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# The Impact of Social and Economic Infrastructure Investment on Growth and Employment in South Africa: A Comparative Analysis of General Government and Public Corporations


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## DEDICATION

I dedicate this dissertation to my amazing children, Gofaone, Amantle, and Leruo-Larona. This journey, which took many long hours and required immense perseverance, was completed with you in my heart. I appreciate your patience and support. I dedicate this achievement to you as a permanent reminder that hard work pays, and when life presents hurdles, push through them and remember education is the single most powerful tool you possess. Use it wisely, and it will guarantee your success.

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Thank you, and God bless you all.

## ABSTRACT

Infrastructure investment plays a vital role in providing the physical structures and systems necessary to support economic activities, which in turn fosters economic growth, job creation, and poverty alleviation. South Africa has launched various policy initiatives to enhance infrastructure development. Given this, the study examines the impact of economic and social infrastructure investment on economic growth and employment from 1992 to 2024 and compares the effects of these investments between the general government and public corporations in South Africa. The study employed the autoregressive distributed lag (ARDL) model and found that investing in economic and social infrastructure significantly boosts economic growth. These findings imply that an immediate injection of capital into both economic and social infrastructure sectors generates a strong growth multiplier, both in the short and long-term, making them exceptionally effective tools for fiscal stimulus

The study further investigated the impact of both economic and social infrastructure investment on employment. Economic infrastructure showed a statistically significant positive correlation with employment, while social infrastructure showed both significant positive and negative associations with employment. The negative correlation was particularly evident in the health sector, with a high coefficient of -3.92 observed. This finding contradicts the theoretical premise that a healthier population would result in enhanced productivity and, consequently, higher employment levels. Policymakers ought to reconsider their strategies for health infrastructure funds.

The study concluded that capital investment by both the general government and public corporations exerts a significant positive effect on growth and employment in South Africa, emphasizing the need for continued investment in infrastructure to support productivity gains and sustained economic growth.

***Key Words:*** Infrastructure Investment; Economic Growth; Employment; Foreign Direct Investment; South Africa; Auto-Regressive Distributed Lag (ARDL) Model.

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## LIST OF ACRONYMS

ADF: Augmented Dickey-Fuller

AIC: Akaike Information Criterion

ASGISA: Accelerated Shared Growth Initiative South Africa

ARDL: Autoregressive Distributed Lag

BPG: Breusch-Pagan-Godfrey

BRICS: Brazil, Russia, India, China, and South Africa

CESA: Consulting Engineers South Africa

CGE: Computable General Equilibrium

CUSUM: Cumulative Sum of Recursive Residuals

CUSUMQ: Cumulative Sum of Recursive Residuals of Squares

DF: Dickey Fuller

DW: Durbin-Watson

DBSA: Development Bank of Southern Africa

DOLS: Dynamic Ordinary Least Squares

DoRA: The Division of Revenue Act

ECDoE: The Eastern Cape Department of Education

ECM: Error Correction Model

ECT: Error Correction Term

EDU: Education Infrastructure Investment

EI: Electricity Coverage

EG: Engle Granger

EMP: Employment

ENE: Energy Infrastructure Investment

FDI: Foreign Direct Investment

FIDPM: The Framework for Infrastructure Delivery and Procurement Management

FIFA: Federation of International Football Associations

FMOLS: Fully modified Ordinary Least Squares

FPE: Final Prediction Error

GDP: Gross Domestic Product

GEAR: The Growth, Employment and Redistribution

GFCF: Gross Fixed Capital Formation

GMM: The Generalized Method of Moments

HEA: Health Infrastructure Investment

HFRG: Health Facility Revitalisation Grant

HQC: Hannan-Quinn Criterion

ICU: Intensive Care Units

IEA: International Energy Agency

IMF: International Monetary Fund

INF: Economic Infrastructure Investment

IRF: Impulse Response Function

JB: Jarque-Bera

JET: Just Energy Transition

LFS: Labour Force Survey

LM: Lagrange Multiplier

MTEF: Medium Term Expenditure Framework

MTDP: Medium Term Development Plan

MUNSPSI: Minimum Uniform Norms and Standards for Public School Infrastructure

NDP: National Development Plan

NGP: New Growth Path

NHI: National Health Insurance

NME: Nano Modified Emulsions

NPC: National Planning Commission

NT: National Treasury

OECD: Organisation for Economic Co-operation and Development

OHS: October Household Survey

OLS: Ordinary Least Squares

PVT: Private Capital Investment

PP: Phillips Perron

PFMA: Public Finance Management Act

RDP: Reconstruction and Development Programme

SAM: Social Accounting Matrix

SAMRC: The South African Medical Research Council

SARB: South African Reserve Bank

SBC: Schwarz Bayesian Criterion

SD: Standard Deviation

SOE: State Owned Enterprise

SPA: Structural Path Analysis

Stats SA: Statistics South Africa

TRA: Transport

UNCTAD: United Nations Conference on Trade and Development

VAR: Vector Auto Regression

VD: Variance Decomposition

VECM: Vector Error Correction Model

VIF: Variance Inflation Factors

# CHAPTER ONE

## INTRODUCTION AND BACKGROUND OF THE STUDY

### 1.1 Background of the Study

A number of factors, including population growth, changing economic structures, technological advancements, and growing environmental protection needs, continue to drive demand for infrastructure developments globally. Countries, particularly those in developing economies, rely on the reliability of their public infrastructure, including roads, water, and electricity, to achieve sustainable economic growth while providing essential services such as healthcare, water access, and sanitation to their citizens (Camane, 2013). South Africa is no exception; it has recognized insufficient infrastructure as one of the six key limitations to growth (Selamolela, 2018). From an academic perspective, a swiftly expanding body of literature, beginning with the foundational research of Aschauer (1989), has aimed to measure the impact of infrastructure on economic growth and employment. In recent studies, the importance of infrastructure and its impact on economic growth were also emphasised by Yılmaz and Çetin (2018) and Timilsina, Stern, and Das (2021). This study aims to ascertain whether investing in public infrastructure can benefit the country in creating additional employment opportunities, thereby fostering economic growth, which in turn enhances the quality of life for its citizens. Additionally, it aims to explore the correlation between infrastructure investment, economic growth, and employment levels in South Africa.

Since the realisation of democracy in 1994, South Africa has faced ongoing socio-economic issues, including elevated unemployment rates, income disparity, and poverty. The nation's economic growth has not succeeded in generating a sufficient number of jobs to alleviate these three interconnected challenges. This is why the government has prioritised infrastructure in its agenda, intending to transform the economy to inspire growth and employment (Mbanda and Chitiga-Mabugu, 2017). The value of investing in social and economic infrastructure to the socio-economic progress of a state cannot be overemphasised. For this study, social infrastructure can be defined as investment in vital social services necessary for a society to function efficiently, including education, healthcare, and social services. Conversely, economic infrastructure can be defined as government investment in physical structures that facilitate economic activities, such as transportation, communication, and energy infrastructure (Vukeya, 2015). To address the said challenges, the government adopted various policies and strategies, including the 'Accelerated and Shared Growth Initiative of South Africa (ASGISA) introduced in 2006', 'the New Growth Path (NGP) established in 2010', and the more recent 'National Development Plan (NDP) released in 2012'. These initiatives remain pivotal in identifying and integrating the factors, processes, and actions that are necessary to firmly place the South African economy on the path of sustained economic development (Mbanda and Chitiga, 2013).

Infrastructure investment has been acknowledged by these and numerous other efforts as being crucial to firmly putting South Africa on a high-growth path (Fedderke, Perkins, and Luiz, 2006). A substantial amount of research has examined the potential benefits of infrastructure investment for development since the 1990s (World Bank, 1994; Perkins, 2011; Srinivasu and Rao, 2013; National Treasury, 2013). The studies indicate that developments in infrastructure could raise productivity, accelerate private investment (IMF, 2017), and enable domestic and international trade, thereby promoting balanced growth. Fedderke and Garlick (2008) concluded that there is a strong positive correlation between infrastructure and economic growth, supported by both theoretical and empirical data. These results are consistent with Kumo's (2012) conclusion that infrastructure spending promotes economic expansion and that a strong fundamental relationship exists between employment and economic growth.

Policymakers, particularly in developing countries, frequently face a critical question: how much they should invest in physical infrastructure with their limited financial resources, both domestically generated and provided by foreign sources such as bilateral and multilateral donors, as well as direct foreign investment (Timilsina, Stern, and Das, 2021). In 2008 and 2009, South Africa’s economic infrastructure investment was 6.05% and 7.64% of GDP. These years can be regarded as a high economic infrastructure investment period in the post-Apartheid era (Ntjatsane, 2017). In 2014, the South African government authorised capital expenditures totalling R847 billion for infrastructure developments, particularly for the transport and electricity sectors, while in 2015, R813.1 billion was budgeted for infrastructure spending, with R339 billion allocated to transport and R166 billion to the energy sector over the MTEF (National Treasury, 2015). However, despite this public infrastructure investment over the same period, the growth rate declined from 1.4% in 2014 to 1.3% in 2015, while the unemployment rate increased from 25.1% to 25.4%, respectively (IMF, 2024). This results from insufficient infrastructure investment (The Presidency, 2014).

As stated by the ‘National Planning Commission (NPC)’ in 2014, it is essential for emerging economies to allocate 25% of their GDP (gross domestic product) towards infrastructure to realize significant growth. Nevertheless, South Africa's ratio of infrastructure investment to GDP remains significantly below this critical benchmark. According to the ‘South African Reserve Bank (SARB)’, in 2024, the infrastructure investment to GDP ratio was noted to be 19.3% in 2013, which represents a considerable increase from the 14.9% ratio recorded in the year 2000. Furthermore, the national treasury budget review (2021) indicates that resources for expanding infrastructure and maintaining existing assets had not kept pace with inflation even before the onset of COVID-19. In many cases, the execution of projects and the quality of spending were notably inadequate, as evidenced by the information presented to the Judicial Commission of Inquiry regarding allegations of State Capture. Slowing economic growth from 2015 onwards, exacerbated by inconsistent power supplies, has further weakened South Africa's fiscal standing. The February 2020 Budget included 5% budget cuts across the three-year expenditure planning cycle. A further R10 billion was withdrawn from conditional infrastructure grants in the June

2020 Special Adjustment Budget, which redirected funds to the COVID-19 relief package and provincial health allocations. Additionally, during the 2024 MTEF budget, infrastructure conditional grants, including municipal grants, were further reduced due to the National Treasury's fiscal consolidation measures. The South African growth rate continues to deteriorate even further, with recent stats showing that GDP decreased by 0,1% in the first quarter of 2024 from 0,3 in quarter 4 of 2023, while unemployment increased to 32,9% from 32,1% respectively (Stats SA, 2024).

Given that South Africa is not meeting its growth objectives, despite investment in infrastructure being a top government priority, it has become important to investigate the rate of return on investment from different sectors within the government. Considering the above, the present study explores infrastructure from both economic and social viewpoints, while also assessing their impact on growth and the ability to create more jobs through upgrading, refurbishment, maintenance, or construction of new assets from a public sector's perspective, i.e., General government and public corporations.

The general government consists of national and provincial departments as well as municipalities entrusted with providing non-market goods and services for individuals and public consumption, such as health services, provision of basic water, and sanitation services (SARB, 2011). A public corporation can be described as an institution that operates independently of a government department but performs its tasks at arm's length from the central government. These corporations are funded by government departments through transfers and own revenue and are entrusted with the task of providing some public utility, trading, or manufacturing services for and on behalf of the State. They are established by an Act of Parliament and are also accountable to Parliament for their actions/activities (Ovens and Associates, 2013).

## 1.2 Problem Statement

The benefits of infrastructure cannot be disregarded, as research indicates that it contributes to economic growth by lowering production costs, raising the quality of life by supplying capital goods such as transport and communication services, and promoting macroeconomic stability (Ntjatsane, 2017). The South African government has committed significant financial resources to infrastructure development over the past few years to promote economic activity. In the 2018/19, 2019/20, and 2020/21 financial years, the government invested R216.2, R187.4, and R183.4 billion, respectively, towards public infrastructure developments (Budget Review, 2022). While literature from theorists such as Barro (1990), Keynes (1936), Solow (1956), and many others supports this growth strategy, numerous empirical studies carried out both locally and globally provide compelling evidence also supporting the beneficial effects of infrastructure investment on economic growth (Vukeya, 2015).

Given these conclusions, one would anticipate that the economic growth rate of South Africa would be significantly higher than it is now; however, despite this investment, the country's growth rate has not improved. Instead, the growth rate trend has gradually declined over time (National Treasury, 2014).

This is, although not surprising, as the South African government is confronted with a collapsing infrastructure that is failing to meet increased industry and consumer demand for services. Due to primary years of inadequate maintenance of the existing infrastructure, inadequate cost recovery, and service breakdowns, most of the nation's bulk infrastructure has reached the end of its lifecycle it needs to be refurbished, upgraded, or replaced (National Treasury Budget Review, 2021). Most government departments and state-owned enterprises do not have maintenance management plans or a sufficient budget for it; consequently, inadequate maintenance results in the economic cost of reduced business performance.

According to the National Treasury budget review (2020), frequent power outages and disruptions in the water supply cause a considerable increase in the running costs of businesses. Furthermore, if interruptions in electricity and water supply were eradicated, the potential economic benefits could range from 0.5% to 6% for brief and infrequent electricity outages, and from 0.5% to 2% for reduced durations of water interruptions. Nevertheless, the inadequate maintenance of the state-owned electricity supplier, Eskom, has led to a decrease in daily supply, jeopardising economic development as mining operations and businesses experience diminished output, while foreign investors lose trust and relocate their projects to other regions (Alexandra, 2015). Though there is an urgent need to address the energy supply, the South African economy has also suffered from inadequate capacity in several other infrastructure areas, including ports, railways, roads, and the water and sanitation sector's inability to manage services in small towns and rural areas, which remain unsolved (Ntjatsane, 2015).

Most communities in South Africa suffer from inadequate and unreliable infrastructure services; only 66% of people have access to improved water supply, 87% to electricity, and 67% to upgraded sanitation services. This is in contrast to upper-middle-class countries, where 87% of the population has access to better-quality water services, 93% to electricity, and 86% to improved sanitation (Ntjatsane, 2015). The Rooival Wastewater Treatment works in Hammanskraal is one of many examples of inadequate infrastructure maintenance in our country, which led to a tragedy in 2023. The residents of Hammanskraal and the surrounding areas experienced the outbreak of cholera, which consequently resulted in loss of life. The City of Tshwane municipality reported to the Parliamentary Portfolio Committee on Human Settlement, Water, and Sanitation in September 2019 that the water and wastewater services master plan is not being adhered to or implemented regarding the expansions and upgrades required for the infrastructure. Of the fifteen (15) wastewater treatment works, only two (2) are operating within the design capacity, and four (4) are at a critical state (i.e., Rooiwal, Klipgat, Baviaanspoort, and Sunderland Ridge).

In light of the above, it is therefore critical to assess both the immediate and prolonged effects of infrastructure investment on economic growth and employment in South Africa, as well as to ascertain whether the ongoing rise in capital investment is justified, particularly given the fact that it will come at a high cost to the government and thus taxpayers in the foreseeable future. Furthermore, credit rating agencies have questioned the South African government's credibility in preserving fiscal balance, resulting in the recent downgrades.

## 1.3 Research questions

The research aims to answer the following two questions:

Question 1

How does social and economic infrastructural investment impact economic growth and employment levels in South Africa?

Question 2

What is the relative impact of infrastructure investment (social and economic) by general government and public corporations on economic growth and employment levels in South Africa?

## 1.4 Research objectives

### 1.4.1 Main objective

In respect of this research, the study's main objective is to provide a comprehensive assessment of the impact that public infrastructure investment has on economic growth and employment in the South African economy from 1992-2024.

### 1.4.2 The specific objectives are to:

(i) Assess how social and economic infrastructure investment impacts economic growth and employment levels in South Africa;

(ii) Compare the impact of both social and economic infrastructure investment on economic growth and employment between the general government and public corporations in South Africa;

(iii) Make policy recommendations based on the findings.

## 1.5 Hypothesis

To achieve the objective of this research, the following two hypotheses are tested:

Hypothesis 1:

$H_0$: Investment in social and economic infrastructure does not exhibit any significant impact on economic growth and employment levels in South Africa.

$H_1$: Investment in social and economic infrastructure exhibits a significant impact on economic growth and employment in South Africa.

Hypothesis 2:

$H_0$: There is no significant difference in the impact of social and economic infrastructure investment on economic growth and employment between the general government and public corporations.

H1: There is a significant difference in the impact of social and economic infrastructure investment on economic growth and employment between the general government and public corporations.

## 1.6 Definition of key concepts

**1.6.1 Infrastructure investment:** The concept can be defined as investment in physical real assets such as roads, sewerage systems, energy, schools, hospitals, or clinics (Inderst, 2010). Projects related to infrastructure developments can be funded publicly, privately, or through public-private partnerships; however, this study will focus on funding or investment from the general government and public corporations only.

**1.6.2 Economic infrastructure:** Refers to government investment in physical infrastructure that supports economic activities, such as transportation, communication, and energy (Camane, 2013). Energy and Transport infrastructure spending will represent economic infrastructure.

**1.6.3 Social infrastructure:** Refers to investment in the essential social services a society needs to function effectively, such as education, healthcare, and social services (More and Aye, 2017). For this study, social infrastructure will be represented by spending on infrastructure projects by the Education and Health sectors.

**1.6.4 Economic growth:** Refers to the rise in the production of goods and services within an economy. Factors such as enhancements in capital goods, an expanding labour force, advancements in technology, and improvements in human capital all play a critical role in fostering growth (Potters, 2024). The Gross Domestic Product (GDP) will serve as a measure of growth, as it reflects the significance of the output generated and the services provided in an economy, thereby indicating the overall productive activity occurring within it.

