Regional Research Institute

Working Paper Series

Telecommunications Investment and Economic Development: Evidence from a Panel of Sub-Saharan Africa (SSA)

By: Chali Nondo, Assistant Professor, Albany State University; and
Mulugeta S. Kahsai, Post-Doctoral Research Fellow, West Virginia University;

Research Paper Number 2011-04

Website address: rri.wvu.edu

Presented at the Southern Regional Science Association, March 2011,
New Orleans, Louisiana

Telecommunications Investment and Economic Development: Evidence from a Panel of Sub-Saharan Africa (SSA)

Chali Nondo*
Assistant Professor
College of Business
Albany State University

Mulugeta Kahsai
Post-Doctoral Research Fellow
Regional Research Institute
West Virginia University

Abstract

The objective of this paper is to study the role of government effectiveness, institutional and political factors in aggregate output and telecommunications penetration in SSA countries. The contribution of these factors in aggregate output and telecommunications evolution is examined using a framework that accounts for the endogeneity and interactions between aggregate output and telephone penetration rates. Results from the study indicate that government effectiveness is an important determinant for aggregate output. Another supplemental finding is that the incessant political upheavals in SSA countries have a detrimental effect on aggregate output. From this, we endorse that SSA countries should design and implement efficient institutional frameworks and mechanisms that will expand telecommunications network infrastructure in both rural and urban areas and thus spur growth and development.

Key words: telecommunications, economic growth, simultaneous growth equilibrium model

JEL: C33, O47, O57, R11

1.0 Introduction

Because of the high returns that telecommunications technologies offer to the development process, many Sub-Saharan African (SSA) countries have over the past two decades implemented important regulatory and economic reforms that are aimed at improving and expanding access to telecommunications. Internet broadband, mobile cellular phones and main telephone lines are among the primary key telecommunication technologies that have been identified. The potential poverty alleviation and economic development benefits of telecommunications has also been publicized by the United Nations and other international development agencies.[1] Despite these efforts, access, usage, and penetration rates for telecommunications technology remains low and uneven within SSA countries.

While increased accessibility to telecommunications infrastructure is not a panacea to the myriad development challenges faced by SSA countries, it is clear that in this digital era, economic growth and social welfare inextricably depends upon the exchange of information through telecommunications. Recently, two schools of thought on the role of telecommunications in the development process have emerged. The first school of thought hypothesize that telecommunications can help to close the digital divide, and thus, developing countries can use telecommunications infrastructure to leapfrog the development process[2]. On the other hand, the second school of thought postulates that telecommunications exacerbates the information gap between the rich and the poor, the literate and illiterate, to the extent that

[1] Like other infrastructural investments, information and communication technologies (ICTs) have been identified as important drivers for achieving many development goals, including the UN Millennium Development Goals.

[2] The term leapfrog is commonly used in the telecommunications literature to mean that developing countries can use telecommunications technologies to skip or bypass several stages of the development process and thus provide developing countries the opportunity to meet development goals.

telecommunications investment do not benefit the poor. Viewed in this manner telecommunications investment negatively affect development (Roche and Blaine, 1996).

In support of the first school of thought, significant progress has been made in the empirical literature in illuminating the long lasting positive impacts of telecommunications on economic growth and social development (see Roller and Waverman, 2001, Cronin, et. al., 1993; Datta and Agarwal, 2004; Hardy, 1980). These past studies also document that widespread access to telecommunications augments the delivery of goods and services through information flows, which increases overall per capita income, generates employment and revenue. Furthermore, telecommunication technologies have been hypothesized to reduce the search and transaction costs for firms and significantly affect the ability of firms to produce and export goods and services competitively (Norton, 1992; Jensen, 2007).

Although past studies provide important insights on the relationship between telecommunications and economic growth, there is a dearth of literature that have investigated the role played by institutional quality, political stability, and government effectiveness in stimulating telecommunication penetration and growth in SSA countries. To date, resolving growth and development problems in SSA countries has been an elusive and complex task, due to a host of factors, including poor legal and administrative structures, political, institutional, social, and other factors that promote growth and development.

A recent survey conducted by Ernst and Young (2009) provide support for this view by revealing that a major concern of telecommunications operators in SSA countries is political interference. Many researchers including Acemoglu (2005), Lin and Nugent (1995), Scully (1988) and others provide additional evidence on the role played by government effectiveness,

political stability, institutional quality, and social institutions in stimulating the amount and quality of investments, as well as the long-run growth.

