INCLUSIVE GROWTH, INNOVATION AND ECONOMIC DEVELOPMENT IN SOUTH AFRICA: AN EMPIRICAL ANALYSIS

by

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DECLARATION

I declare that the "Inclusive Growth, Innovation, and Economic Development in South Africa: An Empirical Analysis" thesis hereby submitted to the University of Limpopo, for the degree of PhD in Economics has not previously been submitted by me for a degree at this or any other university; that it is my work in design and execution, and that all material contained herein has been duly acknowledged.

Milanzi S.A	....	13th September 2021
Surname & Initials	Signature	Date

DEDICATION

Without God's mercy and blessings nothing is possible. It is his presence that makes us achieve whatever we get in life. I dedicate this thesis to my parents Mr. and Mrs. Milanzi, and all other relatives who took part in motivating me to work hard.

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I am grateful to all of those with whom I have had the pleasure to work during this and other related projects related to this dissertation. I would especially like to thank my mentor Prof. L.T. Mabasa. As a mentor, he has taught me more than I could ever give his credit for here. He has shown me by his example what's a good leader and economic researcher should be.

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ABSTRACT

This study focused on examining the contributions of inclusive growth and innovation towards economic development in South Africa. Empirically literature showed that there must be equitable opportunities for all economic participants regardless of economic class, gender, sex, disability, and religion. Thus, inclusive growth has been seen to be a weapon to curb poverty and inequality on a long-term perspective and the focus is on productive employment rather than merely direct income redistribution as a means of increasing income for excluded groups. This expands from traditional economic growth models such as the equity of health, human capital, environmental quality, social protection and food security in the country. Thus, inclusive growth goes hand in hand with innovation and economic development at large. This study employed the Autoregressive Distributed Lags (ARDL) approach on the annual time series data ranging from 1990 to 2018 obtained from the South African Reserve Bank and the World Bank.

The results revealed that general government expenditure on education, gross fixed capital formation, and information and communication technology have a positive relationship with economic development in the long-run. On the contrary, trade openness and research and development have a negative impact on economic development in the long-run. In the short-run, government expenditure on education, gross fixed capital formation, and information and communication technology has a negative impact on economic development. In that case, trade openness and investment in research and development have a positive impact on economic development. The error correction term was found to be negative and significant which is an indication that the system will revert to equilibrium even though economic development will have a slow rate of speed of adjustment of about 0.04%. Lastly, the existence of unidirectional causality among the series was noticed. Therefore, this study advocate for bridging the gap between income inequality, improving education policies, managing social mobility in the long-run to balance inclusive growth

Keywords: ARDL, Inclusive growth, Innovation, Economic Development, Economic growth.

KEY CONCEPTS

AR	:	Auto-Regressive
ARCH	:	Autoregressive Conditional Heteroskedasticity
ARDL	:	Auto-Regressive Distributed Lags
ARMA	:	Auto-Regressive Moving Average
ASEAN	:	The Association of Southeast Asian Nations
ASSA	:	Allied Social Sciences Association
CGD	:	Computable General Equilibrium
CUSUM	:	Cumulative Sum Control Chart
DIRISA	:	Data-Intensive Research Initiative of South Africa
DST	:	Department of Science and Technology
ECT	:	Error Correction Term
EMDEs	:	Emerging Market and Developing Economies
ENCA	:	e-News Channel Africa
FDI	:	Foreign Direct Investment
GARCH	:	Generalized Auto-Regressive Conditional Heteroskedasticity
GDP	:	Gross Domestic Product
GMM	:	Generalized Method of Moments
GNI	:	Gross National Income
HEIs	:	High education institutions
HQ	:	Hannan-Quinn Criteria
ICT	:	Information and Communication Technology
KPSS	:	Kwiatkowski-Philips-Schmidt-Shin

LM	:	Lagrange multiplier testing (Serial Correlation LM test)
LS	:	Least Squares
MA	:	Moving Average
MENA	:	Middle East and North Africa
NACI	:	National Advisory Council of Innovation
NAICS	:	The North American Industry Classification System
NIPMO	:	National Intellectual Property Management Office
NP	:	Ng-Perron
NRF	:	National Research Foundation
ODA	:	Office of Digital Advantage
OLS	:	Ordinary Least Squares
		Organization
PMI	:	Purchasing Managers Index
R&D	:	Research and Development
RESET	:	The Regression Specification Error Test
SANSA	:	The South African National Space Agency
SARIR	:	South Africa Research Infrastructure Roadmap
SC	:	Schwarz Criteria
SD	:	Sustainable Development
SEE	:	Southeast Europe
SIC	:	Schwarz Info Criteria
SME	:	Medium-Sized Enterprises
SSA	:	Sub-Saharan Africa

TIA	:	The Technology Innovation Agency
UAE	:	United Arab Emirates
UNESCO	:	The United Nations Educational, Scientific and Cultural
USA	:	United States of America
VAR	:	Variance Autoregressive
VECM	:	Vector Error Correction Model
VIFS	:	Variance inflation factors

SYMBOLS USED

α	Alpha,	commonly used as constant or coefficient
β	Beta,	commonly used as constant or coefficient
δ	Delta,	used as a variable and a change in variable
μ	Mu	commonly used as an error term
θ	Theta	
λ	Lambda	
$\sum$	Summation	
$\leq$ & $\geq$	Inequality, meaning is equal to or smaller than or greater than	
Δ	Delta,	meaning a change in a variable
∞	Infinity	

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CHAPTER 1

ORIENTATION OF THE STUDY

1.1. Introduction and background

The promotion of inclusive growth is at the top of both developed and developing nations. This is mainly influenced by high levels of inequality, which negatively affect the well-being and growth of the economy, especially in Africa. Davies (2018) pointed out that inclusive growth refers to diversified economies, hence African economies must copy Asia because they need to diversify, industrialise, to create salaried classes, or at the very least, aspirational middle-class societies. All countries in the world strive for better economic output based on how policymakers decide on managing the economy.

Similarly, Samans (2017) conceptualised inclusive growth as both the pace and pattern of economic growth, which is interlinked and assessed together in all sectors of the economy. The study also indicates that the rapid pace of economic growth is necessary for reducing absolute poverty. For this growth to be sustainable in the end, it should be broad-based across sectors, and inclusive of the large part of a country’s labour force. This implies a direct link between the macro and micro determinants of growth at large. In this perspective, inclusive growth focuses on productive employment, rather than on employment per sector or income redistribution. Employment growth generates new jobs and income, while productivity growth has the potential to lift the wages of workers and the returns of the self-employed. The World Bank (2010) approach adopted a long-term perspective and is concerned with sustained growth, where inclusiveness refers to equality of opportunity in terms of access to markets, resources, and an unbiased regulatory environment for businesses and individuals.

Ali (2007) expressed inclusive growth as an impression that goes beyond broad-based growth. This kind of growth creates new opportunities in the economy. Furthermore, there must be equal access to the opportunities created for all segments of society, particularly for the poor.

Ali and Zhuang (2007) maintained that inclusive growth can be achieved fully when it allows participation of all members of society, with emphasis on the ability of the poor and disadvantaged to participate in growth. This implies by focusing on the process of growth which is associated with declining inequality in those non-income dimensions of well-being that are particularly important for promoting economic opportunities. This includes education, health, nutrition, and social integration, for example, the disadvantage-reducing aspect of inclusive growth, which implies a focus on the outcomes of growth.

It has been seen that Asia's stellar gross domestic product (GDP) growth rate is characterised by rapidly rising relative and absolute inequalities. This was accompanied by rising inequalities leading to an increasing concern that most of the enormous growth benefits were not equally shared (Ali & Zhuang, 2007).

Furthermore, inclusive growth is characterised as both an outcome and a process at which all participants in different sectors contribute towards economic development (Suryanarayana, 2013). It ensures that everyone participates in the growth process, both in terms of decision-making, as well as in terms of growth itself. Inclusive growth benefits are shared equitably in the entire economy. Inclusive growth thus implies participation and benefit-sharing at all costs.

In the Europe 2020 Strategy, inclusive growth is understood as empowering people through high levels of employment, investing in skills, fighting poverty, and modernising labour markets. This includes training and social protection systems to help people anticipate and manage change and build a cohesive society. It is also essential that the benefits of economic growth spread to all parts of the European Union, including its outermost regions, thus strengthening territorial solidity. In this way, it will be ensuring access and opportunities throughout the lifecycle (Barroso, 2013).

Lastly, inclusive growth and innovations should be valued as a situation in which the growth process is valuable to the poor, the old aged, the sick, women, and the youth participating in the process and hence improves their living standards. This basically can be implemented through government enthusiasm in investing in research and development (R&D). Based on that note, the South African government offers the R&D tax incentive under section 11D of the Income Tax Act (Act No. 58 of 1962) to promote both the public and private sector R&D investment in the country. R&D is required to boost innovation in the business sector, by improving the capability for developing new products and processes and improving existing ones. This is crucial for improving the competitiveness and growth of the South African economy.

To show the seriousness in technology advancement, the department of science and technology shows that the government has invested the sum of R300 Million in the new technology platforms such as Information Communication and Telecommunication (ICT) and Biotechnology and about R150 million on technology and innovation for poverty reduction. The government has also invested in technology and innovation advancement in manufacturing and logistics and leverage resource-based industries the sum of R125 million and R90 million respectively (Department of Science and Technology, 2002). For growth to be sustainable and effective in reducing poverty, it needs to be diversified (Kraay, 2004; Berg & Ostry, 2011a). Kraay and Ostray expound inclusive growth and innovation as the process by which proper income distribution and elimination of inequality become an essential input of successful growth strategy, particularly in an unequal society like South Africa.

Inclusive growth cannot function well without bridging innovation and economic development in the country. Based on the 2018 draft White Paper on Science, Technology, and Innovation, Kubayi-Ngubane (2018) showed that South Africa as a developing country has established a range of institutions required for a functional system of innovation. They include the Department of Science and Technology (DST), the National Research Foundation (NRF), the National Advisory Council on Innovation (NACI), the South African National Space Agency (SANSA), the Technology Innovation Agency (TIA), and the National Intellectual Property Management Office (NIPMO). These institutions got established to build government business collaborations such as state-owned enterprises as well as the private sector through increased support via R&D. Furthermore, Kubayi-Ngubane (2018) added that innovation can enhance South Africa’s development and improve the quality of life of its citizens. It has been argued that government expenditure on R&D has a great potential in improving public service delivery, increasing the competitiveness of firms, refurbish and modernise existing industries, boost economic growth and improve the quality of life at local levels, particularly in poor communities.

Correspondingly, the National Planning Commission (NDP) (2018) highlighted that South Africa gets affected by international and regional development in different ways. The country can increase its share of world trade opportunities and investments. Therefore, it must increase investment in R&D for it to benefit from rapid growth as well as an increase in transferred technology. It can also benefit from better use of existing resources to facilitate innovation and enhance cooperation between public and private sector science and technology institutions. This will enable increased demand for various commodities and expand consumer markets in the country. Furthermore, it has been found that technological change helps to curb the biggest challenges in the education and health sectors. The commission also highlighted that the use of digital communications has changed societies in ways that are not yet understood. In this regard, 17 % of South Africa’s population can access the internet. This number gets increased by about 20% annually.

Lastly, Manzini (2019) emphasised that to obtain a comprehensive assessment of innovation in South Africa, there is a need to sharpen the metrics for measuring non-technological innovation and to define, account for and accurately measure the hidden innovations which drive the realisation of value in management, the arts, public service and society in general. It has been indicated that there is limited attention to innovation diffusion. He argued that South Africa relies on local and transferred innovations, therefore, knowledge outputs such as patents that emanate from firms and research institutions might indicate the performance of the individual institutions. However, it is only through the implementation of those institutions that can be realised. A more realistic measure of the impact of those outputs on the economy is the extent to which they are dispersed in the relevant industrial and social sectors.

1.2. Statement of the problem

The emergence of global financial crises, rising levels of inequality, increased corruption, and high unemployment in both developing and developed countries form major negative externalities towards economic growth and development (Ernst & Escudero, 2008). As one of the developing countries, South Africa needs to adapt to the ability to research and develop new technologies, its ability to understand, and its applications to have a great deal of economic development. This is in line with the National Development Plan (NDP) (2018)’s concern about innovation which emanates from the relatively low number of active and productive R&D workers, and the low level of support and coordination of productive partnerships between universities and research councils and across different government departments.

Apart from its well documented interdependent socio-economic phenomena labelled the 'triple challenge' of inequality, poverty, and unemployment, a recent report by the Organisation for Economic Co-operation and Development (OECD) (OECD, 2019) shows that South Africa has a relatively large group of adults who have low levels of education and skills, and limited opportunities for skills development. Similarly, (Mzimba, 2019) reported that South Africa faces challenges such as poverty, low levels of education and employment, as well as an urgent need for economic growth. This triggers the need for inclusive growth, innovativeness, and proper economic development. The approach will enable developing countries to have access to capital and help to improve the allocation of funds wisely. Furthermore, this will help to impose discipline on the government on policymaking and implementation of pro-growth reforms which will benefit the low-income household in the economy.

1.3. Research aim and objectives

1.3.1. Aim of the study

The study aimed to analyse the contribution of inclusive growth and innovation towards South African economic development.

1.3.2. Objectives of the study

To achieve the aim of this study, the following objectives are considered:

- To compute and assess the effect of trade openness on economic development.
- To identify the impact of government expenditure on information and communication technology and research and development on economic development.
- To assess the contribution of government expenditure on education and gross fixed capital formation on economic development.

1.4. Research questions

This study is going to be accomplished by answering the following research questions:

- How to compute trade openness as one of the variables used in the study?
- What is the effect of trade openness on economic development?
- What is the impact of government expenditure on information and communication technology and research and development on economic development?
- What are the contribution of government expenditure on education and gross fixed capital formation and innovation towards economic development?

1.5. Definition of concepts

The following concepts are defined to make sense of the outcome of this study:

- Economic development

It refers to the state at which a nation is stable and improving in terms of political stability, economic growth, social and well-being of its people. In this study gross domestic product per capita has been used as a proxy to measure economic development in South Africa (Todaro & Smith, 2015).

- Trade openness

Trade liberalisation of trade openness is the removal or reduction of restrictions or barriers to the free exchange of goods between nations. This includes the removal or reduction of tariff obstacles, such as duties and surcharges, and non-tariff obstacles, such as licensing rules, quotas, and other requirements (Liberati, 2007).

- Expenditure on education

According to Belassi (2004), public spending on education includes direct expenditure on educational institutions as well as educational-related public subsidies given to households and administered by educational institutions.

- Gross fixed capital formation

Nawaz (2010) defines state investment as the net increase in physical assets (investment minus disposals) within the measurement period. It does not account for the consumption (depreciation) of fixed capital and does not include land purchases.

- Innovation

According to Segerstrom (1991), technology or innovation is the process of translating an idea or invention into a good or service that creates value or for which customers will pay. To be called an innovation, an idea must be replicable at an economical cost and must satisfy a specific need. Innovation involves the deliberate application of information, imagination, and initiative in deriving greater or different values from resources. It includes all the processes by which new ideas are generated and converted into useful products. In business, innovation often results when the company applies ideas to further satisfy the needs and expectations of the customers. In this study government expenditure on information and communication technology (ICT) and R&D are used to represent innovation. Based on Khumalo and Mongale (2015), ICT is measured by outputs of computers, communications equipment, and software.

1.6. Ethical considerations

This study makes use of secondary data and all sources are acknowledged. In addition to that, all the rules and regulations of the University of Limpopo for conducting a research project for PhD in Economics are taken into contemplation, therefore, this study was done without conducting any plagiarism.

1.7. Significance of the study

This study investigated the contribution of inclusive growth and innovation towards economic development in South Africa. South Africa is facing cumbersome economic challenges such as rising levels of income inequality, increased corruption, high unemployment, and a low level of technology. As such, there is a need for the country to invest in education, to enhance innovativeness and inclusiveness to benefit all the sectors of the economy. The novelty of this thesis is to contribute to such a research gap by providing an empirical analysis of the relationship between inclusive growth and innovation and economic development in South Africa. Furthermore, to the best of the author's knowledge, this thesis is the first of its kind to examine in detail the dynamic relationship between inclusive growth and innovation and economic development in South Africa using the recently developed ARDL-bounds testing approach. The study is also envisaged to contribute to policymaking by providing empirical evidence to support the notion that improved innovative and inclusive growth can lead to economic development which will lead to balance the quality of life, income and wealth distribution, and availability of jobs and earnings. This can only be achieved if the economy is growing rapidly, with immense availability of skills for technological advancement and less inequality. This can only be spurred if there are great ways of improving knowledge skills, increasing opportunities, and access to goods and services to all citizens.

1.8. Structure of the study

This thesis is organised as follows:

Chapter 1: It is mainly the orientation of the study, which is mainly grounded on introducing the main gist and background of the topic. Thus, the focus was on analysing approaches underpinning inclusive growth and innovation towards economic development. It has been seen that there are a few types of inclusive growth as well as issues behind it. The chapter also presented the problem statement, research aim and objectives, research questions, definitions of the main concepts, ethical considerations, and the significance of the study.

Chapter 2: Focuses on an overview of inclusive growth, innovation, and economic development in South Africa. It provides an insight into some of the implications and issues affecting as well as enhancing inclusive growth, technological progress, and economic development in South Africa.

Chapter 3: Literature Review; comprises of theoretical and empirical literature behind this study.

Chapter 4: Research Methodology; encompasses research methodology whereby explanations on data used and model specifications as estimation technique used discussed. This includes the discussion of the Auto Regressive Distributed lags (ARDL) approach which has been used for both long and short-run analyses. Other estimation techniques such as the unit root tests, diagnostic tests, generalised impulse response and variance decomposition system have been discussed.

Chapter 5: Discussion/presentation/interpretation of results; presents the discussions and the interpretations of analyses made in the study. Thus, the findings are presented in tables, figures and equations format.

Chapter 6: Summary, policy recommendations, and conclusions, covers the summary of the study.

1.9. Summary

In this chapter, much emphasis was put on introducing the contribution of inclusive growth and innovation to economic development. In that case, the research problem, study objectives, and questions, as well as the significance of this study, were stipulated. In addition to that definitions of concepts and other terminologies as well as symbols used to manipulate equations in this study were not neglected. The second chapter will be focusing on the overview and background of inclusive growth, innovation and economic development in South Africa.

CHAPTER 2

AN OVERVIEW OF INCLUSIVE GROWTH, INNOVATION AND ECONOMIC DEVELOPMENT IN SOUTH AFRICA.

2.1. Introduction

The World Bank (2018) showed that global economic activity got revitalised by 3% in the fourth quarter of 2017. This was seen to be a great improvement compared to the previous quarters as growth moderated in the United States, the Euro area, China and other large emerging markets and other developing economies (EMDEs). This incredible improvement boosted the global manufacturing Purchasing Managers Index (PMI) to close 7% in early January of 2018, while industrial production got accelerated only in November and December of 2017. That being the case, South Africa's economy is still experiencing slow growth, mainly due to its reliance on exports of raw materials which carry less value than finished products. This showed that the country is diverging from global growth and this makes it have limited opportunities to benefit from global growth. The economy is experiencing low per capita terms by not providing additional income that could help reduce poverty and inequality in the country.

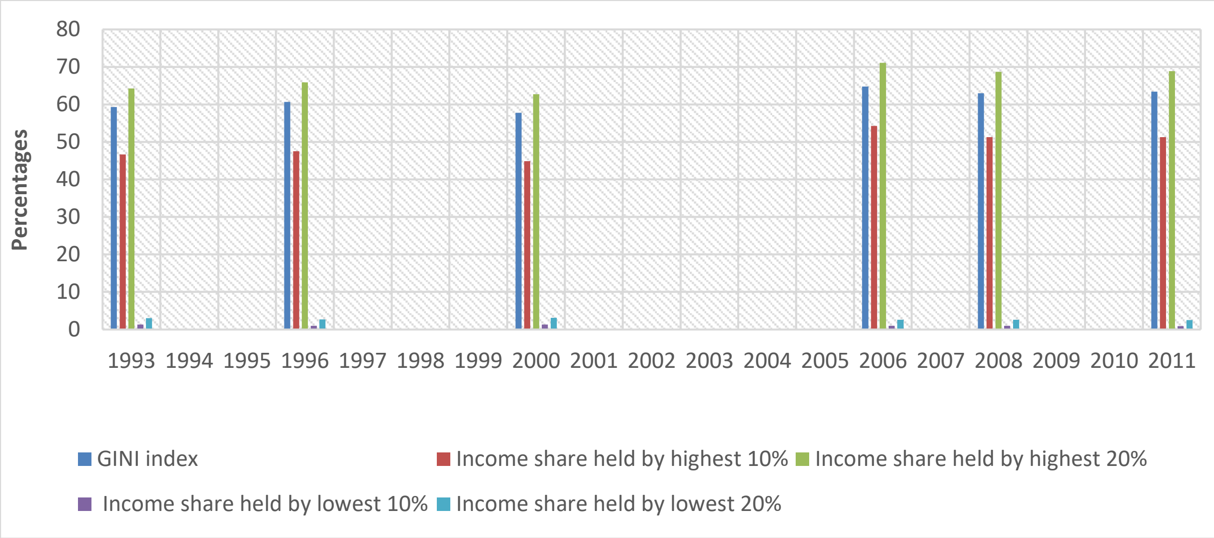
On the contrary, according to the World Bank (2018), South Africa's economy is expected to have positive expectations on the return of investments which will make firms to be more competitive; have great technology transfer; join global supply networks and continue overcoming its historical isolation from the world economy. This anticipation followed a great momentum business cycle and consumer behaviour had early 2018. The report pointed out that the county must change some of its policies that support competition and competitiveness and focus on public and private sector investment and R&D. Besides that, the country must be linked between global and regional values chains including knowledge transfer, and foreign direct investment (FDI) is going to be maintained if the country creates a conducive environment for investors in the country.

2.2. South Africa's inequality and redistributive policies

Inequality remains high in South Africa as compared to the rest of the world (World Bank, 2018). Thus, the Gini coefficient, which measures the income and consumption disperse, is high compared to the rest of the world for which comparable data exist, and by a significant margin. The report also reveals that South Africa's consumption inequality is high in South Africa of which Ukraine is the least out of 101 countries. It also highlighted that South Africa's inequality is associated with a small elite, a large class of poor people and a relatively small middle-class group.

Income distribution is the smoothness or equality in which income is distributed out among members of society. If only a few earn money, then the income distribution is perfectly unequal. Cingano (2018) pointed out that the high level of inequality in a country could result in political instability, social unrest and harmful effects on economic growth. It has also been noted that imperfections of the financial market can also result in great inequality to invest. This is because poor individuals may not be able to afford a worthwhile investment. For instance, lower-income households may decide to leave education if they cannot afford the fees payable in those institutions. In return, under-investment by poor households implies that aggregate output would be minimal than in the case of the perfect financial market. Therefore, income redistribution is an economic practice, which aims at levelling the distribution of wealth or income in society through a direct or indirect transfer of income from the rich to the poor members of society. If everyone earns the same amount of money, then the income distribution is equal (Lambert, 1992).

Berg (2011) showed that apart from having high levels of racial inequality, South Africa has high and persistent income inequality. That is for an upper-middle-income country in terms of GDP per capita and economic structure. Besides, the South African social indicators like life expectancy, infant mortality or quality of education are all closer to those of lower middle income or even low-income countries. This reflects the unequal distribution of resources and opportunities in the country. The study also reflected that the situation above can be lessened by fiscal redistribution through the grant system, job creation and provisioning of quality education to balance the labour market. The table below shows the existence of income inequality in South Africa from 1993-2011.



Source: Quantec Easy Data

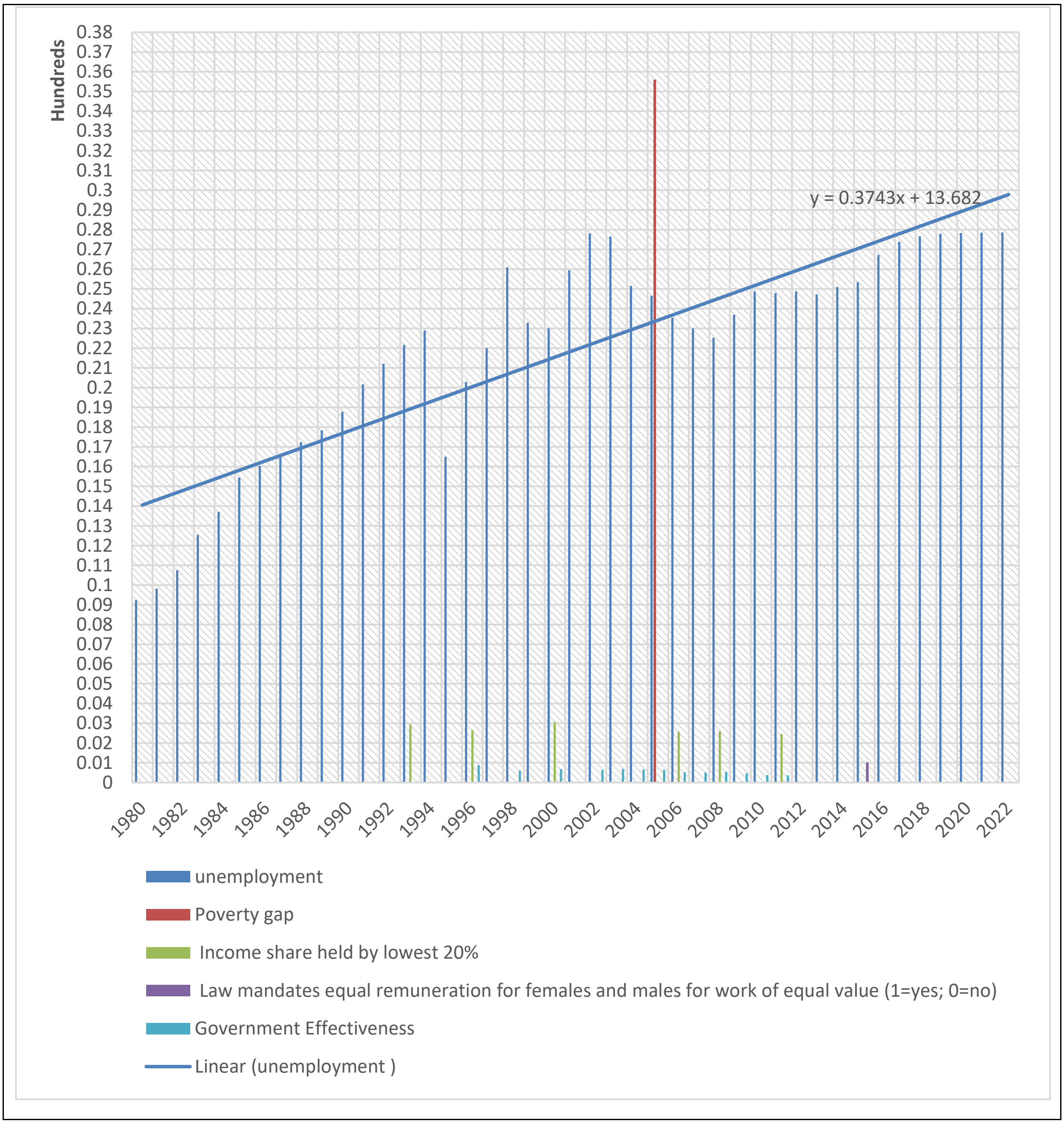
Figure 2. 1 GNI, high and lowest percentages of income

Based on figure 2.1, the GNI index, which is a measure of statistical dispersion, intended to represent the income or wealth distribution of a nation's residents and the most commonly used measure of inequality has been unstable. High inequality was noted in 1993 and 1996 by 60%, in 2000 due to improved grants and education the inequality was reduced to 58%. In 2006, 2008 and 2011 the inequality was recorded to be high due to lack of inclusivity in the economy.

As indicated by the International Monetary Forum (IMF), growth is considered inclusive if it is high, sustained, and extensive across sectors in per capita terms. Thus, it must cover all these factors:

i. Reduces poverty (includes the poor in the group with socially acceptable levels of income),
ii. Reduces inequality (includes the poor in prosperity sharing),
iii. Creates jobs (includes people in the productive part of society),
iv. Reduces the gender gap (includes both women and men in the economy),
v. Improves governance (includes everyone in the wealth distribution, not just a few at the top), and
vi. Responds to climate change (includes future generations in prosperity sharing). (Kireyev, 2017).

Concisely, inclusive growth can be achieved better through increased economic opportunities for all stakeholders, and these opportunities must be sustainable so that all stakeholders can feed themselves (Kireyev, 2017).



Source: Quantec Easy Data

Figure 2. 2 Poverty gap, Inequality, Unemployment, Gender gap, and governance.

Based on figure 2.2 above government effectiveness measures the quality of public services, the quality, and degree of independence from political pressures of the civil service, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Law mandates equal remuneration for females and males for work of equal value whereby (one=yes; zero=no). Poverty gap data were calculated at national poverty lines in a percentage format. The data were compiled from official government sources and computed by the World Bank using national poverty lines. Data on income share held by the lowest 20% were based on primary household survey data obtained from government statistical agencies and World Bank country departments. Data for high-income economies are from the Luxembourg Income Study database. The equation $y = 13.682 + 0.3743X$ represents the trend line at the unemployment level.

In this regard, there was about 35 percent of the unemployment rate being recorded in 2006 alone. The income share held by the lowest 20 percentage remains lower in all sectors. Political instability remains a great risk in reaching inclusiveness.

2.3. Implications of inclusive growth, innovation, and economic development

Explained below are some of the factors which have great implications on inclusive growth, innovation, and economic development.

2.3.1. Political

Possony (1974) argued that economic development denotes a concrete force at which the government and large cooperations reach specific major goals for instance industrialisations, modernised agriculture, high level of exports and good living standards. This mainly works if the development of the economy plus the growing complexity of the society brings alterations of the psychological makeup of the citizens, distributions of skills and knowledge as well as adjustive restructuring and expanding the capacity of political institutions. Bishop (2019) described South Africa's economy as noisy and disruptive. Thus, political stability brings harmony and positive growth as well as curbs unemployment in the economy. Therefore, all stakeholders should have an equal chance to compete in political affairs and contribute fully to the economy. Alesina (1996) expressed the consequences of political instability in Argentina and Japan's economic downfall in 1960. The paper showed that the uncertainty associated with an unstable political environment may reduce private investment and, therefore, growth. On the other hand, poor economic performance may lead to government collapse and political unrest. Therefore, in countries and periods with a high degree of political instability, growth is significantly lower than otherwise. Lastly, investment and growth fall as a result of the shock, further increasing the likelihood of government collapse, leading to even more political uncertainty.

Davis (2017) showed that the situation which the South African economy is going through since 1994. The report pointed out that in the year 2017, the economy slowed tremendously due to increased corruption and political instability. Furthermore, the report displayed that political and policy uncertainty along with perceptions of widespread corruption are significant contributors to the depressed mood of business and consumers in the country. It has also shown that South Africa is nowhere near worst off among Britain, Russia, India, China, and South Africa (BRICS) nations and as well makes it be ranked the second to Venezuela whose significantly worse economic and political situation has left grocery stores bare and hospitals without medications.

The News24 (2017) report showed that the regular political shocks, such as surprise cabinet reshuffles and the ensuing votes of no confidence brought pressure to both private investment outlooks.

2.3.2. Economic and financial

All stakeholders must have equal opportunities for educational attainment, skill development, credit facilities and ownership of infrastructures (Klein, 1999). The study further highlights that countries with open accounts are a significantly greater increase in financial depth than countries with continuing capital account restrictions.

Similarly, Lam (2016) highlighted the effect of the business-government relationship on economic development. Fostering economic development, many governments, especially those of a small economy, such as Singapore, Taiwan, and Hong Kong, had taken a leading role in managing their economies, despite the free-market rhetoric that some of them have made. Thus, the paper tried to examine the involvement of the government in economic development. Therefore, the findings showed that government interventions lead inevitably to both cooperation and conflict with the private sector. Lastly, Eltony (2007) indicated that economic diversifications like the reduction of the indirect role of the public sector, while increasing private sector activities, promote the private sector's size and its role in the economy. The study was focused on Kuwait's oil-exporting sector. Thus, the necessity of economic reform and structural adjustment come up to the top of the policy action agenda only when oil prices are down, and the government with budgetary pressure.

2.3.3. Cultural

The tradition and customs must be tolerable or not being segregated in decision-making in the economy. Harutyunyan (2017) clarified the importance of culture in the decision-making towards economic development. The study articulated that cultural differences relative to the technological frontier like not sharing religion or language might act as cultural barriers to innovativeness and thus lower economic development.

2.3.4. Social

Primordial loyalties e.g., races, languages, and religions must not come to be the problem or an excuse in participating in some of the economic activities in the economy. On contrary to this, Lorrain (2016) highlights some of the socio-economic problems South Africa as a country is facing, and how it can affect economic development. The article shows that endangered marriage legacy, absent fatherhood, teenage parenthood, cultural distortion, alcohol abuse, anarchy culture, high unemployment and low wages, corruption, lack of leadership and heritage illiteracy are some of the issues affecting the economic development in the country.

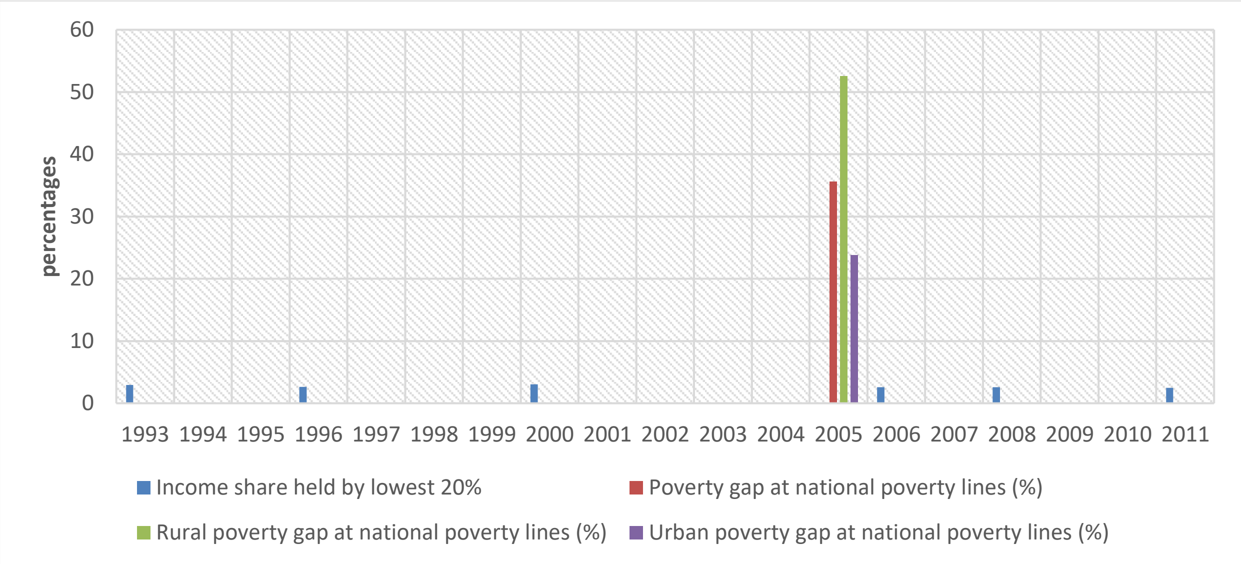
Similarly, Sacks, Wolfers and Stevenson (2010) explored the relationship between subjective well-being and income, as seen across individuals from different countries. In that case, it shows that rich people showed more satisfaction with their lives than poor people do around the world. Similarly, countries with greater GDP experience more life satisfaction than countries with lower GDP. Thus, the magnitude of the satisfaction-income gradient is the same whether the comparison is based on individuals or countries. The main issue is that the absolute income of individuals in those countries plays a great role in influencing well-being. Therefore, countries that focus on developing their GDP increase the value of satisfaction to their citizens and those countries experience economic growth.

2.4. Issues behind inclusive growth, innovation, and economic development

Explained below are some of the issues that every government must tackle to achieve better inclusive growth and innovativeness towards economic development (Ali & Zhuang, 2007).

2.4.1. Poverty reduction

The government must bridge poverty by looking at necessary policies. Thus, poor people do not have resources and good health facilities. Therefore, informal workers' provisioning can be a good start. Eradicating extreme poverty and hunger was the first goal adopted by the united nation and was supposed to be achieved by the year 2015 worldwide. The table below shows the percentages of income distribution and poverty line among South African citizens.



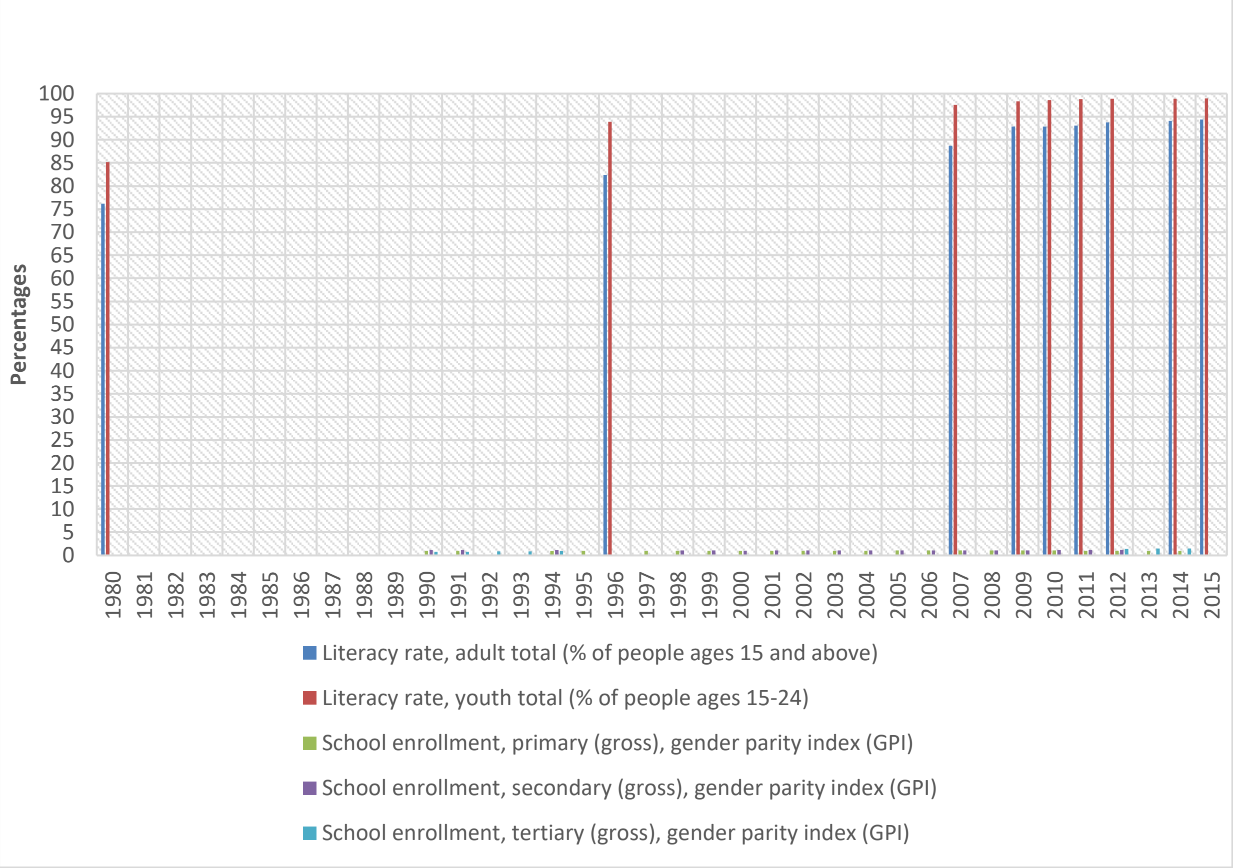
Source: Quantec easy data

Figure 2. 3 Income share held by the lowest 20% of the population and poverty lines.

Figure 2.3 shows the statistics of the lowest 20% of the poor people and poverty lines in South Africa in the period of 1993-2011. Based on the graph, the rural poverty line was high in 2005 compared to the urban poverty line. It has been further discovered that the national poverty line stood at 50.2% as of 2016 (Statistics South Africa, 2017). Similarly, World Bank (2018) forecasted that the poverty reduction by 2030 will depends on whether South Africa has improved on economic growth and minimised income equality.

2.4.2. Education and literacy

Education is recognised, as a universal right of each individual and an essential element in the economic and social development of nations, is a key factor in the future of Africa. The United Nations Educational, Scientific and Cultural Organization (UNESCO) defines literacy rate as the ability to identify, understand, interpret, create, communicate and compute, using printed and written materials associated with varying contexts. Knowledge must be dependent on education provisioning to attain skills to the nation (UNESCO, 2015). Table 2.4 below shows youth and adult literacy rates as well as school enrolment.



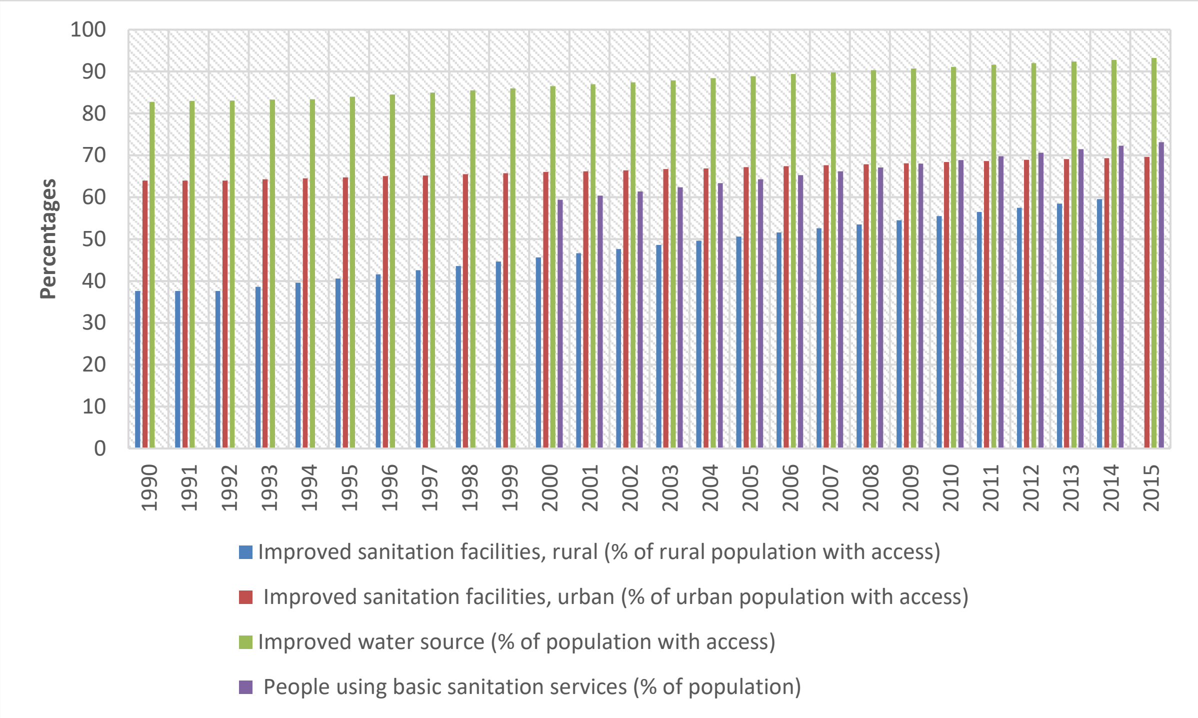
Source: Quantec Easy Data

Figure 2. 4 Literacy rate and education enrolment in South Africa.

Based on figure 2.4 above it has been seen that youth attendance in education has escalated from 1980-2015. On the other hand, the adult literacy rate has ranged between 75%-98%. Thus, the gender parity index for primary, secondary and tertiary remains low.

2.4.3. Health

It has been noted that healthier people can work and boost the economy unlike the malnourished group in the economy. Poor health can lead to the inability of a person to work and provide for the growth of the economy. Aguayo-Rico and Guerra-Turrubiates(2015) highlighted that health is one of the most important assets of a human being. Thus, poor health standard causes physical and emotional weakening causing many complications in the lives of people. Economically, a healthier person is seen to be keen on participating in different economic activities.



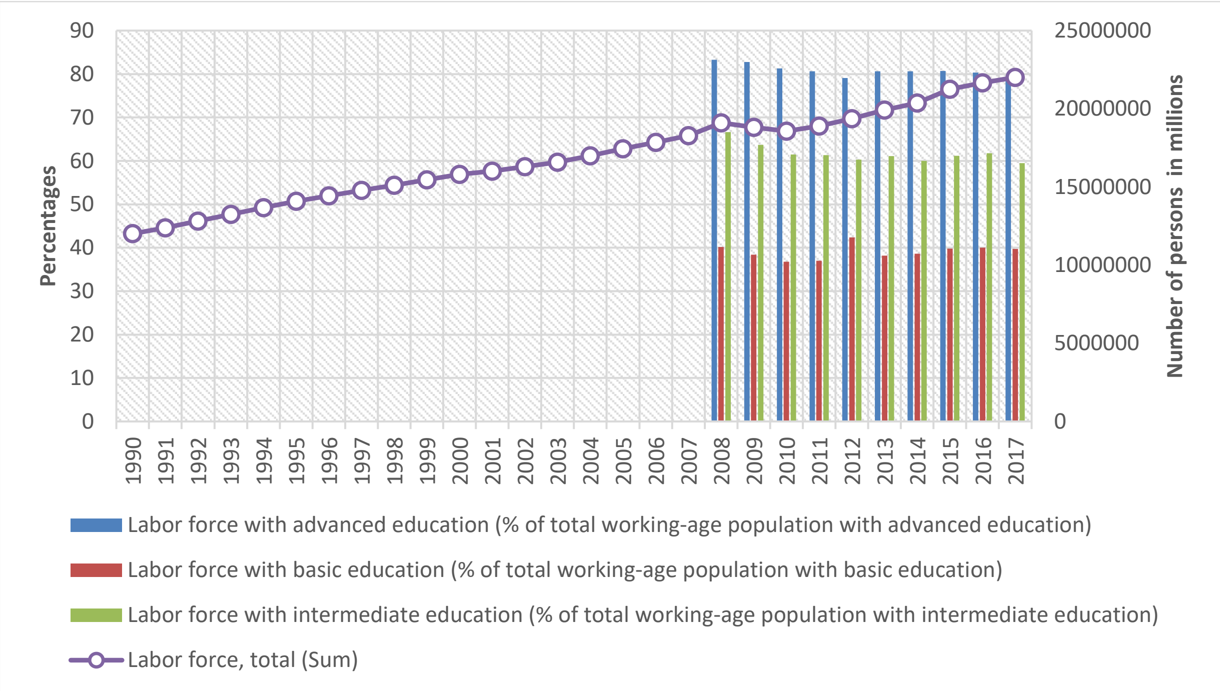
Source: Quantec easy data

Figure 2. 5 Access to sanitation facilities and water sources.