**1.6.5 Employment:** In the context of this study, employment refers to the aggregate number of individuals engaged in the formal sector, excluding agricultural activities. Various sectors within the economy, including the mining sector, manufacturing, financial institutions, the construction industry, government entities, and state-owned enterprises, exemplify the institutions that offer formal employment opportunities in South Africa (Stats SA, 2024).

## 1.7 Significance of the study

The government's contribution to infrastructure investment has not been extensively studied; thus, this research seeks to expand the analysis in three specific domains. Firstly, this study examines the effects of both economic and social infrastructure on economic growth and job creation, since analysing both investments is of high significance and will assist in guiding the government's policy direction and decision-making. Several studies have been conducted on the subject matter; however, the bulk of the existing literature, such as studies done by Fedderke and Garlick (2008), Mbanda and Chitiga-Mabugu (2017), and Mbanda and Bonga-Bonga (2023), have all overlooked differentiating between economic and social perspectives and examining their different influence on growth. Exploring both types of infrastructure is vital for understanding their impact on economic policy. This study aims to enhance the existing body of knowledge by thoroughly examining both economic and social infrastructure. Secondly, the study will provide a comprehensive analysis of the relationships among key macroeconomic indicators, drawing on the latest data from 1992 to 2024. This approach enables a deeper evaluation of how these variables interact and influence one another. Lastly, this dissertation analyses the impact of both types of infrastructure from the public sector's perspective, by looking into the general government and public corporations. Importantly, it is hoped that the potential findings of this research will be of value to the South African government, policymakers, and researchers.

## 1.8 Organisation of the Study

This research is structured into six distinct chapters. The first chapter introduces the study and provides background information, detailing the research problem, objectives, questions, hypotheses, purpose, definitions of key concepts, and the significance of the study. Chapter two offers a comprehensive examination of how investments in public infrastructure influence economic growth and job creation. Additionally, it explores the trends associated with investments in energy, transportation, education, and health infrastructure in relation to economic growth. Chapter three outlines pertinent economic theories and reviews the existing empirical literature regarding the link between infrastructure investment, economic growth, and employment, while also highlighting gaps identified in the current literature on this topic. Chapter four presents the methodological framework to be utilised in the study, model specification, definition of variables, and the expected prior, and further provides an analysis of the adopted tests on the South African data. Chapter five offers a detailed presentation, interpretation, and analysis of the gathered data, illustrating how these findings are contextualized within the existing literature, while chapter six presents the overall summary of the study, conclusions, policy recommendations, and limitations of the study. The reference list and appendices are located at the end of the thesis.

# CHAPTER TWO

## OVERVIEW OF SOUTH AFRICA'S INFRASTRUCTURAL INVESTMENT, GROWTH, AND EMPLOYMENT

### 2.1 Introduction

This chapter aims to present a comprehensive overview of how investing in public infrastructure influences economic growth and employment levels in South Africa. It begins by defining public infrastructure and distinguishing between its two categories: social and economic infrastructure. Following this, the chapter offers an overview of public infrastructure investment in South Africa, detailing the benefits of infrastructure for economic growth, the social connections fostered by infrastructure, and trends in employment. The chapter concludes with a comparative analysis of the General Government and Public Corporations.

### 2.2 Public Infrastructure

The Framework for Infrastructure Delivery and Procurement Management (FIDPM) (2019) characterizes infrastructure as either immovable assets, which are obtained, built, or arise from construction activities, or as movable assets that cannot operate independently of purpose-built immovable assets. Infrastructure assets encompass a variety of facilities, including ports, airports, roads, bridges, tunnels, parking areas, educational institutions, healthcare clinics, hospitals, correctional facilities, power generation stations, water treatment facilities, and numerous other infrastructure goods that deliver essential services.

There are two categories of infrastructure: economic and social infrastructure. According to Inderst (2010), economic infrastructure is characterized as the type of infrastructure that facilitates economic activities, which includes roads, highways, electrical lines, railroads, airports, seaports, telecommunications, electricity, water supply, and sanitation. Selamolela (2018) proposed that economic infrastructure can be classified into three distinct categories. The initial category encompasses utilities such as power, gas, telecommunications, water, sanitation, and waste management; the second category consists of public works, including roads, water catchments in reservoirs, irrigation systems, and drainage facilities; whereas the final category comprises transportation sub-sectors like railroads, waterways, seaports, airports, and urban transit networks. Social infrastructure encompasses educational institutions such as schools and other learning facilities, healthcare establishments, nursing homes, defence and judicial buildings, correctional facilities, and sports stadiums (Inderst, 2010). However, the author cautioned that there are significant grey areas in infrastructure classification, as it depends largely on the motive for which the classification is done (Camane, 2013).

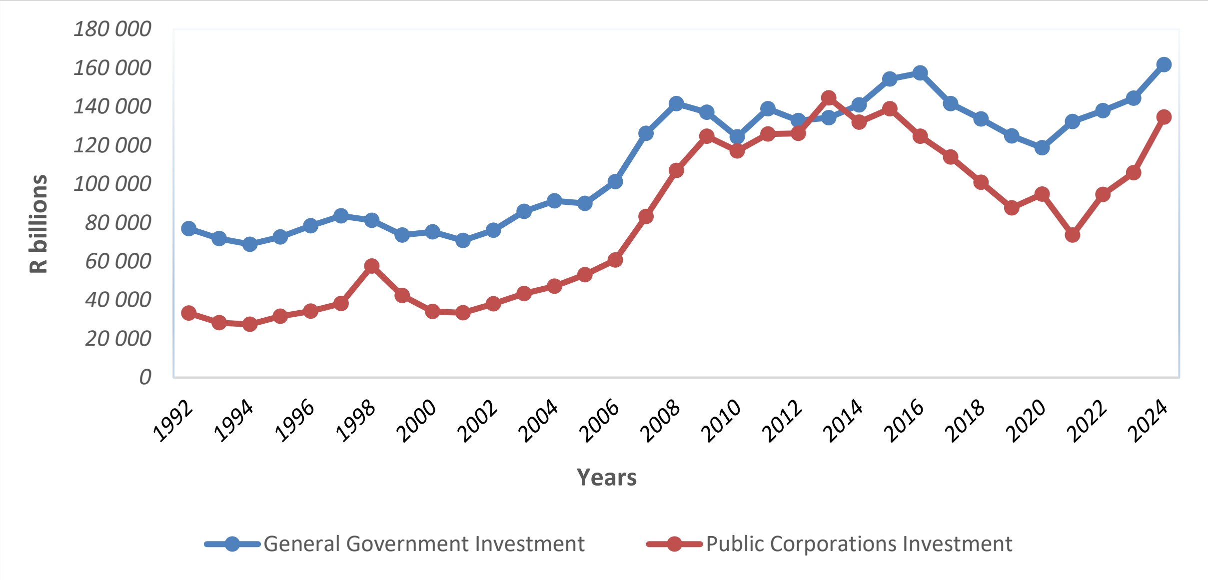
This study focuses on both categories of infrastructure; however, for economic infrastructure, the focus will be on the transport and energy sectors only, and for social infrastructure, the focus will be on the health and education sectors only. Moreover, Infrastructure can be measured both monetarily and physically. Financial measurements examine the expenditures made in infrastructure. Physical measurements differ depending on the infrastructure under consideration, such as the number of schools constructed each year or the total length of roads that have been repaired (More and Aye, 2017). This study will measure infrastructure financially using expenditure outcomes obtained from the South African Reserve Bank statistics data and the National Treasury.

## 2.3 Overview of Infrastructural Investment in South Africa

Throughout the apartheid period, a significant portion of the government's financial resources was allocated to infrastructure projects that primarily benefited the white population. This resulted in minimal investment in the social infrastructure for the black majority and other racial groups. Such detrimental fiscal decisions exacerbated poverty and widened the gap of inequality, as capital expenditures on essential services such as education, healthcare, housing, municipal services, and welfare for the majority were compromised to support the infrastructure development for a privileged minority (More and Aye, 2017).

After 1994, given the imperative of addressing basic needs, the focus of the democratic government shifted to reversing the injustices of the past by correcting the imbalances in the infrastructure sector and beginning to focus on the country's reconstruction and development. By the end of the second decade of democracy, significant progress had been made in the delivery of social infrastructure, despite the economic challenges posed by poverty, poorly located and inadequate infrastructure, elevated unemployment rates, and sluggish growth rates. South Africa has excelled in comparison to global standards for the majority of the post-1994 era (Presidency, 2014). Access to an improved basic level of sanitation increased from 61,7% in 2002 to 83,1% in 2024. Access to improved sources of clean water increased from 84.4% in 2002 to 87.7% in 2024. The proportion of households connected to the mains electricity supply rose from 76.7% in 2002 to 90.2% in 2024, which coincided with a decline in the consumption of wood (from 20.0% to 7.7%) and paraffin (from 16.1% to 2.2%) during the same period (General Household Survey, 2024).

**Figure 2.1: Trends in Public Sector Infrastructure Spending**




*Source: Own graph based on SARB data (2024)*

Figure 2.1 above illustrates the performance of public sector investment in infrastructure from 1992-2024, which shows that the South African government prioritized investing in the general government as social infrastructure had to be given priority as before 1994, the nationalist government channelled public funds towards building social services that served mainly the white minority and towards reinforcing the security of the apartheid state (Presidency, 2014). In 1994, a new democratically elected government took office and updated and developed socioeconomic policies aimed at addressing lower growth rates, poorly placed infrastructure, inequalities, joblessness, and deprivation caused by the Apartheid government (Ncube et al. 2012). In so doing, by the end of the first decade of democracy, the government through the 'Reconstruction and Development Programme (RDP) of 1994' and the 'Growth, Employment and Redistribution (GEAR) of 1996', had built an estimated 1.6 million subsidised houses, about 56.000 new classrooms and 38.000 school toilets, with 2 700 more schools receiving potable water and about 4.000 more schools being connected to electricity. Health services have expanded into new regions, marked by the establishment of more than 700 new clinics, the enhancement of an additional 212 clinics, the acquisition of 215 mobile clinics, and the refurbishment of 2,298 clinics. Three modern tertiary hospitals, comprising more than 2,000 beds, were constructed as part of the Hospital Rehabilitation and Reconstruction Programme. In addition, the government facilitated basic water supply for over 9 million additional individuals, ensured access to fundamental sanitation, and provided approximately 4 million more electricity connections to underprivileged households. (Presidency, 2014).

In the early 2000s, the democratic government began investing more in projects of economic value as a way of stimulating economic activities and dealing with the demands of the growing economy by increasing spending on public corporations such as the energy sector through the construction of the two (2) major coal-fired power stations, Medupi and Kusile, in 2005. The telecommunication sector was modernised through public and private investment in cellular infrastructure and increased access to telephone, television, postal services, and later data communications. A new airport was built in Durban, and those in major cities expanded and improved (Presidency, 2014). All these initiatives were designed to enhance economic activities recognized by programmes such as the' Accelerated and Shared Growth Initiative of South Africa (ASGISA), established in 2006', the 'New Growth Path (NGP) introduced in 2010', and the 'National Development Plan (NDP) launched in 2012', which are considered crucial drivers for economic growth and job creation.

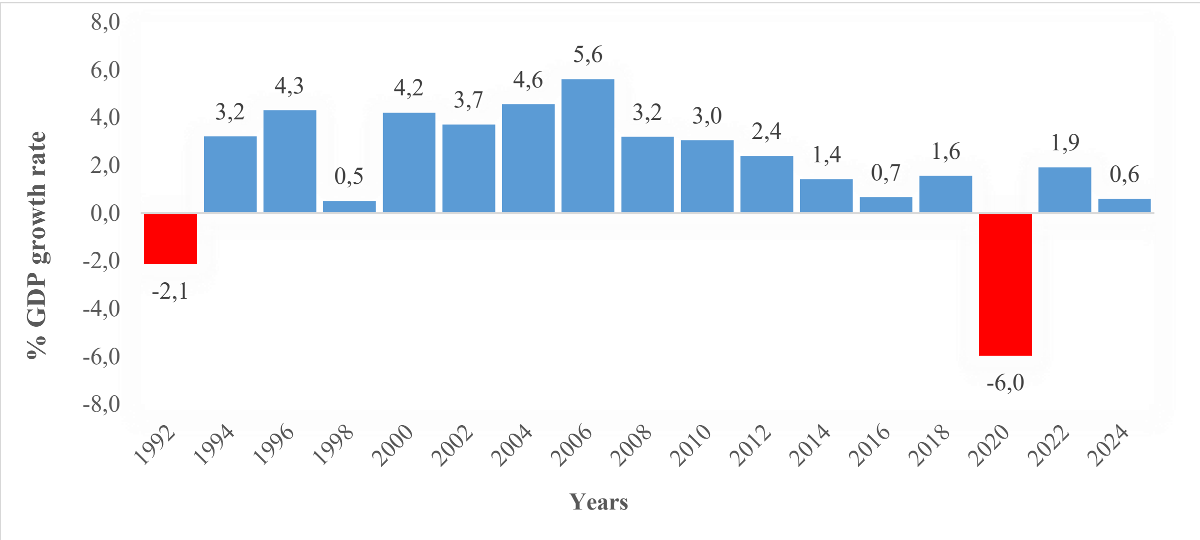
### 2.3.1 Infrastructure and Economic Growth Benefits to the Economy

The correlation between infrastructure and economic development has been extensively researched. Empirical studies demonstrate that infrastructure investment increases output in the long run, improves productivity, simplifies commerce, and improves access to key services, ultimately boosting total economic activity and quality of life (Calderón and Servén, 2010; Srinivasu and Rao, 2013; Timilsina, Stern, and Das, 2023). Furthermore, infrastructure serves as an input that enhances the overall efficiency of other inputs in the production process, while also fostering opportunities for economic connections. It enables the private sector, individuals, and government to respond to evolving demands across various regions (Yılmaz and Çetin, 2018). Investing in world-class infrastructure makes the country more attractive to businesses and investors, which boosts investment and spurs economic expansion. Construction of roads and the establishment of transmission lines linking rural regions to national networks facilitate the participation of individuals, enterprises, and communities in income-generating activities. These roadways offer access to markets and incorporate them into the broader economy (Vukeya, 2015). Labour-intensive construction programmes, particularly in the rural parts of the country, frequently lead to short- to medium-term employment opportunities, thereby contributing to the reduction of rural poverty (Kumo, 2012).

The buildup of well-maintained infrastructure correlates positively with a country's economic performance and development (Ntjatsane, 2017). The World Bank (2014) found that prioritizing the quality of infrastructure rather than its quantity leads to a notable correlation between increased investment in infrastructure and economic development. This highlights the necessity of a suitable blend of effectively managed infrastructure to tackle issues related to development and economic growth. To capitalise on development opportunities and drive economic growth, existing infrastructure assets must be properly financed and managed to enhance productivity and durability. According to the National Treasury budget review (2022), cost-benefit analysis should be used to guide the selection and upkeep of infrastructure projects to promote economic growth. Furthermore, the National Treasury should transition from merely recommending to enforcing a mandatory requirement linked to the annual budget and conditional grants distribution,  by making the ring-fencing of maintenance budget a prerequisite for receiving all infrastructure grants (PFMA, 1999).

South Africa has invested less in infrastructure than its counterparts. Since 1990, it has spent less than 20% of GDP on critical capital investments. The reduction in investment, particularly following 2008, can be partially linked to the global financial crisis, which had a detrimental impact on public sector financing and spending capabilities (Budget Review, 2022). Nonetheless, in 2022, the proportion of capital investment relative to GDP rose to 14.2%, up from 13.1% in 2021. However, in the year 2023, this percentage fell to 15.2% (MTDP, 2025). To reach the NDP target, infrastructure investment must increase to 30% of GDP by 2030 (National Treasury, 2022). The South African government has allocated R983.7 billion for public sector infrastructure spending during the 2024/25 MTEF.

**Figure 2.2: Trends in South Africa's Real GDP Growth Rate 1992-2024**




*Source: Own graph based on Stats SA data (2024)*

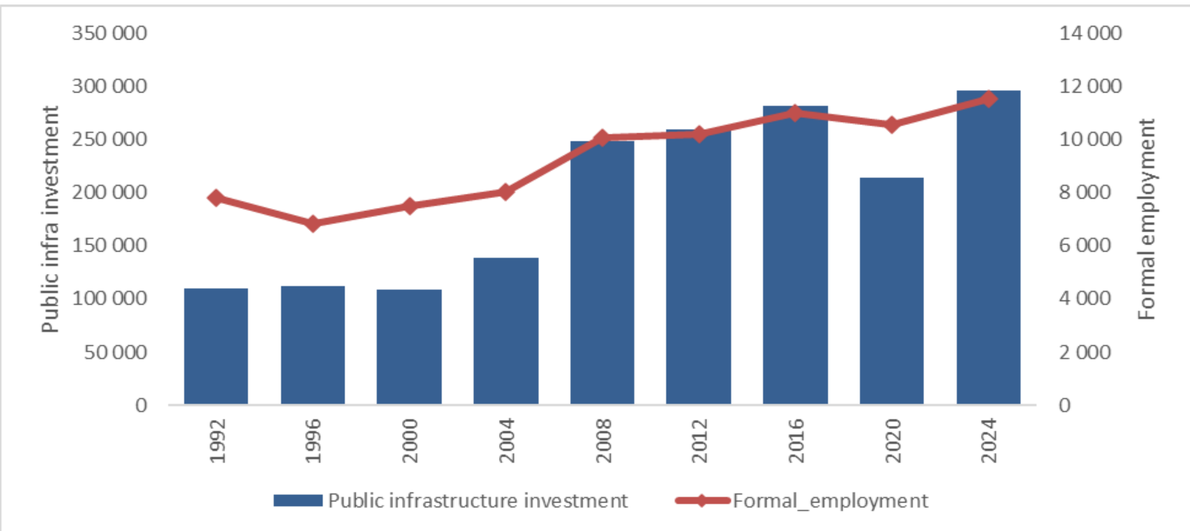
The South African economy has faced numerous challenges, characterised by fluctuating GDP growth, high unemployment rates, and a persistent energy crisis. During the ten years leading up to 2024, the average real GDP growth rate was around 1.0%, a growth rate that fails to adequately address the significant levels of unemployment and poverty (Budget Review, 2024), a growth rate that is significantly lower than the Sub-Saharan Africa average of 3.0% (IMF, 2024). From an economic perspective, South Africa struggles with one of the highest unemployment rates in the world, estimated at around 33%, while youth unemployment surpasses 50% (Statistics South Africa, 2024). Ongoing power outages and the inadequate condition of ports and rail freight are still negatively impacting businesses and exports (Budget Review, 2024). Additionally, the high cost of living continues to strain household finances, leading to hesitance among businesses to invest, as they are discouraged by economic uncertainties and a lack of confidence (New Development Bank Report, 2024).

