THE IMPACT OF ICT INFRASTRUCTURE ON HUMAN DEVELOPMENT: AN ANALYSIS OF ICT-USE IN SADC COUNTRIES

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Abstract

Over the past decade African nations have been increasing their investments in Information and Communication Technologies (ICT) infrastructure to aid social and economic development. The provision of ICTs such as the Internet, mobile phone and fixed line telephone aims to bring digital opportunities to all citizens in Africa. The United Nations under the auspices of UNDP and the World Bank affirm that such infrastructure would improve the level of development in poor nations. The HDI (Human development Index) as specified by the UN serves as a measure of development in a country. In this paper, we investigate the effects of ICT infrastructure use on human development in Southern African countries. We use regression analysis to explore the impact of Internet, mobile and telephone usage on the human development measures. The empirical analysis suggests that use of these ICTs has a significant bearing on human development in Southern African countries.

Keywords

ICT-Use, Human Development, ICT Development Index, Structural Equation Modeling, SEM, SADC (Southern African Development Community) Countries, Millennium Development Goals (MDGs).

1.0 INTRODUCTION

A decade ago, the world leaders and the international community gathered at the United Nations Millennium Summit to adopt Millennium Development Goals (MDGs), an initiative to support the world's poorest countries. The MDGs were aimed at reducing poverty, disease, lack of education and human deprivation by setting eight time bound goals to be achieved by 2015 (UNDP, 2000; Steinberg, 2003). This intent was to provide yardsticks for international organizations such as the United Nation (UN), the World Bank, the International Monetary Fund (IMF) as well as Policy makers and industry leaders to ensure human development is within the reach of everyone (UNDP, 2010).

Several initiatives have been stimulated in both developed and developing countries to achieve these common ends, such as the provision of information and communication technologies (ICT). As a result of this mandate, many African nations have invested hugely in ICT infrastructure in response to the demand of MDGs through the influence of development organizations (Bollou, 2006). There have also been suggestions that investments in ICT can support Africa through the stages of economic reformation and development (Braga et al., 2000).

The positive impact of ICT investments on global economic growth in developed and developing nations has been established in most literature (Zhen-Wei Qiang & Pitt, 2004). Yet opinion on the potential of ICT to transform economic and social development in Africa is inconclusive and empirical studies in this regard are few (Akpan 2000; Mwesige, 2004; Bollou, 2006; Ngwenyama et al., 2006; Morawczynski & Ngwenyama, 2007; Bollou & Ngwenyama, 2008).

At present, Africa is facing many developmental challenges such as lack of education, health epidemics, and poverty to mention but a few. There is a crucial question African policy makers must answer: Are increased investments in ICT infrastructure providing improvement in human development in Africa? The objective of this article is to investigate the link between ICT infrastructure use and human development in SADC countries and report the progress made. ICT infrastructure use consists of main telephone line usage, mobile cellular usage and Internet usage in a given country.

We focus our central question on: What are the impacts of ICT use on human development? To further provide better explanation to this question, we stated our secondary research

questions as follows: (1) What are the impacts of three components of ICT use on standard of living? (2) What are the impacts of three components of ICT use on health? (3) What are the impacts of the three components of ICT use on education? (4) Does ICT use contribute to growth in overall human development?

To investigate the relationship between ICT infrastructure use and human development, we employed Structural Equation Modeling (SEM), an important tool for empirical research in social sciences, widely used for its ability for specifying and estimating interrelationships among a set of variables (Crowley & Fan, 1997; Bauer, 2003; Samoilenko, 2006). SEM expresses relation among variables either directly or in-directly.

The rest of this article is organized as follows: Section two discusses human development. Section three presents on ICT infrastructure. Section four provides the background on SADC countries while Section five presents the theoretical background. Section six provides detail on the data collection and analysis procedure. In Section seven, findings and discussions are presented. Section eight provides a conclusion.