Figure 2.5 shows that most of the population has access to clean water and improved sanitation both in rural and urban areas. The sanitation facilities in the urban areas seem to be stable from 1990-2015, on the other hand, there are many improvements in rural areas which shows that there are better living standards in most of the remote areas of the country. Similarly, the World Bank reports show that even though South Africa lags on an average upper-middle-income country it performs better than an average country in Sub-Saharan Africa (World Bank, 2018).

2.4.4. Skill development and knowledge transfer

Any available market needs skilled labour. Therefore, lack of this item can lead to high unemployment in the economy hence hindering growth. In a growing economy, all sectors need well-furnished labour. Hindle (2018) defined skills development such as education, training and development activities designed to help employees and future employees gain knowledge, skills, and attitudes that would improve their performance in the positions that they currently hold and improve their prospects. Hindle's report showed that the implementation of the policy led to skills development interventions in the country. Table 6 below shows the labour force in South Africa based on the attainment of basic, intermediate and advanced education in the country.



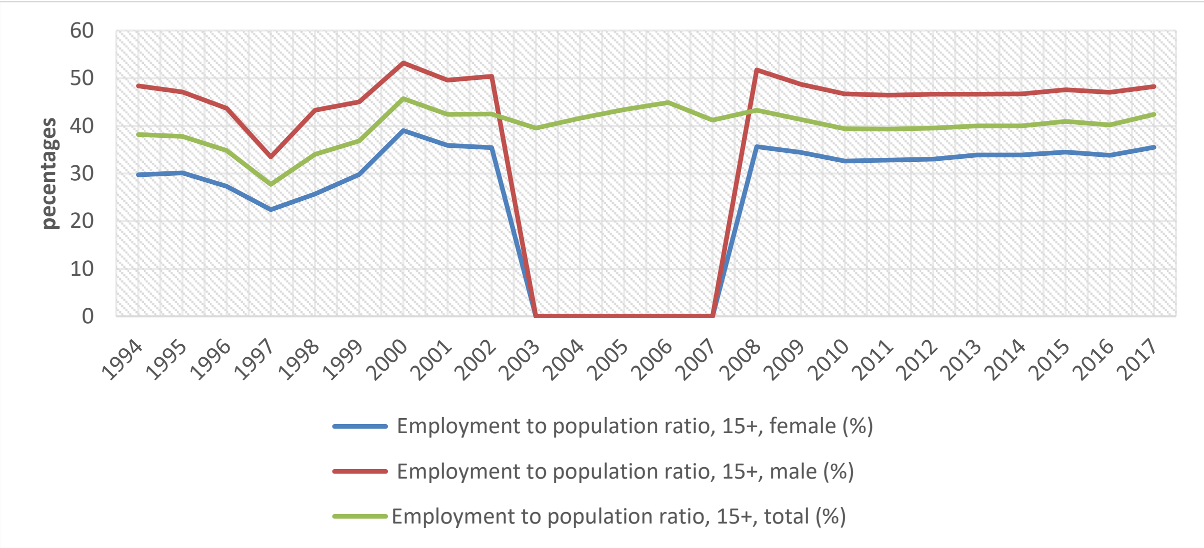
Notes: Data on advanced, intermediate and basic education were calculated on percentages of total labour force except the sum of the total labour force, which is in millions.Source: Quantec Easy Data

Figure 2. 6 Labour force based on educational attainment.

Figure 2.6 above shows that there was a high statistic of the advanced skilled labour force] compared to those having basic and intermediate education. There is an uprising trend of a sum of labour, which gives good sureness of a good future labour force.

2.4.5. Employment opportunities

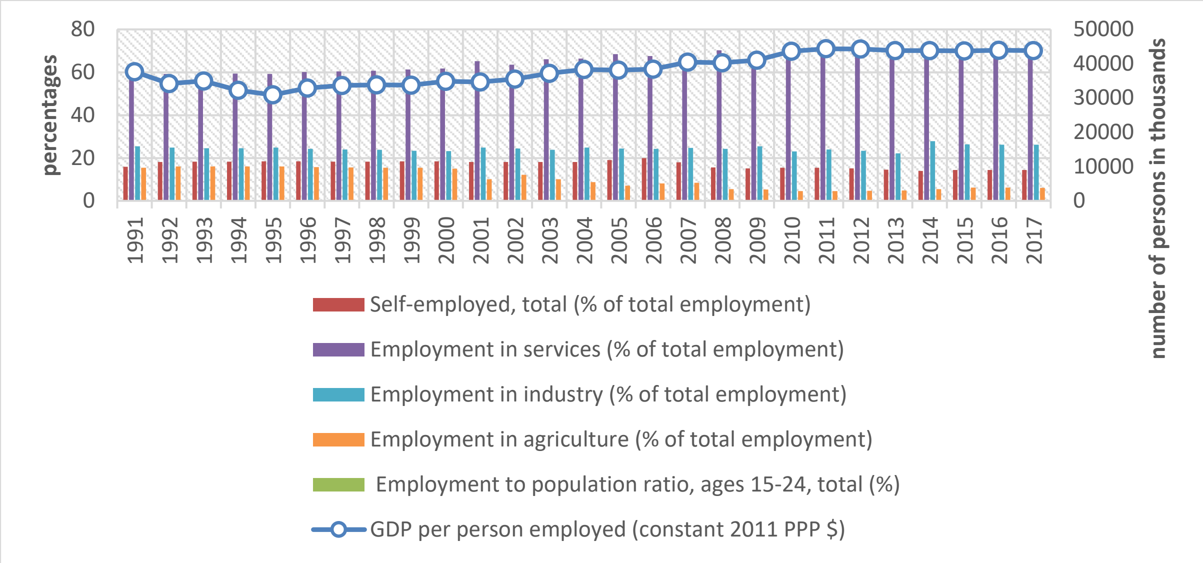
If there are no jobs in the economy, inclusive growth becomes a problem. The government must make sure that people have access to jobs without discrimination. According to Natarajan (2010), employment has to be recognized as a fundamental human right and it is the responsibility of governments to take all possible steps to achieve and maintain full employment in both developing and developed countries. That is in a world in which individual citizens are expected to provide for their economic livelihood and that of their families, access to employment is an absolute necessity for physical survival and human welfare. Figure 2.7 shows the employment to population ratio ranging from 15 years of age and above in South Africa from 1994-2017.



Source: Quantec Easy Data

Figure 2. 7 Employment opportunities.

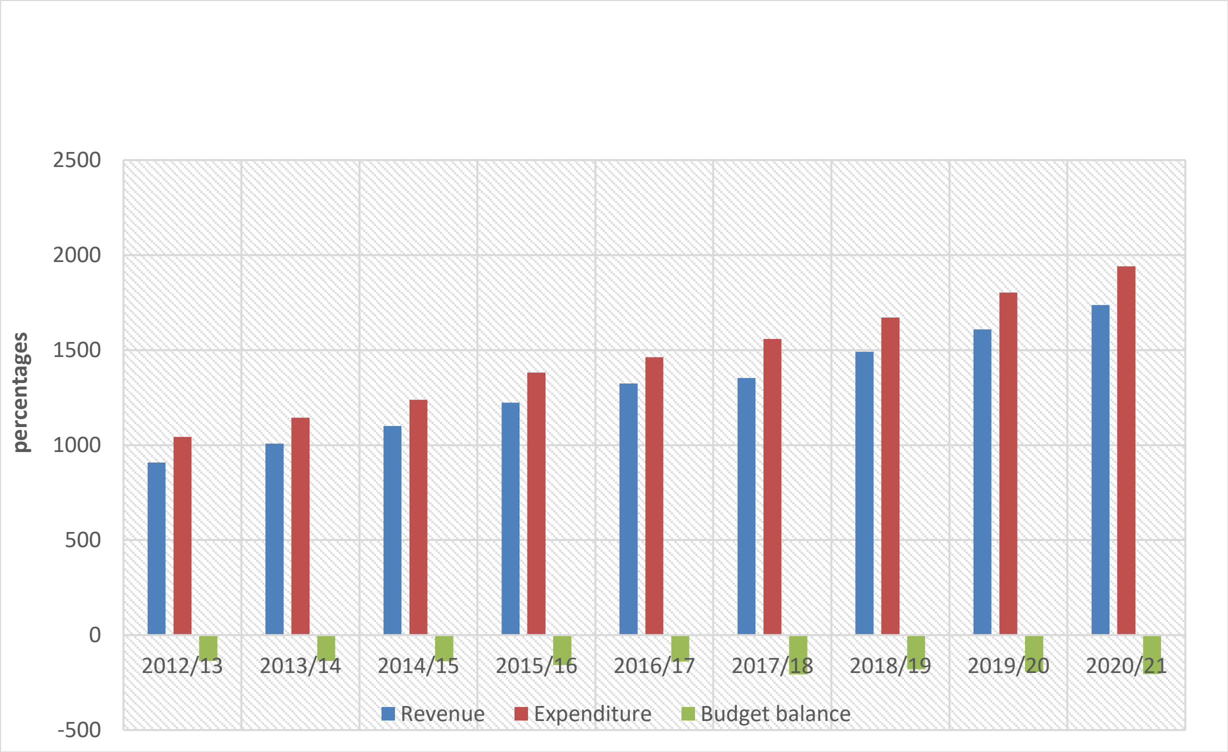
Based on figure 2.7 above, there is more population aged 15 years and above who are employed in different sectors of the economy than the female population of the same range of years. On the other hand, table 8 below shows the employment opportunities given by different sectors.



Source: Quantec Easy Data

Figure 2. 8 Employment opportunities by sector.

Figure 2.8 above shows that most of the working population are self-employed and this group ranges between 25%-30% of the labour force. The GDP per employed person, which was calculated based on the 2011 purchasing power parity, shows a rising trend since 1995. Most of the working group are employed in service delivery. At the same time, employment in agriculture shows a decline, which can be due to lack of subsidies in those years, lack of confidence in agriculture and climate change. On the other hand, industrial employment seems to be stable while the labour force ranging from 15-24 seems to be very low in the economy. All these figures given in table 2.8 above were calculated in percentages of the labour force.



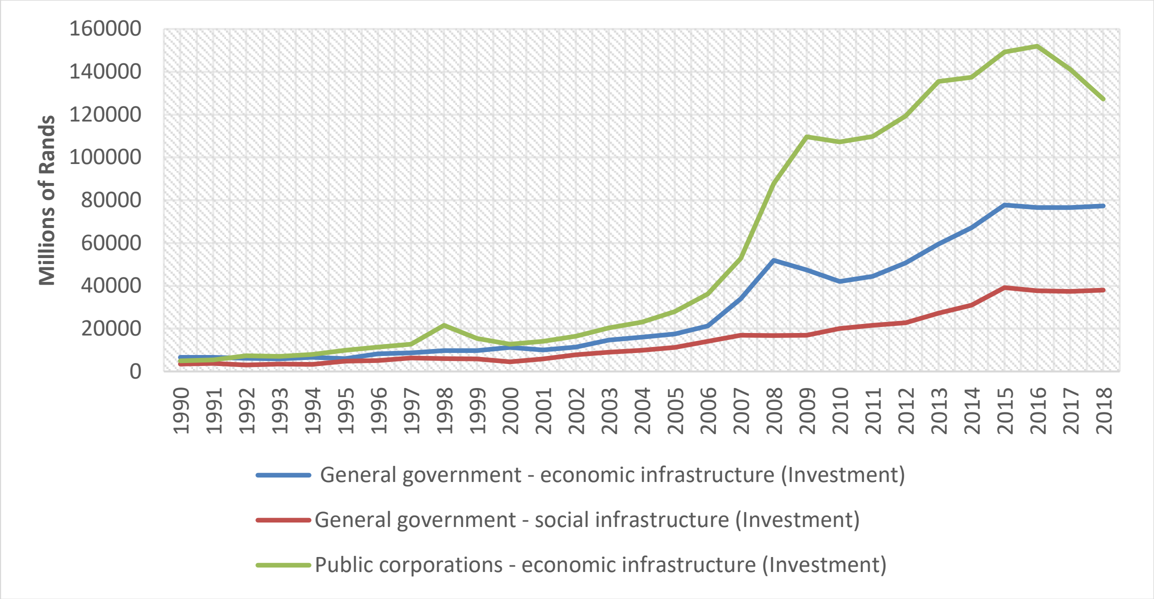
Source: National Treasury

Figure 2. 9 Revenue, expenditure, and budget balance.

Figure 2.9 shows that the government expenditure has been high, that is its' revenue since 2012 and has been forecast to continue this situation until 2021. This implies that the country has been in debt and will continue to be in it if nothing is not going to happen to the economy. All sorts of debts the public can entice in can have a great consumption effect on the future and current generation. This also means a future tax increase.

2.4.6. Social and economic infrastructure

Infrastructure acts as a bridge between human resources and the market. Therefore, without infrastructure, investment jobs cannot be produced, as it is one of the important factors that hold inclusive growth. Regardless of the slow growth, the South African economy is experiencing, the country tries its best to boost its investments in social and economic infrastructure. There are three types of areas on which the expenditure is based; these based are on fixed and gross fixed capital formation. The government invests most in health care, the education sector, on public facilities like community housing and prisons and roads and rail on the transportation side. Besides the general government expenditure, public corporations also invest in infrastructure (Department of Science and Technology, 2002).



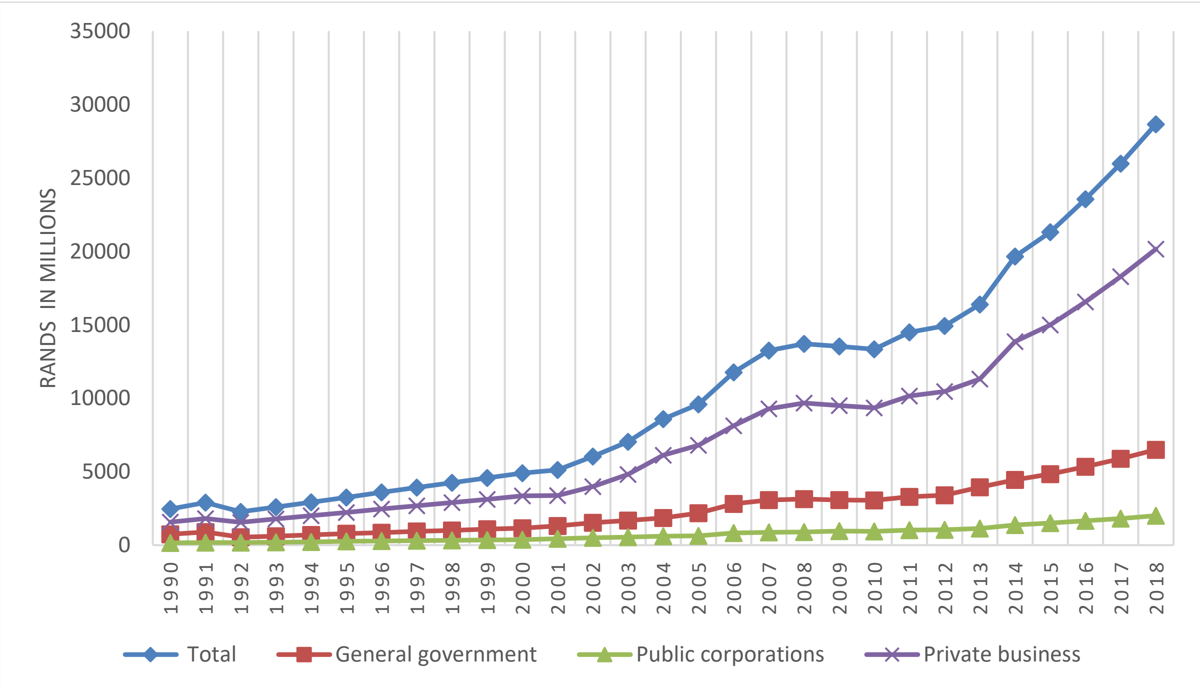
Source: South African Reserve Bank

Figure 2. 10 Government investment in social and economic infrastructure.

Based on figure 2.10, public corporations have a keen interest in investing in economic infrastructures such as transportations, energy, water, safety and resilience, financial markets, health, and education. Such that it invests more millions of rand than the general government which invests in both social and economic infrastructures. The investment of the general government in public schools, universities, hospitals, community housing, and prisons seems to be from 1990 to 2005 and got improved in 2008. There was a slight decrease in social infrastructure by the general government from 2008 to 2010, which then after the world cup it improved and became stable from 2015 up to 2018. On the contrary, the public corporation investment in social infrastructure is declining from 2016 up to 2018.

2.4.7. Research and development and ICT expenditure

Based on the report done by the NDP (2018) by 2030 South Africa must put much emphasis on achieving the best out of R&D. The report points out that R&D can improve the quality of education, technology transfer as well as health standards. Thus, it must be fostered in universities for the institution's link between innovation and business requirements in all sectors of the economy. Skills and human capital are necessary to support inclusive growth and development. According to the NDP (2018), DST published the Human Capital Development Strategy for Research, Innovation, and Scholarship to address the following main challenges which include the low rate of production of research students; under-representation of black and female South African students in research degrees and careers; the need to promote and steer R&D and training activities, especially within domains and disciplines closely linked to technological innovation; the relatively low number of active and productive R&D workers, and the low level of support and coordination of productive partnerships between universities and research councils and across different government departments. Figure 2.11 below shows the general government, public corporations, and private sector gross fixed capital formation in R&D in South Africa from 1990 to 2018.

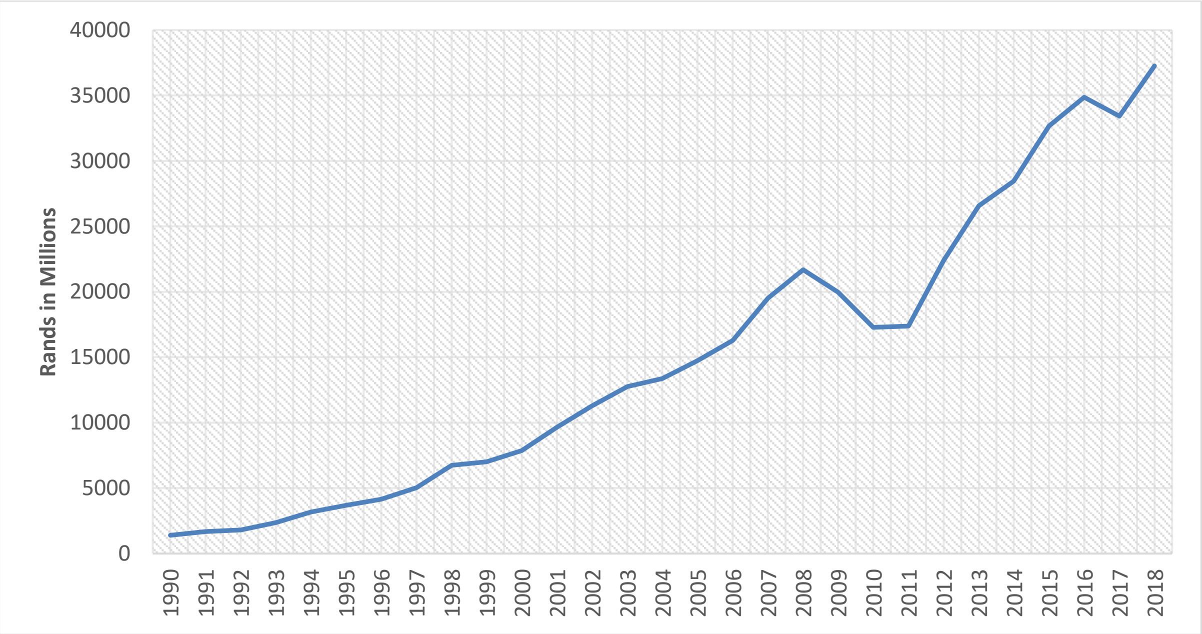


Source: South African Reserve Bank

Figure 2. 11 Research and development investment

Figure 2.11 above shows that private business invests more millions of rand on R&D compared to the general government. Thus, the public corporations become the least to invest in R&D based on the data collected from the South African Reserve Bank ranging from 1990 to 2018. Therefore, the government has to put more investment for the country to have advanced technology, alleviation of poverty and the increased employment rate.

Similarly, ICT plays a great role in promoting digital society. Thus, the 2016 National Integrated Information and Communication and Technology policy white paper stipulates that the South African government through the Department of Science and Technology bridges the gap of availability of universal service and access to ICT services and infrastructure to encourage ICT innovation and fair competition. The department achieves this through initiatives from the Data-intensive Research initiative of South Africa (DIRISA), the office of Digital Advantage (ODA) and South African Research Infrastructure Roadmap (SARIR). The target of these initiatives is to mobilise research infrastructure investment in scientific domains such as energy, humans and society, health, biology, and food security, earth and environment, and materials and manufacturing (National Planning Commission, 2018). Figure 2.12 below shows total government expenditure on ICTs in South Africa from 1990 to 2018.

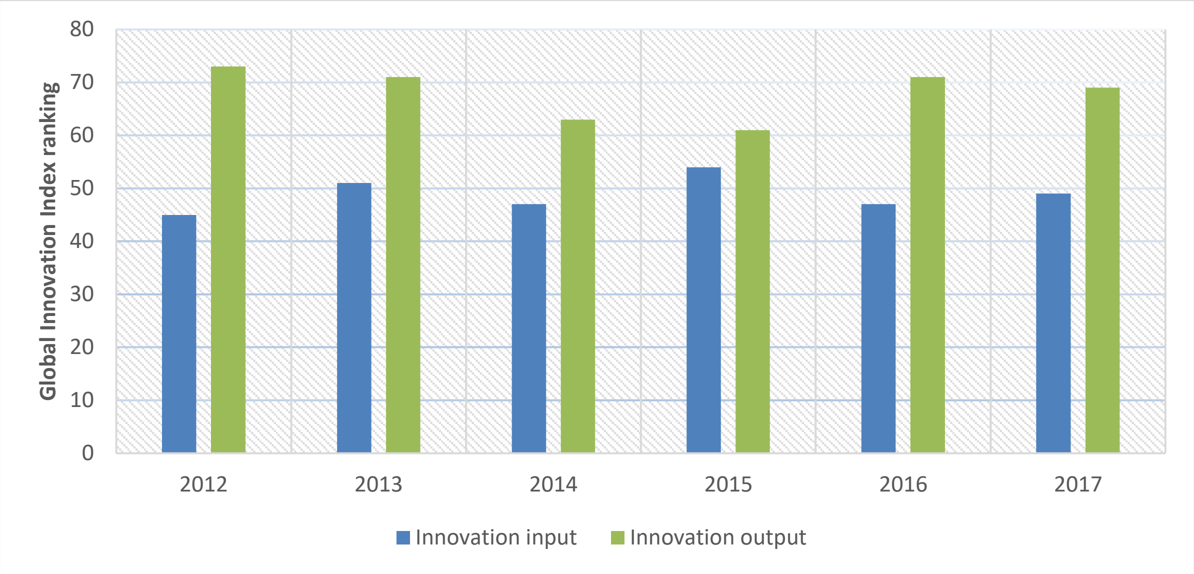


Source: South African Reserve Bank

Figure 2.12 Total government investment in ICT equipment

Based on figure 2.12 total government investment in ICTs equipment has been increasing from 1990 to 2008. A sharp decline was noticed between 2008 and 2010 where it became stable to the end of 2011. The government then initiated its investment from 2011 to 2016. The investment got declined in 2017 but got improved in early 2018.

On that note, South Africa got ranked by using the global innovation index to explore a broad vision of innovation, including the political environment, education, and infrastructure and business sophistication. Figure 2.13 below shows the trends in the ranking in terms of the global innovation index starting from 2012 to 2017.



Source: Department of science and technology (2017)

Figure 2. 13 Trends in South African ranking on the Global Innovation Index

Based on figure 2.13 above shows the ranking of South Africa in terms of global innovation index performance out of 127 countries. The ranking comprises institutions, human capital and research, infrastructure, markets, and business sophistication which makes up the innovation input in the analysis. On the other hand, knowledge and technology outputs and creativity build up innovation output analysis. Based on figure 2.13 above South Africa is ranked 48 on input innovation and 69 on output innovation as of 2017.

2.5. Summary

The chapter presented the overview and background of inclusive growth, innovation, and economic development in South Africa. By so doing, South African inequality and redistribution policies were enunciated. Additionally, implications and issues behind inclusive growth, innovation, and economic development were analysed. The next chapter focuses on the discussion of the empirical literature and theoretical literature behind the study at hand

CHAPTER 3

LITERATURE REVIEW

3.1. Introduction

This chapter presents both the theoretical and empirical literature review of this study. The purpose is to provide a conceptual framework for the investigation and to place it within the context of the existing body of knowledge.

3.2. Theoretical Framework

The investigation of the contribution of inclusive growth and innovation towards economic development in South Africa is grounded on the following theories:

3.2.1. Structural transformation for economics diversifications

Structural transformation is a shift or change in the basic ways a market or economy functions or operates. Thus, structural transformation can be achieved by diversifying activities. Papageorgiou (2013) indicates that the structural transformation and the process of diversification are critical for economic development. The study describes such process as the reallocation of economic activity across agricultural, manufacturing and service delivery activities. This gives overviews of the link between growth, the structural transformation itself and different dimensions of diversifications. Furthermore, an increase in income per capita is associated with diversification and with re-concentration in production and employment. Therefore, the development and structural transformation crucially deal with changes in the quality and levels of goods produced.

Thus, producing quality products due to improvement in technology results in the construction of a positive comparative advantage. Thus, sectoral output and consumption shares may not represent good indicators of a country's growth and diversification process unless the concentration in sectors with limited scope for horizontal diversification and quality upgrading, for instance, the primary sector becomes innovative. The patterns and changes in sectorial employment drive demand for instance shifts through the income elasticity. Shifting demand for both locally sourced goods and imported products is a fundamental part of development. The structural changes that move countries through the development process are often viewed in terms of shifts from primary, to secondary and finally, to tertiary production. Technical progress is seen as crucial in the process of structural change as it involves the obsolescence of skills, vocations, and permanent changes in spending and production resulting in structural unemployment

3.2.2. Total factor productivity

According to Carlaw (2004), technological growth and efficiency are regarded as the two biggest sub-sections of total factor productivity in all economic sectors. Total factor productivity refers to the portion of output not explained by the number of inputs used in production. Carlaw (2004) further clarify technology as not only the collection of a set of ideas that specifies activities to create economic value but as well knowledge about product technologies, specifications of all products that are being produced, the process of production and its organization. Total factor productivity measures the economy's long-term technological change or technological dynamism.

On estimating total factor, productivity and its components evidenced by major manufacturing industries of Pakistan. Raheman, Afza, and Bodla (2009) state that comprehensive proficiency of productivity changes is important for policymakers because productivity growth is an important source of economic growth. They maintained that the two different factors which bring about productivity change are the adoption of technological innovation in the product and processes, and the capability of firms to increase production with given input and technology. A productivity comparison between different sectors can also lead to the source of industrial growth and will help in resource allocation to different sectors. Thus, technical efficiency change can make use of existing input to produce more of the same product.

3.2.3. Endogenous growth model

Romer (1994) stipulates that the endogenous growth theory holds that economic growth is primarily the result of endogenous and not external forces. Furthermore, endogenous growth theory holds that investment in human capital, innovation, and knowledge are significant contributors to economic growth. The theory also focuses on positive externalities and spill-over effects of a knowledge-based economy which will lead to economic development. The endogenous growth theory mostly holds that the long-run growth rate of an economy depends on policy measures.

Jones (1995) revisited the studies of Romer (1990) and Solow (1956), which state that permanent change on certain policy variable that has a direct effect on the rate of growth. Thus, the exoneration of human capital accumulation affects the coefficients on physical capital investment and economic growth. South Africa is one of the countries experiencing a high level of unemployment and a low-skilled labour force, which may result from a lack of human capital investment. Pack (1994) identified that the main problem is that the accumulative human capital will put pressure on natural resources because they will have to be spread thinly within the entire population in the long-term growth. The population is growing at a faster rate for the government to be able to provide food, quality living conditions. The government of South Africa has gone all-out to supply the inhabitants with electricity and clean water yet some inhabitants until life in shacks in an informal settlement. Most of the rural areas in South African people have no access to clean water, sanitation or electricity and in most households, you find parents having more than three children. In such a situation, it is difficult for the government to provide for the entire population since some resources such as water are scarce.

3.2.4. Pro-poor growth approach

Kakwani, et al., (2004) clarify pro-poor growth like the one in the economy that benefits the poor and provides them with opportunities to improve their living standards. Thus, achieving rapid economic growth, reduce extreme poverty and reducing inequality becomes the main priority. Furthermore, Duclos (2009) delineated pro-poor growth as an ideology that the poor should get more growth than some predefined benchmark. Thus, pro-poor growth is judged on how fast the incomes of the poor rise. Growth is pro-poor if the incomes of poor people grow faster than those of the population. The study further shows that growth will be deemed to be pro-poor if it increases the incomes of the poor by proportionately more than relative standards. Similarly, a recession will be deemed pro-poor only if it does not lead to an absolute decrease in those same incomes. Kakwani (2004) analysed the interrelation between growth, inequality, and poverty. By applying the pro-poor notion, the study’s findings showed that economic growth overall is the main determinant that reduces poverty in all segments of the economy. Pasha (2004) commented on pro-poor growth based on pro-poor growth and policies on Asian experience. The study highlights that the apparent sacrifice of growth in pursuit of macroeconomic stability has diminished the impact on poverty reduction. Given the relatively weak trade-off between inflation and growth about the impact on poverty and the fact that inflation rates are currently low, it is argued that countries can be more flexible in their policy stance about the adoption of more growth oriented as opposed to stabilization policies. Kakwani (2004) shows that pro-poor growth can be measured by the monotonicity axiom. Thus, the monotonicity axiom sets out a condition that the proportional reduction in poverty is a monotonically increasing function of the pro-poor growth measure, which considers both the magnitude of growth and how the benefits of growth are distributed to the poor and the non-poor.

3.2.5. Cobb-Douglass production theorem

The Cobb–Douglas production function is a particular functional form of the production function, widely used to represent the technological relationship between the amounts of two or more inputs particularly physical capital and labour and the amount of output that can be produced by those inputs. The Cobb–Douglas form was developed and tested against statistical evidence by Charles Cobb and Paul Douglas during 1927–1947 (Cobb & Douglass, 1928).

Adams (2005) expressed a theory of production being still worth as Cobb and Douglass presented it. The study articulates that production function plays a great role in analysing economic growth and productivity. Thus, critically, the estimation of the parameters of aggregate production functions is vital in measuring all sorts of change on growth, technological change, productivity, and labour.

Lastly, it is confirmed by Adams (2005) that empirical estimates of aggregate production functions are a tool of analysis essential in macroeconomics, and important theoretical constructs, such as potential output, technical change or the demand for labour, are based on them.

Furthermore, Saini (1974) supported the study of Cobb (1928) about the index of physical volume of production which forms the dependent variable to proxies of fixed capital in the manufacturing sector. The index was described as building, machinery and equipment and probable wage earners employed in the manufacturing sector.

The function was presented as follows:

$$Y_t = \int (K * L) \text{..} \quad (3.1)$$

Based on Cobb (1928 and 1948) the Cobb-Douglass production function, innovation is as follows:

$$Y_{it} = A_{it} K_{it}{}^{a} \times L_{it}{}^{1-a} \text{..} \quad (3.2)$$

By making A the subject of the formula, $K^a * L^{1-a}$ cancels on both sides of equation 3.2 above and the new equation can be re-written as follows:

$$\frac{Y_t}{K^a * L^{1-a}} = \frac{AK^a * L^{1-a}}{K^a * L^{1-a}} \text{..} \quad (3.3)$$

Therefore, $A = \dfrac{Y_t}{K^a * L^{1-a}}$ .... (3.4)

Whereby the quantity of output *Y,* in-country *i* at a time *t* is achieved by capital accumulation *K* and total labour force *L*. In that case, *A* represents the level of technology. Thus, the advancement of technology is dependent on the given subscript "a" as indicated above in equation (3.4). Saini (1974) showed that for perfection purposes Cobb-Douglass production function was primarily calculated by using the index of physical volume of production" developed by each employee presented as *(P),* an index of the probable average number of wage earners employed in the manufacturing sector given as (*L*) and an index of fixed capital in the manufacturing sector in the United States given as (*K*) and the equation formulated in this process was with a constant that the function is a homogenous of degree on e.g. $Y = AL^{\alpha} * K^{1-\alpha}$ .Thus the exponent of the equation represents the respective proportional contributions of both labour and capital to the total product.

Also, Sain (1974) shows that the second study which Douglass conducted in 1947 (Douglass, 1976), indicated that the variables used changed. Such that the P became a net value added in the manufacturing sector, the *L* became the person-hours, person-days spent at the workplace, the *K,* became the fixed capital, and working capital in the manufacturing sector and the equation formulated was without constant e.g., $Y = AL^{\alpha} * K^{\beta}$. In both equations, formulated technology is calculated but now the advantage of the second equation is that the findings exhibit, constant, decreasing or increasing returns to scale. That is if the $\alpha+\beta>1$ the results exhibit increasing returns to scale and $\alpha+\beta<1$ signifies decreasing returns to scale and $\alpha+\beta=1$ connotes constant returns to scale. Miller (2008) added that the calculated technological progress (*A*) is always greater than zero, mathematically (A>0).

3.2.6. Creative destruction model

Creative destruction, which is also known as Schumpeter's gale, is an approach that became readily identified in Australia in the early 1950s by an economist Joseph Schumpeter. He applied for Karl Marx's work and popularised it as a theory of economic innovation and business cycle. Based on Schumpeter's study the gale of destructive implies a process of industrial, product or service transformation that continuously develops the economic structure from within destroying the old one and creating the new one. In so doing the restructuring process allows major macroeconomic performance aspects in the long-run, corrects economic fluctuations, balances structural adjustment and the functioning of factor markets. The model pinpoints that any hindrance to the process can have severe short-run and long-run macroeconomic consequences since 50% of the process accounts on productivity growth and restructuring decline during recessions at business cycle frequency and this adds a significant cost to downturn (Caballero & Hammour, 2000; Chun, et al., 2007).

Furthermore, Sledzied (2013) added that equitable entrepreneurship abilities and wealth distribution are fundamental in economics. It has been seen that with the application of the creative destruction approach, entrepreneurship embraces innovation and wealth redistribution. Thus, Schumpeter's theory guide entrepreneurs to focus on the redistribution of wealth, as well and not being adamant on innovation alone (Spencer, et al., 2009).

Anon (1992) and Diamond (2006) complemented that with the applications of the creative destruction approach endogenous growth can be achieved with the help of innovativeness of the research sector. Consequently, equilibrium is determined by forwarding expectations according to which amount of research in a period depends upon the expected amount of research in the next period. Thus, more future research discourages current research by threatening to destroy the rents created by the current researches. Therefore, the size of skilled labour and the productivity of the research outcome determined the essence of innovativeness.

Aghion and Howitte (1989) and Aghion and Howitt (1990) applied Schumpeter's approach of creative destruction to the obsolescence of old technology. Aghion and Howitt (1990) indicated that the accumulation of knowledge due to the results of industrial innovation has both positive and negative consequences on growth. Thus, a high level of research in the future dissuade research today by threatening the results of that study with rapid replacements, therefore this blockage creates a negative externality from innovations. Therefore, the extreme growth in developing countries is induced due to the enormous improvement in technology rather than the accumulation of capital. The study commented that technological progress creates losses as gains by rendering obsolete old skills, goods, markets and manufacturing processes.

3.3. Empirical literature

This section covers some of the empirical literature by various authors from different parts of the world. The idea is to provide a conceptual framework for the investigation to place it within the context of existing knowledge and on the research the problem. In an attempt to remain relevant to the main thesis of the study, the empirical literature section is aligned with the objectives of the study as outlined in Chapter 1. Therefore, GDP per capita is used as a proxy for economic development while government expenditure on education, gross fixed capital formation and trade openness have been used as proxies to represents inclusive growth as suggested by Oluseye and Gabriel (2017). Similarly, in line with Adak (2015), government expenditure on ICT and R&D have been used as proxies for innovation.

3.3.1. Trade openness and economic development

The literature search revealed that the relationship between trade openness has received attention from several countries and different regions. Billmeier (2009) evaluated the impact of trade openness on economic growth. In applying OLS estimates the results shows that countries with increased trade openness result in positive economic growth. Similarly, Kim (2010) used pooled mean group estimator on unbalanced panel data for 87 OECD and non-OECD countries for 1960-2005 in estimating whether financial development and trade openness are complements or substitutes. Kim (2010) established the long-run complementarity and short-run substitutionary between financial development and trade openness. Furthermore, the OECD countries showed an insignificant effect on trade openness, unlike financial development.

In another study involving OECD, Liberati (2007) expressed the relationship which lies between trade openness, capital openness and government size in a cross-sectional time-series context in a sample of 18 OECD countries ranging from 1965-1975 and OLS was used. The study shows that hat increasing trade openness may facilitate the development of social infrastructures - the density of unionisation, the scope of collective bargaining and the strength of labour confederations - and lead to an enlargement of the public sector. Auer (2016)' study highlights that the welfare effects of trade openness rely on how citizens spend on locally produced goods, thus the magnitude of the welfare effect depends on the elasticity of aggregate trade flows.

Neagu (2016) analysed the link between inequality, economic growth, and trade openness in some of the countries ten countries in eastern and central Europe. The study employed a panel data analysis covering the period 2000-2014. The study described income inequality as an economic, social and political issue that can affect economic growth and economic development. The results showed that financial globalisation factors and inward stock of FDI as market capitalisations are the main cause of the increase in inequality in those countries.

Waugh (2016) derived a new measure of trade openness by using a standard multicountry trade model that quantifies the potential gains from trade as a simple function of data. His studies pointed out that trade potential depends on only the elasticity and two observable statistics that is the countries home trade share and its income level. Statistically, the results of the study showed that poor countries have greater potential gains from trade relative to rich countries. Thus, rich countries stand a great potential to be more open to trade.

Fetahi-Vehapia (2015) analysed the effects of trade openness on economic growth from 1996 to 2012. The study focused on ten South-East Europe (SEE) countries and

GMM were used in assessing the results. The findings revealed positive effects of trade openness on economic growth which is conditioned by an increase in the initial income per capita. Thus, countries with improved FDI, a higher level of initial income per capita and high fixed capital formation benefit much from trade openness.

Pradhan (2017) investigated the linkages between banking sector depth, trade openness and economic growth in the Association of Southeast Asian Nations commonly known as the ASEAN region. The study employed panel data and Engel and Granger's cointegration approaches. The results revealed the existence of long-run equilibrium among all variables used and the implication was that there was a great correlation between trade openness, banking sector depth and economic growth in the region. Therefore, it was recommended that the region had to reform the monetary policy of the banking sector for quick development and increased trade openness.

Another study in the ASEAN region was carried out by Trejos (2015) who focused on the relationship between trade openness and output growth for the sample of twenty-three Asian countries. The analysis was done by applying the dynamic ECM estimation and OLS models on data ranging from 1950-2010. The results showed that trade openness is not the main engine explaining the Asian economic-growth miracle during the stipulated period. On the contrary, the authors found that physical capital accumulation is the main factor observed to promote long-run output per worker. Empirically, it has been shown that countries with a growing degree of trade openness experience faster per capita growth due to increased capital accumulation rather than technological spillover effects from the trading sector. Nasreen (2014) also explored the causal relationship between economic growth, trade openness and energy consumption by employing 15 Asian countries from 1980 to 2011. Panel cointegration and causality approaches were used to examine the results of the study. The empirical results revealed the presence of cointegration between the variables used. There were a positive influence and bidirectional causality between growth and trade openness on energy consumption in those countries.

Mukherjeea (2017) examined the performance of different types of Indian manufacturing firms from 1999-2004 and 2004-2009 periods. The semi-parametric Difference-in-Difference model used revealed that policy had a positive effect on firm-level productivity. On the other hand, profitability in the case of non-food and non-agro based firms experienced significant trade openness, while food and agro-based firms, which remained relatively protected, exhibited stagnant and weak performance. Thus, by reducing the trade protection, most firms that participate in international trade benefited and in the end allowed growth and development. Another study in India by Vashisht (2016) showed that after India focused on foreign trade in the early 1990s, there has been much improvement in trade integration. The study analysed the impact of trade on jobs in the manufacturing sector using the accounting approach. The findings revealed the positive results of trade openness and job creation in the manufacturing sector. Further, it showed that diminishing supply-side constraints can enhance job gains from international trade.

Bowdler (2017) provided evidence of the negative effect of openness and the effects of both average inflation and the exchange rate regime by using quarterly unbalanced panel data of 96 countries from the period 1961-2000. The generalised autoregressive conditional Heteroscedasticity (GARCH) model was used. The results showed that increased trade openness resulted in greater diversity to consumption which can reduce inflation volatility by decreasing the sensitivity of consumer prices to price shocks in a specific market. Further, it has been shown that trade openness can increase the rate of specialisation in production that increase exposure to volatility.

Sbia (2014) investigated the relationship between FDI, clean energy, trade openness, carbon emissions and economic growth in the case of the United Arab Emirates. The study employed quarterly time series data from 1975-2011 using the ARDL approach. The results confirmed the presence of correlation and causal relationships between the variables. Thus, FDI, trade openness and carbon emissions decline energy demand while usage of clean energy leads to economic growth.

Asghar (2014) investigated the causal relationship between financial development and economic growth in developing countries for 1978-2012. Panel cointegration and panel causality techniques were used. The findings revealed strong evidence of the long-run relationship between financial development and economic growth in developing countries. A bi-directional causality between financial development and FDI was established. Furthermore, trade openness has an impact on financial development in all the countries, which calls for the introduction of effective policy measures to promote trade between countries.

Karras (2014) analysed whether trade openness reduces the domestic fiscal multiplier, but increases the impacts of foreign fiscal shocks, for instance, the spillover effect. The study applied a cointegration approach to time-series data from the period of 1970 to 2011, for 179 developed and developing economies. The results showed that domestic fiscal shocks are less powerful in more open economies than foreign fiscal shocks. Thus, greater openness of the domestic economy to international trade is predicted to weaken the ability of domestic fiscal policy to affect the domestic output but increase the effects of foreign fiscal policy on domestic output.

Kim (2013) investigated whether the impacts of trade and FDI on domestic investment depend upon the social capability of a country. By employing instrumental variable threshold regressions approach to cross-sectional data for 85 countries, the results proofed that social capability like human capital, financial development, and political institutions influenced the trade and FDI on domestic investment. Thus, trade openness affected investment in low-human-capital, less-financially-developed, or more-corrupted countries, but positively affected it in countries with opposite attributes.

Haddad (2013) addressed the mechanisms by which trade openness affects growth volatility by using a diverse set of export concentrations on an unbalanced panel of 77 developing and developed economies over the period 1976-2005. The findings of the effects of openness on volatility turn to be negative on those countries with relatively diversified exports.

Shahbaz (2012) investigated the impact of trade openness on economic growth in the long-run. ARDL approach was used on time series data ranging from 1971-2011 and the results showed the presence of a strong correlation between in the long-run and thus trade openness promotes economic growth.

Liargovas (2012) examined the importance of trade openness for attracting FDI inflows, using a sample of 36 developing economies for the period 1990-2008. Fixed effect model was used for accurate results on panel data provided. The results showed a positive and significant relationship between FDI inflows and trade openness.

Furthermore, some factors like political stability, exchange rate stability and market size as expressed by GDP have a positive influence on the existence of FDI.

Chongvilaivan (2012) examined the relationship between openness and the pattern of vertical integration using the six-digit North American Industry Classification System (NAICS) of U.S. Manufacturing data from 2002-2006 and logit transformation were used in analysing the findings. The results showed that trade openness undermines the motives for vertical integration. Thus, import penetration, export shares, and trade penetration have negative effects on industries that are too concentrated.

Brülhart (2011) surveyed the spatial effects of trade openness. There was no significant effect of trade openness on urban concentration or regional inequality. Furthermore, the study revealed that countries with fewer costs in access to foreign markest reap the largest gains from trade hence improves economic growth and development in those countries. In another development Giovanni (2009) examined the mechanisms through which output volatility is related to trade openness using an industry-level panel data set of manufacturing production and trade. The robustness of the results lied in the phenomenon that sectors that are mostly engaged in foreign trade are more volatile and hence leads to increased specialisation.

Volker (2006) re-examined the empirical relationship between trade openness and urban concentration. Using cross-sectional estimation on panel data set of more than 110 countries for the period from 1970 through 2000 proves to have positive results. Thus, leaves no evidence that trade openness significantly reduces urban concentration, hence geographic characteristics are insignificant on trade openness.

Naveed (2006) investigated the impact of FDI and trade openness on per capita GDP growth. The study used data from 1971-2000 collected from developed countries and the fixed effect approach was utilised in analysing the results. The findings show that openness is significant and positively affecting GDP per capita growth, while FDI appeared to be insignificant. Thus, trade openness results in a transfer of benefits of industrialisation and enhancement of innovation in those countries practising such trade.

Dowrick (2004) examined the relationship between economic growth and trade openness and investigating whether trade openness benefits vary over time and across the country. The results support the findings of Billmeier (2009) that an increase in foreign trade results in robust growth and levels of development. Thus, as the level of development increase, the citizens tend to gain increased benefits out of that.

Chen (1999) hosted an argument between trade openness and economic growth. The results of the study show that the degree of openness which results due to government policies in both areas can be an important factor in contributing to growth. The test of the study was based on analysing the relationship between the trade regime and economic development. The results show that countries with free trade areas grow faster and achieve economic development. Lloyd (2002) also measured trade openness by applying the computable general equilibrium (CGE) and the results reveal that national welfare increases monotonically with the measure of trade openness.

