The Role of Information and Communication Technology (ICT) and FDI on South African Economic Growth

Thomas HABANABAKIZE [1]
Mulatu ZERIHUN[2]

DOI: 10.24818/mer/2024.03-01

ABSTRACT
Information, communication, technology (ICT) and foreign direct investment plays a substantial role in various spheres of social and economic development. Therefore, changes in these variables can significantly impact a country's economy. The current study aims to assess the implication of information and communication technology (ICT) and FDI on South African economic growth. To achieve this objective, the autoregressive distributed lag (ARDL) model and Error Correction Model (ECM) were applied to time series data over the period 1991 to 2021. Findings obtained from econometric modelling and analysis indicate that besides the positive effect of FDI on South African economic growth, all the analysed components of ICT namely mobile phone subscriptions, fixed phones, and internet subscriptions are drivers of economic growth in South Africa. Based on the findings, from the policy perspective, it was suggested that South African economic authorities increase and improve investment in the ICT infrastructure while also attracting more foreign investors. Additionally, to benefit from FDI and ICT's drivers of economics, policymakers should endorse policies and strategies that enhance economic openness and the ICT's resource allocation.

KEYWORDS: *digitalisation, economic growth, FDI, ICT, South Africa.*

JEL CLASSIFICATION: *C33, O30, O47.*

1. INTRODUCTION

The 21st century is marked by an inordinate dispersal of information and communication technology (ICT), the cause of a significant transformation and burgeoning of global connectedness and societal information (Bahrini & Qaffas, 2019). Through improvement of the ICT's components such as internet access, mobile phones and fixed-line telephones; economic growth stakeholders (individuals, firms and governments) found an adequate and quick way to access and share, information, knowledge, opportunities, and challenges.

Consequently, the ICT's diffusion has substantively enhanced the effectiveness of resource allocation, immensely decreased costs of production, and stimulated demand and investment within various economic sectors (Grimes et al., 2012; Pradhan et al., 2015). Investing in information and communication technologies (ICT) is not only a key driver of productivity growth, but also an economic growth engine (Niebel, 2018). This view was highlighted in the World Bank (2012) report stating that the future productivity growth, poverty reduction, and economic growth in developing countries will be contingent on those countries' ability to adapt and improve their existing competencies in ICT (Steinmueller, 2001).

[1] Tshwane University of Technology, South Africa, tomhaban15@gmail.com (Corresponding author)
[2] Tshwane University of Technology, South Africa, zerihunmf@tut.ac.za.

Following the expansion of ICT and its importance in the global socio-economic transformation, many scholars and researchers were attracted to analyse and investigate the existing relationship between ICT and economic growth. However, although economic theories or a priori knowledge suggest a solo positive impact of ICT on economic growth, empirical results or posteriori knowledge revealed the opposite, as various studies conducted produced an ambiguous or mixture of results in respective of the relationship between economic growth and ICT (Vu, 2011; Sassi & Goaied, 2013). Although several empirical studies have found a positive relationship between economic growth and ICT (e.g., Roller & Waverman, 2001; Inklaar et al., 2005; Koutroumpis, 2009), other studies conducted within different countries found an inverse relationship between economic growth and ICT diffusion (e.g., Papaioannou & Dimelis, 2007; Yousefi, 2011; Pradhan et al., 2015); while other studies did not find any significant relationship between ICT components and economic growth (e.g., Pohjola, 2002; Bahrini & Qaffas, 2019). This implies that it would be irrational to generalise the relationship between ICT and economic growth.

Besides ICT, the FDI inflow is another economic variable that impacts economic growth, especially within developing economies. The importance of FDI in developing countries is justified by two main reasons. First, foreign direct investment (FDI) increases domestic capital stock within the host country (Jude & Levieuge, 2017; Akadiri et al., 2019). Second, the FDI inflows are considered to possess the positive potential for both productivity and output growth by introducing new technologies, enhancing human capital, and promoting domestic 10 exports through access to foreign markets (Jude & Levieuge, 2017; Philip et al., 2021).

Although various theoretical discussions, in the literature, emphasise the positive effect of FDI on economic growth with the hosting countries, empirical evidence has failed to provide consensus results. While some empirical findings supported the hypothesis of a positive relationship between FDI and economic growth (e.g., Javorcik, 2004; Pegkas, 2015; Aurangzeb & Stengos, 2014; Hayat, 2018; Hobbs et al., 2021), other studies (e.g., Jeon et al., 2013; Saqib et al., 2013; Rahman, 2015; Rehman, 2016) have found a converse relationship between FDI and economic growth where increase in the former causes a decline in the latter.