2.0 HUMAN DEVELOPMENT

Human development is the process of enlarging people's choices as well as raising their levels of well being. A broad definition of human development addresses the need to lead a long and healthy life, to acquire knowledge and to have access to the resources for a decent standard of living (UNDP, 2006). At all levels of development, the above three essential choices should be made accessible to people. The concept of Millenium Development Goals (MDGs) was adopted by UNDP to assess the level of human development in many nations. The MDGs were used as a standard scale for human development. They consist of eight specific goals as follows:eradication of poverty, universal primary education, gender equality and women empowerment, reduction in child mortality rate, improved maternal health, eradication of HIV/AIDS, malaria and other diseases, environmental sustainability and global partnership for development (Moran et al., 2008; Chacko, 2005). These MDGs goals have a broader measure named the Human Development Index (HDI). The HDI measures a country's economic and social well being. It serves as a standard to specify the improvement of development of a country (Sun, 1993; Sagar & Najam, 1998). The index consists of three major components. These are as follows:

- GDP per Capita (standard of living) - This can be described as a measure of average distribution of income among the citizens of a nation (UNDP, 2003). It is measured in US dollars based on the purchasing power parity exchange (PPP USD).
- Literacy rate (education) - This is a measure of enrolment in primary, secondary and tertiary institutions (UNDP, 2008).It is also referred to as the level of literacy of people in a society (Despotis, 2005).
- Life expectancy at birth (health and longevity) - This is the average number of years a person is expected to live from the time of his/her birth or the average age of individuals in a country (UNDP, 2008).

Recently, there has been much discussion on human development in Sub-Sahara Africa. For example, the British government has indicated that is the duty of the international community to support human development goals in Africa. As a result, many African countries have benefited in the form of foreign aid, debt relief, the provision of health care facilities and the provision of new Information and Communication Technologies (ICTs). There have been several initiatives for ICT expansion in Africa by both African governments and international organizations (Ngwenyama et al., 2006; Bollou, 2006). For instance, African leaders have been investing in ICT infrastructure such as for the Internet, mobile phones and fixed line telephones as an avenue to transform the productive capacity of their nations.

3.0 ICT INFRASTRUCTURE

On a global level, ICT infrastructure has brought communication and access to information to the forefront of development. People are forming new social networks, and sharing knowledge across geographical boundaries. Fixed line telephony, computers, the Internet and mobile communications have become part of the daily life of millions of people around the world, providing them with instant access to voice, video telephony, messages, video streaming, e-mail, file transfer and other applications. More than 118 million PCs were installed in homes and schools worldwide by the late 1990s (WITSA, 1998).

In Africa, the technology age presents many challenges due to lack of adequate ICT infrastructure. ICT adoption and diffusion has been tied to socio-economic development of a country (Musa, Meso & Mbarika, 2005). Therefore, the United Nations ICT task force has

advised African leaders to focus on ICT infrastructure expansion as part of their human development strategies (Bollou, 2006). In response to this demand, many African governments have been investing in their ICT infrastructures. ICT infrastructure use can be conceptualized in terms of three major dimensions (measures) as follows (ITU, 2008; ITU, 2009; Musa et al., 2005):

- Main telephone lines per 100 inhabitants (MTL)
- Cellular subscribers per 100 inhabitants (MCS)
- Internet users per 100 inhabitants (IU)

In this study, we employ the above ICT infrastructure use dimensions (measures) to show the impact of ICT adoption, use and penetration on human development in SADC countries.

4.0 BACKGROUND ON THE SADC COUNTRIES

SADC consist of 15 member states within a regional community (Figure 1). One of the aims of SADC is to support human development in Southern Africa (SADC, 2010). The vision is to reinvigorate the positive values, principles, culture and history that existed among the people of the region prior to colonization.

The SADC region was formed as a result of the Lusaka declaration of 1980 where each member state committed to the development of ICT, human resources and economic integration (Mutala, 2002). The SADC countries have a combined population of over 200 million with 80 percent of people living in the rural areas (Mutala, 2002; SADC, 2009). During the 1990s the region experienced growth in its ICT sector (Mutala, 2002; Bollou, 2006).

