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Analysis of Internet Diffusion and Adoption in Selected African Countries

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Abstract The study identifies and analyses the major determinants that influenced the diffusion and adoption of Internet technology in the selected African countries. The selected Africa countries were purposely chosen based on their Internet connectivity and usage pattern. A model was developed and used to explain inter-country differences in adoption as measured by the following parameters: Internet Usage (UI), Internet Host (IH), Gross Domestic Product (GDP) per capita, Investment in Telecommunication Infrastructures (ITI) per capita and Telephone Density (TD). These variables were analysed using Statistical Package for Social Sciences (SPSS). The results of the study confirm past findings that Economic strength, Telecommunications and Technology Infrastructure, and number of Internet Host in the observed countries play a fundamentally important role in determining diffusion rates of Internet technology. However, correlation test and regression analysis do not show any significant relationship between Internet diffusion and telephone density. To this end, the work thus suggested some appropriate policy directions that will guide the government in telecommunication and economic policies in order to promote public as well as private investments in ICTs that in turn might further boost economic growth.

Keywords Internet Adoption, Digital Divide, Internet Diffusion

1. Introduction

The twentieth century has witnessed various changes in communication technology much more with its advancement. Successive waves of different innovations in telephone, radio, television, satellite communication, digital networks among others have altered the way people communicate with each other[1-2]. The widespread of Internet adoption and its integration into the communication infrastructure has brought transformation into the communication technology. The digital communication networks have been in existence in the United States since the establishment of ARPANET by the Department of Defence in 1969[3]. The change in communication technology development that led to the popularity of Internet technology today was characterized by the advent of World Wide Web (Web) and Mosaic Internet browser[1]. The Internet adoption started primarily with government organization and educational institution that already possessed the communications infrastructure to support the Internet technology. This gradually spread to other segments of the society as access to Internet connections over standard telephone lines became more widely available[1].

Globally, the diffusion and adoption of Internet technology started with just a few countries in 1990, and by the mid of 1998, over 200 countries were connected. Today, Internet technology has spread across all continents of the world. It has experienced exponential growth in popularity among the nations. The Internet World Stat gave the following recent world statistics. It was reported that the number of users has increased tremendously with current estimates of worldwide Internet users being above 2 billion. However, the pattern of adopting the technology varies across the world. Developed countries account for a disproportionately high number of Internet users worldwide: 44% of the world's Internet users live in Asia. Europe and North America, which represent 16.8% of the world population, house close to 35.7% of worldwide Internet users. As of March 2011, African which represents 14.9% of the world population has less than 5.7% of worldwide users of Internet. Table 1 details the global distribution of the number of Internet users in March 2011.

The observed difference in the levels of Internet adoption across countries raises important policy questions. Of particular interest to policymakers in developing countries is the need to understand the process of diffusion in order to anticipate if their countries will eventually catch up and close the digital divide and, more generally, to implement the right policies to increase the speed of Internet adoption. It is within this context that an evaluation research like this

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is imperative. The objectives of the study are therefore to: (i) examine factors influencing the adoption of Internet Technology within the context of developing countries, (ii) carry out a comparative analysis of the selected Africa countries and (iii) suggest some useful policies which will facilitate the diffusion and adoption of Internet.

Table 1. Regional Distribution of Internet Users

World Regions	Internet Users (millions)	User %
Africa	**118.61**	**5.7**
Asia	922.33	44.0
Europe	476.21	22.7
Middle East	68.55	3.3
North America	272.07	13.0
Latin America	215.94	10.3
Australia	21.29	1.0
World Total	2095.01	100

Source: InternetWorldStats (2011)

2. Overview of Internet Diffusion

According to[4], there are various indicators through which Internet diffusion could be measured; these include but not limited to: connectivity, number of Internet hosts, number of websites, languages and number of Internet users in proportion to population. Numerous studies conducted on Internet diffusion have shown that the slow uptake of Internet services and broadband Internet offerings have been as a result of prohibitive costs and poor infrastructure by the telecommunication company[6-8].

