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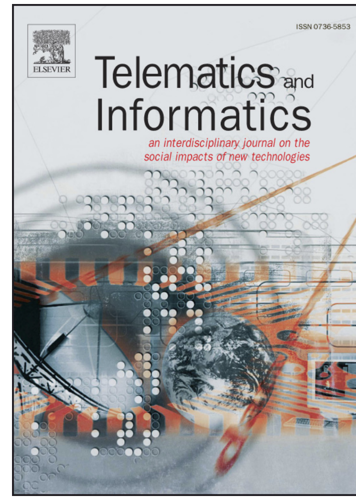

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The effects of Internet usage, financial development and trade openness on economic growth in South Africa: A time series analysis

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Abstract

This study estimates the effects of Internet usage, financial development and trade openness on economic growth using annual time series data for South Africa for the period 1991-2013. Structural unit root test and Johansen and ARDL cointegration tests are performed to examine the long run relationship amongst Internet usage, financial development, trade openness and economic growth. Findings from ARDL cointegration tests indicate a long-run relationship between the variables. Results from the ARDL estimates indicate a positive and significant long run relationship between Internet usage and economic growth in South Africa. Also, there is significant positive relationship between financial development and economic growth. However, the short run relationship among the variables was found to be insignificant. The robustness of the long-run relationship between the variables was checked by the application of dynamic ordinary least squares (DOLS) estimation. The Granger causality test reveals that both Internet usage and financial development Granger-cause economic growth in South Africa. This causal link is found to be robust from the application of impulse response and variance decomposition analysis. Based on these findings, this study recommends that the South African government continue with policies that aim to invest more resources into its Internet infrastructure to further expand its network and usage.

Keywords: ARDL, DOLS, Economic growth, Granger causality, Internet usage, South Africa

1. Introduction

The enormous spread of the Internet over the last 20 years has encouraged research on the various economic consequences of this expansion. The effects of the Internet on the economy span a wide range of areas from increased technological productivity to increased foreign direct investment, from inflation to political economy issues and from corruption to democratic freedom issues and the shadow economy (Elgin, 2013; Sassi and Goaied, 2013). From a broader perspective, the penetration of the Internet and its uses are part of the ICT revolution.

Various governments, both in the developed and the developing world, have recognized the significant growth potential of the Internet to their economies. Many governments have adopted policies that have led to the massive growth of the use of the Internet in their countries. Unfortunately, South Africa is lagging behind in this regard. However, in recent times, Internet usage in South Africa has been increasing at an accelerated rate, helping to catch up with similar economically developed middle income countries. At present, 40% of South Africans are using the Internet (World Bank, 2013). South Africa has the highest penetration of any country in Africa which provides a favorable platform for extensive broadband and Internet usage (Luiz and Stephan, 2012). The number of Internet users has quadrupled in just a few years (World Bank, 2013). The rising trend in the use of Internet is depicted in Figure 1. Recently expanded capacity of undersea cables connecting South Africa to the world has contributed towards providing improved international connectivity and reducing costs. This is an encouraging sign for South Africa given its bid to become a digital economy and be on par with its counterparts in the world (Republic of South Africa, 2005). South Africa's macro economy also remained stable during the period 1991-2013 as reflected in Figure 2 which demonstrates the logarithmic trend in South Africa's real GDP per capita and financial development.

This study examines the long-run relationship between the Internet usage and economic growth in South Africa. Up to 2014, the growth effects of increased Internet usage have only been studied in panel data settings. In the South African context, this time series study is believed to be the first of its kind.

The rest of the paper is structured as follows: Section 2 discusses the literature and the methodology and data are outlined in section 3. Section 4 presents the results and policy implications are discussed in section 5, whilst the conclusions complete the paper in section 6.

2. Literature review

2.1 Internet and the economy: Theoretical perspective

Internet usage allows the generation and distribution of decentralized information and ideas in markets increasingly relying on information as an input. In the light of modern theories of endogenous growth (e.g., Lucas 1988; Romer 1986, 1990; Aghion and Howitt 1998; Barro, 1998), the Internet should accelerate economic growth by facilitating the development and adoption of innovation processes. The new growth theories suggest that the growth effects of modern communication networks that have emerged since the arrival of Internet technology may have a different quality. Internet usage may accelerate the distribution of ideas and information and foster competition for and development of new products, processes, and business models, thereby further facilitating macroeconomic growth.

Romer's (1986, 1990) endogenous growth model explained that endogenous growth theories model the generation and distribution of ideas and information as the key drivers of economic growth (Lucas, 1988; Romer 1990; Aghion and Howitt 1998). As such, the massive growth in Internet usage may affect the innovative capacities of the economy through creation of knowledge spill over, development of new products and processes, and business models to promote growth. Moreover, cheaper information dissemination can facilitate the adoption of new technologies devised by others, which again promotes economic growth (Nelson and Phelps 1966; Benhabib and Spiegel 2005). This also suggests that spillovers of codified knowledge across firms and regions may constitute another channel by which information technology in general and Internet usage in particular affect economic growth.

The Internet enables the exchange of data across multiple locations and aids decentralized information processing. It also potentially contributes towards the emergence of new business and firm-cooperation models that rely on the spatial exchange of large batches of information, which boosts competition and innovation processes. The Internet may increase market transparency and thus additionally intensify competition. Extensive use of the Internet fundamentally changed and improved the processing of information, resulting in significant productivity growth of IT-using firms (Stiroh 2002; Jorgensen, Ho, and Stiroh 2008).

2.2. The Internet and the economy: Empirical evidence

The evidence outlining the direct economic impacts of the internet is very scarce despite its growing role in almost every aspect of everyday economic life. In one of the earliest studies Frehund and Weinhold (2002) investigated the effect of the internet on services and trade and found a positive and significant relationship between them. Choi (2003) studied the effect of the internet on inward foreign direct investment (FDI) using data for a panel of 14 source countries and 53 host countries. The study applied cross country regression using a gravity FDI equation and the findings indicated that a 10% increase in the number of internet users in a host country raised FDI inflows by 2%. Frehund and Weinhold (2004) argued that the internet has a positive effect on bilateral trade. Running both time series and cross sectional regressions on a sample of 53 countries, they found that the internet stimulated trade flows. The study further claimed that the internet reduces market-specific fixed costs which further contribute towards export growth.

