# Will the Internet Help Africa Grow? A Dynamic Panel Analysis

Stephen E Armah

Ashesi University, Ghana

armah.stephen@gmail.com

**ABSTRACT**

*Using an unbalanced panel we employ Barro (1997)'s empirical model of growth to estimate the correlation between the level of the Internet Penetration Variable (IPV) and the growth rate of GDP per capita growth (GDPPG) for 47 African countries over 9 years. We find that growth is correlated with the level of IPV at 95% confidence level using fixed effects and system GMM panel data techniques. Our results suggest that IT investment in Africa will pay off in the long run. However, since our panel is limited by the short time the internet has operated in Africa, our results may be premature because of the possibility of structural shifts with time.*

**Keywords:** Foreign Aid, Political Stability, Economic Growth, and Sub-Saharan Africa

## INTRODUCTION

Once promising a contribution to growth on the scale of the impact of the steam engine (Lichtenberg and Lehr, 1998), the growth promise of the Internet has diminished. Even in the USA which has the highest concentration of Internet users and where e-commerce did best, the economy has slowed down (Gordon, 2000). What contribution if any can internet-access, given that its performance in OECD countries has been mixed, make to a relatively poorer region such as Africa? This question is pertinent given efforts by businesses and government institutions alike in Africa to go online in an apparent effort to stimulate performance and growth.

Economic growth is a complicated process so many factors have to be taken into account to explain it. The basic models of economic growth such as the neoclassical model predict that technological innovations like the internet should be growth enhancing (Kaldor, 1957; Romer, 1997). These models predict that poorer regions grow faster because of convergence. Convergence is the phenomenon where poorer countries grow faster than richer ones due to bigger differentials of current output from their potential outputs (Solow, 1956). Econometric models such as Barro (1997) that have strived to validate the neoclassical models have been successful in OECD countries because these countries have met most of the other requirements of the theoretical model such as trained labor, good governance, low population etc. However, even in these OECD countries sometimes the convergence theory cannot be validated empirically (Barro, 1997). Some economists like Galton believe convergence is a fallacy (Barro, 1997). Arguably Africa like other poor regions might not meet the requirements of the theoretical neoclassical model (Collier and Gunning). The introduction of an innovative technology such as the Internet might therefore not unambiguously promote growth (Kenny, 2002).

In this paper we quantify the statistical relationship between GDP per Capita growth and an Internet Penetration Variable (IPV) using panel data methods.[1] To achieve this, the IPV variable was included as n explanatory variable in Barro's 1997 empirical growth model along with a number of dummy variables.

## LITERATURE REVIEW

There is contrasting evidence in the literature concerning the Internet's contribution to growth Gordon (2000) argues that the Internet's contribution to growth was small even in OECD countries because total investment in e-commerce and the Internet relative to total gross investment was small (Gordon, 2000; Diner and Sichel, 2000). By contrast, Wienhold and Freund (2002) find that the Internet positively contributes to growth in trade and services. Baring technology transfer costs, the Internet can help remove some of the bottlenecks to growth in Africa through its impact on the banking and financial industry, manufacturing, health etc (Kenny, 2002). Specifically the Internet can help bridge the technology gap typically associated with poor regions (Fargenberg, 1994).

What are the main reasons, theoretical or empirical, in the literature that suggests that that the Internet can promote growth in general and Africa in particular and what are the counterarguments? Not surprisingly, the literature on the growth potential of the IT industry in the recent past has experienced reversals in opinions. These changes mirror the performance of

[1] The total number of Internet hosts in a country. See also Freund and Weinhold, 2002.

the World economy in the recent past. The Internet and e-commerce were originally hailed as a great innovation (Lerh and Lichtenberg, 1998). For example, Lau and Tukutsu (1992) find evidence for positive contribution to growth on the macro level. Siegel and Griliches (1992) also find support at the micro level for the growth-promoting hypothesis of the Internet for the US. By the end of the 1990s, however, opinion had swung in the opposite direction (Gordon (2000). Gordon argues that the productivity gains from the Internet do not measure up to past similar innovations such as the steam engine. In fact, according to him, the positive externalities due to the IT industry and the Internet are very limited in scope given the scale of the investment in IT technology, the Internet and e-commerce.