The cost of Internet access has hindered more of the population in gaining Internet access[5],[7]. The cost of Internet service in Africa is extremely high when compared to other countries in North America, Europe, Asia and Australia. These high costs make it difficult for majority of the population to gain access to the Internet, resulting in Internet access figures becoming stagnant or behind the rest of the world in terms of broadband speeds and broadband penetration. There are many factors contributing the high cost of Internet in Africa, many argues that this is as a result of monopolies in the telecommunication industries and government policy which is in place to protect telecommunication companies at the expense of users and potential users[9-10]. Several suggestions have been made on how to make Internet assessable for majority of the population; these include introduction of competitions among telecommunication industries[11], liberation of telecommunication industry to lower the costs of telecommunication infrastructure and provision of better services. Study have shown that competition brings consumer benefits, by forcing companies to cut costs, improve services, and reduce excessive profits[12].

2.1. Factors Influencing Internet Adoption

The goal of this study is to identify and measure the effects of the major determinants of Internet diffusion and its adoption in the selected African countries. For this study, per capital income (GDP), Telephone Density, Investment in Telecommunication Infrastructure and Internet Host have been indentified and selected as the parameters for analysing the diffusion and adoption of the Internet.

2.1.1. Gross domestic product (GDP)

Economic wealth, which is represented by GDP per capita in this study, has been known to always been a major factor in the production and diffusion of a new technology. Empirical studies[13-14] suggested that economic wealth is a prerequisite for the diffusion of the Internet. Research has also shown that countries whose people are better off economically tend to have higher Internet penetration[14-16]. Similarly,[17] showed that richer countries have more telecommunications networks and higher media penetration. The development of Internet technology was adopted by individuals as well as corporate bodies. Thus, individual income, as well as institutional financial capital, is expected to influence the growth of the Internet.

2.1.2. Investment of telecommunication infrastructure (ITI)

A nation's information infrastructure is expected to play an important role in Internet diffusion levels and rates[18]. The presence of adequate infrastructure is crucial for adoption of the Internet, particularly in developing countries[19]. Although, the type of technology used for networking of computers depends on the nature and configuration of the network. Studies[13-14],[20] have shown the role of communication network in diffusion of the Internet. Furthermore,[21-23] found that existing telecommunications infrastructure, personal computing, and software are factors that affect Internet diffusion.

2.1.3. Telephone Density

Internet technology requires a well-functioning telecommunications network 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 network via modem. However, today, information transmission technology has advanced dramatically. Innovation has paved the way for a much faster Internet. More people get connected to the Internet through Integrated Service Digital Network (ISDN), Digital Subscriber Line (DSL), Public Switched Telephone Network (PSTN), Very-Small-Aperture Terminal (VSAT) and even through mobile phones. While such technologies are readily available in most developed countries, their availability is extremely limited in less developed parts of the world[2]. Empirical study[13] has analysed the role of telephone density on the diffusion of the Internet, and found it to significantly influence the technology. Based on the empirical evidences, it is expected in this study that telephone density will have significant association with the diffusion of Internet in the selected African countries.

2.1.4. Internet Host

A host is a computer through which Internet can be accessed.[13] suggested a positive correlation between the density of Internet host and Internet diffusion in OECD and other developed countries. However, in developing countries, only a few have access to the Internet in their various homes. Majority of the Internet users get connected through service providers such as cyber cafes and other institutions. This implies a host will provide access to a large number of people[24]. Ease of access to the Internet is enhanced by the wide availability and quality of Internet host. Thus the number of Internet hosts in a country tends to associate with a high dispersion rate of the Internet.

3. Methodology

The core focus of this research is to critically analyse the factors influencing the diffusion of Internet in Selected African countries by using four parameters mentioned in the previous sections.