Yiheyis (2013) tested the relation between openness and inflation in the context of 31 African countries. Based on the study findings the regression analyses produced no conclusive evidence that increased openness would lower inflation. In a static setting and at a level form, the effect of openness on inflation is found to be statistically zero. The positive effect becomes stronger when lagged inflation is included as an additional control. On the other hand, a negative relationship between inflation and openness exists when the latter is measured by import penetration and is assumed to be exogenous. Earlier, Menyah (2014) examined the causal relationship between financial development and economic growth by using panel data from 21 African countries. Granger causality approach was utilised and the feedback shows limited support finance and trade-led growth in all twenty-one countries. Thus, financial development and trade openness does not seem to have a significant impact on growth.

By focusing on Sub-Saharan Africa (SSA) region, Zohonogo (2016) investigated how trade openness affects economic growth in developing countries. The Pool mean group estimation technique was used on 42 SSA countries covering the period 1980 to 2012. The study provided evidence that the relationship between trade openness and economic growth is not linear for SSA. Thus, controlling imports shows to be more effective to achieve high economic growth through international trade. On the other hand, Kwakwa (2016) focused on the effects of income, energy consumption and trade openness on carbon emissions in SSA. Through the cointegration technique, the study covered 19 SSA countries using time series data covering the period 1977–2012. The results showed that the estimated effects of climate change and global warming are numerous and diverse, ranging from the deterioration of the environment to the health implications for the human population. Thus, the current high trend of carbon emissions can be said to be associated with a high level of economic growth, energy consumption, and international trade.

3.3.2. Innovation and Economic Development

The more innovative a society becomes the more developed it becomes. Thus, the citizens have to be able to translate ideas or inventions into a good or service that creates value or for which consumers will pay (Nakamori, 2020). Omar (2020) assessed the impact of innovation and economic performance in the Middle East and North Africa (MENA) region. The study showed that innovation has become the driving force towards growth, especially with the fourth industrial revolution. In the application of the panel corrected standard method for heteroskedasticity Omar (2020) concluded that R&D expenditure is positive and statistically significant in explaining GDP. Therefore, these findings highlighted the importance of innovation and education on fostering economic growth, urging MENA governments to further invest in the R&D and innovation sector.

Similarly, Claude and Ralph (2019) analysed the long-run impact of human capital on innovation and economic development in the regions of Europe. By using a large new dataset on regional human capital and other factors in the 19th and 20th century the results of the study showed that the long-run impact of human capital on the current innovation and economic development is complex. Lastly, it was concluded that human capital is a key factor explaining current regional disparities in innovation and economic development.

In the application of an endogenous growth model, covering the period 1970-2008 Kaies, et al., (2019) inspected the link between innovation and economic development in Tunisia. The results of the study proved that Tunisia was not able to benefit from its R&D capital stock in one part, neither from the R&D conducted in developed countries through international trade and foreign direct investment, that means R&D does not seem to be a technology transfer vector due to inefficiency of the Tunisian educational systems. A significant investment in R&D combined with some brain gain could be adequate solutions for any country in terms of technology.

Pradhana (2018) analysed the interactions between innovation, financial development and economic growth in 49 European countries on time series data between 1961 and 2014. In applying a panel cointegration approach the results showed that financial development and innovation are both causative factors of economic growth in the long-run.

Torkkeli (2015) emphasised that the relationship between management and internationalisation among small and medium enterprises (SMEs) is dependent on the ability at which the firms adapt to innovation. Thus, the engagement of those firms in innovations results in growth and adaptation into international performance and expansion of the business. Thus, the combination of innovation and internationalisation has shown the potential to generate the highest growth potential performance among SMEs. Based on Torkkeli (2015)'s findings, Holzl (2013) realized that the analysis of innovation perceived by high growth firms provides information policy priorities.

Pansera (2011) explained the moments of the industrial revolution as the origins of innovation. The study shows that technical change has always been associated with humankind's ability to dominate the natural world. Similarly, when the modern notion of innovation was formalised by Schumpeter and his followers, it was defined in terms of the expansion of capitalism. Thus, in the early sixties, the combination of innovation and sustainability resulted in more attrition in the interest of the academic world. The work implicitly suggested that technology cannot solve the problems caused by infinite material growth on a finite planet. Thus, the technological approach itself will only result in instrumentalism and substantives while the application of Eco-innovation will result in vast market-driven innovation, ecological modernisation, efficiency, transfer of clean technology to developing countries and new values with different structures can emerge.

Neusser (1993) complemented the issue of total factor productivity by modelling the dynamics of sectorial total factor productivity in several OECD countries. The findings showed that productivity growth in a sector is too large to an extent dependent on the past productivity differential levels.

The relationship between innovation and economic development received attention from several authors who focused on different proxies of innovation concerning economic growth or development. Edquist and Henrekson (2017) investigated the association between ICT, R&D capital and the value-added growth in Sweden by analysing 47 different industries from the period of 1993-2012. The study showed that ICT and R&D capital were significantly associated with value-added growth and they have been emphasised as important for technical change and economic growth. Similarly, Liao, et al., (2016) examined the contribution of ICT on economic growth in the United States of America (USA). Their results revealed that investment in ICT in the USA contributes to increased productivity and economic growth. The study pointed out that increase investment in ICT fosters economic development as well as growth.

In a slightly different focus, Asongu et al., (2019) examined how ICT could be employed to dampen the potentially damaging effects of environmental degradation in Sub-Saharan Africa (SSA) to promote inclusive human development. In applying panel data of 44 SSA countries the study found out that ICT usage improves human development. Another study in the SSA context was done by Khumalo and Mongale (2015) who focused on South Africa. They investigated the impact of ICT on economic growth in South Africa by applying the cointegration and causality analyses. Their results showed a positive relationship between ICT advancement and economic growth in the country.

In their study, Capello and Lenzi (2016) examined the relevance and utility of European Union research, technology development and innovation policies for smart growth. Their findings proved that research, technological development, and innovation funds are in general relevant to increase innovation. However, the findings warn on the utility of research, technological development and innovation initiatives for socio-economic growth in regions lacking internal scientific research and technological activities.

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. R&D has been seen 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 particular country, while the long transition effect of R&D depends on tremendous economic, political and social impacts.

Thakur and Malecki (2015) provided an understanding of the regional determinants of R&D in Indian institutions. They pointed out that its facilities are located across regions in response to features such as science and technology, manpower availability, banking facilities, transport infrastructures, favourable real estates prices, state domestic product, patents, literacy rate, quality engineering colleges, higher education institutions and investment in R&D. By enhancing regional development, as well as generating knowledge for the production of high-quality goods, promotion of technical efficiency, increasing exports and enhancing the competitiveness in the country results in rapid economic growth.

It appears that innovation has been seen as a driver in growth and as a tool for improving social wellbeing. This can only be achieved by fostering the use of ICT and R&D in all sectors of the economy by creating an enabling environment. That means properly equipping individuals with the necessary ICT tools such as accessibility to the internet and so forth, as a deliberate action of improving growth.

3.3.3. Inclusive growth and economic development

Human capital accumulation and technological advancement are regarded as the main important engines of economic growth in every country (Stadler,2012). The findings of this study showed that the quality of education given to citizens and a variety of innovations bring scale variant growth in the economy. Thus, the government needs to subsidise education to accelerate growth or by enhancing the effectiveness of the education sector. Similarly, in the study of growth and innovation rates in the high-technology industry. Stuart (2017) articulated that the performance of an industry is dependent on the resource profiles of its alliance partners. Thus, large firms and those that possess leading growth in technological advancement are posted to be the most valuable associates. The findings of the study showed that organisations with large innovative alliance partners perform better than otherwise comparable firms that lack such a relationship in any other means.

Similarly, it is very important to refurbish all the issues that support the country's competitiveness through the modernization of the education system and professional retraining of personnel (Alexey, et al., 2019). The study also stipulates that with the introduction of the fourth industrial revolution there is a need for carrying out an improvement of educational infrastructure which is necessary to create opportunities for self-realisation for the successful development of the digital economy, the education and retraining system should provide the economy with specialists who meet the requirements of the technological change.

Innovative education is the requirement of the development of the times, conforms to the characteristics of the times, and in the mainstream educational thought. Therefore, innovative education is a teaching concept and teaching model (Fu, 2019). The study shows that based on Chinas growth, there is a need for the citizens to cultivate students' innovative spirit and entrepreneurial ability. Therefore, delivering new syllabuses with innovative skills in schools will instil innovative talents which can be used to train high-quality talents in the new era.

There are different areas where direct and indirect impacts of high education institutions (HEIs) on sustainable development (SD) may occur. Even though that is the case lack of study implicates the balance of sustainable development. Therefore, there is a need for decision-makers in HEIs, researchers and educators to better understand how their activities may affect society, the environment and the economy, and it provides a solid foundation to tackle these impacts (Findler, et al., 2019).

Homer-Dixon (1999) tried to assess whether poor countries can attain endogenous growth through resource scarcity and innovation. The finding of the study showed that if public and private sector investments in human capital and innovation are optimal, then it is possible to attain a perpetual constant rate of growth in output and consumption. On the contrary, the study showed that poor countries fail to achieve higher rates of growth because they fail to generate or use new technological ideas to reap greater economic opportunities. Furthermore, Homer-Dixon proved that resource depletion and degradation in poor countries have an unfavourable effect not by directly constraining growth but by indirectly affecting the potential of these economies to innovate their economies.

In Smith (2007)'s report, the growth of any industry is dependent on its approach to new directions of the business. Thus, technical advancement gives an advantage for businesses to expand. This applies to the effective use of resources and their allocations. On the other hand, Abrol (2013) investigated the direction of Indian's economic performance based on the country's innovation policy. The findings of the study showed that the performance of the economic status of the country is dependent on the transformation of the organisations and other private entities in adapting the technological change worldwide. Thus, only innovation and inclusivity of all the sectors in the economy might bring gradual change in the direction of the economy.

Bhagwati (2013) questioned the possible roles of market-led economic growth in the eradication of poverty in India. The study highlights how economic growth in India has reduced poverty and it proved that countries that adapted themselves to innovation and technological change grow faster economically. Thus, technological change and human capital investment hold as the basic engine to economic growth and development.

Miller (2001) evaluated the effectiveness of innovation for business growth. The study shows the background of how a profitable business can put its inclination on innovation. The study focused on the restrictions and gaps at which profitable business growth that creates shareholder values face at the market. Based on the study's perspectives, a firm can be profitable if innovation principles that limit the scope and its strategy, marketing, R&D and investment management can be implemented in line with the firms.

Luca (2013) analysed the relationship between legal institutions, innovation, and growth. The focus was more on the situation whereby government sets laws before and after the introduction of new technology in any institution. The objective of the study was to find out how flexible in terms of welfare, amount of technology and output growth at intermediate stages of technological development could be. The outcomes showed lawmakers face a trade-off between providing private firms with the incentives to invest in research thus increasing the probability that innovation occurs and protecting the public from the externalities arising from the new technologies.

Horvat (2011) reviewed the New Framework for European Union research and innovation. The findings showed that there is a need for inclusivity in Europe to tackle basic societal challenges. These include health; demographics changes and well-being; food security and the bio-based economy; secure, clean and efficient energy; smart, green and integrated transport; resource efficiency and climate; supply of raw materials; and inclusive, innovative and secure societies. All these activities shall cover the range from research to the market, integrating innovation activities, cross-disciplinary approaches and socioeconomic and humanities. Furthermore, by creating industrial leadership, competitive frameworks shall cover key enabling technologies, such as information and communication technologies (including micro-and non-electronics and photonics; none-technology, advanced materials, and advanced manufacturing systems; industrial biotechnology; low carbon and adaptation technologies; and space research and innovation. Access to risk finance and venture capital; support for innovation in small and medium-sized enterprises (SMEs) with high growth potential. Lastly, they assumed that with excellence conscious in the science base they could achieve their entire objective through research and development projects.

Gupta (2006) deduced the effect of institutionalizing innovation for growth and profitability in India. The results of the study showed that innovative businesses result in high profits. Thus, relying on R&D results in the achievement of good outcomes. Northover (1999) emphasized that evolution and adaptation of change are dependent on realism which is a commitment to the existence of an entity that is or may be disputed. Furthermore, the accumulation and application of existing knowledge are very important for better decision making in the economy.

Macro-economic policy, gross fixed capital formation, which is the major component of domestic investment, is seen as an important process that could accelerate economic growth (Daniel & Kazeem, 2019). The study used South African quarterly data from 1995Q1 to 2016Q4 within the framework of the Johansen Cointegration and Vector Error Correction Models (VECM). The findings show a long-run relationship that exists between domestic investment, employment and economic growth, with causality running from economic growth to investment and not vice versa. Furthermore, the results also demonstrate that investment has a positive long-run impact on employment

The economic development process is very sensitive since many factors for instance such as natural, social or technological change can influence the development negatively or positively (Maksimovic, et al., 2019). Gross fixed capital formation is seen to be the most input that can make economic development improve positively.

Similarly, Afonso and Aubyn (2019) studied the macroeconomic effects of public and private investment in 17 OECD economies through a VAR analysis with annual data from 1960 to 2014. From impulse response functions. The results show that public investment had a growth effect in most countries and a contractionary effect on other countries.

3.4. Summary

The chapter focused on the discussion of the literature behind inclusive growth, innovation, and economic development. The different theoretical literature on structural transformation, total factor productivity, endogenous growth, creative destruction approach, and the Cobb-Douglas production was covered. Similarly, empirically diversified literature under trade openness, innovativeness, inclusive growth and economic development have been discussed. Inclusive growth has been seen to be influenced by GDP per capita, trade openness, FDI, expenditure on education, gross fixed capital formation, population growth, general government financial consumption expenditure, and inflation (Oluseye & Gabriel, 2017). Not all these variables have been seen to be relevant in analysing the findings of this study. In that case, the only GDP per capita, trade openness, FDI, expenditure on education, gross fixed capital formation has been used.

Empirically, it has been seen that inclusive growth involves managing the pace and patterns of economic growth, interlinked with all sectors of the economy. Similarly, the process should focus on providing innovativeness and employment to citizens rather than putting much effort into sectoral development and income redistribution. Thus, an improved GDP leads to the generation of employment hence development to the nation. Therefore, the availability of markets, resources and unbiased regulatory environment for the public sector, private sector and individuals leads to developments in the economy. Lastly, the combination of available technology and provisioning of opportunities to people without access leads to the achievement of inclusive growth.

The subsequent chapter presents the research methodology where model specifications, data source, and estimations are discussed.

CHAPTER 4

RESEARCH METHODOLOGY

4.1. Introduction

This study used the autoregressive distributed lag (ARDL) bound testing and the Granger causality approaches to analyse the contribution of inclusive growth and innovation towards South African economic development. As a result, this chapter deals with the econometric steps which are used to achieve the objectives of the study and it covers several aspects of the research approach which includes the nature and sources of data and model specification.

4.2. Data

This study employed the secondary annual time series data ranging from 1990-2018 which was obtained from different sources as outlined in Table 4.1. As indicated in Chapter 3, to quantify inclusive growth, the following proxies are used; general government expenditure on education, gross fixed capital formation, and trade openness. Similarly, innovation is quantified by expenditure on ICT and expenditure on R&D while economic development is proxied by GDP per capita.

Table 4. 1 Source of data

Variables	Definition	Source of data	Measurement
Gross Domestic Product per capita (GDPPC)	The annual percentage growth rate of GDP per capita is based on constant local currency.	World Bank (South African Indicators)	R' Millions
General government expenditure on education (EDUEX)	General government expenditure on education (current, capital, and transfers) is expressed as a % of GDP.	World Bank (South African Indicators)	R' Millions
General Fixed Capital formation (GFCF)	The annual GFCF is based on constant local currency. GFCF consists of outlays on additions to the fixed assets of the	World Bank (South African Indicators)	R' Millions

	economy plus nett changes in the level of inventories.		
Trade openness (TOP)	Trade openness is usually measured by analysing imports and exports indices which are economic matrices calculated as the ratio of a country's total trade, the sum of exports plus imports, to the country's gross domestic product.	Authors calculations $\frac{(Import + Export)}{GDP} X100$	Converted into percentages of GDP
Government expenditure on Information and communication technology (ICTE)	Investment in ICT projects with private participation refers to commitments to projects in ICT backbone infrastructure that have reached financial closure and directly or indirectly serve the public.	South African Reserve Bank	R' Millions
Government expenditure on Research and Development (RDEX)	Gross domestic expenditures on research and development (R&D), expressed as a percent of GDP. R&D covers basic research, applied research, and experimental development.	South African Reserve Bank	R' Millions

Source: Authors' compilation

4.3. Model specification

There are two models which are used to achieve the outcomes of this study and they are presented as follows; the first model was used to compute the values of trade openness and to determine the contribution of inclusive growth and innovation on economic development.

4.3.1. Trade openness model

The trade openness model was used to compute the values of trade openness. These values were then used in the main model to determine the contribution of inclusive growth and innovation to economic development. In executing trade openness, equation 4.1 is usually measured by analysing imports and exports indices which are economic matrices calculated as the ratio of a country's total trade, the sum of exports plus imports, to the country's GDP (Auer, 2016).

$$GDP_t = \alpha + \beta_1 M_1 + \beta_2 X_2 \quad (4.1)$$

Based on the equation (4.1) the following trade openness equation has been derived

$$T_t = \frac{\sum(\beta_1 M_1 + \beta_2 X_2)}{GDP_t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(4.2)}$$

Where *M* represents imports and *X* represents exports on goods and services calculated on the percentage of GDP. The in the equations above represents constant and β_1 and β_2 coefficients of both imports and exports respectively. Thus, GDP represents annual GDP and T_t trade openness.

4.3.2. Economic development model

Even though several economic theories were discussed in Chapter 3, the specification of the economic development model (equation 4.4) of this study is based on the Cobb-Douglas production function ($Y = AL^{\alpha} * K^{1-\alpha}$) which was discussed in detail under subsection 3.2.5. Following, Edquist and Henrekson (2017) the standard augmented production function includes R&D capital it is specified as follows;

$$\ln V_{it} = \beta_{ICT} \ln K_{ICT,it} + \beta_N \ln K_{N,it} + \beta_R \ln R_{it} + \beta_L \ln L_{it} + \delta_t D_t + \varepsilon_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(4.3)}$$

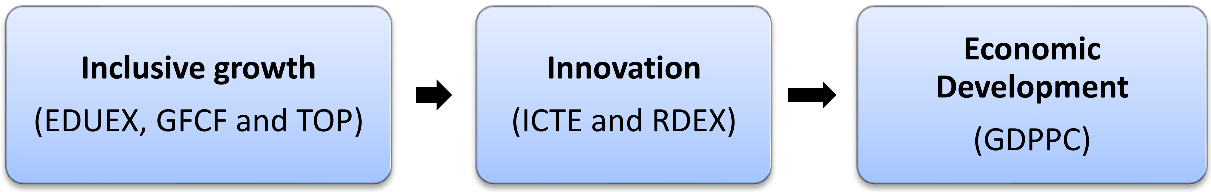
Where V_{it} is a value-added in the industry i at the time t, K_{ICT} is ICT capital, K_N is non-ICT capital, R is R&D capital, and L is labour input measured in hours. Furthermore, D_t represents a set of year dummy variables included as a control for an economic shock. Similarly, β is the elasticity of the subscripted variables and ε denotes serially uncorrelated random errors for each industry.

This study also followed Oluseye (2017) who used the following factors as determinants of inclusive growth: GDP per capita, trade openness, FDI, expenditure on education, gross fixed capital formation, population growth, general government financial consumption expenditure, and inflation. However, variables such as population growth, general government financial consumption expenditure, and inflation do not form part of a model in equation 4.4. Similarly, Adak (2015) pointed out that innovation is represented by a patent variable and hence, the technology level and development are usually raised by importing new technological tools, equipment, and machines. In that case, innovation is computed by a total patent application, electronic device imports, and machinery imports. Adak (2015) also suggested that technology investment leads to the country's innovativeness, hence economic growth. On the other hand, Bennette (2017) showed that the log of GDP per capita can be used as a primary measure of economic development. Therefore, for this study, an inclusive growth model is presented as follows:

$$GDPPC_t = \beta_0 + \beta_1 EDUEX_t + \beta_2 GFCF_t + \beta_3 TOP_t + \beta_4 ICTE_t + \beta_5 RDEX_t + \mu_t \quad \text{............ (4.4)}$$

where, GDPPC represents GDP per capita in South Africa at a time t; EDUEX represents total government spending on education expressed in million Rands; GFCF is gross fixed capital formation expressed in Millions of Rands; and TOP is trade openness, which is the summation of exports and imports expressed as a percentage of GDP. Finally, information and telecommunication expenditure (ICTE) and research and development expenditure (RDEX) which are proxies for innovation represent the country's technological advancement in all sectors of the economy and μ represents error term.

Following Adak (2015) the model of the thesis in equation 4.4 was conceptualised as follow:



Source: (Adak, 2015)

Figure 4. 1 Conceptual framework

The conceptual framework postulate that inclusive growth results in innovation which then results in economic development. This assumes that an increase in government investments in education will result in improvement in human capital. Similarly, investments in R&D, ICT, and improved trade openness results in advancement in technology or innovativeness which will then results in better economic growth and human development. All these assumptions will then be tested by employing the following estimation techniques.

4.4. Estimation techniques

In this study, the ARDL approach is used due to limited data in this field of study. According to Pesaran (1999) and Shin (1999), the ARDL model is an appropriate approach if there are limited data samples. The following econometric procedures will be undertaken to analyse the contribution of inclusive growth and innovation towards South African economic development

4.4.1 Descriptive statistics

Lane et al., (2019) and Peatman (1947) described descriptive statistics as a graphical or tabulation presentation of data distribution. The purpose of running these tests is to inspect the location of central distribution in a data set. Secondly, they help to find out how spread the data is and help to measure the variability of the data set.

The following are the components of descriptive statistics according to Vans (2012):

4.4.1.1. Mean

Its purpose is to determine the average of the series, which is obtained by adding up the series and divide it by the number of observations. Mean can prove to be an effective tool when comparing different sets of data; however, this method might be disadvantaged by the impact of extreme values.

4.4.1.2. Median

It refers to the middle value or simply the average of the two middle values of the series when the values are ordered from the smallest to the largest or vice-versa. It is the robust measure of the centre of the distribution that is less sensitive to outliers than meaning itself.

4.4.1.3. Maximum and minimum values

This is the presentation of the maximum and minimum values of the series in the current sample. This helps to calculate the range of the sample given.

4.4.1.4. Standard deviation

Standard deviation is the measure of dispersion or spread in a sample. Statistically, it is given as:

$$\sqrt{\sum_{i=1}^{N}\frac{(y_i-\bar{y})^2}{N-1}} \ldots\ldots(4.5)$$

Whereby N represents the number of observations in the current sample and the $\bar{y}$ is the mean of the series in the sample given.

4.4.1.5. Skewness

This is the measure of the asymmetry of the distribution of the series around the mean. It is statistically computed as follows:

$$S=\frac{1}{N}\sum_{i=1}^{N}\frac{(y_i-\bar{y})^3}{\hat{\sigma}} \ldots\ldots(4.6)$$

Based on the equation above $\hat{\sigma}$ is an estimator for the standard deviation that is based on the biased estimator for the variance $(\hat{\sigma})=\sqrt[s]{\frac{(N-1)}{N}}$. In this regard, the skewness of asymmetric distribution, such as the normal distribution, is zero. Therefore, the positive skewness of the series means that the distribution has a long right tail and a negative skewness implies that the distribution has a long-left tail (Vans, 2012).

4.4.1.6. Kurtosis

Kurtosis is the measure of peakedness or flatness of the distribution of the series. It is computed as follows:

$$k=\frac{1}{N}\sum_{i=1}^{N}\frac{(y_1-\bar{y})^4}{\hat{\sigma}} \ldots\ldots(4.7)$$

whereby $\hat{\sigma}$ is based on the biased estimator for the variance. Statistically, the kurtosis of a normal distribution is 3. Therefore, if it exceeds 3, the distribution is peaked (leptokurtic) relative to normal. Similarly, if it’s less than 3 the distribution is flat (platykurtic) relative to normal distribution.

4.4.1.7. Jarque-Bera

It tests whether the series is normally distributed. This measures the difference between skewness and kurtosis of the given sample. The statistics of Jarque-Bera is therefore computed as follows:

$$J = \frac{N}{6}\left(S^2 + \frac{(k-3)^2}{4}\right) \qquad (4.8)$$

In equation 4.7, *S* is the skewness and *k* represent kurtosis. In this test, the null hypothesis is stated as normally distributed and the alternative hypothesis of not normally distributed.

4.4.2 Unit root tests

Unit root testing has been utilized to check whether the time series data is stationary or not under the assumption of the autoregressive model. The study has employed both the informal and formal approaches to establish whether the variables are stationary or not.

4.4.2.1. Informal unit root testing

This approach is mainly done by visual inspections of both the line graphs and correlogram. This test will be carried out before the formal unit roots test to get a visual idea about the stationarity of the variables.

4.4.2.2.1. Line graphs

Line graphs are done by plotting the time series and look for evidence of a trend in mean, variance, autocorrelation, and seasonality (Metes, 2005). If any such patterns are present, then these are signs of non-stationarity and different mechanisms exist to turn the series into a stationary one. The trend exhibits in the mean if it has a clear upward slope. The graph will have a vertical fluctuation if the variance is not constant. Therefore, the line graph will seem to be stationary if the line graph will have a trend that fluctuates around its mean.

4.4.2.2.2. Correlogram squared residuals

This estimation checks the autocorrelations and partial autocorrelations of the squared residuals up to any specified number of lags and computes the Ljung-Box Q-statistics for the corresponding lags. The correlogram of the squared residuals can be used to check autoregressive conditional heteroscedasticity (ARCH) in the residuals. Therefore, if there is no ARCH in the residuals, the autocorrelations and partial autocorrelations should be zero at all lags and the Q-statistics should not be significant (Gujarati, 2009).

Correlogram -Q test displays the autocorrelations and partial autocorrelations of the equation residuals up to the specified number of lags. It is available for the residuals from least squares, two-stage least squares, nonlinear least squares and binary, ordered, censored, and count models. In calculating the probability values for the Q-statistics, the degrees of freedom are adjusted to account for estimated ARMA terms (Gujarati, 2009).

4.4.2.2. Formal unit root testing

There are several unit root tests such as the Augmented Dickey Full-Test (ADF), Philips-Peron (PP), Ng and Peron (NP), Kwiatkowski–Phillips–Schmidt–Shin (KPSS) (Kwiatkowski, et al., 1992) , Dickey-Fuller test generalized least squares (DF-GLS) test by Elliot, Rothenberg, and Stock (Elliot, et al., 1996) and Zivot-Andrews test (Zivot & Andrews, 1992) which are used test the stationarity of the variables. As indicated, the statistical theory offers a wide range of unit root tests but according to Arltová and Fedorová (2016), the choice of an appropriate one depends primarily on a subjective judgement of the analyst. Therefore, the study decided to apply the most common ones in the form of the ADF and the DF-GLS.

The process uses the following autoregressive;

$$Y_t = \alpha + \phi Y_{t-1} + e_t \quad -1 \leq p \leq 1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4.9)$$

Where e_t represents white noise term. Based on the mode above if $p = 1$, the unit root becomes a random walk model without drift, which is a nonstationary stochastic process.

Based on the autoregressive model (AR), which is defined as the model in which the explanatory variables are lags of the dependent variables. The value in the AR (1) model above is closely related to the behaviour of the autocorrelation function and the concept of nonstationary (Koop, 2009). In the AR above if ρ=1, then Y has a unit root.

If ρ<1 then Y is stationary. On the other hand, if Y has a unit root, then its autocorrelations will be near one and will not drop as much as lag length increases. Furthermore, Y will have a long-term memory and will exhibit trend behaviour that is if it contains a unit root. Lastly, if Y has a unit root then ∆Y will be stationary. For this reason, a series with a unit root is often referred to as a differenced stationary series (Thomas, 1997).

When testing for unit root, the non-stationary time series variables on which we focus are those time series containing the unit root. These time series are the ones containing stochastic trends. Therefore, if we difference these time series the resulting time series will be stationary. For this reason, we say the time series is differenced stationary. However, these time series can exhibit trend behaviour through the incorporation of the deterministic trend. In this case, they are referred to as trend stationery (Thomas, 1997).

Koop (2009) shows that there are different ways of thinking about whether a time series variable Y is stationary or has a unit root by following the criteria's below:

- In the AR (1) model ($Y_t = \alpha + \phi Y_{t-1} + e_t$), if $\phi = 1$, then Y has a unit root. But if $|\phi| \leq 1$ then Y is stationary.
- It Y has a unit root, then its autocorrelations will be near 1 and will not drop much as lag length increases.
- It Y has a unit root, then it will have a long memory. Stationary time series does not have a long memory.
- It Y has a unit root, then the series will exhibit trend behaviour (especially if α is nonzero)
- It Y has a unit root the ΔY will be stationary. For this reason, series with unit roots are often referred to as a difference stationary series (Koop, 2009).

In this study, much emphasis will be based on the ADF and DF-GLS unit root tests.

4.4.2.2.1. Augmented Dickey-Fuller test

The Augmented Dickey-Fuller test (ADF) tests are based on the null hypothesis that a unit root is present in a time series sample. The alternative hypothesis is different depending on which version of the test is used but is usually stationarity or trend-stationarity. The ADF model is explained in the form of regression as follows:

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i-1}^{m} \alpha i \Delta Y_{t-i} + \varepsilon_t \quad \text{...} (4.10)$$

where e_t is a pure white noise error term and $\Delta Y_{t-1} = (Y_{t-1} - Y_{t-2}), \Delta Y_{t-2} = (Y_{t-2)} - Y_{t-3}), \Delta Y_{t-3} = (Y_{t-3} - Y_{t-4}) ...etc$. The number of lagged difference terms to include is often determined empirically, the idea being is to include enough terms so that the error term is serially uncorrelated.

4.4.2.2.2. Dickey-Fuller Generalized Least Squares Test

For series featuring deterministic components in the form of a constant or a linear trend Elliott, Rothenberg, and Stock (ERS) developed an asymptotically point optimal test to detect a unit root. This testing procedure dominates other existing unit root tests in terms of power. It locally de-trends (de-means) data series to efficiently estimate the deterministic parameters of the series and use the transformed data to perform a usual ADF unit root test. This procedure helps to remove the means and linear trends for series that are not far from the non-stationary region (Koop, 2009).

As proposed by Elliot, et al., (1996) the modified Dickey-Fuller test performs a t-test which is known as DF-GLS. In this test, the time series is transformed via a generalised least squares (GLS) regression before performing the test. That is the reason why Elliot, et al., have shown that this test has significantly greater power than the previous version of the ADF test.

According to Wang (2009), the basic Dickey-Fuller test is to examine whether $p < 1$ which can after subtracting Y_{t-1} from both sides, be written as:

$$\Delta y_t = \mu + (p-1) y_{t-1} + \varepsilon_t = \mu + \theta y_{t-1} + \varepsilon_t \quad \text{..} (4.11)$$

The null hypothesis is that there is a unit root in Y_t or $H_0 : \theta = 0$ against the alternative $H_1 : \theta < 0$ or there is no unit root in Y_t. The DF test procedure emerged since under the null hypothesis the conventional t-distribution does not apply. In that case, if $\theta < 0$ or not, cannot be confirmed by the conventional t-statistic for the θ estimate. Indeed, what the Dickey-Fuller procedure gives us is a set of critical values developed to deal with the non-standard distribution issue, which is derived through simulation. Then, the interpretation of the test result is no more than that of simple conventional regression.

To allow for the various possibilities, the DF test is estimated in three different forms, that is, under three different null hypotheses as shown below:

- It Y_t is a random walk, then $\Delta Y_t = \delta Y_{t-1} + \mu_t$.
- It Y_t is a random walk with drift, then $\Delta Y_t = \beta_1 + \delta Y_{t-1} + \mu_t$.
- It Y_t is a random walk with a drift around a stochastic trend, then $\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \mu_t$.

where t represents time or trend variable. In each case, the null hypothesis is that $\delta = 0$ that is a unit root time series is nonstationary. In this regard, the alternative hypothesis is that $\delta \leq 0$ that is the time series is stationary. In this case, if the null hypothesis is rejected, it means that Y_t is stationary time series with zero mean in the case of random walk, Y_t is stationary with a nonzero mean for instance $[= \beta_1 / (1 - p)]$ in the case of a random walk with drift and lastly, that Y_t is stationary around a deterministic trend as in the case of a random walk with drift around a stochastic trend (Gujarati, 2009).

4.4.3 Cointegration analysis

Cointegration is an econometric technique used for testing the relationship between nonstationary time series variables. Two or more variables are said to be cointegrated when they move together at the same wavelength. It has been seen that the study of Yule (1926) questioned why do we sometimes get spurious or nonsense correlations between time series data. Since most of the economists had a great interest in using linear regressions the study of Granger and Newbold (1974) showed how dangerous it is to use time-series regressions equations with high degrees of fit. The study showed that detrending does not help to eliminate the problem of spurious correlation. Therefore, due to that problem, Granger (1981) and Engel and Granger(1987) formalised the idea of cointegration, providing its test and estimations procedures in the estimation of both short-run and long-run relationship between a set of variables provided that independent estimation of that similar variables forms spurious regression.

Brooks (2008) shows that if two variables that are I (1) are linearly combined, then the combination will also be I (1). More generally, if variables with different orders of integration are combined, the combination will have an order of integration equal to the largest.

For example, if $X_{i,t} \sim I(d_i)$ for $i = 1, 2, 3.......k$ so that there are k variables of each are integrated of order d_i and letting;

$$z_t = \sum_{i=1}^{k} \alpha_i X_{i,t} \quad \text{...} \quad (4.12)$$

Then $z_t \sim I(\max d_i)$. z_t In this context is simply a linear combination of the k variables X_i. Rearranging the equation above:

$$X_{1,t} = \sum_{i=2}^{k} \beta_i X_{i,t} + z_t' \quad \text{...} \quad (4.13)$$

Where $\beta_i = -\frac{\alpha_i}{\alpha_1}, z_t' = \frac{z_t}{\alpha_1}, i = 2, ...k$. All that has been done is to take one of the variables $X_{1,t}$ and rearrange equation 4.12 to make it the subject. Thus, the equation can be said as it has been normalised $X_{1,t}$. Similarly, equation 4.13 z_t' is a disturbance term. These error terms would have a very undesirable

The outcome of this estimation shows the Eigenvalues, Condition Numbers, corresponding Variance Decomposition Proportions and, for comparison purposes, the corresponding Eigenvectors. As an example, we estimate an equation using data from Longley (1967), as republished in Greene (2008).

In dealing with spurious regressions problems few tests were suggested.

i. Engel- Granger two-step method
ii. Johansen test

iii. Philips-Ouliaris cointegration test
iv. Auto-Regressive Distributed Lags

The difference in these methods is that the Engel-Granger method first constructs residuals or errors based on the static regression. That issue is only corrected by applying the Johansen and Philips-Ouliaris cointegration test. Similarly, Philips-Ouliaris assumes that regression errors are independent with a common variance which is rarely true in real life. The residuals are estimates instead of the actual parameter value. Furthermore, Johansen avoids the issue of choosing a dependent variable (Armstrong, 2001).

In that case, Engel-Granger two steps, the Johansen test and Philips-Ouliaris cointegration test, are applicable only if the data set is big. In that case, ARDL applies to data set with limited observations. Therefore, the data set of this study is limited in that case the ARDL test is going to be used.

4.4.3.1. ARDL approach to Cointegration testing

The ARDL approach by Pesaran (1999) and Pesaran et al., (2001) was preferred mainly due to limited data in this field of study. This is based on Pesaran (1999) and Shin (1999)'s notion that is an appropriate approach if there are limited data samples.

4.4.3.2. Requirements of ARDL

According to Pesaran (1999) and Pesarn et al. (2001), the approach is valid if none of the variables is I (2). This means all the variables have to be cointegrated of the same order or at least a mixture of (0) and I(1). This can be achieved by using ADF, PP, Ng Peron or KPSS tests to check the order of integration of the variables. It is sometimes advisable to formulate an unrestricted error correction model if it is necessary to do so.

Furhermore, Nkoro and Uko (2016) suggest the following requirements to follow when running the ARDL approach:

i. If the variable is integrated of order I (0) or I (1), or a combination of both the technique is applicable.
ii. The ARDL error correction becomes efficient if the data sample size is small.

iii. ARDL is inapplicable if the Wald test F-statistics has multiple long-run relations. In that case, the Johansen approach is applicable.
iv. If the trace or Maximal eigenvalue or the F-statistics establishes that there is a single long-run relationship, the ARDL approach can be applied rather than applying Johansen and Juselius approach.

4.4.3.3. Advantages of using ARDL

i. Endogeneity is less of a problem in the ARDL technique because it is free of residual correlation that is all variables are assumed endogenous.
ii. The ARDL procedure can distinguish between dependent and explanatory variables.
iii. ARDL enables the identification of the cointegrating vectors where there are multiple cointegrating vectors unlike the rest of the cointegration tests.
iv. The Error Correction Model (ECM) can be derived from the ARDL model through a simple linear transformation, which integrates short-run adjustments with long-run equilibrium without losing long-run information. The associated ECM model takes enough lags to capture the data generating process in general to specific modelling frameworks (Pesaran, et al., 2001).

4.4.3.4. ARDL steps

To achieve the best results from the model of the study, the following steps will be followed:

4.4.3.4.1. Appropriate Lag length choice criteria

According to Liew (2004), most of the economic data are time series in nature and that a popular kind of time series model known as the autoregressive (AR) model has been directly or indirectly applied in most economic research, therefore, the foremost exercise in the application of AR model is the determination of autoregressive lag length. Therefore, the lag selection is very important when dealing with ARDL and the following models: Akaike Information Criterion (AIC), Schwarz Bayesian Criterion (SBC), Bayes information criterion (BIC), and Hannan-Quinn Criterion (HQ) will be used to determine the proper lag length for cointegration analysis.

Bound testing validation is dependent on Pesaran (2001) indicating that the computed F-statistics should fall below the lower bound if the variables are I (0), and this makes cointegration impossible. However, if the F-statistics exceeds the upper bound; we then conclude that we have cointegration. Lastly, if the F-statistics fall between the bounds, the test is inconclusive.

4.4.3.4.2. Long-run relationship determination

The first step is the determination of the long-run relationship of the variables by computing the F-statistics of the bound test for cointegration. Therefore, the bound F-statistics test is carried out on each of the variables as endogenous variables while assuming the rest of the variables as exogenous variables. By following the study done by Pesaran et al., (2001) the ARDL model used in this study is therefore specified as follows:

$$\Delta GDPPC_t = \beta_0 + \sum_{i=1}^{m}\beta_1\Delta GDPPC_{t-i} + \sum_{i=1}^{m}\beta_2\Delta EDUEX_{t-i} + \sum_{i=1}^{m}\beta_3 GFCF_{t-1} + \sum_{i=1}^{m}\beta_4\Delta TOP_{t-i} + \sum_{i=1}^{m}\beta_5\Delta ICTE_{t-i} + \sum_{i=1}^{m}\beta_6\Delta RDEX_{t-i} + \alpha_1 GDP_{t-1} + \alpha_2 EDUEX_{t-1} + \alpha_3 GFCF_{t-1} + \alpha_4 TOP_{t-1} + \alpha_5 ICTE_{t-1} + \alpha_6 RDEX + \mu_{t-1} \quad (4.14)$$

$$\Delta EDUEX_t = \beta_0 + \sum_{i=1}^{m}\beta_1\Delta GDPPC_{t-i} + \sum_{i=1}^{m}\beta_2\Delta EDUEX_{t-i} + \sum_{i=1}^{m}\beta_3\Delta GFCF_{t-i} + \sum_{i=1}^{m}\beta_4\Delta TOP_{t-i} + \sum_{i=1}^{m}\beta_5\Delta ICTE_{t-i} + \sum_{i=1}^{m}\beta_6\Delta RDEX_{t-i} + \alpha_1 GDP_{t-1} + \alpha_2 EDUEX_{t-1} + \alpha_3 GFCF_{t-1} + \alpha_4 TOP_{t-1} + \alpha_5 ICTE_{t-1} + \alpha_6 RDEX_{t-1} + \mu_{t-1} \quad (4.15)$$

$$\Delta GFCF_t = \beta_0 + \sum_{i=1}^{m}\beta_1\Delta GDPPC_{t-i} + \sum_{i=1}^{m}\beta_2\Delta EDUEX_{t-i} + \sum_{i=1}^{m}\beta_3\Delta GFCF_{t-I} + \sum_{i=1}^{m}\beta_4\Delta TOP_{t-i} + \sum_{i=1}^{m}\beta_5\Delta ICTE_{t-i} + \sum_{i=1}^{m}\beta_6\Delta RDEX_{t-i} + \alpha_1 GDP_{t-1} + \alpha_2 EDUEX_{t-1} + \alpha_3 GFCF_{t-1} + \alpha_4 TOP_{t-1} + \alpha_5 ICTE_{t-1} + \alpha_6 RDEX_{t-1} + \mu_{t-1} \quad (4.16)$$

$$\Delta TOP_t = \beta_0 + \sum_{i=1}^{m}\beta_1\Delta GDPPC_{t-i} + \sum_{i=1}^{m}\beta_2\Delta EDUEX_{t-i} + \sum_{i=1}^{m}\beta_3\Delta GFCF_{t-i} + \sum_{i=1}^{m}\beta_4\Delta TOP_{t-1} + \sum_{i=1}^{m}\beta_5\Delta ICTE_{t-i} + \sum_{i=1}^{m}\beta_6\Delta RDEX_{t-i} + \alpha_1 GDP_{t-1} + \alpha_2 EDUEX_{t-1} + \alpha_3 GFCF_{t-1} + \alpha_4 TOP_{t-1} + \alpha_5 ICTE_{t-1} + \alpha_6 RDEX_{t-1} + \mu_{t-1} \quad (4.17)$$

$$\Delta ICTE_t = \beta_0 + \sum_{i=1}^{m}\beta_1\Delta GDPPC_{t-i} + \sum_{i=1}^{m}\beta_2\Delta EDUEX_{t-i} + \sum_{i=1}^{m}\beta_3\Delta GFCF_{t-i} + \sum_{i=1}^{m}\beta_4\Delta TOP_{t-i} + \sum_{i=1}^{m}\beta_5\Delta RDEX_{t-i} + \sum_{i=1}^{m}\beta_6\Delta ICTE_{t-i} + \alpha_1 GDPPC_{t-1} + \alpha_2 EDUEX_{t-1} + \alpha_3 GFCF_{t-1} + \alpha_4 TOP_{t-1} + \alpha_5 ICTE_{t-1} + \alpha_6 RDEX_{t-1} + \mu_{t-1} \quad (4.18)$$

$$\Delta RDEX_t = \beta_0 + \sum_{i=1}^{m}\beta_1\Delta GDPPC_{t-i} + \sum_{i=1}^{m}\beta_2\Delta EDUEX_{t-i} + \sum_{i=1}^{m}\beta_3\Delta GFCF_{t-i} + \sum_{i=1}^{m}\beta_4\Delta TOP_{t-i} + \sum_{i=1}^{m}\beta_5 ICTE_{t-i} + \sum_{i=1}^{m}\beta_6\Delta RDEX_{t-1} + \alpha_1 GDPPC_{t-1} + \alpha_2 EDUEX_{t-1} + \alpha_3 GFCF_{t-1} + \alpha_4 TOP_{t-1} + \alpha_5 ICTE_{t-1} + \alpha_6 RDEX_{t-1} + \mu_{t-1} \quad (4.19)$$

Based on the equations from 4.14 to 4.19 β_0 up to β_5 and α_0 to α_6 rare the coefficients of the independent variables. Δ is the first difference between the operator and the µt is a white noise disturbance term. The coefficients, β_0 to β_6 denote the short-run dynamics of the model and the coefficients α_0 to α_6 denote the long-run part of the model. Based on equations (4.14 to 4.19) above the null hypothesis is given as $H_0 = \beta_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_{6=} 0$ that is there is no cointegration among the variables and the alternative hypothesis is formulated as follows $H_1 \neq \beta_0 \neq \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq \beta_6 \neq 0$ which denotes there is cointegration among the variables.

4.4.3.4.3. Parameterization of ARDL model into ECM

An error correction model belongs to a classification of multiple time series models most used for data where the underlying variables have a long-run equilibrium, also known as cointegration. Based on Brooks (2008), a vector error correction (VEC) model is a restricted vector autoregression (VAR) designed for use with non-stationary series that are known to be cointegrated. The VEC has cointegration relations built into the specification so that it restricts the long-run behaviour of the endogenous variables to converge to their cointegrating relationships while allowing for short-run adjustment dynamics. The cointegration term is known as the error correction term (ECT) since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments.

The cointegration analysis may be done by using an estimated VAR object, Equation object estimated using nonstationary regression methods, or using a Group object ECMs are a theoretically driven approach useful for estimating both short-term and long-term effects of one-time series on another. The ECT relates to the fact that the last period's deviation from a long-run equilibrium, the error, influences its short-run dynamics. Thus, ECMs directly estimate the speed at which a dependent variable returns to equilibrium after a change in other variables (Enders, 2010).

A simple cointegrating equation on two variable systems with one cointegrating equation and no lagged difference terms can be given as follows:

$$Y_{2,t} = \beta y_{1,t} \quad (4.20)$$

Therefore, the corresponding VEC model is given as follows:

$$\Delta y_{1,t} = \alpha_1 (y_{2,t-1} - \beta y_{1,t-1}) + \mu_{1,t} \quad (4.21)$$

$$\Delta y_{2,t} = \alpha_2 (y_{2,t-1} - \beta y_{1,t-1}) + \mu_{2,t} \quad (4.22)$$

Based on the simple model given above, the only right-hand side variable is the error correction term. In the long-run equilibrium, this term is zero. However, if y_1 and y_2 deviate from the long-run equilibrium, the error correction term will be nonzero, and each variable adjusts to partially restore the equilibrium relation. The coefficient α_i measures the speed of adjustment of the endogenous variable towards the equilibrium (Studenmund, 2006)

Furthermore, the ECM of the ARDL is formulated as follows,

$$\Delta GDPPC_t = \beta_0 + \sum_{i=1}^{m} \beta_1 \Delta GDPPC_{t-i} + \sum_{i=1}^{m} \beta_2 \Delta EDUEX_{t-i} + \sum_{i=1}^{m} \beta_3 \Delta GFCF_{t-i} + \sum_{i=1}^{m} \beta_4 \Delta TOP_{t-i} + \sum_{i=1}^{m} \beta_5 \Delta ICTE_{t-i} \sum_{i=1}^{m} \beta_6 \Delta RDEX_{t-i} + ECM_{t-1} + \lambda \mu_{t-1} \quad (4.23)$$

4.4.3.5. Cointegration graph

This is just the graphical confirmation stationary in the data set. The possible presence of cointegration must be considered when choosing a technique to test hypotheses concerning the relationship between two variables having unit roots. The usual procedure for testing hypotheses concerning the relationship between non-stationary variables was to run ordinary least squares (OLS) regressions on data, which had been differenced. This method is biased if the non-stationary variables are cointegrated (Gujarati, 2009).

