 have 7 peoples using the internet out of hundred people. This indicates countries at the lower level of GDP percapita have lower number of internet users while countries at the higher level of GDP per capita have higher number of internet users on average.

**Table 4. 4: Average number of internet users by GDP quantile**

| Quantiles of Gdp Per capita | Average number of internet users per 100 people |
|---|---|
| <1000 | 2.0 |
| 1000-2000 | 4.4 |
| >2000 | 7.9 |
| Total | 4.7 |

Source: Own computation based on World Bank data (2013)

**B. Mobile cellular subscription and average number of internet users**

There have been studies showing that mobile cellular subscription affects the use of internet, typically countries with a higher number of mobile cellular subscription have higher number of internet users and countries with the lowest number of mobile cellular subscription have lower number of internet users(Miria,2008).As can be seen from the table countries at the lowest quantiles of mobile cellular subscription have

the lowest average number of internet users while countries at higher quantiles of mobile cellular subscription have higher number of average internet users.

**Table 4. 5: Average number of internet users with quantiles of mobile cellular subscription**

| Quantiles of mobile cellular subscription per 100 people | Average internet users per 100 people |
|---|---|
| 1 | 1.5 |
| 2 | 3.1 |
| 3 | 4.9 |
| 4 | 9.5 |
| Total | 4.7 |

Source: Own computation based on World Bank data (2013)

### C. Average number of internet users and Literacy rate

Table 4.6 below presents average number of internet users against level of adult literacy in countries under study. As can be seen from the table, average number of internet users varies with the level of literacy rate. Countries at the higher level of literacy rate have almost 4 times higher number of internet users than those countries whose literacy level is lower. In other words countries at lowest quantiles of literacy rate have lower number of internet users while countries at higher quantiles of literacy rate have higher number of internet users

**Table 4. 6: Average number of internet users by level of adult literacy rate**

| Quantiles of adult Literacy rate | Average number of internet users per 100 people |
|---|---|
| 1 | 2.1 |
| 2 | 4.1 |
| 3 | 8.3 |
| Total | 4.7 |

Source: Own computation based on World Bank data (2013)

**D. Average number of internet users and ICT goods import**

To examine the relationship between Internet use and import of ICT goods from developed countries, average number internet users is cross tabulated against quantiles of ICT goods import. As can be seen from the table countries with higher percentage of ICT goods import have higher number of internet users while countries whose ICT goods import is lower have lower number of internet user. This shows that sub-Saharan countries are highly dependent on import of technology products to use internet.

**Table 4. 7: Average number of internet users by level of adult literacy rate**

| Quantiles of ICT goods import | Average number of internet users per 100 people |
|---|---|
| 1 | 0.9 |
| 2 | 1.9 |
| 3 | 3.5 |
| 4 | 11.5 |
| Total | 4.7 |

Source: Own computation based on World Bank data (2013)

E. Description of Summary Statistics

This section tries to highlight the descriptive nature of variables under consideration. Table 4.7shows the summary statistics of the variables included in the regression model.

**Table 4. 8: Summary statistics of variables**

| Variables | | Mean | Standard Deviation | Min | Max | Observations |
|---|---|---|---|---|---|---|
| **intern~e** | **overall** | **4.781621** | **6.043336** | **0.54** | **39** | **N = 125** |
| | between | | 5.899249 | 0.71 | 26.938 | n = 25 |
| | within | | 1.686232 | -9.80638 | 19.15362 | T = 5 |
| | | | | | | |
| **Cpiaqual** | **overall** | **2.856** | **0.470141** | **1.5** | **4** | **N = 125** |
| | between | | 0.47 | 1.9 | 3.6 | n = 25 |
| | Within | | 0.085194 | 2.456 | 3.256 | T = 5 |
| | | | | | | |
| **Gdppc** | **Overall** | **1304.007** | **432.3618** | **603.743** | **2794.981** | **N = 125** |
| | between | | 437.2695 | 641.5735 | 2560.419 | n = 25 |
| | Within | | 43.58935 | 1038.706 | 1538.57 | T = 5 |
| | | | | | | |
| **Agedep** | **Overall** | **89.3607** | **8.546659** | **76.44904** | **111.4636** | **N = 125** |
| | between | | 8.67466 | 78.14276 | 110.5334 | n = 25 |
| | Within | | 0.472304 | 87.66698 | 91.15746 | T = 5 |
| | | | | | | |
| **ICT goods** | **Overall** | **3.286177** | **2.484163** | **1.12** | **11.8** | **N = 125** |
| | between | | 2.581922 | 1.6 | 9.272429 | n = 25 |
| | Within | | 0.310121 | 1.0613 | 9.767329 | T = 5 |
| | | | | | | |
| **Inf** | **Overall** | **8.034446** | **9.491776** | **-9.55876** | **74.29817** | **N = 125** |
| | between | | 8.953604 | -4.51724 | 40.05029 | n = 25 |
| | Within | | 3.537346 | -2.96258 | 42.28233 | T = 5 |
| | | | | | | |
| **Mobile** | **Overall** | **42.3052** | **23.57107** | **2.539274** | **129.0669** | **N = 125** |
| | between | | 23.76369 | 3.919914 | 103.4061 | n = 25 |
| | Within | | 3.016421 | 32.15691 | 67.96603 | T = 5 |
| | | | | | | |
| **Teleline** | **Overall** | **0.902497** | **0.938496** | **0.01733** | **4.621999** | **N = 125** |
| | between | | 0.916527 | 0.031743 | 3.501428 | n = 25 |
| | Within | | 0.260481 | 0.200956 | 2.483833 | T = 5 |
| | | | | | | |
| **Unemp** | **Overall** | **8.7464** | **4.151458** | **0.7** | **17.1** | **N = 125** |
| | between | | 4.200511 | 0.7 | 17.02 | n = 25 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Within | | 0.399354 | 7.3464 | 11.6464 | T = 5 |
| | | | | | | |
| **Urban** | **Overall** | **30.8234** | **11.37153** | **10.376** | **58.373** | **N = 125** |
| | between | | 11.54801 | 10.918 | 56.989 | n = 25 |
| | Within | | 0.507021 | 29.1636 | 32.2626 | T = 5 |
| | | | | | | |
| **Liter** | **Overall** | **64.57147** | **18.97151** | **23.52378** | **91.73** | **N = 125** |
| | between | | 19.24966 | 28.73296 | 91.09493 | n = 25 |
| | Within | | 1.149742 | 59.3623 | 68.84276 | T = 5 |