2.3.2 Infrastructure and Social Links

The contributions of publicly provided sanitation systems, clean water, schools, health facilities, and housing are helping to meet basic human needs while enhancing the quality of life and promoting social well-being (DBSA, 2025; Gnade et al., 2017). More and Aye (2017) argue that the availability and ability to utilise infrastructure facilities have a substantial impact on people's quality of life and productivity. Furthermore, as noted by Gnade et al. (2017), the welfare effect is more pronounced in communities that have access to a comprehensive set of essential infrastructure services, as compared to those where certain components of infrastructure services are lacking. Access to an efficient transport system, improved school facilities, and a safer road network help to raise school attendance. Furthermore, access to electricity provides more time for studying and computer use (Calderon and Serven, 2010).

Infrastructure investment makes a substantial contribution to job creation across various sectors. The construction, engineering, and associated industries witness a rise in job opportunities during both the construction and maintenance stages of infrastructure initiatives. Additionally, improved infrastructure has the potential to stimulate private-sector investments, leading to further employment opportunities and economic development (Vukeya, 2015). The Lufhereng (Soweto) mega housing project initiated by the City of Johannesburg has already created 7,000 jobs since its inception. The R22 billion mega project is part of the government's effort to provide reasonably priced housing to low-income families. The project will be implemented in 10 phases to develop over 30,000 houses, and it is expected to reach completion in 2029 (Charlton, 2017).

**Figure 2.3: The Relationship between Public Infrastructure Investment and Employment**




*Source: Own graph based on Stats SA and SARB data (2024)*

Figure 2.3 illustrates that investment in public infrastructure was relatively stable from 1992 to 2000; while employment experienced a decline until 1996, followed by a steady rise until the year 2000. This indicates that other factors played a more significant role in driving employment during the initial years of the democratic transition. Between 2004 and 2016, this timeframe represented the most robust period of a positive relationship. With a notable increase in public infrastructure investment starting in 2004, formal employment also exhibited a consistent upward trajectory, reaching its peak around 2016.

This indicates that substantial public spending, exemplified by preparations for significant events such as the FIFA World Cup in 2010, has stimulated major activities within the construction industry. This, in turn, resulted in job creation, as the construction sector is typically labour-intensive, offering employment opportunities for individuals across various skill levels. A significant decline in 2020 for both variables may be attributed to the economic repercussions of the COVID-19 pandemic, which necessitated the closure of numerous industries. This situation resulted in job losses across various sectors nationwide. Following the pandemic in 2020, both infrastructure investment and employment showed a positive recovery trend up to 2024. Based on the trends observed, there is substantial evidence indicating a positive correlation between investments in public infrastructure and employment levels, thereby reinforcing the perspective that spending on public infrastructure serves as a crucial catalyst for job creation in South Africa (NDP, 2012).

## 2.4 A Comparative Analysis between General Government and Public Corporations

### 2.4.1 The General Government

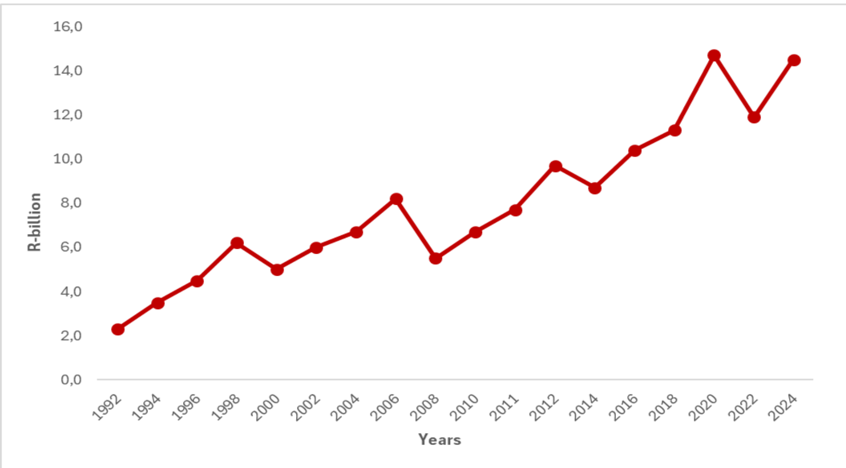
It is responsible for providing non-market goods and services for individuals and public consumption, such as health services, education facilities, housing, and the provision of basic water and sanitation services provided by national, provincial, and local governments. In this study, the general government will be represented by health and education infrastructure spending. As noted by Gnade et al. (2017), social infrastructure can enhance both the economic growth and social advancement of the country's citizens, while also ensuring more effective utilization of basic infrastructure. Furthermore, economic growth and social development can significantly contribute to confronting long-term growth issues in South Africa, such as the persistently high unemployment rates and the inadequate quality of human capital (More and Aye, 2017).

#### *2.4.1.1 Health Infrastructure Development*

The development of health infrastructure in South Africa is crucial for improving public health outcomes, stimulating economic growth, and ensuring equitable access to healthcare services. Investing in this sector is crucial for modernising facilities, improving service delivery, and supporting national health initiatives, such as the National Health Insurance (NHI), as well as addressing challenges like inequity and the effects of climate change. Reflecting on South African history, it is evident that many of the current challenges faced by the healthcare system are significantly influenced by the country's past. The legacy of decentralisation during the apartheid era, characterized by the creation of various independent health departments across Bantustan regions, has led to a fragmented healthcare system. This system, marked by inadequate coordination and disparities in service delivery, continues to create obstacles for current initiatives focused on providing equitable healthcare today (SAMRC, 2024).

The South African government provides funding for health facilities through a conditional grant named Health Facility Revitalisation Grant (HFRG), whose purpose is to fund the construction of new facilities, and upgrade, rehabilitate, and maintain the existing ones, particularly in areas where infrastructure is lacking or outdated (DoRA, 2024/25). In the 2023/24 budget, the National Treasury emphasised the necessity of climate-resilient and sustainable infrastructure in light of the growing frequency of catastrophic weather events such as floods.  The KwaZulu-Natal province in 2024 faced devastating floods that destroyed 84 health facilities. With no additional funds from the Fiscus, the provincial health department had to re-prioritise an estimated R184 million intended for other health priorities to repair the damages. This also applies to the Eastern Cape, where 12 health facilities were destroyed, yet there have been no specific additional funding allocations to aid in the recovery of these facilities (SA News, 2025). Neglecting to invest in health infrastructure that is robust enough to endure severe weather events induced by climate change will compel South Africa to persist in depending on disaster relief funds or reallocating dedicated funds to address losses and damages. This approach is both expensive and unsustainable, providing minimal mitigation against the anticipated detrimental effects of climate change on health infrastructure and systems.

**Figure 2.4: Trends in the Health Infrastructure Investment**




*Source: Own graph based on National Treasury data (2024)*

Figure 2.4 depicts the trend in health infrastructure investment spanning from 1992 to 2024. The overarching trend indicates a notable, although fluctuating, long-term rise in health infrastructure. Throughout the past three decades, the South African government has prioritized investment in health infrastructure, as evidenced by a substantial nominal increase, reaching up to R13.5 billion in 2024. The initial increase in spending from 1994 to 1999 was driven by a robust policy initiative aimed at correcting the imbalances from the apartheid era by enhancing access to fundamental social infrastructure, particularly primary healthcare clinics in neglected areas. This required substantial investment in either new or improved primary healthcare facilities. The decline observed in the years 2000, 2008, and 2014 may be attributed to inadequate performance in infrastructure delivery, characterized by project delays and poor contractor performance, which led to ineffective spending. Additionally, the global financial crisis of 2008 impacted numerous sectors, and stricter fiscal controls were implemented, alongside a shift in economic focus towards other sectors, which may have further contributed to this decline.

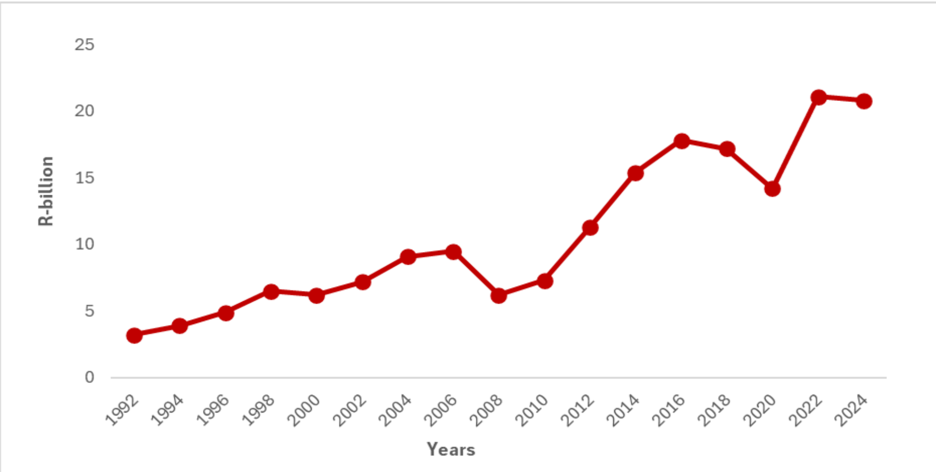
The significant increase in expenditure observed in 2020 can be attributed to heightened infrastructure investments prompted by the COVID-19 pandemic. This period prioritized health initiatives, which included the establishment of field hospitals, testing and isolation facilities, and upgrading hospital capacities, particularly in intensive care units (ICUs), to accommodate the surge in patients, leading to a temporary increase in capital expenditures. In contrast, the decrease noted in 2022 stems from budget reductions enacted by the National Treasury as part of fiscal consolidation efforts; these reductions affected all conditional grants, notably the Health Facility Revitalization Grant. The anticipated increase towards 2024 reflects a sustained commitment to strengthening the health system and ongoing initiatives aimed at rectifying maintenance and infrastructure shortcomings within the public sector.

#### *2.4.1.2 Education Infrastructure Development*

Education is a fundamental right for every child, and access to quality education is crucial for their development (Ndungane et al, 2024). Educational institutions in developing nations, including South Africa, face a range of challenges related to infrastructure development, which are shaped by economic, political, socio-cultural, geographical, and environmental factors. Economic constraints, marked by a lack of financial resources, hinder substantial investments in school infrastructure, resulting in issues like insufficient facilities and overcrowded classrooms (World Bank, 2018). Inadequate school infrastructure and uneven distribution of resources adversely impact students' academic performance and success, restrict teachers' capacity to deliver effective instruction, and contribute to increased absenteeism rates among both educators and students (Maldonado and DeWitte, 2020).

Delivering the best-quality education in the rural regions of South Africa presents distinct challenges. In the Eastern Cape Province, rural educational institutions encounter substantial infrastructure problems that hinder the delivery of quality education to numerous children (Ndungane et al, 2024). The Eastern Cape Department of Education (ECDoE) has encountered various difficulties in adhering to the Minimum Uniform Norms and Standards for Public School Infrastructure (MUNSPSI) regulations, which aim to ensure that all schools meet specific minimum requirements for offering quality education. Despite these regulations, numerous rural schools in the Eastern Cape lack vital services such as electricity, water, and sanitation. They face substandard building conditions, have restricted access to technology and Internet connectivity, and struggle with inadequate funding for infrastructure development, which resulted in the shutdown of schools in certain regions, leading to disruptions within the community and necessitating that learners travel considerable distances to merged schools, often without sufficient transportation options (Ndungane et al, 2024). Tackling these infrastructure issues is essential for enhancing the academic performance and educational results of rural schools in the country (Kaffenberger, 2021). Casale and Shepherd (2021) contend that having sufficient infrastructural facilities is essential for creating a supportive learning environment for students. On the other hand, proper facilities can significantly enhance equity, boost enrolment figures, and lower dropout rates. Furthermore, research indicates that high-quality infrastructure enhances student performance (Maldonado and DeWitte, 2020).

**Figure 2.5: Trends in the Education Infrastructure Investment**




*Source: Own graph based on National Treasury data (2024)*

Figure 2.5 above displays the trends in education infrastructure investment from 1992 to 2024, highlighting the democratic government's dedication in addressing historical inequalities. This dedication spurred the initial consistent growth from the 1990s through the mid-2000s, followed by a surge in investment from 2010 to 2016. The funds were allocated for the construction of new schools, the upgrading and replacement of mud schools, the eradication of pit toilets, and maintenance backlogs. The downturn observed in 2008 and 2020 can be attributed to the global financial crisis and the COVID-19 pandemic, both of which adversely impacted spending as the construction sector was significantly affected by these economic challenges.

### 2.4.2 Public Corporations

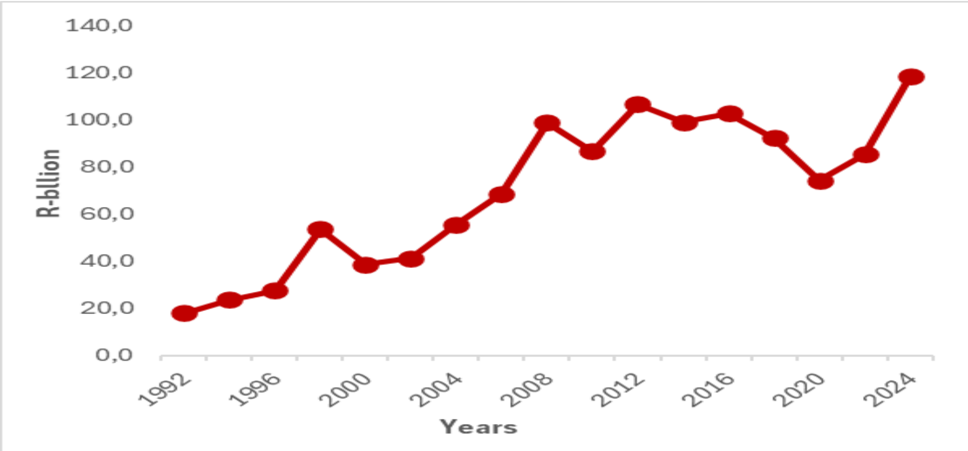
In South Africa, public corporations, commonly referred to as State-Owned Enterprises (SOEs), play an essential role in the economy, often serving as instruments for economic development, poverty alleviation, and the provision of vital services. These entities are created to tackle market deficiencies and guarantee access to essential infrastructure services such as energy, transportation, and water, while also fostering social equity (Fourie, 2014). SOEs are typically established to deliver public goods and services in areas where the private sector may lack the capacity or willingness to invest. They play an important role in ensuring that essential infrastructure services, including energy, transport, and water, are available to all citizens, thereby promoting social equity. As the owner and shareholder, the state holds SOEs accountable for their performance, while simultaneously refraining from interfering in their commercial decision-making (National Treasury, 2024). In this study, the Public Corporations will be represented by transport and energy sector infrastructure spending.

#### *2.4.2.1 Transport Infrastructure Development*

Most developing countries continue to rely on transport infrastructure as a significant driver of development (Diaz, 2021). The quality of transport infrastructure is crucial to international competitiveness and trade facilitation (OECD, 2018; DBSA, 2023). An efficient transportation network enables companies to effectively manage their inventory, transport it at a low cost, and gain access to a variety of suppliers and markets for their products, benefits the working class by allowing them easier access to employment, and connects rural areas to the mainstream economy, ultimately boosting productivity and improving living conditions (Selamolela, 2018). The transport infrastructure is crucial for the economic and social advancement of South Africa; it accounts for approximately 8% of the nation’s Gross Domestic Product (Stats SA, 2024).

Inadequate transportation infrastructure weakens productivity, fosters poor market integration, and affects export levels (Diaz, 2021). Lack of investment, inadequate maintenance, and operational difficulties in ports, freight, and rail are plaguing South Africa's transport industry, which continues to impede the nation's export potential and disrupt economic activity (CESA, 2023). Additionally, the sector's ability to generate jobs and increase output is reduced by inefficient transportation networks, high fuel prices, and regulatory barriers that raise operating costs (Malapane, 2024). As the second-largest economy in Africa, South Africa has a substantial trading relationship with many countries (IMF, 2024); therefore, the importance of a dependable and efficient road infrastructure network cannot be underestimated if the region aims to enhance its intra-regional trade and achieve full market integration (Kgamanyane, 2015). Moreover, reliable infrastructure is a crucial element that potential investors evaluate when determining whether to invest in a nation.