4.4.4 Granger causality

In line with Türsoy (2017) after confirming the long-run relationship between inclusive growth, innovation, and economic development by applying the ARDL bounds test, the Granger causality will be applied to investigate the direction of causality among the variables.

Brooks (2008) and Gujarati (2009) displayed the distinction between correlation and causality. In reality, most econometrics analyses suffer correlation problems that are simply spurious or meaningless. On the other hand, Granger (1981) described the approach based on the question of whether *X* causes *Y* as the way of checking how much of the current *Y* can be explained by the past values of *Y* and as well to see whether adding lagged values of *X* can improve the explanation.

Econometrically *Y* is said to be Granger-caused by *X* if x helps in the prediction of y or equivalently if the coefficient of the lagged *X*'s is statistically significant. Sometimes two-way causality is frequently the case, *X* Granger causes *Y* and *Y* Granger causes *X*. The statement *X* Granger causes *Y* does not necessarily imply that *Y* is the effect or the result of *X*. Literally, Granger causality measures the precedence and information content but does not by itself indicate causality in the more common use of the term.

The bivariate equations of Granger causality are presented in the following order:

$$\begin{aligned} y_t &= \alpha_0 + \alpha_1 y_{t-1} + \ldots + \alpha_i y_{t-i} + \beta_1 x_{t-1} + \ldots + \beta_i x_{-i} + \varepsilon_t \\ x_t &= \alpha_0 + \alpha_1 x_{t-1} + \ldots + \alpha_i x_{t-i} + \beta_1 y_{t-1} + \ldots + \beta_i y_{-i} + \mu_t \end{aligned} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4.24)$$

For all the pairs of (x, y) series in the group. The reported F-statistics are the Wald statistics for the joint hypothesis, $\beta_1 = \beta_2 = \ldots = \beta_i = 0$ for each equation given. Therefore, the null hypothesis for the above approach is that x does not Granger-cause y in the first regression and that y does not Granger cause x in the second regression (Granger & Newbold, 1974).

4.4.5 Coefficient diagnostic

This section presents tests such as scaled coefficients, confidence interval and ellipse, variance decomposition and Wald test.

4.4.5.1. Scaled coefficients

The scaled coefficients demonstrations show the coefficient estimates, the standardised coefficient estimates and the elasticity at means. The standardised coefficients are point estimates of the coefficients standardised by multiplying the standard deviation of the dependent variable divided by the standard deviation of the regressor (Brooks, 2008).

4.4.5.2. Confidence interval

The confidence interval shows a table of the confidence interval of each of the regressors used in the estimation process. Thus, in statistics and econometrics, a confidence interval is a type of interval estimate, computed from the statistics of the observed data, which might contain the true value of an unknown population parameter. The interval has an associated confidence level that, loosely speaking, quantifies the level of confidence that the parameter lies in the interval. More strictly speaking, the confidence level represents the frequency of possible confidence intervals that contain the true value of the unknown population parameter. In other words, if confidence intervals are constructed using a given confidence level from an infinite number of independent sample statistics, the proportion of those intervals that contain the true value of the parameter will be equal to the confidence level (Thomas, 1993).

The confidence intervals consist of a range of potential values of the unknown population parameter. However, the interval computed from a sample does not necessarily include the true value of the parameter. Since the observed data are random samples from the true population, the confidence interval obtained from the data is also random.

The desired level of confidence is set by the researcher is, the 95% confidence level is used. However, other confidence levels can be used, for example, 90% and 99%.

Factors affecting the width of the confidence interval include the size of the sample, the confidence level, and the variability in the sample. A larger sample will, all other things being equal, tend to produce a better estimate of the population parameter (Gujarati, 2009).

4.4.5.3. Confidence ellipse

The confidence ellipse shows a joint region of two functions estimated parameters from an E-Views estimation. For instance, 5% can be displayed depending on which dimension the test statistics lie to accept the null hypothesis. The dimensional confidence interval may be generalised to the case involving two restrictions, where a joint confidence region or confidence ellipse is formed. The confidence ellipse may be interpreted as the region in which the realisation of two test statistics must lie for us not to reject the null hypothesis (Brooks, 2008).

4.4.5.4. Variance inflation factor

Variance inflation factors (VIFs) are a method of measuring the level of collinearity between the regressors in an equation. VIFs show how much of the variance of a coefficient estimate of a regressor is inflated due to collinearity with the other regressors. It can be calculated by simply dividing the variance of a coefficient estimate by the variance of that coefficient had other regressors not been included in the equation.

There are two forms of VIFs namely, the centred VIF and un-centred VIF. The centred VIF is the ratio of the variance of the coefficient estimate from the original equation, divided by the variance from a coefficient estimate from an equation with only that regressor and a constant. On the other hand, the un-centred VIF is the ratio of the variance of the coefficient estimate from the original equation divided by the variance from a coefficient estimate from an equation with only one regressor and no constant. Note that if the original equation did not have a constant only the un-centred VIF will be displayed (Brooks, 2008).

4.4.5.5. Coefficient variance decomposition

The Coefficient Variance Decomposition view of an equation provides information on the eigenvector decomposition of the coefficient covariance matrix. This decomposition is a useful tool to help diagnose potential collinearity problems amongst the regressors. The decomposition calculations follow those given in (Belsley et al., 2005). Note that although the author uses the singular-value decomposition as their method to decompose the variance-covariance matrix, since this matrix is a square positive semi-definite matrix, using the eigenvalue decomposition will yield the same results.

Based on (Hausman, 1978) a simple linear regression, the coefficient variance-covariance matrix can be decomposed as follows:

$$Var(\beta) = \sigma^2 (X'X)^{-1} = \sigma^2 V \delta^{-2} V' \quad (4.23)$$

where δ is a diagonal matrix known to have the eigenvalues of X'X, and V is a matrix, whose columns are equal to the corresponding eigenvectors.

The individual coefficient estimate is therefore presented as follows:

$$Var(\beta_i) = \sigma^2 \sum_i v^2{}_{ij} \quad (4.25)$$

Where μ_j is the jth eigenvalue and v_{ij} is the ($(i, j)^{th}$ element of v .

Therefore, the term $j-th$ condition of the covariance matrix, kj :

$$K_j \equiv \frac{\min(\mu_m)}{\mu_j} \quad (4.26)$$

Lastly, if we let:

$$\phi_{ij} \equiv \frac{v_{ij}^2}{\mu_j} \quad (4.27)$$

Moreover, $\phi_i \equiv \sum_j \phi_{ij}$ …… (4.28)

Therefore, the term variance-decomposition proportion is set as follows:

$$\Pi_{ji} = \frac{\phi_{ij}}{\phi_i} \quad \text{(4.29)}$$

Based on these proportions made, equation 20, serves as the diagnostic tool for determining the collinearity between each of the coefficients (Brooks, 2008).

By following E-views 8.1. Guide II, the following procedure were recommended:

- A condition number smaller than ($\frac{1}{900}$) which is 0.001 could signify the presence of collinearity based on any number greater than 30, but base it on the condition of X, rather than $X'X^{-1}$.
- If there are one or smaller numbers, then the variance decomposition proportions should be investigated. Two or more variables with greater than 0.5 associate with a small condition number indicate the possibility of collinearity between those two numbers.

4.4.5.6. Wald test

This estimation helps to test restrictions on the estimated coefficients from the estimation object. Thus, alternatively, the Wald test can be calculated by an application confidence interval. The Wald test computes a test statistic based on the unrestricted regression. The Wald statistic measures how close the unrestricted estimates come to satisfying the restrictions under the null hypothesis. If the restrictions are true, then the unrestricted estimates should come close to satisfying the restrictions. (Gujarati, 2009)

Suppose the production function has been estimated in a small industry:

$$Y_t = AL^{\alpha} * K^{\beta} \quad \text{(4.30)}$$

Where Y, K and L denote the value-added output of the inputs capital and labour respectively. The null hypothesis of constant return to scale is then tested by the restriction:

$$\alpha + \beta = 1 \quad \text{(4.31)}$$

Similarly, given the following nonlinear regression model:

$$y = f(\beta) + \varepsilon \quad \text{......(4.32)}$$

where y and ε are T-vectors and β is k-vector of parameters to be estimated. Therefore, any restrictions on the parameters can be written as:

$H_0 : g(\beta) = 0$, where $g : R^K \to R^q$, imposing q restrictions on β. The Wald statistics is therefore computed as:

$$W = g(\beta)'\left(\frac{\partial g(\beta)}{\partial \beta'} v(b) \frac{\partial g(\beta)}{\partial \beta'}\right) g(\beta)|_{\beta=b} \quad \text{......(4.33)}$$

where T is the number of observations and b is the unrestricted parameters estimates and where v are estimates of the b covariance. In the regression case, v is given by:

$$v(b) = s^2\left(\sum_i \frac{\partial fi(\beta)}{\partial \beta} \frac{\partial fi(\beta)}{\partial \beta'}\right)^{-1} |_{\beta=b} \quad \text{......(4.34)}$$

where u is the vector of unrestricted residuals and s^2 is the usual estimator of the unrestricted residual variance, $s^2 = (u'u)/(N-k)$ but the estimator v may differ. For example, V maybe a robust variance matrix estimator computing using white or Newey-West techniques.

4.4.6 Residual diagnostic tests

This section includes tests such as the normality test, serial correlation LM test and heteroskedasticity test.

4.4.6.1. Histogram – Normality test

Gujarati (2009) described a histogram normality test as a simple graphic device that shows the shape of the probability density function (PDF) of a random variable.

Under this technique, a histogram and descriptive statistics of the residuals including Jarque-Bera statistics for normality test are used. If the given residuals are normally distributed, the histogram should be bell-shaped and the Jarque-Bera statistics should not be significant. Therefore, the Jarque-Bera statistic has a distribution with two degrees of freedom under the null hypothesis of normally distributed errors (Chris, 2008).

4.4.6.2. Serial correlation LM Test

Autocorrelation is also known as serial correlation or cross-autocorrelation. It is the cross-correlation of a signal with itself at different points in time that is what the cross stands for. Informally, it is the similarity between observations as a function of the time lag between them. This test is an alternative method to the Q-statistics for testing serial correlation.

Unlike the Durbin-Watson statistic for AR (1) errors, the LM test may be used to test for higher-order ARMA errors and is applicable whether there are lagged dependent variables or not. Therefore, we recommend its use (in preference to the DW statistic) whenever you are concerned with the possibility that your errors exhibit autocorrelation (Stewart & Gill, 1998).

The null hypothesis of the LM test is that there is no serial correlation up to lag order p, where p is a pre-specified integer. The local alternative is ARMA (r, q) errors, where the number of lag terms $p = \max(r, q)$. Note that this alternative includes both AR (p) and MA (p) error processes, so that the test may have power against a variety of alternative autocorrelation structures. See Godfrey (1988), for further discussion.

Therefore, the t-statistics are computed by supporting regression as follows. Suppose the following equation is to be estimated:

$$Y_t = \beta X_t + \mu_t \qquad (4.35)$$

Whereby β is the estimated coefficient and μ is the error term. The test statistics for lag order p is based on the supporting regression for the residuals $\mu = y - \hat{\beta} X$:

$$\mu_t = X_t y + \left(\sum_{m=1}^{p} \alpha_m \mu_{t-m\partial} \right) + v_t \qquad (4.36)$$

Davidson and Macknon (1993) suggest that even though E-Views set any pre-sample values of residuals to 0 the asymptotic distribution does not get affected but rather makes the test statistics to better finite sample. Therefore, the Obs*R-squared statistics is the Breusch-Godfrey LM test statistics. The LM statistic is therefore computed as the number of observations multiplied by the uncentered R^2 from the test regression. Thus, the LM test statistic is asymptotically distributed $X^2(p)$. Either the LM test is available for residuals from least squares or two stages of least squares estimation. Thus, the original regression may include AR and MA terms in which case the test regression will be changed to take account of the $ARMA$ terms.

4.4.6.3. Heteroscedasticity tests

Heteroscedasticity is a situation in which the variance of the regression error term conditional on the repressors is not constant (Stock & Watson, 2012). White (1980) developed the White Heteroscedasticity test which helps to test for heteroscedasticity in the residuals where least squares estimates are this set of tests allows you to test for a range of specifications of heteroscedasticity in the residuals of your equation. Ordinary least squares estimates are consistent in the presence of heteroscedasticity, but the conventional computed standard errors are no longer valid. If you find evidence of heteroscedasticity, you should either choose the robust standard errors option to correct the standard errors.

There are different kinds of Heteroscedasticity tests in E-Views. Each of these tests involves performing an auxiliary regression using the residuals from the original equation. These tests are available for equations estimated by least squares, two stages least squares, and nonlinear least squares. For example, we have the following test:

- Breusch-Pagan-Godfrey (BPG)

This test is a Lagrange Multiplier (LM) of the null hypothesis being tested as no heteroscedasticity against heteroscedasticity of the form of, $\sigma_t^2 = \sigma^2 h(z_t^{'}\alpha)$, whereby, z_t is a vector of independent variables. Thus, the vector contains the regressors from the original least square's regression. This test is performed through an auxiliary regression of the squared residuals from the original equation on $(1, z_t)$. The explained sum of squares from this auxiliary regression is then divided by $(2\sigma^2)$ to give an LM statistic, which follows a (X^2)-distribution with degrees of freedom equal to the number of variables in (z) under the null hypothesis of no heteroscedasticity (Koenker, 1981).

The computed statistic of Obs*R-squared (where (R^2) is from the auxiliary regression) be used. Koenker's statistic is also distributed as a x^2 with degrees of freedom equal to the number of variables in(z).

- Harvey

This test of heteroskedasticity is like the Breusch-Pagan-Godfrey test. The null hypothesis of no heteroskedasticity against heteroskedasticity of the form of ($e_t^2 = \exp\ z_t'$), where z_t is a vector of independent variables.

In this test, an auxiliary regression of the log of the original equation is squared residuals on (1,z_t) is performed. This statistic is distributed as x^2 with degrees of freedom equal to the number of variables in (z) (Harvey, 1976).

- Glejser

This test is also like the Breusch-Pagan-Godfrey test. This test also tests against an alternative hypothesis of heteroskedasticity of the form $\sigma_t^2 = (\sigma^2 + z_t'\alpha$ with (m=1, 2). Based on Glejser the auxiliary regression regresses the absolute value of the residuals from the original equation upon (1,z_t).

An LM statistic can be formed by dividing the explained sum of squares from this auxiliary regression by ($\frac{1-2}{\pi}$)$\acute{\sigma}^2$.

Therefore, as with the previous tests, this statistic is distributed from a chi-squared distribution with degrees of freedom equal to the number of variables in (z), (Glejser, 1969).

- ARCH LM Test

Engel (1982) proposed that the ARCH test is an LM test for autoregressive conditional heteroscedasticity (ARCH) in the residual as the previous heteroscedasticity tests. The test specification was motivated by the reflection that in much financial time series, the magnitude of residuals appeared to be related to the magnitude of recent residuals. ARCH does not invalidate standard LS inference. However, ignoring ARCH effects may result in a loss of efficiency. The ARCH LM test statistic is computed from an auxiliary test regression. To test the null hypothesis that there is no ARCH up to order in the residuals, we run the regression:

$$e_t^2 = \beta_0 + \left(\sum_{s=1}^{q} \beta_s e_{t-s}^2 \right) + v_t \quad \text{..(4.37)}$$

Where (e) is the residual. This is a regression of the squared residuals on a constant and lagged squared residuals up to order (q). EViews reports two test statistics from this test regression. The F-statistic is an omitted variable test for the joint significance of all lagged squared residuals. The Obs*R-squared statistic is Engle's LM test statistic, computed as the number of observations times the R^2 from the test regression. The exact finite sample distribution of the F-statistic under H_0 is not known, but the LM test statistic is asymptotically distributed as a $R^2(q)$ under quite general conditions

- White's Heteroscedasticity Test

White's (1980) test is a test of the null hypothesis of no heteroskedasticity against heteroskedasticity of the unknown, general form. The test statistic is computed by an auxiliary regression, where we regress the squared residuals on all possible (nonredundant) cross products of the regressors. For example, suppose we estimated the following regression:

$$y_t = b_1 + b_2 x_t + b_3 z_t + e_t \quad \text{..(4.38)}$$

Where the (b) is the estimated parameters and (e) the residual. The test statistic is then based on the auxiliary regression:

$$e_t^2 = \alpha_0 + \alpha_1 x_t + \alpha_2 z_t + \alpha_3 x_t^2 + \alpha_4 z_t^2 + \alpha_5 x_t z_t + v_t \quad \text{..(4.39)}$$

White tests always included the level values of the regressors, for instance, the cross product of the regressors and a constant whether the original regression included a constant term. This is no longer the case-level values are only included if the original regression included a constant. The F-statistic is a redundant variable test for the joint significance of all cross products, excluding the constant. It is presented for comparison purposes. The Obs*R-squared statistic is White's test statistic, computed as the number of observations times the centred R^2 from the test regression. The exact finite sample distribution of the F-statistic under H_0 is not known, but White's test statistic is asymptotically distributed as a x^2 with degrees of freedom equal to the number of slope coefficients (excluding the constant) in the test regression.

White (1980) also described this approach as a general test for model misspecification, since the null hypothesis underlying the test assumes that the errors are both homoscedastic and independent of the regressors and that the linear specification of the model is correct. Failure of any one of these conditions could lead to a significant test statistic. Conversely, a non-significant test statistic implies that none of the three conditions is violated (White, 1980).

4.4.7 Stability and diagnostic testing

The tests provided in this section will help to examine whether the parameters of the model are stable across various sub-samples of the data.

4.4.7.1. Ramsey reset test

The Regression Specification Error Test (RESET) was proposed by Ramsey (1969). The classical normal linear regression model is specified as:

$Y_t = \beta X + \mu$ ………………………………………………………………….... (4.40)

Where the disturbance vector μ is presumed to follow the multivariate normal distribution $N(0,\sigma^2 I)$. Specification error is a collective term that covers any departure from the assumptions of the maintained model. Serial correlation, heteroscedasticity, or non-normality all violate the assumption that the disturbances are distributed $N(0,\sigma^2 I)$. Tests for these specification errors have been described above (Brooks, 2008).

RESET is a general test for the following types of specification errors:

- Omitted variables; X does not include all relevant variables.
- Incorrect functional form, some or all the variables in y and x should be transformed to logs, powers, reciprocals, or in some other way.

• Correlation between X and μ may be caused, among other things, by measurement Error in X simultaneity, or the presence of lagged y values and serially correlated disturbances (Brooks, 2008).

Under such specification errors, LS estimators will be biased, and inconsistent, and conventional inference procedures will be invalidated. Ramsey (1969) exhibited that any of these specification errors produce a non-zero mean vector μ. Therefore, the null and alternative hypotheses of the RESET test are:

$$H_0 = \mu \approx N(0, \sigma^2 I)$$
$$H_1 = \mu \approx N(0, \sigma^2 I) \ldots\ldots \mu \neq 0 \qquad \text{(4.41)}$$

The test is based on an augmented regression:

$$Y = \beta X + Z\gamma + \mu \qquad \text{(4.42)}$$

The test of specification error evaluates the restriction $y = 0$. The crucial question in constructing the test is to determine what variables should enter the Z matrix. Note that the Z matrix may, for example, be comprised of variables that are not in the original specification, so that the test $y = 0$ is simply the omitted variables test described above.

In testing for incorrect functional form, the nonlinear part of the regression model may be some function of the regressors included in X. For instance, if a linear relation,

$$Y_t = \beta_0 + \beta_1 X + \mu \qquad \text{(4.43)}$$

The equation above therefore is specified instead of the true relation:

$$Y_t = \beta_0 + \beta_1 X + \beta_2 X^2 + \mu \qquad \text{(4.44)}$$

Equation 27 has $z = x^2$ and we are back to the omitted variable case. A more general example might be the specification of an additive relation,

$$Y_t = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \mu \qquad \text{(4.45)}$$

Instead of the true multiplicative relation:

$$Y_t = \beta_0 X_1^{B_1} X_2^{B_2} + \mu \qquad \text{(4.46)}$$

A Taylor series approximation of the multiplicative relation would yield an expression involving powers and cross products of the explanatory variables. Ramsey's suggestion is to include powers of the predicted values of the dependent variable in Z:

$$Z_t = \left[\hat{y}^2, \hat{y}^3, \hat{y}^4 ...\right] \text{.. (4.47)}$$

Where is the vector of fitted values from the regression of Y on X. The superscripts used in the equation (4.13) above, indicate the powers to which these predictions are raised. The first power is not included since it is perfectly collinear with the X matrix (Gujarati, 2009).

The output from the test reports the test regression and the F-statistic and log-likelihood ratio for testing the hypothesis that the coefficients on the powers of fitted values are all zero. A study by Ramsey and Alexander (1984) showed that the RESET test could detect specification error in an equation, which was known a priori to be not specified, but which nonetheless gave satisfactory values for even more traditional test criteria-goodness of fit, test for first-order serial correlation, high t-ratios.

4.4.7.2. CUSUM test

The CUSUM test by Brown, Durbin, and Evans (1975) is based on the cumulative sum of the recursive residuals. This option plots the cumulative sum together with the 5% critical lines. The test finds parameter instability if the cumulative sum goes outside the area between the two critical lines.

The CUSUM test is based on the statistic:

$$W_t = \sum_{r=k+1}^{t} \frac{w_r}{s} \text{.. (4.48)}$$

For $t = k+1, ...T,$ where w is the recursive residual defined above, and s is the standard deviation of the recursive residuals, W_t. If the β vector remains constant from period to period, $E(W_t) = 0$ but if β changes, W_t will tend to diverge from the zero mean value line. The significance of any departure from the zero lines is assessed by reference to a pair of 5% significance lines, the distance between which increases with t. The 5%

significance lines are found by connecting the points. Movement W_t outside the critical lines is suggestive of coefficient instability.

3.4.6.1. CUSUM of squares test

The CUSUM of squares test (Brown, Durbin, and Evans, 1975) is based on the test statistic:

$$S_t = \frac{\left(\sum_{r=k+1}^{t} w_r^2\right)}{\left(\sum_{r=k+1}^{T} w_r^2\right)} \qquad (4.49)$$

The expected S_t value under the hypothesis of parameter constancy is:

$$E(S_t) = \frac{(t-k)}{(T-k)} \qquad (4.50)$$

Which goes from zero at $t = k$ to unity at $T = k$. The significance of the departure from its expected value is assessed by reference to a pair of parallel straight lines around the expected value. See Brown, Durbin, and Evans (1975) or Johnston and DiNardo (1997, Table D.8) for a table of significance lines for the CUSUM of squares test.

The CUSUM of squares test provides a plot S_t against t and the pair of 5 percent critical lines. As with the CUSUM test, movement outside the critical lines is suggestive of parameter or variance instability. The cumulative sum of squares is generally within the 5% significance lines, suggesting that the residual variance is somewhat stable. Thus, the cumulative sum of squares is generally within the 5% significance lines, suggesting that the residual variance is stable.

4.4.7.3. Influence statistics

Influence statistics are a method of discovering influential observations, or outliers. They are a measure of the difference that a single observation makes to the regression results, or how different an observation is from the other observations in an equation's sample. E-views provides the following six different influence statistics:

- R-Student is the studentized residual; the residual of the equation at that observation divided by an estimate of its standard deviation:

$$\vec{e}_i = \frac{e_i}{s(i)\sqrt{1-h_i}} \qquad (4.51)$$

where e_t is the original residual for that observation, $s(i)$ is the variance of the residuals that would have resulted had observation i not been included in the estimation, and h_i is the $i-th$ diagonal element of the Hat Matrix, i.e. $x_i(X'X)^{-1}x_i$. The R-Student is also numerically identical to the t-statistic that would result from putting a dummy variable in the original equation, which is equal to one, on that observation and zero elsewhere. Thus, it can be interpreted as a test for the significance of that observation.

- DFFITS is the scaled difference in fitted values for that observation between the original equation and an equation estimated without that observation, where the scaling is done by dividing the difference by an estimate of the standard deviation of the fit:

$$DEFITS_i = \left[\frac{h_i}{1-h_i}\right]^{\frac{1}{2}} \frac{e_i}{s(i)\sqrt{i-h_i}} \qquad (4.52)$$

- DRResid is the dropped residual, an estimate of the residual for that observation had the equation been run without that observation's data.
- COVRATIO is the ratio of the determinant of the covariance matrix of the coefficients from the original equation to the determinant of the covariance matrix from an equation without that observation.
- Hat-Matrix reports the $i-th$ diagonal element of the Hat Matrix: $x_i(X'X)^{-1}x_i$
- DFBETAS are the scaled difference in the estimated betas between the original equation and an equation estimated without that observation:

$$DFBETAS_{i,j} = \frac{\beta_j - \beta_j(i)}{s(i)\sqrt{\mathrm{var}(\beta_j)}} \qquad (4.53)$$

where β_j the original equation's coefficient estimates, and $\beta_j(i)$ is the coefficient estimate from an equation without observation i.

4.4.8 Covariance analysis

the covariance analysis helps to determine the direction of a linear relationship between two variables as follows:

- If both variables tend to increase or decrease together, the coefficient is positive.
- If one variable tends to increase as the other decreases, the coefficient is negative.

4.4.9 Generalized Impulse Response Function

The impulse response system (IRF) traces out the response of the dependent variable in the VAR system to shocks in the error terms, such as μ_1 and μ_2 in equations. Such a shock or change will change M_1 in the current as well as future periods. Since M_1 appears in the R-regression, the change in μ_1 will also have an impact on R. Similarly, a change of one standard deviation is μ_2 of the R equation will have an impact on M_1 The impulse response system traces out the impact of such shocks for several periods in the future. Although researchers have questioned the utility of such IRF analysis, it is the centrepiece of VAR analysis.

4.4.10 Variance decomposition system

Variance decomposition (VDS) or forecast error variance decomposition (FEVD) is used to aid in the interpretation of a vector autoregression (VAR) model once it has been fitted. The variance decomposition indicates the amount of information each variable contributes to the other variables in the autoregression. It determines how much of the forecast error variance of each of the variables can be explained by exogenous shocks to the other variables.

4.5. Summary

The main emphasis in this chapter was the introduction and the discussions of all the econometric approaches which will be used in this study. Both the ADRL and the Granger causality approaches were adopted to achieve the objectives of the study. The next chapter presents the summary of results, recommendations

CHAPTER 5

DISCUSSION / PRESENTATION / INTERPRETATION OF FINDINGS

5.1. Introduction

This chapter presents the results of all the econometric tests undertaken by this study. The results have been outlined based on the ARDL approach requirements such as the unit root tests, and all other tests required to validate the results and the conclusion made from the entire analysis.

5.2. Empirical tests results

This section presents the empirical findings and the discussions of the analysis.

5.2.1. Descriptive statistics results

The results in Table 5.1 shows the nature of the data in terms of its skewness, dispersion and its distribution.

Table 5. 1 Descriptive statistics results

	LNGDPPC	LNEDUEX	LNGFCF	TOP	LNICTE	LNRDEX
Mean	10.32464	11.32697	12.44891	0.534224	9.242286	8.971396
Median	10.35361	11.32135	12.40103	0.548016	9.500469	9.058936
Maximum	11.36408	12.70055	13.69496	0.728654	10.52562	10.26357
Minimum	9.039552	9.642642	11.04479	0.374875	7.243513	7.729296
Std. Dev.	0.729126	0.902650	0.927158	0.091678	0.989440	0.800461
Skewness	-0.168261	-0.088020	-0.081938	-0.122227	-0.585490	-0.028748
Kurtosis	1.747517	1.907228	1.547337	2.213345	2.175711	1.629401
Jarque-Bera	2.032369	1.480378	2.582311	0.819957	2.477863	2.273899
Probability	0.361974	0.477024	0.274953	0.663665	0.289694	0.320796
Sum	299.4145	328.4822	361.0185	15.49249	268.0263	260.1705
Sum Sq. Dev.	14.88549	22.81376	24.06941	0.235338	27.41177	17.94064
Observations	29	29	29	29	29	29

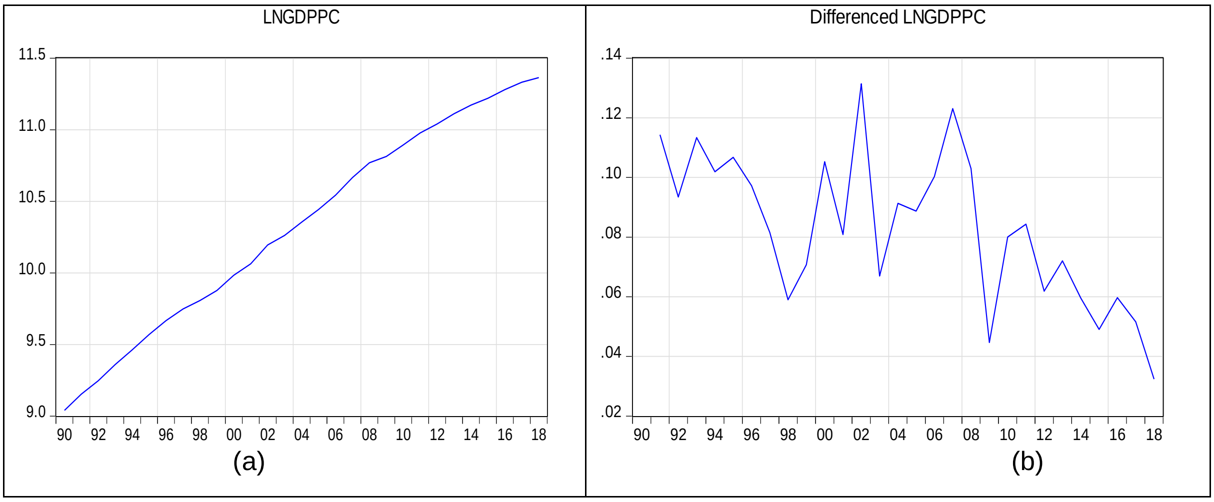
Source: Authors' calculations

The results in table 5.1 present the descriptive statistics applied in this study. Therefore, the model has used 29 observations. The results comprise the mean, which is an average used to derive the central tendency of the data in question. The median shows the middle number calculated on each variable and this shows a simple measure of central tendency. The sample maximum and sample minimum presented above is also called the largest observation and smallest observations. These are the values of the greatest and least elements of a sample.

The kurtosis of the data given is less than 3 significant level. Therefore, the data sample follows a platykurtic characteristic, which means that the data distribution runs from flat to relative normal distribution. The skewness reveals that the data sample contains negative skewness. This sample implies that the data distribution has a long-left tail. The data shows to have negative asymmetry of its mean. This means that the model has a long-left tail on negative numbers. Finally, the Jarque-Bera values measure the difference of the skewness and kurtosis of the series given. Thus, the given probability is less than 5% significance which implies that the data is normally distributed.

5.2.2. Informal unit root testing results

The informal unit root testing was used to provide a preliminary assessment of the stationarity of the variables under study. This was done through the visual inspections of the line graphs and correlogram and the results are presented in Figure 5.1 to Figure 5.12. The findings have been separated into two panels (a) and (b) respectively. Panels (a) of each figure presents the results at their level or raw data while panels (b) provide the results at their first difference.



Source: Authors Compilation

Figure 5. 1 LNGDPPC visual unit root test results at a level and first difference

LNGDPPC at Level

Lag	AC	PAC	Q-Stat	Prob
1	0.901	0.901	26.075	0.000
2	0.801	-0.057	47.462	0.000
3	0.701	-0.060	64.442	0.000
4	0.602	-0.049	77.476	0.000
5	0.504	-0.058	86.993	0.000
6	0.408	-0.053	93.510	0.000
7	0.315	-0.053	97.575	0.000
8	0.224	-0.064	99.720	0.000
9	0.134	-0.068	100.52	0.000
10	0.046	-0.067	100.62	0.000
11	-0.039	-0.066	100.70	0.000
12	-0.118	-0.058	101.43	0.000

(a)

LNGDPPC at 1st Difference

Lag	AC	PAC	Q-Stat	Prob
1	0.368	0.368	4.2115	0.040
2	0.318	0.211	7.4784	0.024
3	0.202	0.039	8.8479	0.031
4	0.105	-0.036	9.2355	0.055
5	0.156	0.100	10.127	0.072
6	0.182	0.115	11.390	0.077
7	-0.095	-0.282	11.754	0.109
8	-0.072	-0.079	11.972	0.152
9	0.000	0.151	11.972	0.215
10	-0.207	-0.237	13.965	0.175
11	0.032	0.130	14.015	0.232
12	-0.049	0.034	14.143	0.292

(b)

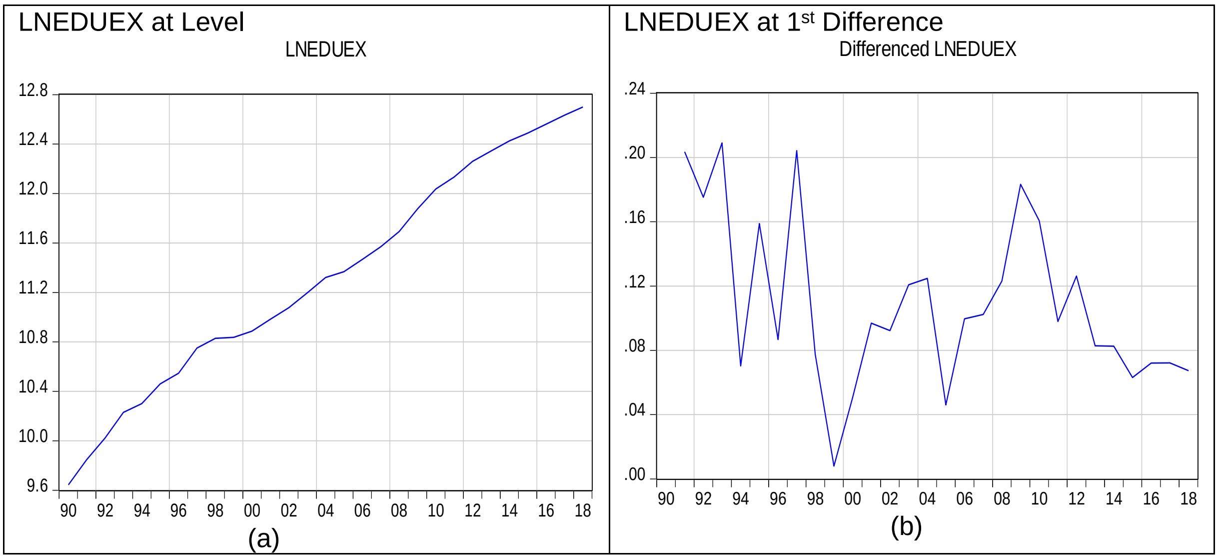
Source: Author's compilation

Figure 5. 2 LNGDPPC correlogram results at a level and first difference

The figures, 5.1. and 5.2 show the visual unit root and correlogram presentation of the log of LNGDPPC. The presentation was done at a level and first difference.

Under visual inspection in figure 5.1, graph (a) shows LNGDPPC at a level. The graph has a positive upward trend and is not stationary. In graph (b) shows LNGDPPC at first difference. In this graph, the trend fluctuates around its mean, this shows that the variable seems to be stationary at first difference. Figure 5.2, shows the reflection of the findings in figure 5.1. The variable LNDGPPC is not stationary under graph (a) of the correlogram. The bars of both autocorrelation and partial autocorrelation is not stable at a level.

In graph (b) the graph shows the correlogram of LNGDPPC at first difference. The AC and PAC show that the variable is stationary.



Source: Authors Compilation

Figure 5. 3 LNEDUEX unit root test results at a level and first difference

LNEDUEX at Level

Lag	AC	PAC	Q-Stat	Prob
1	-0.499	-0.499	7.4977	0.006
2	0.189	-0.080	8.6113	0.013
3	-0.243	-0.243	10.531	0.015
4	0.082	-0.192	10.761	0.029
5	-0.048	-0.131	10.842	0.055
6	0.174	0.092	11.965	0.063
7	-0.033	0.137	12.007	0.100
8	-0.071	-0.028	12.215	0.142
9	0.071	0.111	12.436	0.190
10	-0.216	-0.159	14.582	0.148
11	0.096	-0.194	15.034	0.181
12	0.009	-0.083	15.039	0.239

(a)

LNEDUEX at 1st Difference

Lag	AC	PAC	Q-Stat	Prob
1	0.281	0.281	2.4640	0.116
2	0.234	0.168	4.2375	0.120
3	-0.108	-0.235	4.6315	0.201
4	0.032	0.090	4.6682	0.323
5	-0.042	0.007	4.7322	0.449
6	0.036	-0.011	4.7817	0.572
7	-0.243	-0.270	7.1414	0.414
8	-0.334	-0.275	11.815	0.160
9	-0.200	0.100	13.584	0.138
10	-0.194	-0.150	15.338	0.120
11	-0.007	0.004	15.340	0.167
12	0.048	0.133	15.460	0.217

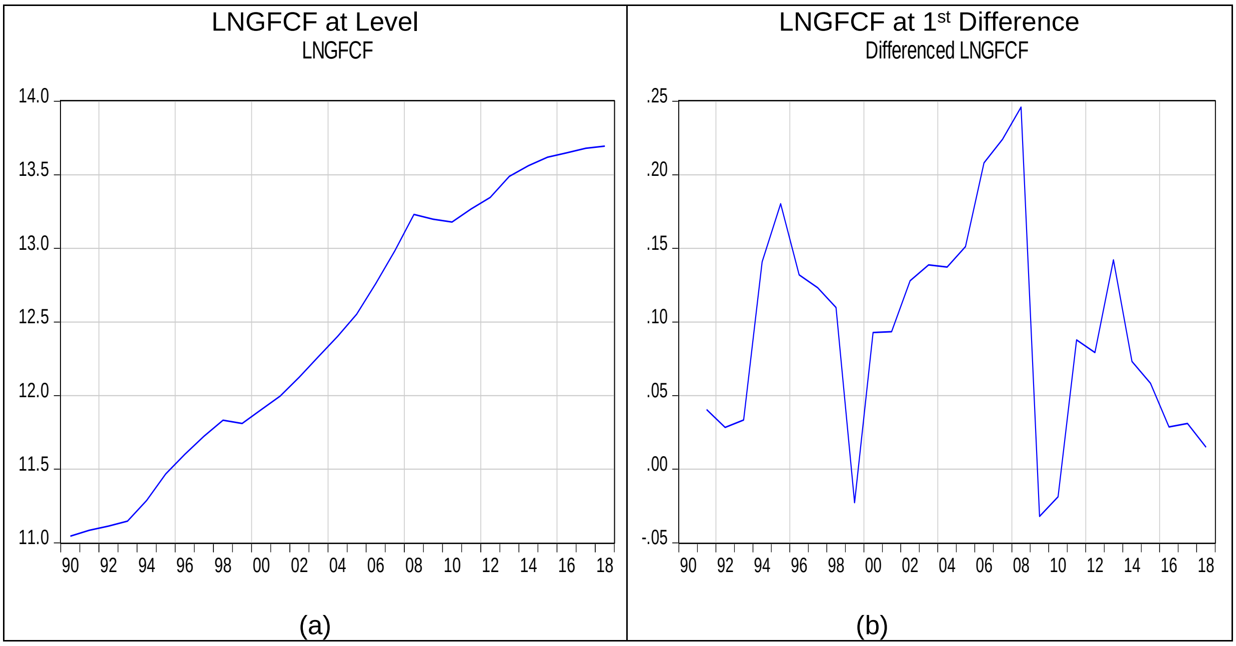
(b)

Source: Authors Compilation

Figure 5. 4 LNEDUEX correlogram results at a level and first difference

Similarly, the Log of expenditure on education in panel (a) and panel (b) in figure 5.3 and figure 5.4. are both in level and first difference. The level form is demonstrated by pane (a) in both figures. Panel (a) indicates non-stationary because of the upward trend of the graph which is influenced after time. The trend of these panels is positive that is increasing over time. This trend is removed by differencing it once.

In panel (b) of both Figures 5.3 and 5.4, shows that the variable is now stationary after differencing. Hence, the variable fluctuates around its mean. Hence, the variable LNEDUEX seem to be stationary and integrated into the first order



Source: Authors Compilation

Figure 5. 5 LNGFCF visual unit root test results at a level and first difference

LNGFCF at Level (a)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.919	0.919	27.091	0.000
		2	0.827	-0.107	49.862	0.000
		3	0.728	-0.096	68.173	0.000
		4	0.622	-0.093	82.093	0.000
		5	0.519	-0.045	92.177	0.000
		6	0.420	-0.036	99.080	0.000
		7	0.327	-0.036	103.46	0.000
		8	0.237	-0.061	105.85	0.000
		9	0.149	-0.062	106.85	0.000
		10	0.051	-0.150	106.97	0.000
		11	-0.053	-0.123	107.11	0.000
		12	-0.146	-0.032	108.23	0.000

LNGFCF at 1st Difference (b)

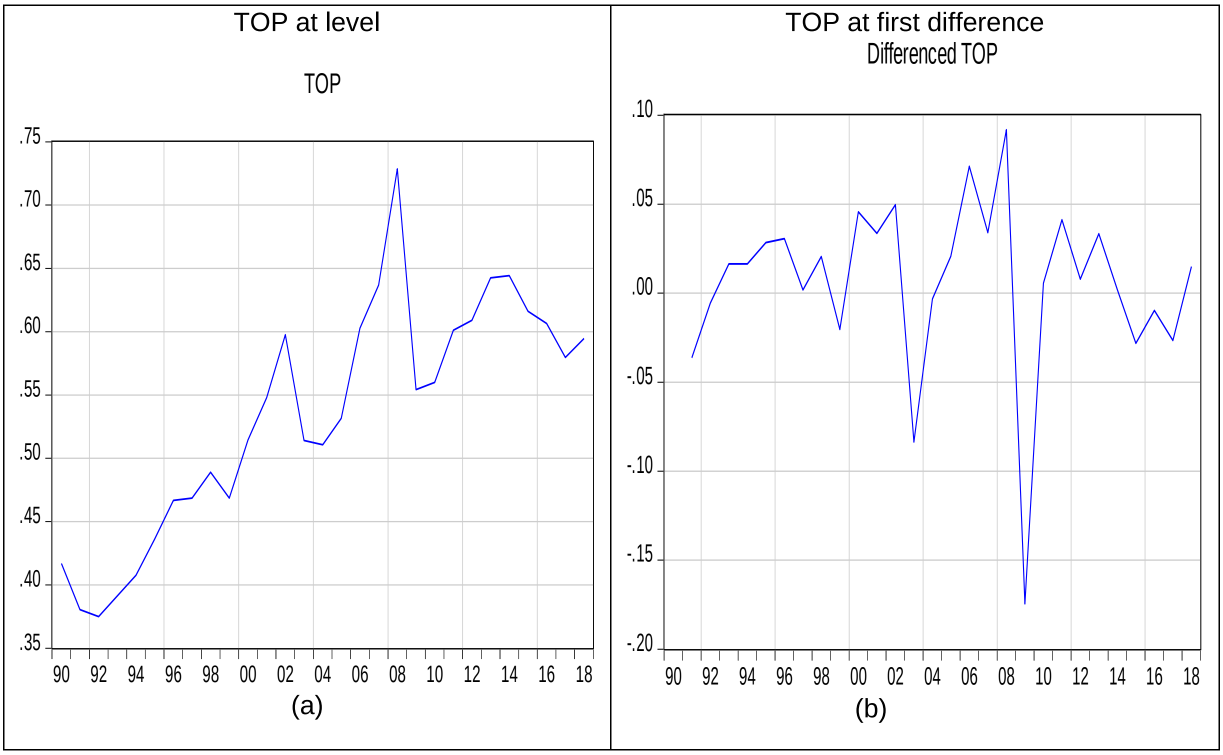
Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.448	0.448	6.2361	0.013
		2	0.041	-0.199	6.2903	0.043
		3	-0.186	-0.155	7.4549	0.059
		4	-0.234	-0.088	9.3759	0.052
		5	-0.041	0.127	9.4374	0.093
		6	0.067	-0.010	9.6092	0.142
		7	0.019	-0.098	9.6229	0.211
		8	-0.004	0.022	9.6236	0.292
		9	-0.128	-0.126	10.345	0.323
		10	-0.013	0.146	10.353	0.410
		11	0.023	-0.073	10.380	0.497
		12	-0.062	-0.129	10.583	0.565

Source: Authors Compilation

Figure 5. 6 LNGFCF correlogram results at a level and first difference

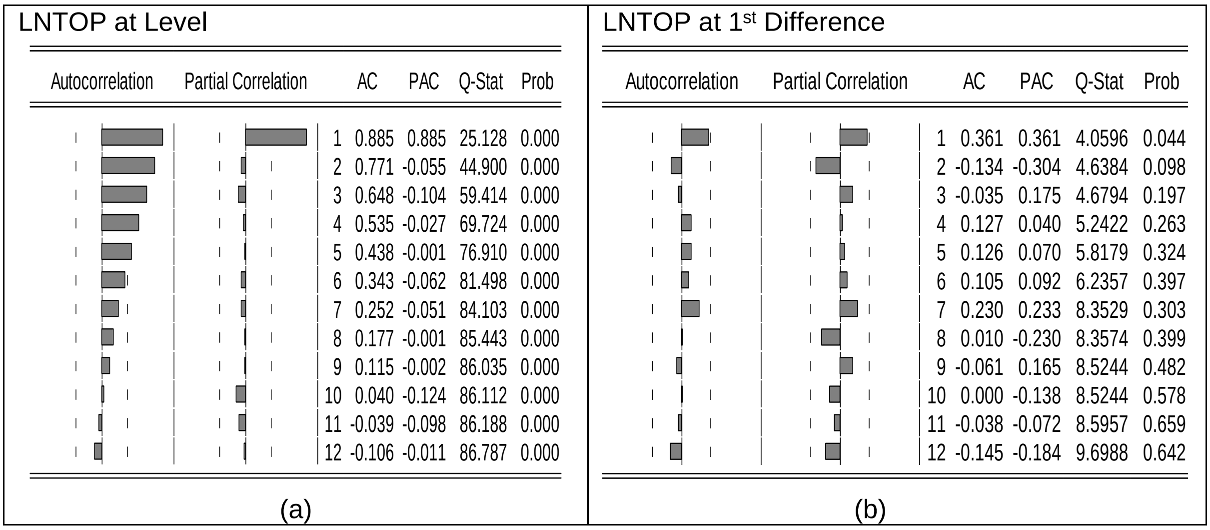
Figure 5.5 and figure 5.6 show the visual unit root and correlogram of a log of generally fixed capital formation at a level and first difference in panels (a) and (b). Panel (a) demonstrates level form results and panel (b) shows the results at the first difference. Panel (a) of graph 5.5 has a positive and an upward trend. Similarly, in panel (a) of graph 5.6, the autocorrelation is high at lag 1 and decreases as the number of lags increases. In both cases, shows that the variable is non-stationary.

