DETERMINANTS OF THE INTERNET USE IN AFRICA

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Abstract

The objective of this paper is double. On one hand, it intends to approach the African economy and its international institutional framework. On the other hand, it tries to analyze the influence of a set of variables on the degree of Internet penetration in the African countries.

It has been carried out an econometric study comparing, at a longitudinal level, the different African countries, to determine the significance of the selected variables on the degree of development and penetration of Internet in the African economy.

The methodology of the study is a fixed effects panel data model using all the available data for the period 1996-2005. This model tries to capture the common evolution of Internet use in 38 African countries. At the same time, it tries to explain the unequal (heterogeneous) evolution of telecommunications in Africa.

As result of this paper, we can conclude that it is possible to talk about a double digital divide: Firstly the world digital divide, and secondly the African digital divide, explained by the importance of telecommunication infrastructures on the Internet penetration.

Keywords
Africa, Internet users, panel data model, ICT and International institutional framework.

JEL Classification: O30, L69.

1. INTRODUCTION

Approaching to the African economy and its international institutional framework is the preliminary objective of this paper. Once analyzed the institutional framework, the main conclusion is that there is a hyperinflation of international organizations in Africa.

The increase of the ICT importance worldwide, since 1981 when it was sold the first personal computer, forced to the international organizations to include the information society issues in their agendas. The boom of the Internet society could be understood by reading the data from the Internet Software Consortium: 1000 personal computers connected to Internet in 1984, 100.000 in 1989, 10.000.000 in 1996, and 800.000.000 in 2002.

In 1990 the birth of the World Wide Web was a great acceleration factor for e-commerce and the even faster increase of the Internet use worldwide, so the international organizations, leaded by the International Telecommunication Union, the Organization for Economic Cooperation and Development and the World Trade Organization took very seriously this issue into consideration.

The global institutions designed the legal framework that enables the Internet diffusion and the e-commerce evolution. These global institutions constituted the legal framework of the information society.

Institutions are of fundamental importance for the economic growth and for the human relationships and economic cooperation, so the importance of the institutional framework study. International Organizations must be coordinated and do not waste human and economic resources. If the “yearbook of international organizations” published yearly in Brussels is checked, it is possible to identify more than 30 International Organizations in Africa.

The most important African organization is, since 1963, the African Union, which has a continental dimension, as happens with the African Telecommunication Union, the African Development Bank and the African Economic Community.

After 1960, the birth of new States and the African institutionalism was a favourable environment for the creation of new sub regional agreements and organizations. (Manuel Diaz de Velasco, 2006). The proliferation of African sub-regional organizations was amazing and had as main consequence the overload of bureaucracy and waste of human and economic resources.

The most important sub-regional organizations in Africa are, from North to South: The Arab Maghreb Union, The Economic Community of Central African States, The West African Monetary Union, The Economic Community of West African States, The Economic and Monetary Community of Central Africa, and The East African Development Bank.

2. LITERATURE SURVEY

Not only African organizations (specially the African Union), but also International organizations, such as the United Nations through the International Telecommunication Union and the United Nations Global Alliance for ICT and Development, focus their efforts on the diffusion of the ICT over Africa.

A very good example of common efforts on this goal, happened in October 2007 during the Connect Africa Summit in Kigali, where it has been mobilized the private sector and international organizations for its commitment to connecting Africa. Connecting Africa is one of the objectives of the United Nations within the Millennium Development Goals to build a better world in the 21st century.

Narrowing the digital divide means much more than technological diffusion: it also contributes to the fight against illiteracy and poverty.

The use of Internet increases the social knowledge network and improves the communication efficiency (Jovanovic and Rob, 1989). Internet also makes easier and provides better political agreements (Norris, 2001), increases the productivity (Brynjolfsson and Hitt, 2003; Dedrick, 2003), and allows to the less developed countries to accelerate the change from the traditional methods to the new techniques (Steinmuller, 2003).