The pro-Internet technology economists argue that the internet will spur growth by reducing transactions costs throughout the economy. Specifically, assuming information transfer is slow cost of information tends to increase, thus increasing transaction costs (Teece, 1977). The Internet could facilitate the speed of execution of transactions in Africa just like it did in the West reducing transaction costs and promoting growth (Kenny, 2002). Lehr and Lichtenberg (1998) find strong correlation between investment in IT and productivity in the US public sector. This might be good news for Africa given the dominance of central governments in African economies. IT diffusion might be expected to improve business practices, generate spillover effects, and raise productivity throughout the economy. The potential for supporting e-commerce in Africa is therefore very real. There still exist places in Africa that are not easily accessible by vehicular traffic although phone services exist (Bloom, Sachs, Collier and Udry, 1998). Access to the Internet through phone-modems at a few key large shops, farms and distribution centers would reduce the need for physical movement of people to gather information about sources of supply, identify demand centers and to conduct transactions. This will lead to less dependence on road transportation by passengers, reducing traffic since only goods need move so frequently to complete a deal. This will also help eliminate some of the deadweight losses due to excess demand not being met by firms. Processing of orders can be executed speedily so that more orders can be completed and transaction costs minimized thus promoting growth.

The Internet could also be an effective tool in education both in the African classroom and as a medium for effective distance learning from places as far as the Western World (Kenny, 2002). Evidence from OECD countries on distance learning is encouraging (Kenny, 2002). Healthcare in Africa could also benefit from increased access to the Internet (Kenny, 2002). Malaria, Aids and Buruli ulcer prevention-techniques that are well known in OECD countries and some African countries but not available to a majority of Africans could be made available online to all. Improved healthcare would stimulate growth and improve life expectancy.

With ever improving digital audio, text and document transfer being available online, proliferation of standard operating procedures and best marketing practices in Africa are bound to improve, helping Africa grow. The Internet has been documented to improve functioning of markets and firms in the west and should do the same for Africa (Kenny, 2002). The value of external networks that are associated with moving business and other transactions online are well documented (Kenny, 2002) and is growth promoting.

On the negative side, Africa is clearly poor, underdeveloped, cannot attract investment and perennially suffers from brain drain (O'Connell and Ndulu, 2002 also Easterly and Levine, 1997). This might limit the potential gains from the Internet ordinarily available to a well-educated populace in a richer region. The urban centers in Africa are most likely to be the only commercially viable centers that can effectively make use of the technology (Collier and Gunning, 1999). This will reduce the impact of the potentially useful contribution the Internet can make to agriculture and growth. Given that most African economies are still primary export driven this effect might severely retard growth (O'Connell and Ndulu, 1999).

According to the neoclassical model, the Internet could help Africa grow conditional on the region having the necessary stockpiles of knowledge trained labor, and capital. However, Africa is an impoverished region that lacks these necessary ingredients so the Internet would not necessarily help the continent grow. Given the ambiguity inherent in the model prediction the actual growth response of the internet in Africa remains an empirical question.

## THE EMPIRICAL MODEL AND METHODS

The model used builds on Barro's (1997) econometric model of economic growth, which is derived from the neoclassical model (Barrow, 1997). Barrow lists the following factors to account for the growth in OECD countries' GDP per capita: High levels of schooling (ED), good health (measured by life expectancy LE), low fertility rates (FER), low government consumption expenditures (GC), the rule of law (measured by a Rule of Law Index (RL), and favorable terms of trade (TOT). In the spirit of Barrow's model, we execute the model in a panel setting. We include all but 6 African countries (out of a total of 54 possible countries) in the panel. To Barro's original model, we add the growth rate of IPV (GRIPV) and dummies for Sub-Saharan Africa (SSA), Oil Exporting Countries (OIL), economies significantly affected by war in the last 20 years (WAR), time and the interaction of IPV with time.

Panel data is used because cross-sectional data often misses unobserved effects or time-constant country-specific effects (Anderson and Hsiao, 1987). Ignoring the unobserved effect if it exists will lead to inconsistent estimates and wrong inferences. The unobserved effect captures such subtle differences as regional location. The unobserved effect is included to capture aggregate shocks, which may appear in any year. Dummies for time account for inadvertent policy changes that might have occurred during the time period. We discuss below the sign of the theoretical or expected relationship between the explanatory variables and growth.