Yi and Choi (2005) investigated the effects of the internet on inflation. They employed pooled OLS and random effects models for a panel of 207 countries. Their results showed that a 1% increase in the number of the internet users led to a 0.42% drop in inflation. Noh and Yoo (2008) tested the empirical relationship amongst internet adoption, income inequality and economic growth. They used a panel of 60 countries for the period 1995-2002 and found that the effect of the internet on economic growth is negative for countries with high income inequality as it hampers the economic growth effect of the internet. The findings were attributed to the presence of a digital divide in these countries where only the rich who are few in number can access it whilst the vast majority who are poor cannot. Given the high level of income inequality in South Africa a similar result would be expected here.

Choi and Yi (2009) used a panel of 207 countries for the period 1991-2000 to examine the impact of the internet on economic growth while controlling for some macro variables namely the investment ratio, government consumption ratio and inflation. They used a number of panel econometric techniques such as pooled OLS, individual random effects, individual fixed effects, time-fixed effects, individual random and time fixed model and finally panel GMM to control for endogeneity among the explanatory variables. Their findings supported the significant positive role of the internet in spurring economic growth. Choi (2010) estimated the effect of the internet on services trade using panel data for 151 countries for the period 1990-2006. Pooled OLS, fixed effects model and panel GMM were employed for estimation. The study found a significant and positive relationship between the number of internet users and total services trade. It was concluded that a 10% increase in the number of internet users prompted an increase in services trade of between 0.23% and 0.42%.

Lio et al. (2011) estimate the effects of internet adoption on reducing corruption in a panel of 70 countries for the period 1998-2005. They conducted firstly a Granger causality test to assess the causal direction of the relationship. Having found the causal link, they further applied dynamic panel data models (DPD) to estimate the relationship between variables while addressing the endogeneity problem. The results indicated a significant role for the internet in reducing corruption. Goel et al. (2012) used internet penetration as an indicator of corruption awareness. They found that there is negative relationship between the number of internet hits about corruption awareness with corruption perception and corruption incidence.

Elgin (2013) used a panel data of 152 countries for the period 1999-2007 to investigate the effects of the internet on the size of the shadow economy. The study used cross country regressions and found that the association between internet usage and the shadow economy strongly interacts with GDP per capita. The study further highlighted two opposing effects of internet usage which were the increasing productivity effect which reduced the size of the shadow economy and the increasing tax evasion effect which increased the size of the shadow economy. These results were robust across different econometric specifications.

Choi et al. (2014) investigated the determinants of international financial transactions using cross country panel data on bilateral portfolio flows from 38 countries to the USA for the period 1990-2008. It employed a gravity model and found that the internet reduces information asymmetry and thus increases cross border portfolio flows. The results were robust across different empirical models.

Najarzadeh et al. (2014) investigated the effect of the Internet on labor productivity using data for a panel of 108 countries for the period 1995-2010. Employing the pooled OLS, fixed effect, and one-step and two-step GMM methods to estimate the relationship. The empirical exercise suggested a positive and strong significant relationship between Internet use and labor productivity.

Gruber et al. (2014) estimated the returns from broadband infrastructure for the period 2005-2011 and also assessed the cost of broadband roll out under different assumptions of technical performance. Their findings contrasted with the forecasted benefits from the expansion of broadband coverage. However, the study also found that the future benefits to be reaped from a broadband roll out project outweigh the investment involved therein for the highest performance technologies. The study recommended public subsidies to promote building high- speed broadband infrastructure.

Czernich (2014) examined the relationship between broadband Internet and unemployment rate using data of various municipalities of Germany. Simple OLS regression indicated a negative relationship between broadband Internet and unemployment while such an association between these variables could not be confirmed with the introduction of an instrument variable in the same study. Lechman and Marszk (2015) examined the relationship between ICT penetration and exchange traded funds (ETF) for Japan, Mexico, South Korea and the United States over the period 2002-2012 using two core indicators of ICT, 'number of Internet users per 100 people' and 'Fixed Broadband Internet subscriptions per 100 people'. Using logistic growth models to analyse the data, the study found a positive, strong and significant relationship between ICT penetration and ETF.

From the above discussion it is clear that studies on the economic effects of the Internet have utilized only panel data for estimation purposes. Only exception is a study in which Ishida (2015) uses time series data for Japan. He found that in Japan over the period from 1980 to 2010 that ICT investment did not contribute to an increase in GDP. The current study is an addition to the existing Internet-economic growth time series literature.

2.3 Economic growth, financial development and trade openness

In the literature, it is recognized that financial development is one of the most important endogenous variables that impacts profoundly upon economic growth of countries. The relationship between financial development and economic growth was pioneered by Goldsmith (1969), McKinnon (1973) and Shaw (1973). Early economic growth theories didn't include financial development as a variable to be explicitly modeled. However, a growing theoretical and empirical body of literature shows how financial intermediation mobilizes savings, allocates resources, diversifies risks and is an important contributor to economic growth (Greenwood and Jovanovic, 1990; Jibili et al. 1997). Endogenous growth models argue that financial institutions and markets reduce information and transaction costs, influence decisions in favor of more productive activities, evaluate efficiently the most promising investments all of which eventually contribute towards long-run economic growth.

The literature on the financial development-economic growth nexus mostly support a positive relationship between the two variables. However, there is considerable disagreement over the direction of the causal link between them. Some authors support the direction from financial development to economic growth while others support the opposite that the direction is from economic growth to financial development. There is a small cohort in the literature that supports a bi-directional link between them.

Empirical research stresses the contribution of financial development to economic growth. In one of the earliest studies, King and Levine (1993) used cross country data for 80 countries for the period 1960-1989 and found a strong and robust relationship between GDP and the indicators of financial development. Hansson and Jonung (1997) investigated the empirical relationship between financial development and GDP for Sweden from the 1830s to 1990s. They found a stable positive relationship between the variables. Bencivenga and Smith (1998) observed that the lack of smooth financial development causes rise to various development traps. They also argued that different policy interventions of the government may reduce the potential for development traps to rise.

Most of the panel and cross country studies find support in favor of a positive relationship between financial development and economic growth when other growth determinants are controlled for as well as taking into account variable omission bias, simultaneity and country specific effects. These studies also support a causality running from financial development to economic growth. On the other hand, most of the time series studies find both a unidirectional and bidirectional causal relationship between financial development and economic growth.

Different results also emerged when different proxy measures for financial development are used. However, the overall literature supports a positive effect of financial development on long-run economic growth. Examples of some recent studies that support the positive effect of financial development on economic growth include: Hassan (2003), Hassan et al. (2011), Khoutem et al. (2014) and Uddin et al. (2013). Hsueh et al. (2013) report that financial development stimulates economic growth in Asian countries including China. Zhang et al. (2012) suggest that the traditional measures of financial development have a positive effect of financial development on economic growth. Adu et al. (2013) argues that whether financial development affects economic growth positively or negatively depends on which proxy measure is being used for estimation purposes.