Within this context, the economic-telecommunications relationship within SSA must be analyzed in a broader perspective by incorporating political and institutional environments. Dismissing the importance of these factors in the development process of SSA countries may lead to offering imprecise policy recommendations. With a dataset of 35 SSA countries covering the period 1996-2006, the objective of this paper is to study the role of government effectiveness, institutional and political factors in economic growth and telecommunications penetration in SSA countries.

We accomplish the above objective by testing the following two hypotheses: (1) aggregate output in SSA countries is influenced by telecommunications penetration, government effectiveness and political factors; (2) per capita income, political and institutional factors, and geographic area explain the variations in telecommunications penetration rates in SSA countries. We test the above hypotheses by specifying a model that takes into account the endogeneity and interactions between aggregate output and telephone lines (sum of main telephone lines and mobile phones).

Data from the International Telecommunications Union (ITU, 2007) show that out Africa's 55 countries, over 75% of the 26 million fixed lines are concentrated in just 10 countries. By the end of 2006, SSA had an average of 3 fixed lines per 100 inhabitants, a number which remains low compared to other continents. For example, during the same period North America has an average of 34 fixed lines per 100 inhabitants. Overall, there has been a substantial growth in telephone penetration (particularly the growth rate of mobile cellular phones) over the past decade (see figures 1 and 2).

Figure 1:

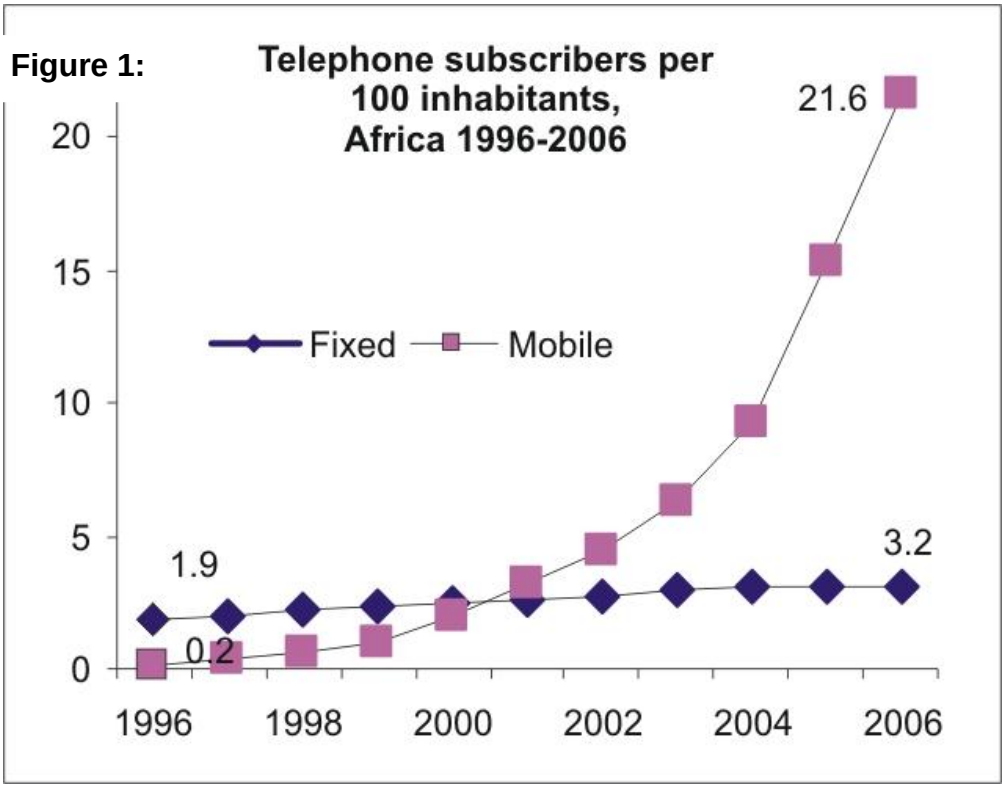
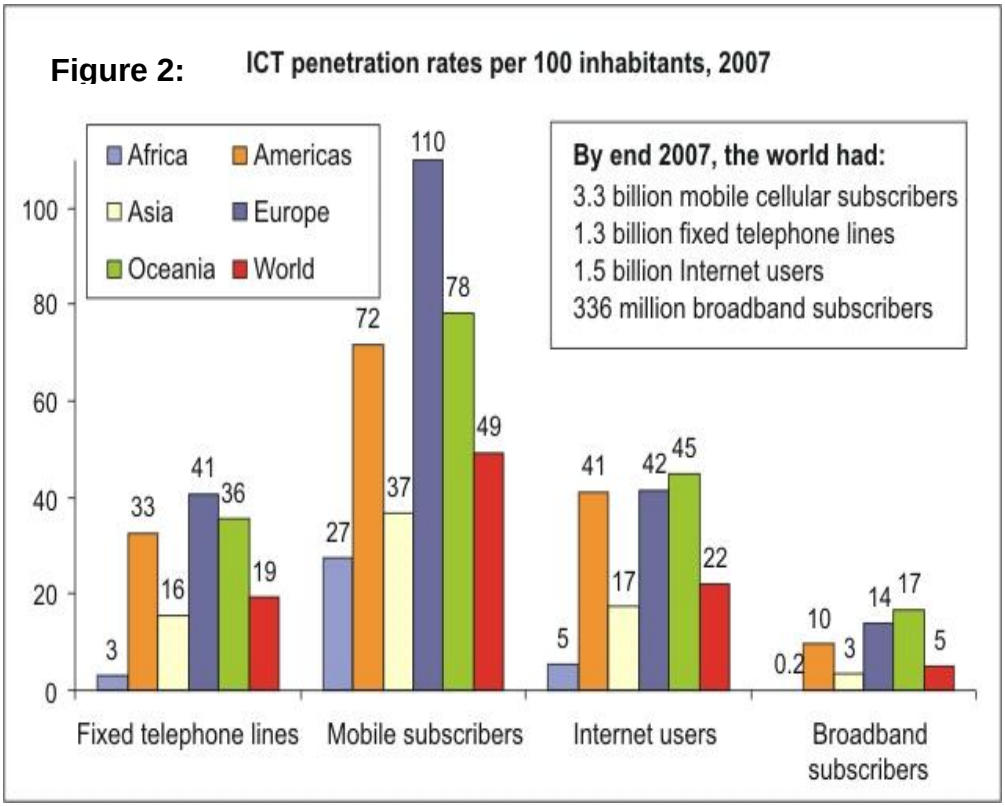


