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## **Long Term Factors of Internet Diffusion in Sub-Saharan Africa: A Panel Co-Integration Analysis**

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### **ABSTRACT**

*Identifying factors that influence the diffusion of the Internet is paramount for researchers as well as policy makers in articulating strategies to improve the availability and subsequent use of the Internet. Most existing empirical studies have focused on this problem by analyzing diffusion data for countries for one fixed year and identified variables affecting the Internet diffusion. These variables, generally, come from the economic, technological, policy, culture, and human capital realms. These results have provided a good “snapshot” of what factors are important towards the diffusion of the Internet and the results tend to vary for studies conducted in different time frames. This paper also addresses, the phenomenon of cross-country dependence – the economic, political, and technological environment of one country affecting other countries- into account in their analyses. This paper, for the first time in the literature, empirically identifies long-term determinants of the Internet diffusion in sub-Saharan African (SSA) countries by considering data for the period 1997-2013. It employs a recently-developed technique named “panel co-integration analysis” to model the diffusion of the internet among the SSA countries. The analysis reveals that in SSA countries, the number of telephones, the level of per capita real gross product and the extent of ruralization (conversely, the degree of urbanization) are the key long-term drivers of the diffusion of the Internet. Finally, the paper concludes with a discussion of policy implications.*

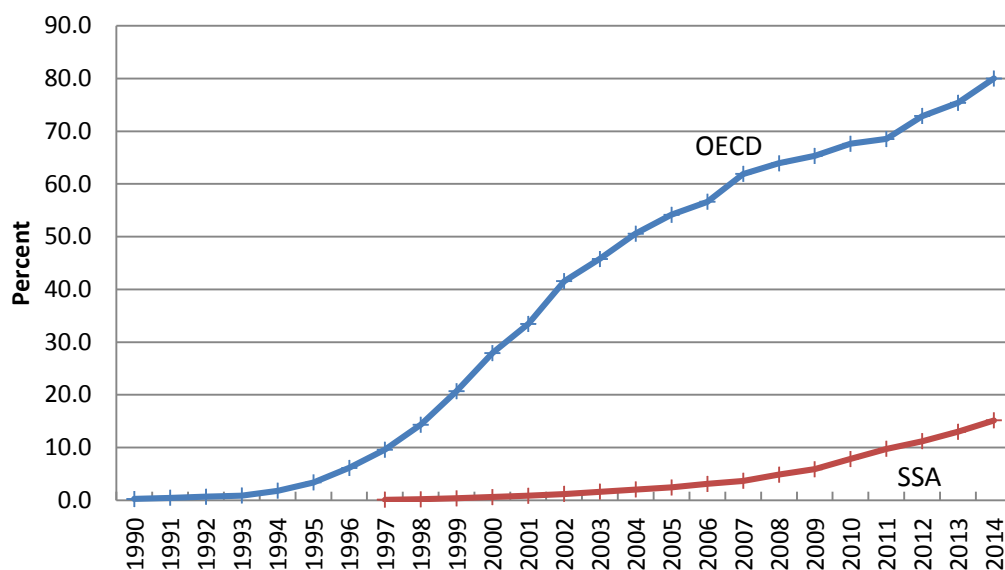
**Keywords:** Long term factors, Sub-Saharan Africa, Internet diffusion

### **INTRODUCTION**

In the contemporary global economy, for countries that aspire for better economic, business and social progress, rapid diffusion of the internet is highly beneficial and warranted. It is widely recognized that highly developed countries, especially the Organization for Economic Co-operation and Development countries (OECD) with a high level of the Internet usage and accelerating rate of Internet diffusion, on both extensive and intensive bases have reaped benefits in the areas of education, e-commerce, healthcare, communications, technology, social media and labor productivity (Hargittai, 1999; Kiiski & Pohjola, 2002). While these OECD countries have

garnered substantial gains from greater diffusion of the internet, developing countries, especially, the sub-Saharan African (SSA) countries have generally lagged behind and hence, have experienced the effect of this digital-divide. Overall, in the SSA countries, the Internet diffusion rates remain relatively low with a wide variation among the diffusion rates of countries. According to ITU (2015) data, in 2013, the average Internet diffusion rate for SSA countries was about 13% with a median rate of 9%. South Africa had the highest diffusion rate of 46.5%<sup>1</sup> and over a dozen countries had rates below 10%. Figure 1 shows the Internet diffusion rates for the OECD and SSA countries over a period of several years. And, it clearly shows the relatively low level of the Internet penetration in SSA as well as the consequent widening digital gap between the OECD and SSA.