**Figure 2.6: Trends in the Transport Infrastructure Investment**




*Source: Own graph based on National Treasury data (2024)*

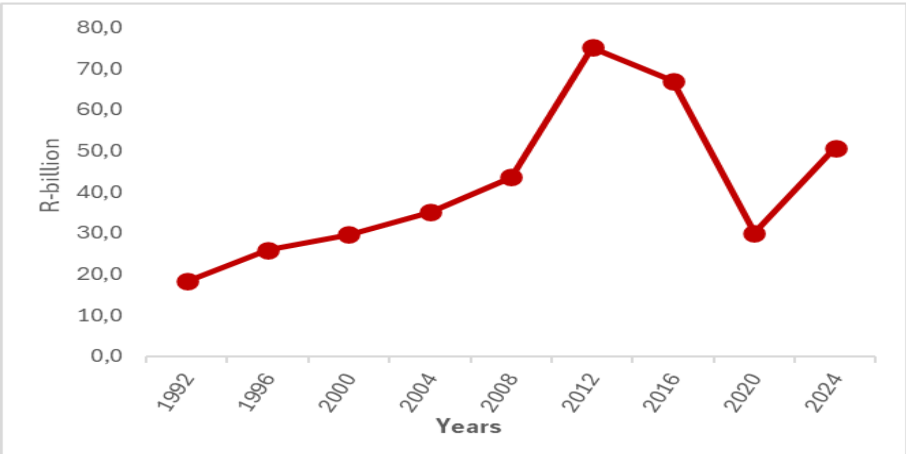
As presented above, the trends in transport infrastructure are influenced by cycles of economic growth, fiscal capabilities, and the priorities set by government policies. There was a consistent low-level growth from 1992 to 1998, which was followed by a brief decline in 2000, succeeded by a robust and accelerated growth phase that saw an increase from R40 billion in 2001 to R98 billion in 2008. This substantial investment was driven by a policy initiative, specifically the 'Accelerated and Shared Growth Initiative of South Africa (ASGISA)', aimed at enhancing the economy's potential growth through the development of economic infrastructure. Additionally, the transport sector gained from the government's initiative to enhance the public transport system in preparation of the 2010 FIFA World Cup. The decline observed in 2012 corresponds with a phase characterized by a low GDP growth rate and escalating pressures from sovereign debt; consequently, the government was compelled to restrict public expenditure. Furthermore, there was a reduction in capital spending due to the inefficiencies present in major transport state-owned enterprises (SOEs) such as Transnet. The sector has faced substantial challenges in executing projects effectively, which include inadequate project preparation, cost overruns, and capacity limitations. These issues have significantly contributed to the instability and underperformance of key SOEs within the transport sector following the decline in 2012. Following the aftermath of the COVID-19 pandemic in 2020, the sector is beginning to show signs of recovery.

#### *2.4.2.2 Energy Infrastructure Development*

South Africa has a well-established electricity network and one of the highest electricity access rates in sub-Saharan Africa (IEA, 2020). In both urban and rural areas, electricity is the most popular and preferred option for home use, such as cooking and lighting. However, due to the ageing infrastructure and capacity limitations, the country's rolling blackouts have had a damaging effect on local industry and economic growth (Energy Annual Report, 2022). The generation capacity of Eskom, South Africa's state-owned utility, which represents 95% of the total net maximum, has faced supply challenges since 2007. This situation is largely attributed to the ageing coal-fired power stations that are deteriorating in quality, nearing the end of their economic lifespan, and have undergone minimal maintenance in recent years (Energy Annual Report, 2023). The inability to meet existing demands, coupled with insufficient investment, results in obstacles to economic development and growth (Ntjatsane, 2017). In 2023, South Africa suffered over 330 days of load-shedding, even though it had a technical reserve margin of more than 30% (New Development Bank, 2024).

South African policymakers have been aware of the competing energy challenges and have sought to expand the sources of power generation and lower emission levels by initiating Eskom's Just Energy Transition (JET) to progress the evolution towards a cleaner and greener energy future (New Development Bank, 2024). All South Africans will benefit from a more reliable and sustainable energy supply by integrating renewable energy sources such as wind, solar, and hydroelectric power into the energy mix. This transition aligns with global trends that prioritize clean and sustainable energy solutions to tackle climate change concerns (Energy Annual Report, 2023). The National Treasury has set aside R219.2 billion for the 2025/26 MTEF for energy infrastructure projects (Budget Review, 2025).

**Figure 2.7: Trends in the Energy Infrastructure Investment**




*Source: Own graph based on National Treasury data (2024)*

Figure 2.7 depicts the trends in energy infrastructure investment in South Africa spanning from 1992 to 2024. This trend is marked by an extended period of moderate growth from 1992 to 2008, during which the sector concentrated on addressing electrification backlogs and expanding the grid to previously underserved regions, particularly within black communities. A surge in investment occurred from 2009 to 2012, driven by a crisis as the national grid faced near-collapse conditions due to the aging power fleet. Consequently, the construction of two significant coal-fired power stations, Medupi and Kusile, along with other initiatives, was launched, resulting in an investment boom. The steady decline in investment from 2013 stemmed from governance issues within Eskom, which hindered the capacity to effectively implement additional large-scale capital projects, ultimately leading to poor performance. The significant decline observed in 2020 is linked to the economic impact of the COVID-19 pandemic;

however, in the aftermath of the pandemic, the sector began to show signs of recovery, as investment is now driven by the ongoing energy crisis characterized by loadshedding and load reduction, alongside investments in renewable energy and grid enhancement.

In the forthcoming three years, it is projected that public infrastructure expenditures will amount to R1.029 trillion, as illustrated in Table 2.1 below.

**Table 2.1: Public Sector Infrastructure Expenditure and Estimates, 2021/2022 - 2027/2028**

| R billion | 2021/22 | 2022/23 Outcomes | 2023/24 | 2024/25 Revised estimate | 2025/26 | 2026/27 Medium-term estimates | 2027/28 | MTEF Total |
|---|---|---|---|---|---|---|---|---|
| **Energy** | 35,5 | 38,7 | 46,1 | 50,7 | 66,2 | 73,4 | 79,6 | 219,2 |
| Water and sanitation | 30,6 | 35,4 | 27,5 | 45,3 | 49,9 | 50,1 | 56,3 | 156,3 |
| **Transport and logistics** | 65,9 | 86,4 | 75,1 | 118,3 | 133,1 | 137,7 | 131,1 | 402,0 |
| Other economic services | 21,8 | 18,9 | 48,1 | 23,0 | 22,1 | 19,5 | 20,0 | 61,5 |
| **Health** | 16,4 | 11,9 | 13,1 | 14,5 | 15,6 | 14,8 | 15,0 | 45,5 |
| **Education** | 14,5 | 21,1 | 14,5 | 20,8 | 19,4 | 19,3 | 18,3 | 57,0 |
| Human settlements | 13,4 | 14,3 | 21,3 | 17,8 | 17,3 | 15,6 | 16,3 | 49,2 |
| Other social services | 2,2 | 3,3 | 0,5 | 2,9 | 2,6 | 2,5 | 2,5 | 7,6 |
| Administration services | 12,0 | 9,0 | 10,7 | 10,1 | 11,3 | 9,8 | 10,1 | 31,2 |
| **Total** | **212,3** | **238,8** | **256,9** | **303,5** | **337,5** | **342,8** | **349,3** | **1 029,5** |
| National departments | 12,5 | 13,2 | 14,2 | 15,0 | 15,0 | 12,6 | 12,6 | 40,1 |
| Provincial departments | 57,7 | 60,1 | 73,2 | 77,1 | 75,5 | 69,6 | 70,8 | 215,9 |
| Local government | 62,1 | 64,7 | 56,8 | 69,7 | 67,7 | 65,1 | 68,0 | 200,8 |
| Public entities[3] | 20,2 | 26,8 | 26,4 | 33,4 | 45,3 | 47,4 | 44,1 | 136,8 |
| Public-private partnerships | 6,5 | 6,0 | 6,8 | 7,1 | 7,9 | 8,4 | 8,7 | 25,0 |
| State-owned companies[3] | 53,4 | 67,9 | 79,4 | 101,2 | 126,0 | 139,8 | 145,1 | 410,9 |
| **Total** | **212,3** | **238,8** | **256,9** | **303,5** | **337,5** | **342,8** | **349,3** | **1 029,5** |

*Source: The National Treasury Budget Review (2025).*

The above Table 2.1 presents spending outcomes and the latest forecasts regarding public sector infrastructure expenditures, emphasizing both 'economic and social infrastructure' investments. Spending on social infrastructure, evidenced by cuts in health and education, has been declining due to fiscal consolidation measures by the government, leading to a reduction in government expenditure. This has directly affected the funding available for projects related to social infrastructure, such as schools, hospitals, housing, and other social services. A significant portion of the decline is attributed not only to budget reductions but also to the inability to utilise the funds that have been allocated.

As illustrated in the table above, the government has prioritised spending on economic infrastructure, evidenced by a rise in energy, transport, and water and sanitation sectors, which are directed towards large-scale projects deemed essential to stimulate economic growth. This demonstrates the commitment of the democratic government to enhance infrastructure investment; however, given the growing demands for services and the insufficient maintenance funding for infrastructure, the government is required to devise innovative methods and strategies to bridge the funding gaps that can be addressed through private financing.

## 2.5 Conclusion

This chapter offered a summary of the investments in social and economic infrastructure in South Africa, highlighting their role in fostering growth and generating employment. The literature reviewed in this chapter reveals that the development of infrastructure for both the economy and communities is a primary method through which South Africa aims to achieve inclusive and employment-rich growth (Joynt, 2019). Previous studies have highlighted that infrastructure investment increases output in the long run, improves productivity, and access to key services, ultimately boosting total economic activity and quality of life (Calderón and Servén, 2010; Srinivasu and Rao, 2013; Timilsina, Stern, and Das, 2023).

South Africa has, over the years, experienced significantly high levels of unemployment and low growth rates driven by a combination of structural, economic, and social factors. The country's economy has faced challenges in creating enough job opportunities to keep pace with the expanding workforce, resulting in what is referred to as "jobless growth" (World Bank, 2024). Infrastructure bottlenecks represent one of the fundamental limitations that have contributed to economic stagnation and elevated unemployment rates. Insufficient and inadequately maintained infrastructure, particularly in the areas of energy and logistics, has constrained economic activities. The country's dependence on Eskom has resulted in frequent and lengthy power outages, pushing businesses to either stop production or invest in costly alternative power solutions, which diminishes their competitiveness and deters investment. Similarly, challenges with the rail and port systems overseen by Transnet have impeded the transportation of goods, particularly affecting crucial export sectors such as mining (World Bank, 2024).

Despite the country's commitment to enhance investment in infrastructure through public funding, the financial requirements to address infrastructure challenges are immense and the magnitude of investment necessary significantly surpass the capabilities of the government alone; therefore, it is essential to acknowledge more innovative approaches such as financial pledges, donations, foreign direct investment, including private-sector involvement via public-private partnerships (PPPs), which not only improve public funding but also have the potential to release skilled professionals capable of conducting feasibility studies and determining the financial viability of projects (DBSA, 2023).

Most of the literature pertinent to this study has examined the correlation between economic infrastructure investment and economic growth, with little attention to the literature concerning social infrastructure. Recent research has predominantly concentrated on individual variables, including the development of rail networks (Fosu, 2021) and transportation accessibility (Banerjee, Duflo, and Qian, 2020). This study aims to close this gap by investigating the effects of both social and economic infrastructure on growth and employment in South Africa, building upon the foundational works of Kumo (2012), Kaya (2013), and Vukeya (2015).

# CHAPTER THREE

## LITERATURE REVIEW: THEORIES AND EMPIRICAL STUDIES

### 3.1 Introduction

This chapter offers a comprehensive analysis of the existing literature concerning theories and empirical research related to infrastructure investment, economic growth, and employment. The first section introduces pertinent theories aimed at investigating the factors influencing economic growth and employment levels. The subsequent section reviews relevant empirical evidence from developing and developed countries, as well as literature dedicated to South Africa. The final section concludes the chapter.

### 3.2 Theories of Economic Growth

This section seeks to examine the theoretical rationale behind public infrastructure investment and its connection to economic growth and employment in South Africa. The theories under review include: the general theory of employment, interest, and money; the Solow growth model; and the primary theoretical framework for this research is the Cobb-Douglas production function theory. The equation of the production function will be utilised to select suitable variables for the study.

#### 3.2.1 The General Theory of Employment, Interest, and Money

Keynes (1936) developed this theory, intending to uncover the underlying factors that influence fluctuations in levels of total production and employment. He suggests that the levels of output and employment are influenced by present production choices, which are in turn shaped by current investment decisions and anticipations regarding both existing and prospective demand. Importantly, he emphasizes the critical role of short-term investments and proactive government intervention in boosting total income, productivity, and job creation (Vukeya, 2015). This theory, which focuses on the impact of repeated shocks that significantly reduce aggregate demand, is linked to the premise that increasing government expenditure to generate employment and facilitate the use of infrastructure capital enhances the overall demand within the economy, thereby stimulating economic activities, growth, and job creation (Keynes, 1936). He further argues that consumption spending is endogenous and influenced by total earnings, which are in turn affected by the level of employment. He goes further to demonstrate the positive correlation between employment and productivity, asserting that the anticipated revenue generated from the output produced by the employed workforce affects the demand for labour. According to this theory, new investments are determined by the anticipated returns, which are affected by interest rates. When interest rates are low, as a result of adjustments in monetary policy, investment is stimulated. Thus, a rise in investment spending will result in an increase in employment in firms that manufacture capital goods. Newly employed workers in the capital sector will spend some of their earnings on consumption goods and save what is left of their income. Furthermore, an increase in demand for consumer products will result in greater employment opportunities within consumer goods sectors, thereby initiating further cycles of expenditure. Rather than relying on monetary policy to stimulate investment from the private sector, Keynes (1936) advocates for direct government engagement in capital investment to address failures in the markets and economic uncertainty. He argues that economies are inherently unstable, and that maximum efficiency can only be achieved by government policy and public investment (Vukeya, 2015). Keynes' (1936) theory serves as the foundation for this study by acknowledging the critical role of government investment in promoting economic growth.

### 3.2.2 The Solow Growth Model

Solow's (1956) growth theory is classified as an exogenous model within the neoclassical economic growth paradigm. This economic theory, developed by Robert Solow and Trevor Swan, describes the pathways through which infrastructure can exert a beneficial influence on economic growth. This theory builds upon the 'Harrod-Domar growth model' established in 1946. Solow seeks to interpret the factors that drive long-term growth and illustrate how the accumulation of capital, efficient employment, and population growth contribute to economic development. He discovers that technological advancement has enduring effects on the output and growth of an economy. The model predicts that in a steady-state (long-run economic equilibrium), the level of income per capita will be influenced by saving rates, population growth, and technological advancement, which are considered exogenous. The significance of technological advancement as a crucial component of a nation's input lies in its ability to enhance production and improve the efficiency of the labour force (Broughel and Thierer, 2019; Olawale, 2024). For example, the introduction of nanotechnology in the re-gravelling of roads using polymer material could reinforce road surfaces and significantly reduce water seepage (Writer, 2023). According to a study by Jordaan and Steyn (2022), the new age nano-modified emulsions (NME) are a technological solution that can extend the lifespan of roads and reduce damage caused by overloading, which is one of the biggest problems facing South Africa at the moment.

Moeketsi (2017) indicates that numerous nations share fundamental characteristics necessary for the advancement and development of their infrastructure economy. These characteristics include stable governments that implement pragmatic economic policies, the provision of essential infrastructure and services, and a commitment to a long-term economic outlook. The Solow model asserts that a sustained surge in capital spending results in a temporary elevation of the growth rate, as the ratio of capital to labour inputs increases. In the long run, however, the marginal returns from additional infrastructure capital may decline, causing real GDP to expand at a rate that corresponds to the growth of the labour force, supplemented by a factor that reflects enhanced productivity. The Solow model posits that a continuous growth in capital spending leads to a temporary boost in the growth rate, as the capital-to-labour input ratio rises (Vukeya, 2015). Nevertheless, in the context of long-term economic growth, the marginal returns from additional units of infrastructure capital may diminish, with real GDP expanding at a rate equal to the growth of the labour force, augmented by a factor that accounts for enhanced productivity (Olawale, 2024).

The supply of goods in the Solow model is grounded in the production function, which indicates that output is contingent upon the capital stock and the labour force, represented by the notation: $Y = F(K, L)$. In this equation, Y denotes output, K signifies capital, and L represents labour. An increase in output is reliant on capital growth through investment and depreciation, while any enhancement in labour is dependent on supply driven by population growth. This equation demonstrates constant returns to scale and diminishing returns for each factor of production (Selamolela, 2018). The model assumes that output grows at a diminishing rate as the level of capital utilised increases. In addition, this theory describes growth as a complex phenomenon influenced by multiple causes. These elements include innovation, technology, convergence, investment, and institutional arrangements (Selamolela, 2018). The model suggests that output grows at a decreasing rate as the amount of capital utilised increases. Furthermore, this theory characterizes growth as a multifaceted phenomenon shaped by various factors. These factors encompass innovation, technology, convergence, investment, and institutional frameworks (Selamolela, 2018). The significance of this theory in the context of the study is that enhancing one of the production factors, such as investing in infrastructure, results in greater output and economic development, based on the premise that more individuals will gain employment through the construction of roads, hospitals, and numerous other capital goods.

The Solow-Swan model does not provide a holistic perspective on the complete growth process, as technological advancement or the increasing returns associated with new knowledge act as the main drivers for long-term economic stability (Ozdemir, 2017). The shared premise of this argument is the capacity to enhance the economy through the augmentation of knowledge rather than through labour. Additionally, the model neglects to consider the positive relationship between saving and investment rates and the growth of income per capita among different countries (Vukeya, 2015). Consequently, the Cobb-Douglas Production Function theory presents a more effective explanation of the public sector's role and its contributions to economic growth.

### 3.2.3 The Cobb-Douglas Production Function Theory

A Cobb-Douglas production function illustrates the relationship among two or more variables, particularly physical capital, labour, and various other metrics that can be generated by these variables. It is utilised to assess the ratios of inputs relative to each other for the purpose of optimizing manufacturing efficiency and to evaluate technological advancements in production methods (McKenzie, 2020). The Cobb-Douglas production function is a commonly used economic model owed to the mathematician Charles Cobb and the economist Paul Douglas, (1928) after whom it is named.

Although this model provides a streamlined perspective of the economy, especially considering the multitude of additional factors and inputs that influence economic performance, it has proven accuracy (Vukeya, 2015). The model is based on a multiplicative representation of the economy:

$$\gamma = \mathrm{A}\mathrm{K}^{\beta 1} L^{2} \qquad (2.1)$$

Where Y is denoted as GDP per capita, $A$ determines the level of technology, K signifies infrastructure investment, and L denotes labour, and infrastructure services are assumed to be non-rival and non-excludable, to support these assumptions. For infrastructure investment, the Cobb-Douglas equation's marginal product represents the impact of a change in investment on GDP per capita (y), while all other inputs remain constant. Thus, total productivity is measured by:

$$\mathrm{A} = \frac{\mathrm{Y}}{\mathrm{K}^{\beta 1}\mathrm{L}^{\beta 2}} \qquad (2.3)$$

The parameters $\beta 1$ and $\beta 2$ denote the shares of output attributed to capital and labour, respectively. When the total of these coefficients equals one, it indicates the presence of constant returns to scale; conversely, if this total exceeds or falls short of one, it suggests the existence of increasing or decreasing returns to scale.

