INNOVATION INVESTMENTS AND ECONOMIC DEVELOPMENT IN SOUTH AFRICA: AN EMPIRICAL ANALYSIS

Sayeed Aboobakr Milanzi
School of Business and Leadership, University of South Africa, South Africa
milansa@unisa.ac.za

Itumeleng Pleasure Mongale
School of Economics and Management, University of Limpopo, South Africa
itumeleng.mongale@ul.ac.za

Binganidzo Muchara
School of Business and Leadership, University of South Africa, South Africa
muchab@unisa.ac.za

ABSTRACT

While innovation is vital to economic growth, African nations lag far behind in the development frontier than China. The paradox is that most developing countries' investment in innovation is proportionately far less than their developed counterparts. This article examines the contributions of innovation investments towards economic development in South Africa. We employed the autoregressive distributed lag (ARDL) bound testing and the Granger causality approach to analyse the annual time series data from 1990 to 2022 from the South African Reserve Bank. The findings revealed the positive impact of innovation investments (expenditures on ICT and R&D) on economic development in South Africa. The current study employed a relatively new ARDL bounds testing approach to analyse quantitative data to provide empirical evidence, which according to the literature, is not always evident and remains hard to quantify on the impact of innovation investments on economic development in South Africa. The study recommends that developing economies address the basics in the form of robust investment in human capital and upward investments in higher education.

Keywords: Innovation, Information, Communication and Technology, Research and Development, Economic Growth, South Africa.

1. INTRODUCTION

While innovation is widely acknowledged as vital to economic growth, African nations are lagging in the development frontier more than China. Global research spending grew faster than the global economy over 2014 –2018, but the level of spending and rate of growth remains geographically uneven. China accounts for about 44% of growth research spending, the USA for 19%, the European Union for 11%, the Republic of Korea for 5% and India for 4% (UNESCO, 2021). The paradox is that most developing countries' innovation investments are proportionately less than their developed counterparts. For instance, investment in research and development (R&D) is lower in Africa than anywhere (Blankley and Moses 2009; Diop 2017). This happens despite evidence from empirical literature suggesting that innovation transforms the economy in numerous passages, including growth, competitiveness, financial systems, quality of life, infrastructure development, employment, and trade openness (Maradana et al., 2017).

Based on the 2020 Global Innovation Index, the most innovative countries in Africa are Mauritius, South Africa, Tunisia, and Morocco. Their common weakness is that they are rated low in several indicators, such as R&D, high government reliance and challenging business (Sá, 2020). According to UNESCO (2021), these countries are among the 80% of countries which devote less than 1% of their GDP to research. They remain recipients of foreign scientific expertise and technology.

Kubayi-Ngubane (2018) showed that South Africa established a range of institutions in the form of DST, the National Research Foundation, and the National Advisory Council on Innovation, which is a requirement for a functional system of innovation. The purpose was to build government business collaborations such as the state-owned enterprises and the private sector through increased support via R&D. Manzini (2019) argued that South Africa relies on local and transferred innovations, which may indicate the performance of individual institutions through knowledge outputs such as patents issued by companies and research institutions.

Correspondingly, the National Planning Commission (2020) highlighted that South Africa is affected by international and regional development in different ways. The country must increase investment in R&D for it to benefit from rapid growth and an increase in transferred technology. It can also benefit from using existing resources to facilitate innovation and enhance cooperation between public and private sectors of science and technology institutions. This action will enable increased demand for various commodities and expand consumer markets in the country because technological change helps curb the biggest challenges in the education and health sectors.

In the same vein, Mzekandaba (2020) urged the government to boost its support for R&D in the country, to help the economy weather the economic storm of the COVID-19 pandemic. The pandemic has been belligerent in economic and human life activities, further deepening South Africa's unemployment and poverty levels. Given all these, Mzekandaba (2020) further argued that Africa's post-COVID-19 economic activities should focus on stimulating innovation and the digital economy. The basis of this argument is that even though the pandemic brought up a vortex of emotions, it created opportunities and challenges for the national system of innovation, brought changes in innovation investment levels and affected economic performance. The challenge facing South Africa is that even though is regarded as the most innovative country in Africa, its expenditure on R&D declined from 0.76% in 2017 to 0.62% in 2019 (World Bank, 2022).

The need for this kind of study in South Africa was motivated by limited literature on this aspect and by Sá's (2020) notion that African countries are rated low in several innovation indicators. The idea is corroborated by Farhadi and Ismail (2014), who also bemoaned that despite the numerous studies, the evidence of ICT contribution to economic growth in developing countries is still scarce. In addition, Vu et al. (2020) indicated that most of the studies, along with the impact of ICT on growth, are concentrated mainly in the US, UK, and Europe. They maintained that there is a significant disparity among countries and regions in reaping the benefits of ICT for growth. Finally, Anakpo and Oyenubi (2022) contend that the effect of technological innovation on economic growth has received significant attention in the developed world over the last decades due to its speedy development and potential impacts. However, little is known in the context of developing countries, arguably due to data challenges.