The ICT state and FDI levels in South Africa have recently experienced significant growth. For instance, the proportion of households using cellular phones for communication increased from 89.4% to 90.8% between 2020 and 2021 respectively; while the proportion of the population with internet access notionally increased to 77.5% in 2021 (Independent Communications Authority of South Africa (ICASA), 2023). On the other hand, South Africa has been considered one of the African economies that attract more foreign investors, and the country enjoyed capital inflows. For instance, despite the COVID-19 pandemic economic impediment, the FDI inflows have increased from $136 billion in 2020 to $173 billion in 2021(Investment Framework and Opportunities, 2023). Regardless of the aforementioned growth in ICT and FDI, since 2015, South African productivity and economic growth have faced crucial fluctuations in some economic sectors (Godongwana, 2021). Thus, it is pertinent to assess whether there is any significant relationship between economic growth, ICT 35 and FDI in South Africa; and if it does exist, to know how FDI and ICT affect South African economic growth. The existing literature highlights a positive effect of FDI and ICT development on economic growth in developed and developing courts (Dimelis & Papaioannou, 2010; Papaioannou & Dimelis, 2007). However, South Africa being one of the African countries that attract foreign investors, experienced economic sluggishness over decades. This leaves a gap or opportunity to investigate the role of FDI on economic growth

in South Africa. In other words, given the importance of the FDI and ICT on economic growth, yet with the knowledge that the relationship between these variables is contingent on an individual's economic structure, the current study aims to assess the effect of ICT diffusion on South African economic growth.

The main hypothesis of the study is that both ICT and FDI positively influence economic growth in South Africa; while the alternative hypothesis suggests that ICT and FDI have either a negative or no relationship with economic growth.

The remaining part of the study is structured as follows: Section 2 provides a concise literature review of the topic. Section 3 presents and elucidates employed data and methodology. Section 4 focuses on the presentation and discussion of empirical findings, while Section 5 concludes the study, dispenses policy implications, and suggests adequate recommendations.

2. LITERATURE REVIEW

2.1 Theoretical literature

The relationship between economic growth and ICT` is not a sudden topic and various protuberant. Economic theories such as neoclassical growth theory (Solow, 1956) and neoSchumpeterian theories (Schumpeter, 1934) have highlighted the existence of that relationship during the 20th century. These theories indicated that the advent of ICT in the economy came as a new input that improved labour quality, enhanced the production process, and thereafter increased the output. Consequently, Quah (2002), Aghaei and Rezagholizadeh (2017) argue that not only the ICT create value added at firm and sectoral level, it also increases labour productivity and economic growth. Additionally, in the traditional neoclassical economy, specifically the new growth theories, the Solow model identifies and highlights the role of technology improvement in transforming economic growth and the standard of living (Mankiw, 2020). This view was also supported by the non-traditional economic view asserting that ICT stimulates innovation enabling production spillovers, network externalities, and business-to-business transactions (Cardona et al., 2013; Paunov and Rollo, 2016).

Despite the fact that the relationship between ICT and economic growth is not a new concept, the recent rapid global progress of ICT stimulated growing attention from economists, scholars, and other researchers whose research interest was in investigating the effect of ICT diffusion on the economic growth of both developed and developing economies. Surprisingly, contrary to the solo positive effect highlighted by several economic theories, empirical findings have proven that, although irrefutable, the relationship between ICT components (mobile cellular phone, Internet usage, fixed landline telephone) and economic growth can be positive or negative (Vu, 2011; Sassi & Goaied, 2013; Niebel, 2018; Bahrini & Qaffas, 2019). Additionally, depending on the country and economic policies, in some cases, the ICT diffusion has no significant impact on economic growth. The subsequent paragraphs provide some empirical findings suggesting a mixture of the relationship between economic growth and ICT.

Economic theories also classify the FDI flow as one variable that influences economic growth, especially in developing economies. Those theories suggest that FDI enhances capital stock in the host country (Solow, 1957; De Mello, 1997; Akadiri et al., 2019), brings new technology, and improves labour productivity (DeMello, 1997; Hymer, 1976). Through

export promotion, FDI also improves market access and improves the competitiveness of the host country (Akinlo, 2004; Dunning, 1973; Akadiri & Ajmi 2020). Generally, the theoretical relationship between DFI and economic growth is highlighted in the endogenous and neoclassical theories. In the neoclassical theories view, the long-run effect of FDI on economic growth comes from labour force growth and technological innovation (Solow, 1957; De Mello, 1997). On the other hand, the endogenous growth theories hypothesise that the long-run impact of the FDI in the host economy is contingent on technological change, knowledge and technology transfer, and the growth spillover effect stimulated by FDI inflows (Akinlo, 2004; De Mello, 1997; Iamsiraroj, 2016). Consequently, theoretically, the PDF positively influence economic growth in the recipient country through capital accumulation, technology, and knowledge spillovers (Iamsiraroj, 2016).

2.2 Empirical Review and Hypothesis Development

2.2.1 ICT-Growth nexus

Analyzing the effect of telecommunication infrastructure on economic growth within 45 SubSaharan (SSA) countries, Donou-Adonsou (2019) found that internet access leads to economic growth. However, the study did not find substantial evidence that economic growth determines telecommunication improvement. Similarly, using the GMM estimator, Myovella et al. (2020) investigated the impact of digitalisation on economic growth for Economic Cooperation and Development (OECD) and SSA countries. The findings of the study indicated that the impact of mobile telecommunications on economic growth was significantly greater in SSA countries, 54 compared to OCED countries whereas Internet communication has a high influence on economic growth in OECD countries compared to SSA countries. The results of Donou Adonsou (2019) and Myovella et al. (2020) corroborated the findings from Bahrini and Qaffas (2019)'s study. Using the GMM growth model, the study analysed how ICT impacted economic growth in developing countries, the findings suggested that diffusion of ICT was a key driver of economic growth within the investigated countries. Further, Torkayesh and Torkayesh (2020) investigated the role of ICT in the G 7 economies and found that those countries that have advanced in ICTs such as the United States of America and Japan experienced high economic growth compared to other country members such as Italy and Canada. Additionally, analysing the effect of ICT on economic growth in China, Ward and Zheng (2016) applied a GMM estimator to 32 Chinese regions. The result has shown that fixed telecommunication had minimal impact on Chinese economic growth compared to the high impact of mobile telecommunication on economic growth within the regions analysed.