The contribution of education to growth in our model is adequately proxied by the total number of males that have received secondary school education or higher. Paradoxically Barro finds that the education rate of women does not contribute to growth. A higher education rate in a country promotes growth by augmenting labor as explained by the neoclassical model. By the convergence argument we expect that the higher the initial GDP of a country the narrower the gap between that initial GDP and potential GDP. A country would therefore be expected to grow slowly if it has a high initial GDP. High fertility rates increase a country's population and reduce the ratio of labor to capital therefore if there were not a corresponding increase in capital then by the neoclassical model prediction growth would slow down. The excess labor would not get the necessary capital it needs to add to output. That is, part of any new capital is used by the additional labor instead of raising capital per worker. Even though the neoclassical model does not explicitly make a prediction about this variable, Barro finds that it is necessary to fully account for the growth experience of OECD countries. Intuitively, countries that have high life expectancies have healthy happy citizens that are more productive. Life expectancy is therefore expected to positively contribute to growth. The terms of trade variable is defined as the ratio of export prices to import prices. Increasing terms of trade growth rate often coincide with increasing GDP per capita growth. Export price of goods rising for a country translates to increase in employment and the accumulation of capital, which promotes growth. Rising inflation in a country is often associated with slowing growth. This variable is expected to be negatively correlated with growth rate of GDP per capita. Government consumption ratio is defined as the ratio of government expenditure to total output and serves as an indicator of the relative size of the government in the economy. A large government consumption ratio often indicates the absence or malfunctioning of free markets. This retards the growth process. The variable is therefore expected to cause growth to decrease.

The rule of law variable illustrates the extent to which property rights are enforced in a country. There are several formulae in the literature to calculate this variable. Recall that by Coase's theorem if property rights are not properly defined nor enforced most transactions would not take place. This would stifle the production process and retard growth. The variable therefore assigns higher positive magnitudes to countries where well-defined property rights are strictly enforced. The Democracy variable assigns a *higher* positive weight to countries with properly functioning democratic governments. There is strong empirical evidence in the literature that democratic countries often grow faster than non-democratic ones. The War dummy assumes a value of one if the country has been destabilized by war in the last 20 years and takes a value of 0 otherwise. We expect this variable to be negatively correlated with GDP per capita growth. Countries like Rwanda, Liberia and Sierra Leone will typically take a value of 1 while relatively war free countries like Ghana will take a value of 0.

*Panel Data Models*

Different panel data models; Pooled Least Squares (PLS), Random Effects (RE) and Fixed Effects (FE) were used to first verify convergence for Africa. The correlation between GDP Per Capita growth rate (GDPG) and IPV for African countries and other RHS variables was also investigated. However, because GDPG and IPV may be jointly determined or endogenous, IV Panel data techniques and System GMM panel data techniques were used in estimation. Two main types of regressions were performed. The first type involved the regressions GDPG on the levels of IPV and the rest of the RHS variables. The second part involved regressions of (GDPG) on the growth rates of IPV (GRIPV). The assumptions underlying the models used were also tested to confirm applicability. For example Breusch Pagan tests were executed to choose between RE and PLS and Hausman specification tests were used to Choose between FE and RE. To test for validity of instruments in the IV regressions, Sargan tests of overriding restrictions were used and Hansen tests were used in the system GMM formulation where applicable. The methods section that follows the model description expands on this.

**Pooled LS (PLS)**

$$Y_{it} = \mathbf{B}_s' \sum_{s=1}^{k} Xit,s + \upsilon_{it} + \boldsymbol{\gamma}$$

Where $\gamma$ is an over-all constant, $\upsilon_{it}$ is assumed to be an *iid* random error term, t is the time variable and i indexes SSA countries PLS ignores country-specific effects.

**Random Effects (RE)**

$$Y_{it} = \mathbf{B}_s' \sum_{s=1}^{k} Xit,s + \varepsilon_i + \upsilon_{it} + \boldsymbol{\gamma}$$

Where $\varepsilon_i$ is the random disturbance characterizing the i-th country. All variables retain original definitions. RE does not ignore country-specific-effects but assumes that the correlation between the unobserved country-specific-effect and the right-hand side matrix of explanatory variables is zero. All other variables retain earlier definitions.

*Least Square Dummy Variables (LSDV)*

LSDV ignores neither the country-specific nor does it assume that it is unobservable. LSDV tries to control for the country specific effect by using dummy variables. However, LSDV does assume $E(X_{it,s}, u_{it}) = 0$. Suppose $E(X_{it,s}, u_{it}) = 0$ so that there is no feedback from past values of the dependent variable to affect the present level of the dependent variable then LSDV is unbiased and efficient. However, *ex ante* it is not clear whether a high level of GDP today is not affected by yesterday's GDP. In fact, OECD GDP is known to be persistent (Romer, 1999) so we might expect African countries' GDP to be persistent as well.