**Figure 1. Internet diffusion rates for the OECD and SSA Countries (1990-2014).**



Generally, it has been observed that the SSA countries tend to have inadequate telecommunications, low level of the internet infrastructure, low tele density, poor electricity infrastructure, rigid and monopolistic structure of telecommunications market, redundant regulations and finally, low levels of real per capita GDP. Thus, from the policy perspective of these countries, there is definitely, an imminent need to identify the long term factors that influence the diffusion of the Internet. Economists, telecommunications scholars and policy makers are interested in learning about the factors that drive Internet diffusion in the SSA. While there are many published studies on the diffusion of the Internet in the OECD and other highly developed countries, there is a paucity of such studies for the SSA countries. Of the existing empirical studies on the Internet diffusion in the SSA countries, most of them use cross-sectional data for a given year. Thus, they provide a good guide for the short run but lack the long term perspectives on diffusion factors. For countries, a longer horizon is necessary in first formulating and then

<sup>1</sup> Mauritius and Seychelles (island nations in the Indian Ocean) are not included in these calculations.

implementing policies and strategies that strengthen and prompt the use of the Internet for economic development and social welfare.

The present study overcomes many of the problems by using the panel data and applying the panel cointegration techniques in identifying the enduring long-run determinants of the diffusion of the Internet in the SSA countries. It utilizes a panel data set comprising 30 SSA countries for the period 1997-2013. To the best of our knowledge, this type of study does not currently exist in the literature.

## **LITERATURE REVIEW**

There exist numerous studies that examine and identify factors affecting the global diffusion of the Internet (Beilock & Dimitrova, 2003; Birba & Diagne, 2012; Chinn & Fairlie, 2007; Dewan, Ganley & Kraemer, 2010; Dholakia, Dholakia & Kshetri, 2003; Hargittai, 1999; Huang & Chen, 2010; Kiiski & Pohjola, 2002; Li & Shiu, 2012; McCoy, Cha & Durcikova, 2012; Meijers, 2006; Murthy, 2004; Nath & Murthy, 2003, 2004, 2015; Oyelaran-Oyeyinka & Lal, 2005; Wunnava & Leiter, 2009). At the country level, these factors typically fall into one of the five general categories: human capital, technological, economic, political, and cultural.

Among the human capital factors that correlate positively with the Internet diffusion include a nation's adult literacy rate, per capita spending on education, and percent of school age children enrolled in schools (Bali moune-Lutz, 2003; Li & Shiu, 2012; McCoy, Cha & Durcikova, 2012; Nath & Murthy, 2003; Noce & McKeown, 2008; Wunnava & Leiter, 2009).

Key technological factors leading to improved diffusion of the Internet have been identified in many empirical studies and they are: percent of the population with access to PCs (or other net-enabled devices – tablets, smart phones, etc.), mobile phone subscribers per 100 inhabitants, telephone lines per 100 inhabitants, bandwidth per capita, and reliability of electric power (Bali moune-Lutz, 2003; Nath & Murthy, 2003, 2004; Wunnava & Leiter, 2009). Further, a study by Arnum & Conti (1998) examined the “wired ratio” of a nation, which is, the sum of the phone lines, televisions, and electricity usage per capita. They showed that the wired ratio has a positive association with the Internet ratio (the sum of the Internet hosts, domains, and web pages per capita).

With respect to economic factors, many researchers have shown that, across countries, GDP per capita and Internet access costs are good predictors of the growth of the Internet (Kiiski & Pohjola, 2002; McCoy, Cha & Durcikova, 2012; Perkins & Neumayer, 2011). As one would expect, higher income (as indicated by the GDP per capita) results in an increase in the Internet penetration rate and high Internet access costs serve as an impediment to improving the diffusion rates (Nath & Murthy, 2004).

Political factors encompass government policies and regulations necessary to foster an environment that promotes the development of proper technology infrastructure, governance rules, and appropriate incentives and investments. There are several broad indicators in this arena that have been shown to affect the diffusion of the Internet. Prominent amongst them are the nation's economic freedom index (EFI), and the innovation capability. Both are shown to play a positive role towards the adoption of the Internet (Bali moune-Lutz, 2003; McArthur & Sachs, 2000; Nath

& Murthy, 2003, 2004; Perkins & Neumayer, 2011).

Finally, among cultural factors, “uncertainty avoidance” and “masculinity” are known to be associated with the diffusion of the Internet (Nath & Murthy, 2004). In fact, there is considerable evidence indicating that cultural factors play a role in the adoption of technological innovations. Yaveroglu and Donthu (2002) have shown that the use of cell phones, home computers, and microwave ovens is high in countries with low power distance, low uncertainty avoidance, and high individualism. Further, Yenyurt and Townsend (2003) conclude that lower acceptance of new products is related to power distance and uncertainty avoidance. Cultural considerations even play a role in how information systems, in general, are designed, implemented, and used (Gallupe & Tan, 1999; Jarvenpaa & Leidner, 1998; Montealegre, 1997; Nelson & Clark, 1994; Straub, 1994; Thatcher et al., 2003; Watson, Ho, & Raman, 1994).