Although all the aforementioned reviewed empirical studies indicated a positive impact on economic growth, in developed and developing countries, some other empirical studies that scrutinised the relationship between economic growth and ICT diffusion, specifically in developing countries, found a mixture of results. For instance, studies conducted by Aghion and Howitt (1998) and Freeman and Soete (1997) indicated that, in developing countries, ICT had a negative effect on economic growth. They explained that ICT facilities allowed developed countries to open their new market within the developing countries at their expense instead of improving their economies. Additionally, ICT development permits developed countries to advance their power on the global market through the manipulation of their competitive advantage over the less competitive countries, which are the developing ones (Bahrini & Qaffas, 2019).

In addition to the negative or positive relationship that may exist between economic growth and ICT in some developed and developing countries, some studies on the interaction

between economic growth and ICT in developing countries found inconclusive results. Analysing the relationship between economic growth and ICT in 43 countries, Pohjola (2002) found that the ICT diffusion had no statically significance to cause changes of economic growth within the analysed countries. Similarly, Pradhan et al. (2015) investigated the effect of ICT infrastructure on economic growth in western Asian countries and the results suggested that the ICT diffusion in those countries had no significant impact on economic growth.

2.2.2 FDI-Growth nexus

Over a long period, several empirical studies were conducted to analyse the impact of foreign direct investment on economic growth in the host country. However, the findings of these studies provide a mixture of results, as some suggest a positive effect, while others found a negative relationship between the two variables. (Rjoub et al., 2017). The dichotomy among findings may be due either to the analysed economy or employed technical analysis. Studies by authors such as Akinlo (2004), Keho (2017), Mustafa (2023), and Yimer (2023) found that through human capital development, capital accumulation, increased export, and new technology diffusion, FDI positively influences economic growth. Contrary to those studies endorsing the theoretical hypothesis suggestion of a positive relationship between FDI and economic growth, studies by Mustafa (2023) and Wu, et al. (2020) suggested an inverse relationship between FDI and economic growth. Furthermore, other empirical results indicated the insignificant impact of FDI on economic growth (e.g., Akinlo (2004), Aynwale (2007), Arshad and Shujaat (2011). Given that it is difficult to conclude the effect of FDI on economic growth, due to various factors, it is important to conduct this study to determine the effect of FDI on South African economic growth.

3. RESEARCH AND METHODOLOGY

The study focuses on quantitative analysis using time series data obtained from World Development Indicators (WDI) for the period between 1991 and 2021. The restriction or delimitation of the data sample was that the data for ICT components (internet, mobile, and telephone subscription) were available only from 1991. The response variable of the study is gross domestic product (GDP), while the explanatory variables are internet users (INTER), mobile cellular subscription (MOB), telephone landline subscription (TEL), and foreign direct investment (FDI).

Internet users refer to all people who use the Internet from any location. It denotes the global public computer network that allows access to various forms of communication, including emails, entertainment, and news and data files. Individuals access the Internet using game machines, computers, digital television and internet-enabled mobile phones. *Mobile cellular subscription* denotes the totality of individuals subscribed to the public mobile telephone service that offers open access to switched telephone networks through the use of cellular technology. *Fixed or landline telephone subscription* variable refers to the aggregate number of fixed wireless local loop (WLL) subscriptions, voice-over-IP (VoIP) subscriptions, analogue fixed telephone lines, fixed public payphones, and ISDN voice-channel equivalents. Lastly, *the FDI* denotes a cross-border investment through foreign individual investors, companies, firms, or government, establishing a long-term interest in the domestic economy or country. The study hypothesis suggests that efficient exploitation of the ICT components and well-managed FDI will have a positive impact on South African economic growth. In other words, the coefficients of the explanatory variables are expected to have a positive sign.

The relative statistics and the correlation matrix of the described variables are presented in Table 1 which displays descriptive statistics and correlation results.

3.1 Descriptive statistics and correlation analysis

During the analysed period the annual average of South African GDP was around $14.43 billion, while the maximum and minimum were around $15.64 and $12.83 billion. The average of foreign direct investment moved around $1.43 billion, while the maximum and minimum moved around 9.86 and 0.002 respectively. Looking at the usage of ICT's components, Telephone subscriptions dominated internet usage and mobile subscriptions with an average of 24.9, 23.14 and 16.18 respectively. In other words, for 100 people in South Africa, over the study period, 23.14 were using the Internet, 16.18 subscribed to mobile phone survives and 24.93 subscribed to fixed or landline phones. Nonetheless, with a high standard deviation, over the analysed period, internet usage experienced high changes compared to other variables of the study. The landline telephone subscription was the variable with fewer fluctuations. While FDI and internet usage are right-skewed; GDP, mobile, and telephone subscriptions are left-skewed. In addition, Jarque-Bera statistics and its probability values suggest that while the data for DGP, INTERNET and TEL was normally distributed, FDI and MOBILE data was not normally distributed.