Intuitively, we could argue the finding of a high GDP is usually associated with a high level of existing technology because there is enough money to invest into IT. Since Internet access can be defined as a form of technology the levels of the two variables may be correlated. High level of GDP represents a financial ability to purchase Internet hosts thus increases Internet Penetration. By contrast, increased access to the Internet can be argued to increase business productivity, improve education through long distance instruction and reduce transaction costs by shortening time of information delivery thus increasing productivity. The feedback processes involved are self-evident. We should therefore include the lagged dependent variable on the right hand side of the growth model. However if we include the lagged dependent variable, LSDV is biased and inconsistent (Green, 2000). We must use instrumental variables or in this setting, dynamic panel methods. We cannot use LSDV because then we are faced with the problem of estimating the unobserved effect when the correlation between the matrix of explanatory variables and the error matrix is non-zero. We cannot use first differencing in this case either. First differencing gets rid of the unobserved effect but creates and inadvertent and unwanted correlation between the first differenced error and the lagged dependent variable (Yasar and Nelson, 2004).The Dynamic panel data technique solves the problem by initially eliminating unobserved effects using first differencing of the levels of the variables. Next it uses the lagged values of the regressors as instruments to reduce bias and inconsistency due to simultaneity bias.

**Dynamic Panel Model**

$$Y_{it} = Y_{it-1} + \mathbf{B}_s' \sum_{s=1}^{k} Xit,s + \alpha_t + \alpha_i + \upsilon_{it} + \boldsymbol{\gamma}$$

What kinds of instruments are appropriate? Recall that the first differencing techniques used to eliminate the country-specific characteristic create and inadvertent correlation between the first differenced error and the lagged dependent variable. We can however use $Y_{it-2}$, $Y_{it-3}$ … $Y_{it-j}$ & j= 2, 3,…as well as the lagged differences of the dependent variables d. $Y_{it-2}$, d. $Y_{it-2}$… and independent variables d. $X_{it-j,\, s}$ where j= 2, 3… and s = 1, 2, 3 as instruments. However to avoid the bias and inconsistency problem we cannot use d. $Y_{it-1}$ as an instrument. A combination of the levels and lagged levels can be used as instruments in a GMM system framework upon the satisfaction of the necessary moment conditions (Arellano and Bover, 1997 and also Blundell and Bond, 1997.) The system GMM is preferable because the differenced dynamic panel model often suffers from the weak instrument problem (also not all instruments are being used). The weak instrument problem can lead to finite sample bias and inefficiency even in large samples

The System GMM estimates the differenced dynamic panel model and in addition, the level equations are simultaneously estimated using the values of the lagged differences as instruments. The relevant moment conditions have to be satisfied for all possible moments to be used. By mitigating the weak instrument problem, the System GMM produces a consistent and efficient estimator.

## METHODS

In the first part of this exercise we try to verify convergence for Africa using Barro's model. We begin by using PLS and the full set of time dummies. We attempt to replicate Barro's results using African data. Table 1 contains the results from this regression. Growth rates are calculated using the log difference estimator. STATA dropped a few observations that had incomplete units along either the time or country dimension. We next execute a Random (RE) Effects model and then use the Breusch Pagan procedure to test for the appropriateness of the PLS model. Tables 2 contain results from this part of the exercise. Next we run a fixed effects model and carry out a Hausman specification test in order to choose between Random and Fixed effects. Table 3 contains the fixed effects model while Table 4 contains the results from the Hausman specification tests. Recall that PLS would ignore the country-specific effect, however, pooled OLS is valid if the explanatory variables matrix can account for all the country-specific heterogeneity (Hsiao, 1981). One way to account for country specific heterogeneity is to implement RE model if the heterogeneity is observed. If the country specific differences are not observable, however, RE is invalid. To account for unobservable heterogeneity, we also use the LSDV or fixed effect model. As has been argued previously, it is possible that African countries'

GDP is persistent just like OECD country GDP. We therefore also use the Anderson and Hsiao (1981) dynamic panel data method.

In part 2, we first add the growth rate of the Internet penetration variable (GRIPV) to the right hand side of Baro's original model and repeat the regressions in part 1. Then we add the level of IPV instead of the growth rate of IPV to the RHS of the model and repeat the part 1 regressions with IPV instead of GRIPV on the RHS of Barro's model. That is we again run PLS on the full set of time dummies. We then execute a random effects model and then test for the appropriateness of the PLS model using the Breusch-Pagan test. Next we run a fixed effects model and carry out a Hausman specification test in order to choose between Random and Fixed effects. We also include the square of the Internet penetration variable to the RHS of both the equation in levels and the equations in growth rates and run fixed effects RE and pooled LS.