Figure 2: ICT penetration rates per 100 inhabitants, 2007



Source: International Telecommunications ICT Indicators Database

In the preceding section, we present the empirical model and types of data used, while in section 3, presents results from the empirical model. The final section offers concluding remarks and policy recommendations.

2.0 Empirical Model and Data

In order to analyze the impact of telecommunications on aggregate output, we use a modeling approach that accounts for simultaneity between telecommunications and aggregate output (GDP in constant values). As already argued, there exists a simultaneous relationship between telecommunications and growth. Good telecommunications infrastructure increases the flow of information, facilitates the transfer of knowledge, reduce transaction costs and market imperfections. Viewed in this manner, telecommunications spurs growth; conversely, increased growth will stimulate demand for telecommunications infrastructure.

Thus in order to understand the simultaneous interactions between GDP and telecommunications, we specify a system of equations, which borrows from Waverman et al. (2005). Departing from Waverman et al.'s (2005) work, the focus of this study is on 35 SSA countries and we explicitly explore the role of political and institutional variables, and government effectiveness in shaping the direction and evolution of GDP and telecommunications penetration.

Based on the discussion above, our empirical analysis involves estimating the following systems of equations (1) national aggregate output (GDP), which is a function of lagged values of GDP, government effectiveness, political stability, telecommunications penetration, and other exogenous variables; (2) demand for telecommunications, which relates price of telecommunications services, per capita income, and other factors to demand; and (3) change in

telecommunication penetration rate as a function of initial telecommunications demand, GDP, and other exogenous factors.