Source: Own computation based on World Bank data (2013)

In table 4.8 of summary statistics, the overall mean, standard deviation, the minimum and maximum as well as the within and between standard deviation, minimum and maximum of each variable are provided in the table. Making our discussion based on the overall summary statistics of each variable: internet use has great variation among the countries under study with maximum value recorded in Kenya with value 39 peoples per hundred residents using the internet during the year 2013 and Eritrea had the minimum internet users, almost one person per hundred inhabitants using the internet during the year 2009.There are also other countries which have the lowest internet users(below two peoples per hundred inhabitants using the internet these include Sierraleon, Burundi, Ethiopia, Niger, Chad, Congo dem.rep, Guinea). This shows that within the same region (in sub Saharan Africa), there is high variation in internet use among countries, although majority of countries have internet users roughly below 5 peoples per hundred inhabitants using the internet.

GDP per capita, PPP(current international USD) is used as a measure of economic performance, it has overall mean of 1304 USD and standard deviation of 432.36 in countries under study, this indicates that there is a great variation among countries

under study in their economic performance. Central African Republic has a minimum value of 603.743 USD per capita in 2013 where as Kenya has a maximum value of 2794.981 GDP per capita in the year 2013.There are also other SSA countries with per capita income at the lower level, countries like Liberia (622 USD) in 2009, Congo Dem.Rep.(636 USD) in 2009,Malawi (690 USD) in 2009 recorded the lowest percapita incomes among SSA countries under the study period. Whereas countries like Chad had a GDP per capita of 2088 in 2013, Zimbabwe (1832 USD) in 2013, Tanzania (1775) in 2013, and Benin had a Percapita income 0f 1790 in 2013. This indicates that although countries under study are low income countries, their percapita income strictly differ.

Age dependency ratio (% of working-age population) is indicated in the 4th row of the variables column, as indicated the average dependency ratio is 89.36 with minimum dependency ratio (76%) recorded in Zimbabwe and maximum dependency ratio recorded in Niger in the year 2013.

ICT goods import as a percentage of GDP is used as a proxy measure how import from high income countries is determining technology use(here to show how imported technology affects internet use in SSA),since the countries under study are all low income countries which typically manifests import of technology goods. Import of ICT goods as a percentage of total goods import varies from 11.8% in Ruanda in 2010 to 1.12% in Congo Dem.Rep. in 2009.There are however other countries were their import of ICT goods has a significant share of their total goods import, these include ,Ethiopia (8.38) in 2010,Kenya (7.22 %) in 2013 and

Uganda(7.8%) in 2011.This indicates that ICT goods import has a significant share from total goods import.

Coming to Inflation, GDP deflator (annual %), In fact it has average value of 8.0344.However,the maximum value,74.24 % which is found in Zimbabwe during the year 2009,Next to Zimbabwe, Congo Dem .Rep. (33.85%) and Ethiopia(33.54%) have recorded the highest inflationary problem during the years 2009 and 2012 respectively. The minimum value ( -9.55 %) is recorded in Chad in 2009.All these indicate existence of price instability in these countries.