In the 3rd part of the exercise, we try to correct for possible endogeneity in the data using dynamic panel methods. We assume initially that the lagged dependent variable (single lag) is correlated with the dependent variable and is endogenous in the system. Of course OLS results will then be biased and inconsistent so we must use IV techniques. Another possibility is that the dependent variable is correlated with the current realizations of the unobserved country-specific effects (Marschak and Andrews, 1944). Suppose the country specific effect $\alpha$ is correlated with the lagged dependent variable so corr ($Y_{it-1}$, $\alpha$) is not zero or suppose $\alpha$ is correlated with one or all of the lagged independent variables so corr ($X_{it-1}$, $\alpha_i$) is not zero then RE is not appropriate (Marschak and Andrews, 1944). A remedy is to implement the LSDV estimator. This estimator eliminates $\alpha$ but creates a new correlation between $Y_{it-1}$ and the transformed error term, which is a function of the dependent variable. When the panel is short in the time dimension the problem is compounded. A solution involving 2SLS or IV techniques is proposed by Anderson and Hsiao (1981). We use the twice-lagged growth rate of the Internet penetration variable together with the other RHS variables as instruments and run an instrumental variable regression following Anderson and Hsiao (1981). In order to ensure that we are not inadvertently imposing invalid restrictions on the model, we interact IPV and GRIPV respectively with the time dummies and repeat the IV regression using these interaction variables and the full set of time dummies In all these regressions described, one of the time dummies (D94), the 1994 dummy is dropped to avoid the dummy variable trap. Lastly we implement the system GMM estimator (Arrelano and Bover, 1997 and Blundell and Bond, 1997) in order to use all the instruments available and to increase the efficiency of the instrumental variable difference panel data estimator. We repeat the GMM estimation but this time we assume use the square of IPV and GRIPV respectively.

## DESCRIPTION OF THE DATA

Time series data over 9 years (1994-2002) for each of the 47 African countries in the initial sample was obtained from the World Bank's development indicators website. The choice of the initial 47 African countries was made purely on the grounds of data availability. The period 1994 –2002 was also selected by the same criterion. The Internet penetration variable started to assume non-zero values for most African countries from the year 1994. Data was obtained for all the 13 main variables (defined and discussed in the model above) isolated by Barro to contribute to growth. To circumvent the isolated instances of missing data for a particular year, the average of observations before and succeeding that year was used. To avoid missing any correlation present between IPV and GDPG (level and growth rate) different years were dropped and each time the regression was run again. No significant change in the results was noticeable. The Results section that follows contains the regression outputs from the various regression exercises described above. A summary table that compares the results and makes the point that GDPG I correlated with IPV in the system GMM framework is also included in the results section.

Part 1: Convergence

**Table 1**: **Pooled LS** Convergence verification. $\mathbf{R^2} = 0.3684$ **Adj** $\mathbf{R^2} = 0.2903$ D94 dropped (To prevent co linearity)

| Y= GDP per capita growth | Xi =independent Vars | Sign conformity with theory |
|---|---|---|
| *GRTOT | 0.040000<br>(0.1254526) | YES |
| *LogIGDP | -1.747904<br>(0.5592048) | YES |
| *GRINF | -0.7664275<br>(0.5034507) | YES |
| LFER | -3.234737<br>(1.74126) | YES |
| *GCR | -0.1751933<br>(0.020177) | YES |
| LLE | (dropped) | |
| DEM | -0.005027<br>(0.11428) | NO |
| DEMSQ | -0.0008828<br>(0.001824) | |
| SSA | 0.1238415<br>(0.23672) | NO |
| OIL | 1.337014<br>(1.834871) | |
| EDLogIGDP | -0.0261300<br>(0.0146800) | |
| ED | 0.06340000<br>(0.0002507) | YES |
| D95 | | |
| D96 | | |
| D97 | | |
| D98 | | |
| D99 | | |
| D00 | | |
| D01 | | |
| D02 | | |

**Table 2**: RE Convergence Verification. **$R^2$ overall** = 0.3600 **$R^2$ Within** = 0.6864 **$R^2$ Between**

| **Y = GDP per capita growth** | **Xi = Independent Variables** | **conformity with theory** |
|---|---|---|
| GRTOT | 0.0256590<br>(0.1146164) | YES |
| *LogIGDP | -2.0.067754<br>(0.668206) | YES |
| *GRINF | -0.9948137<br>(0.483807) | YES |
| LFER | -2.967791<br>(2.101215) | YES |
| *GCR | -0.1943251<br>(0.047731) | YES |
| LLE | | |
| DEM | -0.0290803<br>(0.1714826) | NO |
| DEMSQ | -0.0005557<br>(0.0023571) | |
| SSA | 0.0390364<br>(3344524) | NO |
| OIL | 1.337014<br>(1.834871) | |
| EDLogIGDP | -0.0405980<br>(0.0014311) | |
| ED | 0.06340000<br>(0.0002507) | YES |
| D95 | | |
| D96 | | |
| D97 | | |
| D98 | | |
| D99 | | |
| D00 | | |
| D01 | | |
| D02 | | |
| *CONS | 74.13672<br>(23.17322) | |