The Cobb-Douglas production function model represents this study's core theoretical background and is used to select the suitable variables needed for analysis. The variables include two dependent variables, namely: growth in gross domestic product and total employment, with five (5) independent variables, namely: energy infrastructure investment, transport infrastructure investment, health infrastructure investment, education infrastructure investment, and foreign direct investment.

## 3.3 Empirical Literature

The literature on the effects of public infrastructure investment on economic growth was pioneered by Aschauer (1989a, 1989b). Using a production function method that considers both private and public capital, the elasticity of output concerning public capital is calculated to be 0.34 to 0.39. Aschauer's work sparked a significant increase in the literature. Subsequent analyses using the same methods on international, regional, and sector-specific data failed to duplicate such huge effects and more often found no significant beneficial effects, which made most researchers question Aschauer's approach, and most of the earlier literature was questioned on econometric grounds (Vukeya, 2015; Selamolela, 2018). Further empirical studies were undertaken regarding the topic. Aschauer’s (1989) research gained support from researchers like ‘Munnell (1990a) and Lynde and Richmond (1993)’, who similarly identified a beneficial relationship between infrastructure investment and economic growth.

This section reviews the impact of public infrastructure investment on economic growth and employment in the South African economy over the past three decades, building on Aschauer's contributions and recent literature on the subject matter. The study will review relevant empirical studies in developed and developing countries, as well as in South Africa.

### 3.3.1 Empirical Overview from Developed Countries

The empirical literature on public infrastructure investment in developed economies reveals a fundamental, though not universal, agreement on its growth-enhancing effects. While the majority of researchers support a positive correlation, consistent with the foundational work of Aschauer (1989a, 1989b), a critical synthesis of recent findings suggests that the extent and nature of this impact are significantly dependent on the time frame and the specific infrastructure sector under consideration. In the province of Quebec in Canada, between 1997 and 2002, Boccanfuso et al. (2015) employed a dual approach to model the contribution of public spending on infrastructure, and the findings support a favourable relationship between public capital and economic growth. Another study that identified a positive correlation is the investigation by Pereira and Pihno (2011), which examined the effects of public investment on long-term output from 1980 to 2003, focusing on twelve European countries. The results demonstrated that effective public investment significantly contributes to growth in eight out of the twelve eurozone countries. Another study conducted by Martinez and Singh (2022) also focused on European cities to determine how public transport infrastructure investment affects neighbouring regions. The study used a spatial autoregressive model to capture inter-regional linkages and found that transit investments in one location generated favourable externalities for neighbouring regions, resulting in a "multiplier effect" on economic growth. This demonstrated that well-planned transport investments could set off a chain reaction of growth, benefiting not only the investing region but also its neighbouring countries.

While Pereira and Pinho (2011) and Boccanfuso et al. (2015) identify robust long-term output gains across the Eurozone and other developed nations, these benefits are not always immediate. This is highlighted by Zhang and Cheng (2023), who explored the relationship between the development of transport infrastructure and economic growth in the UK, utilizing the Vector Error Correction Model (VECM) to reveal that transport development can actually exert a substantial negative effect on economic development in the short term. This suggests a "J-curve" effect where the initial fiscal burden and construction disruptions may temporarily outweigh the eventual productivity gains found in long-term studies like those of Yılmaz and Çetin (2018), and Timilsina et al. (2023), who argued that infrastructure investment increases output in the long run, improves productivity, and access to key services, ultimately boosting total economic activity and quality of life.

The literature further diverges when examining different infrastructure types. Broadband and digital assets appear to offer more uniform returns; Czernich et al. (2011) investigated the effects of broadband infrastructure on economic growth in OECD countries from 1996 to 2007, and the results revealed that a 10% enhancement in broadband infrastructure led to an annual GDP per capita increase ranging from

0.9% to 1.5%. In contrast, the findings regarding physical transport are more complex. Martinez and Singh (2022) emphasized that transport generates a "multiplier effect" that benefits neighbouring regions. However, Olawale (2024) offers a critical perspective within the United States context, arguing that if transportation systems are poorly designed or managed inefficiently, they may act as a barrier rather than a driver of growth. This suggests that the quality and connectivity of the network are more indicative of growth than simply the amount of gross fixed capital formation (GFCF).

The empirical analysis of developed countries reveals a broad consensus regarding the beneficial effects of infrastructure investment on economic growth, along with variations in the degree and nature of this impact. Ultimately, while Fosu and Twumasi (2022) and Yılmaz and Çetin (2018) support the conventional perspective that diversified infrastructure investment (in areas such as water, energy, and aviation) enhances overall economic performance, the "negative" outliers identified in the literature of Zhang and Cheng (2023) and Olawale (2024) provide valuable insights. These studies indicate that the "broad consensus" on positive outcomes is constrained by the methodological approaches employed. Studies focusing on long-term productivity tend to yield favourable results, whereas those examining short-term shocks or system inefficiencies reveal the underlying risks of public capital expansion.

### 3.3.2 Empirical Overview from Developing Countries

The empirical landscape in developing nations suggests that while infrastructure is a "fundamental prerequisite" for development, its impact is highly sensitive to financing strategies and sectoral priorities. Unlike developed economies, where the focus often lies on maintenance or high-tech upgrades, the literature on emerging markets emphasizes the role of infrastructure in structural transformation and poverty alleviation. Sahoo et al. (2012) examined the impact of infrastructure on economic growth. The study focused on the role of infrastructure, particularly physical infrastructure, in facilitating economic development in China using various econometric techniques, including ARDL, GMM, and VECM. The findings reveal that both human capital and infrastructure developments significantly contribute to growth, thereby validating China's substantial investment in infrastructure development since the early 1990s. This indicates that for emerging nations to achieve sustained economic growth, infrastructure investment is most effective when paired with policies that enhance labour productivity. This multi-dimensional strategy is supported by Batool and Akbar (2023), who emphasize a "whole-sector" perspective, particularly highlighting energy and telecommunications as the key drivers of extensive economic development throughout South Asia.

A crucial point of divergence in the research pertains to the funding mechanisms of these projects and the timeline for their returns. Ahmed et al. (2013) offer a detailed perspective on Pakistan, demonstrating that although both tax-financed and debt-financed infrastructure ultimately result in a multiplier effect, the selected fiscal approach determines the extent of GDP growth (1.01% compared to 1.29%, respectively). Furthermore, the "gestation lag" observed in developed countries is even more evident in developing regions. Acharya et al. (2024) investigated the long and short-term relationship between transport infrastructure investment and economic growth in Nepal. The study revealed a notable short-term negative impact on growth, which eventually becomes positive over time. This indicates that for low-income nations, the initial fiscal shock resulting from substantial transport investments may lead to a temporary decline in growth prior to the realization of long-term advantages associated with trade and connectivity, as noted by Dhungel (2020), who also focused on Nepal's growth, and Syadullah and Setyawan (2020), whose study focused on Indonesia.

The impact of infrastructure also appears to be sector-specific, leading to conflicting empirical results. While Oladipo (2015) investigated the relationship between road infrastructure development, poverty rates, and economic growth in Nigeria and found a positive link between road expansion and poverty reduction, the results for other sectors are less consistent. For instance, Apurv and Uzma (2020) explored the impact of infrastructure development on economic growth within the BRICS nations, Brazil, Russia, India, China, and South Africa, employing the ordinary least squares regression technique (OLS), and the results revealed that telecommunications investments can sometimes show an inverse correlation with growth, whereas energy remains positive. These results contradict the findings of Olawale (2024), who found electricity coverage (EI) to have a negative yet statistically insignificant impact in different geographic contexts, implying that although the provision of electricity is crucial, other elements might play a more substantial role in fostering economic growth. Furthermore, these discrepancies suggest that infrastructure efficacy is geography dependent; factors such as population density and existing industrial maturity determine whether a new energy grid or transport link actually unlocks economic potential.

The inference derived from the above literature indicates that the impact of infrastructure investment on economic growth in emerging economies is an increasingly contentious subject. This issue has attracted significant interest in contemporary academic research and policy discussions. A majority of the studies referenced above establish a positive correlation between infrastructure development and economic growth, whereas some report only a slightly positive or negligible association. Many factors are responsible for these varying results, such as differences in econometric methods, financing constraints, specific econometric proxies used to measure infrastructure, the different development stages of the countries included in the sample, varying periods, and geographical factors such as high or low population density.

Empirical Overview from South Africa

The body of literature concerning infrastructure in South Africa has evolved from foundational assessments of output elasticity to complex analyses of structural breaks and sectoral interdependencies. While the broad consensus supports a positive relationship between public capital and economic growth, a critical synthesis reveals that the direction of causality and the magnitude of sectoral shocks remain key points of academic discussion. Early South African research, such as that by Abedian and Van Seventer (1995), Coetzee and Le Roux (1998), and the Development Bank of Southern Africa (DBSA) (1998), established the positive effect baseline using the Ordinary Least Squares (OLS) estimation technique. These initial studies identified output elasticities varying between 0.17 and 0.33, providing the first empirical evidence that infrastructure is a driver of growth. However, recent literature has moved towards more sophisticated techniques to capture the "multiplier effect." For instance, Ngandu et al. (2010) utilized Structural Path Analysis (SPA) to demonstrate how infrastructure spending specifically around the 2010 FIFA World Cup created a shock that pervaded the construction, tourism, and hospitality sectors. Similarly, Mbanda and Chitiga-Mabugu (2017) used dynamic Computable General Equilibrium (CGE) analysis to quantify the impacts of increasing public economic infrastructure investment on economic growth and employment, and the results indicate that investing in infrastructure not only raises GDP but also reduces unemployment by stimulating aggregate labour demand.

Kumo (2012) introduced a significant dimension by accounting for the 1994 structural break, revealing a bidirectional link where growth and infrastructure reinforce each other. This suggests a virtuous cycle where infrastructure creates jobs, which in turn drives demand for more infrastructure. On the contrary, Gadinabokao and Daw (2013) found a unidirectional relationship, arguing that while public capital is a "Granger cause" for long-term growth, its short-term impact can be negligible or even slightly negative (-0.02). This tension suggests that the economic benefits of South African public capital are primarily realized over extended horizons rather than through immediate fiscal stimuli. While a significant portion of recent research, such as Selamolela (2018), Moeketsi (2017), and Hlotywa & Ndaguba (2017), has focused heavily on transport infrastructure as a proxy for development, the literature reveals a notable gap, as most studies emphasize economic infrastructure (roads, energy, and telecommunication) due to its direct link to productivity and the 2010 World Cup legacy. However, as noted by Kumo (2012) and Kularatne (2005), the social implications, such as poverty reduction and quality of life, are often secondary to GDP metrics in the current empirical body.

The South African literature review confirms that infrastructure investment is a core driver of economic advancement, yet the returns are non-linear. The conflict between the bidirectional findings of Kumo (2012) and the unidirectional findings of Gadinabokao and Daw (2013) highlights that the impact of public capital may depend on the specific economic climate or era being studied. By moving beyond the transport-heavy focus of existing literature, there is a clear academic need to analyse the interconnection between economic and social infrastructure, ensuring that public investment fosters not just GDP growth, but a viable and inclusive society.

Assessment of Empirical Literature

A number of research studies have been conducted worldwide regarding the impact of infrastructure investment on economic growth and job creation. Evidence from both developed and developing countries, including South Africa, illustrates the mixed nature of the findings on this topic; nevertheless, the majority of studies indicate a positive link between infrastructure investment and economic growth. The body of literature focused on assessing the economic effects of both economic and social infrastructure is, however, quite limited, with most research concentrating exclusively on the effects of economic infrastructure on growth and transport infrastructure, potentially overlooking the transformative power of social infrastructure. Research that has examined both ‘economic and social infrastructure’, such as the works of Kaya (2013) and Sahoo et al. (2012), has yielded diverse results based on the indicators employed for various categories of social infrastructure.

However, despite these findings, there are still gaps in our understanding of the precise effects of various forms of infrastructure and how they interact with other economic variables. The present study therefore, aims to close this gap by focusing on the South African recent data from 1992 to 2024 and investigating the distinct roles of public infrastructure investment by general government and public corporations, with a focus on transport, energy, education, and health infrastructure investment on economic growth and employment, to provide a more holistic understanding of how public capital can foster a sustainable, inclusive, and high growth economy.

## 3.4 Conclusion

This chapter explored the following theories: ‘The general theory of employment, interest, and money’; the Solow growth model; and the Cobb-Douglas production function theory. The chapter also reviewed empirical evidence from developed and developing countries, as well as literature from South Africa. The prevailing consensus amongst the reviewed literature is that increased public infrastructure expenditure is generally favourable to economies around the world, and most of the literature reviewed concurs with the notion that investing in public infrastructure has a beneficial effect on economic growth and employment, which is consistent with economic theories reviewed in this study.

The following chapter presents the analysis of the impact of public infrastructure investments on economic growth and employment in the South African economy from 1992-2024 and further discusses all the estimation techniques relevant to the study and procedures thereof.

# CHAPTER FOUR

## RESEARCH DESIGN AND METHODOLOGY

### 4.1 Introduction

This research seeks to explore the effects of investments in social and economic infrastructure on economic growth and employment, while also comparing the returns on these investments between the general government and public corporations in the South African economy. The primary aim of this chapter is to examine all pertinent estimation methods and model specifications that will be evaluated throughout the estimation process in Chapter 5 of this research. A thorough discussion will be provided on the concept of stationarity, the Bounds test for co-integration, and Autoregressive Distributed Lag (ARDL) analysis. These will be calculated to assess the short-term adjustment dynamics and the long-term relations that exist between the chosen macroeconomic variables. These include economic growth (GDP), employment, energy infrastructure investment, transport infrastructure investment, education infrastructure investment, health infrastructure investment, and foreign direct investment (FDI). The study analyses this relationship by utilizing yearly time series data covering the period from 1992 to 2024 using the EViews 12 software program to estimate empirical findings. To conduct an effective quantitative data analysis, researchers typically utilize two main statistical instruments; the first is associated with 'descriptive analysis', which statistically defines, integrates, and displays the variables of interest. The second is linked to 'inferential analysis', which statistically assesses the hypothesis (Bhattacherjee, 2019). This study will employ both descriptive and inferential analysis methods to investigate the relationship between public infrastructure investment, economic growth, and employment.

### 4.2 Research Design

This research follows a correlational research design and employs a quantitative research methodology that utilises secondary data analysis. Quantitative research fundamentally depends on the gathering of observable variables. As noted by Creswell (2009), quantitative research entails the numerical representation and manipulation of data to explain and interpret the phenomena that these observations signify. This technique can further be employed to spot trends and averages, formulate hypotheses, investigate causality, and generalise results to larger populations (Bhandari, 2022). The quantitative approach to be used in this study is the correlational analysis technique, which will be used to determine the extent of the relationship between infrastructure investment, economic growth, and employment using statistical data.

## 4.3 Data Sources

The study uses annual time-series data from 1992 to 2024, thus giving 32 observations, to capture recent trends and developments in infrastructure, economic growth, and employment in South Africa. The data is sourced from Statistics South Africa (Stats SA), the South African Reserve Bank (SARB), National Treasury (NT), and the United Nations Trade and Development Data Hub (UNCTAD). These esteemed organizations are known for generating official and trustworthy data that has been subjected to quality assurance evaluations. The data is freely accessible through the institutions' websites or by e-mail request. Ensuring the reliability and precision of the gathered data is essential, and measures were taken to confirm compatibility and resolve any inconsistencies among various data sources. All six variables, i.e., employment, foreign direct investment, energy, transport, education, and health infrastructure investment, excluding GDP, were converted into logarithmic form, as it allows for coefficients to be interpreted as elasticity values, thus enabling the researcher to interpret the percentage change between two variables. GDP remained in its original form, as it is already represented as a percentage. Furthermore, all financial figures are expressed in the local currency, specifically the South African Rand, and all infrastructure values are at 2015 constant prices. The gathered data underwent descriptive analysis to reveal trends, patterns, and relationships among public infrastructure investment, employment, and economic growth variables. Additionally, the data was analysed using E-Views 12 to facilitate the simplification and interpretation of the time series data utilised in this research.

## 4.4 Model Specification

The study adopts and modifies Vukeya's (2015) model, which is based on the Cobb-Douglas production function. Vukeya's study analysed the impact of government economic and social infrastructure investment on South African economic growth for the period 1983-2013. Single and multiple equation methodologies were utilised to conduct an econometric evaluation.