Mauritius and Seychelles are the only countries placed highly on the UN Human Development Index (HDI) rankings. Mauritius has a population of 1.2 million, and a literacy rate of 80%. Seychelles has a population of about 0.09 million and a literacy rate of 91.8 %. The two countries had the highest ICT development ranking in Africa in 2007. Angola, South Africa, Botswana, Namibia, Swaziland, Tanzania, Madagascar and Lesotho are ranked as medium in terms of human development. Zambia, Mozambique, Malawi, DRC and Zimbabwe are grouped as low on human development according to the rankings. Zimbabwe which has the highest literacy rate of 91% and population of 13.3 million was not ranked in

the list of all the countries in human development ranking due to recent political and economic stagnation (UNDP, 2007).

Figure 1: Map of SADC countries. Source: SADC, 2009.

The SADC countries have increased their ICT infrastructure investments and usage since 1994 due in part to the liberalization of telecommunication policies in the states (The Africa Initiative, 2004). South Africa has the most sophisticated ICT infrastructure in the region (Brown & Brown, 2008), while other countries such as Zambia, Tanzania, Mozambique and Lesotho are categorized as Least Developed Countries (LDC) with poor ICT infrastructure (UNCTAD, 2005). Table 1 below shows a summary of demographic data for the countries. The trends of ICT infrastructure growth in SADC between 1998- 2007 are presented in Appendix A.

TABLE 1. Demographic Data for the Countries (UNDP, 2008; ITU, 2007; UNCTAD, 2010)

Countries	HDI Subgroup Level	Population (Millions)	Life Expectancy (Years)	GDP per Capita (US $)	Literacy Rate %	HDI	IDI	HDI Ranking 2007	IDI Ranking 2007
Seychelles	**HHD**	0.09	72.8	16,394	91.8	0.845	3.44	57	62
Mauritius	**HHD**	1'262	72.1	11,296	87.4	0.804	3.45	81	62
Botswana	**MHD**	1'882	53.4	13,604	82.9	0.694	2.1	125	109
Namibia	**MHD**	2'074	60.4	5,155	88	0.686	1.92	128	112
South Africa	**MHD**	48'577	51.5	9,757	88	0.683	2.7	129	87
Swaziland	**MHD**	1'141	45.3	4,789	79.6	0.572	1.73	142	113
Angola	**MHD**	17'024	46.5	5,385	67.4	0.564	1.31	143	138
Madagascar	**MHD**	19'683	59.9	932	70.7	0.543	1.27	145	139
Tanzania	**MHD**	40'454	55	1,208	72.3	0.53	1.13	151	145
Lesotho	**MHD**	2'008	44.9	1,541	82.2	0.514	1.48	156	123
Malawi	**LHD**	13'925	52.4	761	71.8	0.493	1.20	160	145
Zambia	**LHD**	11'922	44.5	1,358	70.6	0.481	1.39	164	129
Mozambique	**LHD**	21'397	47.8	802	44.4	0.402	1.02	172	148
DRC	**LHD**	62'636	47.6	298	67.2	0.389	1.13	176	147
Zimbabwe	**LHD**	13'349	43.4	2,038	91.2	Not Ranked	1.46	Not Ranked	126

Key:

HHD	**High Human Development**
MHD	**Medium Human Development**
LHD	**Low Human Development**
IDI:	**ICT Development Index**

5.0 THEORETICAL BACKGROUND

The Impact of ICT Infrastructure on Human Development

Several studies have affirmed that ICT infrastructure could improve the level of human development in both developed and developing countries (Bollou, 2006; Ngwenyama et al., 2006; Ngwenyama & Morawczynski, 2007). ICT usage has furthermore been shown to improve firm level performance and growth in many countries (OECD, 2003). Thus we propose that:

P_1: *Increased ICT infrastructure use facilitates improvement in the level of human development in SADC countries*

The Impact of Main Telephone Lines (MTL) on Human Development

Bollou (2006) posits that the use of main telephone lines in Sub-Sahara African countries increases per capita GDP in these countries. Thus we propose that:

P_{1a}: *Main telephone line penetration facilitates improvement in the standard of living (GDP per capita) in SADC countries*

Mbarika et al. (2002) claims that the growth in main telephone line usage has brought a variety of social benefits such as better education, health service delivery, development projects, stabilization of migrants, handling of natural and social disaster in Sub-Sahara African countries. Therefore we propose that:

P_{1b}: *Main telephone line penetration facilitates improvement in the level of education (Literacy) in SADC countries*

As stated in P_{1b} above, main telephone line usage in Sub-Sahara African countries has brought about improvement in health service delivery (Mbarika et al., 2000; Mbarika, 2002b). The provision of telephone lines and telecentres furthermore provides individuals access to health information (Info Dev, 2006). Thus we propose that:

P_{1C}: *Main telephone penetration facilitates improvement in health (Life expectancy) in SADC countries*

The Impact of Mobile Phone Subscribers on Human Development

Several studies on the impact of telecommunications on economic growth in developing countries have shown that increase in mobile cellular penetration has a positive and significant impact on GDP growth (Waverman, Meschi & Fuss, 2005; Wang, 1999; Hamilton, 2003, Avegerou, 1998; Collechia & Schreyer, 2002). Thus we propose that:

P_{2a}: *Mobile phone penetration facilitates improvement in the standard of living (GDP per capita) in SADC countries.*

In recent times, education has been shaped by the use of mobile phones due to its capability for continous learning, learning during leisure time and interaction for more knowledge (Attewell & Svill-Smith, 2004). Chigona, Beukes, Vally & Tanner (2009) state that the mobile phone is an essential tool for communication in skills acquisition and business. Thus we propose that:

P_{2b}: *Mobile phone penetration facilitates improvement in the level of education (Literacy) in SADC countries.*

There has been evidence of the impact of mobile phones on population health in both developed and developing countries (Kaplan, 2006; Patrick, William, Grisworld, Intille,2008). The use of mobile phones has aided in increasing household income which has led to improvements in food security, health and education (InfoDev, 2006). Thus we propose that:

P_{2c}: *Mobile phone penetration facilitates improvement in health (Life expectancy) in SADC countries.*

The Impact of Internet Usage on Human Development

The use of the Internet in both developed and developing countries has been shown to improve productivity, trade, business transactions, income and socio- economic status (Litan & Rivlin, 2000; Oyelaran-Oyeyinka, 2003; Oyelaran-Oyekinka & Lal, 2003). Thus, we propose that:

P_{3a}: *Internet penetration facilitates improvement in the standard of living (GDP per capita) in SADC countries*

There has been a wealth of research affirming that Internet usage contributes significantly to the level of education (Chigona el., 2009; Chogona, Kamkwenda & Manjoo, 2008; Chivhanga, 2000) Mbarika (2002a) states that the Internet is beneficial to both academic and research sectors in least developing countries. Thus, we proposed that:

P_{3b}: *Internet penetration facilitates improvement in the level of education (Literacy) in SADC countries.*

Improvement in the health of a population, and strengthening health systems such as prevention and detection of disease are important to development. The use of the Internet has provided opportunities for health providers, media and stakeholders to disseminate health information in developing countries (Curioso & Kurth, 2007; Ojo, 2006). In general health information management processes are facilited by ICT infrastructure usage (InfoDev, 2006).Thus we propose that:

P_{3c}: *Internet penetration facilitates improvement in health (Life expectancy) in SADC countries.*

These propositions are summarized in Figure 2 below. Figure 2 also illustrates that there are other factors besides ICT which have an impact in human development, but these are outside the scope of this study.