**Table 3**: **FE** Convergence Verification. **$R^2$ overall** = 0.1022 **$R^2$ Within** = 0.2791 **$R^2$ Between = 0.2472**

| Y= GDP per capita growth | Xi =independent Vars | Sign conformity with theory |
|---|---|---|
| GRTOT | -0.0327608 (0.1172443) | YES |
| *LogIGDP | -11.91407 (5.988186) | YES |
| *GRINF | -0.63599953 (0.653193) | YES |
| LFER | -0.847096 (4.553501) | YES |
| GCR | -0.0430551 (0.020177) | YES |
| LLE | 4.741584 (5.5097700) | |
| DEM | -0.0546851 (0.4581432) | NO |
| DEMSQ | -0.0025953 | |
| SSA | 0.1238415 (0.23672) | NO |
| OIL | Dropped | |
| EDLogIGDP | -0.00333491 (0.0050137) | |
| ED | 0.06340000 (0.0002507) | YES |
| D95 | | |
| D96 | | |
| D97 | | |
| D98 | | |
| D99 | | |
| D00 | | |
| D01 | | |
| D02 | | |
| *CONS | 72.84654 (19.5288) | |

Table 4: Hausman Specification test to distinguish between Fixed and Random Effects

**Coefficients**

| Variables | (b) fixed | (B) random | (b-B) Difference | sqrt((diag(v_b-V-B) |
|---|---|---|---|---|
| GRTOT | -0.0327608 | 0.025659 | -0.0584198 | 0.024684 |
| *LogIGDP | -11.91407 | -2.067754 | -9.846317 | 5.950788 |
| GRINF | -0.6359953 | -0.7948137 | -1.0901858 | 4.562962 |
| LFER | -0.2847096 | -2.967791 | 2.683081 | 4.039711 |
| LLE | 4.7415884 | -0.5327473 | 5.274331 | 4.0363 |
| DEM | | | | |
| DEMSQ | | | | |
| SSA | | | | |
| OIL | | | | |
| EDLogIGDP | | | | |
| ED | | | | |
| **D95** | | | | |
| **D96** | | | | |
| **D97** | | | | |
| **D98** | | | | |
| **D99** | | | | |
| **D00** | | | | |
| **D01** | | | | |
| **D02** | | | | |
| **CONSTANT** | | | | |
| | | | | |

**However we define b= inconsistent under Ho and Ha; obtained from xtreg**

**B = inconsistemt under Ha, efficient under Ho; from xtreg**

**Test: Ho: difference in coefficients not systematic**

**Chi2 (15) = (b-B)' [(b-B)'[(V-b-V_B)^(-1)] (b-B)'**
**= 8.93**
**Prob >chi2 = 0.8810**

**V-b-V_B is not positive definite so the results are not valid**

## DISCUSSION OF THE RESULTS

As Tables 1, 2 and 3 illustrate, we can verify convergence for the African countries in the sample. Table 1 contains the pooled LS square results. The Adjusted R-square value of 0.3 shows 30% of the variation of GDPC can be explained by the explanatory variables. It is also evident from the table that most of the theoretical predictions of the neoclassical model are borne out. The independent variables have the expected signs though most of them are significant at lower confidence levels than 95%. The Pooled LS results are not very different from either the fixed effects or the random effects model though the Breusch Pagan tests favors the RE over Pooled LS. Also the Hausman specification (Table 4) test to choose between RE and FE yields a non-positive definite matrix and is ignored. Most importantly the log of initial GDP is significant and negative substantiating the convergence argument; countries that start out with a higher level of GDP grow slower. Growth rate of the terms of trade is positive and significant at 95% confidence as is the level of education. As these variables increase GDPG for a country in Africa is expected to rise. The coefficient on the growth rate of inflation is negative, a welcome result as predicted in the theory section. The government consumption ratio is also negative in accordance with the theoretical neoclassical model prediction.