Table 1. Summary statistics and correlation coefficients

	GDP	**FDI**	**INTER**	**MOB**	**TEL**
Mean	14.43012	1.437218	23.13870	16.18314	24.92925
Median	14.53705	0.903381	8.065375	17.49590	25.04788
Maximum	15.64148	9.855513	72.31049	18.42396	25.45784
Minimum	12.83024	0.002285	0.013284	8.867850	24.32870
Std. Dev.	0.875966	1.913416	25.61363	2.716319	0.354381
Skewness	-0.287006	3.117544	0.759349	-1.433284	-0.187904
Kurtosis	1.785358	13.60434	1.942604	4.053994	1.536302
Jarque-Bera	2.331257	195.4657	4.423348	12.04882	2.949707
P-Value	0.311727	0.000000	0.109517	0.002419	0.228812
GDP	1.0000				
P-Value	-----				
FDI	0.3241	1.0000			
P-Value	0.0753	-----			
INTER	0.8699	0.2889	1.0000		
P-Value	0.0000	0.1150	-----		
MOB	0.9155	0.3133	0.6510	1.0000	
P-Value	0.0000	0.0861	0.0001	-----	
TEL	0.8407	0.2177	0.7117	0.6916	1.0000
P-Value	0.0000	0.2392	0.0000	0.0000	-----

*Source***:** authors

The coefficient of the correlation matrix in Table 1 indicates that all explanatory variables, namely the FDI and ICT components, have a positive and statistically significant association with South African economic growth. However, the mobile subscription has the strongest correlation with GDP, while the FDI has the lowest correlation coefficient.

3.2 Cointegration modelling

As stated in the introductory section, the study analyses the effect of ICT and FDI on economic growth in South Africa. To meet the study objective, the researcher employs an econometric approach for cointegration. Cointegration approaches are methods used to

determine the long-term relationship among the variables assessed. There exist several approaches useful for cointegration tests. These approaches include Engle and Granger (1987) based on residuals, Phillips and Hansen (1990) based on modified ordinary least squares, Johansen (Johansen, 1988; Johansen, 1996), and Johansen and Juselius (1990) based on multivariate and maximum likelihood, respectively. The common weakness of the aforementioned cointegration techniques is that they require all series under consideration to have the same integration order. A cointegration approach able to overcome that limitation is the autoregressive-distributed lag (ARDL) or bound test for cointegration proposed by Pesaran et al. (2001). This approach applies to series that are integrated at the level and/or first difference. However, it cannot produce valid results when applied to the I (2) series. The study model, in its implicit form, is described as follows:

$$GDP_t = f(FDI_t,\ ICT_t) \ldots \ldots \ldots \ldots [1]$$

Considering ICT as a function of internet usage, mobile subscription, and Fixe (or landline) telephone subscription, the subsequent is the extended implicit form of the study:

$$GDP_t = f(FDI_t, INTER_t, MOB_t, TEL_t) \ldots \ldots \ldots \ldots [2]$$

Using the ARDL approach, Equation 2 can be rewritten as follows:

$$\Delta GDP_t = \propto + \sum_{i=1}^{m} \beta_{1i} \Delta GDP_{t-1} + \sum_{i=0}^{m} \beta_{2i} \Delta FDI_{t-i} + \sum_{i=0}^{m} \beta_{3i} \Delta INTER_{t-i} + \sum_{i=0}^{m} \beta_4 \Delta MOB_{t-1} + \sum_{i=0}^{m} \beta_5 \Delta TEL_{t-1} + \varphi_1 GDP_{t-1} + \varphi_2 FDI_{t-1} + \varphi_3 INTER_{t-1} + \varphi_4 MOB_{t-1} + \varphi_5 TEL_{t-1} + u_t \ldots \ldots \ldots [3]$$

Where $\propto$ and u_t are intercept and error term respectively; $\beta_1 \ldots \beta_5$ are short-run coefficients and $\varphi_1 \ldots \varphi_5$ are long-run coefficients. Δ denotes changes while m represents the optimum number of selected lags. The presence of a long-term relationship among variables is established using the Bounds test. The latter is applied to the null hypothesis of no cointegration $H_0: \varphi_1 = \varphi_2 = \varphi_3 = \varphi_4 = \varphi_5 = 0$ against the alternative hypothesis$H_0: \varphi_1 \neq \varphi_2 \neq \varphi_3 \neq \varphi_4 \neq \varphi_5 \neq 0$. The calculated F-statistics are compared with the Pesaran et al. (2001) tabulated critical values. If the calculated F-statistic is greater than the upper-bound critical values, the null hypothesis is rejected, and the conclusion will be that a long-run relationship exists between variables. The bound test results are inconclusive if the value of F-statistics falls between the lower bounds and upper bounds critical values. If there is a cointegration among variables, the next step of the ARDL process holds for the subsequent equation for a long-term relationship.