Following the notion of Morris (2018), the study envisaged enlarging the series of countries to provide a more comprehensive worldwide view of the relationship between innovation and economic development in developing economies. The literature search has revealed that several studies focused on aspects of innovation and economic growth in South Africa. They include Habiyaremye et al. (2022), who focused on an overview of macroeconomic social and environmental indicators and trends necessary to enhance an understanding of the role of innovation in creating inclusive social-economic development. Ndabeni et al. (2016) examined the shift in national policy thinking toward the use and role of innovation in driving economic and social change in the marginalised spaces of South Africa. Blankley and Moses (2009) used an innovation survey to compare several aspects of innovation in the 27 member states of the European Union, as well as Norway and Iceland, where available and South Africa.

As indicated in the studies mentioned above, one study examined the shift in national policy thinking about innovation, while others used overview and survey approaches to understand the role of innovation. Khumalo and Mongale (2015) focused only on the impact of ICT on economic growth, and Maradana et al. (2017) investigated the linkage between innovation and economic growth in the selected European countries.

Given that some of the studies in this area in South Africa used qualitative data, the current study employed a relatively new autoregressive distributed lag (ARDL) bound testing approach to provide empirical evidence on the impact of innovation investments on economic development in South Africa. In addition, different regressors from those used by the previous studies are used to quantify innovation investments. The study is keen to contribute to this aspect because of the OECD's (2016) notion that innovation is all around us, but its impact on economic growth and well-being is not always evident and remains hard to quantify.

The rest of the paper is structured as follows; Section 2 presents the literature review. Section 3 outlines the research methodology and elaborates on the data, model and estimation techniques employed. Section 4 presents the empirical results and discussion, and section 5 covers the conclusion and the recommendations.

2. LITERATURE REVIEW

The theoretical framework of this study hangs on the total factor productivity (TFP) and creative destruction, dubbed the Schumpeter gale. The TFP is growth through technological innovation and efficiency achieved by enhanced labour skills and capital management. Carlaw and Lipse (2004) demarcated the TFP into technological development and efficiency in all economic sectors. In addition, Carlaw and Lipse (2004) elucidated technology as not just a gathering of ideas that define economic value-building activities but as a piece of knowledge about product technologies, the requirements and the organisation of all products produced, the production process, and the organisation.

On the other hand, Joseph Schumpeter's creative destruction is a theory of economic innovation and the business cycle. It is about the transformation of industrial products or services that develop the economic structure through the destruction of the old and the creation of new ones. The model states that any obstacle to the process can have severe short- and long-lasting macroeconomic consequences because 50% represents growth in productivity and a decline in restructuring during business cycle recessions, adding significant downside costs (Caballero & Hammour, 2000).

Furthermore, with the applications of creative destruction, endogenous growth is achieved with the help of the innovativeness of the research sector (Diamond & Arthur, 2006). Consequently, transmitting expectations that the amount of research in one period determines the equilibrium anticipated for the next period. Hence, Aghion and Howitt (1992) indicated that increased research discourages current research by threatening to destroy the income from such research. The size of the skilled workers and the productivity of research output determine the essence of innovation. Similarly, the accumulation of knowledge due to the results of industrial innovation has both positive and negative consequences for growth. Hence, the bone of Aghion and Howitt's (1992) contention is that the enormous increase in technology rather than the accumulation of capital in developing countries leads to growth.

The moments of the Industrial Revolution explained by Pansera (2011) as the source of innovation demonstrated that technical changes should link to the ability of humans to control the natural world. When Schumpeter and his supporters standardised the modern concept of innovation, defining it in terms of capitalism expansion, the combination of innovation and sustainability led to the attrition of the university's interest at the beginning of the 1960s. The work implied that technology should solve the problem caused by infinite material growth on a finite planet.

Concerning the TFP and creative destruction theories, empirical studies indicate a positive association between innovation and growth. The premise is that the more innovative a society becomes, the more developed it becomes. As a result, Nakamori (2020) opines that citizens translate ideas or inventions into a good or service that creates value or for which consumers will pay. Thakur and Malecki (2015) gave an understanding of the Indian institutions regarding regional R&D determinants. They indicated that its facilities respond to scientific and technological features, employee availability, financial facilities, transportation infrastructure, and R&D investment. Increasing regional development and generating knowledge for high-quality goods, improving technical efficiency, export growth and competitiveness lead to fast economic growth in the country.

On the other hand, Omar (2020) maintained that innovation has become, particularly during the fourth industrial revolution, the driving force for growth. His study shows that expenditure on R&D in terms of GDP is positive and statistically significant. He emphasised the importance of innovation and education in fostering economic growth and encouraged governments in the Mediterranean and North Africa to invest more in innovation indicators.

Similarly, Claude and Ralph (2019) examined the long-term impact on innovation and economic development of human capital in the regions of Europe. The results showed that the long-term impact of human capital on the current innovation and economic growth is complex through a large, new dataset on the regional capital and other factors in the 19th and 20th centuries. They deduce that the current regional discrepancies in innovation and economic development are key factors explaining human capital.