Panel (b) of figure 5.5, shows a fluctuating trend of the graph at the first difference. This show that the variable is now wavering around its mean at this stage. Similarly, in panel (b) of figure 5.6, the autocorrelation has a wavering pattern like some lags increases. This pattern shows that the variable LNGFCF seem to be stationary at first different and integrated of order 1.



Source: Authors compilation

Figure 5. 7 TOP visual unit root test results at a level and first difference



LNTOP at Level

Lag	AC	PAC	Q-Stat	Prob
1	0.885	0.885	25.128	0.000
2	0.771	-0.055	44.900	0.000
3	0.648	-0.104	59.414	0.000
4	0.535	-0.027	69.724	0.000
5	0.438	-0.001	76.910	0.000
6	0.343	-0.062	81.498	0.000
7	0.252	-0.051	84.103	0.000
8	0.177	-0.001	85.443	0.000
9	0.115	-0.002	86.035	0.000
10	0.040	-0.124	86.112	0.000
11	-0.039	-0.098	86.188	0.000
12	-0.106	-0.011	86.787	0.000

(a)

LNTOP at 1st Difference

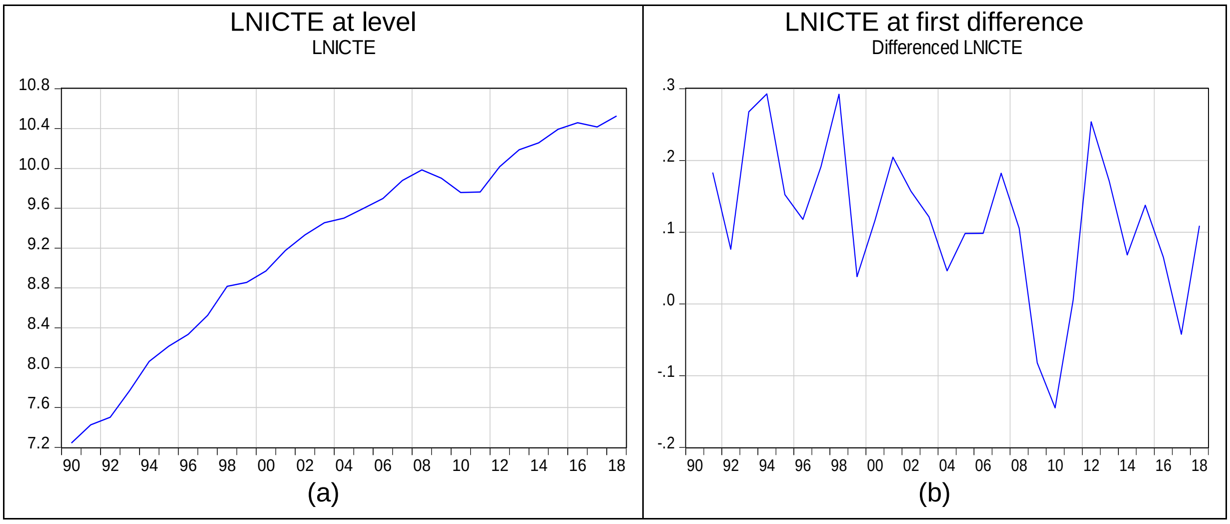
Lag	AC	PAC	Q-Stat	Prob
1	0.361	0.361	4.0596	0.044
2	-0.134	-0.304	4.6384	0.098
3	-0.035	0.175	4.6794	0.197
4	0.127	0.040	5.2422	0.263
5	0.126	0.070	5.8179	0.324
6	0.105	0.092	6.2357	0.397
7	0.230	0.233	8.3529	0.303
8	0.010	-0.230	8.3574	0.399
9	-0.061	0.165	8.5244	0.482
10	0.000	-0.138	8.5244	0.578
11	-0.038	-0.072	8.5957	0.659
12	-0.145	-0.184	9.6988	0.642

(b)

Source: Authors compilation

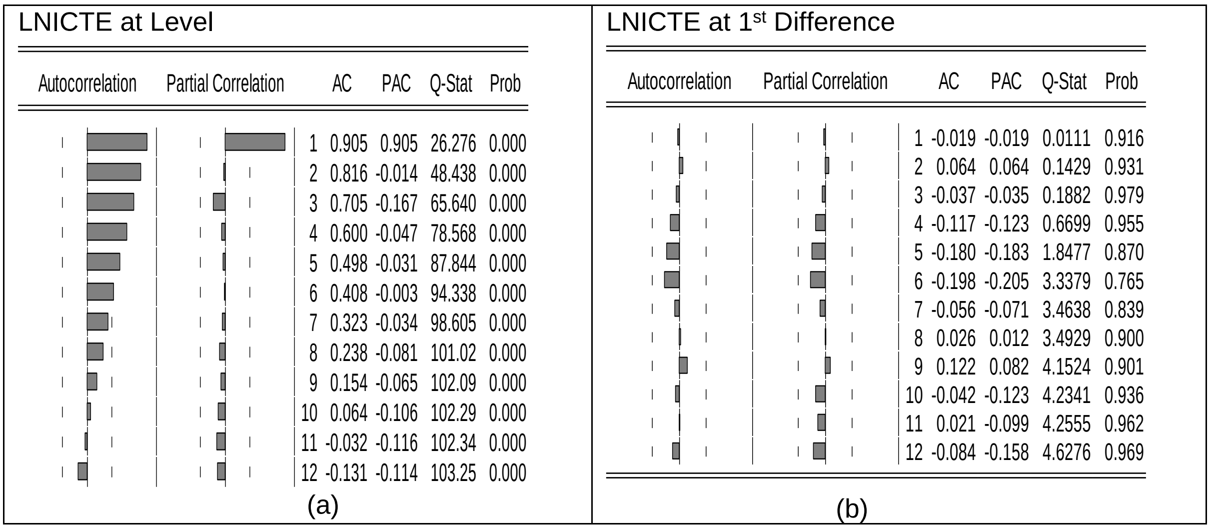
Figure 5. 8 TOP correlogram results at a level and first difference

Figures 5.7 and 5.8 show a log of trade openness in panels (a) and (b). In both diagrams, panel (a) shows variable LNTOP at level and panel (b) shows the same variable at first difference. In diagram 5.7, panel (a) shows the visual unit root at a level. The diagram has a positive and upward trend which makes it non-stationary. Similarly, in figure 5.8, panel (a) shows autocorrelation which is decreasing from lag one as the number of lags increases. In panel (b) of both diagrams has a fluctuating trend meaning that the variable LNTOP wavers around its mean. Therefore, panels labelled (b) in both figures shows that the variable seems to be stationary at first difference.



Source: Authors Compilation

Figure 5. 9 LNICTE visual unit root test results at a level and first Difference



	AC	PAC	Q-Stat	Prob
1	0.905	0.905	26.276	0.000
2	0.816	-0.014	48.438	0.000
3	0.705	-0.167	65.640	0.000
4	0.600	-0.047	78.568	0.000
5	0.498	-0.031	87.844	0.000
6	0.408	-0.003	94.338	0.000
7	0.323	-0.034	98.605	0.000
8	0.238	-0.081	101.02	0.000
9	0.154	-0.065	102.09	0.000
10	0.064	-0.106	102.29	0.000
11	-0.032	-0.116	102.34	0.000
12	-0.131	-0.114	103.25	0.000

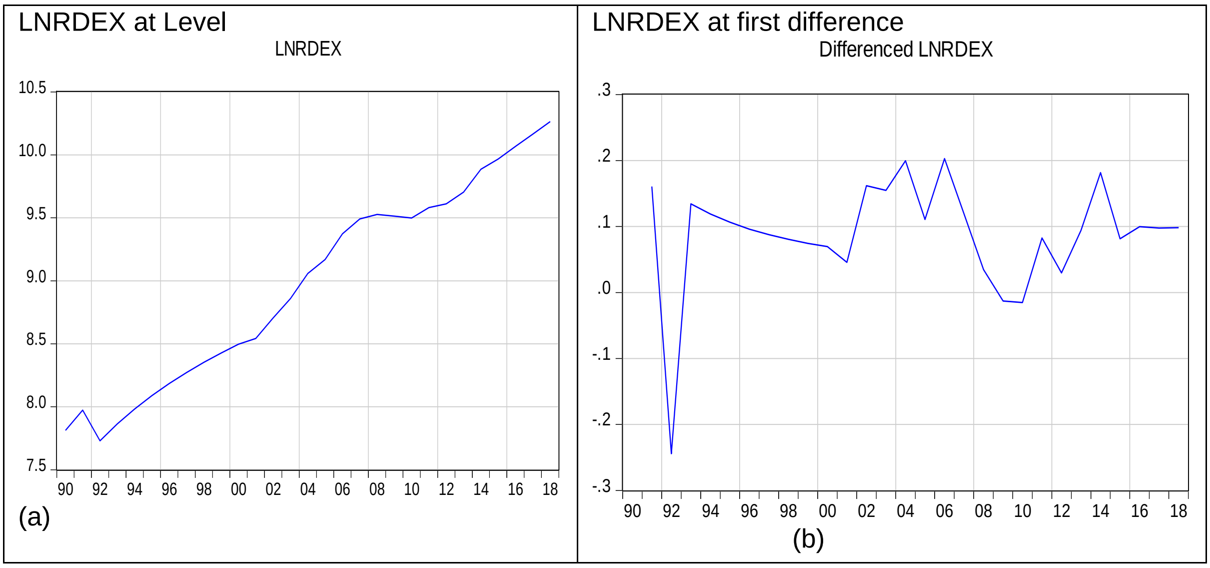
	AC	PAC	Q-Stat	Prob
1	-0.019	-0.019	0.0111	0.916
2	0.064	0.064	0.1429	0.931
3	-0.037	-0.035	0.1882	0.979
4	-0.117	-0.123	0.6699	0.955
5	-0.180	-0.183	1.8477	0.870
6	-0.198	-0.205	3.3379	0.765
7	-0.056	-0.071	3.4638	0.839
8	0.026	0.012	3.4929	0.900
9	0.122	0.082	4.1524	0.901
10	-0.042	-0.123	4.2341	0.936
11	0.021	-0.099	4.2555	0.962
12	-0.084	-0.158	4.6276	0.969

Source: Authors Compilation

Figure 5. 10 LNICTE correlogram results at a level and first difference

The visual unit root and correlogram results of the log of information communication and technology variable is presented in figure 5.9 and figure 5.10. The results have been present at all levels in panel (a) and the first difference in panel (b) of both diagrams. Panel (a) of both diagrams has a positive trend, this shows that the variable is non-stationary at a level.

In panel be (b) the variable in both diagrams has been differenced once and this has removed the trend. This makes the variable seem to be stationary.



Source: Authors Compilation

Figure 5. 11 LNRDEX visual unit root test results at a level

LNRDEX at Level

Lag	AC	PAC	Q-Stat	Prob
1	0.820	0.820	21.571	0.000
2	0.665	-0.022	36.274	0.000
3	0.524	-0.044	45.778	0.000
4	0.467	0.166	53.614	0.000
5	0.433	0.056	60.631	0.000
6	0.399	-0.003	66.863	0.000
7	0.253	-0.325	69.471	0.000
8	0.126	-0.045	70.147	0.000
9	0.024	-0.015	70.172	0.000
10	-0.016	0.006	70.184	0.000
11	-0.093	-0.213	70.618	0.000
12	-0.133	0.048	71.552	0.000

(a)

LNRDEX at 1st Difference

Lag	AC	PAC	Q-Stat	Prob
1	-0.160	-0.160	0.7946	0.373
2	-0.110	-0.139	1.1883	0.552
3	-0.297	-0.356	4.1579	0.245
4	-0.105	-0.303	4.5437	0.337
5	0.028	-0.241	4.5718	0.470
6	0.469	0.301	12.957	0.044
7	-0.076	0.012	13.190	0.068
8	-0.026	0.074	13.219	0.105
9	-0.267	-0.049	16.367	0.060
10	0.030	0.105	16.409	0.089
11	-0.006	-0.032	16.411	0.127
12	0.170	-0.111	17.928	0.118

(b)

Source: Authors Compilation

Figure 5. 12 LNRDEX correlogram results at a level and first difference

Similar, analyses done in figures 5.1 to 5.10, figure 5.11 and figure 5.12 show the visual unit root and correlogram presentation of a log of government expenditure on research and development. In this regard, the level form is demonstrated by a panel (a) in both figures indicating non-stationary because the sample is marked by the trend that is influenced by time. In figure 5.11 panel (a) shows a positive and upward trend proving the non-stationary state. Similarly, in figure 5.12 panel (a) of the correlogram, the autocorrelation is big in lag one and shows a decreasing trend as the number of lags get increased to 12.

On the contrary, panel (b) of figure 5.11 now shows a fluctuating trend after being differenced once. In this state, the variable is now fluctuating around its mean. Similarly, in panel (b) of figure 5.12, the autocorrelation shows a stable and fluctuating pace of the variable from lag one to lag 12. This state shows that the variable LNICTE seem to be stationary after it has been differenced. Hence, the variable is integrated into 1st order.

Finally, the legibility of the results has been confirmed after running a formal unit root test in the form of the ADF and the DF-GLS tests. The results are presented in tables 5.2 and 5.3 respectively.

5.2.3. Formal Stationarity test results

Since the study could not rely solely on the visual inspection analysis, the formal unit root tests in the form of ADF and DF-GLS unit root tests were also performed. The summary of ADF and DF-GLS test results for each series are presented in the tables below and were solely tested on intercept and trend and intercept. The reason for including intercept and trend in the model is because the model with these parameters is the least restricted. The summary of the results was presented in Tables 5.2 and 5.3 as follows:

Table 5. 2 ADF Unit root test results

Variable	Model	Lag-length	T-statistics	P-value	Order of integration	Decision
LNGDPPC	Intercept	6	-4.084044***	0.0038	I (0)	Stationary
	Trend & intercept	6	-4.289886***	0.0112	I (1)	
LNEDUEX	Intercept	6	-3.936539***	0.0057	I (1)	Stationary
	Trend & intercept	6	-4.100500***	0.0170	I (1)	
LNGFCF	Intercept	6	-2.962762***	0.0514	I (1)	Stationary
	Trend & intercept	6	-3.017028	0.1461	I (1)	
LNTOP	Intercept	6	-5.958653***	0.0000	I (1)	Stationary
	Trend & intercept	6	-5.533217***	0.0009	I (1)	
LNICTE	Intercept	6	-3.645328*	0.0117	I (0)	Stationary
	Trend & intercept	6	-5.201776**	0.0015	I (1)	
LNREDEX	Intercept	6	-5.169033***	0.0003	I (1)	Stationary
	Trend & intercept	6	-5.199560**	0.0014	I (1)	

Notes: (i)*- Statistically significant at 10% level (ii) **- Statistically significant at 5% level (iii) ***- Statistically significant at 1% level

Source: Authors' calculations

Table 5. 3 DF-GLS Unit root test results

Variable	Model	Lag-length	T-statistics	P-value	Order of integration	Decision
LNGDPPC	Intercept	6	-2.787804**	0.0098	I (1)	Stationary
	Trend & intercept	6	-4.439014***	0.0001	I (1)	
LNEDUEX	Intercept	6	-3.219603***	0.0034	I (1)	Stationary
	Trend & intercept	6	-4.039645***	0.0001	I (1)	
LNGFCF	Intercept	6	-2.851681**	0.0084	I (1)	Stationary
	Trend & intercept	6	-3.082535***	0.0048	I (1)	
TOP	Intercept	6	-5.645817***	0.0000	I (1)	Stationary
	Trend & intercept	6	-2.938056***	0.0067	I (0)	
LNICTE	Intercept	6	-3.761570**	0.0010	I (1)	Stationary
	Trend & intercept	6	-5.334614**	0.0000	I (1)	
LNRDEX	Intercept	6	-4.884721***	0.0000	I (1)	Stationary
	Trend & intercept	6	-5.212494**	0.0000	I (1)	

Notes: (i)*- Statistically significant at 10% level (ii) **- Statistically significant at 5% level (iii) ***- Statistically significant at 1% level

Source: Authors' calculations

The results in table 5.2 and table 5.3 follow the ADRL requirements as stipulated by Pesaran (1999) that the unit root test becomes valid only if the results are stationary and are integrated of order I (0) and I (1). Both ADF and DF-GLS results were Statistically significant at 1% level. On that note, the ADF results show that gross domestic product per capita and government investment in information and telecommunications is stationary at level, while government expenditure on education, gross fixed capital formation, trade openness and expenditure on research and development are stationary at first difference. Similarly, the DF-GLS results show that only trade openness is stationary at a level while the rest of the variables are stationary at first difference. Therefore, we reject the null hypothesis of data being having unit root or not stationary and accept the alternative hypothesis of no unit root or the model being stationary.

5.2.4. ARDL Cointegration bounds test

The legitimacy of this study is based on whether the findings reflect the long-run relationship among the variables used. Thus, bound testing follows the procedure stipulated by Pesaran et al., (2001).

5.2.4.1. Lag length selection

Before cointegration analysis was made, the appropriate lag length selection criteria were undertaken, and the results are presented in Table 5.4 as follows;

Table 5. 4 Model selection criteria table results

Model	LogL	AIC*	BIC	HQ	Adjusted R^2	Specification
1	82.498572	-5.392755	-5.059704	-5.290938	0.999559	ARDL(1, 0, 0, 0, 0, 0)

Source: Authors' calculations

Based on Table 5.4, the Akaike information criteria was chosen to be the best out of the rest. In that case, unrestricted constant trend specifications with a maximum number of lags of one of the dependent variables and zero lags on regressors were the best.

5.2.4.2. Cointegration bound test results

The results obtained in Table 5.4 were used to help to determine the number of lags to be used in running the ARDL approach and the bound test for cointegration results are presented in Table 5.5.

Table 5. 5 Bound test for cointegration results

Test Statistic	Value	K
F-statistic	5.592251	5
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.26	3.35
5%	2.62	3.79
2.5%	2.96	4.18
1%	3.41	4.68

Source: Authors' calculations

The results have been achieved by running the ARDL bound test on five variables hence given k=5 they are presented in two sections, that is, integrated of order zero and one. It was found that the F-statistics is bigger than any of the critical values at 10%,5%,2.5%, and 1% respectively which means it is above the I (0) and I (1) orders of integrations hence they are all found to be cointegrated. This is in line with (Narayan, 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.

5.2.4.3. Long-run and short-run elasticities

After implementing the bounds testing procedure, and the long-run relationship was established, the cointegrated long-run model for the sample period was estimated and the summary of the results is presented in Table 5.6. The ECM was also estimated within the ARDL framework and the results are presented in Table 5.7.

Table 5. 6 Long-run coefficients results

Variable	Coefficient	Standard Error	T-Statistic	Probability value
LNEDUEX	0.504234	0.241164	2.090831	0.0489
LNGFCF	0.728409	0.549068	1.326627	0.1989
TOP	-3.077916	2.879096	-1.069057	0.2972
LNICTE	0.380063	0.276736	1.373375	0.1841
LNRDEX	-0.465783	0.554714	-0.839682	0.4105

Source: Authors' calculations

The long-run coefficients results indicate that general government expenditure on education, gross fixed capital formation, and ICT are positively related the economic development. The coefficients indicate that a 1% change in general government expenditure, gross fixed capital formation and ICT will affect the economic development by 0.50%, 0.72%, and 0.38 % respectively. On the other hand, the results indicate that trade openness and R&D harm economic development in the long-run. This means that a 1% change in trade openness and R&D affect economic development by -3.08% and -0.47% respectively. Lastly, LNEDUEX is statistically significant at 5% significance level unlike the rest of the variables in the long run.

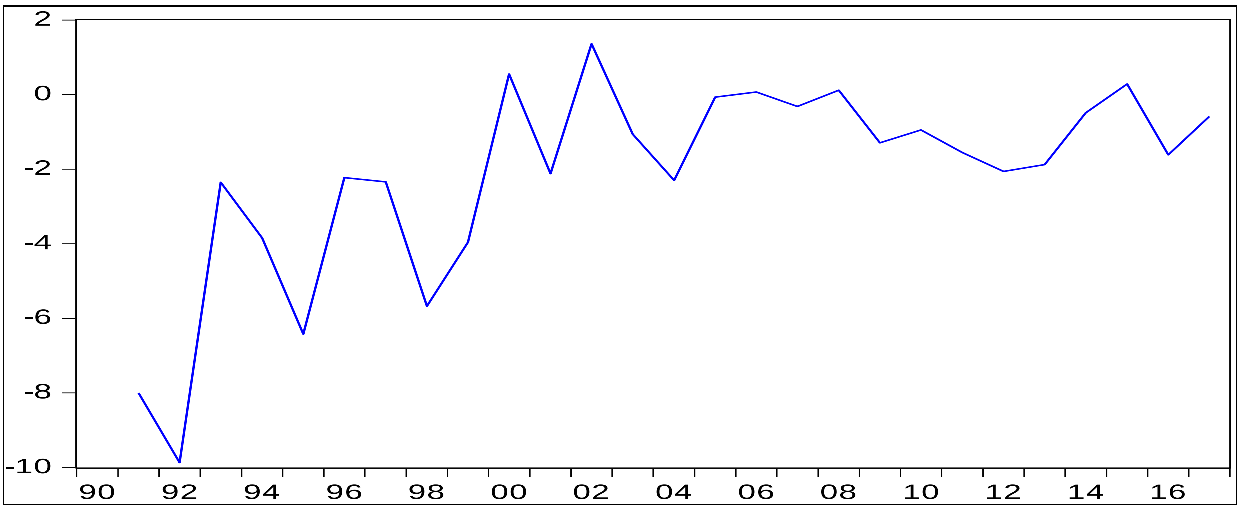
Table 5. 7 Short-run relationship and ECM results

Variable	Coefficient	Std. Error	T-Statistic	Probability value
LNEDUEX	-0.050987	0.039260	-1.298710	0.2081
LNGFCF	-0.029456	0.049040	-0.600658	0.5545
TOP	0.361573	0.106587	3.392287	0.0027
LNICTE	-0.030785	0.017721	-1.737209	0.0970
LNRDEX	0.062271	0.033297	1.870190	0.0755
C	0.477529	0.092786	5.146565	0.0000
CointEq(-1)	-0.039847	0.028948	-1.376498	0.1832

Source: Authors' calculations

The short-run analysis indicates that government expenditure on education, gross fixed capital formation and ICT harm economic development. Unlike in the long-run, trade openness and investment in R&D have a positive impact on economic development. In addition, the error correction term coefficient (CointEq (-1) -0.039847) is negative and significant and 10% significance level. The implication is that the economic development model has a slow rate of speed of adjustment of about 0.04%. This adjustment might be due to governments' lower investment in R&D as noted in figure 2.11 whereby the general government and public corporations spend less amount of money on R&D.

Similarly, the presence of the long-run relationships amongst the variables in the model was further confirmed by the outcomes of the Cointegration line graph as illustrated in figure 5.13.



Source: Authors' calculations

Figure 5. 13 Cointegration graph

The confirmation of the long-run association is confirmed by the upward trend of the line graph, which suggests the presence of Cointegration in the model. Therefore, the implication shows that when the variables used in this study are combined, they show a negative and positive relationship. This is in line with the humorous example of a drunk and her dog which illustrates Cointegration much as "the drunkard's walk" illustrates random-walk processes (Murray, 1994).

5.2.5. Granger causality test results.

The results of Granger causality are going to help in understanding whether x causes y as the way of checking how much of the current y can be explained by the past values of y and as well to see whether adding lagged values of x can improve the explanation. These results are presented in Tables 5.8 to 5.11 below.

Table 5. 8 Granger causality results at Lag 2 with 27 observations

Null Hypothesis:	F-Statistic	P-value	Decision
LNEDUEX does not Granger Cause LNGDPPC	3.15516	0.0624	Accept the H_0
LNGDPPC does not Granger Cause LNEDUEX	4.51749	0.0227	Reject the H_0
LNGFCF does not Granger Cause LNGDPPC	0.33325	0.7201	Accept the H_0
LNGDPPC does not Granger Cause LNGFCF	6.70132	0.0053	Reject the H_0
TOP does not Granger Cause LNGDPPC	0.16130	0.8520	Accept the H_0
LNGDPPC does not Granger Cause TOP	2.84272	0.0798	Accept the H_0
LNICTE does not Granger Cause LNGDPPC	0.82307	0.4522	Accept the H_0
LNGDPPC does not Granger Cause LNICTE	1.28351	0.2970	Accept the H_0
LNRDEX does not Granger Cause LNGDPPC	0.11939	0.8880	Accept the H_0
LNGDPPC does not Granger Cause LNRDEX	5.76043	0.0097	Reject the H_0
LNGFCF does not Granger Cause LNEDUEX	6.09847	0.0078	Reject the H_0
LNEDUEX does not Granger Cause LNGFCF	0.87409	0.4312	Accept the H_0
TOP does not Granger Cause LNEDUEX	1.81224	0.1868	Accept the H_0
LNEDUEX does not Granger Cause TOP	2.17478	0.1374	Accept the H_0
LNICTE does not Granger Cause LNEDUEX	0.91235	0.4162	Accept the H_0
LNEDUEX does not Granger Cause LNICTE	1.54645	0.2353	Accept the H_0
LNRDEX does not Granger Cause LNEDUEX	6.21021	0.0073	Accept the H_0
LNEDUEX does not Granger Cause LNRDEX	4.59500	0.0215	Accept the H_0
TOP does not Granger Cause LNGFCF	0.70283	0.5060	Accept the H_0
LNGFCF does not Granger Cause TOP	2.23916	0.1303	Accept the H_0
LNICTE does not Granger Cause LNGFCF	0.91564	0.4150	Accept the H_0
LNGFCF does not Granger Cause LNICTE	0	0.9578	Accept the H_0

LNRDEX does not Granger Cause LNGFCF	1.65368	0.2143	Accept the H_0
LNGFCF does not Granger Cause LNRDEX	0.64654	0.5335	Accept the H_0
LNICTE does not Granger Cause TOP	4.22924	0.0279	Reject the H_0
TOP does not Granger Cause LNICTE	3.97064	0.0337	Reject the H_0
LNRDEX does not Granger Cause TOP	2.16399	0.1387	Accept the H_0
TOP does not Granger Cause LNRDEX	0.44593	0.6459	Accept the H_0
LNRDEX does not Granger Cause LNICTE	0.04551	0.9556	Accept the H_0
LNICTE does not Granger Cause LNRDEX	6.15896	0.0075	Accept the H_0

Source: Authors' calculations

Table 5.8 shows the Granger causality findings. Based on the results above LNGFCF does granger cause LNGDPPC and visa-Versa. Similarly, LNRDEX does granger cause LNGDPPC and visa-Versa. Furthermore, LNGFCF does Granger cause LNEDUEX and visa-Versa. Therefore, we fail to reject the null hypothesis in the rest of the variables since the probability values are bigger than the significant level of 5%. Based on the findings we conclude that there is unidirectional causality between the following variables, LNEDUEX and GDPPC, LNGFCF and LNGDPPC, LNRDEX and LNGDPPC, LNGFCF and LNEDUEX while bidirectional causality exists between LNICTE and TOP.

Table 5. 9 Granger causality results at Lag 4 with 25 observations

Accept the H_0	F-Statistic	Probability value	Decision
LNEDUEX does not Granger Cause LNGDPPC	2.26202	0.1078	Accept the H_0
LNGDPPC does not Granger Cause LNEDUEX	4.10361	0.0178	Reject the H_0
LNGFCF does not Granger Cause LNGDPPC	0.31424	0.8643	Accept the H_0
LNGDPPC does not Granger Cause LNGFCF	1.80125	0.1780	Accept the H_0
TOP does not Granger Cause LNGDPPC	0.24648	0.9076	Accept the H_0
LNGDPPC does not Granger Cause TOP	0.82810	0.5265	Accept the H_0
LNICTE does not Granger Cause LNGDPPC	1.18360	0.3554	Accept the H_0
LNGDPPC does not Granger Cause LNICTE	1.97350	0.1473	Accept the H_0
LNRDEX does not Granger Cause LNGDPPC	0.16986	0.9506	Accept the H_0
LNGDPPC does not Granger Cause LNRDEX	1.18062	0.3566	Accept the H_0
LNGFCF does not Granger Cause LNEDUEX	2.30154	0.1034	Accept the H_0
LNEDUEX does not Granger Cause LNGFCF	0.09983	0.9810	Accept the H_0
TOP does not Granger Cause LNEDUEX	1.44130	0.2660	Accept the H_0
LNEDUEX does not Granger Cause TOP	0.56043	0.6947	Accept the H_0
LNICTE does not Granger Cause LNEDUEX	0.34540	0.8433	Accept the H_0
LNEDUEX does not Granger Cause LNICTE	2.66944	0.0703	Accept the H_0

LNRDEX does not Granger Cause LNEDUEX	2.23909	0.1105	Accept the H_0
LNEDUEX does not Granger Cause LNRDEX	0.86220	0.5074	Accept the H_0
TOP does not Granger Cause LNGFCF	0.33374	0.8512	Accept the H_0
LNGFCF does not Granger Cause TOP	0.38867	0.8136	Accept the H_0
LNICTE does not Granger Cause LNGFCF	0.76630	0.5625	Accept the H_0
LNGFCF does not Granger Cause LNICTE	1.48081	0.2545	Accept the H_0
LNRDEX does not Granger Cause LNGFCF	1.53223	0.2402	Accept the H_0
LNGFCF does not Granger Cause LNRDEX	0.64343	0.6394	Accept the H_0
LNICTE does not Granger Cause TOP	2.89436	0.0560	Reject the H_0
TOP does not Granger Cause LNICTE	2.76359	0.0639	Accept the H_0
LNRDEX does not Granger Cause TOP	0.91518	0.4789	Accept the H_0
TOP does not Granger Cause LNRDEX	0.18596	0.9423	Accept the H_0
LNRDEX does not Granger Cause LNICTE	2.10156	0.1281	Accept the H_0
LNICTE does not Granger Cause LNRDEX	0.76655	0.5624	Accept the H_0

Source: Authors' calculations

The findings in table 5.9 show were observed at lag 2 with 25 observations. The study accepts the null hypothesis that government expenditure on education does not Granger cause GDP per capita but we reject the opposite since the probability value is less than 5% significant level. Therefore, GDP per capita does granger cause expenditure on education. Similarly, information and communication technology does Granger cause trade openness as the probability values are less than the significant level of 5%. In that case, there is an existence of unidirectional causality.

Table 5. 10 Granger causality results at Lag 6 with 23 observations

Null Hypothesis:	F-Statistic	Probability value	Decision
LNEDUEX does not Granger Cause LNGDPPC	3.30327	0.0464	Reject the H_0
LNGDPPC does not Granger Cause LNEDUEX	2.12137	0.1402	Accept the H_0
LNGFCF does not Granger Cause LNGDPPC	0.55652	0.7557	Accept the H_0
LNGDPPC does not Granger Cause LNGFCF	1.68974	0.2210	Accept the H_0
TOP does not Granger Cause LNGDPPC	0.85890	0.5551	Accept the H_0
LNGDPPC does not Granger Cause TOP	0.42945	0.8435	Accept the H_0
LNICTE does not Granger Cause LNGDPPC	1.14368	0.4049	Accept the H_0
LNGDPPC does not Granger Cause LNICTE	1.69702	0.2192	Accept the H_0
LNRDEX does not Granger Cause LNGDPPC	0.10183	0.9944	Accept the H_0
LNGDPPC does not Granger Cause LNRDEX	1.13379	0.4094	Accept the H_0
LNGFCF does not Granger Cause LNEDUEX	2.43113	0.1029	Accept the H_0

LNEDUEX does not Granger Cause LNGFCF	0.05822	0.9988	Accept the H_0
TOP does not Granger Cause LNEDUEX	1.15721	0.3988	Accept the H_0
LNEDUEX does not Granger Cause TOP	0.84162	0.5656	Accept the H_0
LNICTE does not Granger Cause LNEDUEX	0.66629	0.6795	Accept the H_0
LNEDUEX does not Granger Cause LNICTE	2.11220	0.1415	Accept the H_0
LNRDEX does not Granger Cause LNEDUEX	7.19010	0.0035	Reject the H_0
LNEDUEX does not Granger Cause LNRDEX	0.53301	0.7722	Accept the H_0
TOP does not Granger Cause LNGFCF	2.23167	0.1254	Accept the H_0
LNGFCF does not Granger Cause TOP	0.67306	0.6749	Accept the H_0
LNICTE does not Granger Cause LNGFCF	1.06361	0.4428	Accept the H_0
LNGFCF does not Granger Cause LNICTE	0.85068	0.5601	Accept the H_0
LNRDEX does not Granger Cause LNGFCF	1.25911	0.3557	Accept the H_0
LNGFCF does not Granger Cause LNRDEX	1.08736	0.4312	Accept the H_0
LNICTE does not Granger Cause TOP	1.25963	0.3555	Accept the H_0
TOP does not Granger Cause LNICTE	1.84594	0.1869	Accept the H_0
LNRDEX does not Granger Cause TOP	1.45349	0.2863	Accept the H_0
TOP does not Granger Cause LNRDEX	0.94376	0.5059	Accept the H_0
LNRDEX does not Granger Cause LNICTE	2.19667	0.1299	Accept the H_0
LNICTE does not Granger Cause LNRDEX	0.94347	0.5060	Accept the H_0

Source: Authors' calculations

In table 5.10, we reject the null hypothesis and accept the alternative hypothesis that expenditure on education granger causes gross domestic product per capita. We also reject the null hypothesis and accept the alternative hypothesis that research and development granger cause government expenditure on education. This is because the probability values are less than 5% significant level respectively. The causality is unidirectional in that case.

Table 5. 11 Granger causality results at Lag 8 with 21 observations

Null Hypothesis:	F-Statistic	Probability value	Decision
LNEDUEX does not Granger Cause LNGDPPC	1.77275	0.3041	Accept the H_0
LNGDPPC does not Granger Cause LNEDUEX	2.44516	0.2023	Accept the H_0
LNGFCF does not Granger Cause LNGDPPC	0.85956	0.6052	Accept the H_0
LNGDPPC does not Granger Cause LNGFCF	5.98144	0.0508	Accept the H_0
TOP does not Granger Cause LNGDPPC	0.24306	0.9577	Accept the H_0
LNGDPPC does not Granger Cause TOP	0.61532	0.7412	Accept the H_0
LNICTE does not Granger Cause LNGDPPC	1.59416	0.3435	Accept the H_0

LNGDPPC does not Granger Cause LNICTE	1.52345	0.3611	Accept the H_0
LNRDEX does not Granger Cause LNGDPPC	0.93601	0.5681	Accept the H_0
LNGDPPC does not Granger Cause LNRDEX	3.24439	0.1353	Accept the H_0
LNGFCF does not Granger Cause LNEDUEX	14.0440	0.0110	Reject the H_0
LNEDUEX does not Granger Cause LNGFCF	0.42766	0.8574	Accept the H_0
TOP does not Granger Cause LNEDUEX	3.93748	0.1007	Accept the H_0
LNEDUEX does not Granger Cause TOP	0.49648	0.8147	Accept the H_0
LNICTE does not Granger Cause LNEDUEX	1.03253	0.5250	Accept the H_0
LNEDUEX does not Granger Cause LNICTE	1.34560	0.4112	Accept the H_0
LNRDEX does not Granger Cause LNEDUEX	5.86866	0.0525	Accept the H_0
LNEDUEX does not Granger Cause LNRDEX	1.09835	0.4980	Accept the H_0
TOP does not Granger Cause LNGFCF	2.30025	0.2195	Accept the H_0
LNGFCF does not Granger Cause TOP	0.89317	0.5885	Accept the H_0
LNICTE does not Granger Cause LNGFCF	0.56537	0.7718	Accept the H_0
LNGFCF does not Granger Cause LNICTE	1.50655	0.3655	Accept the H_0
LNRDEX does not Granger Cause LNGFCF	1.11438	0.4917	Accept the H_0
LNGFCF does not Granger Cause LNRDEX	0.84950	0.6103	Accept the H_0
LNICTE does not Granger Cause TOP	2.24849	0.2262	Accept the H_0
TOP does not Granger Cause LNICTE	5.17438	0.0648	Accept the H_0
LNRDEX does not Granger Cause TOP	0.76417	0.6553	Accept the H_0
TOP does not Granger Cause LNRDEX	0.82223	0.6243	Accept the H_0
LNRDEX does not Granger Cause LNICTE	2.32437	0.2165	Accept the H_0
LNICTE does not Granger Cause LNRDEX	5.22674	0.0638	Accept the H_0

Source: Authors' calculations

In table 5.11, we reject the null hypothesis and accept the alternative hypothesis that gross fixed capital formation granger causes government expenditure on education. This is because the probability values are less than 5% significant level respectively. The causality is unidirectional in that case.

5.2.6. Coefficient diagnostic test results

The results of coefficient diagnostic tests are summarised and discussed as follows:

5.2.6.1. Scaled coefficient results

Table 5. 12 Scaled coefficients results

Variable	Coefficient	Standardized Coefficient	Elasticity at Means
LNGDPPC(-1)	1.136468	1.161696	1.127371
LNEDUEX	-0.068812	-0.084517	-0.075557
LNGFCF	-0.099405	-0.128533	-0.119807
TOP	0.420038	0.054409	0.021808
LNICTE	-0.051867	-0.068936	-0.046581
LNRDEX	0.063565	0.071243	0.055243

Source: Authors' calculations

Based on the scaled coefficient obtained in table 5.12, the standard coefficient explains the intercept and slope of each variable in the model. Similarly, the elasticity at means simply explains the responsiveness of each variable to innovation. Therefore, the standard coefficient shows a positive and negative slope. The elasticity at means coefficients shows positive and negative responses towards innovation within the model. Therefore, GDP per capita and trade openness and expenditure on research and development have both positive slope and positive responsiveness towards innovation. On the contrary, government expenditure on education, gross fixed capital formation and information and communication technology has a negative reaction towards innovation with a negative slope.

5.2.6.2. Confidence interval

Table 5. 13 Confidence interval results

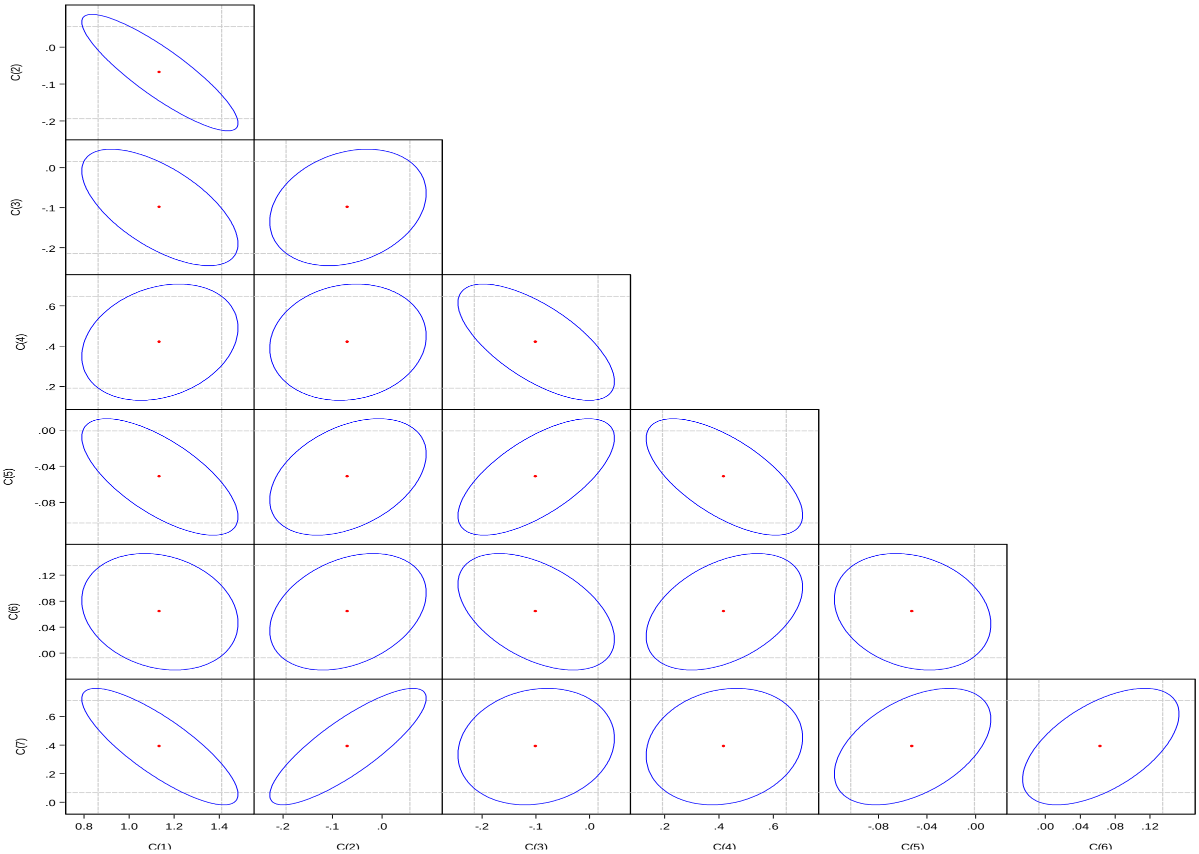
Variable	Coefficient	90% CI		95% CI		99% CI	
		Low	High	Low	High	Low	High
LNGDPPC(-1)	1.136468	0.909985	1.362952	0.862750	1.410186	0.763806	1.509131
LNEDUEX	-0.068812	-0.172022	0.034398	-0.193547	0.055923	-0.238637	0.101013
LNGFCF	-0.099405	-0.194498	-0.004311	-0.214331	0.015521	-0.255874	0.057065
TOP	0.420038	0.231639	0.608438	0.192347	0.647730	0.110040	0.730036
LNICTE	-0.051867	-0.093950	-0.009783	-0.102727	-0.001006	-0.121112	0.017379
LNRDEX	0.063565	0.005025	0.122104	-0.007184	0.134313	-0.032758	0.159887

Source: Authors' calculations

The results provided in table 5.13 show that there is 90% confidence that education expenditure lies between 0.17% and 0.03% and 95% confidence that gross fixed capital formation lies between 0.21 and 0.02%. Likewise, there is 99% confidence that trade openness lies between 0.11% and 0.73%. Furthermore, there is a 90% confidence that information and communication technology lie between 0.09% and 0.010% while expenditure on research and development lies between 0.007% and 0.13%, 95% confidence interval.

5.2.6.3. Confidence ellipse

The outcomes of the confidence ellipse presented in figure 5.14 support the distribution of the data used in this study as presented descriptive statistics in table 5.1 and normality test in figure 5.15



Source: Authors' calculations

Figure 5. 14 Confidence ellipse results

The confidence ellipse in figure 5.14 has been interpreted in two ways; firstly, confidence curves for bivariate normal distributions, and secondly as indicators of correlation. As confidence curves, the ellipses show where the specified percentage of the data should lie, assuming a bivariate normal distribution. Under bivariate normality, the percentage of observations falling inside the ellipse is significant with the specified confidence level. The effect of increasing or decreasing the confidence level has been examined by adjusting the slider in the Confidence in the scatter plot matrix. The confidence ellipses have shown the occurrence of correlations. The confidence ellipse collapses diagonally as the correlation between two variables approaches 1 or -1. The confidence ellipse is more circular when two variables are uncorrelated.

5.2.6.4. Variance inflation factor

Table 5. 14 Variance inflation factor results `

	Data exhibit multicollinearity problem	Results after solving the multicollinearity problem
Variable	Centred VIF	Centred VIF
LNGDPPC (-1)	1107.110	-
LNEDUEX	331.9386	-
LNGFCF	312.2912	-
TOP	12.30187	4.320941
LNICTE	64.62338	-
LNRDEX	88.91989	4.320941

Source: Authors' calculations

The VIF results in table 5.14 show the presence of multicollinearity in the model. Therefore, centred VIF has been presented. The results provided show that the values in table 5. 10 above are larger than 10, this simply implies that the sample exhibits large inflation of standard error of regression coefficients. Thus, the independent variables are correlated with each other. In solving the problem, (Brooks, 2008) suggest three robust solutions. Firstly, ignore it, secondly drop one of the collinear variables and lastly transform the highly correlated variables into a ratio and include only the ratio and not the individual variables in the regression. In this case, the highly correlated variables such as LNGDPPC, LNEDUEX, LNGFCF and LNICTE were dropped from the model.

5.2.6.5. Wald test

Table 5. 15 Wald test results

Test	Null Hypothesis	F- Statistics	P-Value	Conclusion
Wald Test	The set of parameters is equal to zero	119.8403	0.0000	The study fails to reject the Null-hypothesis because the P-value is less than the level of significance at 5%

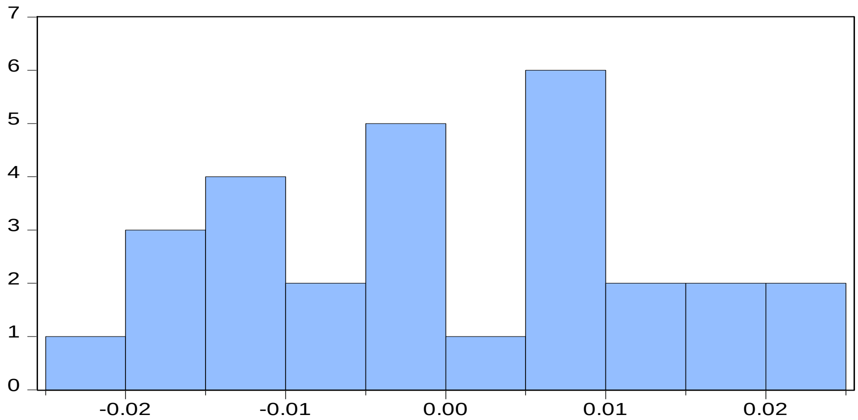
Source: E-Views output

Table 5.15 shows the results of the linear restriction and they indicated that the null hypothesis is not accepted because of the set of parameters which is equal to zero and then the probability value is less than 5% significance level. The advantage of applying a Wald test is that it only requires the estimation of the unrestricted model which lowers the computational burden as compared to the likelihood-ratio test. However, a major disadvantage is that it is not invariant to changes in the representation of the null hypothesis. Similarly, the equivalent expressions of non-linear parameter restriction can lead to different values of the test statistic. Therefore, GDP per capita is a necessary variable in the model.