Following this idea, Proud in 2004 explained the great importance of the ICT implementation for the economic growth, and explained the digital divide as follows "countries with agriculture forming a large part of their economy have not the need of computers and other forms of new technologies, whereas countries with large manufacturing or service industries would be expected to have a greater demand".

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 a huge local and global impact in regions where Internet is used, especially in the African rural areas.

Access to ICT in Africa should not be considered as a privilege, but a tool for achieving economic development and poverty reduction.

There are many urban and rural areas in Africa that are unconnected. From the governments there is a lack of capacity to drive ICT as a tool for the development, so it is necessary the union of government and private-sector leaders, the development of financial institutions, regional communities, academia and civil society organizations, to achieve the common objective of connecting Africa to the world wide web improving the lives of people through the power of ICT.

In this sense, the ten WSIS (World Summit on the Information Society) targets to be achieved by 2015 are: 1.-Connect villages and establish community access points, 2.-Connect universities, colleges, secondary schools and primary schools, 3.-Connect scientific and research institutions, 4.-Connect all public libraries, achieves, museums, cultural centres and post offices, 5.-Connect health centres and hospitals, 6.-Connect all local and central government departments and establish websites and e-mail addresses for them, 7.-Adapt all primary and secondary school curricula to meet the challenges of the information society, taking into account national circumstances, 8.-Ensure that the entire world population has access to television and radio services, 9.-Encourage the development of content and put in place technical conditions in order to facilitate the presence, and use, of all world languages on the Internet, and 10.-Ensure that more than half the world´s inhabitants have personal use of ICT.

To facilitate and establish these objectives before taking decisions, it is necessary to study what are the determinants of the global digital divide and what are the fundamentals of the Internet penetration rate.

In this sense, one of the most important papers developed to understand this issue, is the article written in 2004 by Menzie Chinn and Fairlie Robert to study the determinants of the global digital divide through a cross-country analysis of computer and Internet penetration.

McKormick published in 2002 the article "The Internet access in Africa: A critical review of public policy issues", where he explained that at the end of 1996 only eleven of Africa´s fifty-four countries had local Internet access, but by early 2000 all of the countries had secured access, at least in their capital cities. By this time, of the twenty-two countries in the world with a population of more than one million inhabitants that do not had an Internet host site, sixteen were in Africa.

One of the most important sub-regional studies about the Internet diffusion in Africa is the "Internet diffusion in sub-Saharan Africa: A cross-country analysis", written by Banji Oyelaran-Oyeyinka and Kaushalesh Lal in 2005. In this paper they use a cross-country analysis confirming the vital importance of telecommunications infrastructure, represented by the high correlation between telephone density and Internet, irrespective of per capita income level of the country.

The digital divide has been an important topic of research. The principal studies have been written by Pohjola (2003), Caselli and Coleman (2001), and Dasgupta (2001), where it is explained the huge difference in the diffusion of personal computers and Internet worldwide.

Chinn and Fairlie (2004) explain that the determinant factors of the ICT penetration worldwide are the productivity and the demand of ICT, the energy consumption and availability, the ICT Infrastructures, and the GDP per capita.

About this issue, in 2001 Manuel Castells said "differences in Internet access between countries and regions in the planet at large are so considerable that they actually modify the meaning of the digital divide, and the kind of issue to be discussed".

But what is much more important is not the access to ICT in the narrow sense of having a computer on the desk, but rather in the wider sense of being able to use ICT for personally or socially meaningful goals (Warschauer, 2002).

This evidence of digital divide was pointed out by the International Telecommunication Union as well. In 2003, the ITU reported that "many developing countries have computer and Internet penetration rates that are 1/100th of the rates found in North America and Europe."

In his "status report about the ICT in Africa", Mike Jensen explained that the digital divide is wider in Africa than in other regions of the world, because of the lack of ICT infrastructures and the brain drain that deteriorates the technological skills of the African society.