Bangake and Eggoh (2011) use panel data for 71 countries for the period 1960-2004. They classified the countries into low income, middle income and high income groups. The study report bidirectional long-run causality between financial development and economic growth for all countries but no short-run causality for low income and middle income countries is found. Significant short-run causal link is observed between the variables for the high income countries. Rousseau and Yilmazkuday (2009) show that the relationship between financial development and economic growth is conditioned upon the presence of inflation rate. The study which involved a panel of 84 countries revealed that higher levels of financial development are associated with higher levels of growth when the inflation rate is below 4%. For countries with an inflation rate between 4 to 19%, the effect of financial development on economic growth is observed to be overshadowed. Orgiazzi (2008) showed that financial development can even create output volatility and thus lower economic growth rate.

Recent empirical studies also offer mixed findings on the relationship between economic growth and trade openness. A few examples include Shahbaz and Lean (2012) who in a time series study on Pakistan argue that trade openness promotes economic growth in the long-run. Menyah et al. (2014) in a panel study for 21 African countries found no significant relationship between trade openness and economic growth. Eris and Ulasan (2013) in a cross country analysis found no evidence of any direct and robust relationship between trade openness and economic growth.

3. Methodology and Data

3.1. Model

The model for estimation takes the following Cobb-Douglas functional form:

Y= F (Number of Internet users, financial development and trade openness).

The growth equation for estimation has the functional form of:

$Growth_t = \beta_0 + \beta_1 NET + \beta_2 FD + \beta_3 TO + \varepsilon_t$...(1)

For the convenience of parameter estimation, all variables except GDPCG have undergone logarithmic transformation. Therefore,

$GDPCG = \beta_0 + \beta_1 \ln NET + \beta_2 \ln FD + \beta_3 \ln TO + \varepsilon_t$ ……………………………...(2)

where β_0 and ε_t are constant and the stochastic error term, respectively.

3.2 Data

Annual data for 1991-2012 was sourced from the World Development Indicators Database (World Bank, 2013). Economic growth is measured as the growth of real GDP per capita (GDPC) at constant US$ Year 2000 prices. Internet usage is taken as the number of Internet users per 100 people who have worldwide Internet access and used it at least once in the last twelve months. The variable financial development (FD) is estimated from the ratio of credit to private sector as share of GDP. Real values were considered for the estimation.

3.3 Estimation Procedures

3.3.1 Unit root tests

Since most of the conventional unit root tests such as ADF (Dickey and Fuller, 1979), PP (Phillips and Perron, 1988), KPSS (Kwiatkowski et al., 1992) tests and the DF-GLS (Dickey Fuller Generalized Least Squares) test proposed by Elliott et al. (1996) fail to identify the presence of a structural break, if any, in the series (Baum, 2004), a Zivot and Andrews (1992) unit root test was conducted which overcomes this limitation and accommodates a single structural break point in the level. Considering the series as X, then the structural tests take the following form:

$$\Delta X_t = \Omega + \Omega X_{t-1} + \text{ct} + dD_t + dDT_t + \sum_{j=1}^{k} d_j\, \Delta X_{t-j} + \varepsilon_t \quad (3)$$

$$\Delta X_t = a + aX_{t-1} + \text{bT} + cD_t + \sum_{j=1}^{k} d_j\, \Delta X_{t-j} + \varepsilon_t \quad (4)$$

$$\Delta X_t = \beta + \beta X_{t-1} + \text{ct} + bDT_t + \sum_{j=1}^{k} d_j\, \Delta X_{t-j} + \varepsilon_t \quad (5)$$

$$\Delta X_t = \gamma + \gamma X_{t-1} + \text{ct} + dDT_t + \sum_{j=1}^{k} d_j\, \Delta X_{t-j} + \varepsilon_t \quad (6)$$

where D is a dummy variable and shows the mean shift at each point and DT_t is a trend shift variable. The null hypothesis in Zivot and Andrews (1992) is c=0 meaning the presence of unit root in the absence of structural break hypothesis against the alternative that the series is trend stationary with an unknown time break. Then, this unit root test selects that time break which reduces one-sided t-statistic to test c (=c-1) =1.

3.3.2 Cointegration Tests

Having tested the stationarity of each time series, the next step is to search for cointegration between Internet usage, financial development and economic growth for South Africa. In order to test for multivariate cointegration, the Johansen (1988) maximum likelihood ratio test is employed. This test follows a system-based reduced-rank regression approach. Consider a vector y_t containing n variables, then if y_t is cointegrated, it can be estimated by a vector error correction mechanism (VECM) as shown below:

$$\Delta y_t = \mu + \Psi_1 \Delta y_{t-1} + \ldots\ldots\ldots + \Psi_{k-1} \Delta y_{t-k+1} + \Omega y_{t-1} + u_t \quad (7)$$

where, μ is an $n \times 1$ vector of drifts, Ψ and Ω are $n \times n$ matrices of parameters, and u_t is an $n \times 1$ vector of random error terms. The likelihood ratio test statistic for the cointegration hypothesis having at most r cointegrating vectors can be expressed as follows:

$$\lambda_{Trace} = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i) \quad (8)$$

where, $\hat{\lambda}_i$ includes the estimated values of the characteristic roots (or eigenvalues) obtained from the estimated Ω matrix and the number of observations, T. This is termed as trace statistic (λ_{Trace}), where the null hypothesis is that the number of cointegrating vectors is less than or equal to r against a general alternative hypothesis. An alternative test called maximal eigenvalue or λ_{Max} statistic can be illustrated as following:

$$\lambda_{Max} = -T \ln(1 - \hat{\lambda}_{r+1}) \text{ --(9)}$$

The null hypothesis in maximal eigenvalue (λ_{Max}) is that the number of cointegrating vectors is r against the alternative hypothesis.

3.3.3. ARDL bounds testing approach

Since conventional cointegration techniques such as Johansen's cointegration have certain limitations on their findings as a result of the presence of structural break in macroeconomic dynamics (Lutkepohl, 2006, Uddin et al., 2013), another econometric technique known as ARDL (Autoregressive Distributed Lag) model bounds testing approach developed by Pesaran (1997) and Peseran et al., (2001) is applied to assess the cointegrating relationship between the variables. The ARDL technique has several advantages over other conventional cointegration techniques; first of all, this method can be applied to a small sample size study (Pesaran et al., 2001) and therefore conducting bounds testing is justified for the present study. Second, it can be applied even in case of mixed order of integration of variables [both for I(0) and I(1) variables]. Third, it simultaneously estimates the short-run dynamics and the long-run equilibrium with a dynamic unrestricted error correction model (UCEM) through a simple linear transformation of variables. Fourth, it estimates the short and long-run components simultaneously potentially removing the problems associated with omitted variables and autocorrelation. In addition, the technique generally provides unbiased estimates for the long-run model and valid t-statistic even when the model suffers from the problem of endogeneity (Harris and Sollis, 2003).