5.2.7. Residual diagnostic test results

Several diagnostic residual tests were performed to determine the reliability of the model and the results are presented as follows;

5.2.7.1. Histogram (normality test results)



Series: Residuals	
Sample 1991 2018	
Observations 28	
Mean	6.44e-15
Median	-0.002178
Maximum	0.023596
Minimum	-0.024135
Std. Dev.	0.012944
Skewness	0.002901
Kurtosis	1.997615
Jarque-Bera	1.172278
Probability	0.556472

Source: Authors' calculations

Figure 5. 15 Normality test results

Table 5.15 shows the normal distribution results. The results comprise the average of the data, median, minimum, and maximum value in the range. The standard deviation quantifies the amount of variation or dispersion of a set of data values. Skewness is a measure of symmetry, or more precisely, the lack of symmetry. Kurtosis is a measure of whether the data are heavy-tailed or light-tailed relative to a normal distribution. Based on the results above we fail to reject the null hypothesis of normal distribution since the null hypothesis is a joint hypothesis of the skewness being zero and the excess kurtosis being zero. Samples from a normal distribution have an expected skewness of 0 and an expected excess kurtosis of 0 (which is the same as a kurtosis of 3).

5.2.7.2. Serial correlation LM test

Table 5. 16 serial correlation test results

Test	Null Hypothesis	F- Statistics	P-Value	Conclusion
Breusch-Godfrey Serial Correlation LM Test	No serial correlation	0.877659	0.4319	The study fails to fail to reject the H_0 because the P-value is greater that the level of significance at 5%

Source: EViews output

The results in table 5.16 show that the Chi-square probability value of 0.4319 is more than 0.05% significance level. Therefore, the null hypothesis of no serial correlation in the model cannot be rejected. Based on this result, the serial correlation will not affect the unbiasedness or consistency of Ordinary Least Squares (OLS) estimators, but it does affect their efficiency. With a positive serial correlation, the OLS estimates of the standard errors will be smaller than the true standard errors. This will lead to the conclusion that the parameter estimates are more accurate than they are. There will be a tendency to reject the null hypothesis when it should not be rejected. Therefore, we fail to reject the null hypothesis of no serial correlation.

5.2.7.3. Heteroskedasticity

Table 5. 17 Heteroskedasticity results

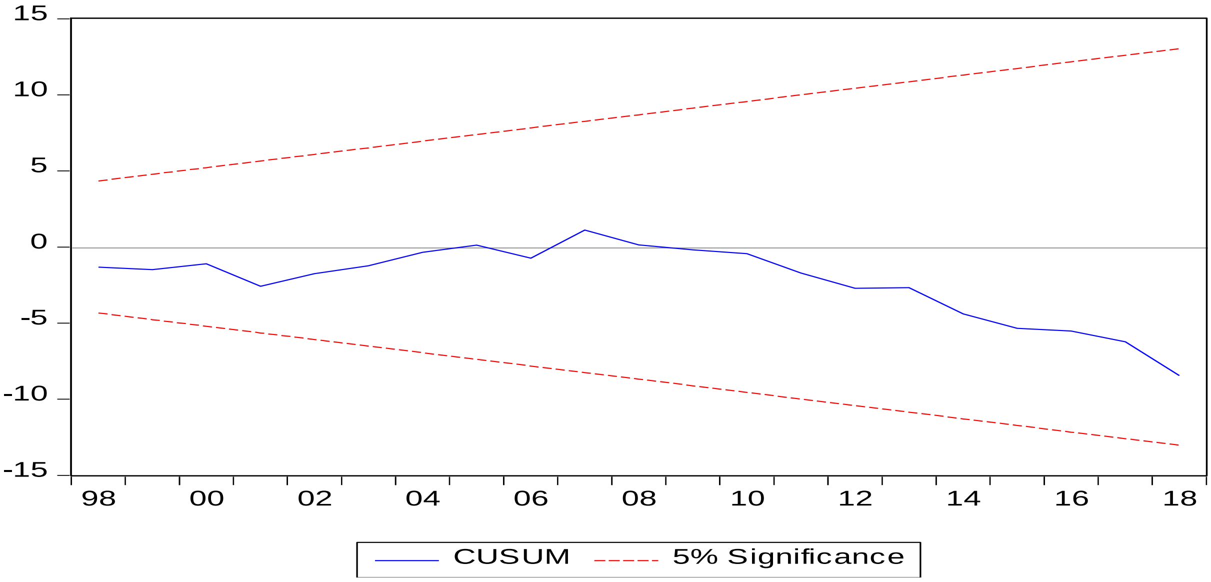
Test	Hypothesis	F- Statistics	P-Value	Conclusion
Breusch-Pagan Godfrey	H_0: Homoskedasticity H_1: Heteroskedasticity	3.340139	0.2561	The study fails to reject the H_0 in all tests because the P-value is greater than the level of significance at 5%
White		3.340139	0.2561	
Harvey		0.320404	0.9189	
Glejser		0.399409	0.8710	
Arch		0.493619	0.4888	

Source: EViews output

Based on the results in table 5.17, we conclude that there is no evidence for the presence of heteroscedasticity since the p-values are considerably more than 0.05 significant level, therefore, we fail to reject the null hypothesis of homoscedasticity. Therefore, the model does not suffer from heteroscedasticity. Heteroscedasticity has more implications on the OLS, for instance, even though the OLS estimators remain unbiased, the estimated standard error (SE) is wrong. This makes the confidence intervals estimator be longer best linear unbiased estimator (BLUE) and which means the transformation of the data corrects the problem.

5.2.8. Stability diagnostic tests results

5.2.8.1. CUSUM test results

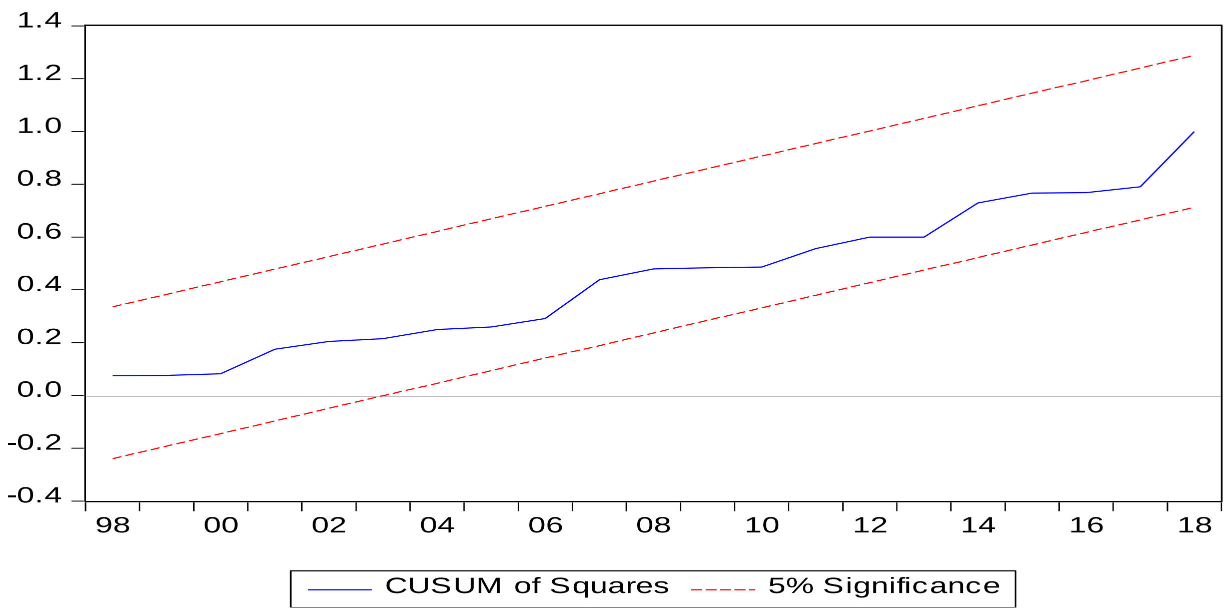


Source: Authors' calculations

Figure 5. 16 CUSUM test results

In the estimation done in figure 5.16, the blue line represents the cumulative sum control chart (CUSUM) and the dotted red line symbolises the 5% significance level of the model. The test finds parameters unstable if the cumulative sum goes outside the area between the two critical lines. The implication is that the model is stable at the cumulative plots of the model lies within the 5% significance level. The significance of any departure from the zero lines (the one lying in the middle) is assessed by reference to a pair of 5% significance lines, the distance between which increases with time (t). Therefore, the 5% significance lines are found by the variation of the middle line. The CUSUM line lies between the 5% significance boundaries showing that the model is stable. In other words, this symbolises that the dependent variable is stable.

5.2.8.2. CUSUM of squares test



Source: Authors' calculations

Figure 5. 17 CUSUM of squares test results

The test in Figure 5.17 shows whether the coefficients of the regression are changing suddenly or not. The CUSUM of squares line still lies between the 5% significance level boundaries. As with the CUSUM test, movement outside the critical lines is suggestive of parameter or variance instability. Therefore, based on the findings above, the graph shows that there is no parameter instability on the cumulative sum since it has not gone outside the area between the two critical lines. Meaning that the lines trend between the two red lines (the two standard error bands around the estimated coefficients) of 5% significance level is significant and stable. Therefore, based on the findings above it clearly shows that there is no structure or simple break hence the model is stable.

5.2.8.3. Ramsey reset test

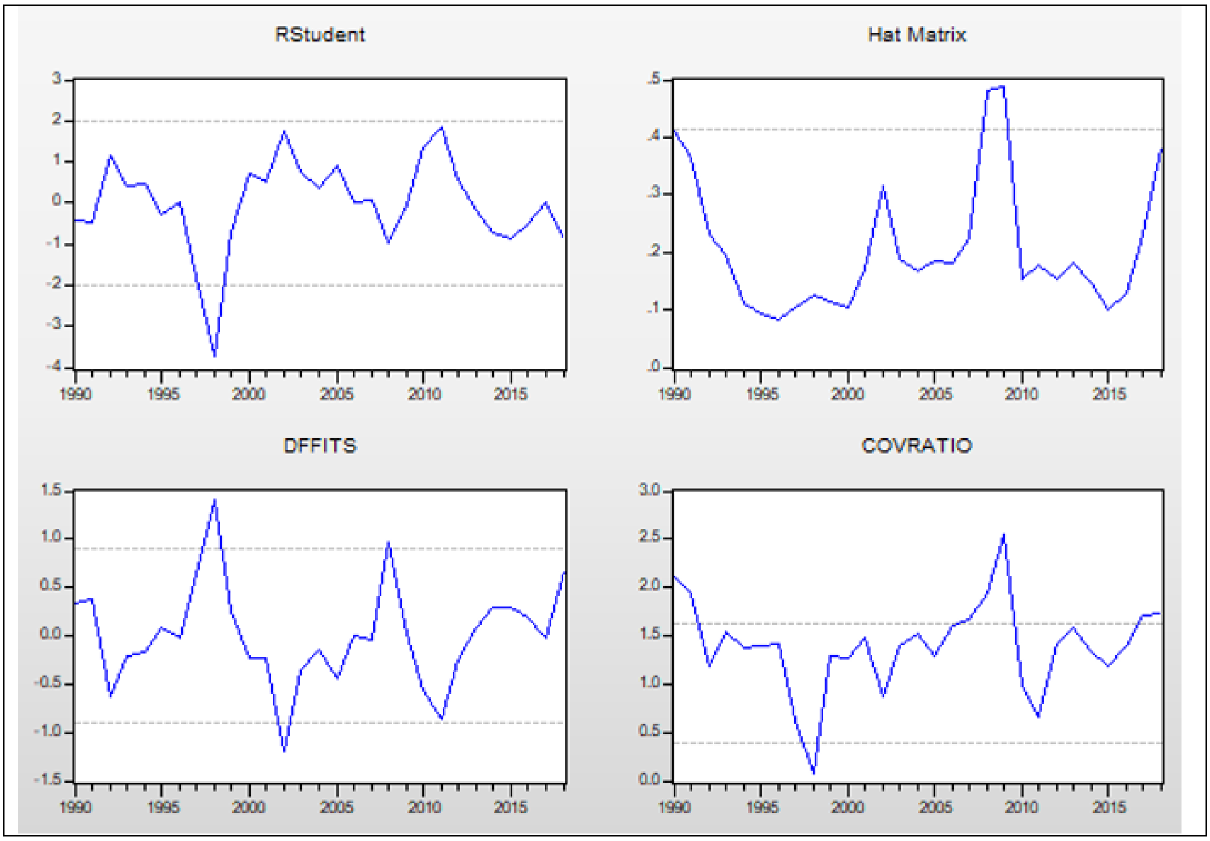
Table 5. 18 Ramsey reset test results

Test	Null Hypothesis	F-Statistics	P-Value	Conclusion
Ramsey Reset test	The model is correctly specified	2.133911	0.0454	The study fails to reject the Null hypothesis because the P-value is greater than the level of significance at 5%

Source: EViews output

In table 5.18, the probability value of T-statistics is less than a 5% significance level. Therefore, the null hypothesis of no autocorrelation should not be rejected. This implies that the model is correctly specified.

5.2.8.4. Influence statistics results



Source: Authors compilations

Figure 5. 18 Influence statistics results

Based on the findings in figure 5.18, the studentised residual is significant since the observations in the data sample have vales less than 3 which shows that there are no outliers in the analysis.

The hat matrix or the leverage values shows that the observations contain values less than 2(K+1)/n where k represents some predictors and n is the sample size. This shows that the observations are not far apart in terms of the levels of independent variables.

The DFFITS shows that the observations have not affected the estimated regression since the values are less than 2*sqrt((k+1)/1).

The COVRATION shows that the values outside the interval 1+/-3(k+1)/n are considered highly influential. Therefore, each observation has a great impact on the variance and standard errors of the regression coefficients and their covariance.

5.2.9. Covariance analysis

Table 5. 19 Covariance analysis results

	LNGDPPC	LNEDUEX	LNGFCF	TOP	LNICTE	LNRDEX
LNGDPPC	0.513293	0.632604	0.649350	0.056589	0.682258	0.557692
LNEDUEX	0.632604	0.786681	0.797649	0.067502	0.835910	0.683525
LNGFCF	0.649350	0.797649	0.829980	0.072851	0.856882	0.711076
TOP	0.056589	0.067502	0.072851	0.008115	0.078982	0.061423
LNICTE	0.682258	0.835910	0.856882	0.078982	0.945233	0.738249
LNRDEX	0.557692	0.683525	0.711076	0.061423	0.738249	0.618643

Source: Authors' calculations

Table 5.19 shows that the covariance between the variables are positively and negatively related and can be interpreted as follows:

The variables are all positively related to each other on which GDP per capita and education are positively related to the variance of 0.632604. Gross fixed capital formation has a variance of about 0.649350, a positive relationship with trade openness with a variance of 0.056589, information and communication technology with a variance of 0.682258 and research and development 0.557692.

The above variances depict that how far a set of variables in this study are spread out from their average value.

5.2.10. Generalized impulse response system results

Table 5. 20 Response of GDPPC results

Response of LNGDPPC:						
Period	LNGDPPC	LNEDUEX	LNGFCF	TOP	LNICTE	LNRDEX
1	0.017695	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.010770	-0.010287	-0.000151	-0.001380	0.006488	-0.002927
3	0.006637	-0.011252	-0.003624	-0.002125	0.007408	-0.001655
4	0.003932	-0.012710	-0.005283	-0.000804	0.007153	-0.001332
5	0.005191	-0.012592	-0.004276	0.001864	0.008340	0.000992
6	0.004385	-0.012133	-0.003115	0.004227	0.009595	0.002005
7	0.002844	-0.010320	-0.004149	0.005310	0.009625	0.004199
8	9.03E-05	-0.008059	-0.006490	0.006784	0.008391	0.006135
9	-0.002386	-0.005058	-0.009472	0.008285	0.006214	0.008369
10	-0.004621	-0.001631	-0.011978	0.009815	0.003614	0.010360

Source: E-views output

One standard deviation shock to GDP per capita reacted positively in the first period. In the second-period education expenditure, gross fixed capital formation and trade openness responded negatively. Similarly, expenditure on education and gross fixed capital formation responded negatively from period 2 up to period 10. The rest of the variables remained in a steady state.

Table 5. 21 Response of EDUEX results

Response of LNEDUEX:						
Period	LNGDPPC	LNEDUEX	LNGFCF	TOP	LNICTE	LNRDEX
1	-0.006066	0.024210	0.000000	0.000000	0.000000	0.000000
2	0.004308	0.015270	-0.011483	-0.001595	-0.020567	-0.005288
3	0.025108	0.003049	-0.004858	-0.003277	-0.008798	-0.002625
4	0.015575	-0.010141	0.003190	-0.004581	0.001695	-0.012108
5	0.017452	-0.013213	0.003256	-0.012534	0.005311	-0.010235
6	0.017756	-0.020499	0.007140	-0.011829	0.010754	-0.011727
7	0.019809	-0.025769	0.008777	-0.010327	0.016542	-0.010755
8	0.016308	-0.030706	0.008244	-0.006636	0.021377	-0.010110
9	0.012108	-0.032124	0.005048	-0.001928	0.023586	-0.007186
10	0.007031	-0.031119	0.001395	0.004356	0.023830	-0.003564

Source: E-views output

A shock in education expenditure harms gross domestic product per capita in the first period. In the first quarter, GDP per capita responded positively. In the tenth period expenditure on R & D reacted negatively leaving the rest of the variables at a steady state. The impulse has left the rest of the variable in a fluctuating form in all periods.

Table 5. 22 Response of GFCF results

Response of LNGFCF:						
Period	LNGDPPC	LNEDUEX	LNGFCF	TOP	LNICTE	LNRDEX
1	0.036537	0.007556	0.037023	0.000000	0.000000	0.000000
2	0.051218	-0.003846	0.037531	-0.026112	0.017685	-0.004542
3	0.023167	-0.023424	0.017254	-0.029652	0.024872	-0.008368
4	0.005204	-0.031849	-0.010699	-0.023969	0.018512	-0.009077
5	-0.002597	-0.038181	-0.019623	-0.006632	0.016704	-0.005788
6	7.09E-05	-0.035337	-0.012493	0.010134	0.018923	-0.001632
7	0.003267	-0.027846	-0.002672	0.017945	0.021686	0.003346
8	0.003090	-0.018359	0.000706	0.019593	0.021620	0.009032
9	-0.002128	-0.009620	-0.004807	0.019142	0.017354	0.013962
10	-0.009677	-0.001641	-0.015280	0.019625	0.009960	0.018577

Source: E-views output

An innovation on gross fixed capital formation, expenditure on education, trade openness results in a negative relationship. In the third quarter, trade openness, ICT and R&D expenditure have a positive relationship with the innovation in gross fixed capital formation. Based on the tenth period GDP per capita and innovation is positively related in the model. The tenth-period results show a decrease in output.

Table 5. 23 Response of TOP results

Response of TOP:						
Period	LNGDPPC	LNEDUEX	LNGFCF	TOP	LNICTE	LNRDEX
1	0.032370	-0.004736	0.019676	0.026624	0.000000	0.000000
2	0.015959	-0.011845	0.013477	0.000875	0.014834	-0.008856
3	-0.006352	-0.009329	0.002809	-0.002231	0.010713	-0.001670
4	-0.004995	-0.003834	-0.005700	-0.000537	0.001007	-0.001953
5	-0.000784	-0.004949	-0.004053	0.004038	0.001568	0.001388
6	-0.000267	-0.003353	-1.57E-05	0.007344	0.003056	0.000863
7	-0.000903	-0.000551	6.07E-05	0.005337	0.002360	0.002089
8	-0.001750	0.001694	-0.000809	0.004324	0.000959	0.003114
9	-0.002343	0.003252	-0.002555	0.003494	-0.000747	0.003571
10	-0.003069	0.004171	-0.004039	0.003021	-0.002161	0.003828

Source: E-views output

An innovation on trade openness only affects expenditure on education and R&D expenditure negatively in the second period leaving the rest of the variable is in its positive steady state. In the fifth period, this affected the rest of the variables as well positively excluding GDP per capita, expenditure on education and gross fixed capital formation in the economy. While in the tenth period this affected education expenditure, trade openness, and R & D expenditure positively in advance.

Table 5. 24 Response of LNICTE results

Response of LNICTE:						
Period	LNGDPPC	LNEDUEX	LNGFCF	TOP	LNICTE	LNRDEX
1	0.026383	-0.015282	0.053547	0.023105	0.050899	0.000000
2	0.036113	-0.009877	0.040521	0.046945	0.035182	0.004728
3	0.007765	-0.016260	-0.008044	0.026399	0.024914	0.002233
4	-0.028246	-0.012893	-0.038092	0.032803	0.010262	0.013678
5	-0.032440	0.004318	-0.046384	0.040302	-0.008660	0.017820
6	-0.019846	0.018805	-0.033768	0.041140	-0.014614	0.025623
7	-0.009092	0.031270	-0.017925	0.034266	-0.015457	0.026744
8	-0.004981	0.038627	-0.014480	0.018228	-0.017937	0.026432
9	-0.006360	0.039382	-0.019531	0.004595	-0.021878	0.024042
10	-0.007862	0.035609	-0.026179	-0.004114	-0.025520	0.020055

Source: E-views output

Innovation and ICT affect expenditure on education negatively in the first period. This has affected expenditure on education, trade openness, and R&D expenditure positively in the fifth period. In the tenth period on GDP per capita, trade openness and information and communication technology itself got affected negatively leaving the rest of the variables in a steady state.

Lastly based on table 5.25 a shock on R&D expenditure in the model affects trade openness negatively in the first period. In the fifth period GDP per capita, gross fixed capital formation and ICT responded positively to the innovation. In the tenth-period government expenditure on education, trade openness and R&D responded positively while GDP per capita, gross fixed capital formation, and ICT reacted negatively to the innovation or shock.

Table 5. 25 Response of LNRDEX results

Response of LNRDEX:						
Period	LNGDPPC	LNEDUEX	LNGFCF	TOP	LNICTE	LNRDEX
1	0.016550	0.006930	0.006523	-0.031991	0.008258	0.042903
2	0.000894	0.006205	0.005812	-0.025735	0.013565	0.019908
3	-0.010224	0.002487	-0.025670	-0.028247	0.005561	0.027533
4	-0.025374	-0.002287	-0.041079	-0.006357	-0.000873	0.023800
5	-0.026744	0.002369	-0.046417	0.008177	-0.007190	0.026206
6	-0.023615	0.010297	-0.037759	0.019112	-0.009503	0.027930
7	-0.016269	0.021089	-0.027908	0.020085	-0.011442	0.029692
8	-0.012391	0.028628	-0.023027	0.015081	-0.013662	0.029889
9	-0.011732	0.032688	-0.024642	0.008251	-0.017225	0.028830
10	-0.012787	0.033157	-0.028897	0.002705	-0.021172	0.026395
Cholesky Ordering: LNGDPPC LNEDUEX LNGFCF TOP LNICTE LNRDEX						

Source: E-views output

The generalized impulse response graphical presentation out is placed is found in Appendix F.

5.2.11. Variance decomposition results

The results in this section are going are presented in two parts. The first part represents the short-run and the last one is the long-run period. The short-run period ranges from the first to the fifth period and the long-run period ranges from the sixth period to the tenth period. Therefore, an impulse, shock or innovation to one of the variables in the model will affect both short-run and long-run periods at a calculated percentage. The overall percentages must sum up to 100%.

Furthermore, Table 5.26 shows that an impulse of GDP per capita in the first quarter of the short-run period results in a variation of 57%, expenditure on education 28%, gross fixed capital formation 1.6%, trade openness 0.8%, ICT 12%, and R&D contributes a variation of about 1.4%. Similarly, in the last quarter, GDP per capita contributes 22% towards itself, expenditure on education results into a variation of

36%, gross fixed capital formation 8.8%, trade openness 6.8%, ICT 21% and R&D by 5.8% in the long-run.

Table 5. 26 Variance decomposition of GDPPC results

Variance Decomposition of LNGDPPC:							
Period	S.E.	LNGDPPC	LNEDUEX	LNGFCF	TOP	LNICTE	LNRDEX
1	0.017695	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.024238	73.03796	18.01161	0.003871	0.324183	7.164099	1.458282
3	0.028869	56.77138	27.88831	1.578338	0.770109	11.63522	1.356645
4	0.033044	44.74769	36.08031	3.761063	0.647029	13.56604	1.197868
5	0.037010	37.63921	40.33825	4.333424	0.769395	15.89303	1.026704
6	0.040741	32.21934	42.15739	4.160810	1.711214	18.66170	1.089543
7	0.043932	28.12669	41.77171	4.470143	2.932540	20.84825	1.850667
8	0.046811	24.77476	39.75702	5.859677	4.683557	21.57695	3.348040
9	0.049895	22.03477	36.02079	8.761641	6.879736	20.54259	5.760473
10	0.053608	19.83163	31.29730	12.58281	9.312263	18.25059	8.725405

Source: E-views output

Table 5. 27 Variance decomposition of LNEDUEX results

Variance Decomposition of LNEDUEX:							
Period	S.E.	LNGDPPC	LNEDUEX	LNGFCF	TOP	LNICTE	LNRDEX
1	0.024959	5.907298	94.09270	0.000000	0.000000	0.000000	0.000000
2	0.038210	3.791763	56.11602	9.030804	0.174234	28.97202	1.915160
3	0.047100	30.91347	37.35173	7.007655	0.598706	22.55736	1.571086
4	0.052387	33.82708	33.93916	6.035311	1.248552	18.33824	6.611663
5	0.059365	34.98399	31.38326	5.000638	5.429917	15.08097	8.121232
6	0.068585	32.91343	32.44695	4.830443	7.042966	13.75777	9.008436
7	0.079582	30.64136	34.58373	4.804064	6.915023	14.53875	8.517074
8	0.090627	26.86567	38.14727	4.531959	5.868268	16.77491	7.811926
9	0.100145	23.46363	41.53046	3.965520	4.842915	19.28503	6.912447
10	0.107927	20.62609	44.07084	3.430948	4.332582	21.47901	6.060525

Source: E-views output

A shock to expenditure on education affects GDP per capita by 3.8%, education expenditure itself 56%, gross fixed capital formation 9%, trade openness 0.17%, ICT

29% and R&D 1.9% in the second period of short-run. In the long-run an impulse to education expenditure results in a variation of 40% under GDP per capita, expenditure on education 44%, gross fixed capital formation 21%, trade openness 3.4 %, ICT 21% and R&D expenditure 6.1% in the tenth period.

Table 5. 28 Variance decomposition of LNGFCF results

Variance Decomposition of LNGFCF:							
Period	S.E.	LNGDPPC	LNEDUEX	LNGFCF	TOP	LNICTE	LNRDEX
1	0.052562	48.31955	2.066433	49.61402	0.000000	0.000000	0.000000
2	0.088457	50.58642	0.918644	35.51978	8.714165	3.997278	0.263707
3	0.103805	41.71382	5.759066	28.55527	14.48713	8.643420	0.841297
4	0.113715	34.96988	12.64354	24.68052	16.51510	9.852716	1.338249
5	0.123033	29.91782	20.43153	23.62736	14.39867	10.26011	1.364504
6	0.130405	26.63103	25.52996	21.94938	13.42068	11.23870	1.230251
7	0.136390	24.40256	27.50686	20.10377	13.99986	12.80212	1.184829
8	0.141004	22.87957	27.43134	18.81202	15.02930	14.32887	1.518889
9	0.144447	21.82369	26.58296	18.03675	16.07766	15.09737	2.381582
10	0.148405	21.10020	25.19596	18.14748	16.98014	14.75310	3.823116

Source: E-views output

In the short-run, an impulse to gross fixed capital formation results in a variation of about 42% on GDP per capita in the first quarter of the short-run. Expenditure on education results into 5.8%, gross fixed capital formation 29%, trade openness 14%, ICT 8.6% and R & D expenditure 0.8%. The innovation effects in the last quarter of the long-run are as follows: GDP per capita 21%, education expenditure 27%, gross fixed capital formation 18%, trade openness 16%, ICT 15% and R&D expenditure 2.4%.

Table 5. 29 Variance decomposition of TOP results

Variance Decomposition of TOP:							
Period	S.E.	LNGDPPC	LNEDUEX	LNGFCF	TOP	LNICTE	LNRDEX
1	0.046543	48.36962	1.035390	17.87211	32.72289	0.000000	0.000000
2	0.055156	42.81534	5.349577	18.69688	23.32662	7.233442	2.578145
3	0.057445	40.69310	7.569216	17.47533	21.65506	10.14602	2.461276
4	0.058114	40.50103	7.831275	18.03769	21.16823	9.943922	2.517857
5	0.058647	39.78609	8.401803	18.18902	21.25927	9.835526	2.528294
6	0.059285	38.93542	8.541562	17.79919	22.33804	9.890484	2.495304
7	0.059618	38.52514	8.455055	17.60125	22.89100	9.937194	2.590355
8	0.059918	38.22520	8.450418	17.44347	23.18290	9.863447	2.834558
9	0.060319	37.87049	8.629383	17.39227	23.21189	9.748344	3.147623
10	0.060909	37.39371	8.931729	17.49648	23.00997	9.686157	3.481951

Source: E-views output

A shock to trade openness in the first period in the short-run results in a variation of about 43% on GDP per capita. Thus, expenditure on education results into 5.3%, gross fixed capital formation 19%, trade openness itself 23%, ICT 7 % and R&D expenditure 3% on both trade openness and innovation.

While in the long-run the impulse on trade openness results in a variation of about 38% on gross domestic product per capita in the third quarter of the long-run. Expenditure on education results into 9%, gross fixed capital formation 17%, trade openness 10%, ICT 10% and R & D expenditure 6%.

Table 5. 30 Variance decomposition of LNICTE results

Variance Decomposition of LNICTE:							
Period	S.E.	LNGDPPC	LNEDUEX	LNGFCF	TOP	LNICTE	LNRDEX
1	0.083195	10.05638	3.374232	41.42672	7.712664	37.43001	0.000000
2	0.115884	14.89447	2.465491	33.57836	20.38627	28.50894	0.166459
3	0.123049	13.60862	3.932785	30.20907	22.68409	29.38486	0.180574
4	0.137567	15.10379	4.024936	31.83688	23.83485	24.06647	1.133075
5	0.155447	16.18396	3.229392	33.83756	25.38888	19.15871	2.201500
6	0.169157	15.04335	3.962917	32.55985	27.35494	16.92535	4.153587
7	0.179233	13.65692	6.573737	30.00232	28.02103	15.81975	5.926241
8	0.187626	12.53285	10.23713	27.97367	26.51392	15.34997	7.392451
9	0.195587	11.63915	13.47499	26.74011	24.45475	15.37711	8.313894
10	0.203321	10.91994	15.53648	26.40207	22.67044	15.80480	8.666278

Source: E-views output

An impulse on trade openness has a variation of 14% on GDP per capita in the first quarter of the short-run period. Expenditure on education contribute 4%, gross fixed capital formation 30%, trade openness 23%, ICT 29% and R&D 0.2%. In the last period of the long-run, GDP per capita contribute 12%, expenditure on education 13%, gross fixed capital formation 27%, trade openness 24%, ICT expenditure 15% and R&D 8%.

Finally, the LNRDEX results in Table 531 show that a shock to expenditure on R&D in the short-run can contribute to variation in GDP per capita amounting to 5% in the first quarter. Expenditure on education results in 1.3%, gross fixed capital formation amount to 11%, trade openness 36%, ICT expenditure 4% and research and development expenditure results into 43%. In the long-run GDP per capita results into 5%, education expenditure 10%, gross fixed capital formation amount to 31%, trade openness 14%, ICT expenditure 4% and R&D expenditure 30%. Lastly, the variance decomposition graphical presentation is found under appendix H.

Table 5. 31 Variance decomposition of LNRDEX results

Variance Decomposition of LNRDEX:							
Period	S.E.	LNGDPPC	LNEDUEX	LNGFCF	TOP	LNICTE	LNRDEX
1	0.057418	8.307883	1.456797	1.290730	31.04416	2.068516	55.83191
2	0.067915	5.955428	1.875937	1.654989	36.54718	5.467601	48.49886
3	0.083480	5.441499	1.330357	10.55073	35.63824	4.062523	42.97666
4	0.099565	10.32025	0.987991	24.43959	25.46157	2.863672	35.92692
5	0.116593	12.78760	0.761778	33.67144	19.05935	2.468631	31.25120
6	0.130073	13.57046	1.238727	35.48075	17.47252	2.517286	29.72026
7	0.140795	12.91749	3.300819	34.21158	16.94764	2.808973	29.81350
8	0.150446	11.99164	6.511927	32.30571	15.84780	3.284828	30.05809
9	0.160135	11.12118	9.914493	30.88248	14.25349	4.056414	29.77194
10	0.169981	10.43606	12.60415	30.29866	12.67544	5.151561	28.83414
Cholesky Ordering: LNGDPPC LNEDUEX LNGFCF TOP LNICTE LNRDEX							

Source: E-views output

5.3. Summary

This chapter was focusing on analysing and interpreting the results of the study. The ARDL approach was conducted to determine the cointegration among the variables and to investigate both long-run and short-run analyses. The ECM of the model was estimated and found to be negative and significant. Diagnostics tests were conducted to determine the reliability of the model. Similarly, Granger causality was employed to check the direction of the causality within the model. Lastly, a Generalized impulse response system and Variance decomposition were conducted to check the effect due to the shock of one of the variables in the model.

CHAPTER 6

SUMMARY, CONCLUSION, RECOMMENDATIONS

6.1. Introduction

This chapter presents the conclusion and recommendations of the study. Based on Chapter 3, the study proposed to analyse contributions of inclusive growth and innovation based on the literature. Therefore, this chapter presents a summary of the empirical results which were presented and discussed in Chapter 5.

6.2. Summary

This study aimed to analyse the contribution of inclusive growth and innovation towards economic development in South Africa. The analysis was achieved through the application of the ARDL approach. Several econometric tests such as descriptive statistics and unit root analysis were performed to determine the characteristics of the variables before the ARDL bounds Cointegration analysis. This was done based on Nielsen (2011)'s notion of the general-to-specific framework, which emphasizes that it is first advisable to find an appropriate statistical description of the data, and then afterwards test hypotheses to link the statistical model to economic theory by testing for cointegration and interpreting the long-run relationship. To achieve the objectives of the study, the whole analyses were managed with the acknowledgement of literature, both theoretically and empirically. Therefore, the quality of education given to citizens and various innovative ideas brings scale variant growth in the economy (Stuart, 2017). Therefore, a country that adapts to technological change and innovativeness its economy grows at a faster rate.

6.3. Conclusions

The conclusion of this study has been drawn based on the objectives suggested in Chapter 1. Therefore, the first objective was to compute and investigate the effect of trade openness on economic development. In tandem with reviewing different literature such as Pradhan (2017), Mukherjeea (2017), Vashisht (2016), Neagu (2016), Kwakwa (2016), Sbia (2014) and many who showed a positive relationship between trade openness and economic growth, the objective was also achieved by an econometric analysis which showed a negative relationship between trade openness and economic development in South Africa. This outcome was found to be in line with Haddad (2013), Zohonogo (2016) and Bowdler (2017) who also found negative results and suggested that an increase in trade openness resulted in great diversity to consumption which can increase inflation volatility through a decrease in the sensitivity of consumer price shocks in a specific market.

The second objective was to investigate the impact of innovation on economic development. Empirically, the results showed that diversification provides a good view of which the economy or market perceive different activities. Following the evidence from the literature, this study used government expenditure on ICT and R&D as proxies for innovation and it was established that government expenditure on ICT is positively related to economic development. On the other hand, General government expenditure on R&D has a negative relationship with economic development and this might be attributed to minimal investment in R&D in South Africa. On contrary (Thakur & Malecki, 2015) found a positive relationship between expenditure on R&D and economic development.

The third objective was to investigate the contribution of inclusive growth to economic development. This was achieved through the quantification of GDP per capita, trade openness, expenditure on education, gross fixed capital formation. The results revealed that general government expenditure on education, Gross fixed capital formation and ICT has a positive relationship with economic development in the long-run. Trade openness harms economic development in the long-run while the study done by (Fetahi-Vehapia, et al., 2015) found a positive relationship between trade openness and economic development.

In the short-run, government expenditure on education, gross fixed capital formation and ICT harms economic development whereas. trade openness and investment in R&D have a positive impact on economic development. The error correction term was negative and significant. In that case, the economic development will have a slow rate of speed of adjustment of about 0.04%. This slow adjustment might be due to governments' lower investment in research and development. Lastly, the existence of unidirectional causality among the series was noticed.

6.4. Recommendations of the study

The recommendations are informed by the findings of this study. This study advocate for bridging the gap between income inequality, improving education policies, managing social mobility in the long-run to balance inclusive growth. That's been the case, several factors affect inclusive growth, for instance, drift in society, loss of unity in the country due to political instability and improper policies laid to manage the economy. Thus, the mismanagement of domestic policies and globalisation leads to ineffective economic growth. The gap between developed and developing firms in the market are big due to intense technological change and product change. In tackling this issue, at hand corrects the social mobility, inequality, and unemployment rate as well as managing growth. People must be given opportunities which in return gives them the courage that they can contribute to the economy. This can be done through the regeneration of individuals' communities, towns, and the country at large.

Further research may focus on the following areas, the intentional focus of this study was to analyse the contribution of inclusive growth and innovation towards economic development in southern Africa. However, there are diverse determinants of innovation and inclusive growth. Therefore, the variables used in this study were selected to suits this study. Therefore, the study needs to be revisited with different variables other than those selected specifically for this study, for instance, population growth, general government financial consumption expenditure, and inflation.

6.5. Limitations of the study

Even though these limitations are not expected to have a significant influence on the conclusions drawn, the findings and results in this study are based on the annual data collected from World Bank ranging from 1990-2017.

REFERENCES

Abrol, D., 2013. Where Is India's Innovation Policy Headed?. *Social Scientist,* 41(3/4), pp. 65-80.

Adak, M., 2015. Technological Progress, Innovation and Economic Growth; the Case. *Procedia - Social and Behavioral Sciences,* 195(1), pp. 776-782.

Afonso, A. & Aubyn, M. S., 2019. Economic growth, public, and private investment returns in 17 OECD economies. *Portuguese Economic Journal,* 18(1), pp. 47-65.

Aghion, P. & Howitte, P., 1989. *A model of growth through creative destructive,* Memorial drive cambridge: Massachusetts institute of technology working paper department of Economics.

Aghion, P. & Howitt, P., 1990. *A model of growth through creative destruction,* Massachusetts avenue Cambridge: National Bureau of Economic Research (NBER) working paper No: 3223.

Aghion, P. & Howitt, P., 1992. A Model of Growth Through creative destruction. *Econometrica,* 60(2), pp. 323-351.

Aguayo-Rico, A. & Guerra-Turrubiates, I., 2015. Empirical Evidence of the Impact of Health on Economic Growth. *Issues in Political Economy,* 14(1), pp. 1-17.

Alesina, A., Ozler, S., Swagel, P. & Roubini, N., 1996. Political Instability and Economic Growth. *Journal of Economic Growth,* 1(2), pp. 189-211.

Alexey , K., Sergey , T. & Julia , G., 2019. Strategic Initiatives of Education Development in Russia in the Conditions of Development of Digital Technologies. *Advances in Social Science, Education and Humanities Research, Proceedings of the 3rd International Conference on Culture, Education and Economic Development of Modern Society (ICCESE 2019),* 310(1), pp. 850-853.

Ali, I. & Zhuang, J., 2007. Inclusive growth toward a prosperous Asia: Policy implications. *Asia Development Bank Economics and Research Department Working Paper,* 97(1), pp. 1-44.

Arltova, M. & Fedorova, D., 2016. Selection of Unit Root Test on the Basis of Length of the Time Series and Value of AR(1) Parameter. *Statistika,* 96(3), pp. 1-3.

Armstrong, J., 2001. Principles of Forecasting: A Handbook for Researchers and Practitioners. *Springer Science and Business Media,* 30(1), pp. 1-848.

Asghar, N. & Hussain, Z., 2014. Financial development, trade openness and economic development in developing countries: Recent evidence from panel data. *Pakistan Economic and Social Review,* 52(2), pp. 99-126.

Asongu, S., Nwachukwu, J. & Pyke, C., 2019. *The Comparative Economics of ICT, Environmental Degradation and Inclusive Human Development in Sub-Saharan Africa,* Capetown: Munich Personal Repec Archive (MPRA), African Governance and Development Insitute (AGI) Working paper.

Auer, R. A., 2016. Comment on measuring openness to trade by M.E. Waugh and B. Ravikumar. *Journal of economic dynamics and control,* 72(C), pp. 42-44.

Barbier, E. B. & Hormer-Dixon, T. F., 1999. Resource Scarcity and Innovation: Can Poor Countries Attain Endogenous Growth?. *springer, Royal Swedish Academy of Sciences,* 28(2), pp. 144-147.

Barroso, 2013. *A strategy for smart, sustainable and inclusive growth,* Brussels: European Commission.

Belsley, D. A., Kuh, E. & Welsch, R. E., 2005. *Regression Diagnostics: Identifying Influential Data and Sources of Collinearity.* UK: John Wiley & Sons, Inc.

Bhagwati, J. & Panagariya, A., 2013. Why Growth Matters: How Economic Growth in India Reduced Poverty and the Lessons for Other Developing Countr. *Public Affairs,* pp. 1-4,ISBN 9781610392716.

Billmeier, A. N., 2009. Trade Openness and Growth: Pursuing Empirical Glasnost. *IMF Staff Papers,* 56(3), pp. 447-475.

Bishop, A., 2019. *The influence of politics on the South African economy.* [Online] Available at: https://www.investec.com/en_za/focus/economy/politics-and-the-south-african-economy.html
[Accessed 27 May 2019].

Bowdler, C. M., 2017. Openness and inflation volatility: Panel data evidence. *Northern American journal of economics and finance,* 41(1), pp. 57-69, https://doi.org/10.1016/j.najef.2017.03.008.

Brooks, C., 2008. *Introductory econometrics for finance 2nd edition.* Cambridge : Cambridge University Press,ISBN-13 978-0-521-87306-2.

Brülhart, M., 2011. The spatial effects of trade openness: a survey. *Review of World Economics / Weltwirtschaftliches Archiv,* 147(1), pp. 59-83.

Caballero, R. J. & Hammour, M. L., 2000. Creative destruction and development: Institutions,crises and restructuring. *National bureau of economic research (NBER) working paper series,* Volume 7849, pp. 1-41.

Capello, R. & Lenzi, C., 2016. Relevance and utility of European Union research, technological development and innovation policies for smart growth. *Environmental and Planning C: Government and policy,* 34(1), pp. 52-72.

Carlaw, R. G. & Lipse , K. I., 2004. Total factor productivity and the measurement of technological change. *The Canadian Journal of Economics / Revue canadienne d'Economique,* 37(4), pp. 1118-1150.

Chen, B., 1999. Trade Openness and Economic Growth: Evidence in East Asia and Latin America. *Journal of Economic Integration,* 14(2), pp. 265-295.

Chongvilaivan, A. &. H., 2012. Trade Openness and Vertical Integration: Evidence from the U.S. Manufacturing Sector. *Southern Economic Journal,* 78(4), pp. 1242-1264.

Chun, H., Kim, J.-W., Morck, R. & Yeung, B., 2007. Creative destruction and firm-specific performance heterogeneity. *National Bureau of Economic Research (NBER) Working paper series,* 13011(1), pp. 1-62.

Cingano, F., 2018. *Trends in income inequality and its impact on economic growth, OECD Social,Employment migration working paper,* Rue Andre-Pascal, France: OECD.

Claude, D. & Ralph, H., 2019. The long-run impact of human capital on innovation and economic development in the regions of Europe. *Applied Economics,* 51(5), pp.

543-563,ISSN: 0003-6846 (Print) 1466-4283 (Online) Journal homepage: https://www.tandfonline.com/loi/raec20.

Cobb, W. C. & Douglass, P. H., 1928. A theory of production. *American economic review,* 18(1), pp. 139-165.

Daniel , M. F. & Kazeem , S. A., 2019. A causality analysis of the relationships between gross fixed capital formation, economic growth and employment in South Africa. *Studia Universitatis Babes Bolyai - Oeconomica,* 64(1), pp. 33-44.

Davis, M., 2017. *How corruption and political instability have thrown SA into recession.* [Online]
Available at: http://www.huffingtonpost.co.za/2017/06/06/how-corruption-and-political-instability-have-thrown-sa-into-a-r_a_22128790

Department of Science and Technology, 2002. *South African's National Research and Development Strategy,* Pretoria: The Government of the Republic of South Africa.

Diamond, J. & Arthur, M., 2006. Schumpeter's Creative Destruction. *Journal of Private Enterprise,* 12(1), pp. 120-146.

Douglass, H., 1976. The Cobb-Douglas Production Function Once Again: Its History, It's Testing, and Some New Empirical Values. *Journal of political economy,* 84(5), pp. 903-916.

Dowrick, S. & Golley, J., 2004. Trade openness and growth: Who benefits?.. *Oxford Review of Economic Policy,* 20(1), pp. 38-56.

Duclos, J.-Y., 2009. What is "Pro-Poor"?. *Social Choice and Welfare,* 32(1), pp. 37-58.

Edquist, H. & Henrekson, M., 2017. Swedish lessons: How important are ICT and R &D to economic growth?. *structural change and economic dynamics,* 42(1), pp. 1-12.

Ekkehard, E. & Escudero , V., 2008. The effects of financial globalization on global imbalances, employment and inequality. *International Institute for Labour Studies,* 1(1), pp. 1-44.

Elliot , B. E., Rothenberg , T. J. & Stock, J. H., 1996. Efficient tests of the unit root hypothesis. *Econometrica,* 64(8), pp. 13-36.