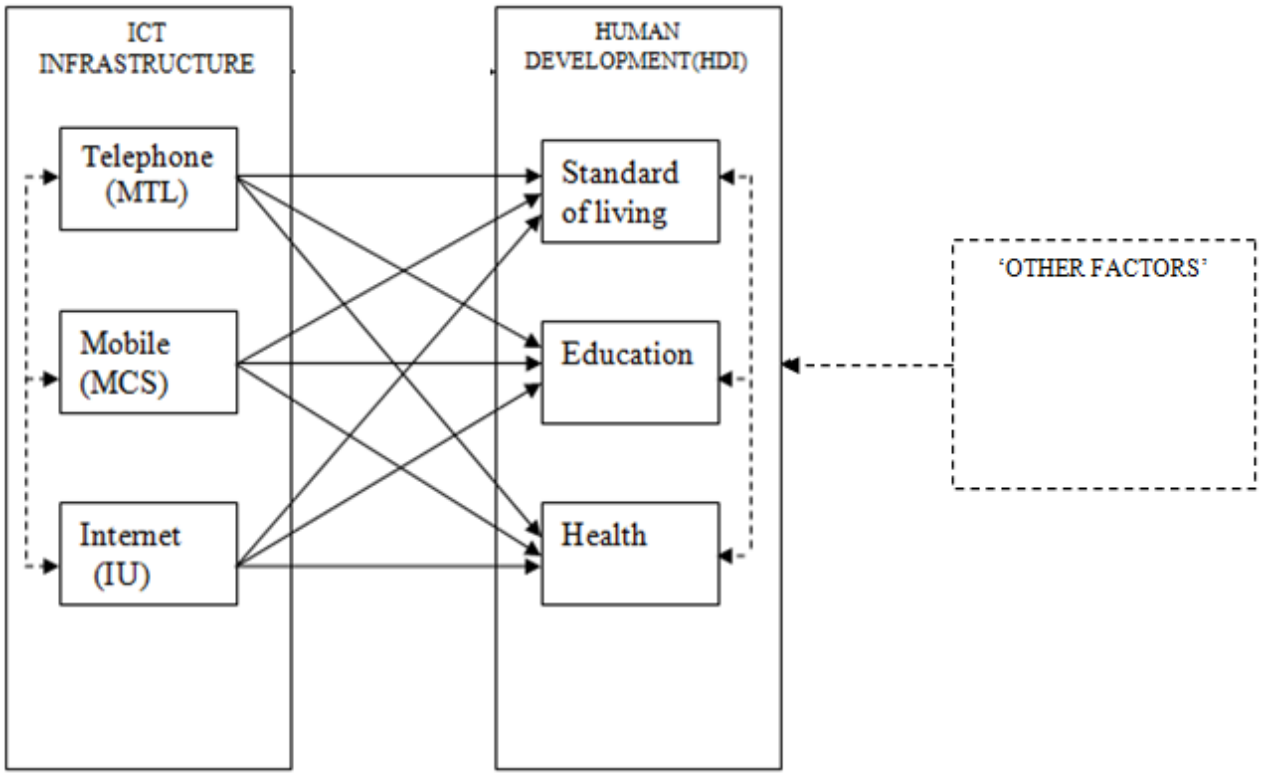

Figure 2: Theoretical Model of ICT Infrastructure and Human Development

6.0 DATA COLLECTION AND ANALYSIS

We gathered data for this analysis from the International Telecommunication Union (ITU) and the United Nation (UN) databases. The ITU database provides telecommunications data for all countries and the UN's archive consist of social developmental indices for all countries. The study employs a country level dataset drawn from the years 1998-2007. This period of 10 years is assumed to be the period of highest ICT use in Africa, as it follows the years of major ICT investments in the continent (Bollou, 2006). The relevant variables are described in Table 2.

The approach we followed to test the propositions is Structural Equation Modeling (SEM) as implemented in the Partial Least Squares (PLS) method (Samoilenko & Osei-Bryson, 2010b; Gefen & Straub, 2005).The data was analyzed using WarpPLS (Version 1). The average values per country from 1998-2007 for all the variables were calculated (i.e. for the three

dimensions of ICT infrastructure and three components of human development). The dimensions of ICT infrastructure use (independent variables) were introduced into the software tool regarding each component of human development (dependent variables).

TABLE 2: List of Variables

Independent Variables (ICT-Use Components)	**Dependent Variables (Human - Development Components**)
Fixed telephone line (100 inhabitants)	Standard of living (Economy ,GDP)
Mobile cellular subscribers (100 inhabitants)	Education(Literacy rate & enrolments)
Internet users subscribers (100 inhabitants)	Health (Life expectancy at birth)