$$\Delta GDP_t = \propto + \sum_{i=1}^{p} \beta_{1i} \Delta GDP_{t-1} + \sum_{i=0}^{q} \beta_{2i} \Delta FDI_{t-i} + \sum_{i=0}^{r} \beta_{3i} \Delta INTER_{t-i} + \sum_{i=0}^{s} \beta_4 \Delta MOB_{t-1} + \sum_{i=0}^{m} \beta_5 \Delta TEL_{t-1} + e_t \ldots \ldots \ldots [4]$$

To determine the value of the selected *p, q, r, s, and m* lags in Equation 4, the Schwarz Information Criterion (SIC) was employed. The short-rem dynamics or error correction model is estimated using Equation 5 below.

$$\Delta GDP_t = \propto + \sum_{i=1}^{p} \beta_{1i} \Delta GDP_{t-1} + \sum_{i=0}^{q} \beta_{2i} \Delta FDI_{t-i} + \sum_{i=0}^{r} \beta_{3i} \Delta INTER_{t-i} + \sum_{i=0}^{s} \beta_4 \Delta MOB_{t-1} + \sum_{i=0}^{m} \beta_5 \Delta TEL_{t-1} + +e_t \ldots \ldots \ldots [5]$$

Where δ is the coefficient of the error correction term (ECM_{t-1}) and determines the speed of adjustment of the model towards long-run equilibrium. The δ is expected to negative and significant. To ensure the robustness of the model and the validity of the findings, diagnostic tests were performed. Those tests include test for normality, test for serial correlation, test for heteroscedasticity and stability tests such as cumulative sum (CUSUM) and cumulative sum of squares (CUSUMQ) tests.

4. FINDINGS AND DISCUSSIONS

4.1 Unit root test

Determining the existence of stochastic stationary in data is important when performing econometric analysis. In this study, the Augmented Dickey-Fuller (ADF) test was performed to determine whether the study series is free of unit root at levels or if there is a need for differentiation to remove unit root. The Schwarz Information Criteria (SIC) was adopted to determine the optimum number of lags to include in the model. Results presented in Table 2 show that FDI and MOB are stationary at the level I(0), while the unit root is removed from GDP, TEL and INTER after the first difference I(1). Since the series are integrated at I(0) and I(1), the ARDL model is a suitable approach for cointegration.

Table 2. Unit root results

Variable	Level		1st Difference		Decision
	intercept	Trends	intercept	Trends	
FDI	0.0441**	-----	-----	-----	I(0)
GDP	1.0000	0.5462	0.4525	0.0000	I(1)
TEL	0.9938	0.9988	0.0214**	-----	I(1)
INTER	0.9683	0.6617	0.0321*	-----	I(1)
MOB	0.0079	0.0194**	-----	-----	I(0)

Source: authors

4.2 Cointegration test results

To assess the long-term effect of ICT and FDI on economic growth in South Africa, bound testing was undertaken. The test outcome in Table 3 suggests that the F-statistics of 6.273849 exceeds the critical values of upper bounds. In other words, the bounds test results confirm the presence of a long-term relationship between economic growth, ICT, and FDI. These results are also supported by the values of R2, suggesting that *ceteris paribus*, approximately %93% of changes in economic growth are explained by ICT and FDI.

Table 3. Bounds testing results

F-statistic:	6.273849				
10%		**5%**		**1%**	
I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
2.45	3.52	2.86	4.01	3.74	5.06
R-squared		0.928882			
Adjusted R-squared		0.735847			
F-statistic		4.811983			
Durbin-Watson stat		2.353838			
Prob (F-statistic)		0.000535			

Source: authors

4.3 Long-term relationship

Subsequent to the bounds testing cointegration, we estimated the value and sign of long-run coefficients. As shown in Table 4, all components of ICT and FDI have a positive effect on economic growth in South Africa. However, considering their respective values, mobile (MOB) and telephone (TEL) subscriptions have a high impact on economic growth compared to FDI and Internet subscriptions. Thus, a %10% increase in mobile subscriptions leads to a %40% increase in economic growth while a 10 %% increase in telephone subscriptions causes economic growth to increase by 44 % *ceteris paribus*. On the other hand, a %10% increase in FDI leads to a 5.7 increase in economic growth, and the latter increases by 0.07 % as a response to a 10%%increase in internet subscription. The results of the study corroborate with previous studies and their findings, implying that ICT development influences economic growth and economic performance (Steinmueller, 2001; Inklaar et al., 2005; Koutroumpis, 2009; Niebel, 2018; Myovella et al., 2020; Torkayesh & Torkayesh, 2020; Mustafa, 2023; Yimer, 2023).

Table 4. Long-run coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
FDI	0.056968	0.071172	0.800430	0.4498
INTERNET	0.007483	0.003385	2.210407	0.0628
MOBILE	0.401557	0.218465	1.838084	0.1086
TEL	0.435707	0.142497	3.057660	0.0184
C	-3.199677	3.203893	-0.998684	0.3512

*Source***:** authors

4.4 ECM results and Short-run dynamics

To establish the model's speed of adjustment towards long-run equilibrium, the error correction model (ECM) was estimated. The obtained results are depicted in Table 5.