Eltony, M. N., 2007. The Economic Development Experience of Kuwait: Some Useful Lessons. *Journal of Economic and Administrative Sciences,* pp. 77-102, https://doi.org/10.1108/10264116200700003.

eNCA, 2018. *SA drought declared a national disaster, Day Zero pushed back.* [Online]
Available at: https://www.enca.com/south-africa/sa-drought-declared-national-disaster

Enders, W., 2010. *Applied Econometric time series.* 3 ed. New York: John Willey & Sons, pp. 272–355.

Engel, R. & Granger, G., 1987. Cointegration and Error Correction: Representation, Estimation and Testing. *Econometrica,* 55(1), pp. 251-276.

Engel, R., 1982. Autoregressive conditional heteroskedasticity with estimates of the variance of U.K inflation. *Econometrica,* 50(1), pp. 987-1008.

Fetahi-Vehapia, M., Sadikub, L. & Petkovskic, M., 2015. Empirical Analysis of the Effects of Trade Openness on Economic Growth: An Evidence for South-East European Countries. *Procedia Economics and Finance,* 19(1), pp. 17-26.

Findler, F., Schönherr, N., Lozano, R. & Reider, D., 2019. The impacts of higher education institutions on sustainable development: A review and conceptualization. *International Journal of Sustainability in Higher Education,* 20(1), pp. 23-38.

Fu, Y., 2019. *College Students' Entrepreneurship and Innovation and Entrepreneurship Education under the Background of Economic Development Mode Transformation.* Atlantis Press, In 2018 8th International Conference on Education and Management (ICEM 2018).

Giovanni, J. &. L., 2009. Trade openness and volatility. *The Review of Economics and Statistics,* 91(3), pp. 558-585.

Glejser, H., 1969. A New Test for Heteroscedasticity. *Journal of the American statistical association,* 64(1), pp. 316-323.

Granger, C. & Newbold, P., 1974. Spurious Regressions in Econometrics. *Journal of econometrics,* 2(2), pp. 111-120.

Granger, C. W., 1981. Granger, Some Properties of Time Series Data and Their Use in Econometric Model Specification. *Econometrica,* 28(1), pp. 121-130.

Gujarati, N. &. P. D., 2009. *Basic econometrics.* 2nd ed. New York: McGraw Hill international.

Gupta, P., 2006. Institutionalizing Innovation for Growth and Profitability. *The Journal of Private Equity, Special Turn Around Management Issue, Euromoney Institutional Investor,* 9(2), pp. 57-62.

Haddad, M., Lim, J., Pancaro, C. & Saborowski, C., 2013. Trade openness reduces growth volatility when countries are well diversified. *The Canadian Journal of Economics / Revue canadienne d'Economique,* 46(2), pp. 765-790.

Hafiz, A., Pasha, P. T., Fateh, C. M. & Dilawar, A. K., 2004. Pro-poor Growth and Policies: The Asian Experience [with Comments]. *The Pakistan Development Review, Papers and Proceedings PART I Nineteenth Annual General Meeting and Conference of the Pakistan Society of Development Economists Islamabad, January 13-15,* 42(4), pp. 313-348.

Harutyunyan, A. & Ozak, O., 2017. Culture, diffusion and economic development: The problem of observation equivalence. *Economic Letters,* 158(1), pp. 94-100.

Harvey, A., 1976. Estimating regression models with multiplicative heteroskedasticity. *Econometrica,* 44(1), pp. 461-465.

Hausman, J. A., 1978. Specification Tests in Econometrics. *Econometrica,* 46(1), p. 1251–1272.

Hindle, D., 2018. *National skills development framework for employees in public education,* Pretoria: Department of education.

Holzl, W. & Janger, J., 2013. Does the analysis of innovation barriers perceived by high growth firms provide information on innovation policy priorities?. *Technological Forecasting & Social Change,* 80(8), pp. 1450-1468.

Hoover, W. E., 1984. *Algorithms For Confidence Circles and Ellipses,* Rockville, MD: National Oceanic and Atmospheric Administration (NOAA) Technical Report NOS 107 C&GS 3.

Horvat, M., 2011. The New Framework for EU Research and Innovation. *American Association for the Advancement of Science, New Series,* 334(6059), pp. 1066-1068.

Jones, C. I., 1995. Time Series Tests of Endogenous Growth Models. *The Quarterly Journal of Economics,* 110(2), pp. 495-525.

Kaies , S., Abdelkarim , Y., Ahlem, . S. & Majid, A. S. I., 2019. Innovation and Economic Development: Case of Tunisia. *International Journal of Economics and Financial Issues,* 9(5), pp. 140-146, https://doi.org/10.32479/ijefi.8444.

Kakwani, N., Shahid , K. & Hyun , S. H., 2004. Pro-poor growth: Concepts and measurement with a country case study. *International poverty centre, united nations development programme, working paper,* 1(1), pp. 1-28.

Kakwani, N., Son, H. H., Qureshi, S. K. & Arif, G. M., 2004. Pro-poor Growth: Concepts and Measurement with Country Case Studies [with Comments]. *The Pakistan Development Review, Papers and Proceedings PART I Nineteenth Annual General Meeting and Conference of the Pakistan Society of Development Economists Islamabad,* 42(4), pp. 417-444.

Karras, G., 2014. Fiscal Policy Spillovers through Trade Openness. *Journal of Economic Integration,* 29(3), pp. 563-581.

Khumalo, Z. Z. & Mongale, I. P., 2015. The impact of information and communication technology (ICT) on economic growth: A case for South Africa. *Corporate ownership of control,* 12(2), pp. 399-407.

Kim, D., Lin, S. & Suen, Y., 2010. Are Financial Development and Trade Openness Complements or Substitutes?. *Southern Economic Association,* 76(3), pp. 827-845.

Kim, D., Lin, S. & Sue, Y., 2013. Investment, trade openness and foreign direct investment: Social capability matters. *International Review of Economics and Finance,* 26(1), pp. 56-69.

Kireyev, J. & Chen, J., 2017. IMF working paper: Inclusive Growth Framework. *International Monetary Fund,* 17(127), pp. 1-28.

Klein, M. &. O. G., 1999. Capital account liberalisation, financial depth and economic growth. *Journal of international money and finance,* 27(6), pp. 861-875.

Koenker, R., 1981. A note on studentizing a test for heteroskedasticity. *Journal of econometrics,* 17(1), pp. 107-112.

Koop, G., 2009. *Analysis of Econometric data.* 1 ed. West Sussex: Wily publications.

Kubayi-Ngubane, T. M., 2018. *Draft white paper on Science, Technology and Innovation,* Pretoria, South Africa: Department of Science and Technology.

Kuntu, A. & Torkkeli, L., 2015. Service innovation and internationalization in SMEs: Implications for growth and performance. *Management Revue, Special Issue: Innovation Networks,* 26(2), pp. 83-100.

Kwakwa, P. A., 2016. Effects of income, Energy consumption, and trade openness on carbon emissions in sub-Saharan Africa. *The Journal of Energy and Development,* 41(1/2), pp. 86-117.

Kwiatkowski, D., Phillips, P. C., Schmidt, P. A. & Shin, Y., 1992. Testing the null hypothesis of stationarity against the alternative of a unit root: how sure are we that economic time series have a unit root?. *Journal of Econometrics,* 54(1), p. 159–178.

Lambert, 1992. The distribution and redistribution of income. *current issues in economics.*

Lam, N. M., 2016. Business-government relationship in economic development. *Asian Education and Development Studies,* pp. 362-370, https://doi.org/10.1108/AEDS-08-2016-0067.

Lane, D. M. et al., 2019. *Introduction to statistics.* Houston, USA: University of Houston.

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(1), pp. 10-25.

Liargovas, P. & Skandalis, K., 2012. Foreign Direct Investment and Trade Openness: The Case of Developing Economies. *Social Indicators Research,* 106(2), pp. 323-331.

Liberati, P., 2007. Trade Openness, Capital Openness and Government Size. *Journal of Public Policy,* 27(2), pp. 215-247.

Liew, V. K., 2004. Which Lag Length Selection Criteria Should We Employ?. *Economics Bulletin,* 3(33), pp. 1-9.

Lloyd, P. M., 2002. Measures of trade openness using CGE analysis. *Journal of Policy Modeling,* 24(1), p. 67–81.

Lorrain, S., 2016. *Top 10 socio-economic problems in South Africa.* [Online] Available at: http://www.heraldlive.co.za/letters-the-herald/2016/10/19/top-10-socio-economic-problems-sa/
[Accessed 18 11 2019].

Luca, A., Leonardo, F., Giovanni, I. & Alessandro, R., 2013. Legal Institutions, Innovation, and Growth. *International Economic Review,* 54(3), pp. 937-956.

Maksimovic, G., Jovic, S., Jovovic, D. & Jovovic, M., 2019. Analyses of Economic Development Based on Different Factors. *Computational Economics,* 53(3), pp. 1103-1109.

Manzini, S. T., 2019. Measurement of innovation in South Africa: An analysis of survey metrics and recommendations. *South African Journal of Science,* 111(11/12), pp. 1-8.

Menyah, K., Nazlioglu, S. & Wole-rufael, Y., 2014. Financial development, trade openness and economic growth in African countries: New insights from a panel causality approach. *Economic modelling,* Volume 37, pp. 386-394.

Metes, D. V., 2005. Visual, unit root and stationarity tests and their power and accuracy. *Department of Mathematical Sciences, University of Alberta, Edmonton, Canada,* pp. 1-26, Available at: www. stat. ualberta. ca/~ wiens/pubs/metes. pdf.

Miller, M., 2008. An Assessment of CES and Cobb-Douglas Production. *Congressional budget office working papers.*

Miller, W. L., 2001. Innovation for business growth. *Research-Technology Management,* 44(5), pp. 26-41.

Mukherjeea, S. & Chanda, R., 2017. Differential effects of trade openness on Indian manufacturing firms. *Economic Modelling,* 61(1), pp. 273-292.

Mzimba, W., 2019. *South Africa needs to wake up, work together and innovate in order to address socio-economic challenges,* Johannesburg: Accenture Africa.

Nakamori, Y., 2020. In knowledge construction. In: *Innovation theory.* Singapore: Springer, pp. 1-17.

Nasreen, S. & Anwar, S., 2014. A causal relationship between trade openness, economic growth and energy consumption: A panel data analysis of Asian countries. *Energy Policy,* 69(1), pp. 82-91.

Natarajan, A., 2010. *Theory & Strategies for Full Employment Proceedings of the World Academy of Arts & Sciences Conference on the Global Employment Challenge.* Geneva - Switzerland, CADMUS, pp. 42-48.

National Development Plan 2030, 2018. *Our future makes it work: Executive summary,* Pretoria: Department of national planning commission: The Presidency.

National Planning Commission, 2018. *Our future-Make it works: Nationa Development Plan 2030.,* Pretoria, South Africa: Department of National Planning Commission.

Naveed, A. & Shabbir, G., 2006. Trade openness, FDI and economic growth: A panel study. *Pakistan Economic and Social Review,* 44(1), pp. 137-154.

Neagu, O., Dumiter, F. & Braica, A., 2016. Inequality, Economic Growth and Trade Openness: a study case for Central and Eastern countries(ECE). *Amfiteatru Economic Journal,* 18(43), pp. 557-574,ISSN 2247-9104.

Neusser, K., 1993. Dynamics of total factor productivities. *Revenue economique:Nouvelles théories de la croissance,* 44(2), pp. 389-418.

News24, 2017. *South Africa's political diagnosis.* [Online]
Available at: https://www.news24.com/MyNews24/south-africas-political-diagnosis-20171102

Nikoloski, D. & Pechijareski, L., 2015. Research and development in post-transition: a case study of western Balkans countries. *Journal for Labour and social affairs in eastern Europe,* 18(2), pp. 231-20.

Nkoro, E. & Uko, A. K., 2016. Autoregressive Distributed Lag (ARDL) cointegration technique: application and interpretation. *Journal of Statistical and Econometric Methods,* 5(4), pp. 63-91.

Northover, P., 1999. Evolutionary growth theory and forms of realism. *Cambridge Journal of Economics,* 23(1), pp. 33-63.

OECD, 2019. *community education and training in South Africa, getting skills right,* Paris, https://doi.org/10.1787/9789264312302-en. : OECD Publishing.

Oluseye, C. I. & Gabriel, A. A., 2017. Determinants of Inclusive Growth in Nigeria: An ARDL approach. *American Journal of Economics,* 7(3), pp. 97-109.

Omar, S. N., 2020. Innovation and economic performance in MENA region. *Emerald Insight,* 4(2), pp. 158-175.

Pack, H., 1994. Endogenous growth theory: Intellectual appeal and empirical shortcomings. *The journal of economic perspectives,* 8(1), p. 55.62.

Pansera, M., 2011. The Origins and Purpose of Eco-Innovation. *White Horse Press, Global Environment,* 4(7/8), pp. 128-155.

Papageorgiou , C., Spatafora, N. & Perez-Sebastian , F., 2013. Structural Change through Diversification: A Conceptual Framework. *Journal of Macroeconomics.*

Peatman, G. J., 1947. *Descriptive and sampling statistics.* Oxford, England: Harper.

Pesaran , M., Shin , Y. & Smith, R. J., 1999. Bounds testing approaches to the analysis of a long-run relationship. *The centennial volume of Ragnar Frisch. Cambridge University,* pp. 1-24.

Pesaran, H. M., Shin, Y. & Smith, R. J., 2001. Boud testing approach to the analysis of level relationships. *Journal of applied econometrics,* 16(1), pp. 289-326.

Possony, S. T., 1974. *Political Aspects of Economic Development. In: Barratt J., Brand S., Collier D.S., Glaser K. (eds) Accelerated Development in Southern Africa.* 1 ed. London: Palgrave Macmillan, London.

Pradhana, R. &. B., 2018. Are innovation and financial development causative factors in economic growth? Evidence from a panel Granger causality test. *Technological Forecasting & Social Change,* Volume 132, pp. 130-142, https://doi.org/10.1016/j.techfore.2018.01.024.

Pradhan, R., Arvin, M., Hall, J. & Norman, N., 2017. ASEAN economic growth, trade openness and banking sector depth: The nexus. *Economia,* 18(3), pp. 359-379.

Pulek, M. H. & Ahmed, M. U., 2017. Does corruption matter for economic development? Long-run evidence from Bangladesh. *International Journal of Social Economics,* pp. 350-361, https://doi.org/10.1108/IJSE-05-2015-0132.

Raheman, A., Afza, T., Qayyum , A. & Mahmood, A., 2009. Estimating Total Factor Productivity and Its Components: Evidence from Major Manufacturing Industries of Pakistan. *The Pakistan Development Review, Papers and Proceedings PARTS I and II Twenty-fourth Annual General Meeting and Conference of the Pakistan Society of Development Economists Islamabad.,* 47(4-11), pp. 677-694.

Riva, M., 2000. Beginning/Ending, Openness/Consistency: Models for the Hyper. *Annali d'Italianistica,* 18(1), pp. 109-131.

Romer, P. M., 1990. Endogenous technological change. *Journal of political economy,* 98(5), pp. 71-102.

Romer, P. M., 1994. The origins of endogenous growth. *Journl of econmics perpectives ,* 8(1), pp. 2-22.

Sacks, D. W., Wolfers, J. & Stevenson, B., 2010. Subjective well being, Income, Economic development and growth. *NBER Working Paper No. 16441.*

Saini, T., 1974. Paul Douglas and the Cobb-Douglas Production Function. *Eastern Economic Journal,* 1(1), pp. 52-58.

Samans, R., Blanke, J., Hanouz, M. D. & Corrigan, G., 2017. *The Inclusive Growth and Development Report,* Geneva: The World Economic Forum.

Sbia, R., Shahbaz, M. & Hamdi, H., 2014. A contribution of foreign direct investment, clean energy, trade openness, carbon emissions and economic growth to energy-demanding UAE. *Economic modelling,* Volume 36, pp. 191-197.

Shahbaz, M., 2012. Does trade openness affect long-run growth? Cointegration, causality and forecast error variance decomposition tests for Pakistan. *Economic modelling,* 29(6), pp. 2325-2339.

Shin, M. H. & Pesaran, Y., 1998. An autoregressive distributed lags Modelling approach to cointegration analysis. *Econometric Society Monographs,* 31(1), pp. 371-413.

Sledzik, K., 2013. Schumpeter's view on innovation and entrepreneurship. *SSRN Electronic Journal,* pp. 89-95.

Smith, C., Cazes, S. & Verick, S., 2013. Economic Development, Technological Change, and Growth. *Journal of Economic Literature,* 51(4), pp. 1276-1283.

Smith, T. A. & Robin, 2007. *APSA Treasurer's Report 2007: Another Year of Growth and Innovation in APSA's FinancialOperations,* San Francisco: American Political Science Association.

Solow, R. M., 1956. A contribution to the theory of Economic growth. *The Quarterly Journal of Economics,* 70(1), pp. 65-94.

Spencer, A. S., Kirchhoff, B. A. & White, C., 2009. Entrepreneurship, Innovation, and wealth distribution: The essence of creative destruction. *International small business journal,* 26(1), pp. 9-26.

Stadler, M., 2012. Engines of Growth: Education and Innovation. *Review of Economics,* 63(2), pp. 113-124.

Statistics South Africa, 2017. *Poverty trends in South Africa: An examination of absolute poverty between 2006 and 2015.,* Pretoria: Statistics South Africa.

Stewart, J. & Gill, L., 1998. *Econometrics.* Edinburgh Gate: Pearson Education Limited.

Stuart, T. E., 2017. Interorganizational Alliances and the Performance of Firms: A Study of Growth and innovation Rates in a High-Technology Industry. *Strategic Management Journal,* 21(8(Aug., 2000)), pp. 791-811.

Studenmund, H. A., 2006. *Using econometrics: A practical guide.* New York: Daryl Fox.

Suryanarayana, 2013. *Inclusive growth: A sustainable perspective,* Mumbai, India: Indira Gandhi Institute of development research Goregaon East, United Nations Development Programme.

Thakur, S. K. & Malecki, E. J., 2015. Regional determinants of research and development institutions in India. *Geo Journal,* 80(4), pp. 533-554.

The World Bank, 2018. *South African Economic Update,* Washington, DC: The International Bank for Reconstruction and Development/THE WORLD BANK.

Thomas, L., 1993. *Introductory Econometrics: Theory and applications.* New York: Longman Group Limited.

Thomas, R. L., 1997. *Modern econometrics: An introduction.* Edinburgh gate: Pearson Education Limited.

Todaro, M. P. & Smith, S. C., 2015. *Economic development.* 12 ed. England: Pearson.

Trejos, S. B., 2015. Dynamic estimation of the relationship between trade openness and output growth in Asia. *Journal of Asian Economics,* 36(1), pp. 110-125.

Tursoy, T., 2017. Causality between Stock Prices and Exchange Rates in Turkey: Empirical Evidence from the ARDL BoundsTestandaCombinedCointegrationApproach. *International Journal of Financial Studies,* 5(1), pp. 1-10.

UNESCO, 2015. Digital services for education in Africa. *UNESCO,* p. 17.

Van der Berg, S., 2011. Current poverty and income distribution in the context of South African history. *Economic History of Developing Regions,* pp. 120-140,Working Papers 22/2010, Stellenbosch University, Department of Economics.

Vans, J., 2012. *Statistics data analysis and decision modelling.* 5th ed. London: Pearson.

Vashisht, P., 2016. Creating manufacturing jobs in India: Has openness to trade helped?. *Journal of Asian Economics,* 42(1), pp. 53-64.

Volker, N., 2006. Trade Openness and Urban Concentration: New Evidence. *Journal of Economic Integration,* 21(2), pp. 340-362.

Wang, P., 2009. *Financial econometrics.* 2 ed. New York: Taylor & Francis e-Library.

Waugh. M. & Ravikumar, B., 2016. Measuring t openness to trade. *Journal of economic dynamics & control,* 72(1), pp. 29-41.

White, H., 1980. Heteroscedasticity -consistent covariance matrix and a direct test for heteroscedasticity. *Econometrica,* Volume 48, pp. 917-838.

World Bank, 2018. *South Africa Economic Update: Jobs and inequality,* Washition DS, USA: The International Bank for Reconstruction and Development/THE WORLD BANK.

World Bank, March,2018. *Overcoming poverty and inequality in South Africa: An assessment of drivers,constraints and opportunities,* Washington DC: World Bank.

Yanikkaya, H., 2003. Trade openness and economic growth: A cross country empirical investigation. *Journal of Development Economics,* 72(1), pp. 57-89, https://doi.org/10.1016/S0304-3878(03)00068-3.

Yiheyis, Z., 2013. Trade Openness and Inflation Performance: A Panel Data Analysis. *African Development Review,* 25(1), p. 67–84.

Yule, U., 1926. Why do we sometimes get nonsense correlations between time series? A study in sampling and the nature of time series. *Journal of royal statistical society,* 89(1), pp. 11-63.

Zivot, E. & Andrews, D., 1992. Further evidence of a great crash, the oil price shock and unit root hypothesis. *Journal of Business and Economic Statistics,* 10(1), pp. 251-270.

Zohonogo, P., 2016. Trade and economic growth in developing countries: Evidence from sub-Saharan Africa. *Journal of African trade,* 3(1-2), pp. 41-56.

APPENDICES

(ARRANGE IN A PROPER ORDER i.e DATA, TRADE OPNESS, UNIT ROOT TESTS, DIAGNOSTIC, GIRF and VD)

Appendix A: Data used in this study

YEAR	GDPPC	EDUEX	GFCF	TOP	ICTE	RDEX
1990	8430	15408	62617	0.416826	1399	2472
1991	9451	18886	65208	0.380508	1680	2903
1992	10377	22505	67087	0.374875	1813	2274
1993	11623	27737	69368	0.391233	2370	2601
1994	12870	29756	79857	0.40769	3176	2930
1995	14320	34878	95632	0.436109	3699	3259
1996	15782	38037	109126	0.466673	4162	3587
1997	17122	46658	123437	0.468453	5039	3916
1998	18162	50417	137762	0.488966	6750	4244
1999	19493	50819	134668	0.468619	7011	4572
2000	21657	53451	147779	0.514378	7874	4901
2001	23481	58891	162257	0.548016	9662	5130
2002	26778	64585	184419	0.597646	11304	6031
2003	28632	72879	211877	0.514018	12762	7040
2004	31370	82566	243052	0.51078	13366	8595
2005	34281	86460	282713	0.531491	14743	9600
2006	37899	95517	348105	0.602773	16269	11761
2007	42863	105805	435548	0.636831	19520	13245
2008	47512	119665	556997	0.728654	21687	13715
2009	49682	143733	539440	0.554183	19975	13541
2010	53823	168778	529431	0.55989	17279	13335
2011	58559	186145	578014	0.601126	17377	14485
2012	62297	211185	625644	0.608997	22396	14921
2013	66952	229426	721234	0.642417	26579	16394
2014	71064	249187	775950	0.644345	28459	19658
2015	74635	265422	822576	0.616171	32659	21324
2016	79225	285241	846552	0.606382	34857	23563

2017	83422	306584	873223	0.579739	33413	25984
2018	86170	327927	886428	0.594703	37258	28669

Appendix B: ARDL Long-run Form and Bounds Test

1. ARDL coefficients

Dependent Variable: LNGDPPC				
Method: ARDL				
Date: 06/18/19 Time: 14:36				
Sample (adjusted): 1991 2018				
Included observations: 28 after adjustments				
Maximum dependent lags: 1 (Automatic selection)				
Model selection method: Akaike info criterion (AIC)				
Dynamic regressors (0 lag, automatic): LNEDUEX LNGFCF TOP LNICTE LNRDEX				
Fixed regressors: C				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LNGDPPC(-1)	1.136468	0.131620	8.634491	0.0000
LNEDUEX	-0.068812	0.059980	-1.147248	0.2642
LNGFCF	-0.099405	0.055263	-1.798760	0.0864
TOP	0.420038	0.109487	3.836411	0.0010
LNICTE	-0.051867	0.024457	-2.120760	0.0460
LNRDEX	0.063565	0.034020	1.868457	0.0757
C	0.389154	0.154954	2.511417	0.0203
R-squared	0.999657	Mean dependent var		10.37054
Adjusted R-squared	0.999559	S.D. dependent var		0.698545
S.E. of regression	0.014677	Akaike info criterion		-5.392755
Sum squared resid	0.004524	Schwarz criterion		-5.059704
Log-likelihood	82.49857	Hannan-Quinn criteria.		-5.290938
F-statistic	10190.11	Durbin-Watson stat		2.309511
Prob(F-statistic)	0.000000			
*Note: p-values and any subsequent tests do not account for model selection.				

2. Cointegration and long-run form.

ARDL Cointegrating And Long-run Form				
Original dep. variable: LNGDPPC				
Selected Model: ARDL(1, 0, 0, 0, 0, 0)				
Date: 06/18/19 Time: 14:39				
Sample: 1990 2018				
Included observations: 28				
Cointegrating Form				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNEDUEX	-0.050987	0.039260	-1.298710	0.2081
LNGFCF	-0.029456	0.049040	-0.600658	0.5545
TOP	0.361573	0.106587	3.392287	0.0027
LNICTE	-0.030785	0.017721	-1.737209	0.0970
LNRDEX	0.062271	0.033297	1.870190	0.0755
C	0.477529	0.092786	5.146565	0.0000
Cointegration Equation(-1)	-0.039847	0.028948	-1.376498	0.1832
Cointegration equation = LNGDPPC - (0.5042*LNEDUEX + 0.7284*LNGFCF - 3.0779*TOP + 0.3801*LNICTE -0.4658*LNRDEX)				
Long-run Coefficients				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNEDUEX	0.504234	0.241164	2.090831	0.0489
LNGFCF	0.728409	0.549068	1.326627	0.1989
TOP	-3.077916	2.879096	-1.069057	0.2972
LNICTE	0.380063	0.276736	1.373375	0.1841
LNRDEX	-0.465783	0.554714	-0.839682	0.4105

3. Bound testing

ARDL Bounds Test Date: 06/18/19 Time: 14:46 Sample: 1991 2018 Included observations: 28				
Null Hypothesis: No long-run relationships exist				
Test Statistic	Value	k		
F-statistic	5.592251	5		
Critical Value Bounds				
Significance	I0 Bound	I1 Bound		
10%	2.26	3.35		
5%	2.62	3.79		
2.5%	2.96	4.18		
1%	3.41	4.68		
Test Equation:				
Dependent Variable: D(LNGDPPC)				
Method: Least Squares Date: 06/18/19 Time: 14:46 Sample: 1991 2018 Included observations: 28				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.136971	0.219924	-0.622812	0.5401
LNEDUEX(-1)	-0.195873	0.063132	-3.102611	0.0054
LNGFCF(-1)	0.005893	0.061832	0.095306	0.9250
TOP(-1)	-0.261150	0.132690	-1.968120	0.0624
LNICTE(-1)	0.019569	0.023994	0.815573	0.4239
LNRDEX(-1)	-0.052834	0.049535	-1.066604	0.2983
LNGDPPC(-1)	0.270860	0.125366	2.160551	0.0424
R-squared	0.615057	Mean dependent var		0.083019
Adjusted R-squared	0.505073	S.D. dependent var		0.025249
S.E. of regression	0.017763	Akaike info criterion		-5.011082
Sum squared resid	0.006626	Schwarz criterion		-4.678031
Log likelihood	77.15515	Hannan-Quinn criteria.		-4.909265
F-statistic	5.592251	Durbin-Watson stat		2.214356
Prob(F-statistic)	0.001343			

Appendix C: Trade openness calculations

YEAR	GDP	IMPORTS	EXPORTS	∑(Imports +Exports)	∑(I+E)/GDP
1990	298971	54376	70243	124619	0.416826
1991	342245	58020	72207	130227	0.380508
1992	383723	64403	79445	143848	0.374875
1993	438884	75919	95787	171706	0.391233
1994	496233	95747	106562	202309	0.40769
1995	563870	121093	124816	245909	0.436109
1996	634611	143340	152816	296156	0.466673
1997	703117	160718	168659	329377	0.468453
1998	761658	181972	190453	372425	0.488966
1999	834753	185037	206144	391181	0.468619
2000	946324	229757	257011	486768	0.514378
2001	1046144	266001	307303	573304	0.548016
2002	1217265	340637	386857	727494	0.597646
2003	1325766	325035	356433	681468	0.514018
2004	1476623	378177	376053	754230	0.51078
2005	1639254	437721	433528	871249	0.531491
2006	1839400	570276	538464	1108740	0.602773
2007	2109502	685783	657613	1343396	0.636831
2008	2369063	882309	843918	1726227	0.728654
2009	2507677	689771	699940	1389711	0.554183
2010	2748008	752233	786349	1538582	0.55989
2011	3023659	896566	921035	1817601	0.601126
2012	3253851	1014415	967171	1981586	0.608997
2013	3539977	1177765	1096378	2274143	0.642417
2014	3805350	1254466	1197492	2451958	0.644345
2015	4049884	1274263	1221157	2495420	0.616171
2016	4359061	1310214	1333041	2643255	0.606382
2017	4653579	1319114	1378747	2697861	0.579739
2018	4873899	1440883	1457641	2898524	0.594703
GDP=Gross domestic product at market prices EXPORTS=Exports of goods & services IMPORTS=Imports of goods & services					

Appendix E: Unit root tests

Appendix E_1: ADF unit root tests

LNGDPPC-intercept

Null Hypothesis: LNGDPPC has a unit root				
Exogenous: Constant				
Lag Length: 0 (Automatic - based on SIC, maxlag=6)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-4.084044	0.0038
Test critical values:	1% level		-3.689194	
	5% level		-2.971853	
	10% level		-2.625121	
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(LNGDPPC)				
Method: Least Squares				
Date: 06/07/19 Time: 04:10				
Sample (adjusted): 1991 2018				
Included observations: 28 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNGDPPC(-1)	-0.022105	0.005413	-4.084044	0.0004
C	0.310428	0.055811	5.562075	0.0000
R-squared	0.390807	Mean dependent var		0.083019
Adjusted R-squared	0.367376	S.D. dependent var		0.025249
S.E. of regression	0.020083	Akaike info criterion		-4.909186
Sum squared resid	0.010486	Schwarz criterion		-4.814028
Log-likelihood	70.72860	Hannan-Quinn criteria.		-4.880095

F-statistic	16.67941	Durbin-Watson stat		1.683403
Prob(F-statistic)	0.000375			

LNGDPPC –trend and intercept

Null Hypothesis: D(LNGDPPC) has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 0 (Automatic - based on SIC, maxlag=6)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-4.289886	0.0112
Test critical values:	1% level		-4.339330	
	5% level		-3.587527	
	10% level		-3.229230	
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(LNGDPPC,2)				
Method: Least Squares				
Date: 06/07/19 Time: 04:44				
Sample (adjusted): 1992 2018				
Included observations: 27 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNGDPPC(-1))	-0.900858	0.209996	-4.289886	0.0003
C	0.099457	0.024845	4.003065	0.0005
@TREND("1990")	-0.001734	0.000626	-2.770342	0.0106
R-squared	0.435408	Mean dependent var		-0.003034
Adjusted R-squared	0.388359	S.D. dependent var		0.026290

S.E. of regression	0.020561	Akaike info criterion		-4.826450
Sum squared resid	0.010146	Schwarz criterion		-4.682468
Log-likelihood	68.15707	Hannan-Quinn criteria.		-4.783636
F-statistic	9.254301	Durbin-Watson stat		1.923152
Prob(F-statistic)	0.001049			

LNGDPPC-none

Null Hypothesis: LNGDPPC has a unit root				
Exogenous: None				
Lag Length: 1 (Automatic - based on SIC, maxlag=6)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			2.081576	0.9889
Test critical values:	1% level		-2.653401	
	5% level		-1.953858	
	10% level		-1.609571	
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(LNGDPPC)				
Method: Least Squares				
Date: 06/07/19 Time: 04:46				
Sample (adjusted): 1992 2018				
Included observations: 27 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNGDPPC(-1)	0.003085	0.001482	2.081576	0.0478
D(LNGDPPC(-1))	0.581777	0.174385	3.336169	0.0027
R-squared	0.098842	Mean dependent var		0.081859

Adjusted R-squared	0.062796	S.D. dependent var		0.024959
S.E. of regression	0.024163	Akaike info criterion		-4.536839
Sum squared resid	0.014596	Schwarz criterion		-4.440851
Log-likelihood	63.24733	Hannan-Quinn criteria.		-4.508297
Durbin-Watson stat	2.308007			

LNEDUEX-intercept

Null Hypothesis: D(LNEDUEX) has a unit root				
Exogenous: Constant				
Lag Length: 0 (Automatic - based on SIC, maxlag=6)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-3.936539	0.0057
Test critical values:	1% level		-3.699871	
	5% level		-2.976263	
	10% level		-2.627420	
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(LNEDUEX,2)				
Method: Least Squares				
Date: 06/07/19 Time: 05:01				
Sample (adjusted): 1992 2018				
Included observations: 27 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNEDUEX(-1))	-0.709342	0.180194	-3.936539	0.0006

C	0.073523	0.022004	3.341370	0.0026
R-squared	0.382660	Mean dependent var		-0.005046
Adjusted R-squared	0.357967	S.D. dependent var		0.060074
S.E. of regression	0.048135	Akaike info criterion		-3.158421
Sum squared resid	0.057925	Schwarz criterion		-3.062433
Log-likelihood	44.63868	Hannan-Quinn criteria.		-3.129879
F-statistic	15.49634	Durbin-Watson stat		2.220161
Prob(F-statistic)	0.000583			

LNEDUEX –trend and intercept

Null Hypothesis: D(LNEDUEX) has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 0 (Automatic - based on SIC, maxlag=6)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-4.100500	0.0170
Test critical values:	1% level		-4.339330	
	5% level		-3.587527	
	10% level		-3.229230	
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(LNEDUEX,2)				
Method: Least Squares				
Date: 06/07/19 Time: 05:06				
Sample (adjusted): 1992 2018				
Included observations: 27 after adjustments				

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNEDUEX(-1))	-0.788338	0.192254	-4.100500	0.0004
C	0.103848	0.034561	3.004742	0.0061
@TREND("1990")	-0.001438	0.001269	-1.133466	0.2682
R-squared	0.414028	Mean dependent var		-0.005046
Adjusted R-squared	0.365197	S.D. dependent var		0.060074
S.E. of regression	0.047863	Akaike info criterion		-3.136494
Sum squared resid	0.054982	Schwarz criterion		-2.992512
Log-likelihood	45.34267	Hannan-Quinn criteria.		-3.093681
F-statistic	8.478792	Durbin-Watson stat		2.134628
Prob(F-statistic)	0.001639			

LNEDUEX- none

Null Hypothesis: LNEDUEX has a unit root				
Exogenous: None				
Lag Length: 0 (Automatic - based on SIC, maxlag=6)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			10.09864	1.0000
Test critical values:	1% level		-2.650145	
	5% level		-1.953381	
	10% level		-1.609798	
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(LNEDUEX)				

Method: Least Squares				
Date: 06/07/19 Time: 05:05				
Sample (adjusted): 1991 2018				
Included observations: 28 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNEDUEX(-1)	0.009480	0.000939	10.09864	0.0000
R-squared	-0.164613	Mean dependent var		0.109211
Adjusted R-squared	-0.164613	S.D. dependent var		0.052061
S.E. of regression	0.056183	Akaike info criterion		-2.885347
Sum squared resid	0.085226	Schwarz criterion		-2.837768
Log-likelihood	41.39486	Hannan-Quinn criteria.		-2.870802
Durbin-Watson stat	1.124058			

LNGFCF-intercept

Null Hypothesis: D(LNGFCF) has a unit root				
Exogenous: Constant				
Lag Length: 0 (Automatic - based on SIC, maxlag=6)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-2.962762	0.0514
Test critical values:	1% level		-3.699871	
	5% level		-2.976263	
	10% level		-2.627420	
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				

Dependent Variable: D(LNGFCF,2)				
Method: Least Squares				
Date: 06/07/19 Time: 05:08				
Sample (adjusted): 1992 2018				
Included observations: 27 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNGFCF(-1))	-0.532212	0.179634	-2.962762	0.0066
C	0.050997	0.021752	2.344467	0.0273
R-squared	0.259872	Mean dependent var		-0.000946
Adjusted R-squared	0.230267	S.D. dependent var		0.076258
S.E. of regression	0.066905	Akaike info criterion		-2.499907
Sum squared resid	0.111906	Schwarz criterion		-2.403920
Log-likelihood	35.74875	Hannan-Quinn criteria.		-2.471365
F-statistic	8.777960	Durbin-Watson stat		1.816867
Prob(F-statistic)	0.006602			

LNGFCF-trend and intercept

Null Hypothesis: D(LNGFCF) has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 0 (Automatic - based on SIC, maxlag=6)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-3.017028	0.1461
Test critical values:	1% level		-4.339330	

	5% level		-3.587527	
	10% level		-3.229230	
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(LNGFCF,2)				
Method: Least Squares				
Date: 06/07/19 Time: 05:20				
Sample (adjusted): 1992 2018				
Included observations: 27 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNGFCF(-1))	-0.545238	0.180720	-3.017028	0.0060
C	0.075293	0.034190	2.202218	0.0375
@TREND("1990")	-0.001535	0.001663	-0.922953	0.3652
R-squared	0.285242	Mean dependent var		-0.000946
Adjusted R-squared	0.225678	S.D. dependent var		0.076258
S.E. of regression	0.067104	Akaike info criterion		-2.460711
Sum squared resid	0.108070	Schwarz criterion		-2.316729
Log-likelihood	36.21960	Hannan-Quinn criteria.		-2.417898
F-statistic	4.788890	Durbin-Watson stat		1.859927
Prob(F-statistic)	0.017779			

LNGFCF-none

Null Hypothesis: D(LNGFCF) has a unit root				
Exogenous: None				
Lag Length: 0 (Automatic - based on SIC, maxlag=6)				

			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-1.673979	0.0884
Test critical values:	1% level		-2.653401	
	5% level		-1.953858	
	10% level		-1.609571	
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(LNGFCF,2)				
Method: Least Squares				
Date: 06/07/19 Time: 05:22				
Sample (adjusted): 1992 2018				
Included observations: 27 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNGFCF(-1))	-0.192774	0.115159	-1.673979	0.1061
R-squared	0.097147	Mean dependent var		-0.000946
Adjusted R-squared	0.097147	S.D. dependent var		0.076258
S.E. of regression	0.072459	Akaike info criterion		-2.375245
Sum squared resid	0.136510	Schwarz criterion		-2.327251
Log-likelihood	33.06580	Hannan-Quinn criteria.		-2.360973
Durbin-Watson stat	2.070125			

TOP-intercept

Null Hypothesis: D(TOP) has a unit root		
Exogenous: Constant		

Lag Length: 0 (Automatic - based on SIC, maxlag=6)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-5.958653	0.0000
Test critical values:	1% level		-3.699871	
	5% level		-2.976263	
	10% level		-2.627420	
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(TOP,2)				
Method: Least Squares				
Date: 06/07/19 Time: 05:25				
Sample (adjusted): 1992 2018				
Included observations: 27 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(TOP(-1))	-1.159793	0.194640	-5.958653	0.0000
C	0.008897	0.009712	0.916145	0.3683
R-squared	0.586815	Mean dependent var		0.001899
Adjusted R-squared	0.570287	S.D. dependent var		0.076417
S.E. of regression	0.050093	Akaike info criterion		-3.078682
Sum squared resid	0.062733	Schwarz criterion		-2.982694
Log-likelihood	43.56221	Hannan-Quinn criteria.		-3.050140
F-statistic	35.50555	Durbin-Watson stat		2.067890
Prob(F-statistic)	0.000003			

TOP-trend and intercept

Null Hypothesis: D(TOP) has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 4 (Automatic - based on SIC, maxlag=6)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-5.533217	0.0009
Test critical values:	1% level		-4.416345	
	5% level		-3.622033	
	10% level		-3.248592	
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(TOP,2)				
Method: Least Squares				
Date: 06/07/19 Time: 05:26				
Sample (adjusted): 1996 2018				
Included observations: 23 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(TOP(-1))	-4.450024	0.804238	-5.533217	0.0000
D(TOP(-1),2)	2.710525	0.658989	4.113155	0.0008
D(TOP(-2),2)	2.000574	0.501412	3.989879	0.0011
D(TOP(-3),2)	1.209572	0.364564	3.317858	0.0044
D(TOP(-4),2)	0.501284	0.206289	2.430007	0.0272
C	0.108126	0.029992	3.605206	0.0024
@TREND("1990")	-0.003983	0.001446	-2.754293	0.0141
R-squared	0.819057	Mean dependent var		-0.000585
Adjusted R-squared	0.751203	S.D. dependent var		0.082668

S.E. of regression	0.041234	Akaike info criterion		-3.293294
Sum squared resid	0.027205	Schwarz criterion		-2.947709
Log-likelihood	44.87288	Hannan-Quinn criteria.		-3.206380
F-statistic	12.07094	Durbin-Watson stat		2.054202
Prob(F-statistic)	0.000036			

TOP –none

Null Hypothesis: D(TOP) has a unit root				
Exogenous: None				
Lag Length: 0 (Automatic - based on SIC, maxlag=6)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-5.909387	0.0000
Test critical values:	1% level		-2.653401	
	5% level		-1.953858	
	10% level		-1.609571	
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(TOP,2)				
Method: Least Squares				
Date: 06/07/19 Time: 05:27				
Sample (adjusted): 1992 2018				
Included observations: 27 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(TOP(-1))	-1.138229	0.192614	-5.909387	0.0000

R-squared	0.572943	Mean dependent var		0.001899
Adjusted R-squared	0.572943	S.D. dependent var		0.076417
S.E. of regression	0.049938	Akaike info criterion		-3.119735
Sum squared resid	0.064839	Schwarz criterion		-3.071741
Log-likelihood	43.11642	Hannan-Quinn criteria.		-3.105463
Durbin-Watson stat	2.038061			

LNCITE-intercept

Null Hypothesis: LNICTE has a unit root				
Exogenous: Constant				
Lag Length: 2 (Automatic - based on SIC, maxlag=6)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-3.645328	0.0117
Test critical values:	1% level		-3.711457	
	5% level		-2.981038	
	10% level		-2.629906	
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(LNICTE)				
Method: Least Squares				
Date: 06/07/19 Time: 05:30				
Sample (adjusted): 1993 2018				
Included observations: 26 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNICTE(-1)	-0.075932	0.020830	-3.645328	0.0014

D(LNICTE(-1))	0.308481	0.167081	1.846298	0.0783
D(LNICTE(-2))	-0.482200	0.169234	-2.849313	0.0093
C	0.849602	0.207037	4.103620	0.0005
R-squared	0.523678	Mean dependent var		0.116265
Adjusted R-squared	0.458725	S.D. dependent var		0.107719
S.E. of regression	0.079250	Akaike info criterion		-2.091772
Sum squared resid	0.138174	Schwarz criterion		-1.898219
Log-likelihood	31.19304	Hannan-Quinn criteria.		-2.036036
F-statistic	8.062414	Durbin-Watson stat		1.798781
Prob(F-statistic)	0.000831			

LNCITE-trend and intercept

Null Hypothesis: D(LNICTE) has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 1 (Automatic - based on SIC, maxlag=6)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-5.201776	0.0015
Test critical values:	1% level		-4.356068	
	5% level		-3.595026	
	10% level		-3.233456	
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(LNICTE,2)				
Method: Least Squares				
Date: 06/07/19 Time: 05:41				

Sample (adjusted): 1993 2018				
Included observations: 26 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNICTE(-1))	-1.183567	0.227531	-5.201776	0.0000
D(LNICTE(-1),2)	0.497091	0.185593	2.678396	0.0137
C	0.258912	0.061687	4.197191	0.0004
@TREND("1990")	-0.007563	0.002618	-2.889392	0.0085
R-squared	0.556730	Mean dependent var		0.001259
Adjusted R-squared	0.496285	S.D. dependent var		0.120408
S.E. of regression	0.085457	Akaike info criterion		-1.940967
Sum squared resid	0.160664	Schwarz criterion		-1.747414
Log-likelihood	29.23257	Hannan-Quinn criteria.		-1.885231
F-statistic	9.210400	Durbin-Watson stat		1.691641
Prob(F-statistic)	0.000387			

LNCITE-none

Null Hypothesis: LNICTE has a unit root				
Exogenous: None				
Lag Length: 2 (Automatic - based on SIC, maxlag=6)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			2.538971	0.9960
Test critical values:	1% level		-2.656915	
	5% level		-1.954414	
	10% level		-1.609329	
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				

Dependent Variable: D(LNICTE)				
Method: Least Squares				
Date: 06/07/19 Time: 05:44				
Sample (adjusted): 1993 2018				
Included observations: 26 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNICTE(-1)	0.008837	0.003480	2.538971	0.0183
D(LNICTE(-1))	0.556217	0.202451	2.747410	0.0115
D(LNICTE(-2))	-0.283189	0.210695	-1.344073	0.1920
R-squared	0.159082	Mean dependent var		0.116265
Adjusted R-squared	0.085958	S.D. dependent var		0.107719
S.E. of regression	0.102985	Akaike info criterion		-1.600295
Sum squared resid	0.243937	Schwarz criterion		-1.455130
Log-likelihood	23.80383	Hannan-Quinn criteria.		-1.558493
Durbin-Watson stat	1.560993			

LNRDEX-intercept

Null Hypothesis: D(LNRDEX) has a unit root				
Exogenous: Constant				
Lag Length: 0 (Automatic - based on SIC, maxlag=6)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-5.169033	0.0003
Test critical values:	1% level		-3.699871	
	5% level		-2.976263	
	10% level		-2.627420	
*MacKinnon (1996) one-sided p-values.				

Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(LNRDEX,2)				
Method: Least Squares				
Date: 06/07/19 Time: 05:52				
Sample (adjusted): 1992 2018				
Included observations: 27 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNRDEX(-1))	-1.019088	0.197153	-5.169033	0.0000
C	0.086481	0.023987	3.605302	0.0014
R-squared	0.516618	Mean dependent var		-0.002310
Adjusted R-squared	0.497282	S.D. dependent var		0.122699
S.E. of regression	0.086997	Akaike info criterion		-1.974703
Sum squared resid	0.189211	Schwarz criterion		-1.878716
Log-likelihood	28.65850	Hannan-Quinn criteria.		-1.946161
F-statistic	26.71890	Durbin-Watson stat		1.166390
Prob(F-statistic)	0.000024			

LNRDEX-trend and intercept

Null Hypothesis: D(LNRDEX) has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 0 (Automatic - based on SIC, maxlag=6)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-5.199560	0.0014
Test critical values:	1% level		-4.339330	

	5% level		-3.587527	
	10% level		-3.229230	
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(LNRDEX,2)				
Method: Least Squares				
Date: 06/07/19 Time: 05:53				
Sample (adjusted): 1992 2018				
Included observations: 27 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNRDEX(-1))	-1.036025	0.199252	-5.199560	0.0000
C	0.060249	0.039161	1.538484	0.1370
@TREND("1990")	0.001847	0.002172	0.850260	0.4036
R-squared	0.530753	Mean dependent var		-0.002310
Adjusted R-squared	0.491649	S.D. dependent var		0.122699
S.E. of regression	0.087483	Akaike info criterion		-1.930307
Sum squared resid	0.183678	Schwarz criterion		-1.786325
Log-likelihood	29.05915	Hannan-Quinn criteria.		-1.887494
F-statistic	13.57287	Durbin-Watson stat		1.163035
Prob(F-statistic)	0.000114			

LNRDEX-none

Null Hypothesis: LNRDEX has a unit root				
Exogenous: None				
Lag Length: 1 (Automatic - based on SIC, maxlag=6)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			3.654435	0.9998
Test critical values:	1% level		-2.653401	
	5% level		-1.953858	
	10% level		-1.609571	
*MacKinnon (1996) one-sided p-values.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(LNRDEX)				
Method: Least Squares				
Date: 06/07/19 Time: 05:54				
Sample (adjusted): 1992 2018				
Included observations: 27 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRDEX(-1)	0.009786	0.002678	3.654435	0.0012
D(LNRDEX(-1))	-0.032734	0.198027	-0.165298	0.8700
R-squared	0.009671	Mean dependent var		0.084817
Adjusted R-squared	-0.029942	S.D. dependent var		0.085323
S.E. of regression	0.086591	Akaike info criterion		-1.984047
Sum squared resid	0.187452	Schwarz criterion		-1.888059
Log-likelihood	28.78463	Hannan-Quinn criteria.		-1.955504
Durbin-Watson stat	1.165921			

Appendix E_2: DF-GLS Unit root test results

LNGDPPC-intercept

Null Hypothesis: D(LNGDPPC) has a unit root				
Exogenous: Constant				
Lag Length: 0 (Automatic - based on AIC, maxlag=6)				
				t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic				-2.787804
Test critical values:	1% level			-2.653401
	5% level			-1.953858
	10% level			-1.609571
*MacKinnon (1996)				
DF-GLS Test Equation on GLS Detrended Residuals				
Dependent Variable: D(GLSRESID)				
Method: Least Squares				
Date: 06/07/19 Time: 06:13				
Sample (adjusted): 1992 2018				
Included observations: 27 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-0.531230	0.190555	-2.787804	0.0098
R-squared	0.219481	Mean dependent var		-0.003034
Adjusted R-squared	0.219481	S.D. dependent var		0.026290
S.E. of regression	0.023226	Akaike info criterion		-4.650742
Sum squared resid	0.014026	Schwarz criterion		-4.602748
Log-likelihood	63.78501	Hannan-Quinn criteria.		-4.636470
Durbin-Watson stat	2.108735			

LNGDPPC-trend and intercept

Null Hypothesis: D(LNGDPPC) has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 0 (Automatic - based on AIC, maxlag=6)				
				t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic				-4.439014
Test critical values:	1% level			-3.770000
	5% level			-3.190000
	10% level			-2.890000
*Elliott-Rothenberg-Stock (1996, Table 1)				
Warning: Test critical values calculated for 50 observations				
and may not be accurate for a sample size of 27				
DF-GLS Test Equation on GLS Detrended Residuals				
Dependent Variable: D(GLSRESID)				
Method: Least Squares				
Date: 06/07/19 Time: 06:15				
Sample (adjusted): 1992 2018				
Included observations: 27 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-0.882728	0.198857	-4.439014	0.0001
R-squared	0.430511	Mean dependent var		-0.000853
Adjusted R-squared	0.430511	S.D. dependent var		0.026290
S.E. of regression	0.019839	Akaike info criterion		-4.965961
Sum squared resid	0.010234	Schwarz criterion		-4.917967
Log-likelihood	68.04048	Hannan-Quinn criteria.		-4.951690
Durbin-Watson stat	1.943361			

LNEDUEX-intercept

Null Hypothesis: D(LNEDUEX) has a unit root				
Exogenous: Constant				
Lag Length: 0 (Automatic - based on AIC, maxlag=6)				
				t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic				-3.219603
Test critical values:	1% level			-2.653401
	5% level			-1.953858
	10% level			-1.609571
*MacKinnon (1996)				
DF-GLS Test Equation on GLS Detrended Residuals				
Dependent Variable: D(GLSRESID)				
Method: Least Squares				
Date: 06/07/19 Time: 06:18				
Sample (adjusted): 1992 2018				
Included observations: 27 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-0.565511	0.175646	-3.219603	0.0034
R-squared	0.279806	Mean dependent var		-0.005046
Adjusted R-squared	0.279806	S.D. dependent var		0.060074
S.E. of regression	0.050981	Akaike info criterion		-3.078393
Sum squared resid	0.067576	Schwarz criterion		-3.030399
Log-likelihood	42.55831	Hannan-Quinn criteria.		-3.064122
Durbin-Watson stat	2.245907			

LNEDUEX-trend and intercept

Null Hypothesis: D(LNEDUEX) has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 0 (Automatic - based on AIC, maxlag=6)				
				t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic				-4.039645
Test critical values:	1% level			-3.770000
	5% level			-3.190000
	10% level			-2.890000
*Elliott-Rothenberg-Stock (1996, Table 1)				
Warning: Test critical values calculated for 50 observations				
and may not be accurate for a sample size of 27				
DF-GLS Test Equation on GLS Detrended Residuals				
Dependent Variable: D(GLSRESID)				
Method: Least Squares				
Date: 06/07/19 Time: 06:19				
Sample (adjusted): 1992 2018				
Included observations: 27 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-0.754082	0.186670	-4.039645	0.0004
R-squared	0.385072	Mean dependent var		-0.001752
Adjusted R-squared	0.385072	S.D. dependent var		0.060074
S.E. of regression	0.047108	Akaike info criterion		-3.236409
Sum squared resid	0.057699	Schwarz criterion		-3.188415
Log-likelihood	44.69153	Hannan-Quinn criteria.		-3.222138
Durbin-Watson stat	2.114054			

LNGFCF-intercept

Null Hypothesis: D(LNGFCF) has a unit root				
Exogenous: Constant				
Lag Length: 0 (Automatic - based on AIC, maxlag=6)				
				t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic				-2.851681
Test critical values:	1% level			-2.653401
	5% level			-1.953858
	10% level			-1.609571
*MacKinnon (1996)				
DF-GLS Test Equation on GLS Detrended Residuals				
Dependent Variable: D(GLSRESID)				
Method: Least Squares				
Date: 06/07/19 Time: 06:22				
Sample (adjusted): 1992 2018				
Included observations: 27 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-0.484062	0.169746	-2.851681	0.0084
R-squared	0.238132	Mean dependent var		-0.000946
Adjusted R-squared	0.238132	S.D. dependent var		0.076258
S.E. of regression	0.066562	Akaike info criterion		-2.545030
Sum squared resid	0.115193	Schwarz criterion		-2.497036
Log-likelihood	35.35791	Hannan-Quinn criteria.		-2.530759
Durbin-Watson stat	1.844259			

LNGFCF-trend and intercept

Null Hypothesis: D(LNGFCF) has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 0 (Automatic - based on AIC, maxlag=6)				
				t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic				-3.082535
Test critical values:	1% level			-3.770000
	5% level			-3.190000
	10% level			-2.890000
*Elliott-Rothenberg-Stock (1996, Table 1)				
Warning: Test critical values calculated for 50 observations				
and may not be accurate for a sample size of 27				
DF-GLS Test Equation on GLS Detrended Residuals				
Dependent Variable: D(GLSRESID)				
Method: Least Squares				
Date: 06/07/19 Time: 06:25				
Sample (adjusted): 1992 2018				
Included observations: 27 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-0.536995	0.174206	-3.082535	0.0048
R-squared	0.267644	Mean dependent var		-0.000148
Adjusted R-squared	0.267644	S.D. dependent var		0.076258
S.E. of regression	0.065260	Akaike info criterion		-2.584538
Sum squared resid	0.110731	Schwarz criterion		-2.536544
Log-likelihood	35.89126	Hannan-Quinn criteria.		-2.570267
Durbin-Watson stat	1.828278			

TOP-intercept

Null Hypothesis: D(TOP) has a unit root				
Exogenous: Constant				
Lag Length: 0 (Automatic - based on AIC, maxlag=6)				
				t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic				-5.645817
Test critical values:	1% level			-2.653401
	5% level			-1.953858
	10% level			-1.609571
*MacKinnon (1996)				
DF-GLS Test Equation on GLS Detrended Residuals				
Dependent Variable: D(GLSRESID)				
Method: Least Squares				
Date: 06/07/19 Time: 06:26				
Sample (adjusted): 1992 2018				
Included observations: 27 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-1.097277	0.194352	-5.645817	0.0000
R-squared	0.550470	Mean dependent var		0.001899
Adjusted R-squared	0.550470	S.D. dependent var		0.076417
S.E. of regression	0.051235	Akaike info criterion		-3.068449
Sum squared resid	0.068251	Schwarz criterion		-3.020455
Log-likelihood	42.42406	Hannan-Quinn criteria.		-3.054178
Durbin-Watson stat	2.009176			

TOP-trend and intercept

Null Hypothesis: TOP has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 0 (Automatic - based on AIC, maxlag=6)				
				t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic				-2.938056
Test critical values:	1% level			-3.770000
	5% level			-3.190000
	10% level			-2.890000
*Elliott-Rothenberg-Stock (1996, Table 1)				
Warning: Test critical values calculated for 50 observations				
and may not be accurate for a sample size of 28				
DF-GLS Test Equation on GLS Detrended Residuals				
Dependent Variable: D(GLSRESID)				
Method: Least Squares				
Date: 06/07/19 Time: 06:27				
Sample (adjusted): 1991 2018				
Included observations: 28 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-0.509804	0.173517	-2.938056	0.0067
R-squared	0.240686	Mean dependent var		-0.002216
Adjusted R-squared	0.240686	S.D. dependent var		0.049558
S.E. of regression	0.043184	Akaike info criterion		-3.411619
Sum squared resid	0.050352	Schwarz criterion		-3.364040
Log-likelihood	48.76266	Hannan-Quinn criteria.		-3.397074
Durbin-Watson stat	1.801846			

LNCITE-intercept

Null Hypothesis: D(LNICTE) has a unit root				
Exogenous: Constant				
Lag Length: 1 (Automatic - based on AIC, maxlag=6)				
				t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic				-3.761570
Test critical values:	1% level			-2.656915
	5% level			-1.954414
	10% level			-1.609329
*MacKinnon (1996)				
DF-GLS Test Equation on GLS Detrended Residuals				
Dependent Variable: D(GLSRESID)				
Method: Least Squares				
Date: 06/07/19 Time: 06:29				
Sample (adjusted): 1993 2018				
Included observations: 26 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-0.817444	0.217314	-3.761570	0.0010
D(GLSRESID(-1))	0.337893	0.201564	1.676360	0.1066
R-squared	0.377509	Mean dependent var		0.001259
Adjusted R-squared	0.351571	S.D. dependent var		0.120408
S.E. of regression	0.096959	Akaike info criterion		-1.755262
Sum squared resid	0.225623	Schwarz criterion		-1.658485
Log-likelihood	24.81840	Hannan-Quinn criteria.		-1.727393
Durbin-Watson stat	1.568397			

LNCITE-trend and intercept

Null Hypothesis: D(LNICTE) has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 1 (Automatic - based on AIC, maxlag=6)				
				t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic				-5.334614
Test critical values:	1% level			-3.770000
	5% level			-3.190000
	10% level			-2.890000
*Elliott-Rothenberg-Stock (1996, Table 1)				
Warning: Test critical values calculated for 50 observations				
and may not be accurate for a sample size of 26				
DF-GLS Test Equation on GLS Detrended Residuals				
Dependent Variable: D(GLSRESID)				
Method: Least Squares				
Date: 06/07/19 Time: 06:30				
Sample (adjusted): 1993 2018				
Included observations: 26 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-1.170493	0.219415	-5.334614	0.0000
D(GLSRESID(-1))	0.495207	0.179783	2.754476	0.0110
R-squared	0.546146	Mean dependent var		0.006325
Adjusted R-squared	0.527235	S.D. dependent var		0.120408
S.E. of regression	0.082790	Akaike info criterion		-2.071215
Sum squared resid	0.164500	Schwarz criterion		-1.974439
Log-likelihood	28.92580	Hannan-Quinn criteria.		-2.043347
Durbin-Watson stat	1.671170			

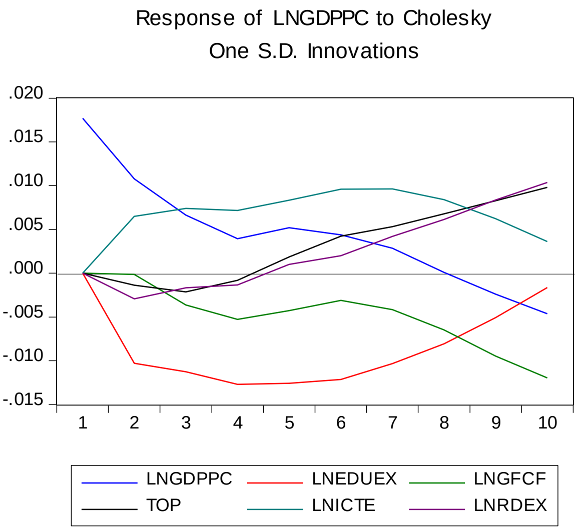
LNRDEX-intercept

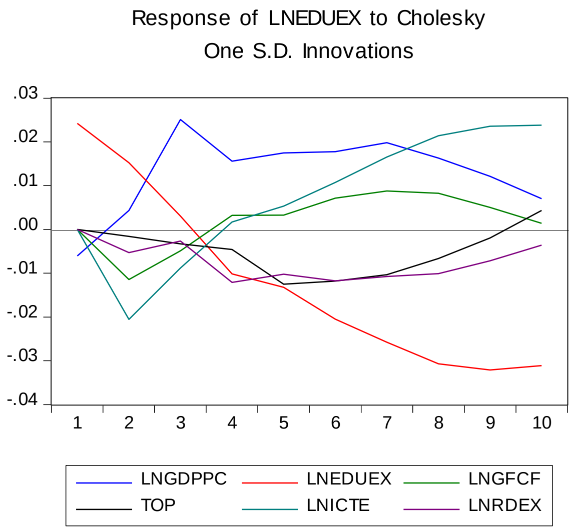
Null Hypothesis: D(LNRDEX) has a unit root				
Exogenous: Constant				
Lag Length: 0 (Automatic - based on AIC, maxlag=6)				
				t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic				-4.884721
Test critical values:	1% level			-2.653401
	5% level			-1.953858
	10% level			-1.609571
*MacKinnon (1996)				
DF-GLS Test Equation on GLS Detrended Residuals				
Dependent Variable: D(GLSRESID)				
Method: Least Squares				
Date: 06/07/19 Time: 06:31				
Sample (adjusted): 1992 2018				
Included observations: 27 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-0.950783	0.194644	-4.884721	0.0000
R-squared	0.478353	Mean dependent var		-0.002310
Adjusted R-squared	0.478353	S.D. dependent var		0.122699
S.E. of regression	0.088620	Akaike info criterion		-1.972594
Sum squared resid	0.204189	Schwarz criterion		-1.924600
Log-likelihood	27.63002	Hannan-Quinn criteria.		-1.958323
Durbin-Watson stat	1.208558			

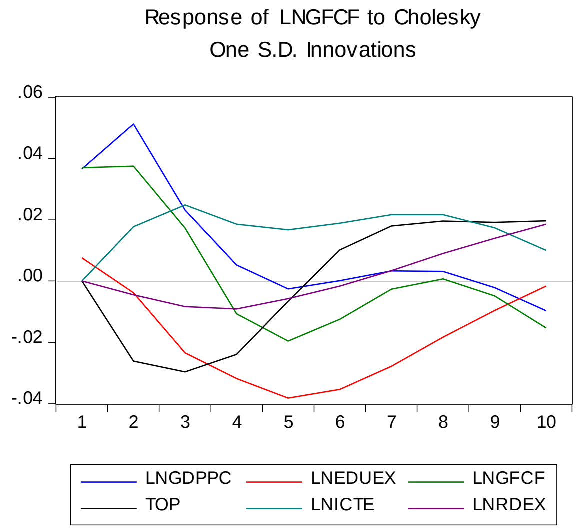
LNRDEX –trend and intercept

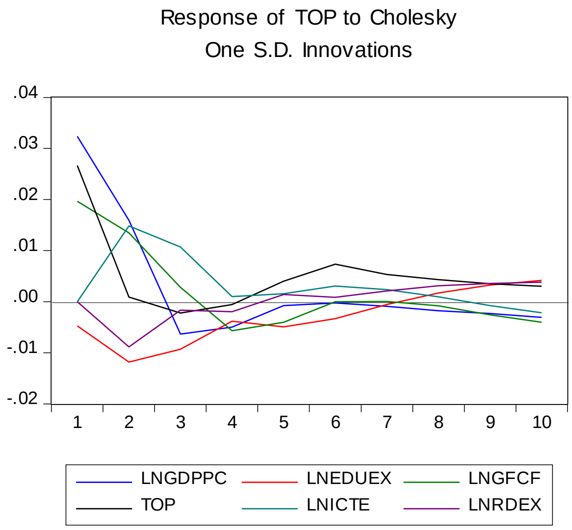
Null Hypothesis: D(LNRDEX) has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 0 (Automatic - based on AIC, maxlag=6)				
				t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic				-5.212494
Test critical values:	1% level			-3.770000
	5% level			-3.190000
	10% level			-2.890000
*Elliott-Rothenberg-Stock (1996, Table 1)				
Warning: Test critical values calculated for 50 observations				
and may not be accurate for a sample size of 27				
DF-GLS Test Equation on GLS Detrended Residuals				
Dependent Variable: D(GLSRESID)				
Method: Least Squares				
Date: 06/07/19 Time: 06:33				
Sample (adjusted): 1992 2018				
Included observations: 27 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-1.010597	0.193880	-5.212494	0.0000
R-squared	0.510833	Mean dependent var		-0.002246
Adjusted R-squared	0.510833	S.D. dependent var		0.122699
S.E. of regression	0.085816	Akaike info criterion		-2.036882
Sum squared resid	0.191475	Schwarz criterion		-1.988888
Log-likelihood	28.49790	Hannan-Quinn criteria.		-2.022611
Durbin-Watson stat	1.168724			

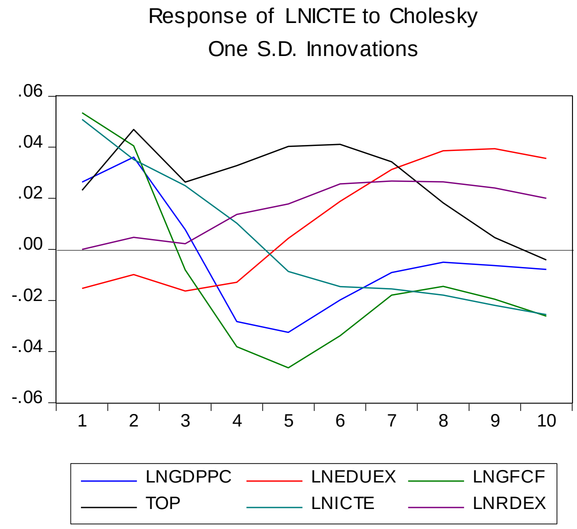
Appendix F: Generalized Impulse response system

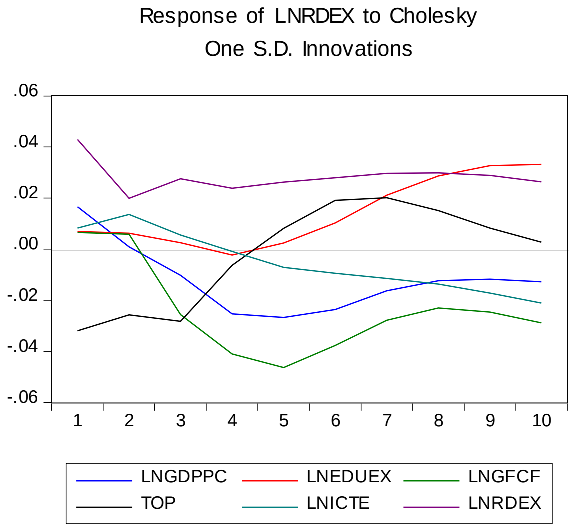




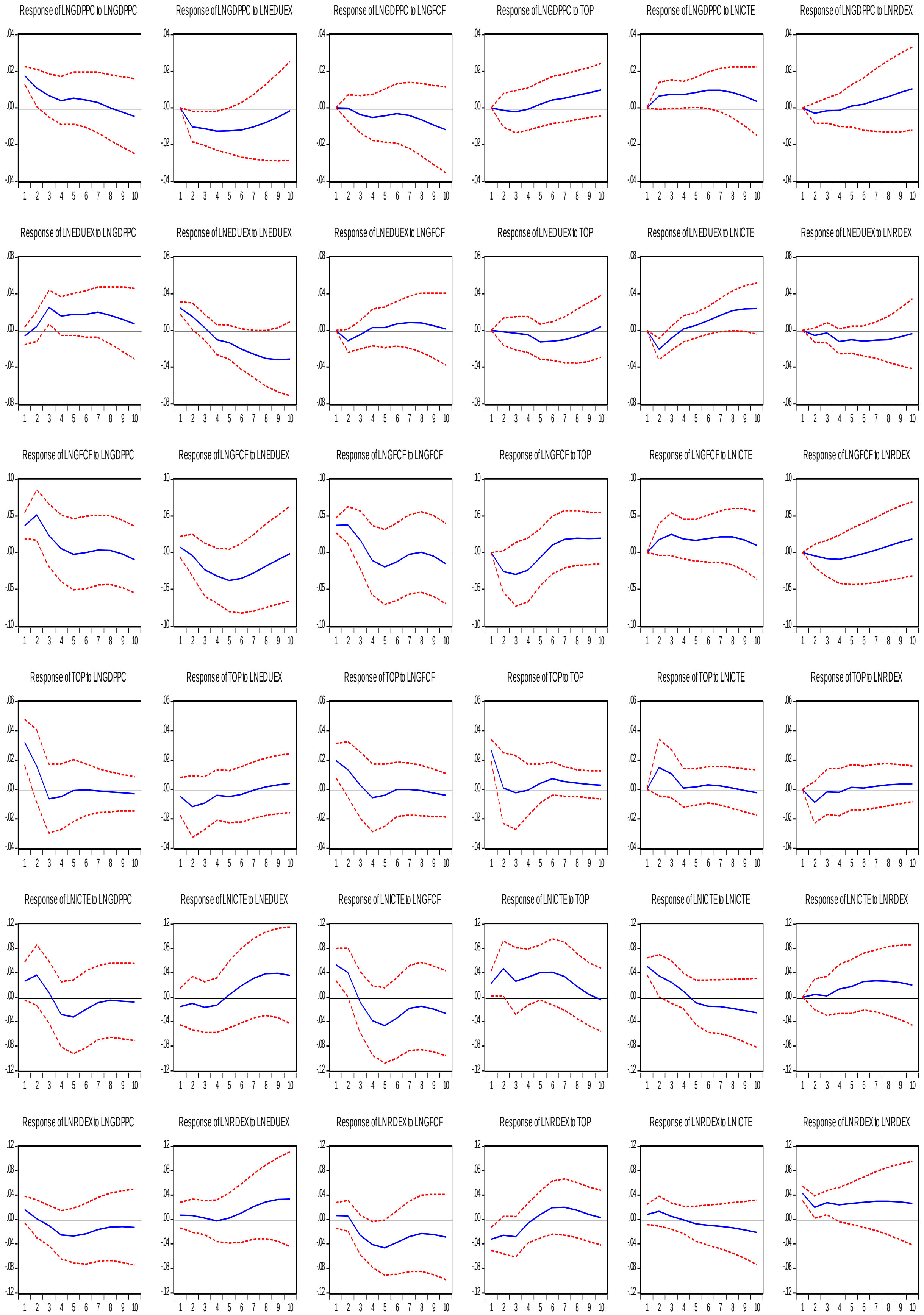




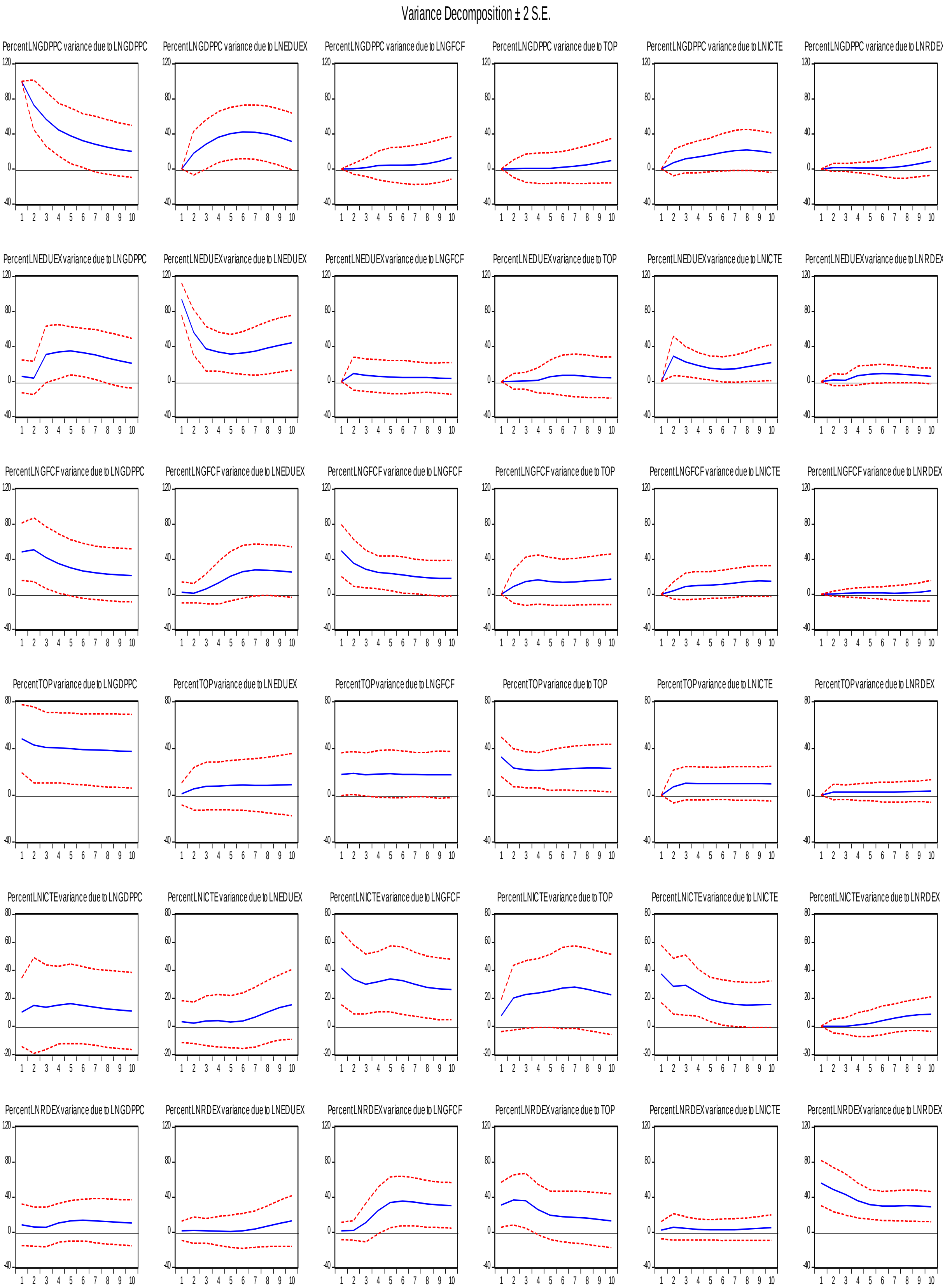




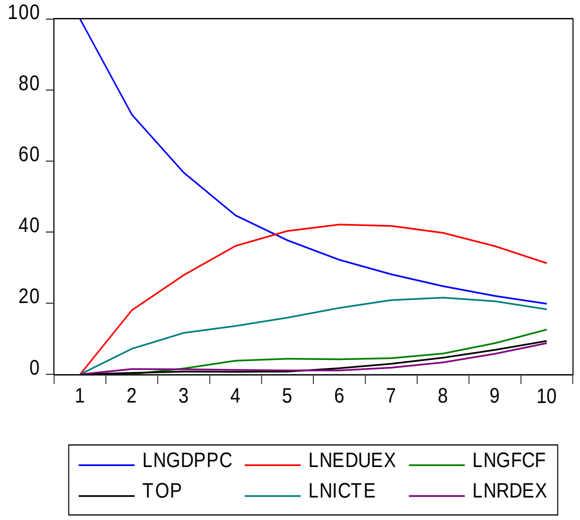
Response to Cholesky One S.D. Innovations ± 2 S.E.



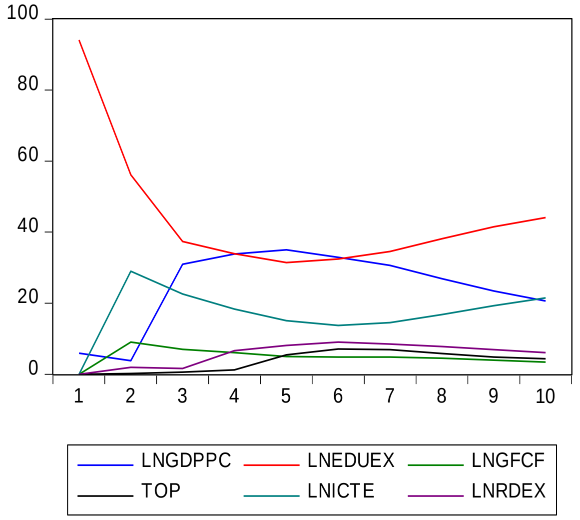
Appendix H: Variance decomposition



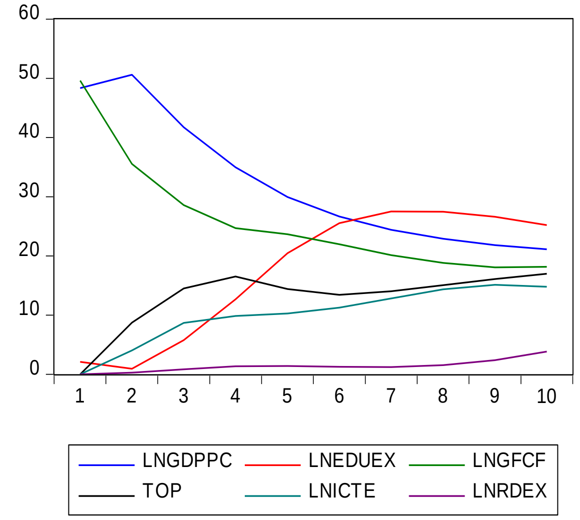
Variance Decomposition of LNGDPPC



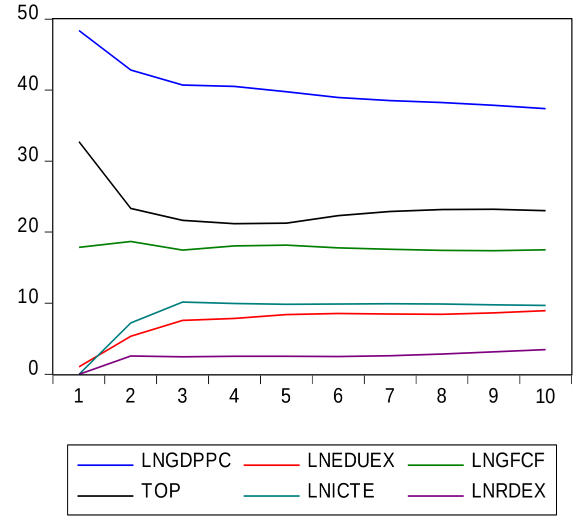
Variance Decomposition of LNEDUEX



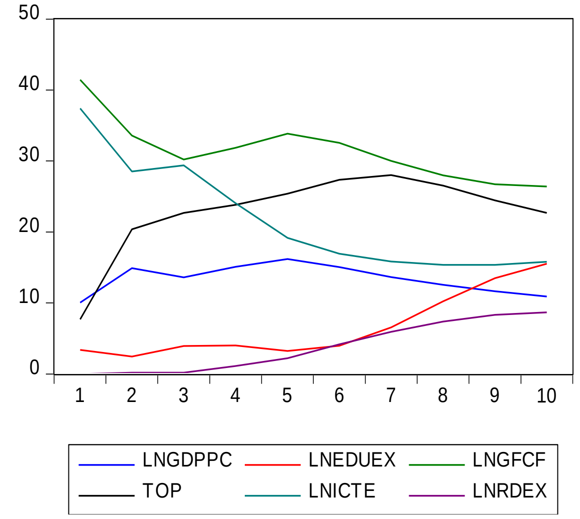
Variance Decomposition of LNGFCF



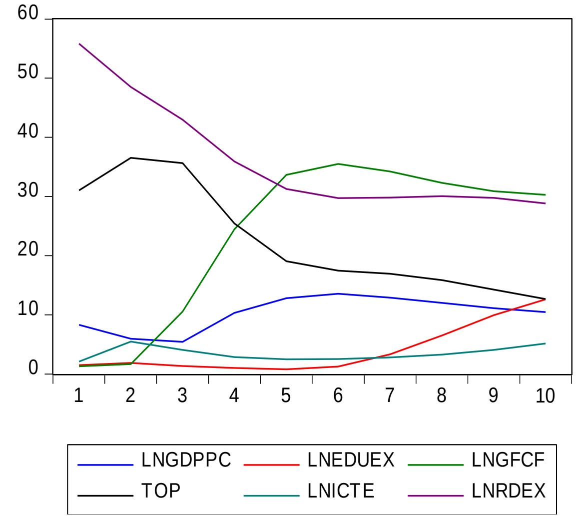
Variance Decomposition of TOP



Variance Decomposition of LNICTE



Variance Decomposition of LNRDEX



Appendix I: Diagnostic test results.

Wald Test:			
Equation: Untitled			
Test Statistic	Value	df	Probability
F-statistic	119.8403	(2, 21)	0.0000
Chi-square	239.6807	2	0.0000
Null Hypothesis: C(1)=C(2)=0			
Null Hypothesis Summary:			
Normalized Restriction (= 0)		Value	Std. Err.
C(1)		1.136468	0.131620
C(2)		-0.068812	0.059980

Breusch-Godfrey Serial Correlation LM Test:				
F-statistic	0.877659	Prob. F(2,19)		0.4319
Obs*R-squared	2.368015	Prob. Chi-Square(2)		0.3060
Test Equation:				
Dependent Variable: RESID				
Method: ARDL				
Date: 06/18/19 Time: 15:38				
Sample: 1991 2018				
Included observations: 28				
Presample missing value lagged residuals set to zero.				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNGDPPC(-1)	0.016082	0.139240	0.115502	0.9093
LNEDUEX	-0.007821	0.061839	-0.126474	0.9007
LNGFCF	-0.004692	0.058383	-0.080361	0.9368
TOP	0.039211	0.114880	0.341320	0.7366
LNICTE	-0.007573	0.025789	-0.293634	0.7722

LNRDEX	0.005152	0.034440	0.149605	0.8827
C	-0.014364	0.158425	-0.090666	0.9287
RESID(-1)	-0.354153	0.268203	-1.320463	0.2024
RESID(-2)	-0.131290	0.265871	-0.493812	0.6271
R-squared	0.084572	Mean dependent var		6.44E-15
Adjusted R-squared	-0.300871	S.D. dependent var		0.012944
S.E. of regression	0.014763	Akaike info criterion		-5.338261
Sum squared resid	0.004141	Schwarz criterion		-4.910053
Log-likelihood	83.73566	Hannan-Quinn criteria.		-5.207354
F-statistic	0.219415	Durbin-Watson stat		1.772229
Prob(F-statistic)	0.983028			

Heteroskedasticity Test: Breusch-Pagan-Godfrey				
F-statistic	0.460927	Prob. F(6,21)		0.8292
Obs*R-squared	3.258317	Prob. Chi-Square(6)		0.7758
Scaled explained SS	0.914216	Prob. Chi-Square(6)		0.9887
Test Equation:				
Dependent Variable: RESID^2				
Method: Least Squares				
Date: 06/18/19 Time: 15:40				
Sample: 1991 2018				
Included observations: 28				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.001622	0.001849	0.876912	0.3905
LNGDPPC(-1)	-0.000375	0.001571	-0.238656	0.8137
LNEDUEX	0.000128	0.000716	0.178783	0.8598
LNGFCF	-0.000313	0.000660	-0.475169	0.6396
TOP	0.000727	0.001307	0.556426	0.5838
LNICTE	0.000117	0.000292	0.402422	0.6914

LNRDEX	0.000374	0.000406	0.921185	0.3674
R-squared	0.116368	Mean dependent var		0.000162
Adjusted R-squared	-0.136098	S.D. dependent var		0.000164
S.E. of regression	0.000175	Akaike info criterion		-14.24949
Sum squared resid	6.44E-07	Schwarz criterion		-13.91644
Log-likelihood	206.4929	Hannan-Quinn criteria.		-14.14767
F-statistic	0.460927	Durbin-Watson stat		2.159596
Prob(F-statistic)	0.829167			

Heteroskedasticity Test: ARCH				
F-statistic	0.493619	Prob. F(1,25)		0.4888
Obs*R-squared	0.522786	Prob. Chi-Square(1)		0.4697
Test Equation:				
Dependent Variable: RESID^2				
Method: Least Squares				
Date: 06/20/19 Time: 10:02				
Sample (adjusted): 1992 2018				
Included observations: 27 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000187	4.66E-05	4.014849	0.0005
RESID^2(-1)	-0.160578	0.228555	-0.702580	0.4888
R-squared	0.019362	Mean dependent var		0.000164
Adjusted R-squared	-0.019863	S.D. dependent var		0.000167
S.E. of regression	0.000169	Akaike info criterion		-14.46474
Sum squared resid	7.12E-07	Schwarz criterion		-14.36875
Log-likelihood	197.2740	Hannan-Quinn criteria.		-14.43620
F-statistic	0.493619	Durbin-Watson stat		1.831828

Prob(F-statistic)	0.488808			

Heteroskedasticity Test: White			
F-statistic	3.340139	Prob. F(25,2)	0.2561
Obs*R-squared	27.34506	Prob. Chi-Square(25)	0.3389
Scaled explained SS	7.672453	Prob. Chi-Square(25)	0.9997

Test Equation:

Dependent Variable: RESID^2

Method: Least Squares

Date: 06/18/19 Time: 15:41

Sample: 1991 2018

Included observations: 28

Collinear test regressors dropped from specification

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.385106	0.290116	-1.327419	0.3156
LNGDPPC(-1)^2	0.017566	0.087619	0.200478	0.8596
LNGDPPC(-1)*LNEDUEX	-0.008731	0.051910	-0.168187	0.8819
LNGDPPC(-1)*LNGFCF	0.018355	0.042017	0.436855	0.7049
LNGDPPC(-1)*TOP	0.269543	0.176308	1.528823	0.2659
LNGDPPC(-1)*LNICTE	-0.005254	0.018957	-0.277125	0.8077
LNGDPPC(-1)*LNRDEX	-0.073934	0.038233	-1.933773	0.1928
LNGDPPC(-1)	0.063446	0.298044	0.212874	0.8512
LNEDUEX*LNGFCF	-0.025304	0.020341	-1.243971	0.3395
LNEDUEX*TOP	-0.146734	0.075380	-1.946593	0.1910
LNEDUEX*LNICTE	-0.024351	0.014239	-1.710228	0.2294
LNEDUEX*LNRDEX	0.090031	0.018243	4.935001	0.0387
LNEDUEX	-0.095198	0.139356	-0.683128	0.5650
LNGFCF*TOP	-0.055017	0.062773	-0.876444	0.4732
LNGFCF*LNICTE	0.032670	0.018265	1.788694	0.2156
LNGFCF*LNRDEX	-0.026779	0.015834	-1.691224	0.2329
LNGFCF	0.073130	0.071858	1.017697	0.4159

TOP^2	-0.166042	0.077105	-2.153452	0.1641
TOP*LNICTE	0.034720	0.032407	1.071384	0.3961
TOP*LNRDEX	-0.008453	0.029261	-0.288898	0.7999
TOP	-0.493483	0.201285	-2.451663	0.1338
LNICTE^2	0.001919	0.003013	0.636876	0.5894
LNICTE*LNRDEX	-0.014417	0.010732	-1.343314	0.3113
LNICTE	0.000340	0.027337	0.012436	0.9912
LNRDEX^2	0.008112	0.007690	1.054840	0.4021
LNRDEX	0.062422	0.056265	1.109439	0.3828
R-squared	0.976609	Mean dependent var		0.000162
Adjusted R-squared	0.684223	S.D. dependent var		0.000164
S.E. of regression	9.23E-05	Akaike info criterion		-16.52404
Sum squared resid	1.71E-08	Schwarz criterion		-15.28700
Log likelihood	257.3366	Hannan-Quinn criteria.		-16.14586
F-statistic	3.340139	Durbin-Watson stat		2.921319
Prob(F-statistic)	0.256108			

Heteroskedasticity Test: Harvey				
F-statistic	0.320404	Prob. F(6,21)		0.9189
Obs*R-squared	2.348261	Prob. Chi-Square(6)		0.8850
Scaled explained SS	0.964079	Prob. Chi-Square(6)		0.9869
Test Equation: Dependent Variable: LRESID2 Method: Least Squares Date: 06/18/19 Time: 15:43 Sample: 1991 2018 Included observations: 28				

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-5.638482	16.60860	-0.339492	0.7376
LNGDPPC(-1)	3.515369	14.10753	0.249184	0.8056
LNEDUEX	-3.141665	6.428907	-0.488678	0.6301
LNGFCF	-1.517560	5.923313	-0.256201	0.8003
TOP	1.837140	11.73529	0.156548	0.8771
LNICTE	0.880262	2.621358	0.335804	0.7404
LNRDEX	0.620556	3.646390	0.170184	0.8665
R-squared	0.083866	Mean dependent var		-9.436137
Adjusted R-squared	-0.177886	S.D. dependent var		1.449490
S.E. of regression	1.573138	Akaike info criterion		3.956340
Sum squared resid	51.97004	Schwarz criterion		4.289391
Log-likelihood	-48.38876	Hannan-Quinn criter.		4.058157
F-statistic	0.320404	Durbin-Watson stat		2.254412
Prob(F-statistic)	0.918936			

Ramsey RESET Test Equation: UNTITLED				
Specification: LNGDPPC LNGDPPC(-1) LNEDUEX LNGFCF TOP LNICTE				
LNRDEX C				
Omitted Variables: Squares of fitted values				
	Value	df	Probability	
t-statistic	2.133911	20	0.0454	
F-statistic	4.553578	(1, 20)	0.0454	
F-test summary:				
	Sum of Sq.	df	Mean Squares	
Test SSR	0.000839	1	0.000839	
Restricted SSR	0.004524	21	0.000215	
Unrestricted SSR	0.003685	20	0.000184	

Unrestricted Test Equation:				
Dependent Variable: LNGDPPC				
Method: ARDL				
Date: 06/18/19 Time: 15:44				
Sample: 1991 2018				
Included observations: 28				
Maximum dependent lags: 1 (Automatic selection)				
Model selection method: Akaike info criterion (AIC)				
Dynamic regressors (0 lag, automatic):				
Fixed regressors: C				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LNGDPPC(-1)	1.833563	0.348616	5.259556	0.0000
LNEDUEX	-0.047474	0.056364	-0.842274	0.4096
LNGFCF	-0.190130	0.066480	-2.859954	0.0097
TOP	0.735182	0.179061	4.105754	0.0005
LNICTE	-0.135006	0.045050	-2.996787	0.0071
LNRDEX	0.164656	0.056869	2.895340	0.0089
C	-2.734717	1.470915	-1.859194	0.0778
FITTED^2	-0.032059	0.015024	-2.133911	0.0454
R-squared	0.999720	Mean dependent var		10.37054
Adjusted R-squared	0.999622	S.D. dependent var		0.698545
S.E. of regression	0.013573	Akaike info criterion		-5.526452
Sum squared resid	0.003685	Schwarz criterion		-5.145822
Log-likelihood	85.37033	Hannan-Quinn criteria.		-5.410090
F-statistic	10213.05	Durbin-Watson stat		2.284692
Prob(F-statistic)	0.000000			
*Note: p-values and any subsequent tests do not account for model selection.				

Heteroskedasticity Test: Glejser				
F-statistic	0.399409	Prob. F(6,21)		0.8710
Obs*R-squared	2.867985	Prob. Chi-Square(6)		0.8252
Scaled explained SS	1.458676	Prob. Chi-Square(6)		0.9622
Test Equation:				
Dependent Variable: ARESID				
Method: Least Squares				
Date: 06/18/19 Time: 15:56				
Sample: 1991 2018				
Included observations: 28				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.056697	0.072875	0.778008	0.4452
LNGDPPC(-1)	-0.003282	0.061901	-0.053014	0.9582
LNEDUEX	-0.002487	0.028209	-0.088147	0.9306
LNGFCF	-0.010070	0.025990	-0.387437	0.7023
TOP	0.022505	0.051492	0.437049	0.6665
LNICTE	0.004912	0.011502	0.427081	0.6737
LNRDEX	0.009365	0.016000	0.585316	0.5646
R-squared	0.102428	Mean dependent var		0.011034
Adjusted R-squared	-0.154021	S.D. dependent var		0.006425
S.E. of regression	0.006903	Akaike info criterion		-6.901521
Sum squared resid	0.001001	Schwarz criterion		-6.568470
Log-likelihood	103.6213	Hannan-Quinn criteria.		-6.799704
F-statistic	0.399409	Durbin-Watson stat		2.224075
Prob(F-statistic)	0.871011			

Recursive estimation coefficients