The empirical formulation of ARDL equation for this study is specified as follows:

$$\Delta lnGDPC_t = \beta_0 + \beta_1 T + \beta_2 D + \beta_3 lnGDPC_{t-1} + \beta_4 lnNET_{t-1} + \beta_5 lnFD_{t-1} + \sum_{i=1}^{p} \beta_6 \Delta lnGDPC_{t-j} + \sum_{j=0}^{q} \beta_7 \Delta lnNET_{t-k} + \sum_{k=0}^{r} \beta_8 \Delta lnFD_{t-l} + \varepsilon_t \text{------} (10)$$

$$\Delta lnNET_t = \beta_0 + \beta_1 T + \beta_2 D + \beta_3 TO_{t-1} + \beta_4 GDPC_{t-1} + \beta_5 FD_{t-1} + \beta_6 NET_{t-1} \sum_{i=0}^{p} \beta_7 \Delta NET_{t-j} + \sum_{j=0}^{q} \beta_8 \Delta GDPC_{t-k} + \sum_{k=0}^{r} \beta_9 \Delta FD_{t-l} + \varepsilon_t \text{------} (11)$$

$$\Delta lnFD_t = \beta_0 + \beta_1 T + \beta_2 D + \beta_3 lnNET_{t-1} + \beta_4 lnGDPC_{t-1} + \beta_5 ln TO_{t-1} + \beta_6 lnFD_{t-1} + \sum_{h=0}^{o} \beta_7 \Delta lnFD_{t-j} + \sum_{i=0}^{p} \beta_8 \Delta lnGDPC_{t-k} + \sum_{j=0}^{q} \beta_9 \Delta lnNET_{t-l} + \sum_{k=0}^{r} \beta_{10} \Delta lnTO_{t-l} + \varepsilon_t \text{------} (12)$$

$$\Delta lnTO_t = \beta_0 + \beta_1 T + \beta_2 D + \beta_3 lnNET_{t-1} + \beta_4 lnGDPC_{t-1} + \beta_5 lnFD_{t-1} + \beta_6 lnTO_{t-1} \sum_{i=0}^{p} \beta_7 \Delta lnTO_{t-j} + \sum_{j=0}^{q} \beta_8 \Delta lnGDPC_{t-k} + \sum_{k=0}^{r} \beta_9 \Delta lnNET_{t-l} + \varepsilon_t \text{------} (13)$$

Where, GDPCG, NET and FD and TR indicate real values of real GDP per capita growth rate, Internet users per 100 people, financial development and trade openness respectively. Δ is the difference operator. T and D denote time trend and dummy variable, respectively. The dummy variable is included in the equation to capture the structural break arising from the series. ε_t is the disturbance term.

To examine the cointegrating relationship, Wald Test or the F-test for the joint significance of the coefficients of the lagged variables is applied with the null hypothesis, H_0: $\beta_3 = \beta_4 = \beta_5$ indicating no cointegration against the alternative hypothesis of the existence of cointegration between variables. F statistics are computed to compare the upper and lower bounds critical values provided by Pesaran (2001).

3.3.4. Gregory Hansen tests for cointegration

In order to check for the robustness of the cointegrating relationship between the variables, the Gregory and Hansen (1996) residual based test of cointegration was employed which allows for one time change in the cointegrating parameters. Gregory and Hansen offer the testing of four models-level, trend, intercept or shifts in the intercept and slope. The intercept and slope model is selected that allows rotation in the long-run equilibrium relationship simultaneously with shift.

3.3.5. Dynamic Ordinary Least Squares (DOLS)

To test the robustness of the long-run coefficients of the variables, the Dynamic Ordinary Least Squares (DOLS) method is applied (Stock and Watson, 1993). The application of this method for robustness check is justified as it provides efficient estimates for small samples (as in this case) and eliminates simultaneity bias. Nevertheless, the cointegrating vectors obtained from DOLS are asymptotically efficient.

3.3.6. The VECM Granger causality test

According to Granger (1969), once the variables are integrated of the same order, the VECM Granger causality test is appropriate to estimate their causal link. Since all the variables in this study are first difference stationary [I(1)] this study proceeds further to determine the causal direction between them. The exact direction of causal link helps with better policy implications of the findings (Shahbaz et. al., 2013). The potential causality pattern for this study is represented by the following VECM specification in a multivariate framework;

$$\Delta lnY_t = \beta_{0i} + \sum_{i=1}^{p} \beta_{1i}\, \Delta lnY_{t-i} + \sum_{i=0}^{p} \beta_{2i}\, \Delta NET_{t-i} + \sum_{i=0}^{p} \beta_{3i}\, \Delta FD_{t-i} + \varepsilon_t \quad (13)$$

3.3.7. Impulse response function and variance decomposition analysis

Since ARDL estimates do not provide any inference about the relationship beyond the sample period covered in the study, the Innovation Accounting Approach (IAA) which consists of variance decomposition analysis and generalized impulse response functions is also used to assess the forecasted impact of internet usage and financial development on economic growth. The generalized impulse response function is preferred over the simple Choleski fractionalization impulse response analysis as the generalized impulse response function is insensitive to the order of the VECM (Shahbaz et al., 2013).

Although the impulse response function traces the effect of a one standard deviation shock on the current and future values of all the endogenous variables through the dynamic structure of VECM, it doesn't provide the magnitude of such effect. Consequently, variance decomposition method is employed to examine this magnitude. Variance decomposition (Pesaran and Shin, 1999) measures the percentage contribution of each innovation to h-step ahead forecast error variance of the dependent variable and provides a means for determining the relative importance of shocks in explaining the variation in the dependent variable. Engle and Granger (1987) and Ibrahim (2005) argued that variance decomposition approach produces more reliable results as compared to those from other traditional approaches.