Infrastructure variable is captured through mobile cellular subscription and telephone line per 100 inhabitants. The variable telephone mainline has an overall mean value of around 1,which implies in SSA one telephone line is used for 100 inhabitants further implying that fixed telephone lines are in a very low position so as to use as a communication media. Telephone main line has a maximum value of 4.66 in Comoros and a minimum value of 0.017 in Central African Republic in the years 2009 and 2013 respectively. In contrast the other infrastructure variable, Mobile cellular subscription had an average value of 42.30 peoples out of 100 inhabitants subscribing to mobile connection. The maximum value is 129.066 in Mali in the year 2013 while the minimum value is 2.539 which is recorded in Eritrea in the year 2009.This implies that peoples in SSA are using mobile than fixed telephone as a communication media.

The variable Quality of public administration is used here as a proxy measure (1=low, to 6=high) for the role of institutions in determining technology use (here internet

use) in SSA, this variable has an average value of 2.85, the lowest value (1.5) is found in Zimbabwe in the period 2009 .There are also other countries whose quality of public administration is below average, these include, Congo Dem.Rep, Central Africa, Burundi, Guinea-Bisassu, Liberia and Madagascar. The highest value is recorded (4) is recorded in Ruanda in the year 2010.This indicates that countries under study have quality of public administration very low on average.

Unemployment, total (% of total labor force) (modeled ILO estimate),is included in the model so as to capture the effect of employment condition on internet use. The average unemployment level in the countries under studies is 8.7 % with maximum number of unemployment (17.1 %) recorded in Liberia in 2009 and in Kenya in the year 2013,and the lowest unemployment level recorded in Ruanda with 0.7 % in 2009.There are also other countries where the unemployment level is higher, including Congo Dem.Rep.(14.6 %),Malawi(13.5 %) in 2013, and Mozambique (14.3) in the year 2009,2013 and 2009 respectively. The standard deviation of unemployment condition in countries under study is around 4.15 which is indicates that there is fluctuation in unemployment level in sub Saharan countries under study.

Urban population (% of total population),which is used as a measure of urbanization is indicated in the 7th row of variables column, the urbanization level has an average value of 30.38 % which indicates that majority of the peoples( almost 70 % of the total population) in sub Saharan countries under study is living outside the city. The maximum urbanization level is recorded in Gambia(58.37%) while the minimum value is recorded in Burundi(10.37) in 2009.There are however other countries with lower level of urbanization, these include Uganda(14.18 %),Malawi(15.42

%),Ethiopia (16.91 %) and Niger (17.36 %) in the year 2009.In General the urbanization level in the countries under study is so low implying that peoples in these countries have very low access for which urban places offer like technology and other infrastructural uses.

Literacy rate, adult total (% of people ages 15 and above) is used to capture the effect of human capital on internet use in sub Saharan countries under study as indicated in the last row of the variables column. The average value of literacy rate in those countries under study is 64.57 % with standard deviation of 18.97 indicating that there is high fluctuation in the literacy rate among countries under study. The lowest value of literacy rate (23.52) is recorded in Niger in 2012, while the highest level of literacy rate is recorded in Togo (91.73%) in 2010.The high value of standard deviation in literacy rate indicates that adult literacy is not a consistent measure of human capital in sub Saharan countries, in this study however due to high missing values of human capital measures, the researcher decides to use adult literacy as a measure of human capital with its pitfalls as described earlier.

## 4.2 Econometric Results and Discussion

### 4.2.1 Diagnostic tests: Multicolinearity test

Ethington(2005) defined multicolinearity as an econometric problem which occurs due to the existence of linearly exact linear relationship between two or more independent variables in the same equation. Many scholars believe that there is a serious multicolinearity problem if the correlation between the independent variables

is in the range of (0.8,1) Kennedy(2008).As can be seen from the above correlation matrix table the correlation coefficient for all variables is below 0.5 hence the variables are taken to the regression.

**Table 4. 9: Table of multicolinearity test**

| | Gdppc | Agedep | ICT goods | Inf | Mobile | Teleline | Unemp | Urban | Liter | Cpia qual |
|---|---|---|---|---|---|---|---|---|---|---|
| Gdppc | 1 | | | | | | | | | |
| Agedep | **-0.0933** | **1** | | | | | | | | |
| ICT goods | **-0.1123** | **-0.0539** | **1** | | | | | | | |
| Inf | **-0.1947** | **-0.0646** | **-0.0318** | **1** | | | | | | |
| Mobile | **0.5665** | **-0.07** | **-0.1853** | **-0.288** | **1** | | | | | |
| Teleline | **0.2696** | **-0.1298** | **0.1079** | **-0.0401** | **0.2912** | **1** | | | | |
| Unemp | **0.0449** | **0.0361** | **-0.1911** | **0.0474** | **-0.1185** | **0.1151** | **1** | | | |
| Urban | **0.0909** | **-0.3583** | **-0.379** | **-0.1498** | **0.5332** | **0.1685** | **-0.0828** | **1** | | |
| Liter | **0.1322** | **-0.3572** | **0.2569** | **0.1626** | **-0.0026** | **0.3212** | **0.352** | **-0.1566** | **1** | |
| Cpia qual | **0.2415** | **0.1916** | **0.266** | **-0.0994** | **-0.0095** | **-0.1203** | **-0.2868** | **-0.3013** | **-0.1736** | 1 |

Source: Own computation based on World Bank data (2013)

### 4.2.2 Estimation Results

To show that internet diffusion is a dynamic process the model is estimated using the dynamic panel data model discussed in chapter three. The model is first estimated using the Arellano and bond (1991) difference GMM (Table 4.10 below) estimation technique.