6.1 Structural Equation Modeling (SEM)

Structural equation modeling (SEM) is a type of multivariate statistical analysis that enables the researcher to solve a set of interrelated questions in a single, orderly and comprehensive way (Crowley & Fan, 1997). SEM allows one to conjecture the presence of relationships between multiple unobserved variables (latent variables) such that each latent variable is associated with multiple observed variables (Samoilenko, Ngwenyama & Osei-Bryson, 2006). In SEM, variables may appear as a response or predictor depending on the level of influence on another (i.e. either directly or in-direct) (Samoilenko, et al., 2006). These are meant to represent a causal relationship among the variables in the model (Fox, 2002). Due to the efficiency of SEM for testing theoretical models (Crowley & Fan, 1997), we use SEM in this study to determine the causal relationships among variables of observational data to facilitate the translation into data analysis (Fox, 2002) while the pattern of relationship among the variables are specified a priori based on theoretical expectation (Crowley & Fan, 1997). Figure 3 below presents the structural equation model of ICT infrastructure use and human development.

7.0 FINDINGS

The Impact of ICT Use on Human Development

The relationship between ICT infrastructure and human development (HDI) is presented in Table 3.

TABLE 3: The Impact of ICT Use on Human Development

	Path Coefficients	P Values	R^2 Coefficients
ICT			
HDI	0.939	0.025	0.881

* P < .05 ** P < .01 *** P < .001

The Impact of Telephone Use on Health, Education and Standard of Living

Table 4 shows the link between main telephone line usage and health, education and standard of living respectively.

TABLE 4: The Impact of Telephone Use on Health, Education and Standard of Living

	Path Coefficients	P Values	R^2
Telephone			
Health	0.911	<0.001	0.831
Education	0.668	<0.001	0.446
Standard of living	0.983	<0.001	0.966

* P < .05 ** P < .01 *** P < .001

The Impact of Mobile Phone Usage on Health, Education and Standard of Living

The relationships between mobile phone usage and health, education and standard of living are shown in Table 5

TABLE 5: The Impact of Mobile Phone Use on Health, Education and Standard of Living

	Path Coefficients	P Values	R^2 Coefficients
Mobile Cellular			
Health	0.773	<0.001	0.598
Education	0.614	<0.001	0.377
Standard of living	0.975	<0.001	0.950

* P < .05 ** P < .01 *** P < .001

The Impact of Internet Usage on Health, Education and Standard of Living

The relationships between Internet usage and health, education and standard of living respectively are presented in Table 6.

TABLE 6: The Impact of Internet Usage on Health, Education and Standard of Living

	Path Coefficients	P Values	R^2 Coefficients
Internet			
Health	0.898	0.026	0.806
Education	0.715	<0.001	0.511
Standard of living	0.898	<0.001	0.806

* P < .05 ** P < .01 *** P < .001

Table 7 below show the results from testing the propositions. All the propositions were supported.

TABLE 7: Test of Propositions

$P_{1:}$ Increased ICT infrastructure use facilitates improvement in the level of human development in SADC countries - **Supported**
$P_{1a:}$ Main telephone line penetration facilitates improvement in the standard of living (GDP per capita) in SADC countries - **Supported**
$P_{1b:}$ Main telephone line penetration facilitates improvement in the level of education (Literacy) in SADC countries - **Supported**
$P_{1C:}$ Main telephone penetration facilitates improvement in health (Life expectancy) in SADC countries - **Supported**
$P_{2a:}$ Mobile phone penetration facilitates improvement in the standard of living (GDP per capita) in SADC countries - **Supported**
$P_{2b:}$ Mobile phone penetration facilitates improvement in the level of education (Literacy) in SADC countries - **Supported**
$P_{2c:}$ Mobile phone penetration facilitates improvement in health (Life expectancy) in SADC countries - **Supported**
$P_{3a:}$ Internet penetration facilitates improvement in the standard of living (GDP per capita) in SADC countries - **Supported**
$P_{3b:}$ Internet penetration facilitates improvement in the level of education (Literacy) in SADC countries - **Supported**
$P_{3c:}$ Internet penetration facilitates improvement in health (Life expectancy) in SADC countries - **Supported**

8.0 DISCUSSION and CONCLUSION

From the analysis, we observed that ICT infrastructure use is playing a tremendous role in promoting human development in SADC countries. The three dimensions of ICT infrastructure are highly correlated with all three dimensions of human development, i.e. standard of living (GDP per capita), education (literacy) and health (life expectancy) respectively. The highest correlation was between ICT use and standard of living. For all of main line telephony, mobile phone usage and the Internet, the relationships with standard of living were stronger than those for education and health. The advent of mobile phones, fixed line telephony and the Internet have improved the life of many citizens in SADC countries. The introduction of mobile applications such as Mpesa, and Wizzit, amongst others, is adding further value (Bangens & Soderberg, 2008). ICT infrastructure are bridging the digital divide, reducing poverty and ensuring socio-economic development thereby sustaining the evolution of Africa.