Several studies focused on SSA have examined the Internet diffusion factors either for a subset of countries or a single country. Notable single-country studies include Foster et al. (2004) - Ghana; Migiro (2006) and Ochara et al. (2008) - Kenya; Anunobi & Mbagwu (2009) and Oyelaran-Oyeyinka & Adeya (2002) - Nigeria; and Brown et al. (2007, 2009) - South Africa. Further, an empirical study by Ojuloge and Awoleye (2012) compared five African countries – four in SSA (Kenya, Nigeria, Rwanda, and South Africa) and Egypt. Other studies that dealt with SSA counties include: Andoh-Baidoo et al. (2014), Birba and Diagne (2012), Koch and Gaskins (2014), and Oyelaran-Oyeyinka and Lal (2005). All these studies have identified the Internet diffusion factors that fall into the five groups of factors identified above. For example, Birba and Diagne (2012) examined the diffusion of the Internet in Ghana and South Africa and concluded that new liberal economic policies of deregulation and privatization of the telecommunications sector have not been effective in bridging the digital divide in Africa. Oyelaran-Oyeyinka and Adeya (2002), using the data from Kenya and Nigeria concluded that the Internet use is constrained by structural and cost factors. Further, using cross-country data for 40 SSA countries spanning the period 1995-2000, Oyelaran-Oyeyinka and Lal (2005) noted that the density of Internet hosts, the number of telephone lines, personal computers, and economic wealth influence diffusion of the Internet. Birba and Diagne (2012) study, using the data from 17 sub-Saharan African countries, revealed that the degree of urbanization, education, and the expansion of the Internet infrastructures play important roles in augmenting the rate of adoption of the Internet.

### **MODEL SPECIFICATION**

One could consider a model with a large number of predictor variables to estimate the Internet diffusion rate. However, for many variables data are not available going back to 1997 and some potential variables did not exist in 1997 (e.g., mobile phone users accessing the Internet using phones). Therefore, it is decided to have a parsimonious model that includes three key variables as established by previous research studies. The variables used are:

- IU: the percentage of individuals using the internet
- TEL: the number of fixed-telephone subscriptions per 100 inhabitants
- INCOME: the level of real per capita GDP in constant 2005 US\$
- RURAL: the percentage of the rural population.

Therefore, the following estimable double-logarithmic panel econometric model is proposed:

$$IU_{it} = \beta_{it} + \beta_{1t} TEL_{it} + \beta_{2t} INCOME_{it} + \beta_{3t} RURAL_{it} + \varepsilon_{it} \quad (1)$$

Where  $i$  = country,  $t$  = year, and  $\varepsilon_{it}$  is the error term for country  $i$  and year  $j$ . Also, all the variables are expressed in natural logarithms. An advantage of the specified double-logarithmic model (1) is that it takes into account any nonlinearity in the economic relationship and the estimated coefficients represent elasticities of the Internet diffusion with respective explanatory variables.

It is hypothesized that TEL, other things being equal, positively affects the diffusion of the Internet as the number of telephones available in a given country facilitates Internet usage and also, it measures the status of the telecommunications infrastructure. Previous studies have considered this variable, tele density, as an important variable. Further, INCOME (real GDP per capita), holding the effect of other factors constant, is hypothesized to impact IU positively because increasing real income in a country enables more individuals to afford personal computers, visit cyber café to surf the Internet, afford the high cost of the Internet. Increasing income also shows the greater role of human capital in augmenting productivity, facilitating and expanding and growing scale of business operations in commerce, office administration, communications and health. Increasing income in these countries would result in reduced digital divide. Finally, RURAL, the degree of ruralization, the effect of other variables held constant, is expected to decrease diffusion of the Internet. Conversely, as SSA countries become more and more urbanized, individuals will have increased access to telecommunications infrastructure, such as cyber café and public libraries to surf the internet, better electricity infrastructure, reduced transaction costs and enhanced opportunities to earn higher level of wages. Increasing urbanization would also result in economies of scale in production and consumption (usage) of the Internet.

In terms of the model (1), these hypotheses imply that  $\beta_{1t} > 0$ ;  $\beta_{2t} > 0$ ;  $\beta_{3t} < 0$ .

## DATA

The data for SSA countries for the period 1997-2013, on IU and TEL are gathered from *International Telecommunication Union* (Various years), the data on INCOME and RURAL are obtained from World Bank's *World Development Indicators* (2014). Summary statistics – mean, median, standard deviation, maximum, and minimum, of the four used variables over the years 1997-2013 for the SSA countries are shown in table 1. They show that, for 2013, the mean Internet diffusion rate for SSA is 12.98%; with the highest rate of 46.5% (South Africa) and the lowest rate of 1.6% (Guinea). Also, a high value for the standard deviation (12.32%) indicates a substantial unevenness in the Internet diffusion rates among the SSA countries. Further the phone adoption rates remain fairly low (mean of 2.34%) since mobile telephone technology has leapfrogged the traditional land-line infrastructures in nearly all developing countries. Real per capita figures (INCOME) also reflect significant variation in income levels – from a high of US\$ 7,028.05 to a low of US\$ 224.41. Further, the mean ruralization level is a little over 60% with Malawi being the most rural (84.56%) and Gabon being the least rural (13.34%).