Table 5. ECM results and Short-run dynamics

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(FDI)	0.003010	0.002205	1.365134	0.2145
D(FDI(-1))	0.006045	0.005998	1.007883	0.3471
D(FDI(-2))	-0.005659	0.005827	-0.971185	0.3638
D(INTERNET)	0.001357	0.001591	0.852676	0.4221
D(INTERNET(-1))	0.002547	0.003138	0.811850	0.4436
D(INTERNET(-2))	-0.003251	0.002162	-1.503289	0.1765
D(MOBILE)	0.056119	0.094175	0.595907	0.5700
D(MOBILE(-1))	-0.012406	0.022512	-0.551077	0.5987
D(MOBILE(-2))	0.035253	0.020775	1.696856	0.1335
D(MOBILE(-3))	0.035004	0.023767	1.472758	0.1843
D(TEL)	0.165612	0.077969	2.124069	0.0713
D(TEL(-1))	-0.095105	0.076693	-1.240067	0.2549
D(TEL(-2))	0.056145	0.061778	0.908824	0.3937
D(TEL(-3))	-0.063850	0.044002	-1.451070	0.1901
ECT(-1)	-0.780157	0.114617	-6.806616	0.0000

*Source***:** authors

As expected, the value of the error correction term (ECT) is negative and statistically significant. Additionally, the ECT coefficient (-0.780157) proposes that %78% of the model distortions are corrected every quarter. Therefore, approximately only 1.28 (1/-0.780157) is required to rectify all model distortions and revert to long-run equilibrium.

Following the short-run coefficients in Table 5, the results are opposite to those of the long-term analysis. None of the short-run dynamics is statistically significant at the %5% level. This suggests that it takes time for ICT and FDI growth to affect South African economic performance.

4.5 Residual diagnostics and model stability

To establish the study outcome and its reliability, an array of residuals and stability tests was performed. Perfumed tests include Jarque-Bera for normality, Breusch-Godffrey for autocorrelation, Breusch-Pagan-Godffrey for heteroscedasticity, and the Ramsey RESET test for model specification. Based on the test outcome, as reported in Table 6, all the null hypotheses were not rejected. This implies that the model's residuals are normally distributed, homoscedastic, and not serially correlated. Additionally, the Ramsey RESET test results indicated the selected model was adequately specified.

Table 6. Residual diagnostics and model stability

Tested item	**Performed test**	**P-value**	**inference**
Normality	Jarque-Bera	0.8815	Residuals normally distributed
Serial correlation	Breusch-Godfrey	0.2297	No serial correlation
Heteroscedasticity	Breusch-Pagan-Godffrey	0.7424	Residual are homoscedastic
Model specification	Ramsey RESET test	0.6754	The model is well-specified

*Source***:** authors

5. CONCLUSIONS

The study focused on assessing the effect of foreign direct investment (FDI) and information, communication, and technology (ICT) on economic growth in South Africa over the period 1991 to 2021. The autoregressive distributed lag (ARDL) model and Error Correction Model (ECM) approaches were used to investigate the effect of FDI and ICT components (fixed telephone, mobile phone, and Internet usage) on economic growth.

Findings from the estimated model indicated that both FDI and ICT are significantly important towards economic growth in South Africa. More specifically, an increase in FDI, fixed telephone, mobile phone, and internet subscriptions results in positive economic growth. However, the magnitude effect of the ICT components differs from one another. While the mobile subscription has the highest impact on economic growth, the Internet subscription has the lowest power on economic growth shocks.

These findings encompass policy implications. First, to determine sustainable economic growth and improve its responsiveness towards changes in FDI and ICT, various policy implications and recommendations are feasible from the findings of the current study. Second, the South African economic authorities and policymakers should strive to improve the ICT infrastructures' investment to allow easy access to the internet and mobile phones as they are cost-effective towards economic growth. Additionally, the stimulation and promotion of ICT diffusion within private sectors through various policies and strategies that include promoting e-commerce, tax reduction, and creation and development of a public–private partnerships and technological linkages. Third, economics and policymakers must create and enhance a

conducive environment that allows more foreign investors to obtain capital inflows, such as tax incentives and regional integration and improve communication between government institutions and investment agencies.

REFERENCES

Adom, P. K., Opoku, E. E. O., & Yan, I. K. M. (2019). Energy demand–FDI nexus in Africa: Do FDI induce dichotomous paths? *Energy Economics, 81*, 928-941. https://doi.org/10.1016/j.eneco.2019.05.030

Aghaei, M. & Rezagholizadeh, M. (2017). The impact of information and communication technology (ICT) on economic growth in the OIC Countries. *Environmental & Socio-Economic Studies*, *17*, 255-76.

Akadiri, A. C., Gungor, H., Akadiri, S. S. & Bamidele-Sadiq, M. (2019). Is the Causal Relation Between Foreign Direct Investment, Trade, And Economic Growth Complement or Substitute? The Case of African Countries. *Journal of Public Affairs*, *20*(2), 1-12

Akadiri, S. S., and Ajmi, A. N. (2020). Causality Relationship between Energy Consumption, Economic Growth, FDI, and Globalization in SSA Countries: A Symbolic Transfer Entropy Analysis. *Environmental Science and Pollution Research*, *27*, 44623-44628.