Although for Beilock (2003) the reasons for this inter-country Internet diffusion are mainly the per capita income and the non economic factors like the civil liberties, he also agrees on the importance of the ICT infrastructure influence.

The ICT infrastructures problem was also pointed out by the ITU in the World Telecommunication Development Report 2003. Here it was reported that the main obstacle for the ICT implementation is the absence of good ICT infrastructures, but also there are other factors that have an important influence, such as technological skills, the ICT quality and the ICT affordability.

3. MOTIVATION OF THE STUDY

Most of the previous studies on the Internet digital divide or cross-country analyses of Internet penetration have been carried out over the OECD countries or at worldwide level, but authors have no focused their studies on the determinants of Internet use in Africa and neither on how Internet has been diffused throughout this Continent.

The main reasons for this lack of studies are, on one hand, that most interesting data are only available under payment to the United Nations Technological Institution: the International Telecommunication Union. On the other hand, the main and most complex problem is the poor and manipulated quality of available data for the African countries.

Nevertheless, it is very important to understand the Internet diffusion process throughout the African economy, because it has a very positive effect on the level of productivity of the African economy. This opinion is based on the worldwide consensus on the benefits of ICT implementation on productivity and the economy as a whole (Jorgenson, 2001; Brynjolfsson and Hitt, 2003; Council of Economic Advisers, 2001).

Nowadays, digital divide is one of the most important problems that faces the global economy. This problem affects specially to Africa, no only beacuse African countries have the lowest ranking in the amount of Internet users as a percentage of total population, but also because they have the highest digital divide between urban and rural areas.

Therefore, it is possible to talk about a double digital divide: Firstly, the world digital divide and, secondly, the digital divide within Africa (explained by the importance of telecommunication infrastructures on the Internet use). This idea is analyzed in this paper.

It has been studied the use of Internet, and the influence of Internet determinants on the penetration of this technology in Africa. The effect of these variables is a very good indicator of the use of information and telecommunication technologies and the new economy framework, given that to use Internet it is necessary the combination of different components, such as computers, telecommunication infrastructures, electricity and technological skills to use the Internet and, thereby, to use all of the other information and telecommunication technologies.

The economic model designed in this paper is a simplified framework that tries to explain the existing relation between the evolution of Internet use in Africa and the determinants of this technology. At the same time, it tries to illustrate the complexity of the Internet diffusion process in African countries.

We developed a very simple model based on a set of variables that was reduced to five, in order to show the effects of these variables on the Internet penetration rate in the African economy. After looking through the specialized literature, and from a logical point of view, we expected the following *a priori* results:

First of all, we expected a positive income effect –measured by the GDP per capita– on Internet use. This effect is positive in the developed world, because when people have more money to expend they tend to use more Internet services. In this respect, the academic literature tends to define Internet as a normal or luxurury good. On the other hand, it has been considered that in the less developed world, where there is a lower ICT implementation, this effect could be even more obvious.

Secondly, price variables –three minutes call cost and monthly subscription cost– should have a negative effect on the Internet use, because it is an *ordinary* good. In other words, Internet is a good that creates increased demand when its user cost drops.

Finally, the infrastructure variables, such as personal computers per 100 inhabitants and main telephone lines (fixed lines) per 100 inhabitants, should have a positive effect on the Internet use, because both of them are key elements in Africa for the use of Internet, and because in Africa most of the Internet connections are done using dial-up connection and a personal computer.

4. INTRODUCTION TO THE QUANTITATIVE STUDY

Besides approaching from an economic perspective to the African international institutional framework, the core objective of this article is to study the determinants of Internet penetration in the African economy. In this sense, we try to identify the effects of the most relevant variables that (potentially) explain the Internet use in Africa.

To achieve this objective, we have implemented an econometric study comparing, at a longitudinal level, the different degrees of Internet use in a broad set of African countries. We have analyzed the significance of different variables on the development and the degree of Internet penetration in the African economy.