**Table 4. 10: Estimation result: One step difference GMM**

| Variables | Coef. | Std.Err. | z | P>z | [95% Conf. Interval] |
|---|---|---|---|---|---|
| **internetusersper100people L1** | 0.76709 | 0.10244 | 7.49 | 0.000 | .5663056 .967889 |
| **Gdppc** | 0.00036 | 0.00359 | 0.1 | 0.919 | -.0066861 .007413 |
| **Agedep** | 0.092143 | 0.173919 | 0.53 | 0.596 | -.2487323 .433018 |
| **Ictgoods** | -0.55028 | 0.16878 | -3.26 | 0.001 | -.881093 .219464 |
| **Inf** | 0.00194 | 0.03174 | 0.06 | 0.951 | -.060275 .064158 |
| **Mobile** | -0.00161 | 0.023737 | -0.07 | 0.946 | -.048129 .044919 |
| **Teleline** | -1.02023 | 1.388686 | -0.73 | 0.463 | -3.74200 1.70154 |
| **Unemp** | -0.21382 | 0.635663 | -0.34 | 0.737 | -1.45969 1.03205 |
| **Urban** | 0.027512 | 0.375456 | 0.07 | 0.942 | -.708367 .763392 |
| **Liter** | 0.011832 | 0.059269 | 0.2 | 0.842 | -.10433 .1279965 |
| **Cpiaqual** | 0.20629 | 1.14517 | 0.18 | 0.857 | 2.038203 2 .45079 |
| **Specification Test Stat.** | | | | | |
| **AR(1) Test 6.55(0.00)** | | | | | |
| **AR(2) Test 0.19(0.84)** | | | | | |
| **Wald Stat 43.63(0.00)** | | | | | |
| **Sargan(Hansen) Chi$^2$ 96.08(0.000)** | | | | | |

The estimated result shows that the model have unexpected signs and most of the variables are insignificant. Furthermore, the sargan test of over identifying restriction shows that under the null hypothesis of valid instruments is rejected and hence, the instruments fail to be valid. In fact, the difference GMM uses only lagged levels as instruments which are often poor instruments for first differenced variables. This would particularly be the case if the time dimension of the study is very small as is the case in this study. Hence, there is a need to resort to system GMM estimation which uses additional moment conditions and hence more efficient than the Arrellano and Bond (1991) difference GMM.

Following the above line of reasoning the model is re-estimated using the system GMM. The results are presented in table 4.11 below.

**Table 4. 11: Estimation result: One step system GMM**

| Variables | Coef. | Std. Err. | Z | P>z | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| **internetusersper100peopleL1.** | 0.33412 | 0.091745 | 3.64 | 0.000 | 0.154303 | 0.513936 |
| **Gdppc** | 0.021018 | 0.004007 | 5.25 | 0.000 | 0.013165 | 0.028872 |
| **Agedep** | -0.09591 | 0.310534 | -0.31 | 0.757 | -0.70454 | 0.512728 |
| **Ictgoods** | 2.099226 | 0.402678 | 5.21 | 0.000 | 1.309992 | 2.88846 |
| **Inf** | -0.11052 | 0.183485 | -0.6 | 0.547 | -0.47014 | 0.249104 |
| **Mobile** | 0.18048 | 0.104208 | 1.73 | 0.083 | -0.02376 | 0.384723 |
| **Teleline** | 0.181453 | 1.274317 | 0.14 | 0.887 | -2.31616 | 2.679069 |
| **Unemp** | -2.98434 | 0.861323 | -3.46 | 0.001 | -4.6725 | -1.29618 |
| **Urban** | 0.446109 | 0.212522 | 2.1 | 0.036 | 0.029574 | 0.862644 |
| **Liter** | 0.102884 | 0.076188 | 1.35 | 0.177 | -0.04644 | 0.252209 |
| **Cpiaqual** | 0.251447 | 1.248314 | 0.2 | 0.84 | -2.1952 | 2.698098 |
| **_cons** | -9.74805 | 19.17247 | -0.51 | 0.611 | -47.3254 | 27.82929 |
| **Specification Test Stat.** | | | | | | |
| **AR(1) Test Z=-2.51(0.012)** | | | | | | |
| **AR(2) Test Z=0.6248(0.532)** | | | | | | |
| **Wald Stat 6182.07 (0.000)** | | | | | | |
| **Sargan(Hansen) $Chi^2$=4.5769(0.862)** | | | | | | |

