THE IMPACT OF INFORMATION COMMUNICATION TECHNOLOGY (ICT) ON ECONOMIC GROWTH: A CASE FOR SOUTH AFRICA

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Abstract

This paper investigates the impact of Information Communication Technology on economic growth in South Africa. The study intends to establish correlation in a developing country such as South Africa where the existence of such a relationship has not been distinctly determined. The model is estimated by using the cointegration and causality analysis and the interrelationships among the variables will be captured by employing the Johansen Cointegration method. The Generalized Impulse Response Function is also introduced to further explore the dynamic relationship among the variables. The results exhibit the incidence of a positive association between Information Communication Technology and economic growth.

Keywords: Information Communication Technology, Economic Growth, Cointegration, Generalized Impulse Response Function, South Africa

JEL Code: C01, O30, O40

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1 Introduction

The emergence of Information Communication Technology (ICT) as a driver of economic growth has intensified the need to develop economic models that will represent the present technological era particularly in developing nations. Avgerou (2003) emphasised this fact by stating that ICT was being consistently identified as a necessity to facilitate economic growth and improve social conditions. However, there was a concern that developing countries were disadvantaged with regard to access to the opportunities for economic growth and life improvement due to the scarcity of ICT and in particular limited internet connectivity due to the digital divide. According to the Organisation for Economic Corporation and Development (OECD) (2005) the scarcity of ICT was assumed to be an imperative factor in terms of its contribution to the widening of the gap between developed and developing countries. Evidence of a positive contribution to the growth of economies as shown by growth in Asia in the 1990s has been provided by several developing countries.

South Africa which exhibits the characteristics of both an advanced and a developing country has not been excluded from this "technology rush". Statistics South Africa (StatsSA) under the Information and Communication Technology Satellite Account drawn from the National Accounts indicates that the contribution made by the ICT sector to the South African economy is progressively increasing. According to the report, the total domestic output at basic prices of the ICT sector stood at R164 895 million in 2006 with telecommunication services making the largest contribution (R120 804 million or 73.3%) and R229 058 million in 2011 with the telecommunication services being the largest contributor at R160 603 million or 70.0%. Whereas the direct input of the information and communication sector to the gross domestic product (GDP) of South Africa was 4.0% of total GDP in 2006 and 3.2% of total GDP in 2011 (Statssa, 2014).

Although Farhadi *et a*l. (2012); Ahmed and Ridzuan (2013) and Vu (2014) have established the correlation in the relationship between ICT and economic growth. Therefore the general observation made this study from the literature is that the majority of these studies have proven the existence of this relationship mainly in the developed countries hence, the same evidence seems to be minimal for developing countries. This might be attributed to the fact that ICT has only been recently seen as one of the key elements in driving up economic growth in this technological era. However, researchers such as Olawepo and Joseph (2014) took the initiative to study the influence ICT had on the economic growth in Nigeria. Other developing countries like South Africa however are still lagging behind in terms of research involving ICT as one of the pillars of economic growth; hence this study intends to fill in this research gap in the literature. Furthermore, this study seems to be the first of its kind to utilise econometric tools for this type of investigation in the South African context.

In essence, the ultimate aim is to investigate the impact of ICT use on economic growth in South Africa. The study is deployed as follows: Section 2 is a review of the literature; Section 3 contains the research method including the data sources, model specification and definition of variables. Section 4 confers on the empirical results of the study and lastly Section 5 concludes the paper.

2 Literature review

Various studies have explored the relationship between ICT and economic growth and in general most of them validate the existence of a positive association between the two variables. Oliner and Sichel (1994) investigated the impact of computer components (hardware, software and telecommunication equipment) on economic growth in the US. Their results indicated the presence of a highly correlated relationship between ICT and economic growth in the late 1990s.

A study conducted by Jalava and Pohjola (2002) cited the production and the usage of ICT as reasons for an enhanced economic performance in the US around the 1990s. Jalava and Pohjola further provide evidence that ICT use contributed to output growth from 0.3 % in the early 1990s to 0.7% in the late 1990s. Jorgenson (2001) also investigated the connection between Information Technology (IT) and the US economy. He used the broad definition of IT which includes outputs of computers, communications equipment and software. Jorgenson stated that US GDP figures also included the services of IT products consumed by households and governments. Furthermore Jorgenson also noted that the increasing importance of steadily rising importance of IT had created new research opportunities in all areas of economics.