Edquist and Henrekson (2017) investigated the association between ICT, R&D capital and value-added growth in Sweden by examining 47 industries from 1993 to 2012. The study showed that the two variables were significantly associated with value-added growth and stressed it as crucial for technical change and economic development. Likewise, Liao et al. (2016) examined the contribution of ICT to economic growth in the USA. Their results revealed that investment in ICT contributes to increased productivity and economic growth. They pointed out that increased investment in ICT fosters economic development and growth.

Capello and Lenzi (2016) examined the significance and usefulness of EU R&D, technology development and growth innovation policies. They discovered that research, technological development, and innovation funds are significant for increasing innovation. However, the results warn about the usefulness in areas lacking internal scientific research, technological development, and innovation initiatives for socioeconomic growth.

Nikoloski and Pechijareski (2015) explored the scope and nature of R&D in the western Balkans as determinants of innovation capacity and its impact on economic development. They discovered R&D to be a crucial input to the innovation process. At the same time, expenditures on it highlight an overview of the innovation capacity of that country, while the long transition effect of R&D depends on tremendous economic, political and social impacts.

Asongu et al. (2019) examined how ICTs can alleviate the potential harmful effects of environmental degradation in Sub-Saharan Africa (SSA) to encourage inclusive human development. In applying panel data from 44 SSA countries, they found that ICT usage improves human development. Another study in the SSA context at a country level by Khumalo and Mongale (2015) focused on South Africa. They investigated the impact of ICT on economic growth in South Africa by applying cointegration and causality analysis. Their results showed a positive relationship between ICT advancement and economic development.

Kaies et al. (2019) examined the link between innovation and economic development in Tunisia through the endogenous growth model. They discovered that Tunisia could not benefit from its R&D share in one part or R&D undertaken in developed countries. They point out that due to inefficiencies of the Tunisian education systems, R&D is not a technological transfer vector but that investment in R&D and brain gain could be sufficient for innovative solutions for any country.

Innovation appears as a driver of growth and a tool for improving social well-being, but certain countries might not notice the full benefits due to the inefficiencies of the education systems.

3. METHODOLOGY

The study employed the ARDL bound testing and, as well as the Granger causality approaches to analyse the contribution of innovation investment toward economic development. This section presents the data, model specification, and econometric techniques used to achieve the aim of the study.

3.1 Data and model of the study

The study used the South African Reserve Bank's annual time series data from 1990 to 2021. The availability of data on all variables in the model limited the period under investigation. Following studies such as Pece (2015), Edquist and Henrekson (2017) and Divisekera and Nguyen (2018), expenditures on ICT and R&D quantify innovation investment. Furthermore, the model of this study follows Nadiri (1993), who used the Cobb-Douglas function to highlight the link between innovation, output and productivity growth. Economic growth was determined by the growth rate of innovations, which is determined exogenously. For this study, innovation investments influence economic development in South Africa.

Table 1. Explanations of variable

Gross Domestic Product per capita (GDPPC)	Gross domestic product (GDP) per capita
Government expenditure on ICT (ICTE)	Gross fixed capital formation: Information, computer, and telecommunications equipment - Total
Government expenditure on R&D (RDEX)	Gross fixed capital formation: Research and development - Total

Source: Authors' compilation

In that regard, the model used has been specified as follows:

$$GDPPC_t = \beta_0 + \beta_1 ICTE_t + \beta_2 RDEX_t + \mu_t \qquad (1)$$

Where *t* represents time, β_0 is the intercept which represents the value of $\boldsymbol{y}$ when $\boldsymbol{x} = 0$, β_1 and β_2 are the coefficients, and μ is a white noise disturbance term.

3.2 Estimation techniques

The following econometric procedures were undertaken to analyse the characteristics of the variables and the model.

3.2.1Descriptive statistics

Lane et al. (2019) and Peatman (1947) described this analysis as a graphical or tabulation presentation of data distribution. Its purpose is to inspect the location of central distribution in a data set. It helps to determine the spread of the data and to measure the variability of the data set by the mean, median, maximum, and minimum values, standard deviation, skewness, kurtosis, and Jarque-Bera form components of descriptive statistics (Evans, 2012).

3.2.2 *Unit root test*

According to Menegaki (2019), the unit root analysis helps to determine the order of integration of each variable to satisfy the bounds test assumption of the ARDL models, in which each variable must be I(0) or I(1). The statistical theory offers a wide range of unit root tests used to test the stationarity of the variables. Arltova and Fedorova (2016) uphold that the choice of an appropriate one depends on the subjective judgement of the analyst. Therefore, we decided to apply the common ones in the form of the Augmented Dickey-Full (ADF) and the Dickey-Fuller Generalized Least Squares (DF-GLS) by Elliot et al. (1996). The DF-GLS unit root test is regarded as the most efficient test for an autoregressive unit root. Finally, the application of two-unit root tests is based on Baumöhl and Lyócsa's (2009) view that providing results of at least two tests is decorum in economic literature.