To assess empirically the effect of telecommunication penetration on aggregate output, we specify a log-linear output equation in the form:

(1) $$\log(YRGDP_{it}) = \alpha_0 + \alpha_1 \log(YGCF) + \alpha_2 \log(YLFR) + \alpha_3 \log YTMMS\_1000 + \alpha_4(YGOVEFF) + \alpha_5 t + \alpha_6 POLST + \log \alpha_7(YRGDP_{it-1}) + \varepsilon_1$$

In the above equation, YRGDP equals real gross domestic product (GDP) and this measures the value of goods and services produced in an economy. The output model is augmented by including the lagged value of GDP ($YRGDP_{it-1}$), which controls for the dynamic process in which past values of GDP influence current GDP values. The expected sign on the coefficient for lagged GDP is positive. Other explanatory variables included in the output equation are: gross capital formation (YGCF), which measures the effect of investment in fixed capital by businesses, households, and government on economic growth. According to classical economic theory, gross capital formation has a positive effect on GDP; thus we hypothesize a positive sign on YGCF. Labor force participation rate ($YLFR$) is included to capture the marginal productivity of labor on output, and the coefficient for $YLFR$ is hypothesized to be positive.

Referring to equation (1) $YTMMS\_1000$ is telecommunications infrastructure penetration, measured as a sum of main telephones and mobile phones per 1,000 inhabitants. Our model extends Waverman's work by directly capturing the effect of government effectiveness ($GOVEFF$) and political instability ($POLST$) on GDP. In a broader sense, government effectiveness encompasses many characteristics, including the quality of the public service, number of ministerial portfolios, quality of the civil service and its independence from political pressures, and ability of the public sector to design and implement efficient and effective policies

that realize development goals (Kaufmann, et al., 2006). Arguably, these characteristics do not often go together in many SSA countries. Other things being equal, improvement in government effectiveness will positively influence GDP. Turning to the political instability variable, a lack of civil and political liberties will negatively affect GDP, and thus the coefficient for $POLST$ is expected to be negative.

The next equation we estimate in the system of equations is the demand for telecommunications. Specifying the demand equation in double-log form, we have:

$$(2) \quad \log(YTMMS\_1000_t) = \alpha_0 + \alpha_1 \log(YGDP\_PC) + \alpha_2 \log(YRTCC) + \alpha_3 \log(YPOP) + \alpha_4 \log(YTACUSS) + \alpha_5 t + \alpha_6 \log(YTMMS\_1000_{t-1}) + \varepsilon_2$$

The left hand variable is the demand for telecommunications ($YTMMS\_1000_t$), which is the sum of main telephone lines and mobile phones per 1,000 inhabitants.[3] With all the coefficients being elasticities, we have: α_1 is the income elasticity of demand for telecommunications, $\alpha_2$is the price elasticity of telecommunication demand, α_3 is the elasticity of population to telecommunication demand, α_4 is the price elasticity of demand, α_5 is the coefficient for the time trend, and α_6 is the elasticity of the lagged value of the total demand for telecommunications, and ε_2 is the disturbance term.

Assuming that the demand for telecommunication is a normal good, we expect per capita income ($YGDP\_PC$) to have a positive coefficient. The own price elasticity of demand ($YRTCC$) is hypothesized to have a negative coefficient. We have also included year dummies to control for technological progress across countries that occurred over the period of the analysis. Another factor that will drive the demand for telecommunications is the overall expansion in population.

[3] Although there is an observed asymmetry in the penetration rates for main telephone lines and mobile phones, with the latter having higher penetration rates, we aggregate telephone lines per 1,000 people and mobile phones per 1,000 people to determine their aggregate impact on GDP.

We hypothesize a positive relationship between $YPOP$ and demand for telecommunications ($YMTSS\_1000$).

The last equation in our system of equations is the growth of telecommunications penetration, which is modeled as a function of GDP, country geographic area, institutional quality, political instability, and telecommunications investment. The growth of telecommunication penetration is specified as follows:

(3) $\log(\Delta YTMMS\_1000) = \alpha_0 + \alpha_1 \log(YRGDP) + \alpha_2 \text{YLASQM} + \alpha_3 t + \alpha_4 \text{IQLTY} + \alpha_5 \text{TTIV} + \varepsilon_3$

Where $\Delta YTMMS\_1000$ is log of the percentage change in the number lines per 1,000 inhabitants (fixed lines plus mobile phones) between the end of the previous period and the end of the current period. Proximate sources of growth in telecommunication penetration in SSA countries will not only depend on economic factors, but also on non-economic factors, such as institutional, political factors, governance, and others. On the economic front, past studies provide a strong case for the positive impact of gross domestic product ($YRGDP$) and telecommunications investment ($TTIV$)[4] on growth of telecommunication penetration ($\Delta YTMMS\_1000$), respectively. Other things being equal, an increase in $YRGDP$ and $TTIV$ will stimulate growth of telecommunication penetration rates ($\Delta YTMMS\_1000$).