This study develops a fixed effects panel data model using all the relevant data available for the period 1996-2005. We assume this information captures the common evolution of Internet penetration in the different African countries. On the other hand, by including a fixed effects specification, we try to determine if there exists an unequal –heterogeneous– evolution and consolidation of telecommunications technologies in Africa.

We design a panel data model for the following list of 38 African countries: Algeria, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Chad, Comoros, Cote D'Ivoire, Egypt, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Kenya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Senegal, South Africa, Sudan, Swaziland, Tanzania, Togo, Tunisia, Uganda, Zambia and Zimbabwe.

The lack of available data, which makes it difficult to increase the time period under study or to expand the number of countries analyzed, has been determinant in the selection of the countries included in the study. The data set has been obtained from two main sources:

On one hand, the *ITU World Telecommunication/ICT Indicators Database* 2008 (12th Edition), that mainly includes technological data on the use of the information and communication technologies (ICT).

On the other hand, the data for economic and demographic variables were taken from the *World Development Indicators Database*, which is the World Bank's primary database for cross-country comparable development data.

Our candidate variables to be included in the panel data analysis were, from the *ITU Database*: Internet subscribers (total) per 100 inhabitants, percentage of digital main lines, and Staff (Total full-time telecommunications staff). With respect the *WDI Database*, we used the following variables: Electric power consumption (kWh per capita), External balance on goods and services (% of GDP), Foreign direct investment, net inflows (% of GDP), Population ages 15-64 (% of total) and Telecommunications revenue (% GDP). However, given the lack of data, these variables were not included in the final model.

The six variables that were finally included in the panel analysis are hereby explained. Firstly, we included as the dependent variable the Internet users per 100 inhabitants, which is available from the *ITU Database* for the 38 countries included in the study for almost all the years of the sample period.

From the *World Development Indicators Database* we obtained the data for the first independent variable included in the study: the GDP per capita in constant 2000 US$.

To evaluate the influence of Internet costs on the Internet use in Africa, we included two additional variables in the regression analysis. Firstly, we decided to include the three minutes call cost, because in Africa most of the Internet connections are made via dial-up, so the cost of telephone use is determinant. Moreover, we included the telephone line monthly subscription cost, because it determines the implementation of fix telephone lines that could support the Internet use. It was not possible to analyze directly the Internet price, because of the lack of information and data in the *ITU* and *WDI* databases.

The technological variables included into the model are: the number of personal computers per 100 inhabitants and the number of main telephone lines (fixed lines) per 100 inhabitants.

With all these variables, we designed a panel regression model given by the following expression:

$$\begin{aligned}\Delta\log(\text{Internet Users})_{it} &= \alpha_0 + \textstyle\sum_{i=1}^{38}\alpha_{0i}P_i + \alpha_1\Delta\log(GDP \text{ per capita})_{it} + \\ &+\alpha_2\Delta\log(\text{three minutes call cost})_{it} + \alpha_3\Delta\log(\text{monthly subscription cost})_{it} + \\ &+\alpha_4\Delta\log(\text{personal computers per 100 inhabitants})_{it} + \\ &+\alpha_5\Delta\log(\text{telephone fixed lines per 100 inhabitants})_{it} + \varepsilon_{it}\end{aligned}$$

In order to improve our understanding of the EViews output we gave the variables a short name:

$$\begin{aligned}\Delta\log USINT_{it} &= \alpha_0 + \textstyle\sum_{i=1}^{38}\alpha_{0i}P_i + \alpha_1\Delta\log YP_{it} + \alpha_2\Delta\log PCALL_{it} + \alpha_3\Delta\log CUOTAMENS_{it} + \\ &+\alpha_4\Delta\log COMPU_{it} + \alpha_5\Delta\log TELINES_{it} + \varepsilon_{it}\end{aligned}$$

Where the intercept term consists of two parts: The first one (α_0) is shared by all cross-sectional units (countries), while the second one ($\sum_{i=1}^{38}\alpha_{0i}P_i$) varies across cross-sectional units. (P_i is a dummy variable that takes on the value of 1 if this observation comes from the i*th* cross-section, and 0 if it doesn't.)