3.1. Area of Study

A stratified sample of 5 African countries was selected to represent various parts of Africa in terms of country size, socio-economic development, telecommunication infrastructure, geographical location, Internet connectivity and usage. These countries include: Egypt from North Africa, Nigeria from West, Kenya from East, Rwanda from Central Africa and South Africa from the South. This was aimed to comparing the results generated among the selected African countries and explains the differences in their rate of adoption and diffusion of Internet technology.

3.2. Methods of Data Collection

This study was primarily a secondary analysis of existing data, which were obtained from different sources, including International Telecommunication Union (ITU), the World Bank, and the Internet World Stats, the Nation Master and the World FactBook. Internet User (IU) was gotten from the Internet World Stats Database and ITU. Gross Domestic Product (GDP), Telephone Density (TD) and Investment in Telecommunication Infrastructure (ITI) were gotten from The World Bank's World Development Indicators (WDI). Internet Host (IH) was gotten from the world Factbook and Nation Master Database.

3.3. Method of Data Analysis

A system of equations was developed and used to explain the variability in the diffusion and adoption of Internet technology in the selected African countries. To examine the role of the variables discussed in the previous sections, it is hypothesized that Internet User (IU), is a function of Internet Host (IH), Telephone Density (TD), Investment in Telecommunication Infrastructure (ITI) and Gross Domestic Product per capital (GDP). Variables employed to represent these factors or parameters and their expected relationships are mathematically expressed in equation (i).

IU = f(IH, TD, ITI, GDP) …..……. Equation i

Where

IU = Internet users per 1,000 persons

IH = Internet hosts per 1,000 persons

TD = Telephone lines per 1, 000 persons

ITI = Per capita investment on telecommunication infrastructure in USD

GDP = Per capita GDP in USD

$IU = \alpha_0 + \alpha_1 IH + \alpha_2 TD + \alpha_3 ITI + \alpha_4 GDP + \varepsilon$ .. Equation ii

In equation (ii), the dependent variable is IU, while the independent variables are IH, TD, ITI, and GDP. $\boldsymbol{\alpha_0}$, $\boldsymbol{\alpha_1}$, $\boldsymbol{\alpha_2}$, $\boldsymbol{\alpha_3}$, and $\boldsymbol{\alpha_4}$ are the magnitudes while $\boldsymbol{\varepsilon}$ is the error term.

Evaluation of the formulated model was carried out to determine if the estimated parameters are theoretically and statistically meaningful and significant. To test the relationship between the Internet penetration and various factors that may affect the Internet diffusion, correlation analysis was conducted using the Pearson correlation coefficients and Ordinary Least Square Method (OLS), under which the criteria for evaluating the models include the following: F-statistic, coefficient of determination, R^2 and Durbin-Watson (DW) statistic.

F-statistics test the overall significance of the regression model. Specifically, they test the null hypothesis that *all* of the regression coefficients are equal to zero. This tests the full model against a model with no variables and with the estimate of the dependent variable being the mean of the values of the dependent variable. The F value is the ratio of the mean regression sum of squares divided by the mean error sum of squares. Its value ranges from zero to an arbitrarily large number. Coefficient of determination (R^2) is a statistics that determine the amount of the total variation in the independent that is associated with the regression model. The value of determination ranges from 0.00 to 1.00. The Durbin-Watson test for autocorrelation is a statistic that indicates the likelihood that the deviation (error) values for the regression have a first-order auto-regression component. The regression models assume that the error deviations are uncorrelated. The Durbin-Watson statistic is always between 0 and 4. A value of 2 means that there is no autocorrelation in the sample, values approaching 0 indicate positive autocorrelation and values toward 4 indicate negative autocorrelation.

3.4. Data Presentation

The necessary data used for the analysis of the variables are between the year 2001 and 2010. The data are presented for each observed countries as shown in the Appendix.