From the above table (table 4.11) the sargan test of over identifying restriction shows that under the null hypothesis of valid instruments is accepted indicating that the instruments in our model are accepted, furthermore the sargan test indicates that the model controls for indogniety of the lagged dependent variable. The diffusion coefficient (the lag of the dependent variable) is positive and highly significant indicating that internet use is a dynamic process depending on its own past experience. GDP per capita and ICT goods import have significant positive effect on internet use.A100 percent increase in GDP percapita is associated with 2 additional peoples using internet per hundred people.. Unemployment has negative impact on internet use at five percent level of significance.A1% increase in the unemployment rate decreases internet users by 2.9 peoples per hundred people in sub Saharan Africa.

Age dependency ratio and inflation has negative impact on internet use in sub Saharan Africa although both come out to be insignificant. Mobile cellular subscription and urban population has positive significant impact on internet use in sub Saharan Africa at 10 percent level of significance. Literacy, quality of public administration and telephone line has positive but insignificant impact on internet use in sub Saharan Africa.

### 4.2.3 Arellano-Bover estimation tests

In most instances one and/or two post estimation procedure(s) is (are) undertaken to evaluate the Arellano and Bover (1995) and Blundell and Bond (1998) model.

The moment conditions used by Arellano and Bover (1995) and Blundell and Bond (1998) are valid only if there is no second order serial correlation in idiosyncratic

errors. Testing for serial correlation in dynamic panel-data models is tricky because a transform is required to remove the panel-level effects, but the transformed errors have a more complicated error structure than that of the idiosyncratic errors. The Arellano-Bond test for serial correlation is reported by estat abond tests for serial correlation in first-differenced errors. In AR(1) models, since the first differenced errors will be serially correlated, rejecting the null hypothesis of no serial correlation in the first-differenced errors at order one does not imply that the model is misspecified. Rejecting the null hypothesis at higher orders however implies that the moment conditions are not valid. Hence under the null of no autocorrelation in the idiosyncratic error the result for the first and second order correlation is reported as follows:

A. Test for autocorrelation

H0: no autocorrelation

**Table 4. 12: Test for autocorrelation**

| Order | Z | prob>Z |
|---|---|---|
| 1 | -2.51 | 0.012 |
| 2 | 0.6248 | 0.532 |

As can be seen from the above test result the model is correlated in its error for the first order (this is as expected since the error terms are serially correlated by construction. Furthermore as can be seen from the above table test for second order autocorrelation indicates that we cannot reject the null hypothesis that there is no second order serial correlation in the differenced residuals, suggesting consistency of our estimates and validity of the System GMM estimator.

B. Test of over identifying restrictions

The reliability of econometric methodology depends critically on the validity of the instruments, which can be evaluated with the sargan(Hansen) test of over-identifying restrictions, asymptotically distributed as $Chi^2$ in the number of restrictions. Rejection of the null hypothesis that instruments are orthogonal to the errors indicate that the instruments as a group appear to be endogenous and hence invalid(Baum et al. 2010).

Although there is no method to test if the moment condition from an exactly identified model are valid, one can test whether the over identifying moment conditions are valid,estat sargan implements the sargan(Hansen) test of over identifying conditions. As can be seen from the table 4.13 below, The sargan(Hansen) test of over-identification shows that the null hypothesis of valid instruments is not rejected implying that the instrument appear exogenous and hence valid.

**Table 4. 13: Sargan (Hansen) test of over identifying restrictions**

| |
|---|
| H0=Over identifying restrictions are valid |
| $Chi^2$=4.5769(0.862) |

## 4.3 Discussion

The Arellano bond system GMM estimation shows that the diffusion coefficient (the lag of the dependent variable) is positive and highly significant indicating that the diffusion

model cannot be rejected. A 100 percent increase in the number of Internet users last year leads to an increase of about 33 peoples out of 100 people in the number of Internet users this year. The importance of the lagged dependent variable is in line with the results of several papers including Goolsbee and Klenow (2002) and Kiiski and Pohjola (2002). The presence of network effects as a determinant of Internet adoption is a striking fact considering that the utility derived from Internet consumption this year is affected by the number of people using it last year (Shy, 2001). It also indicates that internet by itself creates network among peoples in sub-Saharan countries under study, this could be through online research, E-governance, and online activities that could be done through social media.