The next strongest relationships were between the three dimensions of ICT infrastructure and health, with the weakest relationships, relatively speaking, between the dimensions of ICT infrastructure and education. Generally speaking ICT infrastructure is deployed primarily as a means of improving business and economic growth, hence the strongest relationships are with standard of living measures. The fact that the relationships with health are the next strongest may relate to the fact that the measure of health in the human development index is life expectancy. Deployment of ICT infrastructure for economic development, then, has an indirect impact on life expectancy, as there is a relationship between standard of living and life expectancy.

8.1 Limitations and Future Research

The data used in this research was drawn from archival data of the ITU and UN. It covers a period of ten years from 1998 to 2007 with 15 SADC countries. Since SEM offers richer insight when provided with wider data, we envisage that more data from African countries would provide deeper understanding. Also ‘other factors’ contributing to human development should be explored, as ICT infrastructure alone will not improve the level of development. Other complementary factors should be researched. This limitation is not peculiar to this study alone but is characteristic of the research in this area in general. The ten years period

can be used for longitudinal analysis as well in future studies (Samoileko & Osei-Bryson, 2008; Hoskisson et al., 2000).

Future research could also explore more African countries to show if the situations is the same across different regions of Africa. It has been observed that countries have dissimilar capabilities for translating ICT use into macro-outcomes.

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APPENDIX 1

Figure A: Main Telephone Line Penetration Rates (1998-2007)