3.2.3 ARDL Bounds Test for Cointegration

The ARDL approach by Pesaran et al. (1999) and Pesaran et al. (2001) was preferred mainly due to limited data in this field of study. This choice relies on Pesaran et al. (1999) notion that ARDL is an appropriate approach to handling meagre data samples. According to Romilly et al. (2001), compared to alternative multivariate cointegration procedures such as the Engle-Granger two-stage, the Phillips-Hansen fully modified, and the Johansen maximum likelihood methods, the ARDL approach performs better with small samples. Abubakar and Danladi (2018) and Menegaki (2019) noted that ARDL generates robust and reliable results, even if the sample size is small or large. The approach becomes effective if none of the variables is I(2), which means all the variables have the same order of cointegration or at least a mixture of I(0) and I(1) (Pesaran et al. 1999 and Pesaran et al. 2001).

The bound testing validation depends on Pesaran et al. (2001) assertion that the computed F-statistics should fall below the lower bound if the variables are I(0) hence no cointegration. However, if the F-statistics exceed the upper bound, we conclude that there is cointegration. If it falls between the bounds, the test is inconclusive.

The computation is carried out on each variable as endogenous while assuming the rest as exogenous variables. Based on Pesaran et al. (2001), the ARDL model used in this study is specified as follows:

$$\Delta GDPPC_t = \beta_0 + \sum_{i=1}^{m} \beta_1 \Delta GDPPC_{t-1} + \sum_{i=1}^{m} \beta_2 \Delta ICTE_{t-1} + \sum_{i=1}^{m} \beta_3 \Delta RDEX_{t-1} + \alpha_1 GDPPC_{t-1} + \alpha_2 ICTE_{t-1} + \alpha_3 RDEX_{t-1} + \mu_t \quad (2)$$

Where to denote the short-run dynamics of the model whilst α_0 to denote the long-run part of the model. Δ, is the first difference between the operator and the μ is a white noise disturbance term. Based on equation 2 the null hypothesis is given as $H_0 = \beta_0 = \beta_1 = \beta_2 = \beta_3 = 0$ that is, there is no cointegration among the variables and the alternative hypothesis is formulated as follows which denotes the presence of cointegration among the variables. Furthermore, the Error Correction Model of the ARDL is formulated as follows,

$$\Delta GDPPC_t = \beta_0 + \sum_{i=1}^{m} \beta_1 \Delta GDPPC_{t-1} + \sum_{i=1}^{m} \beta_2 \Delta ICTE_{t-1} + \sum_{i=1}^{m} \beta_3 \Delta RDEX_{t-1} + \lambda ECT_{t-1} + \mu_t \quad (3)$$

Where λ is the coefficient of the *ECT* (Error Correction Term) which captures the reversion and speed of adjustment to reach equilibrium (Pesaran et al. 2001).

3.2.4 Granger causality

Since the ARDL bound estimation only divulges the existence of the long-run linear relationship in the model and does not reveal the direction of the relationship among the variables, the Granger causality analysis was preferred for that purpose. The notion aligns with Türsoy (2017) that after confirming the long-run relationship between innovation investment and economic development by the bounds test, the Granger causality test was applied to investigate the causality direction among the variables.

3.2.5 Diagnostic and stability testing

We employed diagnostic tests such as the Wald test, serial correlation, and heteroscedasticity. They measured how close the unrestricted estimates came to satisfying the restrictions under the null hypothesis. Furthermore, the parameter stability of the model was tested by applying both the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) control charts.

4. RESULTS AND DISCUSSION

This section presents and discusses the empirical results of all the tests performed in this study, and they are as follows.

4.1 Descriptive statistics

The outcomes of descriptive statistics are summarised in Table 2 below.

Table 2: Descriptive statistics results

	LNGDPPC	LNICTE	LNRDEX
Mean	10.55090	9.513200	9.499411
Median	10.65566	9.823795	9.768755
Maximum	11.60037	10.42638	10.49651
Minimum	9.126524	7.597396	8.148156
Std. Dev.	0.768089	0.832534	0.803122
Skewness	-0.311641	-1.011117	-0.288138

Kurtosis	1.782323	2.763679	1.563889
Jarque-Bera	2.572924	5.699761	3.292449
Probability	0.276246	0.057851	0.192776
Sum	348.1796	313.9356	313.4806
Sum Sq. Dev.	18.87876	22.17961	20.64015
Observations	33	33	33

Source: Authors' calculations

The results show that the kurtosis of the data obtained is less than 3 which implies that it follows a platykurtic characteristic. This indicates that the data distribution runs from flat to relatively normal distribution. The skewness reveals that the data sample contains negative skewness implying that the model has a long-left tail on negative numbers. Finally, the probability of the Jarque-Bera values is less than 5% which suggests that the data is normally distributed.