GDP per capita and ICT goods import have significant positive effect on internet use.A100 percent increase in GDP percapita is associated with 2 additional peoples per 100 inhabitants using internet suggesting that internet is a normal good; this also implies that wealth is an important determinant of internet use in developing countries. Consistent with other studies in the field the positive and statistically significant relationship between GDP per capita and country's internet users shows that ,an increase in a country's economic wealth is associated with an increase in its share of internet users. This finding makes intuitive sense given that the more an economy grows the more its state is likely to invest in ICT infrastructure and the more the people may have the income to acquire new ICTs. In general, GDP per capita, being one of the key determinants in explaining global digital divide has been verified to be positively related to ICT diffusion and hence internet as observed in most past research efforts. Among research authors that confirms such assertion is Shchetinin and Baptiste (2008). Using the

Generalized Method of Moments estimator to investigate the determinants of digital divide, their findings show that GDP per capita has positive impact on Internet diffusion in developed countries. Apart from that, in a study investigating socio-economic factors driving the digital divide based on a panel of 40 countries from 1985-2001, Dewan, Ganley and Kraemer (2005) also pointed out the positive relationship between IT penetration and GDP. Additionally, they highlight how the marginal impact of a rise in GDP is noticeably higher in countries at a high level of IT penetration. The significance of GDP in causing disparity of ICT and hence internet access and use is also underlined by Srinuan, Rohman and Bohlin (2009). With particular focus on ASEAN countries, the findings show that higher GDP per capita yields a higher digitization index. Furthermore, the significance of GDP percapita also supports the economic demand theory in the sense that higher earnings help to ease the entry of technology among the population.

The finding of this however contradicts from the research by Alberto et al. (2005) where they did a research for 38 African countries for the year 1996-2005 using fixed effect panel data estimation, they found that GDP percapita is insignificant determinant of internet penetration in Africa by arguing that the average level of income in the African countries is very low, so a one percent increase in the average family income level should be use to finance basic necessities and not the use of Internet. Here the feasible explanation is that factors impacting internet use may differ when countries enter in to different stage of development in addition the countries under study and the time period differs.

A 1 percent increase in ICT goods import is associated with 2 peoples per 100 people increase in the number of internet users; this shows that technology use in sub-Saharan

countries is an imported one from the rest of the world, implying that developing countries under study need scientific import products which are available in the developed world to use internet in the region.

Unemployment and age dependency ratio has negative impact on internet use in sub-Saharan countries although the latter has insignificant impact. A 1 percent increase in the unemployment rate is associated with a 2.98 percent decrease in the number of internet users in the countries under study. This could be due to the fact that the unemployed have no ability to pay for the cost of internet use in the countries under study.

Urban population and mobile cellular subscription have positive and significant impact on internet use in sub-Saharan Africa at 10 percent level of significance. A 1 percent increase in the urban population derives up internet users by 0.44 percent in the countries under study on average. This may be due to the fact that cities have more access to telecommunication infrastructure so as to use internet for internet users. Such an effect is also explained by the diffusion of innovations theory of Agerstrand,(1967), which suggests that innovations that depend on shared infrastructure (as internet depends on access to networks) diffuse more quickly in areas where the shared infrastructure is more prevalent which is readily available in urban areas. Furthermore, the result for urbanization is consistent with those of Atkinson et al. (2008) and Kim et al. (2001).

A 1 percent increase in the mobile cellular subscription is associated with a 0.18 percent increase in the number of internet users in sub Saharan countries. This could be due to the fact that mobile use is now becoming an important device (portable) to use the internet in the recent years or Mobile cellular subscription may be important for one of the most

common uses of accessing the Internet. And well developed communication infrastructure is also likely to have other unobservable attributes that encourage Internet use. However, the other infrastructural variable (telephone lines per 100 inhabitants) is insignificant in the result as shown in the table(Table 4.10).In this study mobile cellular subscription and telephone mainlines are used in the regression analysis as an explanatory variables representing infrastructure. The result as explained above is that telephone main lines come out to be insignificant while mobile cellular subscription come out to be as a significant variable. Internet technology requires a well-functioning telecommunications network to operate. As a result, people can only get connected via ISDN, DSL, Modem, VSAT, PSTN,mobile etcAwoleye, (2008) . Therefore, it is natural to assume that a country with high telephone density tend to have greater number of Internet users. However, contrary to expectation, the regression did not show a significant result between telephone line and Internet use. The presence of adequate infrastructure in terms of telephone lines in a country was believed to facilitate the use of internet on individuals. There is an argument that, there are strong linkages between different types of telecom infrastructure (Walter,2001) This could support the above argument, meaning currently as the number of mobile cellular subscription is increasing rapidly(as shown in the descriptive statistics) replacing the traditional telephone mainlines. Therefore fixed and mobile phones could be regarded as substitutes and mobile phones can to some extend leapfrog the extension of the fixed network. This could also be due to the fact that fixed line connections usually have more weighting time to use internet than wireless connection (which mobile is the one).