The model is as follows:

$$\mathrm{Y} = \mathrm{F}\ (\mathrm{K}, \mathrm{G}, \mathrm{L}) \qquad (4.1)$$

Where Y, representing output, is determined by private capital K, public capital G, which includes both physical and human capital, and labour L. The Cobb-Douglas production function, as expressed in equation (4.1), can be formulated as:

$$Y\mathrm{t}=AX_{1t}^{\beta 1}\ X_{2t}^{\beta 2}\ X_{3t}^{\beta 3}\ X_{4t}^{\beta 4}\ \mathrm{e}^{\mathrm{ui}} \qquad (4.2)$$

where:

$Y$ = Gross domestic product (GDP)

$A$ = Intercept coefficient

$X1$ = Private capital investment (PVT)

$X2$ = Economic infrastructure investment (INF)

$X3$ = Total employment (EMP)

$X4$ = Expenditure on health and education (HE)

$\beta i$ = Exponential $Xi$ coefficients

$eui$= Exponential error term

This study specifies the model as follows:

**Model 1: The Growth Model for General Government**

$GDPG\mathrm{t} = f(HEAt, EDUt, FDIt)$ (4.3)

With all variables in logarithmic terms, the model is as follows:

$GDPG_t = \beta_0 + \beta_1 \mathrm{Ln}HEA_t + \beta_2 \mathrm{Ln}EDU_t + \beta_5 \mathrm{LnFDI}_t + \varepsilon_t$ (4.4)

**Model 2: The Growth Model for Public Corporations**

$GDPG\mathrm{t} = f(ENEt, TRAt, FDIt)$ (4.5)

With all variables in logarithmic terms, the model is as follows:

$GDPG_t = \beta_0 + \beta_3 \mathrm{Ln}ENE_t + \beta_4 \mathrm{Ln}TRA_t + \beta_5 \mathrm{LnFDI}_t + \varepsilon_t$ (4.6)

**Model 3: Employment Model for General Government**

$EMP\mathrm{t} = f(HEAt, EDUt, FDIt)$ (4.7)

With all variables in logarithmic terms, the model is as follows:

$\mathrm{Ln}EMP_\mathrm{t} = \beta_0 + \beta_1 \mathrm{Ln}HEA_t + \beta_2 \mathrm{Ln}EDU_t + \beta_5 \mathrm{Ln}FDI_t + \varepsilon_t$ (4.8)

**Model 4: Employment Model for Public Corporations**

$EMP\mathrm{t} = f(ENEt, TRAt, FDIt)$ (4.9)

With all variables in logarithmic terms, the model is as follows:

$LnEMP_t = \beta_0 + \beta_3 \mathrm{ln}ENE_t + \beta_4 \mathrm{ln}TRA_t + \beta_5 \mathrm{ln}FDI_t + \varepsilon_t$ (4.10)

Where:

- $GDPG_t$: Growth in Gross Domestic Product
- $EMP_t$: Total Employment
- $ENE_t$: Energy Infrastructure Investment
- $TRA_t$: Transport Infrastructure Investment

- $HEA_t$: Health Infrastructure Investment
- $EDU_t$: Education Infrastructure Investment
- $FDI_t$: Foreign Direct Investment
- $\beta_0 - \beta_5$ = coefficient parameters
- $\varepsilon_t$ = error term

The study has two dependent variables: growth in gross domestic product (GDPG) and employment (EMP). The explanatory variables include energy infrastructure investment (ENE), transport infrastructure investment (TRA), health infrastructure investment (HEA), and education infrastructure investment (EDU). Foreign direct investment (FDI) is a control variable in the study.

## 4.5 Definition of Variables and Expected Signs

**Table 4.1: Growth Model for General Government (Model 1)**

| Variable | Symbol | Definition | Expected sign | Reference |
|---|---|---|---|---|
| Growth in Gross Domestic Product | **GDPG** | GDP will be used as an indicator of economic growth, and can be defined as an increase in the production of goods and services in an economy. | Dependant Variable | - |
| Health Infrastructure Investment | **HEA** | Refers to spending on infrastructure projects by the health sector in South Africa. | + | Vukeya (2015); More and Aye (2017). |
| Education Infrastructure Investment | **EDU** | Refers to spending on infrastructure projects by the education sector in South Africa. | + | More and Aye (2017); DBSA (2024). |
| Foreign Direct Investment | **FDI** | Refers to an ownership stake in a foreign project made by an investor, company, or government from another country. | + | Mathebula (2023); Woldemedhin (2021). |

**Table 4.2: Growth Model for Public Corporations (Model 2)**

| Variable | Symbol | Definition | Expected sign | Reference |
|---|---|---|---|---|
| Growth in Gross Domestic Product | **GDPG** | GDP will be used as an indicator of economic growth, and can be defined as an increase in the production of goods and services in an economy. | Dependant Variable | - |
| Transport Infrastructure Investment | **TRA** | Refers to spending on infrastructure projects by the transport sector in South Africa. | + | Selamolela (2018); Acharya et al. (2024). |
| Energy Infrastructure Investment | **ENE** | Refers to spending on infrastructure projects by the energy sector in South Africa. | + | Olawale (2024); DBSA (2024). |
| Foreign Direct Investment | **FDI** | Refers to an ownership stake in a foreign project made by an investor, company, or government from another country. | + | Mathebula (2023); Woldemedhin (2021). |

**Table 4.3: Employment Model for General Government (Model 3)**

| Variable | Symbol | Definition | Expected sign | Reference |
|---|---|---|---|---|
| **Total Employment** | **EMP** | Employment indicates the total number of people employed in the formal sector. | **Dependant Variable** | - |
| Health Infrastructure Investment | **HEA** | Refers to spending on infrastructure projects by the health sector in South Africa. | **+** | Vukeya (2015); More and Aye (2017). |
| Education Infrastructure Investment | **EDU** | Refers to spending on infrastructure projects by the education sector in South Africa. | **+** | Leoni (2025); DBSA (2024). |
| Foreign Direct Investment | **FDI** | Refers to an ownership stake in a foreign project made by an investor, company, or government from another country. | **+** | Makhoba (2018); Flores (2022). |

**Table 4.4: Employment Model for Public Corporations (Model 4)**

| Variable | Symbol | Definition | Expected sign | Reference |
|---|---|---|---|---|
| **Total Employment** | **EMP** | Employment indicates the total number of people employed in the formal sector. | **Dependant Variable** | - |
| Transport Infrastructure Investment | **TRA** | Refers to spending on infrastructure projects by the transport sector in South Africa. | **+** | Kumo (2012); Mbanda and Chitiga-Mabugu (2017). |
| Energy Infrastructure Investment | **ENE** | Refers to spending on infrastructure projects by the energy sector in South Africa. | **+** | Eberhard et al. (2020); Dirma et al. (2024). |
| Foreign Direct Investment | **FDI** | Refers to an ownership stake in a foreign project made by an investor, company, or government from another country. | **+** | Makhoba (2018); Flores (2022). |

## 4.6 Estimation Technique and Procedures

The study employs the Autoregressive Distributed Lag (ARDL) approach to cointegration or bounds testing methodology of Pesaran and Shin (1998) and Pesaran et al. (2001) to determine the long-run relationship or cointegration between variables. The selected cointegration technique can handle mixed integration orders, that is, integrated at level $I(0)$ and at first difference $I(1)$, in contrast to conventional cointegration tests that require variables to be integrated of the same order, such as the Johansen and Juselius (1990) cointegration technique. The ARDL allows for estimation of both short and long-term coefficients of explanatory variables, is appropriate for analyses involving small samples, and requires fewer pre-testing conditions compared to alternative cointegration methods. To guarantee the robustness of the estimated results, the study will additionally utilize the Cholesky Impulse Response Function (IRF) and the Variance Decomposition (VD) to analyse the timing and duration of the interactions among variables. Enders (2010) established that the IRF illustrates the trajectory of variables as they diverge and converge towards an equilibrium point over a defined time frame in response to specific economic shocks. Furthermore, the impulse response and variance decomposition play a crucial role in analysing how disturbances to economic variables spread within a system (Makhoba, 2018). This research highlights the sensitivity of employment and GDP to shocks resulting from investments in social and economic infrastructure. The first step in the procedure is to test whether the time series is stationary; thus, the Augmented Dickey-Fuller (ADF) tests and Phillips-Perron (PP) tests are employed to identify the order of integration (that is, the number of times a variable must be differenced to make it stationary).

### 4.6.1 Testing for stationarity/ Unit root

Theoretically, a time series is defined as a sequence of random variables arranged in a temporal order, referred to as a stochastic process (Gujarati, 2006). A stochastic process is considered weakly stationary if its mean, variance, and autocovariance remain constant over time (Vukeya, 2015). A non-stationary time series represents a stochastic process characterized by a unit root. Therefore, the existence of a unit root indicates that the time series in question is non-stationary, whereas its absence signifies that the time series is stationary. The unit roots test serves as a fundamental prerequisite for analysing a time series model and cointegration in the context of the Johansen and Juselius approach (Nkoro and Uko, 2016).

Introduced by Dickey and Fuller (1979, 1981), unit root testing represents the most frequently utilised formal method for analysing the characteristics of time series. There are various methods of testing for unit roots. They include the Durbin-Watson (DW) test, the Dickey-Fuller (DF) test (1979), the Augmented Dickey-Fuller (ADF) test (1981), the Philip-Perron (PP) test (1988), and others. This study will employ the ADF and PP to test the null hypothesis. The ADF test consists of estimating the following regression:

$$\Delta \mathrm{Yt} = \alpha 0 + \mathrm{p1Yt} - 1 + \alpha 2\mathrm{T} + \sum_{i=1}^{k} \alpha\mathrm{i}\, \Delta Yt - i + \mu t \qquad (4.11)$$

Where $\mu t$ is the error term, $\Delta$Yt-1= (Yt-1-Yt-2), $\Delta$Yt-2= (Yt-2-Yt-3), etc. The number of lagged difference terms to include is often determined empirically to confirm that the error term exhibits serial correlation (Gujarati, 2003). The null hypothesis posits the presence of a unit root within the time series (indicating a non-stationary time series), represented as H0: $\alpha$=0, in contrast to the alternative hypothesis, H1: $\alpha$ <0, which asserts that the time series is stationary (lacking a unit root).

The ADF test offers a significant advantage over the DF test by enabling the examination of deterministic trends and drifts. This capability allows for the correction of serial correlation in the residuals through the inclusion of lagged difference terms. Similar to the DF test, the ADF test comprises three specifications: one that excludes drift, another that includes drift, and a specification for a stationary series. Despite the widespread use of DF/ADF tests, they exhibit a limitation in that their statistical power tends to be diminished when applied to series containing moving average terms or when disturbances are distributed heterogeneously (Nkoro and Uko, 2016).

To guarantee the precision of the unit root findings, this research utilises an additional unit root test, introduced by

Phillips and Perron (1988) debated that the ADF tests were inadequate for performing unit root tests in time series analysis and proposed instead a nonparametric statistical method known as the PP test. This approach considers the serial correlation found in the error terms, eliminating the need to include lagged difference terms. The test regression for the PP tests is: $\Delta Yt = \delta Yt{-}1 + ut$ (4.12)

The PP test adjusts the constant $\delta$ to reflect the relationship present in $ut$. Subsequently, the PP test is a generalized form of the DF test statistic, which acknowledges the less stringent characteristics of the error process. As with the DF and ADF tests, the PP test can be executed by incorporating a constant, both a constant and a trend, or neither in a regression analysis. Additionally, the asymptotic distribution of the PP $\tau$-statistic matches that of the ADF $\tau$-statistic when applying the unit root hypothesis testing approach (Gujarati, 2006; Vukeya, 2015).

King and Watson (1997) and Koustas and Serletis (1999) both argue that cointegration methods ought to be utilised solely when the underlying variables are integrated of the same order. Consequently, if both series are determined to be of the same order, they may be examined to ascertain whether a stable long-term relationship exists between them.

### 4.6.2 The Cointegration Analysis

Regression of one non-stationary variable on another is very likely to yield impressive-seeming results that are entirely spurious (Gujarati and Porter 2010). The cointegration technique was initially presented by 'Granger (1981)' and further elaborated by 'Engle and Granger (1987)', providing tests and estimation procedures to assess the existence of long-run relationships between sets of variables within a dynamic framework. Cointegration refers to a stationary linear combination of variables that, while individually non-stationary, are integrated to the same order, denoted as I(d). Furthermore, cointegration is an econometric principle that reflects the presence of a long-term equilibrium among fundamental economic time series that tends to converge over time (Nkoro and Uko, 2016). Testing for cointegration is a crucial procedure to determine whether a model empirically demonstrates significant long-term relationships.

Cointegration among time series variables directly affects the methodology for estimating the proposed model. When all variables are stationary, denoted as I(0), a straightforward vector autoregressive (VAR) model can be employed. In instances where variables exhibit non-stationarity and lack cointegration, they may still be incorporated into the VAR model, as long as they are differenced to attain stationarity prior to estimation. Nevertheless, when variables show cointegration, the appropriate technique to use is a vector error correction model (VECM). In scenarios where there is a combination of both I(0) and I(1), the autoregressive distributed lag (ARDL) method is applied. However, none of the variables must be integrated of order two I(2).

In applied econometrics, three primary and widely utilised methods for testing cointegration include the Granger (1981) and Engle and Granger (EG) (1987) approaches, the Autoregressive Distributed Lag (ARDL) model, and the Johansen and Juselius (1990) cointegration techniques. These methods have emerged as effective solutions for identifying the long-run relationship between non-stationary time series. For this study, the Autoregressive Distributed Lag (ARDL) cointegration procedure will be utilised to examine whether a long-run correlation exists in the recommended models.

#### *4.6.2.1 The Autoregressive Distributed Lag (ARDL) or Bound Testing Approach*

In time series analysis, it is frequently observed that a dependent variable may exhibit correlation with its own time lags as well as the time lags of the explanatory variable. This situation often requires the incorporation of both the lags of the dependent variable and the lag of the explanatory variable within the regression model. This type of regression is referred to as the 'autoregressive distributed lag (ARDL) or bounds testing methodology of Pesaran and Shin (1998) and Pesaran et al. (2001)'. It is the most preferred method due to its flexibility with integration orders, unlike the traditional cointegration tests, such as Johansen or Engle-Granger, the ARDL can be applied to investigate cointegration connections irrespective of the series' integration order, I(0), I(1), or a combination of both. However, it is essential that none of the variables must be integrated of order two I(2). The ARDL methodology is regarded as more robust and yields reliable, consistent results, even when applied to a comparatively small sample size, in contrast to residual-based methods like the Johansen technique, which requires a larger sample size for its validity (Nkoro and Uko, 2016). The ARDL method allows for the variables to have varying optimal lags, setting it apart from other standard cointegration methods. Additionally, whereas other conventional cointegration techniques utilise system equations to evaluate long-term relationships, the ARDL approach uses a singular threshold regression equation to estimate both the long-term and short-term parameters of the model.

The following are the advantages of the ARDL:

- The ARDL technique encounters a reduced challenge from endogeneity, attributed to the lack of residual correlation, with each underlying variable being depicted by a separate equation.
- The ARDL methodology is capable of distinguishing between dependent and explanatory variables in cases where a unique long-run relationship is present.
- The primary benefit of this method lies in its capacity to detect cointegrating vectors in situations where several cointegrating vectors are present.
- The Error Correction Model (ECM) can be obtained from the ARDL model via a simple linear transformation, which integrates short-term adjustments with long-term equilibrium while maintaining long-term information.

To ascertain whether the above requirements are met, specific procedural steps must be adhered to when employing the ARDL technique according to Nkoro and Uko (2016):

I. The existence of the long-run correlation between variables must be determined through the bound test for cointegration, which suggests that, if the $F$-statistic exceeds the upper limit of the critical values, the null hypothesis that no long-run cointegrating vector exists between the series may be rejected against the alternative that there is cointegration among the variables. Conversely, if the calculated F-statistic is below this threshold, the null hypothesis remains unchallenged.

II. To select the most suitable model for the long-run underlying equation, it is essential to ascertain the optimal lag length (k) by using appropriate model order selection criteria, such as the Akaike Information Criterion (AIC), the Schwarz Bayesian Criterion (SBC), or the Hannan-Quinn Criterion (HQC). The model that exhibits the lowest AIC, SBC estimates, or demonstrates minimal standard errors alongside a high $R^2$ is considered to perform better comparatively.

III. The ARDL model is converted into an ECM when there is a single cointegrating vector present among the underlying variables. This reparameterization offers insights into the short-run dynamics as well as the long-run relationship of the underlying variables.

In the context of the ARDL bound testing technique, the null hypothesis asserting the absence of cointegration is evaluated against the alternative hypothesis, which suggests the presence of cointegration among the observed variables through the application of the ARDL limit test. Comparisons are made between the computed F-statistic and the critical values outlined by Pesaran et al. (2001) and Narayan (2005). The critical values set forth by Pesaran et al. (2001) are inadequate for small sample sizes; thus, this study will apply Narayan's (2005) critical values, which are specifically tailored for small sample sizes and pertinent to this research. The null hypothesis can be rejected if the computed $F$-statistic surpasses the upper limit of the critical values. In contrast, if the computed F-statistic falls below this threshold, the null hypothesis remains unchallenged. If the calculated F-statistic is situated within the specified limits, the outcomes of the test are considered inconclusive.

*4.6.2.2 The Error Correction Model (ECM)*

Error Correction Models (ECMs) take cointegration a step further, showing how variables adjust to maintain their long-term relationship. Engle and Granger (1987) proposed that a valid error correction representation applies to a data series when the variables are co-integrated within the framework of the model. Consequently, an Error Correction Model (ECM) will be utilised in scenarios involving multiple time series models, which are often utilised for data exhibiting long-run stochastic trends, typically known as cointegration. Enders (2010) observed that co-integrated variables are significantly affected by their temporal trajectories and the way in which any divergence from long-run equilibrium transpires.

As noted by Engle and Granger (1987), the existence of co-integration between $y$ and $x$ enables the correlation among co-integrated variables to be represented as an ECM, in which the error term produced by the model functions as the error correction term. The ECM describes the behaviour of $y$

and $x$ in the short-run, aligning with a long-term equilibrium state. While co-integration analysis identifies the enduring relationship, the ECM reveals the short-term interactions among the variables. An ECM can be expressed as follows:

$$\Delta Y_t = X_O + X_1 \Delta x_t - \tau(\mu_{t-1}) + \varepsilon_t \qquad (4.13)$$

where $\varepsilon t$ denotes the white noise disturbance term. The variables $xt$ and $yt$ fluctuate in reaction to the shocks indicated by $\varepsilon t$. The coefficient τ represents an error correction term, which, according to economic theory, should be negative. The τ measures the rate at which the system returns to equilibrium following an exogenous shock. Moreover, it is essential that at least one of the speed adjustments is non-zero; if both adjustments are zero, it indicates the absence of a long-run equilibrium relationship between the variables, thereby suggesting that the model does not exhibit characteristics of either error correction or co-integration. An effective model should simultaneously integrate both short-term dynamics and long-term equilibrium; therefore, the Error Correction Model (ECM) is designed to address this gap in the analysis of co-integration.