4.2 Unit root tests

Two-unit root tests in the form of the ADF and DF-GLS were used, and the summary of the results is presented in Table 3 as follows,

Variable	**Model**	**T-stats**	**P-value**	**I(0) or I(1)**	**T-stats**	**P-value**	**I(0) or I(1)**
Variables	**Model**	**ADF Unit root test**			**DF-GLS Unit root test**		
LNGDPPC	Intercept	-4.999***	0.000	I(0)	-4.878**	0.000	I(0)
	Trend & intercept	-5.249***	0.000	I(1)	-5.249***	0.000	I(1)
LNICTE	Intercept	-4.869*	0.000	I(1)	-5.390**	0.000	I(1)
	Trend & intercept	-6.457**	0.000	I(1)	-6.887**	0.000	I(1)
LNRDEX	Intercept	-4.658***	0.000	I(1)	-4.699***	0.001	I(1)
	Trend & intercept	-4.722**	0.003	I(1)	-4.722**	0.004	I(1)

Source: Authors' calculations

The results fulfil the ADRL Pesaran et al.'s (1999) requirements that the unit root test becomes valid only if the results are stationary and are integrated of order I(0) and I(1). The ADF and DF-GLS test results were statistically significant at a 1% level. The ADF results show that GDP per capita and government expenditure in ICT were stationary at level and expenditure on R&D was stationary at first difference. Similarly, the DF-GLS results showed that all the variables were stationary at first difference. Therefore, we do not accept the null hypothesis of data having a unit root or not stationary and accept the alternative hypothesis of no unit root.

4.3 Cointegration analysis

The cointegration results are presented in Tables 4 to 6 as follows

Table 4: ARDL Bounds test results

Test Statistic	Value	K
F-statistic	121.519	3
Critical Value Bounds		

Significance	I(0) Bound	I(1) Bound
10%	2.63	3.35
5%	3.1	3.87
2.5%	3.55	4.38
1%	4.13	5

Source: Authors compilation

The cointegration analysis found that the *F*-statistics was larger than any of the critical values at 10%, 5%, 2.5%, and 1% levels of significance, which means it is above the I(0) and I(1) orders of integrations hence they are all found to be cointegrated. This conclusion is harmonious with Narayan's (2005) notion that if the *F*-statistic value is higher than the upper bound critical value, the null hypothesis of no cointegration can be accepted.

Table 5. ARDL long-run results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNICTE	0.138750	0.122801	1.129878	0.2685
LNRDEX	0.575109	0.173387	3.316903	0.0026

Source: Authors' compilation

Based on the findings from Table 5, the implication is that in the long run, a percentage change in government expenditure on ICT and R&D will contribute positively to economic development.Such that a percentage change in government expenditure on ICT and R&D will affect economic development by 14% and 58% respectively in the long-run.

Table 6. ARDL short-run results

ECM Regression				
Case 3: Unrestricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.412238	0.062431	6.603126	0.0000
D(LNRDEX)	0.125712	0.040941	3.070552	0.0048
CointEq(-1)*	-0.091740	0.016505	-5.558271	0.0000

Source: Authors' calculations

The results in Table 6 illustrate that government expenditure on R&D affects economic development negatively in the short run. On the contrary, government expenditure on ICT affects economic development positively in the short run. In addition, the error correction term coefficient of -0.092 is negative and significant. The implication is that the economic development model has a slow rate of speed of adjustment of about 9%. This speed of adjustment might be due to the below-par investment in R&D, whereby the general government and public corporations spend less on R&D.

4.4 Diagnostic tests

Table 7. Diagnostic test results

Test	Null Hypothesis	F-Statistics	P-Value	Conclusion
Wald Test	The set of parameters is equal to zero	119.840	0.945	Do not reject the H_0
Serial correlation LM test	No serial correlation	0.067	0.936	Do not reject the H_0
Heteroscedasticity	Homoscedasticity	1.110	0.365	Do not reject the H_0

Source: Authors' calculations

The study fails to reject the null hypothesis of the three diagnostic tests because their p-values are greater than 5% levels of significance.