Table 2. Coefficients of Relationship between Internet Users, Internet Host, Investment in Telecommunication Infrastructure, Telephone Density and Gross Domestic Product

	Coefficient of Determination Coefficients							Error Term	Durbin-Watson	F-Statistics
Country	R^2	α_0	α_1	α_2	α_3	α_4	Sig.	E	DW	F
Nigeria	0.880	-564.681	-10265.292	-15.642	4.877	1.778	0.163	1.041	2.099	7.302
South Africa	0.708	199.296	-0.414	-1.373	0.169	0.004	0.572	324225	2.042	2.423
Egypt	0.988	-597.571	-4.531	0.845	0.575	0.350	0.026	0.102	2.823	39.534
Kenya	0.963	-494.464	36.335	-0.367	-0.201	1.255	0.027	0.369	2.137	12.865
Rwanda	0.928	11.917	-64.520	-11.162	1.493	0.118	0.286	1.213	1.262	6.206

Table 2 is an extraction of the regression analysis of independent variables (Internet Host, Investment in Telecommunication Infrastructure, Telephone Density and Gross Domestic Product) on the dependent variable (Internet User) gotten from the SPSS analysis. The values extracted are R2, the coefficients of determinant, Durbin Watson (DW), Sig, and F tests.

Where:

R^2 represents the coefficient of determination

α_0 represents the constant value

α_1 represents the coefficient of Internet Host

α_2 represents the coefficient of Telephone Density

α3represents the coefficient of Investment in Telecommunication Infrastructure

α_4 represents the coefficient of Gross Domestic Product Per Capital

DW represents the Durbin-Watson statistics

Sig represents the significant

F represents the F-statistics

Table 3. Correlation between Internet users and various factors

Country	GDP	TD	IH	ITI
Nigeria	0.891**	0.190	-0.084	0.711
South Africa	0.705*	-0.833**	0.947**	0.124
Egypt	0.969**	0.463	0.799**	0.645
Kenya	0.845**	0.416	0.872**	0.618
Rwanda	0.816**	0.549	-0.530	0.876**

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

4. Interpretation of Results

Table 2 comprised of the five selected African countries (Nigeria, South Africa, Kenya, Rwanda and Egypt). The value of R^2 shows the values accounted by the total change in the dependent variable. Egypt has the highest proportion (98.8%) of R^2 with an error term of 2.2% while South Africa (70.8%) has the lowest. The model's DW statistic shows the model's predictive ability to be good for all the observed countries except Rwanda. With the values of DW statistics close to 2, it means there is no auto correlation within the samples used for the study. The F values show the linear relationship between the independent and dependent values since the values are greater than the significant values.

Table 3 showed a strong relationship between a country's GDP and Internet penetration in all the observed countries. Rich countries tend to boast a higher Internet penetration rate than poor countries. In addition to the correlation analysis, regression of the independent variables on the Internet user further showed the GDP per capita to be powerful determinant of Internet use across all the observed countries. An increment in a unit of GDP per capita for Nigeria, South Africa, Egypt, Kenya and Rwanda is associated with an increase in number of Internet users per 1,000 persons with 1.78, 0.004, 0.35, 1.26 and 0.12 respectively. The results did not only supported the hypothesis but also in line with the findings of earlier studies[13-14] that suggested GDP as an important determinant of the use of Internet in the developing countries.

Internet technology requires a well-functioning telecommunications network to operate. As a result, people can only get connected via ISDN, DSL, Modem, VSAT, PSTN etc[2]. Therefore, it is natural for us to assume that countries with high telephone density tend to have greater number of Internet users. However, contrary to expectation, correlation test did not show any significant relationship between Internet diffusion and telephone density. The regression of telephone density did not show a linear pattern in the relationship between telephone density and Internet diffusion. Therefore, hypothesis that predicted telephone density to have a positive influence on the Internet diffusion and adoption is rejected. The presence of adequate infrastructure in a country was believed to facilitate the adoption of the Internet by organizations and individuals[19]. Therefore, it is not a surprise to see a relationship between telecommunication infrastructure and Internet diffusion in all the observed countries except South Africa.