Akinlo, A. (2004). Foreign Direct Investment and Growth in Nigeria: An Empirical Investigation. *Journal of Policy Modeling*, *26*, 627-639.

Aurangzeb, Z., & Stengos, T. (2014). The role of Foreign Direct Investment (FDI) in a dualistic growth framework: A smooth coefficient semi-parametric approach. *Borsa Istanbul Review*, *14*(3), 133-144.

Bahrini, R., & Qaffas, A. A. (2019). Impact of information and communication technology on economic growth: Evidence from developing countries. *Economies*, *7*(1), 21.

Cardona, M., Kretschmer, T., & Strobel, T. (2013). ICT and productivity: conclusions from the empirical literature. *Information Economics and Policy, 25*(3), 109-125. https://doi.org/10.1016/j.infoecopol.2012.12.002

Dimelis, S. P., & Papaioannou, S. K. (2010). FDI and ICT effects on productivity growth: A comparative analysis of developing and developed countries. *The European Journal of Development Research*, *22*, 79-96.

De Mello, L. (1997). Foreign Direct Investment in Developing Countries and Growth: A Selective Survey. *Journal of Development Studies, 34*(1), 1-34.

Donou-Adonsou, F. (2019). Technology, education, and economic growth in Sub-Saharan Africa. *Telecommunications Policy, 43*(4), 353-360. https://doi.org/10.1016/ j.telpol.2018.08.005

Dunning, J. (1973). The Determinants of International Production. *Oxford Economic Papers 25*, 289-336.

Engle, R. F., & Granger, C. W. (1987). Co-integration and error correction: representation, estimation, and testing. *Econometrica: journal of the Econometric Society*, 251-276. https://www.jstor.org/stable/1913236.

Grimes, A., Ren, C & Stevens, P. (2012). The need for speed: Impacts of internet connectivity on firm productivity. *Journal of Productivity Analysis, 37*, 187–201.

Hayat, A. (2018). FDI and economic growth: the role of natural resources? *Journal of Economic Studies, 45*(2), 283-295.

Hobbs, S., Paparas, D., & Abo Elsoud, E. M. (2021). Does foreign direct investment and trade promote economic growth? Evidence from Albania. *Economies*, *9*(1), 1-18. https://doi.org/10.3390/ economies9010001.

Hymer, S. (1976). *The International Operation of National Firms: A Study of Direct Foreign Investment*. Boston, MA: MIT Press.

Iamsiraroj, S. (2016). The Foreign Direct Investment–Economic Growth Nexus. *International Review of Economics and Finance, 42*, 116-133.

ICASA, (2023). The State of the ICT Sector Report in South Africa. https://www.icasa.org.za/uploads/files/State-of-the-ICT-Sector-in-South-Africa-2023-Report.pdf. [Accessed January 15, 2024].

Inklaar, R., O'Mahony, M. & Timmer, M. (2005). ICT and Europe's productivity performance: Industry-level growth account comparisons with the United States. *Review of Income and Wealth, 51*, 505-36.

Investment framework and opportunities, (2023). Foreign direct investment (FDI) in South Africa. https://www.tradeclub.standardbank.com/portal/en/market-potential/south-africa/investment#. [Accessed January 15, 2024].

Javorcik, B. S. (2004). Does foreign direct investment increase the productivity of domestic firms? In search of spillovers through backward linkages. *American economic review, 94*(3), 605-627.

Jeon, Y., Park, B. I., & Ghauri, P. N. (2013). Foreign direct investment spillover effects in China: Are they different across industries with different technological levels?. *China Economic Review*, *26*, 105-117.

Johansen, S. (1996). Likelihood-based inference in cointegrated vector auto- regressive models. 2nd ed. Oxford: Oxford University Press.

Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of economic dynamics and control, 12*(2-3), 231-254. https://doi.org/10.1016/0165-1889(88)90041-3

Johansen, S., & Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration—with applications to the demand for money. *Oxford Bulletin of Economics and statistics*, *52*(2), 169-210. https://doi.org/10.1111/j.1468-0084.1990.mp52002003.x

Jude, C., & Levieuge, G. (2017). Growth effect of foreign direct investment in developing economies: The role of institutional quality. *The World Economy*, *40*(4), 715-742.

Keho, Y. (2017). The impact of trade openness on economic growth: The case of Cote d'Ivoire. *Cogent Economics & Finance*, *5*(1), 1-14. https://doi.org/10.1080/23322039.2017.1332820

Koutroumpis, P. (2009). The economic impact of broadband on growth: A simultaneous approach. *Telecommunications Policy, 33*, 471-85.

Mankiw, N. G. (2020). *Principles of macroeconomics*. Cengage learning.