Farhadi *et al.* (2012) confirmed the positive association between ICT usage as determined by the number of internet users, fixed broadband internet subscribers and the number of mobile subscription per 100 inhabitants and economic growth using the Generalized Method of Moments (GMM) estimator in 159 countries. The coefficient index of ICT use was found to be 0.17 which meant that an improvement of a country's ICT use index by 1% led to an improvement of the economic growth by 0.17%. Pradhan *et al.* (2014) examined the association between the development of telecommunication infrastructure (DTI), economic growth and four indicators that operationalize a modern economy: gross capital formation, foreign direct investment inflows, urbanization rate and trade openness in the G-20 countries. The study was conducted over the period 1991-2012 by employing a panel vector auto regressive model for identifying Granger causality. They found confirmation of a bi-directional causality between DTI and economic growth in addition to long-run associations between the variables.

Vu (2014) adopted a parsimonious model to examine correlation among ICT and economic growth in Singapore:

$$Z\_gr_{u} = \beta_0 + \beta_1 InZ\_0_{u} + \beta_2 EMP\_gr_{u} + \beta_3 ICTI\_avg_{u} + \delta_i + \eta_t + \varepsilon_{it} \quad (1)$$

Vu found evidence of a substantial positive relationship between the heightened use of ICT and value-added and labour productivity growth at sector level. Secondly, it was found that ICT invested roughly 1% to Singapore's GDP during 1990-2008. Finally, the input made by the ICT manufacturing sector to Singapore's growth was noteworthy but weakening as it encountered problematic restructuring challenges.

In a similar case, Olawepo and Joseph (2014) investigated the impact of ICT on economic development in Nigeria for the period 1970 to 2010. They employed Ordinary Least Squares (OLS) in their analysis and their results revealed that ICT had not only created an avenue for economic growth in Nigeria but they also found that ICT is an important factor determining economic growth in Nigeria. Charlo (2011) studied the impact of ICT and innovation on industrial productivity in Uruguay by using generalized least squares, instead of OLS because he deemed it to be ineffective. Charlo further estimated by weighted least squares for panel data (GWLS), which estimates weighting factors based on the estimations of specific error variances for the respective sample units. The econometric approximations revealed that a rise of ICT capital leads to a rise in productivity the isolated effect of this variable is considered. According to the results, the opposite occurs with innovation, which independently does not yield the anticipated results on productivity. The outcomes do certainly reveal the negative impact carried by innovation, however, this is regressed when it interacts with capital or ICT capital investments.

Although majority of studies indicate a positive relationship between ICT and economic growth, there are a few studies which have found a negative association of this relationship. In their Endogenous Growth Theory, Aghion and Howitt (1998) stated that any form of technological change would result in a fall in the output or capital ratio due to diminishing returns to capital being continually offset by technological processes. Jacobsen (2003) also found no evidence of a noteworthy positive association between computer penetrations on the economic growth of 84 countries during 1990–1999 periods; however the strong correlation between GDP and main telephone lines was confirmed.

3 Data

3.1 Data

Due to data limitations, the study employed annual time series data covering the period 1980 – 2013. That been the case, following studies such as Katz and Koutroumpis (2012) and Kuppusamy *et al*. (2009), a period of 33 years is considered to warrant a sound conclusion in this study. Data for GDP at market prices (current prices in millions (Rands)) and the gross fixed capital formation (current prices in millions (Rands)) are accessed from the South African Reserve Bank Quarterly Bulletin. On the other hand, data for telephone lines per 100, the proxy variable for ICT is obtained from World Development Indicators, whilst the data for unemployment rate, a proxy variable for labour is obtained from Quantec.

3.2 Analytical framework

Following Fosu and Magnus (2006)'s approach this paper employs the standard form of the Cobb-Douglas production function. The function is commonly used for representing the technological relationship between two or more inputs, more specifically physical capital and labour. This production function is widely used by economists because it appears to be a good representation of the real world (Valdés, 1999). The basic form of the Cobb-Douglas function is as follows:

$$Y = AL^{\beta}K^{\alpha} \tag{2}$$

Where Y represents the total production, K refers to the physical capital, L is labour and A is the total factor productivity which caters for output growth not accounted for by the growth in the specified factors of production or a positive constant. Finally, β and α are the output elasticities of capital and labour whose values are determined by the available technology.