From the regression table, investment in telecommunication infrastructure significantly determined Internet use in Nigeria, South Africa, Egypt and Rwanda. The model predicted that for every additional investment in telecommunication infrastructure per capital of Nigeria, South Africa, Egypt and Rwanda, the Internet usage will increase by almost 4.88, 0.17, 0.575 and 1.49 respectively. Thus, an increase in the amount invested in telecommunication infrastructure in a country will likely have a very large effect on the Internet diffusion. However,

this was not the case in Kenya, as the investment in telecommunication infrastructure is not a statistical determinant of the rate at which people adopts the use of Internet technology. An investment in telecommunication infrastructure in Kenya leads to 0.201 decrease in the Internet usage. Finally, our findings show that there is a significant relationship between Internet host and Internet diffusion in South Africa, Egypt and Kenya. However the results of Nigeria and Rwanda showed a negative correlation between the density of Internet host and the diffusion of Internet technology. Higher Internet host density suggests the existence of a large number of Internet access points. The presence of a large number of access points thus promotes ease of the Internet access.

5. Summary and Conclusions

In this study, we examined a number of factors that may have facilitated or hindered the Internet development in the selected African countries. Data for the analyses are sampled between 2001 and 2010 from International Telecommunication Union (ITU), Internet World Stats Database, the World Bank's World Development Indicators, the Nation Master and the World FactBook. The role of macro-economic indicators such as GDP per capita and per capita investment of telecommunication infrastructure was investigated on the Internet users. Technological variables such as telephone density and Internet hosts were also included. The model formulated consists of an equation that identifies the factors, which are expected to directly influence the diffusion of the Internet technology. The paper explored the main determinants of Internet diffusion and it was found that GDP per capita, investment in telecommunication infrastructure, and Internet host correlate with diffusion of Internet in the selected African countries. The study captured the significant role of economic wealth of the country in stimulating the diffusion of the Internet. This outcome is in support of prior studies[13-16] that suggested similar outcomes. GDP per capita indicated a country's economic strength as well as individual wealth. The operation of the Internet is a costly venture and only countries with strong economic power are able to build the Internet in such a way that it is accessible to her citizens.

Table A.1. Nigeria Yearly Time Series of Regression Data

Year	Real GDP per Capita (US $)	IU density (per 10,000)	TD (per 1000)	IH density (per 10,000)	ITI per Capita (US $)
2001	374.17	0.91	4.74	0.006	7.66
2002	370.81	3.23	5.41	0.008	6.53
2003	399.06	5.64	6.68	0.008	12.58
2004	430.58	12.97	7.53	0.007	7.84
2005	442.72	35.76	8.75	0.011	16.54
2006	458.64	55.81	11.78	0.011	17.69
2007	476.22	68.05	10.75	0.013	18.79
2008	492.34	159.17	8.68	0.007	19.88
2009	513.77	284.70	9.18	0.007	19.79
2010	540.34	290.01	6.63	0.009	

Source: International Telecommunication Union (ITU), Internet World Stats Database, The World Bank's World Development Indicators, WorldFactBook

Table A.2. South Africa Yearly Time Series of Regression Data

Year	Real GDP per Capita (US $)	IU density (per 10,000)	TD (per 1000)	IH density (per 10,000)	ITI per Capita (US $)
2001	3039.71	64.35	109.65	5.31	41.50
2002	3108.04	68.08	106.38	4.37	42.95
2003	3159.24	71.19	104.54	6.26	40.98
2004	3264.32	85.72	103.93	7.51	38.29
2005	3397.72	76.27	100.19	9.76	25.07
2006	3548.09	77.52	97.25	13.52	28.43
2007	3704.79	82.18	93.91	22.55	42.34
2008	3795.14	85.81	90.69	26.58	39.49
2009	3691.42	89.62	87.59	35.08	48.40
2010	3745.34	120.83	84.51	75.03	