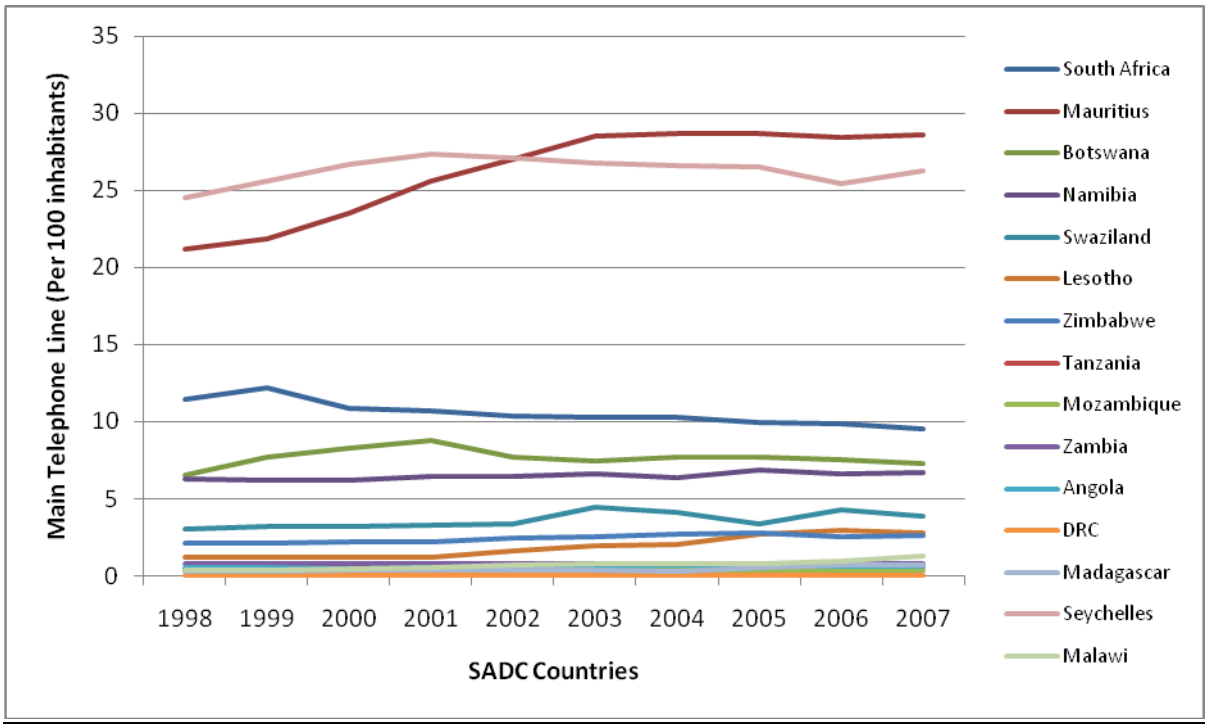

Figure B: Mobile Cellular Subscribers' Penetration Rates (1998-2007)

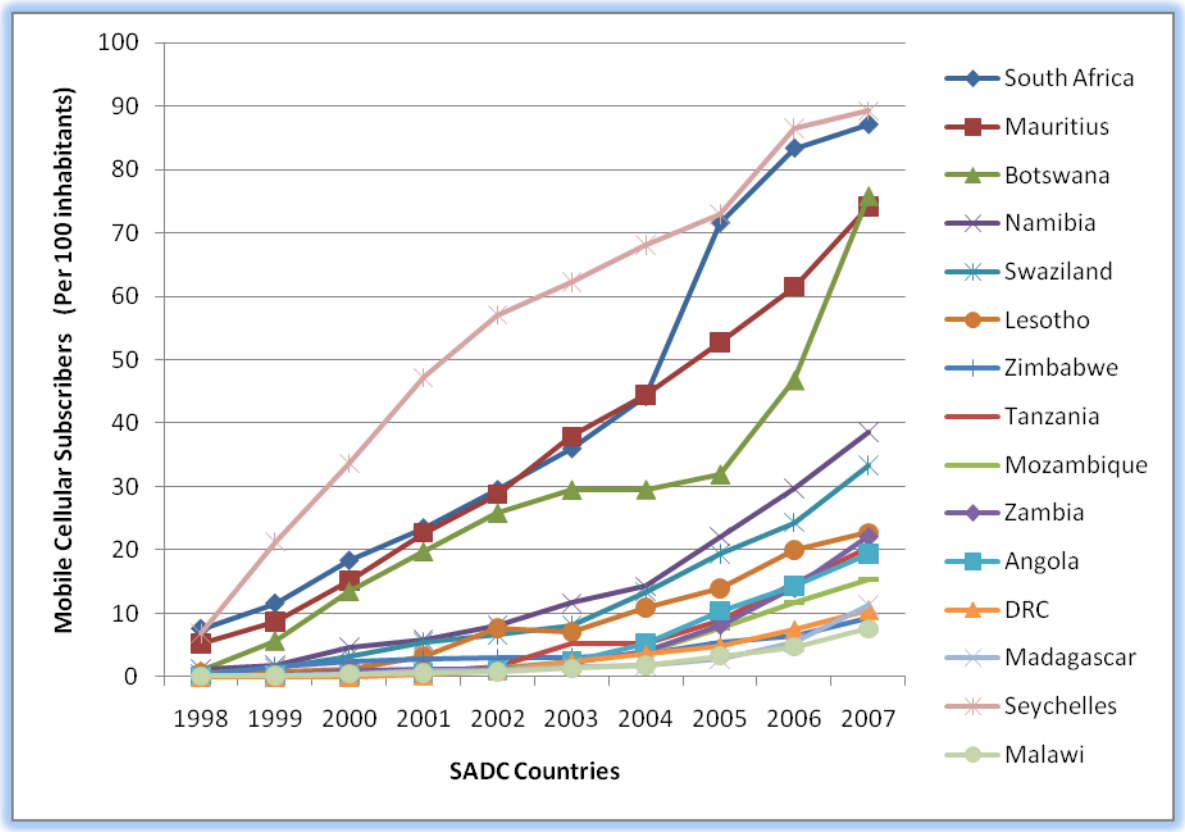

Figure C: Internet Users' Penetration Rates (1998-2007)