The previous equation –which represents the so-called (cross-section) fixed effects panel data model– will be estimated in the last part of this paper.

5. MODEL DESIGN AND IMPROVEMENT IN THREE STEPS

This paper develops a fixed effects generalized least squares (GLS) panel data model. All the variables included in the model are in rates of growth (differenced-log variables).

The panel data model tries to determine if there exists a common pattern in the degree and the evolution of Internet penetration in the analyzed countries.

At the same time, the fixed effects specification, tries to quantify if it is possible to observe a differential behaviour in the rate of growth of Internet users among the considered nations, as a result of the existence of non-observable information which is not captured by the variables included in the model.

We have made a specific effort to avoid problems of misspecification. On the other hand, we have decided to include just five variables which, in most of the cases, are relevant enough to explain the variability of Internet penetration in Africa. In this sense, we have prefered to keep the model as parsimonious as possible.

The model is robust enough in the sense that little variations in the sample size (or in the time period) under analysis, do not provoke relevant changes in the value and significance of the parameters of the model. Finally, by inspecting the matrix of correlations between the independent variables, we cannot infer the existence of collinearity problems.

	DLOGCOMPU	DLOGCUOTAMENS	DLOGPCALL	DLOGTELINES
DLOGCOMPU				
DLOGCUOTAMENS	-0.131068158			
DLOGPCALL	-0.093622206	0.381837813		
DLOGTELINES	0.055940763	-0.117792934	-0.14778477	
DLOGUSINT	0.19615316	-0.160470948	-0.146551056	0.14806125

Figure 1. Correlation matrix of the regressors of the model.

Given this information, we design a strategy in three steps. Firstly, we develop a common effects GLS (cross-section weights) panel data model. Secondly, we improve the model by including a first-order autoregressive structure (AR(1)). Finally, we introduce a fixed effects specification in the model. In this final step the regression fit is substantially improved.

5.1. Common effects (GLS) panel data model

In the first part of the study, we analyze a common effects generalized least squares (cross-section weights) panel data model for the period 1996-2005. We include 38 cross sections that correspond to the 38 African countries for which almost all the data are available. Given this information, we develope an unbalanced panel model with 283 observations.

In order to explain the regression output, it must be pointed out that the most surprising result obtained from this preliminary version, was the irrelevance of the income variable (*YP*).The *t*-statistic is clearly under 2 and the *p*-value is 0.68.

Unfortunately it was not possible to study the behaviour of Internet prices –and their effect on the evolution of Internet users– in the African economies. However, we could analyze the influence of two alternative price variables –the three minutes call cost and the residential monthly telephone subscription– that can be used as proxies for the first one.

Both variables show a negative and a very significant (*p*-value lower than 0.05) coefficient, what makes sense to have into account the negative relation observed between these prices and the Internet use. Particularly, the monthly subscription cost is significant at the 99% (*p*-value lower than 0.001) confidence level (*p*-value lower than 0.001) with a very high t-statistic.

With respect the infrastructure technologies –personal computers and telephone lines per 100 inhabitants–, both of them have positive and very significant (at the 99% confidence level) coefficients. Thus, a one percent increase in the number of personal computers (fixed telephone lines) is associated with a 0.35 (0.67) percent increase in the number of internet users.

The R-squared, which explains of how well the regression line approximates real data points, is quite low: it accounts for a little more than 33% of the total variability of the dependent variable (the rate of growth of Internet users). On the other hand, the low value of the Durbin-Watson statistic (1.622914) could be suggestive of the existence of first-order autocorrelation.