The analytical framework of this study is depicted in equation 3 with ICT as the main dependent variable. The *L* symbol before each variable in our model indicates that they were transformed into logarithms because using an un-logged form of the variables makes the effective relationship non-linear (Benoit, 2011). Established on the Cobb-Douglas production function, our estimable linear function is specified as follows:

$$LGDP = \beta_0 + \beta_1 LGCF + \beta_2 LLAB + \beta_3 LICT + \varepsilon_t \tag{3}$$

Where $LGDP$ is the Gross Domestic Product in Current Prices (R, millions); $LGCF$ is total fixed capital formation(current prices in R millions); $LLAB$ is the unemployment rate which has been used as a proxy variable for labour; $LICT$ is the number of telephone lines per 100 as a proxy variable; β_0 is the constant and ε_t is the stochastic term. The variables $LGCF$ and $LLAB$ are introduced in the model to avoid the problem of omitted variable bias which occurs when causality is tested using only two variables (Eita, 2012). $LICT$, which is our target variable will be placed last in the ordering of variables in our model (Noumbissie and Mongale, 2014).

3.3 Methodology

3.3.1 Unit root tests

Prior to any estimation on the variables, it is imperative to conduct stationarity tests (tests for unit root). According to Mahadeva and Robinson (2004) stationarity is a crucial part of estimation because employing the least squares regression technique on nonstationary variables can result in ambiguous parameter estimates of the relationship between the variables. There are various tests for stationarity that are utilised to declare as to whether a particular series is stationary or exhibits the incidence of a unit root. This paper employs the Augmented Dickey Fuller (ADF) developed by Dickey and Fuller (1979) and the Phillips-Perron (PP) test developed by Phillips and Perron (1988) in order to substantiate the stationarity of the variables. The null hypothesis (H_0) of the ADF test hypothesises that a time series y_t is integrated of order 1 I(1), against the alternative hypothesis (H_1) that a time series is integrated of order zero I(0) with the presumption that the dynamics in the data have an ARMA structure (Zivot and Wang, 2007). The basis for estimating the ADF test regression is as follows:

$$y_t = \beta^{'} D_t + \phi y_{t-1} + \sum_{j=1}^{p} \psi_j \, \Delta y_{t-1} + \varepsilon_t \quad (4)$$

The PP test also hypothesises the incidence of a unit root for the null hypothesis (Kirchgässner *et al*, 2008). The basis for estimating the PP test regression is:

$$\Delta y_t = \beta^{'} D_t + \pi y_{t-1} + \mu_t \quad (5)$$

This test has advantages over the ADF test. It is regarded to have more robustness to general forms of heteroskedasticity in the error term (μ_t) and also for the fact that lag specification for the test regression by the user is not necessary (Zivot and Wang, 2007).

3.3.2 Cointegration test

The Johansen Cointegration Approach has been utilised to investigate the dynamic short-run and long-run relationship among the variables. The Johansen method starts with a VAR representation of the variables:

$$\Delta y_t = \mu + \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-1} + \varepsilon_t \quad (6)$$

Where y_t is an $n \times 1$ vector of variables that are integrated of order one and ε_t is an $n \times 1$ vector of innovations. A coefficient matrix Π with a reduced rank $r < n$, implies the existence of $n \times r$ matrices α and β each with rank r such that Π = $\alpha\beta^{'}$ and $\beta^{'} y_t$ are stationary, whilst r is the number of cointegrating relationships. The Johansen Cointegration approach depends on two different likelihood ratio tests of the reduced rank of the matrix; namely, the trace test and the maximum eigenvalue test denoted as follows:

The trace test

$$LR^0_{trace}(r_0) = -T \sum_{j=r0+1}^{n} \log(1-\lambda_j) \quad (7)$$

and the maximum eigenvalue test

$$LR^0_{\max}(r_0) = -T \log(1-\lambda_{r0+1}) \quad (8)$$

Where T is the sample size and λ_j is the largest canonical correlation of Δy_t with y_{t-1} after correcting for lagged differences and deterministic variables when present (Hjalmarsson and Österholm, 2010). The Johansen Cointegration method is popular for conducting cointegration tests because of its ability to capture the log-run relationships among the variables and to provide the estimates of all possible cointegrating vectors that exist amongst these variables (Yuan and Kochhar, 1994).