### 4.6.3 The Impulse Response Function (IRF)

The examination of how a dependent variable responds to disturbances in error terms is known as impulse response analysis (Asteriou and Hall, 2007). This study will utilize the impulse response function to visually evaluate the immediate effects of public infrastructure investment variables on growth and employment levels. The impulse response illustrates the manner in which both present and upcoming values of each variable respond to a one-unit increase in the present value of a specified error, under the assumption that this error subsequently returns to zero in future periods (Stock & Watson, 2006). Consequently, the impulse response functions reveal the effects of shocks on the adjustment trajectory of the variables within the model. Therefore, it is essential to consider interdependent dynamics to accurately identify the appropriate shock from unobservable data. This presents a challenge in the identification of impulse response analysis (Mathebula, 2023). The Cholesky method is employed to conduct the impulse response analysis in this research.

### 4.6.4 The Variance Decomposition

Alongside the findings from the impulse response function, a variance decomposition analysis was conducted, illustrating the extent to which a change in a variable is attributable to its own shock versus the shocks from other variables within the system. While the impulse response analysis examines the responsiveness of the dependent variable to shocks, the variance decomposition analysis highlights the significance of each shock within the system (Enders, 1995). Thus, this research utilised variance decomposition to identify the extent of movement in growth and employment levels in relation to shocks from other variables. This analysis facilitated the identification of factors influencing growth and employment levels across short, medium, and long-term periods. The Cholesky technique was also used to apply the variance decomposition.

#### 4.6.5 Model Diagnostic and Stability Tests

The purpose of diagnostic and stability tests is to help determine whether a model has been correctly specified by assessing its quality, identifying potential issues, and guiding necessary adjustments to develop a robust and reliable model. The following diagnostic tests will therefore be performed to validate the adequacy of the estimated model.

**4.6.5.1 Normality Test:** To assess whether the error terms follow a normal distribution, a normality test is employed. If the errors in the model do not conform to a normal distribution, this indicates a violation of the OLS assumption, which states that residuals must be normally distributed with zero mean and constant adjustments. For the errors to be considered normally distributed within the regression model, the skewness must be equal to zero (0), and the kurtosis must be equal to three (3) (Gujarati and Porter, 2010). The Jarque-Bera test (JB) serves as a goodness-of-fit assessment pertinent to this analysis, employed to ascertain whether the skewness and kurtosis of the dataset correspond with the attributes of a normal distribution of errors within the model.

**4.6.5.2 Serial Correlation Test:** This method is employed to ascertain whether a relationship exists between current and historical observations. Serial correlation occurs in scenarios where the data possess a temporal dimension and where two or more consecutive error terms exhibit interdependence. In such instances, the error term experiences autocorrelation. Autocorrelation implies that the OLS estimator remains unbiased but loses efficiency, leading to incorrect estimation of its standard errors (Gujarati and Porter 2010). The research utilised the 'Lagrange Multiplier (LM)' test, which serves as a multivariate test statistic for assessing residual serial correlation up to a designated lag order. The LM test evaluates the null hypothesis H0: p1=p2=………… = pp=0 (indicating no autocorrelation) in contrast to the alternative hypothesis, H1: at least one of the Ps is non-zero, thereby indicating the presence of serial correlation.

**4.6.5.3 Heteroscedasticity Test:** Serves as an expansion of White's (1980) test, utilised for systems of equations. The occurrence of heteroscedasticity within the regression model violates the assumptions of the classical regression framework, which asserts that the observations of the error term are drawn from a distribution characterized by a constant variance $\sigma 2$. The presence of heteroscedasticity in the model leads to the regression model underestimating both the variances and standard errors, thereby yielding incorrect statistical results (Asteriou and Hall, 2016). Thus, this research will employ the Breusch-Pagan (1979) test to identify the existence of heteroscedasticity in the chosen models.

**4.6.5.4 Multicollinearity Test:** It is used to discover the presence and severity of multicollinearity between the explanatory variables. When two or more independent variables in a regression model are interconnected with each other, multicollinearity exists. The high correlation makes it difficult for the regression model to accurately estimate the independent impact of each predictor variable on the dependent variable. Common methods to test for multicollinearity include correlation matrices, variance inflation factors (VIF), and tolerance values (Gujarati, 2006). The study will employ the VIF to test the existence of multicollinearity.

**4.6.5.5 Model Stability Test:** Given that the time series extends from 1992 to 2024, the data reflects numerous notable changes in the South African macroeconomic environment, such as the democratic transition in 1994, the Global Financial Crisis of 2008, and the COVID-19 pandemic in 2020. Standard ARDL models assume parameter stability; however, these external shocks may lead to structural breaks that distort the estimated coefficients. To tackle this issue, this research employs the Cumulative Sum of Recursive Residuals (CUSUM) and the CUSUM of Squares (CUSUMQ) tests to pinpoint periods of instability. The CUSUM test is utilised to detect dynamic changes in regression parameters. In contrast, the CUSUMQ follows a similar methodology, but it utilises squared recursive residuals. The plots generated from both tests should remain within the critical bounds to validate the stability of the estimated parameters. However, if a structural break is detected (i.e., when the recursive residuals exceed the 5% significance thresholds), a dummy variable ($D_t$) will then be introduced into the ARDL specification; this dummy variable will take a value of 1 during the shock period and 0 otherwise, thereby absorbing the outlier effect and ensuring that the long-run relationship remains robust and statistically sound (Gujarati and Porter 2010).

## 4.7 Conclusion

The primary aim of this chapter was to examine the statistical techniques that will be utilised in Chapter 5 to produce valid and dependable statistical outcomes. The preferred statistical technique for this study is the Autoregressive Distributed Lag (ARDL) or Bounds testing approach, which was applied to estimate the growth and employment model. This choice is due to its numerous advantages over other methods. Having determined the existence of cointegration, the ARDL can be estimated to investigate whether a long-term relationship exists between the variables. Additionally, the unrestricted error correction model of ARDL, which relies on the corresponding long-run coefficients, was also estimated to assess the short-term adjustment dynamics. The estimated model must successfully undergo all diagnostic tests, which include the autocorrelation LM test, the white heteroskedasticity test, the residual normality test, the multicollinearity test, and the model stability test.

The forthcoming chapter will concentrate on a thorough investigation, interpretation, and discussion of the empirical findings derived from the ARDL estimation method. In order to obtain the most precise and dependable outcomes, the Cholesky impulse response function, along with variance decomposition analysis, were conducted.

# CHAPTER FIVE

## EMPIRICAL ANALYSIS AND INTERPRETATION OF RESULTS

### 5.1 Introduction

This chapter presents empirical results that quantify the interactions among investments in economic and social infrastructure, economic growth, and employment, aiming to understand the dynamics of the South African economy. The main objective of this empirical investigation is to analyse the effects of public infrastructure investment on economic growth and employment, particularly in the context of General Government and Public Corporations. The study does so by applying techniques discussed in the previous chapter, presenting, interpreting, and analysing all test results based on South African data to meet the objectives and test the hypotheses outlined in Chapter 1. It employs annual data spanning from 1992 to 2024. The findings encompass both unit root tests and cointegration analysis. Given the presumption of a cointegration relationship between the variables, the Autoregressive Distributed Lag (ARDL) or bounds testing method is employed. The research concludes with diagnostic assessments to verify that a statistically robust econometric model has been developed.

### 5.2 Descriptive Statistics

The series of data illustrated in Table 5.1 below indicates the proportional distribution of growth (GDP), employment (LNEMP), energy infrastructure investment (LNENE), transport infrastructure investment (LNTRA), health infrastructure investment (LNHEA), education infrastructure investment (LNEDU), and foreign direct investment (LNFDI). The distribution of these series can be identified through the analysis of various statistical measures. Given that the median and mean values are nearly equivalent, along with skewness values that are closer to zero, the variables likely exhibit a normal distribution. The negative skewness observed in the distributions of GDP, LNENE, LNTRA, LNHEA, LNEDU, and LNFDI suggests that these distributions are predominantly concentrated on the left side. In contrast, the skewness value for employment is positive (1.01), which signifies that its distribution possesses a longer positive tail. Additionally, this variable also has the highest standard deviation (2.97), which indicates a higher level of volatility.

**Table 5.1 Descriptive statistics Results**

| | GDP | LNEMP | LNENE | LNTRA | LNHEA | LNEDU | LNFDI |
|---|---|---|---|---|---|---|---|
| **Mean** | 2.145752 | 10.97960 | 3.597348 | 4.112857 | 14.81688 | 14.93651 | 7.566437 |
| **Median** | 2.485468 | 9.287860 | 3.686376 | 4.318821 | 15.51929 | 15.07039 | 8.026908 |
| **Maximum** | 5.603806 | 15.86963 | 4.320151 | 4.773224 | 16.61279 | 16.86478 | 10.60200 |
| **Minimum** | -5.963358 | 8.880965 | 2.617396 | 2.890372 | 11.72183 | 12.53473 | 1.386294 |
| **Std. Dev.** | 2.353027 | 2.972269 | 0.494516 | 0.536257 | 1.602739 | 1.555120 | 1.821475 |
| **Skewness** | -1.260175 | 1.015295 | -0.342012 | -0.763087 | -0.638838 | -0.224076 | -1.806266 |
| **Kurtosis** | 5.645454 | 2.039942 | 1.979308 | 2.324424 | 1.962222 | 1.487467 | 6.929782 |
| **Jarque-Bera** | 18.35706 | 6.936885 | 2.075837 | 3.830215 | 3.725480 | 3.421818 | 39.17867 |
| **Probability** | 0.000103 | 0.031166 | 0.354191 | 0.147326 | 0.155247 | 0.180701 | 0.000000 |
| **Sum** | 70.80983 | 362.3268 | 118.7125 | 135.7243 | 488.9572 | 492.9048 | 249.6924 |
| **Sum Sq. Dev.** | 177.1755 | 282.7002 | 7.825486 | 9.202275 | 82.20072 | 77.38878 | 106.1686 |
| **Observations** | 32 | 32 | 32 | 32 | 32 | 32 | 32 |

Source: Author (compiled from EViews).

The kurtosis coefficient serves as a statistical indicator that characterizes the extent of the tails in a distribution. A distribution is considered normally distributed if its kurtosis coefficient is equal to 3 (mesokurtic), suggesting that the distribution is neither excessively peaked nor overly flat in comparison to a normal distribution. When the kurtosis is below 3, the distribution is classified as platykurtic; conversely, if it exceeds 3, it is referred to as leptokurtic. The kurtosis coefficients for LNEMP, LNENE, LNTRA, LNHEA, and LNEDU are well below the required level, which indicates lighter tails and flatter peaks or platykurtic distributions of the series. Similarly, the kurtosis coefficients for GDP and LNFDI are leptokurtic, indicating heavier tails and sharper peaks than those of a normal distribution.

The Jarque-Bera (JB) test serves as a goodness-of-fit assessment that evaluates whether the sample data display skewness and kurtosis that align with a normal distribution characterized by parameters of 0 and 3, respectively (Olawale, 2024). In the context of the null hypothesis, which asserts that the data points follow a normal distribution, the JB test statistic adheres to a chi-square $\chi 2$ distribution with 2 degrees of freedom. If the absolute value of the JB test statistic surpasses the critical value of $\chi 2$ at a specified significance level, one may reject the null hypothesis in favor of the alternative hypothesis. Therefore, if the calculated probability $(p)$ value associated with the JB test statistic is adequately low, an occurrence that transpires when the statistic's value deviates significantly from 0, the hypothesis asserting that the observations follow a normal distribution can be dismissed (Vukeya, 2015). In this research, the JB test demonstrates that the LNENE, LNTRA, LNHEA, and LNEDU series adhere to a normal distribution, as the p-value considerably surpasses 0.05; on the other hand, for GDP, LNEMP, and LNFDI, we reject the null hypothesis, which suggests that these series are normally distributed, since the p-value is below the significance level.

## 5.3 Estimation Results

### 5.3.1 Unit Root/Stationarity Results

As outlined in the preceding chapter, it is essential to conduct a formal assessment of the stationarity or to investigate the integration characteristics of all series data before proceeding with estimation to prevent erroneous outcomes. Therefore, to determine the order of integration for each variable included in the multivariate model of this research, the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests for stationarity are implemented. The ADF and PP tests are carried out under the null hypothesis that the time series contains a unit root. If the calculated test statistic exceeds the critical value, the null hypothesis is rejected, thus indicating the absence of a unit root or non-stationarity.

**Table 5.2: Summary of Unit Root Test**

| Variables | Test | Lag Length | Lag Difference (0) 5% Critical Value | | Restriction | Decision | Lag Length | Lag Difference (1) 5% Critical Value | | Restriction | Decision |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Test Statistic | Critical Value | | | | Test Statistic | Critical Value | | |
| **GDPG** | ADF | 0 | -4.629 | -2.957 | Constant | Stationary | 1 | -6.430 | -2.963 | Constant | Stationary |
| | PP | 2 | -4.630 | -2.957 | Constant | Stationary | 30 | -16.847 | -2.960 | Constant | Stationary |
| **LnEMP** | ADF | 6 | -1.902 | -3.595 | Constant, Linear Trend | Not-Stationary | 0 | -5.731 | -3.562 | Constant, Linear Trend | Stationary |
| | PP | 0 | -1.627 | -3.557 | Constant, Linear Trend | Not-Stationary | 4 | -5.793 | -3.562 | Constant, Linear Trend | Stationary |
| **LnENE** | ADF | 0 | -2.624 | -3.557 | Constant, Linear Trend | Not-Stationary | 0 | -6.762 | -3.562 | Constant, Linear Trend | Stationary |
| | PP | 2 | -2.555 | -3.557 | Constant, Linear Trend | Not-Stationary | 30 | -14.769 | -3.562 | Constant, Linear Trend | Stationary |
| **LnTRA** | ADF | 0 | -2.210 | -3.557 | Constant, Linear Trend | Not-Stationary | 0 | -5.837 | -3.562 | Constant, Linear Trend | Stationary |
| | PP | 1 | -2.218 | -3.557 | Constant, Linear Trend | Not-Stationary | 2 | -5.822 | -3.562 | Constant, Linear Trend | Stationary |
| **LnHEA** | ADF | 4 | -4.298 | -2.971 | Constant | Stationary | 0 | -5.577 | -3.562 | Constant, Linear Trend | Stationary |
| | PP | 2 | -0.765 | -2.957 | Constant | Not-Stationary | 2 | -5.598 | -3.562 | Constant, Linear Trend | Stationary |
| **LnEDU** | ADF | 0 | -3.415 | -3.557 | Constant, Linear Trend | Not-Stationary | 0 | -8.123 | -3.562 | Constant, Linear Trend | Stationary |
| | PP | 2 | -3.420 | -3.557 | Constant, Linear Trend | Not-Stationary | 6 | -9.555 | -3.562 | Constant, Linear Trend | Stationary |
| **LnFDI** | ADF | 0 | -4.425 | -2.957 | Constant | Stationary | 0 | -7.634 | -2.960 | Constant | Stationary |
| | PP | 4 | -4.966 | -2.957 | Constant | Stationary | 2 | -7.781 | -2.960 | Constant | Stationary |

Notes:

- 'The optimal lag lengths for the ADF tests are automatically determined by the Schwarz Information Criterion (SIC).'
- 'The bandwidths for the PP tests are automatically determined by the Newey-West Bartlett Kernel selection.'

Source: Author (Compiled from EViews).

The objective of the test was to ascertain whether the data displayed stationarity or non-stationarity, with stationarity signifying that the series fluctuates around a stable mean. The hypothesis states that if the absolute value of the test statistic surpasses the critical value, we reject the null hypothesis and endorse the alternative hypothesis. Conversely, if the absolute value of the test statistic is below the critical value, we retain the null hypothesis. The findings presented in Table 5.2 above indicate that both the ADF and PP tests for GDPG and LnFDI reject the null hypothesis and accept the alternative, suggesting that these variables are stationary at level I (0). Meanwhile, all other variables, LnEMP, LnENE, LnTRA, LnHEA, and LnEDU, are stationary at first difference 1(1). This mixture of integration orders 1(0) and 1(1) makes the Autoregressive Distributed Lag (ARDL) model the most appropriate choice for further analysis, based on its ability to handle variables with different orders of integration.

### 5.3.2 Selection of lag length

Determining the suitable lag length for each of the fundamental variables in the ARDL model is crucial, as the objective is to achieve Gaussian error terms (i.e., standard normal error terms devoid of non-normality, autocorrelation, and heteroskedasticity). To identify the correct model for the long-term underlying equation, it is imperative to determine the optimal lag length (k) by utilizing appropriate model order selection criteria, such as the Akaike Information Criterion (AIC), the Schwarz Bayesian Criterion (SBC), or the Hannan-Quinn Criterion (HQC). The model that exhibits the lowest AIC, SBC estimates, or demonstrates minimal standard errors alongside a high $R^2$ It is considered to perform better comparatively. The estimates derived from the most effective model subsequently serve as the long-run coefficients. This approach is appropriate when there is a long-term correlation between the fundamental variables, thereby preventing spurious regression (Nkoro and Uko, 2016).

**Table 5.3: Selection of Lag Length**

| Models | lags | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|---|
| ARDL model for growth (GDPG) | 1 | -110.70 | 122.09* | 0.08* | 9.85* | 11.79* | 10.48* |
| ARDL model for Employment (LnEMP) | 2 | -26.25 | 58.24* | 4.68e* | 6.72* | 10.33 | 7.90* |

'Star (*): Indicates lag order selected by the criterion; **LR**: sequential modified LR test statistic (each test at 5% level); **FPE**: Final prediction error; **AIC**: Akaike information criterion; **SC**: Schwarz information criterion, as the lowest value of each criterion; **HQ**: Hannan-Quinn information Criterion.'