Dependent Variable: DLOG(USINT)
Method: Panel EGLS (Cross-section weights)
Sample (adjusted): 1996 2005
Cross-sections included: 38
Total panel (unbalanced) observations: 283
Linear estimation after one-step weighting matrix
White cross-section standard errors & covariance (d.f. corrected)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.443320	0.051019	8.689229	0.0000
DLOG(YP)	0.185609	0.455625	0.407373	0.6840
DLOG(PCALL)	-0.159864	0.057652	-2.772906	0.0059
DLOG(CUOTAMENS)	-0.278299	0.065577	-4.243871	0.0000
DLOG(COMPU)	0.348392	0.087821	3.967079	0.0001
DLOG(TELINES)	0.674588	0.177012	3.810981	0.0002

Weighted Statistics

R-squared	0.330452	Mean dependent var	0.787999
Adjusted R-squared	0.318366	S.D. dependent var	0.666535
S.E. of regression	0.550299	Sum squared resid	83.88365
Durbin-Watson stat	1.622914		

Figure 2. Common effects (GLS) panel data model output.

5.2. A common effects first-order autoregressive (GLS) panel data model

In order to improve the model's fit, we include a first-order autoregressive structure (AR(1)). The AR(1) term is positive and significant at the 99% confidence level, but now the R-squared is even lower than before.

On the other hand, the Durbin-Watson statistic is near 2 (1.978682), which implies the absence of first-order autocorrelation. The sign and the significance of the independent variables included in the model, are very similar to those derived from the first specification.

Finally, we decided to change the specification of the model by introducing the existence of fixed effects, not only as a consequence of the very low value of the R-squared, but also because the possible heterogeneity of the countries under consideration could be better captured by this new specification. This last aspect could be one of the main reasons of the very low value of the R-squared.

Dependent Variable: DLOG(USINT)
Method: Panel EGLS (Cross-section weights)
Sample (adjusted): 1997 2005
Cross-sections included: 38
Total panel (unbalanced) observations: 243
Iterate coefficients after one-step weighting matrix
White cross-section standard errors & covariance (d.f. corrected)
Convergence achieved after 10 total coef iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.364469	0.033456	10.89391	0.0000
DLOG(YP)	0.615038	0.417688	1.472482	0.1422
DLOG(PCALL)	-0.175890	0.055599	-3.163571	0.0018
DLOG(CUOTAMENS)	-0.149494	0.047154	-3.170350	0.0017
DLOG(COMPU)	0.398860	0.074945	5.322001	0.0000
DLOG(TELINES)	0.427694	0.180354	2.371413	0.0185
AR(1)	0.125912	0.039509	3.186961	0.0016

Weighted Statistics

R-squared	0.292740	Mean dependent var	0.710983
Adjusted R-squared	0.274758	S.D. dependent var	0.523557
S.E. of regression	0.445867	Sum squared resid	46.91623
Durbin-Watson stat	1.973404		

Figure 3. Common effects first-order autoregressive (GLS) panel data model output.

5.3. Fixed effects (GLS) panel data model

Under this new specification of the model, the R-squared improves considerably to 0.57 (compared to 0.33 and 0.29 from the first and second models). Moreover, the introduction of cross-section fixed effects, eliminates the first-order autocorrelation problem (the Durbin-Watson statistic is near 2).

The variables maintain the sign, the significance (at a 95 or 99 percent confidence level) and, in some cases, the value of the previous models. The most relevant variables (at a 99 percent confidence level) are those related to the infrastructure availability: personal computers (COMPU) and telephone lines (TELINES) per 100 inhabitants. These results show the importance of fixed telephone lines and residential computers, in the future development of Internet use in African countries.

Finally, the analysis of the residuals suggests a good specification: there is no evidence of unmodelled residual autocorrelation. The last two columns reported in the correlogram of the residuals (Figure 4) –which are are the Ljung-Box Q-statistics and their *p*-values–, confirm this result.

Number of lags	Q-Stat	Prob
1	0.5487	0.459
2	0.7514	0.687
3	1.1804	0.758
4	4.8379	0.304
5	7.0325	0.218
6	10.408	0.108
7	11.209	0.13
8	11.341	0.183

Figure 4. Correlogram of the residuals

On the other hand, the Jarque Bera tests for normality of the residuals (and their corresponding *p*-values), show that they are normally distributed on a country by country basis. (All the results are available from the authors under request.)