3.3.3 Pairwise Granger Causality test

The standard Granger-Causality has been conducted as means of ascertaining the existence of a causal uni-directional or bi-directional relationship amongst the variables and it is presented as follows:

$$LGDP_t = a_1 + \sum_{j=1}^{p} \alpha_j LGDP_{t-j} + \sum_{j=1}^{p} \beta_j LICT_{t-j} + \varepsilon_t \quad (9)$$

$$LICT_t = a_2 + \sum_{j=1}^{p} \delta_j LGDP_{t-j} + \sum_{j=1}^{p} \phi_j LICT_{t-j} + v_t \quad (10)$$

The Granger Causality method was established by Granger (1969) in which a variable x was said to cause y on condition that the forecast of the existing y was heightened by utilising preceding values of x. Granger causality is implemented empirically by regressing y on past, current and future values of x (Kennedy, 2003).

3.3.4 Generalized impulse response function

According to Tong *et al.* (2011) an impulse response function (IRF) could be a measure of the time profile of the effect of a shock at a given point in time on the expected future values of variables in a dynamical system. They further state that an impulse response is best described if seen as a result of a theoretical investigation in which the time profile at a time, $t+n$ of the effect of a hypothetical $m \times 1$ vector of shocks of size $\delta = (\delta_{1,\ldots\ldots,}\delta_m)'$. Moreover, they also mention that a pivotal mechanism to the properties of the impulse response function is a correct choice of hypothesized vector of shocks δ. The Cholesky decomposition of Σ, $\Sigma = PP'$ orthodox method of the IRF is employed in resolving problem surrounding the choice of δ. Koop *et al.* (1996) instigated the concept of generalized impulse response function (GIRF) and they argued it to be relevant for both linear and nonlinear models and is defined as:

$$GI_x(n,\delta,\Omega_{t-1}) = E(x_{t+n} | \varepsilon_t = \delta, \Omega_{t-1}) - E(x_{t+n}) | \Omega_{t-1}) \quad (11)$$

A distinguishing factor of the GIRF from the IRF is its exclusion of the orthogonalization of shocks and the fact that it is invariant to the ordering of the variables in the VAR system.

4 Empirical results

4.1 Unit root test

All the variables are tested for stationarity using the ADF and the PP unit root tests. The two tests were implemented by including trend and intercept, intercept and also none in the test regression equation and the results are presented in Table 1. The PP test was conducted so as to affirm the ADF test results and results are presented in Table as follows:

Table 1. Unit root analysis

Variables		ADF		PP	
		Levels	1st Difference	Levels	1st Difference
LGDP	Trend & Intercept	-0.119307	-3.981669**	-0.241929	-3.973059**
	Intercept	-6.152447***	-2.241867	-5.403778***	-2.241867
	None	1.399806	-0.884267	9.235436	-1.323487
LGCF:	Trend & Intercept	-4.030458**	-3.619564**	-2.250014	-3.487171*
	Intercept	-0.013224	-4.442522***	-0.354012	-3.542589**
	None	3.730506	-2.038365**	10.14236	-1.936312*
LLAB:	Trend & Intercept	-2.253298	-5.905165***	-2.907022	-10.48824***
	Intercept	-2.976043	-5.330389***	-7.136008***	-5.321372***
	None	1.640201	-4.940221***	1.612115	-4.924358***
LICT:	Trend & Intercept	-0.914222	-4.180538***	-0.996177	-4.013162**
	Intercept	-2.317051	-3.276492***	-3.056099**	-3.276492**
	None	0.647007	-3.210127***	1.181358	-3.210127***

Note: ADF and PP tests statistics and levels of significance = * 10% level, **5% level, *** 1% level

In terms of the ADF test, for the level series, the null hypothesis of a unit root process for the series' LLAB and LICT cannot be rejected because they exhibit the presence of a unit root at levels while series' LGDP and LGCF appear to be stationary at levels. However, under first difference form, all the series appear to be stationary at first difference. The PP test confirms the results obtained via the ADF unit root test for all series because all the variables become stationary in the first difference. Therefore the conclusion is that since stationarity is mainly obtained at first difference, all the variables are integrated of order 1, I (1), hence the null hypothesis of the presence of a unit root is rejected in support of the alternative hypothesis which states that the series does not exhibit a unit root.