Levels of adult literacy, however, emerge as statistically insignificant determinant of internet use in countries under study. The fact that literacy is insignificant does not imply that education is not necessary for technology use in general and internet use in particular, but in this study adult literacy rate is used as a proxy measure for education but in fact it could be argued more if the proxy variable were on the length of education (which is not available for the countries under study due to high missing values) since the literature suggests that peoples who invest more of their time on education are supposed to use internet higher than those who didn't invest more of their time on education. Furthermore, one would presume that increases in literacy levels should lead to an increase in the number of internet users given that accessing and using the internet is contingent on being literate (as well as having some competence in English, it can be argued) and hence another indicator of human capital might be a better predictor of internet use. Hence finding here may complement other studies that suggest that investment in higher education institutions are more important than literacy programs in diffusion of internet for narrowing internet-related aspects of the digital divide. As universities played a critical role in the launch of the internet it would be appropriate that the further development of a country's higher educational institutions would be needed to assist the efforts to narrow the digital divide.

In this study, institutional factor proxied by an index of quality of public administration) seem to play insignificant role in Internet growth in sub Saharan Africa (as shown in Table 4.11). This may be because of the time dimension that this study uses (the time period is short such that there is no significant policy change by the government).Institutions in Africa are generally categorized as "mostly un-free" or

"repressed" (Freedom House, 2005). The role of institutional influence (positive or negative) on technology diffusion has been long predicted Kinget el. (1994).

# CHAPTER FIVE: CONCLUSION AND POLICY IMPLICATION

## 5.1 Conclusion

The use of Internet increases the social knowledge network and improves the communication efficiency, it also makes easier and provides better political agreements, increases the productivity, and allows less developed countries to accelerate the change from the traditional methods to the new techniques .The Internet also offers considerable promise in facilitating the delivery of basic services, such as health and education, which are unevenly distributed at present in the world. Despite this importance's internet use in sub Saharan Africa is very low. To investigate the main determinants of internet use different factors are used in the analysis.

The study aims at identifying and analyzing the factors that influenced the diffusion of Internet access in 25 Sub-Saharan countries. The study uses data for the 2009–2013 periods. To capture network externalities the lag of dependent variable is used in the regression analysis. Macroeconomic indicators such as GDP per capita unemployment, Inflation, urbanization rate, Age dependency rate were used to investigate the role of each indicator in influencing the use of the Internet. Infrastructure variables such as Telephone mainlines per 100 people and mobile cellular subscription were also included.ICT goods import were used as a technological transfer variable in this study. To investigate the role of institutional variables quality of public administration as rated by the World Bank and IDA ( a supporting organization in the world bank to reduce poverty) is used as an

explanatory variable. Since internet is regarded as skill-based technology, the role of human capital (Literacy rate) was also examined.

The parameters of the model were estimated using panel data by Arellano and Bover (1995) dynamic panel data estimation technique. The Internet diffusion equation identifies the factors that are expected to influence diffusion of the Internet directly. The findings are in accordance with the expectations although some variables are insignificant. First, the findings of the study suggest that network externalities are important source of internet use that is last year's internet users are important determinants of internet users in the current year. Second, the study captures the significant role played by economic wealth in stimulating Internet diffusion. Similar results have been produced by previous studies that have examined the predictive role of GDP per capita. The role of economic wealth becomes more relevant in the case of internet because governments need significant investment capital for a reliable and efficient communication network in order to experience a faster diffusion of technologies, where internet is the way to transfer knowledge.

Third, ICT goods import and mobile cellular subscription has positive significant effect on internet use at 1 and 10% level of significance respectively, the former used as a proxy for technology transfer while the latter proxies the availability of updated telecommunication infrastructure. Urban population has positive significant effect on internet use in sub Saharan Africa at 10 % level of significance while unemployment has negative significant effect on internet use at 10 % level of significance in countries under study.

The regression output also indicates that Telephone mainlines availability, literacy rate and quality of public administration has positive but insignificant effect on internet use in sub-Saharan countries under study.

## 5.2 Policy Implications

What then should poor countries do in order to improve access to the Internet and in the end, bridge the digital inequality gap?

Evidently African countries need greater work on improving their country to move from low level of income status to a higher level, since wealth is an important determinant of technology use in this study.

Furthermore sub-Saharan Africa need investment on telecommunication infrastructure since in our regression the infrastructure variable (mobile cellular subscription is significant), huge investments are a prerequisite to building effective communications networks.

In sum, major policy implications that have emerged from this study are twofold: First, countries need to reorient their telecommunication and economic policies to promote investments in ICTs that in turn might further boost economic growth so also saves foreign currency if imported ICT goods are replaced by domestically produced ICT goods and,

Second, governments in developing countries not only need to increase their income status but growth should come together with employment creation.