Mustafa, G. (2023). The dynamic relationship between financial development, economic growth, foreign direct investment and trade openness: Evidence from South Asian countries. *Millennial Asia*. https://doi.org/10.1177/09763996221138465

Myovella, G., Karacuka, M., & Haucap, J. (2020). Digitalization and economic growth: A comparative analysis of Sub- Saharan Africa and OECD economies. *Telecommunications Policy, 44*(2). https://doi.org/10.1016/j.telpol.2019.101856

Niebel, T. (2014). ICT and economic growth - comparing developing, emerging and developed countries [Paper presented] IARIW 33rd General Conference, Rotterdam, the Netherlands.

Niebel, T. (2018). ICT and economic growth–Comparing developing, emerging and developed countries. *World development*, *104*, 197-211. https://doi.org/10.2139/ssrn.2560771

Papaioannou, S.K., & Dimelis, S.P. (2007). Information technology as a factor of economic development: Evidence from developed and developing countries. *Economics of Innovation and New Technology*, *16*, 179-94.

Paunov, C., Rollo, V. (2016). Has the internet fostered inclusive innovation in the developing world? *World Development, 78*, 587-609. Https: //doi.org/10.1016/j. worlddev.2015. 10.029.

Pegkas, P. (2015). The impact of FDI on economic growth in Eurozone countries. *The Journal of Economic Asymmetries*, *12*(2), 124-132.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of applied econometrics*, *16*(3), 289-326. https://doi.org/10.1002/jae.616

Philip, L. D., K. Sertoglu, S. S. Akadiri, and G. Olasehinde-Williams. (2021). Foreign Direct Investment Amidst Global Economic Downturn: Is There a Time-Varying Implication for Environmental Sustainability Targets?. *Environmental Science and Pollution Research, 28*, 21359-21368.

Phillips, P. C., & Hansen, B. E. (1990). Statistical inference in instrumental variables regression with I (1) processes. *The review of economic studies*, *57*(1), 99-125. https://doi.org/10.2307/2297545

Pohjola, M. 2002. The new economy: Facts, impacts and politics. *The Journal of Information Economics and Policy, 14*, 133-44. https://doi.org/10.1016/S0167-6245(01)00063-4

Pradhan, R. P., Arvin, M.B., & Norman, N.R. (2015). The dynamics of information and communications technologies infrastructure, economic growth, and financial development: Evidence from Asian countries. *Technology in Society*, *42*, 135-49. https://doi.org/10.1016/j.techsoc.2015.04.002

Quah, D. (2002). Technology dissemination and economic growth: Some lessons for the new economy. In Technology and The New Economy. Edited by Chong-En Bai and Chi-Wa Yuen. Cambridge: MIT Press, pp. 95-156.

Rahman, A. (2015). Impact of foreign direct investment on economic growth: Empirical evidence from Bangladesh. *International Journal of Economics and Finance*, *7*(2), 178-185.

Rehman, N. U. (2016). FDI and economic growth: empirical evidence from Pakistan. *Journal of Economic and Administrative Sciences*, *32*(1), 63-76.

Rjoub, H., Aga, M., Oppong, C., Sunju, N., & Fofack, A. (2017). The impact of FDI inflows on economic growth: Evidence from landlocked countries in Sub-Saharan Africa. *Bilig-Turk DunyasI Sosyal Bilimler Dergisi*, *10*(1), 153-168. https://doi.org/10.3390/ economies5010001

Roller, L., & Waverman, L. (2001). Telecommunications infrastructure and economic development, a simultaneous equations approach. *American Economic Review, 91*, 909-23.

Saqib, N., Masnoon, M., & Rafique, N. (2013). Impact of foreign direct investment on economic growth of Pakistan. *Advances in Management & Applied Economics*, *3*(1), 35-45.

Sassi, S., & Goaied, M. (2013). Financial development, ICT diffusion and economic growth: Lessons from MENA region. *Telecommunications Policy, 37*, 252-61.

Schumpeter, J.A. (1934). *The Theory of Economic Development*. Cambridge: Harvard University Press.

Solow, R. (1957). Technical Change and the Aggregate Production Function. *The Review of Economics and Statistics, 39*, 312-320.

Solow, R. M. (1956). A contribution to the theory of economic growth. *Quarterly Journal of Economics, 70*, 65–94.

Steinmueller, W. E. (2001). ICTs and possibilities for leapfrogging by developing countries. *International Labour Review, 140*(2), 1-18. https://doi.org/10.1111/j.1564-913X. 2001.tb00220.x

Torkayesh, A. E., & Torkayesh, S. E. (2021). Evaluation of information and communication technology development in G7 countries: An integrated MCDM approach. *Technology in Society*, *66*, 101670.

Vu, Khuong M. (2011). ICT as a source of economic growth in the information age: Empirical evidence from the 1996–2005 period. *Telecommunications Policy*, *35*, 357-72.

Wu, W., Yuan, L., Wang, X., Cao, X., & Zhou, S. (2020). Does FDI drive economic growth? Evidence from city data in China. *Emerging Markets Finance and Trade, 56*(11), 2594-2607.

Yimer, A. (2023). The effects of FDI on economic growth in Africa. *The Journal of International Trade & Economic Development, 32*(1), 2-36. https://doi.org/10.1080/09638199.2022.2079709

Yousefi, A. (2011). The impact of information and communication technology on economic growth: Evidence from developed and developing countries. *Economics of Innovation and New Technology*, *20*(6), 581-596.