4.2 Johansen cointegration

The next step is to establish the existence of a cointegration relationship amongst the variables using the Johansen cointegration approach. The trace statistic and the maximum Eigen value are the two measures used for the cointegration test. The results on Table 2 demonstrate the presence of two cointegrating vectors for the trace statistic and two cointegrating vectors for the maximum Eigen value as well. The study concludes that a long-run association among the variables employed for estimation is present.

Table 2. Unrestricted cointegration rank tests (Trace and Maximum Eigen Value)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Max-Eigen Statistic	0.05 Critical Value
None	0.647092	71.01361*	47.85613	33.32957*	27.58434
At most 1	0.515604	37.68405*	29.79707	23.19525*	21.13162
At most 2	0.351902	14.48880	15.49471	13.87883	14.26460
At most 3	0.018881	0.609964	3.841466	0.609964	3.841466

Note: Trace and Max-Eigen test indicate 2 cointegrating equations(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

The presence of a cointegration relationship implies that LGDP, LGCF, LLAB and LICT have similar stochastic trends.

4.3 Diagnostic and stability tests

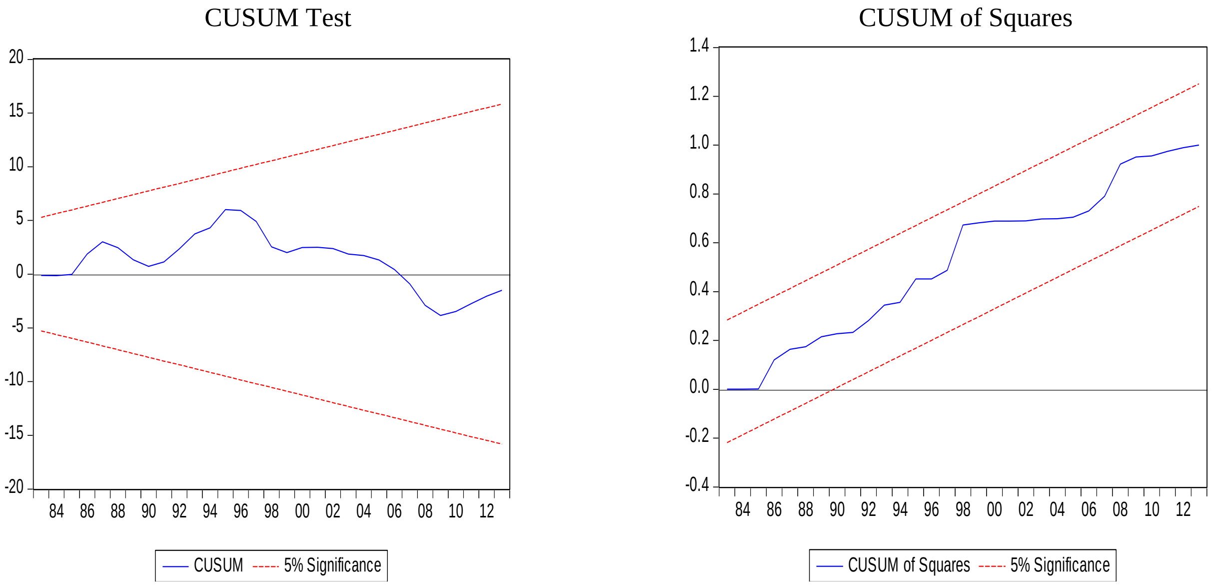
Various statistical diagnostic and stability tests such as White's heteroskedasticity test, Jaruqe-Bera test for normality, Ramsey's RESET test and the CUSUM test (cumulative sum) and the CUSUM test of squares were conducted. The diagnostic tests in Table 3 reveal that the residuals are homoscedastic, there are no misspecification errors and the residuals are normally distributed.

Table 3. Diagnostic tests analysis

Test	p-value	Conclusion
White's Heteroskedasticity test (no cross terms)	0.1552	Failure to reject H_0
Ramsey RESET	0.1042	Failure to reject H_0
Jarque-Bera Normality test	0.9552	Failure to reject H_0

The CUSUM test Figure 2 illustrates that the model is fairly stable as the cumulative sum moves inside the critical lines and continues to the end of the period. This movement between the lines of significance at 5% is therefore an indication of stability. The CUSUM of squares test in Figure 3 gives results similar results.

Figure 2. CUSUM test and CUSUM of squares



Since both the stability tests find the parameters of the model to be stable, the implication is that there is stability in the equation during the sample period is clearly indicated.