4.5 Stability tests

The outcomes of the stability tests are presented in Figures 1 and 2 as follows,

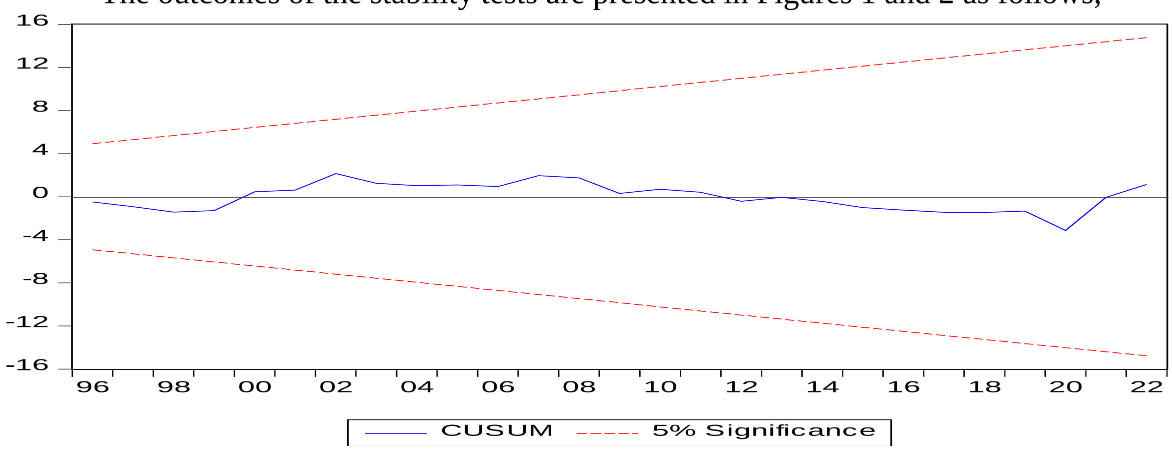

FIGURE 1
CUSUM TEST RESULTS

Source: Authors compilation

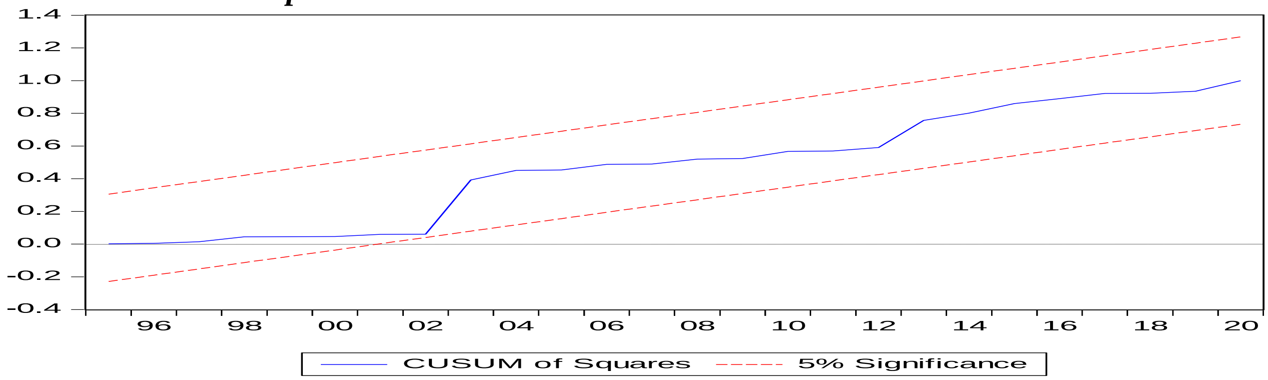

FIGURE 2
CUSUMSQ TEST RESULTS

Source: Authors compilation

The stability test outcomes show that the model was stable throughout the entire period of the investigation. The evidence of stability is that the lines generated in the two figures are within the upper and lower bounds parameter lines of a 5% significance level, and confirm the robustness of the model (Brown et al., 1975).

4.6 Granger causality test results

The outcomes of the causality analysis which was performed to determine causality amongst the variables are presented as follows

Table 8. Granger causality test results

Null Hypothesis:	F-Statistic	Prob.	Decision
LNICTE does not Granger Cause LNGDPPC	2.455	0.107	Reject the H_0
LNGDPPC does not Granger Cause LNICTE	0.355	0.705	Reject the H_0
LNRDEX does not Granger Cause LNGDPPC	1.619	0.218	Reject the H_0
LNGDPPC does not Granger Cause LNRDEX	0.22657	0.7989	Reject the H_0
LNRDEX does not Granger Cause LNICTE	0.07286	0.9299	Reject the H_0
LNICTE does not Granger Cause LNRDEX	3.28899	0.0547	Accept the H_0

Source: Authors compilation

The results in Table 8 show that expenditure on R&D does Granger cause GDP per capita. Similarly, expenditure on ICTE does Granger cause government expenditure on R&D. The p-value of less than 5% shows a bidirectional causality between the variables. On the contrary, expenditure on ICTE does not Granger cause GDP per capita and vice-versa. Therefore, we fail to reject the null hypothesis since the probability values are bigger than 5%. It shows that these variables have unidirectional causality.

5. CONCLUSION AND RECOMMENDATIONS

In conclusion, it is evident from our empirical analysis that innovation investments have a significant impact on economic development in South Africa. The research has shown that countries with more innovation-driven economy tend to have higher economic growth, better income levels, and improved living standards. Additionally, we have seen how investment in research and development, education, and infrastructure can lead to increased productivity, competitiveness, and economic diversification

The unit root tests revealed that variables were stationary at different orders of integration, that is, a mixture of I(0) and I(1) variables, but there was no I(2) variable in the model. The bounds test results revealed the presence of a long-run relationship in the model. The long-run results revealed that a percentage change in government expenditure on ICT contributes positively to economic development by approximately 14%. Similarly, a percentage increase in government expenditure on R&D will contribute positively towards economic development by about 58% in the long-run. These findings are in line with Nakamori (2020), Omar (2020), Nikoloski and Pechijareski (2015), Edquist and Henrekson (2017), Liao et al. (2016), and Asongu et al. (2019). Given the positive impact of innovation investments on economic development, the study recommends that developing economies address the basics first. These include edifying the standard of physical capital, robust investment in human capital through investment in basic education and upward investments in higher education. The recommendation is in line with Diop's (2017) notion that without the elementary factors, countries cannot realise the anticipated gains from innovation. The priority should be given to deliberate actions to improve growth through an efficient environment and providing people with ICT tools. The study provides empirical evidence for policymakers and union leaders alike to appreciate the importance of these indicators in the South African case.