Source: International Telecommunication Union (ITU), Internet World Stats Database, The World Bank's World Development Indicators, World FactBook

Table A.3. Kenya Yearly Time Series of Regression Data

Year	Real GDP per Capita (US $)	IU density (per 10,000)	TD (per 1000)	IH density (per 10,000)	ITI per Capita (US $)
2001	410.62	6.24	9.65	0.08	3.37
2002	402.18	12.15	9.76	0.09	3.28
2003	403.23	29.58	9.71	0.25	3.19
2004	412.86	30.40	8.62	0.29	16.11
2005	426.05	31.20	8.05	0.33	11.82
2006	441.48	75.81	8.03	0.36	16.94
2007	460.52	80.03	12.37	0.06	23.40
2008	455.87	87.36	16.81	0.71	31.20
2009	455.76	101.25	16.83	0.83	7.04
2010	467.47	211.51	11.36	1.18	

Source: International Telecommunication Union (ITU), Internet World Stats Database, The World Bank's World Development Indicators, World FactBook

Table A.4. Egypt Yearly Time Series of Regression Data

Year	Real GDP per Capita (US $)	IU density (per 10,000)	TD (per 1000)	IH density (per 10,000)	ITI per Capita (US $)
2001	1500.52	8.71	97.19	0.03	5.68
2002	1507.93	28.25	111.08	0.04	4.92
2003	1527.27	41.96	122.18	0.05	1.68
2004	1560.38	53.54	130.89	0.05	4.01
2005	1600.32	121.64	141.16	0.02	24.62
2006	1678.95	130.57	144.11	0.03	49.64
2007	1765.87	153.61	145.94	0.07	24.80
2008	1858.86	173.29	151.33	2.24	18.05
2009	1957.08	208.69	129.37	2.23	22.47
2010	2022.81	265.26	118.56	2.31	

Source: International Telecommunication Union (ITU), Internet World Stats Database, The World Bank's World Development Indicators, World FactBook

Table A.5. Rwanda Yearly Time Series of Regression Data

Year	Real GDP per Capita (US $)	IU density (per 10,000)	TD (per 1000)	IH density (per 10,000)	ITI per Capita (US $)
2001	222.58	2.36	2.54	0.13	0.95
2002	240.27	2.87	2.89	0.14	0.90
2003	241.08	3.50	2.89	0.17	0.88
2004	254.55	4.22	2.55	0.19	0.85
2005	272.42	5.43	2.56	0.17	3.59
2006	289.93	0.00	2.49	0.17	1.06
2007	297.40	20.60	2.38	0.16	11.78
2008	321.00	29.99	1.68	0.24	4.36
2009	324.21	43.64	3.24	0.01	17.75
2010	338.27	80.13	3.74	0.08	

Source: International Telecommunication Union (ITU), Internet World Stats Database, The World Bank's World Development Indicators, World FactBook

The result also showed that density of Internet host and telecommunication infrastructure significantly influences the diffusion of the Internet. The emergence of these variables as important determinants is not surprising because the existence of Internet host is a necessary condition for Internet access[13],[24]. The result of the study further support past literature[18] in which large number of Internet hosts facilitate and effective use of the Internet. Furthermore, the telecommunication infrastructure provides the means for the Internet diffusion as the access of most individuals to the Internet depends on the existing telephone or cable lines. Although the development of ICT has increasingly helped to reduce the bias of space in communication, distance remains a handicap to wired

communication, which remains the dominant means for connecting computers together. That naturally increases the cost for building Internet links over vast distances. The main policy implication of this study is the need for a reorientation in telecommunication and economic policies to promote public as well as private investments in ICTs that in turn might further boost economic growth.

Although, the parameters used for explaining the Internet diffusion and adoption in this study may be plausible, more attention needs to be paid to other various factors. Comparative studies in the future should probe more deeply into the macro level and socio-cultural contexts of these countries.

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