4.4 Pairwise Granger causality

This paper also anticipated to establish the presence of a causal relationship between GDP and ICT by performing the Vector Autoregressive Methodology (VAR) which permits the testing of a causal relationship using the Granger procedure. The results in Table 4 show that causality occurs amongst LGDP and LICT therefore null hypothesis of no causality is rejected. Evidence of causality is also found amongst the variables LGCF and LGDP, LLAB and LGDP, LLAB and LGFCF and LICT and LGFCF therefore the null hypothesis for these variables is also rejected.

Table 4. Granger Causality results

Null Hypothesis	Obs	F-Statistic	Probability
LOG_GFCF does not Granger Cause LOG_GDP	31	0.20859	0.8894
LOG_GDP does not Granger Cause LOG_GFCF		1.48619	0.2435
LOG_LAB does not Granger Cause LOG_GDP	31	0.68839	0.5680
LOG_GDP does not Granger Cause LOG_LAB		0.57320	0.6381
LOG_ICT does not Granger Cause LOG_GDP	31	0.78960	0.5116
LOG_GDP does not Granger Cause LOG_ICT		0.82480	0.4931
LOG_LAB does not Granger Cause LOG_GFCF	31	1.38939	0.2701
LOG_GFCF does not Granger Cause LOG_LAB		0.68396	0.5706
LOG_ICT does not Granger Cause LOG_GFCF	31	0.28820	0.8334
LOG_GFCF does not Granger Cause LOG_ICT		2.29243	0.1037
LOG_ICT does not Granger Cause LOG_LAB	31	4.18252	0.0162
LOG_LAB does not Granger Cause LOG_ICT		1.73259	0.1871

$\alpha = 0.05$ Decision rule = reject H_0 if P-value<0.05

4.5 Generalized impulse response function

As indicated in section 3, this study is also imperative to introduce the impulse response function to investigate the dynamic relationship of the variables and the results are presented in Figure 4.

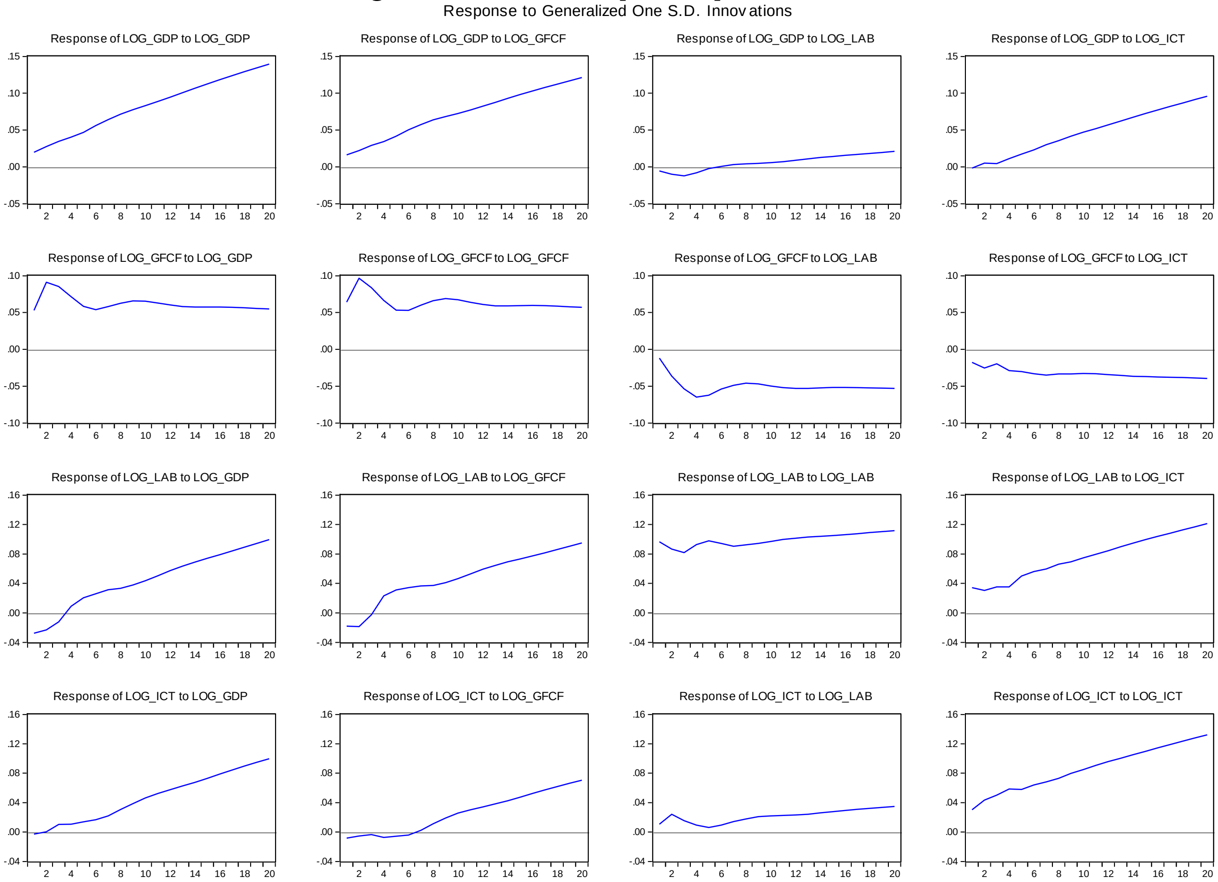
The results reveal a positive relationship between LOG_GDP and LOG_ICT from the beginning until the end of the projected period. The positive impact continued through the estimated period with the level of the impact steadily rising up to the 20^{th} period.