**Table 1: Summary statistics for the SSA Countries for 2013.**

Variable	IU (%)	TEL (%)	INCOME (\$)	RURAL (%)
Mean	13.10	2.34	1494.80	60.45
Median	7.65	0.93	673.92	62.02
Maximum	48.90	13.27	7028.05	84.00
Minimum	1.60	0.16	224.41	13.23
SD	12.76	3.23	1972.45	17.84
Jarque-Bera (JB) test for Normality	13.40	44.57	33.60	2.17

The SSA Countries included are: Benin, Botswana, Burkina Faso, Cameroon, Cape Verde, Chad, Congo, Ethiopia, Gabon, Gambia, Ghana, Guinea, Kenya, Lesotho, Madagascar, Malawi, Mali, Mauritania, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, South Africa, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe.

### EMPIRICAL FINDINGS

Next, before estimating the coefficients of the specified model (1) using a panel cointegration analysis, the appropriateness of the technique needs to be established. First, the stationarity or a lack thereof of the dependent variable (IU) and the explanatory variables (TEL, INCOME, and RURAL) requires testing. If we disregard this phenomenon and use the Ordinary Least Squares (OLS) or any other pooling-cross-section estimator, the resulting model will be a spurious regression model. However, if in a model, both the non-stationary dependent and non-stationary explanatory variables form a long-run link or economic relationship, the resultant phenomenon is called cointegration. Second, the presence of the cross-sectional dependence among the SSA countries, i.e., whether the environment in one or a group of countries affects the Internet diffusion in other countries, requires testing. Only when the non-stationarity of the variables involved in estimation is confirmed, we proceed with the panel cointegration analysis.

#### *Non-stationarity tests*

A series that is non-stationary in level is said to contain a unit root or integrated of the order one. The first two moments, the mean and variance, of a non-stationary variable are dependent on time and any shock to it will not be mean reverting. In this paper, as a first-step, we conduct a comprehensive unit root testing that includes both the first and second-generation panel unit root tests. The first-generation panel unit root tests performed in this paper are the Levin-Lin-Chu (LLC) test, the Breitung test (BTG), the Im-Pesaran-Shin (IPS) and the Maddala-Wu (MW) Fisher ADF test. We also employ Hadri's test (2000) that assumes stationarity or absence of a unit root and the alternate hypothesis non stationarity for, at least some of the cross-sections included. It should be noted here that the first –generation panel unit tests assume that there is cross-sectional independence. But, in a cross-sectional sample we expect the presence of many economic, political and global factors and linkages that induce cross-sectional dependence. Sometimes, cross-

sectional dependence occurs due to spatial and spillover effects or due to unobserved common factors affecting all the panel members, For instance, some political, economic and cultural factors in one SSA country might affect those of other SSA countries. There might be similar economic and political characteristics among the members of a panel. If there is cross-sectional dependence in the data sample used in the estimation, the resulting parameters will be biased (See, Breitung & Pesaran, 2008; Pesaran, 2004, 2007). If we ignore cross-sectional dependence and conduct the first-generation panel unit root tests, these tests will be size-distorted. Therefore, we also employ the Pesaran's cross-sectional IPS (CIPS) test that tests for the presence of a unit root (non-stationarity) in a cross-section, controlling for any cross-sectional dependence (Pesaran, 2007).

As the above mentioned panel unit root tests have become standard in practice and widely used in the literature, we omit any detailed explanation of them (Baltagi, 2008; Breitung & Pesaran, 2008; Levin et al., 2002; Pesaran, 2007). We have not tested the presence of a unit root with structural breaks as the time-series span used in the analysis and estimation is not long enough (See, Perron, 1989). Furthermore, we assume that the time period is short such that these SSA countries do not experience any statistical discernible structural breaks.

In Table 2, we report the results of first generation panel unit root tests for the level series. The results for the first-differenced series are not reported here for space constraints. From examining the observed p-values of the tests, the findings on the presence of a unit root are mixed, although the majority of the tests results indicate that the variable series are non-stationary. For the IU variable series, majority of tests, with the exception of Breitung tests, show that it is stationary. While all the tests maintain the null hypothesis as the presence of a unit root (Non-stationarity), the Hadri states the null of stationarity (absence of a unit root in the data generating process). The Hadri test (adjusted for heteroscedasticity) statistics indicate that we can reject the null hypothesis of stationarity for all the variable series at the 1% level of significance. Thus, the findings from a majority of the first generation unit root tests indicate that the variable series included in model (1) are non-stationary, hence they contain a unit root. However, given the fact that these first-generation panel unit root tests ignore cross-sectional dependence, we cannot conclude that the variable series contains a unit root.

**Table 2: First-generation panel unit root test results.**

Series	LLC	IPS	MW	BTG	HADRI
IU	15.828*	8.980*	180.602	2.771	11.997*
TEL	-1.694	0.283	77.655**	3.562	8.970*
INCOME	-1.738	0.296	-70.758	2.514	8.400*
RURAL	-2.580*	5.039	-1.153	-0.966	13.887*
Number of cross-sections (N)	30				
Number of observations	460				

\* denotes statistical significance at the 1% level.

Lag lengths are based on the Schwartz information criterion (SIC). Deterministic terms used are an individual constant and a time trend in regressions.