With regard to the non-economic factors, the variable of interest is government institutional quality ($IQLTY$). North (1990) presents strong evidence on the correlation between institutional quality and economic growth. Quality and effective government policies, including the ability of the government to design and implement programs focused on growth, as well as the promotion of competition will positively influence telecommunications penetration rates. To control for market size, we include geographic area (YLASQM). A larger geographic area implies

[4] Investment in telecommunications is computed as a percentage of telecommunication revenues.

installing telecommunications equipment over a larger area, and thus increasing costs. Therefore, we expect the coefficient for geographic area to be negative.

Our dataset contains 352 observations for 35 countries covering the period, 1996 to 2006. Countries covered in the analysis and summary statistics for the variables used in the model are presented in appendix 1 and 2, respectively. Data for our analysis come from various sources, including PennWorld, International Telecommunications Union (ITU) and the World Development Indicators (WDI) database. Specific 2007 country penetration rates for fixed telephone and mobile cellular phones are shown in Appendix 1.

3.0 Estimation and Results

We estimate a system of three equations, where the dependent variables are: nominal GDP; telecommunications penetration per 1,000 inhabitants; and growth in telecommunication penetration rates. We estimate the equations using the instrumental variable technique (3SLS), which allows us to overcome potential biases induced by endogeneity problems between telecommunications and gross domestic product.

Estimates for the aggregate output equation are shown table 2, columns 2 and 3. The empirical model for aggregate output is statistically significant at the 1 percent level and has an adjusted R-squared of 0.82. Except for one variable, all the coefficients for the explanatory variables are statistically significant; however, two variables do not have the predicted signs. The coefficient of telecommunications penetration ($YTMMS\_1000$) is positive and statistically significant. This confirms the hypothesis that telecommunication penetration positively influences productivity across all sectors and that telecommunications is a prerequisite for growth. Results on the relationship between lagged aggregate output (YRGDP) and current

output are also robust. According to the results, a 1 percentage increase in previous GDP increases current GDP by 0.87 percent.

Table 1: Three Stage Least Squares (3SLS) Results

Variable	Output Equation LOG(YRGDP)		Demand Equation YTMMS_1000		Telephone Penetration Equation (ΔYTMMS_1000)	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
LOG(YRGDP)						
YTMMS_1000	**0.989****	2.05				
YGCF	-0.0031	-0.86				
YLFR	**-0.0086****	-2.49				
YGOV_EFF	**0.141****	2.80				
POLST	**-0.121****	-3.24				
LOG YRGDP(-1)	**0.866*****	33.45				
LOG YGDP_PC			**0.991*****	16.15		
YRTCC			**-0.003*****	-4.27		
LOG YPOP			-0.029	-1.08		
YTACCUS_3M			-0.043	-0.18		
LOG YTMMS_1000(-1)			**0.287*****	11.17		
Time			**0.267*****	22.59	**16.333*****	9.09
LOG YLASQKM					**-5.641***	-1.81
IQLTY					4.034	0.19
TTIV					1.48E-11	0.17
Intercept	**3.800*****	**5.40**	**-540.00*****	**-22.68**	**-32636.93*****	**-9.07**
Adjusted R-squared	0.82		0.87		0.20	
Observation	331		321		347	

Contrary to expectations, the coefficient of labor force rate ($YLFR$) has a negative and statistically significant effect on aggregate output. One plausible explanation for this negative correlation could that increased labor unemployment in SSA countries effectively reduces the size of the labor force; hence, in the short run, labor force has a negative effect on aggregate output. Consistent with our hypothesis, model estimates show that an increase in political

instability reduces aggregate output, while an increase in government effectiveness positively influences aggregate output.