5 Concluding remarks

This study analysed the impact of ICT an economic growth in South Africa. ICT has recently gained importance as a driver of economic growth in both developing and developed countries with various countries finding evidence of a positive association between the two. The study adopted the Cobb-Douglas production function as a basis for the econometric model and the Johansen Cointegration Approach was applied in the estimation of the model. The estimation covered the period 1980-2013. Telephone lines per 100 were included as a proxy for ICT in South Africa. The results indicate a positive relationship between economic growth and ICT. The results further show the incidence of a long run relationship between ICT and economic growth. This may be attributed to the significance of the ICT coefficient and the conclusion is that this variable has a noteworthy influence on GDP in South Africa. The conclusion is that ICT has a considerable effect on the level of GDP in the South African economy.

Empirical literature has also proven the positive impact that ICT has on economic growth around the globe. The implication of our results to the policy makers in South Africa and other emerging economies is that ICT should be integrated in issues of the economy which will in turn translate into growth. The paper therefore aims to advise policymakers to adopt policies aimed at increasing the use of ICT on all levels. This can be achieved by creating an enabling environment, that is, properly equipping individuals with the necessary ICT tools such as accessibility to the internet and so forth as a deliberate action of improving growth.

Figure 4. Generalized impulse response function



References

1. Aghion, P. and Howitt, P. (1998). Endogenous Growth Theory. Cambridge MA: MIT Press.
2. Ahmed, E.M. and Ridzuan, R. (2012). The Impact of ICT on East Asian Economic Growth: Panel Estimation Approach, Journal of the Knowledge Economy, Vol.4: pp.540-555.
3. Avgerou, C. (2003). The Link Between ICT and Economic Growth in the Discourse of Development, in M. Korpela, R. Montealegro and A. Poulymenakou (eds.) Organizational Information Systems in the Context of Globalization, Dordrecht: Kluwer.
4. Benoit, K. (2011). Linear Regression Models with Logarithmic Transformations. http://www.kenbenoit.net/courses/ME104/logmodels2.pdf Date of Access: 6 September 2014, London School of Economics and Political Science Manuscript.
5. Charlo, G. (2011). In ICT in Latin America: A Microdata Analysis. Impact of ICT and Innovation on Industrial Productivity in Uruguay, United Nations, Santiago, Chile – United Nations.
6. Dickey, D.A. and Fuller, W.A. (1979). Distribution of the Estimators for Autoregressive Time Series with a Unit Root, Journal of the American Statistical Association, Vol.74: pp. 427-431.
7. Eita, J.H. (2012). Modelling Macroeconomic Determinants of Stock Market Prices: Evidence from Namibia, Journal of Applied Business Research, Vol.28: pp. 871-884.
8. Farhadi, M., Ismail, R. and Fooladi, M. (2012). Information and Communication Technology Use and Economic Growth, PLoS ONE 7: 1-7.
9. Fosu, O.A.E. and F.J. Magnus, (2006). Bounds testing approach to cointegration an examination of foreign direct investment, trade and growth relationships, American Journal of Applied Sciences, Vol. 3: pp. 2079-2085.
10. Granger, C. W. J. (1969). Investigating Causal Relations by Econometric Models and Cross-spectral Methods, Econometrica, Vol. 37: pp. 424–438.
11. Hjalmarsson, E. and Österholm, P. (2010). Testing for Cointegration Using the Johansen Methodology When the Variables are Near-Integrated: Size Distortions and Partial Remedies, Empirical Economics, Vol. 39: pp. 51-76.
12. Jacobsen, K.F.L. (2003). Telecommunications: A Means to Economic Growth in Developing Countries? CMI Report, Chr. Michelsen Institute, Bergen, Norway.
13. Jalava, J. and Pohjola, M. (2002). Economic Growth in the New Economy: Evidence from Advanced Economies, Information Economics and Policy, Vol. 14: pp. 189–210.
14. Johansen, S. (1991). Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models, Econometrica, Vol. 59: pp. 1551–1580.
15. Jorgenson, D.W. (2001). Information Technology and the U.S. Economy, American Economic Review, Vol. 91: pp. 1–32.
16. Kennedy, P. (2003). A Guide to Econometrics, 5th Edition, Cornwall: MPG Books.