### Cross-dependence tests

In Table 3, we present the results from the Pesaran et al.,(2008)s' modified CD tests for detecting the cross-sectional dependence among the panel SSA countries and the cross-sectional IPS (CIPS) unit root test which is robust to the presence of cross-sectional dependence in the data (Pesaran, 2004, 2007; Pesaran, Ullah & Yamagata, 2008). The results of the adjusted CD tests clearly indicate that with the exception of the IU variable, for TEL, INCOME and RURAL variables, we reject the null hypothesis of no cross-sectional dependence at the 1% level. This shows that while the IU variable series is non-stationary in levels at the 1% statistical significance, all other variable series, TEL, INCOME, and RURAL are non-stationary in levels at the 5% significance level, indicating that the variables included in the model(1) are non-stationary and therefore are integrated of the order one. Thus, the results from Table 3 further emphasize that econometric modelling of model (1) requires a panel cointegration analysis.

**Table 3: Second-generation panel unit root tests.**

Series	CD <sub>adj</sub> LM statistics**	CIPS statistics	Determination *
IU	0.42	-2.26 (0.00)	I (1)
TEL	7.68 *	-1.85 (0.28)	I (1)
INCOME	27.75*	-1.09 (1.00)	I (1)
RURAL	26.94*	-1.39 (0.97)	I (1)

\* The notation, (1) denotes that the variable series is of the order 1 or it is non-stationary. The observed p-values are in parentheses.

\*\* Modified Pesaran-Yamagata (2008) cross-sectional dependence test (CD) statistics, with a constant and trend and lag of three.

### Cointegration tests

Next, to further reinforce the fact that co-integration analysis is the most appropriate approach, Kao's (Kao, 1999; Kao & Chiang, 2000), Pedroni's (Pedroni, 1999, 2004), and Fisher type panel cointegration tests (see, Maddala & Wu, 1999) are employed. It is worth noting that since Kao's test excludes deterministic trend and also allow for homogeneous coefficients across individual members of the panel, to have robust results, we also employ the widely used Pedroni panel cointegration test that allows for both deterministic terms of a constant and trend and heterogeneity of individual coefficients. The results of these tests are shown in Tables 4, 5 and 6.

Kao's test indicates the cointegration at the .01 level of significance as evidenced by the p-value of 0.000. Pedroni proposed two sets of tests; Panel and group mean panel tests (within and between tests). It is clear from the results that a majority of tests statistically determine that the variables in model (1) are cointegrated; four of the seven Pedroni's tests reject the null of no cointegration at the 1% level. Given the evidence that Pedroni's panel PP-statistics are more powerful than the rho-statistics, we can easily reject the null of no cointegration. The Johansen system -based cointegration technique (Table 6) also reaches the same conclusions. Thus, there is strong support for the hypothesis that the variables, IU, TEL, GDP and RURAL do form a long-run economic relationship during the period under consideration.

**Table 4: Kao's residual panel cointegration test.**

ADF test statistics	Observed p-value*
-5.848	0.000

\* Significant at the 1% level. No deterministic trend included. The tests are asymptotically normally distributed.

**Table 5: Pedroni panel co-integration tests.**

Test statistics	Observed test statistics*
Panel -statistics	6.91 (0.30)
Panel rho-statistic	2.51 (0.99)
Panel PP-statistics	4.33 (0.00)
Panel ADF-statistics	5.19 (0.00)
Group rho-statistics	4.68 (1.00)
Group PP-statistics	-8.52 (0.00)
Group ADF-statistics	-8.35 (0.00)

\* denotes the inclusion of the deterministic terms of a constant and a trend. Lags of 2 based on the SIC criterion. The observed p-values are in parentheses. The tests are asymptotically normally distributed.

**Table 6: Results of a Fisher type panel co-integration based on Johansen technique.**

Model	Fisher statistic from trace test	Fisher statistic from max-eigen test
None	862.5 (0.000)*	581.5(0.000)*
At most 1	426.3 (0.000)*	268.9 (0.000)*
At most 2	240.7 (0.000)*	
At most 3	175.0 (0.000)*	175.0 (0.000)*

\*Significant at probabilities are calculated using asymptotic Chi-square distribution. The observed p-values are in parentheses.

Having statistically determined that the dependent variable and explanatory variables in model (1) are cointegrated, the next step is to model the long-run economic relationship and estimate the associated panel coefficients, using a panel cointegrating estimator. The most widely used panel cointegrating technique with good statistical and power properties is the Pedroni fully-modified Ordinary Least Squares method [Panel FMOLS] (See, Pedroni, 1999, 2000, 2001, 2004). For robustness of results, we also employ the Dynamic Ordinary Least Squares technique (PANELDOLS) (See, Mark & Sul, 2003). The FMOLS estimator corrects for the presence of

endogeneity and through common time dummies, it controls for cross-sectional dependence. The results including the coefficient estimates using these two methods are presented in Table 7.