Finally, the panel unit root tests of the residuals (Figure 7), confirm that they are stationary.

Dependent Variable: DLOG(USINT)
Method: Panel EGLS (Cross-section weights)
Sample (adjusted): 1996 2005
Cross-sections included: 38
Total panel (unbalanced) observations: 283
Linear estimation after one-step weighting matrix
White cross-section standard errors & covariance (d.f. corrected)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.521389	0.022763	22.90470	0.0000
DLOG(YP)	-0.231485	0.512061	-0.452065	0.6516
DLOG(PCALL)	-0.111735	0.043711	-2.556250	0.0112
DLOG(CUOTAMENS)	-0.296772	0.044409	-6.682690	0.0000
DLOG(COMPU)	0.368039	0.051515	7.144358	0.0000
DLOG(TELINES)	0.773367	0.168548	4.588422	0.0000

Effects Specification

Cross-section fixed (dummy variables)

Weighted Statistics

R-squared	0.565832	Mean dependent var	0.909574
Adjusted R-squared	0.489853	S.D. dependent var	0.787407
S.E. of regression	0.562402	Sum squared resid	75.91116
Durbin-Watson stat	1.990414		

Figure 5. Fixed effects (GLS) panel data model output.

Redundant Fixed Effects Tests
Equation: EQ03
Test cross-section fixed effects

Effects Test	Statistic	d.f.	Prob.
Cross-section F	2.207911	(37,240)	0.0002

Figure 6. Redundant Fixed Effects Tests. (The hypothesis of redundant fixed effects is rejected.)

Group unit root test: Summary
Sample: 1995 2005
Series: RESIDBENIN, RESIDBOTSWANA, RESIDBURKINAFASO, RESIDBURUNDI, RESIDCAMEROON, RESIDCAPE, RESIDCENTAFRIREP, RESIDCHAD, RESIDCOMOROS, RESIDCOTEDIVOIRE, RESIDEGYPT, RESIDERITREA, RESIDETHIOPIA, RESIDGABON, RESIDGAMBIA, RESIDGHANA, RESIDGUINEA, RESIDKENYA, RESIDMADAGASCAR, RESIDMALAWI, RESIDMALI, RESIDMAURITANIA, RESIDMAURITIUS, RESIDMOROCCO, RESIDMOZAMBIQUE, RESIDNAMIBIA, RESIDNIGER, RESIDSENEGAL, RESIDSOUTHAFRICA, RESIDSUDAN, RESIDSWAZILAND, RESIDTANZANIA, RESIDTOGO, RESIDUGANDA, RESIDVERDE, RESIDZAMBIA, RESIDZIMBABWE
Exogenous variables: Individual effects
Automatic selection of maximum lags
Automatic selection of lags based on SIC: 0 to 1
Newey-West bandwidth selection using Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-40.0941	0.0000	36	225
Breitung t-stat	-2.31183	0.0104	36	189
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-13.5774	0.0000	36	225
ADF - Fisher Chi-square	254.962	0.0000	36	225
PP - Fisher Chi-square	277.786	0.0000	37	236

** Probabilities for Fisher tests are computed using an asympotic Chi -square distribution. All other tests assume asymptotic normality.

Figure 7. Panel unit root test summary. (Residuals are *stationary*.)

6. CONCLUSIONS

The principal conclusion of our study is that in African countries the income effect on the Internet use it is not relevant. All the variables included in the different specifications of the model are significant but not the rate of growth of GDP per capita. A feasible explanation of this result is 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. In some countries and in some academic articles Internet is considered a “luxury” good. Therefore, given this preliminary study, we cannot characterize Internet as a normal or luxury good in African countries.