On the contrary the log of the fertility rate is positive and significant. Even though it goes against the model prediction the peculiar capital deficient and labor-intensive nature of African economies might explain why increase in fertility rate actually promotes instead of retarding growth. The very high child mortality rates might be the reason why substance farming may have to depend on child labor in Africa so that capital labor ratios can hold constant in the steady state. The democracy and democracy square variables however give us the unexpected results. Both variables are negative and significant. Given the very complex mix of traditional, authoritarian, democratic and socialist regimes in Africa, it might actually be the case that democracies are prone to Coup d'états and actually contribute nothing but un-recouped costs to growth. Even though the Anderson and Hsiao dynamic panel results are somewhat disappointing in verifying convergence because we do not get the expected theoretical signs of the variables, we ignore the result in favor of the fixed effect result. As is clear from the results, convergence is verified for Africa using Barro's neoclassical model of growth. However when the model is used to investigate whether there is a statistical dependence between African growth rate per capita and the growth rate of Internet penetration, the result is disappointing at first but ultimately gratifying. After correcting for possible endogeneity in the data, GRIPV is still not significant at 95% using both FE and RE and using the square of GRIPV. However, on using IPV (the level of Internet penetration) instead of GRIPV FE yields significant correlation between GDPG and IPV. A unit increase in the level of IPV leads to an increase of 0.000287 in the rate of growth of GDP per capita (Chart 2). The correlation is also significant at 95% confidence level although the low $R^2$ value indicates that only about 30% of the variation n the dependent variable is explained by the system of RHS variables. The implication for an increase in the level of GDP per capita as the level of IPV increases is self-evident. Further, by specifying a dynamic panel system of Arrellano and Bover and Blundell and Bond GMM model we get significance between GDPG and IPV at 5% significance level or 95% confidence level, a welcome result.

**Chart 2:** Coefficients and Standard Errors of the Internet's Growth Response Using Different Estimation Techniques Compared

| Values in tables are coefficients On either the level of IPV or the Growth rate (GRIPV) | WITH IPV ON RHS | WITH GRIPV ON RHS | WITH IPVSQ ON RHS | WITH GRIPVSQ ON THE RHS |
|---|---|---|---|---|
| POOLED LS | -0.00000048 (0.000006192) | 0.0108183 (0.007803) | -0.000000000012 (0.000000000017) | |
| RE | -0.000000814 (0.00000189) | 0.0108183 (0.007803) | 0.0000000000008 (0.0000000000185) | |
| BREUSCH PAGAN TEST | Choose RE | Choose RE | Choose RE | Choose RE |
| FE | 0.00028700* (0.00001200) | 0.009354200 (0.01277001) | 0.00000000649* | -0.007320000 (0.075020000) |
| HAUSMAN | Inconclusive | Inconclusive | Inconclusive | LS is efficient And consistent |
| ANDERSON & HSIAO | 0.2386906000 (0.320842100) | 0.02531130 (0.0189882) | 0.276472500 (0.29339310) | 0.005129600 (0.00926370) |
| ARELLANO & BOND SYSTEM GMM- PREDETERMINED | 0.000046300* (0.0000179000) | **-0.0136045** (0.01258160) | 0.00000002189* (0.000000000699) | -0.0027222 (0.0030880) |

Chart 2 compares and summarizes the estimators obtained from using the different dynamic panel methods. As is clear from the Chart significance is obtained at 5% for IPV on the right hand side of Barro's model when Arrelano and Bond system GMM dynamic panel is used with the RHS variables defined as predetermined. The results for IPV on the RHS are also significant when FE is used. The potential policy implications for these results is pertinent because the exercise makes the point that investment by African companies or the government into internet hosts will eventually spur growth. Even though the magnitude of the response of IPV to GDPG using the system GMM is small is (a unit increase in IPV will lead to a GDP growth rate of 0.000046300) it is positive meaning investing in IPV will increase GDP per Capita growth rate (and by inference the level of GDP). The Hansen test statistic is 0.9, greater than 0.1 as it should be but paradoxically extremely high. We know from theory that the first order serial correlation AR (1) can be significant (doesn't have to be) but AR (2) shouldn't be significant. The P-value for AR (2) should be greater than .10. We find that the p-value for AR (2) is greater than 0.1 so AR (2) is indeed insignificant. So the second order correlation test result is valid.

The result of this exercise, that African GDP per capita will eventually increase as the Internet penetration in Africa increases, cannot be overemphasized. With abundant cheap labor present in Africa and a recent inclination of Multinational companies to outsource manufacturing procedures, it seems obvious that investment in Internet resources will eventually pay off in Africa. Despite the very low existing level of technological knowledge, low level of education, lack of capital and the inability of Africa to attract capita due to high risk our results prove the long run output response for IT investment in Africa is worthwhile. However as we initially argued our results are only primary and structural changes with time are possible for the effect of GDPG on IPV.