17. Kirchgässner, G., Wolters, J. and Hassler, U. (2008). Introduction to Modern Time Series Analysis, 2nd Edition, New York: Springer.
18. Kuppusamy, M., Raman, M. and Lee, G. (2009). Whose ICT Matters to Economic Growth: Private or Public? The Malaysian Perspective, Electronic Journal of Information Systems in Developing Countries, Vol. 37: pp. 1-19.
19. Mahadeva, L. and Robinson, P. (2004). Unit Root Testing to Help Model Building, Handbooks in Central Banking, (Eds. Andrew Blake and Gill Hammond), Centre for Central Banking Studies, Bank of England.
20. Noumbissie, F.F. and Mongale, I.P. (2014). The Impact of Monetary Policy on Financial Markets in South Africa: VAR Analysis. Journal of Economics and Behavioral Studies, Vol.6: pp. 636-646.
21. OECD. (2005). Good Practice Paper on ICTs for Economic Growth and Poverty Reduction. http://www.oecd.org/dac/35284979.pdf Date of Access: 6 September 2014.
22. Olawepo, G.T. and Joseph, A.L. (2014). The Impact of Information Communication Technology (ICT) on Economic Growth: Evidence from Nigeria, Journal of Social Sciences and Public Policy, Vol. 6: pp. 46-53.
23. Oliner, S.D. and Sichel, D.E. (2000). The Resurgence of Growth in the late 1990s: Is Information Technology the Story?, Journal of Economic Perspectives, Vol. 14: pp. 3–22.
24. Phillips, P.C.B and P. Perron. (1988). Testing for a Unit Root in Time Series Regression, Biometrika, Vol. 75: pp. 335–346.
25. Pradhan, R.P, Arvin, M.B., Norman, N.R and BELE, S.K. (2014). Economic Growth and the Development of Telecommunications Infrastructure in the G-20 Countries: A Panel-VAR Approach, Telecommunications Policy, Vol. 38: pp. 634–649.
26. Raul, K and Koutroumpis, P. (2012). The Economic Impact of Telecommunications in Senegal, Communications and Strategies, Vol. 1: pp. 21-42.
27. Statistics South Africa. (2014). National Accounts: Information and Communication Technology Satellite Account for South Africa, 2006 – 2011. Report No.: 04-07-01, March 2014.
28. Tong, H., Kumar, K and Huang, Y. (2011). Developing Econometrics, Chichester: John Wiley & Sons, Ltd.
29. Valdés, B. (1999). Economic Growth: Theory, Empirics and Policy, Cheltenham: Edward Elgar Publishing Limited.
30. Vu, K. (2014). Information and Communication Technology (ICT) and Singapore's Economic Growth, Journal of Information Economics and Policy, Vol. 25: pp. 284–300.
31. Yuan, M. and Kochhar, K. (1994). China's Imports: An Empirical Analysis Using Johansen's Cointegration Approach, International Monetary Fund Working Paper, WP/94/145.
32. Zivot, E. and Wang, J. 2007. Modeling Financial Time Series with S-PLUS, 2nd Edition, New York: Springer Science + Business Media Inc.