4. Results

Table 1 presents summary statistics of the data. Table 2 reports results from Variance Inflation Factor (VIF) test. It confirms that the data are free from the threat of multicollinearity. Table 3 displays the results of KPSS, PP and DF-GLS unit root tests. All three series are found first difference stationary in all these tests which confirms that they are integrated of the first order or I(1). But these tests fail to consider the presence of structural break, if any, in a time series data. Hence, the Zivot and Andrews (1992) structural break unit root test is performed as shown in Table 4. All the series are found stationary at first difference in the presence of structural break. The Johansen cointegration test results are reported in Table 5. Both the trace statistic and the maximum eigenvalue test statistic indicate at least two cointegrating vectors at the 1% level of significance. This implies that there is a cointegrating relationship between the variables. This test also fails to consider the presence of structural break. Table 6 reports the results from Gregory Hansen cointegration test allowing for change both in regime and trend. The results suggest cointegrating or long-run relationship among the variables in the presence of structural break.

Table 7 reports the long-run coefficients from the ARDL estimation. The long run estimates show that there is significant positive long run relationship between Internet usage and economic growth in South Africa and between financial development and economic growth. However, the short run relationship presented in Table 8 is found to be insignificant in both cases. Table 9 demonstrates results from the diagnostic tests carried out from the ARDL lag estimates. The LM test confirms no serial correlation while Ramsey's RESET test suggests that the model (equation 1) has the correct functional form. The normality test reveals that the disturbance terms are normally distributed and are homoscedastic as supported by the heteroscedasticity test. The stability of parameters over time is reflected through the graphical plots of CUSUM and CUSUM sum of squares (Figures 3A and 3B respectively). Granger causality results reported in Table 10 show that there is unidirectional causal link running from Internet usage to economic growth and from economic growth to financial development.

Results from DOLS estimation are presented in Table 11 which confirms that the long-run coefficients obtained from the ARDL estimates are robust. Furthermore, the impulse response functions support the positive relationship between Internet usage and economic growth and between financial development and economic growth as demonstrated in Figure 4.

Results from the variance decomposition analysis are reported in Table 12. The study allows a 22 year forecasting horizon. Interestingly, over the 5-year forecasting horizon, about 79% of the one-step forecast variance in real GDP per capita is accounted for by its own innovations and altogether 21% is accounted for by Internet users per 100 people and financial development. In the long-run after a period of 22 years, the response to own innovative shocks declines drastically to only 15% while the response of real GDP per capita to the shocks in the Internet users per 100 people alone dramatically rises to 74%. The response of GDP per capita to financial development rises to 14% from the first 5-year forecast horizon of 8%. The findings from this variance decomposition analysis reveal significant future potential of Internet use in transforming the South African economy.

5. Policy Implications

The recent growth of Internet penetration in South Africa (Figure 1) is impressive in the context of Africa but is lagging behind similar middle income countries elsewhere in the world. Currently Internet access is reaching under 40% of South Africans whereas similar income level countries have 70 to 90% Internet uptake by their populations. Given the results of this and other studies there is clear evidence that increasing Internet usage will contribute to increasing economic growth in South Africa. To this end, the South African government has in 2014 launched a high level inquiry into the state of competition in the ICT sector. This action was prompted by the belief that a lack of competition in the market for Internet and telephone services was resulting in prices that were much higher than the cost of providing the services and that inadequate infrastructure investment combined with the high prices was dramatically constraining uptake of ICT in the country.

The Independent Communications Authority of South Africa (ICASA) is the regulator for the South African communications, broadcasting and postal services sectors. ICASA was established by an Act of statute, the Independent Communications Authority of South Africa Act of 2000, and regulates through the power of the Electronic Communications Act of 2005 (ECA) and the Broadcasting Act of 1999 (the Broadcasting Act). The ECA was enacted in part to take account of the convergence in communications technologies as a result of technological development and advancement over the years.

The ICASA enquiry has received submissions from smaller players in the market that the two largest players (MTN and Vodacom) who control over 80% of the ICT market are not interested in competing on price which would increase demand for Internet services because of the large infrastructure investments that would need to be made to cater for a rapid scale up. This duopoly situation means that there is insufficient competition resulting in consumers not benefiting and that the national interest is adversely affected by the lack of access to reasonably priced communications.

The results of this study are strong evidence for South Africa to expand access to the Internet which has already proved to be playing a significant role in transforming economies across the globe. South Africa is yet to tap the full potential of this revolutionary technology. Therefore, this study recommends that the South African government pursue policies that aim to promote aggressive investment not only into Internet infrastructure to further expand its network and usage, but also in addressing demand side issues by adopting schemes such as promoting education, providing training, improving internet skill etc.

6. Conclusions and limitations

This study estimates the long-run relationship among Internet usage, financial development and economic growth using annual time series data for South Africa for the period 1991-2012. DF-GLS unit root test is conducted to check for stationarity of the data. All the series were found first difference stationary. Both Johansen and ARDL cointegration tests confirm the long run relationship between Internet usage, financial development and economic growth in South Africa.

Results from the ARDL estimates indicate a long-run positive and significant relationship between Internet usage and economic growth in South Africa. Also there is significant positive relationship between financial development and economic growth. The robustness of the long-run relationship between the variables is checked by the application of dynamic ordinary least squares (DOLS) estimation which produced similar results. The Granger causality test reveals that both Internet usage and financial development Granger-cause economic growth in South Africa. The causal link between the variables is strongly robust as supported by the impulse response function and variance decomposition analysis. Moreover, variance decomposition analysis provides strong forecasts on the potential future impact of Internet use on South African economy.

Despite encouraging findings, the study suffers from a number of limitations. First, the empirical results derived from the current model having a Cobb-Douglas type functional form seem to be plagued with omission bias especially when labor augmenting technology such as the Internet is incorporated in the model (Miller, 2008). Also, this study used aggregate data which has been theoretically challenged as appropriate for the Cobb-Douglas functional form (Miller, 2008). Second, the weakness of using such functional form is the assumption of constant returns to scale. Internet technology is a General Purpose Technology (GPT) which enables economic activity. It is argued that without substantial investment on complementary assets, such as electricity networks, broadband networks, up to date computers as some examples, the expected returns from the Internet on economic growth may not be as high as expected in the long-run if this enabling and related investment does not occur or occurs at a sub-optimal level (Shahiduzzaman and Alam, 2014; Ceccobelli et al., 2012).

Third, it is an issue for foreign exchange reserves and the fiscal policy of a country like South Africa to manage the required size of its R&D expenses, especially on third level industrial technology like the Internet and its complementary assets which are mostly imported. High tariff barriers are likely to reduce the expected returns from investment in such technology because of its cost implications. This is one of the key factors that contribute towards the digital divide in many countries like South Africa (Oyedemi, 2012). This might even result in decreasing returns to scale which will reduce capital and labor incomes. In contrast, subsidizing enabling technologies would raise the welfare of many people in South Africa where a significant percentage of population are still deprived of basic facilities such as food, education and accommodation (Oyedemi, 2012). Fourth, this study uses only a 22-year long time series data, findings from the analysis of which, may not be very reliable. Use of longer time series data is likely to produce more robust findings that is expected to potentially be more comfortably tied to the discussion on policy implications. This is left for future research.