**REFERENCES**

1. Martin, B., Gordon, R., Romer, D., & Nordhause, W (1998). “The Productivity Slowdown, Measurement Issues, and the Explosion of Computer Power” *Brookings Papers on Economic Activity*. 2: 347-431

2. Barro, R (1997). “Determinants of Economic Growth: A Cross- Country Empirical Study. *The MIT Press* Cambridge, Massachusetts London, England

3. Bloom, S., P. Collier & C. Udry, (1998) “Geography, Demography, and Economic Growth in Africa”. *Brookings Papers on Economic Activity* 2: 207-295.

4. Bond, S (2002) Dynamic panel Data Models and Practice. *Center for Microdata Methods.* Cemmap working paper CWP09/02

5. Brander, J (1992). “Comparative Economic Growth: Evidence and Interpretation.” *The\ Canadian Journal of Economics*, 25 (4): 792-818

6. Collier, P & W. Gunning (1999). “Explaining African Economic Performance”. *Journal of Economic Literature*, (37):1

7. Easterly, P & R. Levine (1997). “Africa's Growth Tragedy: Policies and Ethnic Divisions.” *The Quarterly Journal of Economics* 112 (4): 1203-1250.

8. Fagerberg, J (1994) “Technology and International Differences in Growth Rates” *Journal of Economic Literature*, 32 (3): 1147-

9. Freund, C & D. Wienhold (2002). The Internet and International Trade in Services. *American Economic Review*. 92(2): 236-240

10. Goffe (1994) "Computer Network Resources for Economists" *The Journal of Economic Perspectives*, 8 (3): 97-119.2.

1I. Goffe, W & Parks, R (1997) "The Future Information Infrastructure in Economics" *Journal of Economic Perspectives*, 11 (3): 75-94.

12. Gordon, J (2000). "Does the New Economy Measure up to the Great Inventions of the Past" The *Journal of Economic Perspectives* 14 (4): 49-74

13. Green, W.H (2000) Econometric Analysis. *Prentice Hall.* New York

14. Hahn, F. H & R. C. O. Matthews "The Theory of Economic Growth: A Survey" *The Economic Journal*, 74 (296): 779-902.

15. Jorgenson W, J.K. Stiroh., R. Gordon and D. Sichel (2000) "Raising the Speed Limit: U.S. Economic Growth in the Information Age" *Brookings Papers on Economic Activity*, 2000 (1): 125-235.

16. Kaldor, N (1957). "A Model of Economic Growth". *The Economic Journal*, 67: 591-624

17. Klenow, P and M. (2000) "Does Schooling Cause Growth" *The American Economic Review,* 90 (5): 1160-1183.

18. Kenny, C (2002). "The Internet and Economic Growth in LDCs. A Case of Managing Expectations" *United Nations University Discussion paper*

19. Lau, L. J and Tukutsu, I (1992) "The Impact of Computer Technology on the Aggregate Technology on the Aggregate Productivity of the United States: An Indirect Approach" NBER Working Paper

20. Li. X., Greenway, D., and R. C. Hine (2003) “Imports of services and economic growth: A Dynamic panel Approach”. *GEP, School of Economics, University of Nottingham*

21. Lehr, W., &F. Lichtenberg (1998) “Computer Use and Productivity Growth in US Federal Government Agencies, 1987-92.” *The Journal of Industrial Economics*, 46 (2): 257-279.

22. Martin, R and P. Sunley “Slow Convergence? The New Endogenous Growth Theory and Regional Development. *Economic Geography*, 74 (3) 201-227

23. O'Connell, S and B. J. Ndulu (1999), “Governance and Growth in Sub-Saharan Africa”. *Journal of Economic Perspectives* 13(3): 41-66

24. Oliner, S and D. Sichel (2000) “The Resurgence of Growth in the Late 1990s: Is Information Technology the Story? *The Journal of Economic Perspectives*, 14 (4): 3-22.

25. Oliner, S., Sichel, D., J. Triplett and R. Gordon (1994) “Computers and Output Growth Revisited: How Big is the Puzzle?” *Brookings Papers on Economic Activity*, 1994, (2): 273-334.

26. Romer, P (1997). *Advanced Macroeconomic Theory*. The MIT press.

27. Solow, R. M. (1956): "A Contribution to the Theory of Economic Growth." *Quarterly Journal of Economics* 70:65-94

28. Siegel, D. & Z. Griliches (1992). "Purchased Services, Outsourcing, Computers, and Productivity in Manufacturing," NBER

29. Teece, 1977 (1977) “Technology transfer by multinational corporations: The resource cost of transferring technological know-how *Economic Journal* 87

30. Temple, J (1999). “The New Growth Evidence.” *Journal of Economic Literature* 37: (1).