**Table 7: Results from Panel DOLS and Pedroni FMOLS Estimation.**

IU	TEL	INCOME	RURAL
Panel DOLS	0.941* (2.79)	1.329* (2.65)	-2.168* (-3.05)
R <sup>2</sup> = 0.87; Adj. R <sup>2</sup> = 0.64			
Panel FMOLS	1.256** (6.06)	4.137** (7.48)	-13.474** (-8.56)
R <sup>2</sup> = 0.73; Adj. R <sup>2</sup> = 0.71			

Observed t-values are in parentheses. \* and \*\* denote statistical significance at the 5% and 1% levels, respectively. Adj. R<sup>2</sup> refers to R<sup>2</sup> adjusted for degrees of freedom.

From Table 7, we observe that the estimated coefficients of the explanatory variables display the theoretically expected signs and are statistically significant at the .01 level. The observed explanatory power measures, coefficient of determination and the adjusted coefficient of determination, are considerably high indicating that roughly 71% of the variation in the dependent variable, IU, is explained by the explanatory variables, TEL, INCOME and RURAL.

At an individual country level, this model also provides a way to assess the significance of each of the four variables in determining the diffusion of the Internet. For most of the SSA countries, the individual coefficients of the explanatory variables were statistically significant at the 5% level and had the expected sign. The empirical findings reveal that in the group of sub-Saharan African countries included in the sample, during the period 1997-2013, as the number of telephones increases, the degree of diffusion of the internet increases. Furthermore, as the level of per capita real income (INCOME) increases, the internet diffusion improves. The coefficient of INCOME is very high. As INCOME variable is a proxy for economic growth, we can infer that with increased income levels, citizens of these countries can afford complements and infrastructure needed for the internet usage. Also, with increased income level the opportunity cost of time increases and therefore the Internet can be used as a labor –saving resource, which would eventually augment the level of labor productivity. The degree of ruralization (RURAL) has a negative impact on the internet diffusion. Conversely, as the degree of urbanization increases, diffusion of the internet increases. This finding makes economic sense as urbanization is a proxy variable for increased human capital (higher literacy) and enterprising nature of the people to seize economic and business opportunities. This finding is consistent with the observed high rate of the internet diffusion in countries such as Australia that is highly urbanized.

## SUMMARY AND CONCLUSIONS

The purpose of this study is to identify long term factors influencing the diffusion rates of the Internet in the sub-Saharan African (SSA) countries using the recently developed panel

cointegration analysis. Annual data series for the period 1997-2013 for 30 countries (cross-sections) are used. The analysis shows that the telephone density and the GDP have a significant positive effect on the Internet diffusion rate and the extent of ruralization (urbanization) has a negative (positive) influence. While these findings are, generally, in line with the conclusions reached in several previous studies (Oyelaran-Oyeyinka & Lal, 2005; Andres et al., 2010), the innovative aspects of this study are that it examines the most recent and longer data series from 30 SSA countries on diffusion rates of the internet (1997-2013) and employs the recently developed, panel cointegration analysis.

Telephone density serves as a proxy for access to the Internet vis-a-vis telecommunications infrastructure and, as expected, has a positive association with the Internet diffusion. While in SSA, like the rest of the world, the mobile phone is supplanting the landline-based phones, it is the quality of the telecom infrastructure that really matters in enhancing Internet usage.

The GDP is an economic indicator of financial resources and it plays a pivotal role in promoting the Internet diffusion. Not only the countries need capital to develop and improve its telecommunications infrastructure, and build public cyber cafes and libraries, but also, the citizens must have the means to pay for the associated technologies (PCs, tablets, mobile phones, etc.) and the Internet access costs.

Finally, urban populations, typically, have better access to the telecommunications and electric infrastructures as well as the public facilities (libraries, community centers, etc.) to gain access to the Internet. On the other hand, the rural citizens are at a disadvantage with respect to accessing the Internet and fully exploiting and reaping the benefits of the Internet. From a policy perspective, countries in SSA need to take steps and set policies in place to accelerate economic development. Consequently, improved GDP will accrue dual benefits: increasing investment in the country's digital infrastructure, and improving the financial well-being of its citizens. The saying "rising tide lifts all boats" perfectly summarizes the role that GDP plays in enhancing almost all determinants of the Internet diffusion. The policy makers in these countries by raising the rate of economic growth can positively bring about an increasing rate of diffusion of the internet.

## REFERENCES

- Andoh-Baidoo, F. K., Osatuyi, B., & Kunene, K. N. (2014). ICT capacity as the investment and use of ICT: Exploring its antecedents in Africa. *Information Technology for Development*, 20(1), 44-59.
- Andrés, L., Cuberes, D., Diouf, M., & Serebrisky, T. (2010). The diffusion of the internet: A cross-country analysis. *Telecommunications Policy*, 34 (5-6), 323-340.
- Anunobi, C. V., & Mbagwu, F. C. (2009). Determinants of Internet use in Imo State, Nigeria. *Educational Research and Reviews*, 436-442.
- Arnum, E., & Conti, S. (1998). Internet deployment worldwide: The new superhighway follows the old wires, rails, and roads. In Proceedings of the Annual meeting of the Internet Society. [http://www.isoc.org/inet98/proceedings/5c/5c\\_5.htm](http://www.isoc.org/inet98/proceedings/5c/5c_5.htm) (last accessed July 25, 2015).