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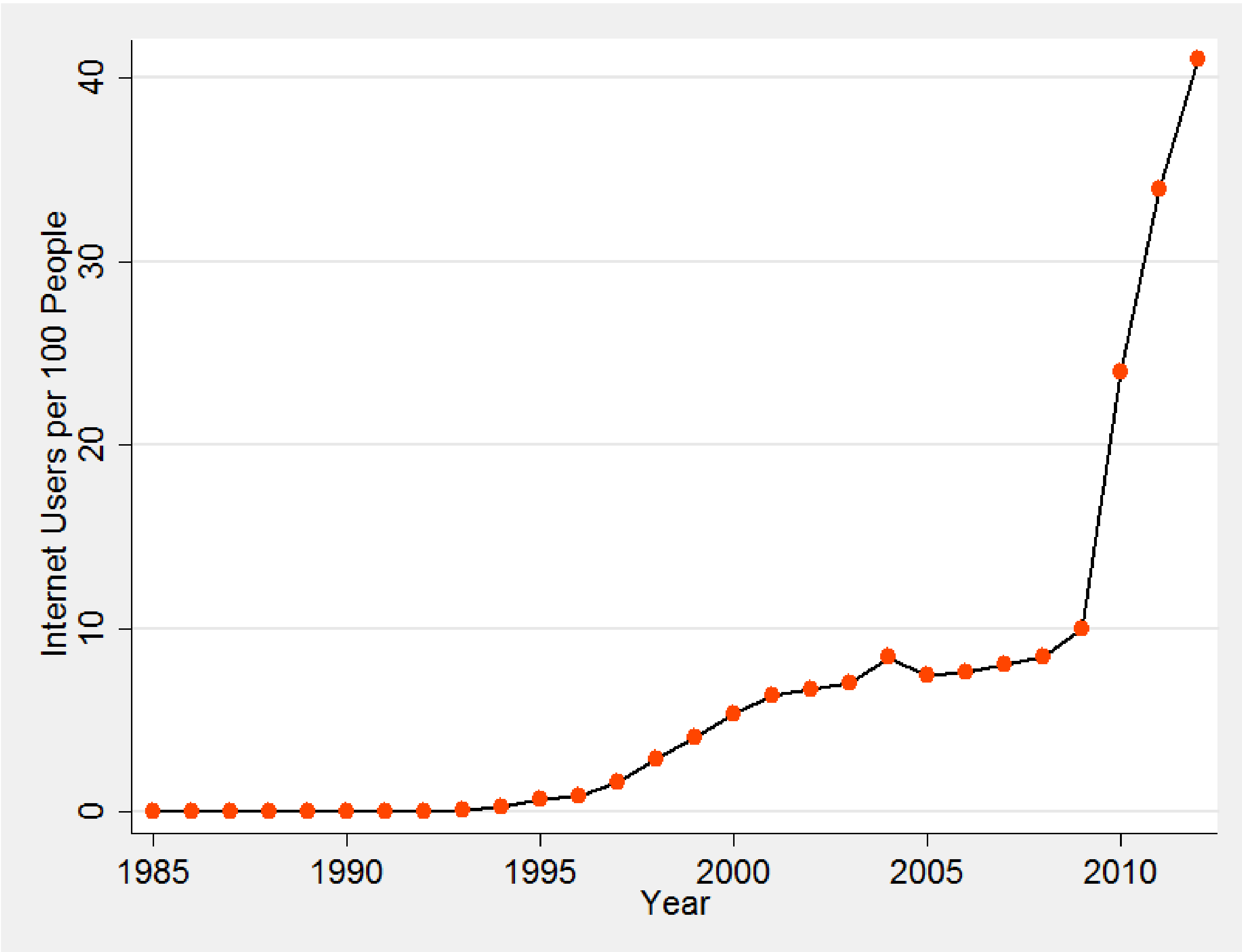
Figure 1
Internet users per 100 people in South Africa (1985-2012)



Source: World Development Indicators Database, The World Bank, 2013

Figure 2
Logarithmic trends in real GDP per capita and financial development in South Africa (1985-2012)