Results for the demand equation (all telephone lines per 1,000 inhabitants) are shown in table 2, columns 3 and 4. Overall, the empirical model is statistically significant at the .1 percent level. The adjusted R-squared indicates that 87 percent of the variations are explained by the model. From table 2, it can also be seen that all coefficients, except one (log of population) have the predicted signs and two coefficients are statistically insignificant. The estimates show that a 1 percentage increase in per capita income will increase demand for telephones by 0.9 percent. Although the coefficient for price elasticity is statistically significant, its effect on final demand for telephones is very small. According to model results, current telephone demand significantly responds to lagged values (or previous levels) of telephone demand. Accordingly, a 1 percentage increase in previous telephone demand increases current demand for telephones by 0.29 percent.

The last equation estimated is the growth in telephone penetration. The model is statistically significant at the 1 percent level and its adjusted R square is 0.20. Despite the fact that all the explanatory variables have the predicted signs, two of the key variables in the growth of telecommunication penetration (institutional quality and telecommunications investment) are statistically insignificant. The coefficient of country geographic area ($YLASQKM$) is negative and significant at the 10 percent level. The interpretation of the negative coefficient on $YLASQKM$ is that growth of telecommunication penetration in SSA countries diminishes with the geographic area of a country. The coefficient estimate for the time trend is also statistically significant.

Conclusions and Recommendations

This paper presents an analysis of the simultaneous relationship between aggregate output (GDP) and telecommunication penetrations on 35 SSA countries for the period 1996-2006. Most importantly, the econometric results presented in this study shed light on some of the strategies for stimulating aggregate output and telecommunication penetration. We find that an increase in telecommunication penetration reinforces aggregate output (GDP) and that per capita income reinforces demand for telecommunications. From this we conclude that the associated network and spillover effects of telecommunications have important implications for stimulating productivity across sectors. Our study also shows that government effectiveness is an important determinant for aggregate output. Another supplemental finding is that the incessant political upheavals in SSA countries have a detrimental effect on aggregate output.

Although the coefficients for institutional quality and telecommunication investment fail to attain any statistical significance, we endorse that SSA countries should design and implement efficient institutional frameworks and mechanisms that will expand telecommunications network infrastructure in both rural and urban areas and thus spur growth and development. Finally, because of the important role played by telecommunications in national economies, policy measures of facilitating the expansion of telecommunications through private and public investment should be pursued vigorously.

REFERENCES

Acemoglu, D., and J. A. Robison. (2005). *Economic Origins of Dictatorship and Democracy*. New York: Cambridge University Press.

Cronin, F., E. Colleran, P. Herbert, and S. Lewitzky. (1993). "Telecommunications and Economic Growth: The Contribution of Telecommunication Infrastructure Investment to Aggregate and Sectoral Productivity." *Telecommunications Policy,* 6: 529-535.

Datta, A. and S. Agarwal. (2004). "Telecommunications and Economic Growth: A Panel Data approach", *Applied Economics*, 15: 1649 -1654.

Ernst &Young. (2009). Survey on the Development Telecommunications Center.

Hardy, A. (1980). "The Role of the Telephone in Economic Development", *Telecommunications Policy*, 4: 278-286.

Jensen, R. (2007). "The Digital Provide: Information (Technology), Market Performance, and Welfare in the South Indian Fisheries Sector." *Quarterly Journal of Economics*, 3: 879-924.

Kaufmann, D., A. Kraay, and M. Mastruzzi. (2006). "Governance Matters: Aggregate and Individual Governance Indicators for 1996-2005." World Bank.

Lin, J., and J. Nugent. (1995). Institutions and Economic Development, in *Handbook of Economic Development*, vol. 3A. Amsterdam: The Netherlands.

North, D. C. (1990). *Institutions, Institutional Change and Economic Performance*. Cambridge, Cambridge University Press.

Norton, S.W. (1992). Transaction Costs, Telecommunications, and the Microeconomics of Macroeconomic Growth. *Economic Development and Cultural Change,* 41(1): 175-196.

Roche, E.M. and M. J. Blaine. (1996). *Information Technology, Development and Policy*, Avebury, U.K.: Aldershot.

Röller, L. and L. Waverman. (2001). "Telecommunications Infrastructure and Economic Development: A Simultaneous Approach," *American Economic Review*, 74: 909-923.

Saith, A. (2002). "ICT: Hope or Hype." Paper presented at ICTs and Indian Development. Bangalore.

Scully, G. W. (1988). "The Institutional Framework and Economic Development." *Journal of Political Economy,* 3: 652-62.