Even though relevant research approaches were employed, regarding the sample size, a lack of sufficient observations for time series analysis in this field of research is an apparent limitation in developing countries. Therefore, the development of quarterly rather than annual data could be more advantageous in terms of the number of observations which will improve the reliability of the results.

However, South Africa still faces challenges when it comes to innovation and economic development. The country's economy is largely based on traditional industries, such as mining and agriculture, which are increasingly becoming unsustainable. In addition, the lack of access to finance and the high costs associated with research and development can hinder innovation efforts, particularly for small and medium-sized enterprises.

Considering these findings, South Africa needs to prioritize and increase its investments in innovation to drive sustainable economic development. The government should focus on creating an enabling environment for innovation by providing tax incentives, grants, and subsidies for research and development activities. Additionally, efforts should be made to improve the regulatory environment and reduce red tape to attract more private-sector investment in innovation.

Furthermore, research and investment in innovation have significant practical and social implications for economic development in south Africa. As such there is a need to strengthen the linkages between academia, industry, and government to promote knowledge transfer, technology diffusion, and the commercialization of innovative ideas. Encouraging collaboration and partnerships between different stakeholders can help foster a culture of innovation in the country and ultimately drive economic growth.

Lastly, innovation investments play a crucial role in driving economic development in South Africa. The government, private sector, and academic institutions all have a role to play in fostering a culture of innovation and creating an enabling environment for research and development activities. By prioritizing innovation, South Africa can harness its potential for economic diversification, job creation, and improved living standards for its citizens.

REFERENCES

1. Abubakar, M. I., & Danladi, Y. U. (2018). Foreign direct investment and stock market development in Nigeria: Evidence from ARDL bound test approach to cointegration. *IOSR Journal of Economics and Finance*, *9*(1), 79-85.
2. Aghion, P., & Howitt, P. (1990). A model of growth through creative destruction.
3. Anakpo, G., & Oyenubi, A. (2022). Technological innovation and economic growth in Southern Africa: application of panel dynamic OLS regression. *Development Southern Africa*, *39*(4), 543-557.
4. Arltová, M., & Fedorová, D. (2016). Selection of Unit Root Test on the Basis of Length of the Time Series and Value of AR (1) Parameter. *Statistika: Statistics & Economy Journal*, *96*(3).
5. Asongu, S. A., Nwachukwu, J. C., & Pyke, C. (2019). The comparative economics of ICT, environmental degradation and inclusive human development in Sub-Saharan Africa. *Social Indicators Research*, *143*, 1271-1297.
6. Baumohl, E., & Lyocsa, S. (2009). Stationarity of time series and the problem of spurious regression. *Available at SSRN 1480682*.
7. Blankley, W., & Moses, C. (2009). How innovative is South Africa?: news & views. *South African Journal of Science*, *105*(1), 15-18.