Source: World Development Indicators Database, The World Bank, 2013

Figure 3A
Cumulative Sum of Recursive Residuals

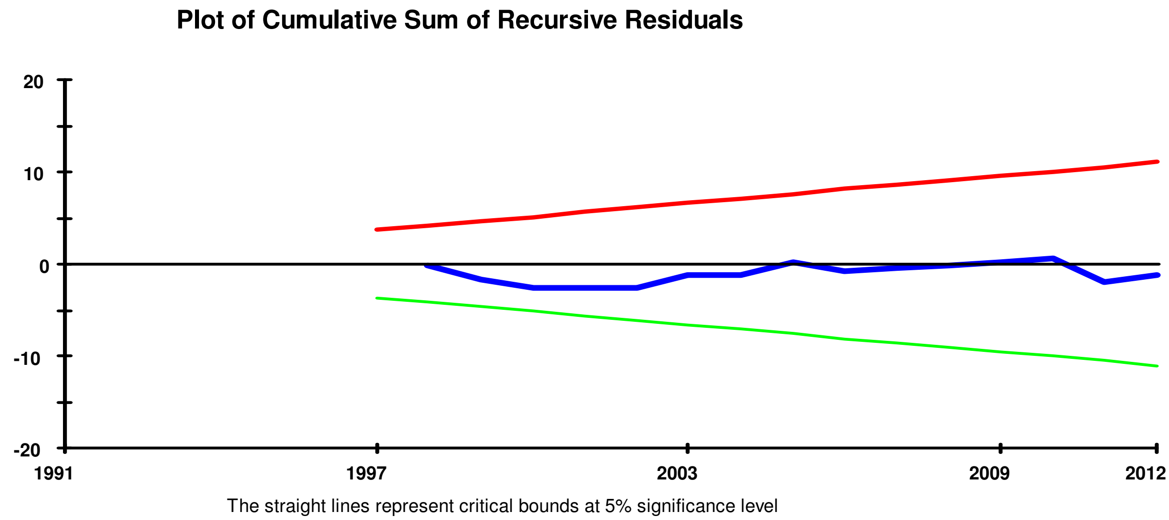


Figure 3B
Cumulative Sum of Squares of Recursive Residuals

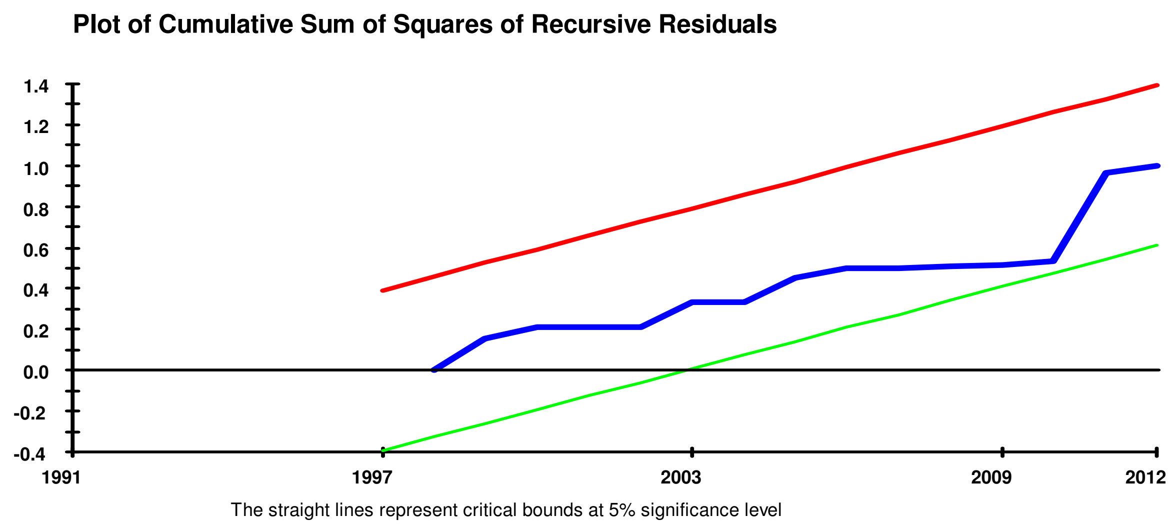
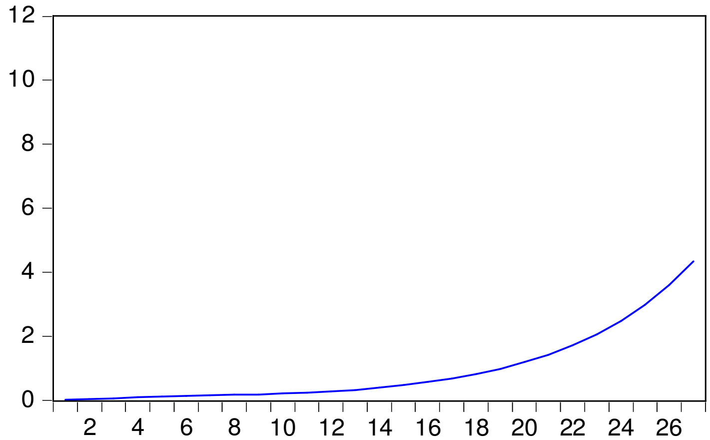


Figure 4

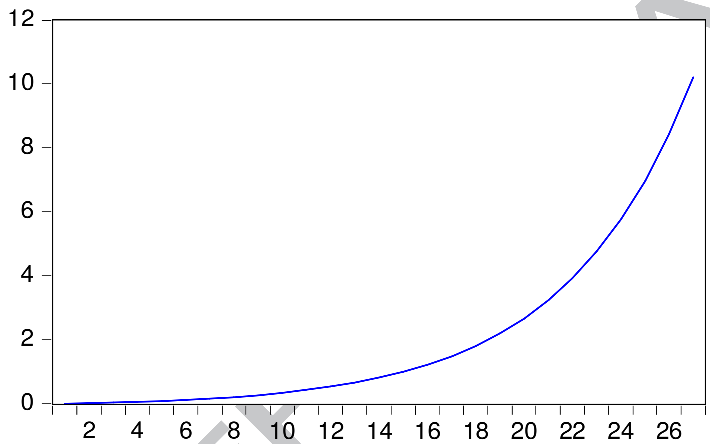
Impulse response functions of real GDP per capita for South Africa

Accumulated Response to Generalized One S.D. Innovations

Accumulated Response of REAL_GDP_PC to REAL_GDP_PC



Accumulated Response of REAL_GDP_PC to INTERNET_USER



Accumulated Response of REAL_GDP_PC to FD

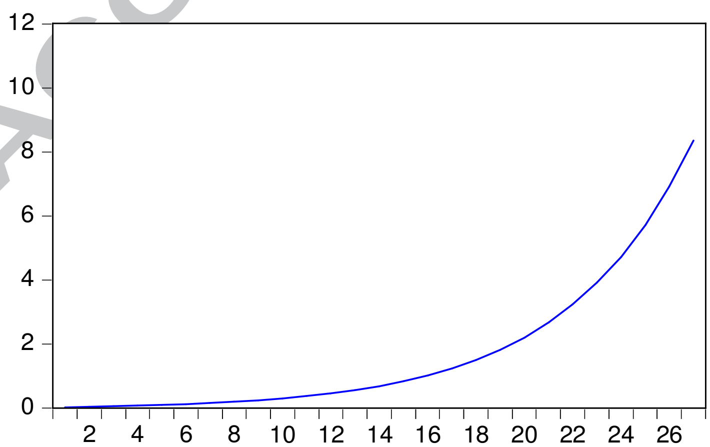


Table 1: Descriptive statistics

	REAL_GDP_PC	MOBILE_SUBS_	INTERNET_USER	FD	SQUARE_INTERNET_USER
Mean	8.512553	41.26847	8.042842	4.844971	174.9706
Median	8.467849	23.70081	6.346619	5.083703	40.27958
Maximum	8.679104	130.5580	41.00000	5.306172	1681.000
Minimum	8.405700	0.015438	0.000000	0.000000	0.000000
Std. Dev.	0.096169	44.21209	10.73761	1.072034	416.8652
Skewness	0.610196	0.672753	2.008935	-4.266593	2.791164
Kurtosis	1.741307	2.001529	6.166241	19.83417	9.598705
Jarque-Bera	2.945594	2.690360	25.07801	341.3628	71.59258
Probability	0.229283	0.260493	0.000004	0.000000	0.000000
Sum	195.7887	949.1747	184.9854	111.4343	4024.324
Sum Sq. Dev.	0.203465	43003.59	2536.516	25.28364	3823084.
Observations	23	23	23	23	23

Table 2: Variance Inflation Factors (VIF) results

Variable	Coefficient Variance	Centered VIF
FD	0.000650	5.358750
INTERNET_USER	0.000719	1.733282
TO	2.46E-14	6.246992
C	4.390224	NA