Sridhar, K. S. and V. Sridhar. (2004. "Telecommunications infrastructure and economic growth: Evidence from developing countries." National Institute of Public Finance and Policy, Working Papers.

Waverman, L., M. Meschi, and M. A. Fuss, (2005). "The Impact of Telecoms on Economic Growth in Developing Countries, in *The Vodafone Policy Paper Series 3*, Vodafone, 10-24.

World Bank, World Development Indicators Report:Infrastructure

TELECOMMUNICATION/ICT MARKETS AND TRENDS IN AFRICA, 2007

Population		*Main telephone lines*		*Mobile subscribers*	
			per 100		*per 100*
000s		*000s inhabitants*		*000s inhabitants*	
South Africa	47'594	*4729.0*	*9.97*	39'662.0	83.33
Angola	15'802	98.2	0.62	2'264.2	14.33
Benin	8'703	77.3	0.89	1'056.0	12.13
Botswana	1'760	136.9	7.78	979.8	55.68
Burkina Faso	13'634	94.8	0.70	1'016.6	7.46
Burundi	7'834	31.1	0.41	*153.0*	*2.03*
Cameroon	16'601	100.3	0.61	*2'252.5*	*13.80*
Cape Verde	519	71.6	13.80	108.9	20.99
Central African Rep.	4'093	10.0	0.25	*100.0*	*2.48*
Chad	10'032	13.0	0.13	466.1	4.65
Comoros	819	*16.9*	*2.12*	*16.1*	*2.01*
Congo	4'117	*15.9*	*0.40*	*490.0*	*12.25*
Côte d'Ivoire	18'454	260.9	1.41	4'065.4	22.03
D.R. Congo	59'320	9.7	0.02	4'415.0	7.44
Djibouti	807	10.8	1.56	*44.1*	*6.37*
Equatorial Guinea	515	10.0	1.99	*96.9*	*19.26*
Eritrea	4'560	37.5	0.82	62.0	1.36
Ethiopia	79'289	725.1	0.91	866.7	1.09
Gabon	1'406	36.5	2.59	764.7	54.39
Gambia	1'556	52.9	3.40	404.3	25.99
Ghana	22'556	356.4	1.58	5'207.2	23.09
Guinea	9'603	26.3	0.33	*189.0*	*2.36*
Guinea-Bissau	1'634	*10.2*	*0.76*	*95.0*	*7.10*
Kenya	35'106	293.4	0.84	6'484.8	18.47
Lesotho	1'791	*48.0*	*2.67*	*249.8*	*13.92*
Liberia	3'356	6.9	0.21	*160.0*	*4.87*
Madagascar	19'105	129.8	0.68	1'045.9	5.47
Malawi	13'166	*102.7*	*0.80*	*429.3*	*3.33*
Mali	13'918	82.5	0.59	1'513.0	10.87
Mauritania	3'158	34.9	1.10	1'060.1	33.57
Mauritius	1'256	357.3	28.45	722.4	61.50
Mozambique	20'158	67.0	0.33	2'339.3	11.60
Namibia	2'052	*138.9*	*6.84*	*495.0*	*24.37*
Niger	14'426	*24.0*	*0.17*	*323.9*	*2.32*
Nigeria	134'375	1688.0	1.26	32'322.2	24.05
Rwanda	9'230	16.5	0.18	314.0	3.40
Senegal	11'936	282.6	2.37	2'982.6	24.99
Seychelles	81	20.7	25.44	70.3	86.52
Sierra Leone	5'678	24.0	0.49	*113.2*	*2.21*
Somalia	8'496	*100.0*	*1.22*	*500.0*	*6.08*
Sudan	36'993	636.9	1.72	4'683.1	12.66
Swaziland	1'029	44.0	4.27	250.0	24.29
Tanzania	39'025	157.3	0.40	5'767.0	14.78
Togo	6'306	82.1	1.30	708.0	11.23
Uganda	29'856	108.1	0.36	2'008.8	6.73
Zambia	11'861	93.4	0.79	1'663.0	14.02
Zimbabwe	13'085	331.7	2.54	832.5	6.36
Sub-Saharan	**719'220**	**7080.4**	**0.99**	**92'220.0**	**12.90**

Source: ITU World Telecommunications ICT Indicators Database