8. Brown, J. C., Pusey, P. N., Goodwin, J. W., & Ottewill, R. H. (1975). Light scattering study of dynamic and time-averaged correlations in dispersions of charged particles. *Journal of physics A: Mathematical and General*, *8*(5), 664.
9. Caballero, R. J., & Hammour, M. (2000). Creative destruction and development: Institutions, crises, and restructuring.
10. Capello, R., & Lenzi, C. (2016). Relevance and utility of European Union research, technological development and innovation policies for a smart growth. *Environment and Planning C: Government and Policy*, *34*(1), 52-72.
11. Lipsey, R. G., & Carlaw, K. I. (2004). Total factor productivity and the measurement of technological change. *Canadian Journal of Economics/Revue canadienne d'économique*, *37*(4), 1118-1150.
12. Diebolt, C., & Hippe, R. (2019). The long-run impact of human capital on innovation and economic development in the regions of Europe. *Applied Economics*, *51*(5), 542-563.
13. Diamond Jr, A. M. (2006). Schumpeter's creative destruction: A review of the evidence. *Journal of Private Enterprise*, *22*(1), 120.
14. Diop, M. (2017). https://www.worldbank.org/en/news/speech/2017/11/30/innovation-in-africa.
15. Divisekera, S., & Nguyen, V. K. (2018). Determinants of innovation in tourism evidence from Australia. *Tourism Management*, *67*, 157-167.
16. Edquist, H., & Henrekson, M. (2017). Swedish lessons: How important are ICT and R&D to economic growth?. *Structural Change and Economic Dynamics*, *42*, 1-12.
17. Elliot, B. E., Rothenberg, T. J., & Stock, J. H. (1996). Efficient tests of the unit root hypothesis. *Econometrica*, *64*(8), 13-36.
18. Evans, J. R., & Basu, A. (2010). *Statistics, data analysis, and decision modeling*. New Jersey: Prentice Hall.
19. Farhadi, M., & Ismail, R. (2014). The impact of information and communication technology availability on economic growth. *Research Journal of Applied Sciences, Engineering and Technology*, *7*(7), 1226-1231.
20. Habiyaremye, A., King, N., & Tregenna, F. (2022). Innovation and socio-economic development challenges in South Africa: An overview of indicators and trends.
21. Samet, K., Yahyaoui, A., Saidi, A., & Al Saggaf, M. I. (2019). Innovation and economic development: Case of Tunisia. *International Journal of Economics and Financial Issues*, *9*(5), 140.
22. Khumalo, Z. Z., & Mongale, I. P. (2015). The impact of Information Communication Technology (ICT) on economic growth: A case for South Africa. *South Africa. North West University*.
23. Kubayi-Ngubane, T.M. (2018). “Draft of white paper on Science, Technology and Innovation”. Pretoria, South Africa: Department of Science and Technology.
24. Hahs-Vaughn, D. L., & Lomax, R. G. (2020). *An introduction to statistical concepts*. Routledge.
25. Liao, H., Wang, B., Li, B., & Weyman-Jones, T. (2016). ICT as a general-purpose technology: The productivity of ICT in the United States revisited. *Information Economics and Policy*, *36*, 10-25.
26. Manzini, S. T. (2015). Measurement of innovation in South Africa: An analysis of survey metrics and recommendations. *South African Journal of Science*, *111*(11-12), 1-8.
27. Maradana, R. P., Pradhan, R. P., Dash, S., Gaurav, K., Jayakumar, M., & Chatterjee, D. (2017). Does innovation promote economic growth? Evidence from European countries. *Journal of Innovation and Entrepreneurship*, *6*(1), 1-23.
28. Menegaki, A. N. (2019). The ARDL method in the energy-growth nexus field; best implementation strategies. *Economies*, *7*(4), 105.
29. Morris, D. M. (2018). Innovation and productivity among heterogeneous firms. *Research policy*, *47*(10), 1918-1932.
30. Mzekandaba, S. (2020). *“Innovation, digital economy engine to drive SA’s growth”*. https://www.itweb.co.za/content/5yONPvEg1mpMXWrb.
31. Nadiri, M. I. (1993). Innovations and technological spillovers.
32. Nakamori, Y. (2020). “In knowledge construction. In Innovation theory”. Singapore: Springer, 1-17.
33. Narayan, P. K. (2005). The saving and investment nexus for China: evidence from cointegration tests. *Applied economics*, *37*(17), 1979-1990.
34. National Planning Commission. (2020). https://opac.capetown.gov.za/client/en_US/a/search/detailnonmodal

35. Ndabeni, L. L., Rogerson, C. M., & Booyens, I. (2016). Innovation and local economic development policy in the global South: New South African perspectives. *Local Economy*, *31*(1-2), 299-311.
36. Nikoloski, D., & Pechijareski, L. (2015). Research and development in post-transition: a case study of western Balkans countries. *SEER: Journal for Labour and Social Affairs in Eastern Europe*, 231-240.
37. OECD. (2016). *"Innovation Matters and Policy can do something about it."* Available at: www.oecd.org/sti
38. Omar, N. S. (2019). Innovation and economic performance in MENA region. *Review of Economics and Political Science*, *4*(2), 158-175.
39. Pansera, M. (2011). The origins and purpose of eco-innovation. *Global Environment*, *4*(7-8), 128-155.
40. Peatman, J. G. (1947). Descriptive and sampling statistics.
41. Pece, A. M., Simona, O. E. O., & Salisteanu, F. (2015). Innovation and economic growth: An empirical analysis for CEE countries. *Procedia Economics and Finance*, *26*, 461-467.
42. 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.
43. 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.
44. Romilly, P., Song, H., & Liu, X. (2001). Car ownership and use in Britain: a comparison of the empirical results of alternative cointegration estimation methods and forecasts. *Applied economics*, *33*(14), 1803-1818.
45. Sá, J.F. (2020). "Ranking (trademark) innovation in Africa". World Trademark Review. Available at: https://www.worldtrademarkreview.com/ranking-trademark-innovation-in-africa
46. Thakur, S. K., & Malecki, E. J. (2015). Regional determinants of research and development institutions in India. *GeoJournal*, *80*, 533-554.
47. Türsoy, T. (2017). Causality between stock prices and exchange rates in Turkey: Empirical evidence from the ARDL bounds test and a combined cointegration approach. *International Journal of financial studies*, *5*(1), 8.
48. UNESCO. (2021). https://unesdoc.unesco.org/ark:/48223/pf0000377250
49. World Bank., 2022. "Research and development expenditure (% of GDP)". Available at: https://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS?locations=ZA (accessed 04 November 2022)
50. Vu, K., Hanafizadeh, P., & Bohlin, E. (2020). ICT as a driver of economic growth: A survey of the literature and directions for future research. *Telecommunications Policy*, *44*(2), 101922.