Table 3: Unit root tests

DF-GLS		KPSS		PP	
	Trend &intercept		Trend &intercept		Trend &intercept
GDP		**GDP**		**GDP**	
Level	-1.3910*,**,***	Level	0.172095*	Level	-1.375(0.85)*,**,***
1st Diff:	-3.1051*,**	1st Diff:	0.074310*,**,***	1st Diff:	-3.115(0.12)*,**,***
Internet User		**Internet User**		**Internet User**	
Level	-2.0625	Level	0.1479*	Level	1.5891(1.00)
1st Diff:	-2.5856*,**,***	1st Diff:	0.1313*,**	1st Diff:	-2.488 (*0.32)*,**,***
FD		**FD**		**FD**	
Level	-5.323**,***	Level	0.077	Level	-5.176(0.00)**,***
1st Diff:	-8.6154*,**,***	1st Diff:	0.500*,**,***	1st Diff:	8.263(0.00)*,**,***

Notes
* indicates statistical significance at the 1% level
** indicates statistical significance at the 5% level
*** indicates statistical significance at the 10% level

Table 4: Zivot–Andrews structural break unit root test

Variable	Z&A test for level			Z&A test for 1st difference		
	T-Statistic	TB	Outcome	T-Statistic	TB	Outcome
LGDPC	-3.747	2001	Unit Root	-4.022[c]	2007	Stationary
LFD	-3.910	2007	Unit Root	-6.990[a]	1996	Stationary
LNET	-4.336	1994	Unit Root	-6.963[a]	2006	Stationary
Poverty	-2.092	2000	Unit Root	-1.691	1996	Unit Root

Note a, b, & c indicate 1 %, 5%, & 10% significance level respectively

Table 5: Johansen maximum likelihood estimation results

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.708327	50.37344	29.79707	0.0001
At most 1 *	0.442301	17.10612	15.49471	0.0284
At most 2	0.048412	1.339832	3.841466	0.2471

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.708327	33.26733	21.13162	0.0006
At most 1 *	0.442301	15.76629	14.26460	0.0287
At most 2	0.048412	1.339832	3.841466	0.2471

Table 6: Gregory-Hansen test for cointegration model: change in regime and trend

Test				Asymptotic Critical Values		
	Statistic	Breakpoint	Date	1%	5%	10%
ADF	-6.21	17	2006	-6.89	-6.32	-6.16
Zt	-6.40	17	2006	-6.89	-6.32	-6.16
Za	-28.22	17	2006	-90.84	-78.87	-72.75

Table 7: Estimated Long Run Coefficients using the ARDL (1,0,1,0) based on AIC

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
LGDPC	1.5120	8.4926	-0.17804[.071]
FD	2.2060	1.1354	-1.9430[.070]
LNET	0.2084	0.10411	2.0018[.063]
C	17.5860	13.4424	1.3082[.209]

Testing for existence of a level relationship among the variables in the ARDL model

		95% Lower Bound	95% Upper Bound
F-statistic	12.3622	3.9424	5.3660

Table 8: Error Correction Representation for the ARDL (1,0,1,0) based on AIC

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
dLGDPC	0.40043	2.4051	0.16649[.070]
dFD	0.22787	0.13387	1.7022[.107]
dLNET	0.05519	0.010939	-5.0455[.000]
ecm(-1)	0.26483	0.12044	2.1989[.042]

Table 9: Diagnostic Tests

Test Statistics	LM Version
R Square 0.98	Adjusted R Square 0.97
Serial Correlation $\chi^2(1)$= 3.307[0.069]	Normality $\chi^2(2)$= 0.419[0.081]
Functional Form $\chi^2(1)$= 0.159[0.690]	Heteroscedasticity $\chi^2(1)$= 2.388[0.022]

Table 10: Granger causality test results

Null Hypothesis:	Obs	F-Statistic	Prob.
INTERNET_USER does not Granger Cause REAL_GDP_PC	27	3.27750	0.1828
REAL_GDP_PC does not Granger Cause INTERNET_USER		1.08493	0.0080
FD does not Granger Cause REAL_GDP_PC	27	10.1675	0.1239
REAL_GDP_PC does not Granger Cause FD		0.32793	0.0722
FD does not Granger Cause INTERNET_USER	27	0.00013	0.1009
INTERNET_USER does not Granger Cause FD		1.70191	0.0244

Table 11: Results from Dynamic ordinary least squares (DOLS)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INTERNET_USER	0.018648	0.006548	2.847963	0.0116
FD	0.017460	0.034494	-0.506181	0.0696
C	8.516761	0.153078	55.63662	0.0000
R-squared	0.755725	Mean dependent var		8.504958
Adjusted R-squared	0.733588	S.D. dependent var		0.085313
S.E. of regression	0.051642	Sum squared resid		0.042670
Durbin-Watson stat	0.570407	Long-run variance		0.005626

Table 12: Results from Variance decomposition analysis

Period	S.E.	REAL_GDP_PC	INTERNET_USER	FD
1	0.017596	100.0000	0.000000	0.000000
2	0.031709	94.27769	0.580184	5.142128
3	0.044279	91.82932	1.794630	6.376052
4	0.054554	87.51238	5.358725	7.128892
5	0.063894	78.61335	13.12273	8.263920
6	0.074143	65.60554	24.91782	9.476635
7	0.086830	51.29053	38.19887	10.51060
8	0.102745	38.65510	50.01227	11.33263
9	0.122194	29.07286	58.89879	12.02835
10	0.145539	22.55727	64.78232	12.66042
11	0.173505	18.60169	68.16930	13.22901
12	0.207207	16.57043	69.72455	13.70503
13	0.248057	15.80792	70.12403	14.06805
14	0.297698	15.72308	69.95644	14.32049
15	0.358021	15.87399	69.64419	14.48182
16	0.431239	16.00208	69.42064	14.57728
17	0.519987	16.00639	69.36374	14.62988
18	0.627428	15.88743	69.45527	14.65730
19	0.757374	15.69205	69.63630	14.67165
20	0.914428	15.47477	69.84488	14.68034
21	1.104154	15.27760	70.03514	14.68726
22	1.610000	15.01973	70.27980	14.70047

HIGHLIGHTS OF THE RESULTS

- **Investigate the relationship among Internet use, economic growth and financial development**
- **Internet use has grown rapidly in the last few years in South Africa**
- **The ARDL bounds testing is applied**
- **Internet use and financial development stimulate economic growth**
- **Further investment in Internet infrastructure is recommended.**