- Balioune-Lutz, M. (2003). An analysis of the determinants and effects of ICT diffusion in developing countries. *Information Technology for Development*, 10, 151-169
- Baltagi, B. (2008). *Econometric analysis of panel data* (Vol. 1). John Wiley & Sons.
- Beilock, R., & Dimitrova, D.V. (2003). An exploratory model of inter-country Internet diffusion. *Telecommunications Policy*, 27, 237-252.
- Birba, O., & Diagne, A. (2012). Determinants of adoption of Internet in Africa: Case of 17 sub-Saharan countries. *Structural Change & Economic Dynamics*, 23(4), 463-472.
- Breitung, J., & Pesaran, M. H. (2008). *Unit roots and cointegration in panels*, 279-322, Springer Berlin Heidelberg.
- Brown, I., Collins, T., Malika, B., Morrison, D., Muganda, N., & Speight, H. (2007). Global diffusion of the Internet XI: Internet diffusion and its determinants in South Africa: The First Decade of Democracy (1994 - 2004) and Beyond. *Communications of the Association for Information Systems*, 19, 142-182.
- Brown, I., Letsididi, B. N., & Nazeer, M.N. (2009). Internet access in South African homes: A preliminary study on factors influencing consumer choice, *The Electronic Journal on Information Systems in Developing Countries*. 38(2), 1-13.
- Chinn, M. D., & Fairlie, R. W. (2007). The determinants of the global digital divide: A cross-country analysis of computer and internet penetration. *Oxford Economic Papers*, 59(1), 16-44.
- Dewan, S., Ganley, D., & Kraemer, K. L. (2010). Complementarities in the diffusion of personal computers and the Internet: Implications for the global digital divide. *Information Systems Research*, 21(4), 925-940.
- Dholakia, N., Dholakia, R. R., & Kshetri, N. (2003). *Internet Diffusion. The Internet Encyclopedia*, John Wiley & Sons, New York.
- Foster, W., Goodman, S. E., Osiakwan, E., & Bernstein, A. (2004). Global Diffusion of the Internet IV: The Internet in Ghana. *Communications of the Association for Information Systems*, 13(38), 653-680.
- Gallupe, R. B., & Tan, F. (1999). A research manifesto for global information management. *Journal of Global Information Management*, 7(3), 5-18.
- Hadri, K. (2000). Testing for heterogeneous panel data. *Econometrics Journal*, 3, 148-161.
- Hargittai, E. (1999). Weaving the western web: Explaining differences in internet connectivity among OECD countries. *Telecommunications Policy*, 23(10-11), 701-718.

- Huang, C., & Chen, H. (2010). Global digital divide: A dynamic analysis based on the Bass model. *Journal of Public Policy and Marketing*, 29(2), 248-264.
- International Telecommunication Union. (2015). [www.itu.int/itu-ict/statistics/pages/stat/default.aspx](http://www.itu.int/itu-ict/statistics/pages/stat/default.aspx)
- Jarvenpaa, S., & Leidner, D. (1998). An information company in Mexico: Extending the resource-based view of the firm to a developing country context. *Information Systems Research*, 9(4), 342-361.
- Kao, C. (1999). Spurious regression and residual-based tests for cointegration in panel data. *Journal of Econometrics*, 90(1), 1-44.
- Kao, C., & Chiang, M. H. (2000). On the estimation and inference of a cointegrated regression in panel data. *Journal of Econometrics*, 15, 179-222.
- Kiiski, S., & Pohjola (2002). M. Cross-country diffusion of the internet. *Information Economics and Policy*, 14(2), 297- 310.
- Koch, N. & Gaskins, L. (2014). The mediating role of voice and accountability in the relationship between Internet diffusion and government corruption in Latin America and sub-Saharan Africa. *Information Technology for Development*. 20(1), 23-43.
- Levin, A., Lin, C. F., & Chu, C. S. J. (2002). Unit root tests in panel data: asymptotic and finite-sample properties. *Journal of econometrics*, 108(1), 1-24.
- Li, R., & Shiu, A. (2012). Internet diffusion in China: A dynamic panel data analysis. *Telecommunications Policy*, 36(10), 872-887.
- Maddala, G. S., & Wu, S. (1999). A Comparative study of unit root tests with panel data and a new simple test. *Oxford Bulletin of Economics & Statistics*, 61, 631–652.
- Mark, N. C. & Sul, D.(2003). Cointegrating vector estimation by panel DOLS & long run money Demand. *Oxford Bulletin of Economics & Statistics*, 65, 655-680.
- McArthur, J. W., & Sachs, J. D. (2000). The growth of competitiveness index: Measuring technological advancement and the stages of development, in *The Global Competitiveness Report 2000*, Oxford University Press, New York.
- McCoy, S., Cha, H. S., & Durcikova, A. (2012). Modeling Internet diffusion in developing countries. *Australasian Journal of Information Systems*, 17(2), 5-23.
- Meijers, H. (2006). Diffusion of the Internet and low inflation in the information economy. *Information economics and Policy*, 18(1), 1-23.