Secondly, we can conclude that both price variables –the three minutes call cost and the monthly subscription cost–, have a negative effect on the Internet use. Finally, we observe that there is an important effect, with a very high significance, of technological factors on the Internet use in African countries.

References

BANJI O. and Kaushalesh LAL. (2005). *Internet diffusion in sub-Saharan Africa: A cross-country analysis.* United Nations University-Institute for New Technologies, Telecommunications Policy 29, Maastricht, The Netherlands.

BEILOCK, R., and Dimitrova, D. V. (2003). “An Exploratory Model of Inter-Country.

CASELLI, F. and Coleman, II W.J. (2001). Cross-country technology diffusion: the case of computers. National Bureau of Economic Research, Cambridge, MA, Working paper no. 81.

CHAUDHURI, Anindya et alii (2004). A*n Analysis of the Determinants of Internet Access.* Washington D.C., October, 27pp.

CHINN, M. D. and Fairlie, R. W. (2004). “The Determinants of the Global Digital Divide: A Cross-Country Analysis of Computer and Internet Penetration”. New Haven, March 2004, 36 pp. *Department of Economics, UCSC*, Working Paper 562.

CRENSHAW, E. M. and Robison K. K. (2006). “Globalization and the Digital Divide: The Roles of Structural Conduciveness and Global Connection.

DiMAGGIO, P., Hargittai, E., Neuman, W. R., and Robinson, J. P. (2001). Social implications of the internet. Annual Review of Sociology, 27, 307–336.

GROSSO, M. (2003). Determ*inants of Broadband Penetration in OECD Nations.*

GUILLENA, M. F. and Suarez, S.L. (2004). “Explaining the Global Digital Divide: Economic, Political, and Sociological Drivers of Cross-National Internet Use.” Wharton eBusiness Initiative Working Paper Series, to be published in a forthcoming issue of the journal “Social Forces”.

HARGITTAI, E. (2001). Holes in the net:The Internet and International Stratification. Accessed through ohttp://www.isoc.org/inet98/proceedings/5d/5d_1.htm4

INTERNATIONAL TELECOMMUNICATION UNION (2002). Trends in telecommunication reform: Covergence and regulation. Geneva:ITU.

INTERNATIONAL TELECOMMUNICATION UNION (2003). *World Telecommunication Development Report 2003.* Geneva, December, 28pp.

INTERNATIONAL TELECOMMUNICATION UNION (2008). World Telecommunication/ICT Indicators Database (12th Edition), accessed through, http://www.itu.int/ITU-D/ict/publications/world/world.html

JENSEN, M. (2003). *ICT in Africa: a status report-chapter 6.* S.L. S.F., 15pp.

KELLY, T. and Petrazzini, B. (1997). What does the Internet mean for development? Telecom interactive development symposium, Geneva, 11 September.

KIISKI, S. and Pohjola, M. (2002). Cross-country diffusion of the internet. Information Economics and Policy, 14(2), 297–310.

LANDES, D. S. (1999). The wealth and the poverty of nations, why some are so rich and some so poor. New York, London: W.W. Norton and Company.

MADON, S. (2000). “The Internet and socio-economic development: exploring the interaction.” Information Technology and People, vol. 13(2), 85-101.

McKORMICK, P. (2003). *The Internet access in Africa: A critical review of public policy issues.* Comparative Studies of South Asia, Africa and the Middle East, Vol.XXII, Nº102.

MURTHY, V. N. R. (2004). “Internet Diffusion: An Econometric Analysis.” Asian-African Journal of Economics and Econometrics, vol. 4(1), 45-54.

PROUD, S. M. (2004). *Cross-country technological diffusion: A data panel analysis of computer imports*. Bristol, September, 60pp.

ROLLER, L.-H. and Waverman, L. (2001). Telecommunication infrastructure and economic development:A simultaneous approach. The American Economic Review, 91(4), 909–923.

WORLD BANK (2008). World Development Indicators Database, accessed through http://devdata.worldbank.org/dataonline/