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# APPENDIX

## APPENDIX: A

## List of countries under study

**Benin**
**Burkina Faso**
**Burundi**
**Central African Republic**
**Chad**
**Comoros**
**Congo, Dem. Rep.**
**Eritrea**
**Ethiopia**
**Gambia**
**Guinea**
**Guinea-Bissau**
**Kenya**
**Liberia**
**Madagascar**
**Malawi**
**Mali**
**Mozambique**
**Niger**
**Rwanda**
**Sierra Leone**
**Tanzania**
**Togo**
**Uganda**
**Zimbabwe**

## APPENDIX: B

System dynamic panel-data estimation — Number of obs=125
Group variable: country — Number of groups=25
Time variable: year — Obs per group min=5
Number of instruments=20 — max=5
Max=5

One step results

Wald chi2(11) = 6182.07
Prob > chi2 = 0.0000

| Variables | Coef. | Robust Std. Err. | z | P>z | [95%Conf. | Interval] |
|---|---|---|---|---|---|---|
| **Internet users per 100 peopleL1.** | **0.33412** | **0.091745** | **3.64** | **0.000** | **0.154303** | **0.513936** |
| **gdppc** | **0.021018** | **0.004007** | **5.25** | **0.000** | **0.013165** | **0.028872** |
| **agedep** | **-0.09591** | **0.310534** | **-0.31** | **0.757** | **-0.70454** | **0.512728** |
| **ictgoods** | **2.099226** | **0.402678** | **5.21** | **0.000** | **1.309992** | **2.88846** |
| **inf** | **-0.11052** | **0.183485** | **-0.6** | **0.547** | **-0.47014** | **0.249104** |
| **mobile** | **0.18048** | **0.104208** | **1.73** | **0.083** | **-0.02376** | **0.384723** |
| **teleline** | **0.181453** | **1.274317** | **0.14** | **0.887** | **-2.31616** | **2.679069** |
| **unemp** | **-2.98434** | **0.861323** | **-3.46** | **0.001** | **-4.6725** | **-1.29618** |
| **urban** | **0.446109** | **0.212522** | **2.1** | **0.036** | **0.029574** | **0.862644** |
| **liter** | **0.102884** | **0.076188** | **1.35** | **0.177** | **-0.04644** | **0.252209** |
| **cpiaqual** | **0.251447** | **1.248314** | **0.2** | **0.84** | **-2.1952** | **2.698098** |
| **_cons** | **-9.74805** | **19.17247** | **-0.51** | **0.611** | **-47.3254** | **27.82929** |

Instruments for differenced equation

GMM-type: L(2/.).internetusersper100people

Standard: D.gdppc D.agedep D.ictgoods D.inf D.mobile D.teleline D.unemp D.urban D.liter

D.cpiaqual

Instruments for level equation

GMM-type: LD.internetusersper100people

Standard: _cons

## APPENDIX: C

Un robust System dynamic panel-data estimation — Number of obs=125
Group variable: country — Number of groups=25
Time variable: year — Obs per group min=5
Number of instruments=20 — max=5
Max=5
One step results — Wald chi2(11) = 19633.53
Prob > chi2 = 0.0000

Instruments for differenced equation

| variables | Coef. | Std. Err. | z | P>z | [95%Conf. | Interval] |
|---|---|---|---|---|---|---|
| **internet users per 100 peopleL1.** | **0.33412** | **0.107996** | **3.09** | **0.002** | **0.122451** | **0.545788** |
| **gdppc** | **0.021018** | **0.01078** | **1.95** | **0.051** | **-0.00011** | **0.042147** |
| **agedep** | **-0.09591** | **0.197273** | **-0.49** | **0.627** | **-0.48255** | **0.29074** |
| **ictgoods** | **2.099226** | **1.302273** | **1.61** | **0.107** | **-0.45318** | **4.651635** |
| **inf** | **-0.11052** | **0.164415** | **-0.67** | **0.501** | **-0.43277** | **0.211729** |
| **mobile** | **0.18048** | **0.117341** | **1.54** | **0.124** | **-0.0495** | **0.410464** |
| **teleline** | **0.181453** | **1.163329** | **0.16** | **0.876** | **-2.09863** | **2.461536** |
| **unemp** | **-2.98434** | **2.634192** | **-1.13** | **0.257** | **-8.14726** | **2.178582** |
| **urban** | **0.446109** | **0.271748** | **1.64** | **0.101** | **-0.08651** | **0.978725** |
| **liter** | **0.102884** | **0.06573** | **1.57** | **0.118** | **-0.02594** | **0.231712** |
| **cpiaqual** | **0.251447** | **1.069518** | **0.24** | **0.814** | **-1.84477** | **2.347663** |
| **_cons** | **-9.74805** | **20.06586** | **-0.49** | **0.627** | **-49.0764** | **29.5803** |

GMM-type: L(2/.).internetusersper100people

Standard: D.gdppc D.agedep D.ictgoods D.inf D.mobile D.teleline D.unemp D.urban D.liter D.cpiaqual

Instruments for level equation

GMM-type: LD.internetusersper100people

Standard: _cons

**Declaration**

I, the undersigned, declare that this thesis is my original work and has not been presented for a degree in any other university, and that all source of materials used for the thesis have been duly acknowledged.

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Signature:_____

Date:_____

Place and date of submission:_____