- Migiro, S . O. (2006). Diffusion of ICTs and E-commerce adoption in manufacturing SMEs in Kenya. *South African Journal of Libraries & Information Science*, 72(1), 35-44.
- Montealegre, R. (1997). The interplay of information technology and the social milieu. *Information Technology and People*, 10(2), 106-131.
- Murthy, N. R. (2004). Internet diffusion: An econometric analysis. *Asian-African Journal of Economics and Econometrics*, 4(1), 45-54.
- Nath, R., & Murthy, N. R. (2003). An examination of the relationship between digital divide and economic freedom: An international perspective. *Journal of International Technology and Information Management*, 12(1), 15-23.
- Nath, R. & Murthy, N. R. (2004). A study of the relationship between Internet diffusion and culture. *Journal of International Technology & Information Management*, 13(2), 123-132.
- Nath, R., & Murthy, N. R. (2015). Perspectives on global Internet diffusion. *Encyclopedia of Information Science and Technology*, 3<sup>rd</sup> ed., 3777-3784.
- Nelson, K., & Clark, T. (1994). Cross-cultural issues in information systems research: A research program. *Journal of Global Information Management*, 2(4), 19-29.
- Noce, A. A., & McKeown, L. (2008). A new benchmark for Internet use: A logistic modeling of factors influencing Internet use in Canada, *Government Information Quarterly*, 25, 462-476.
- Ochara, N. M., Van Belle, J. P., & Brown, I. (2008). Global diffusion of the Internet XIII: Internet diffusion in Kenya and its determinants: A longitudinal analysis. *Communications of the Association for Information Systems*, 23, 124-150.
- Ojuloge, B., & Awoleye, M. O. (2012). Analysis of Internet diffusion and adoption in selected African countries. *International Journal of Internet of Things*. 1(3), 5-11.
- Oyelaran-Oyeyinka, B., & Adeya, C.N. (2002). Determinants of academic use of the Internet in Nigerian universities. *UNU/INTECH Discussion Paper*, DP-2002-5.
- Oyelaran –Oyeyinka, B., & Lal, K. (2005). Internet diffusion in sub-Saharan Africa: A cross-country analysis. *Telecommunications Policy*, 29(7), 507-527.
- Pedroni, P. (1999). *Critical values for cointegration tests in heterogeneous panels with multiple regressors*. *Oxford Bulletin of Economics & statistics*, 61(S1), 653-670.
- Pedroni, P. (2001). Fully modified OLS for heterogeneous cointegrated panels. In *Nonstationary Panels, Panel Cointegration, and Dynamic Panels* by Baltagi, B. H., Fomby, T. B. & Hill, R. C., 93–130.

- Pedroni, P. (2004). Panel cointegration: Asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis. *Econometric Theory*, 20(3), 597-625.
- Perkins, R., & Neumayer, E. (2011). Is the Internet really new after all? The determinants of telecommunications diffusion in historical perspective. *The professional Geographer*, 63(1), 55-72.
- Perron, P. (1989). The great crash, the oil price shock, and the unit root hypothesis. *Econometrica*, 57(6), 1361-1401.
- Pesaran, M. H. (2007). A simple panel unit root test in the presence of cross-section dependence. *Journal of Applied Econometrics*, 22(2), 265-312.
- Pesaran, H. (2004). *General diagnostic tests for cross sectional dependence in panels*. CESifo Group Munich, CESifo Working Paper Series. 1229.
- Pesaran, M. H., Ullah, A., & Yamagata T. (2008). A bias adjusted LM test of error cross section dependence. *The Econometrics Journal*, 11, 105–127.
- Straub, D. (1994). The effect of culture on IT diffusion: E-mail and FAX in Japan and the U.S. *Information Systems Research*, 5(1), 23-47.
- Thatcher, J. B., Srite, M., Stepina, L. P., & Liu, Y. (2003). Culture overload and personal innovativeness with information technology: Extending the nomological net. *Journal of Computer Information Systems*, 44(1), 74-81.
- Watson, R. T., Ho, T. H., & Raman, K. S. (1994). Culture: A fourth dimension of group support systems. *Communications of the ACM*, 37(10), 44-55.
- World Bank (2014). *World development report, infrastructure for development*. Washington, DC.
- Wunnava, P. V., & Leiter, D. B. (2009). Determinants of intercountry Internet diffusion rates, *American Journal of Economics and Sociology*, 68(2), 413-426.
- Yaveroglu, I. S., & Donthu, N. (2002). Cultural influences on the diffusion of new products. *Journal of International Consumer Marketing*, 14(4), 49-63.
- Yeniyurt, S., & Townsend, J. D. (2003). Does culture explain acceptance of new products in a country? *International Marketing Review*, 20(4), 377-396.



## **ENDNOTES**

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Mina Soleimani served as a Graduate Research Assistant (GRA) while pursuing her Master's degree in Business Intelligence & Analytics during the completion of this research.