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 al. (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:

$$Z_{gr} = \beta_0 + \beta_1lnZ_{0} + \beta_2EMP_{gr} + \beta_3ICTI_{avg} + \delta_1 + \eta_i + \epsilon_t$$

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 Quantecc.

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:

\[ Y = AL^\beta K^\alpha \]  

(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, \( \beta \) and \( \alpha \) are the output elasticities of capital and labour whose values are determined by the available technology.

\[ LGDP = \beta_0 + \beta_1 LGCF + \beta_2 LLAB + \beta_3 LICT + \varepsilon_i \]  

(3)

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:
\begin{equation}
y_i = \beta D_t + \phi y_{t-1} + \sum_{j=1}^{p} \gamma_j \Delta y_{t-j} + \epsilon_i
\end{equation}

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:

\begin{equation}
\Delta y_t = \beta D_t + \gamma y_{t-1} + \mu_t
\end{equation}

This test has advantages over the ADF test. It is regarded to have more robustness to general forms of heteroskedasticity in the error term (\(\mu_t\)) 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:

\begin{equation}
\Delta y_t = \mu + \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \epsilon_t
\end{equation}

Where \(y_t\) is an \(n \times 1\) vector of variables that are integrated of order one and \(\epsilon_t\) is an \(n \times 1\) vector of innovations. A coefficient matrix \(\Pi\) with a reduced rank \(r < n\), implies the existence of \(n \times r\) matrices \(\alpha\) and \(\beta\) each with rank \(r\) such that \(\Pi = \alpha \beta^\prime\) 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

\begin{equation}
LR^0_{\text{trace}} (r) = -T \sum_{j=r+1}^{n} \log(1 - \lambda_j)
\end{equation}

and the maximum eigenvalue test

\begin{equation}
LR^0_{\text{max}} (r) = -T \log(1 - \lambda_{r+1})
\end{equation}

Where \(T\) is the sample size and \(\lambda_j\) is the largest canonical correlation of \(\Delta y_t\) 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 unidirectional or bi-directional relationship amongst the variables and it is presented as follows:

\begin{equation}
LGDP_i = \alpha_1 + \sum_{j=1}^{p} \alpha_j LGDP_{i-j} + \sum_{j=1}^{p} \beta_j LICT_{i-j} + \epsilon_i
\end{equation}

\begin{equation}
LICT_i = \alpha_2 + \sum_{j=1}^{p} \delta_j LGDP_{i-j} + \sum_{j=1}^{p} \phi_j LICT_{i-j} + \epsilon_i
\end{equation}

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 an effect of a hypothetical m×1 vector of shocks of size δ=(δ₁,⋯,δₘ). 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=ΠΠ' 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:

\[ G_{t+s}(n,δ,Ω_{t-1}) = E(x_{t+s} | x_{t+s} = δ,Ω_{t-1}) - E(x_{t+s} | Ω_{t-1}) \]  

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>
<thead>
<tr>
<th>Variables</th>
<th>ADF treated</th>
<th>PP treated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Levels</td>
<td>1st Difference</td>
</tr>
<tr>
<td>LGDP: Trend &amp; Intercept</td>
<td>-0.119307***</td>
<td>-3.981669***</td>
</tr>
<tr>
<td>Intercept</td>
<td>-6.152447***</td>
<td>-2.241867</td>
</tr>
<tr>
<td>None</td>
<td>1.399806</td>
<td>-0.884267</td>
</tr>
<tr>
<td>LGCF:</td>
<td>Trend &amp; Intercept</td>
<td>-4.030458***</td>
</tr>
<tr>
<td>Intercept</td>
<td>-0.013224</td>
<td>-4.442522***</td>
</tr>
<tr>
<td>None</td>
<td>3.730506</td>
<td>-2.038365</td>
</tr>
<tr>
<td>LLAB:</td>
<td>Trend &amp; Intercept</td>
<td>-2.253298</td>
</tr>
<tr>
<td>Intercept</td>
<td>-2.976043</td>
<td>-5.330389***</td>
</tr>
<tr>
<td>None</td>
<td>1.6402</td>
<td>-9.490221***</td>
</tr>
<tr>
<td>LIC:</td>
<td>Trend &amp; Intercept</td>
<td>-0.914222</td>
</tr>
<tr>
<td>Intercept</td>
<td>-2.317051</td>
<td>-3.276492***</td>
</tr>
<tr>
<td>None</td>
<td>0.647007</td>
<td>-3.210127***</td>
</tr>
</tbody>
</table>

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 LIC 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)**

<table>
<thead>
<tr>
<th>Hypothesized No.</th>
<th>Eigenvalue</th>
<th>Trace Statistic</th>
<th>0.05 Critical Value</th>
<th>Max-Eigen Statistic</th>
<th>0.05 Critical Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0.647092</td>
<td>71.01361*</td>
<td>47.85613</td>
<td>33.32957*</td>
<td>27.58434</td>
</tr>
<tr>
<td>At most 1</td>
<td>0.515604</td>
<td>37.68405*</td>
<td>29.79707</td>
<td>23.19525*</td>
<td>21.13162</td>
</tr>
<tr>
<td>At most 2</td>
<td>0.351902</td>
<td>14.48880</td>
<td>15.49471</td>
<td>13.87883</td>
<td>14.26460</td>
</tr>
<tr>
<td>At most 3</td>
<td>0.018881</td>
<td>0.609964</td>
<td>3.841466</td>
<td>0.609964</td>
<td>3.841466</td>
</tr>
</tbody>
</table>

Note: Trace and Max-Eigen test indicate 2 cointegrating equation(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, Jarque-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**

<table>
<thead>
<tr>
<th>Test</th>
<th>p-value</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>White’s Heteroskedasticity test (no cross terms)</td>
<td>0.1552</td>
<td>Failure to reject H₀</td>
</tr>
<tr>
<td>Ramsey RESET</td>
<td>0.1042</td>
<td>Failure to reject H₀</td>
</tr>
<tr>
<td>Jarque-Bera Normality test</td>
<td>0.9552</td>
<td>Failure to reject H₀</td>
</tr>
</tbody>
</table>

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

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

\( \alpha = 0.05 \) 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 20th 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.
References