Source: Author compiled from E-Views

The above table demonstrates that the optimal lag for the growth model is 1, which is supported by all five criteria (LR, FPE, AIC, SC, and HQ), providing strong evidence for the selected lag order. For the employment model, an optimal lag length of 2 seems robustly supported by most criteria, except for SC, which suggested a lag order of 1; however, given that the majority of the criteria (especially the AIC and FPE, which are widely considered for VAR model selection) point to lag 2, it would generally be the recommended lag order for the Bounds test for cointegration.

### 5.3.3 Autoregressive Distributed Lag Model (ARDL)

The ARDL or bound test for cointegration investigates the existence of a long-term correlation between the variables, evaluating the null hypothesis, which suggests that no long-term cointegrating vector is present, in contrast to the alternative hypothesis that suggests the existence of cointegration among the variables. In the context of the ARDL bounds testing hypothesis methodology, the null hypothesis can be dismissed if the computed $F$-statistic surpasses the upper critical threshold. Conversely, if the calculated F-statistic is below this threshold, the null hypothesis remains unchallenged. Should the computed F-statistic lie within the bounds, the results of the test are deemed inconclusive; thus, prior knowledge regarding the order of integration of the variables is essential for decision-making. The first step of the ARDL bounds testing procedure involves identifying the lag lengths for the first differenced variables derived from the unrestricted models. To achieve this, the study utilises the AIC and the FPE criteria because of their superiority concerning the data characteristics of the study. Thus, in accordance with the recommendations of the AIC and FPE, the ARDL (4, 4, 4, 4, 3) growth model and the ARDL (1, 1, 2, 1, 1) employment model are estimated.

The F-statistics pertaining to the bounds test outcomes for the growth model are presented in Table 5.4 below.

**Table 5.4: Bounds test for co-integration**

| F-Bounds Test | | Null Hypothesis: No levels relationship | | |
|---|---|---|---|---|
| Test Statistic | Value | Signif. | I(0) | I(1) |
| | | | Asymptotic: n=1000 | |
| F-statistic | 31.71020 | 10% | 2.2 | 3.09 |
| k | 4 | 5% | 2.56 | 3.49 |
| | | 2.5% | 2.88 | 3.87 |
| | | 1% | 3.29 | 4.37 |
| Actual Sample Size | 29 | | Finite Sample: n=35 | |
| | | 10% | 2.46 | 3.46 |
| | | 5% | 2.947 | 4.088 |
| | | 1% | 4.093 | 5.532 |
| | | | Finite Sample: n=30 | |
| | | 10% | 2.525 | 3.56 |
| | | 5% | 3.058 | 4.223 |
| | | 1% | 4.28 | 5.84 |

Source: Author (Compiled from E-views)

The bounds test for cointegration was utilised to assess the existence of a long-term relationship between economic growth and its explanatory variables, which include energy infrastructure investment, transport infrastructure investment, health infrastructure investment, education infrastructure investment, and foreign direct investment. The null hypothesis asserting the absence of a long-run relationship among the variables was evaluated, and Table 5.4 reveals that the calculated F-statistic of 31.71 significantly exceeds the upper critical values of 4.37, 3.49, and 3.09 at the 1%, 5%, and 10% significance levels, respectively. Thus, the null hypothesis of no cointegration was rejected, leading to the conclusion that there is a long-term correlation between economic growth, investments in economic infrastructure, investments in social infrastructure, and foreign direct investment. The existence of cointegration aligns with the results reported by Olawale (2024), Dhungel (2020), and Kumo (2012), who utilised the ARDL, Error Correction Model (ECM), and Pairwise Granger Causality methods to investigate cointegration. The study proceeded with the ARDL analysis.

### *5.3.3.1 Long-Run Coefficients Estimates*

The confirmation of cointegration indicates that the long-term equilibrium effects of investing in economic and social infrastructure on economic growth and employment can be analysed. Table 5.5 below presents the long-run estimates for the growth model.

**Table 5.5: Long Run Coefficients (4, 4, 4, 4, 3)**

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| LNFDI | -0.551415 | 0.316607 | -1.741641 | 0.1420 |
| LNEDU | 1.322969 ** | 0.509153 | 2.598375 | 0.0483 |
| LNENE | 2.701168 * | 1.080552 | 2.499803 | 0.0545 |
| LNTRA | - | - | - | - |
| LNHEA | 1.142955 * | 0.499212 | 2.289518 | 0.0707 |
| C | 19.96486 | 3.334921 | 5.986608 | 0.0019 |

EC = GDP - (-0.5514*LFDI +1.3230*LNEDU +2.7012*LNENE + 1.1430 *LNHEA + 19.9649 )

'Notes: *** Statistically significant at 1% level
** Statistically significant at 5% level
* Statistically significant at 10% level'

Source: Author (Compiled from E-views)

The findings for the long-term elasticity coefficients suggest that, within the economic infrastructure category, which represents spending by public corporations, energy infrastructure is found to be a powerful and significant driver of long-term economic growth, with a coefficient of 2.701 and a statistically significant p-value at the 10% level. The findings indicate that in the long run, a 1% increase in energy infrastructure investment leads to a substantial 2.70 percentage point increase in GDP. This highlights the critical importance of energy supply to the South African economy. These findings are consistent with the Solow growth model, which asserts that enhancing one of the factors of production, like investing in infrastructure, results in greater output and economic expansion. Timilsina et al. (2023) found a positive link between electricity generation and economic growth in developing countries. Similar results were obtained by Apurv and Uzma (2020), whose study focused on BRICS countries and found that investing in energy infrastructure developments promotes growth. On the other hand, Transport infrastructure seems to have no significant long-run effect on economic growth. This contradicts previous studies conducted by Selamolela (2018), Moeketsi (2017), and Hlotywa & Ndaguba (2017), who examined the impact of transport infrastructure on economic growth in South Africa and found that a causal relationship exists between growth and transport infrastructure investment in South Africa. In their study, Badassa and Baiqing (2019) utilised the ARDL bound testing methodology in Ethiopia to explore the link between transport infrastructure and economic growth. The results indicate that, within the Ethiopian context, investments in road infrastructure did not yield a statistically significant positive long-term effect on economic growth. In South Africa, several potential factors may have contributed to this insignificant outcome, including inadequate maintenance leading to rapid degradation, prioritisation of politically prominent projects over economically viable ones, political instability, and insufficient public funding.

Within the social infrastructure category, which is also a form of public spending by the general government, both Health and Education infrastructure have a significant and positive long-term impact on economic growth at the 10% and 5% significance level, respectively. Meaning in the long run, a 1% increase in Health infrastructure investment leads to a 1.14 percentage point increase in growth; equally, a 1% increase in Education infrastructure investment leads to a 1.32 percentage point rise in growth. This positive relationship is consistent with the literature presented in Chapters 2 and 3 of the study, as improved public health and education infrastructure enhances human capital and productivity, thereby boosting economic growth. Moreover, More and Aye (2017) found a significant positive relationship between education expenditure and growth, which aligns with the expectations. DBSA (2024) obtained comparable findings using the ARDL model, concluding that investing in social infrastructure has a substantial, favourable influence on economic growth in South Africa, thereby broadly supporting policies aimed at infrastructure development.

Table 5.5 also reveals that foreign direct investment has a coefficient of -0.55 and a p-value of 0.14, which is insignificant, indicating that it has no long-term impact on economic growth. This discovery contradicts the anticipated notion of a positive correlation between FDI and economic growth, implying that this relationship may be bidirectional. This assertion is further supported by various studies that advocate for the hypothesis of a positive connection between FDI and economic growth. For instance, research conducted by Tshepo (2014) validated a positive association between FDI and economic growth in South Africa. Nevertheless, Woldemedhin (2021) noted that empirical research frequently indicates a negative correlation between foreign direct investment (FDI) and economic growth. This observation supports the notion that the relationship between FDI and economic growth is not straightforward. According to the findings illustrated in Table 5.5, it can be concluded that GDP exhibits a positive long-term correlation with LNENE, LNEDU, and LNHEA. At the same time, the coefficients for LNFDI and LNTRA were found to be statistically insignificant in their capacity to explain growth.

#### *5.3.3.2 Short-Run Coefficients Estimates*

The unrestricted error correction model of ARDL (4, 4, 4, 4, 3), which relies on the corresponding long-run coefficients, is illustrated in Table 5.6.

**Table 5.6: Short Run Coefficients of (4, 4, 4, 4, 3)**

| | Coint Eq (-1) | LNFDI | LNEDU | LNENE | LNTRA | LNHEA |
|---|---|---|---|---|---|---|
| Coefficient | -0.5094*** | -0.8323 | 1.9969** | 4.0773** | - | 1.7252* |
| P-value | 0.0000 | 0.1433 | 0.0425 | 0.0208 | - | 0.0521 |

'Notes: *** Statistically significant at 1% level
** Statistically significant at 5% level
* Statistically significant at 10% level'
Source: Author (Compiled from E-views)

The cointegration equation (-1) serves as an error correction term (ECT) that illustrates the rate at which equilibrium is re-established within the growth model. It reflects the speed at which any disequilibrium from the previous period is rectified. A negative coefficient denotes convergence, whereas a positive coefficient suggests divergence; thus, the cointegration error correction term (-1) is considered significant when it is negative and less than one, with its probability value falling below the 5% significance threshold (Nkoro and Uko, 2016). Table 5.6 presents the highly significant cointegration equation (-1) value of -0.51, indicating that the model is effectively moving towards its long-term equilibrium at around 51%. This reflects a swift adjustment from short-term fluctuations to long-term stability in reaction to disturbances within the model. Furthermore, this validates the existence of a consistent long-term relationship among the variables. The findings further demonstrate that investment in economic infrastructure (LNENE) has a statistically substantial short-term impact on economic growth at the 5% significance level, measured at 4.07 percentage points. This implies that investment in economic infrastructure is a vital element in promoting short-term economic growth. Similarly, a 1% increase in government spending on social infrastructure (LNEDU and LNHEA) leads to a notable rise in economic growth, specifically by 1.99 percentage points at 5% significance level and 1.72 percentage points at a 10% significance level, respectively. These findings align with the expected prior of an anticipated positive correlation between LNEDU, LNHEA, and GDP as explained in chapter 4 of the study.

Table 5.6 further indicates that foreign direct investment has a negative correlation with economic growth at 0.14 percentage points. The coefficient is statistically insignificant and thus has no effect on growth in the short-term. Similarly, investment in transport infrastructure was found to be statistically insignificant, with no measurable short-run impact on growth. The study, therefore, concludes that LNENE, LNEDU, and LNHEA are the only variables that have a significant positive effect on growth in the short run.

#### *5.3.3.3 Impulse Response Function of Economic Growth*

The impulse response function serves as an effective instrument to complement the findings obtained from the ARDL-ECM model, as it offers insights into how shocks behave within the growth model. The results of the impulse response analysis are presented in Figure 5.1a-e. The solid blue line represents the impulse response function, the dotted red lines represent the 95% confidence interval, and the zero line represents the threshold for determining significance. When the red dotted lines encompass the zero line, the effect is deemed statistically insignificant. Conversely, if both red bands are positioned either entirely above or entirely below the zero line, the effect is considered statistically significant.

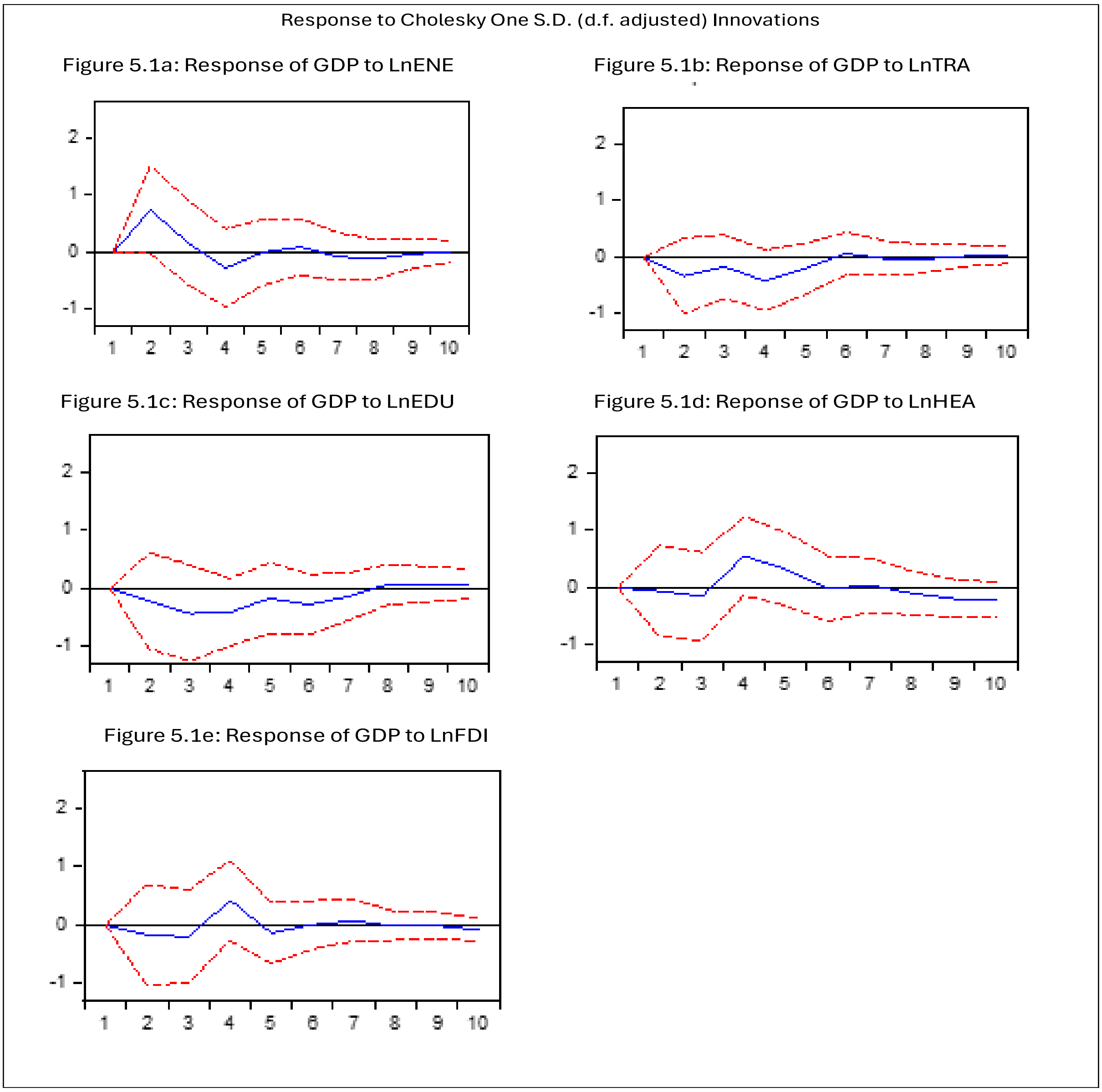
The response of GDP to LnENE is depicted in Figure 5.1a, demonstrating that GDP exhibits a positive response to energy shocks during the early stages, specifically in periods 1-3, at a variation of 0.75% that is statistically significant. However, in periods 4-5, the response of GDP turns negative and falls below the zero line, indicating that the initial positive shock is short-lived. This suggests that the effect of energy infrastructure shocks on GDP is temporary and does not persist in the long-run.

GDP's response to LnTRA is shown in Figure 5.1b. GDP responds negatively to transport infrastructure shocks from period 1-5 at a variation of -0.25%. The response to GDP from period 6-10 approaches the zero line. This indicates that the negative effect of transport infrastructure shock on GDP is also temporary, however, not statistically significant, as the confidence band almost always encompasses the zero line.

Figure 5.1c illustrates the effect of a one standard deviation shock in LnEDU on GDP across a 10-period horizon. The findings indicate that GDP reacts adversely to the shock in educational infrastructure, attaining its minimum value between periods 4 and 5 with a variation of -0.25%. This negative reaction gradually diminishes and reaches a steady state from period 8 to 10, suggesting that the adverse effect is temporary. This implies that shocks to LnEDU will negatively impact GDP in the short-run. As discovered in Figure 5.1d, a one standard deviation shock to LnHEA has a positive effect on GDP, as evidenced by a sharp increase from period 3 and continues to period 6 at a variation of 0.5% but gradually declines and reaches the steady state, then continues to stay closer to zero up to the $10^{th}$ period. This implies that shocks to health infrastructure investment will positively impact GDP at both the short and long-term.

Figure 5.1e illustrates that a shock in LnFDI results in a temporary fluctuating response, characterized by an initial negative slope followed by a positive peak. Nonetheless, the findings indicate that the overall effect lacks statistical significance, implying that, in accordance with the study's growth model, an unexpected shock in the foreign direct investment variable does not lead to a substantial change in the path of GDP.

**Figure 5.1: The Cholesky Impulse Response Function (Economic Growth).**




Source: Author (Compiled from E-views)

### *5.3.3.4 The Variance Decomposition of Economic Growth*

The variance decomposition analysis provides a method for assessing the relative significance of shocks in explaining variations in the variable of interest. In this study, it thus help in examining the relative significance of shocks to each factor influencing economic growth. The findings are presented in Table 5.7, which depicts the share of forecast error variance in economic growth that can be attributed to its own shocks as well as those of its determinants.

**Table 5.7: Variance Decomposition**

| Variance Decomposition of GDP | | | | | | | |
|---|---|---|---|---|---|---|---|
| Period | S.E. | GDP | LnFDI | LnENE | LnHEA | LnTRA | LnEDU |
| 1 | 2.094250 | 100.0000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| 2 | 2.270108 | 85.76543 | 0.565837 | 10.60815 | 0.056192 | 2.103106 | 0.901288 |
| 3 | 2.346752 | 81.12082 | 1.281313 | 10.37761 | 0.485407 | 2.505191 | 4.229655 |
| 4 | 2.534252 | 69.83354 | 3.901164 | 10.09361 | 5.123994 | 4.843706 | 6.203980 |
| 5 | 2.575524 | 67.92077 | 4.058325 | 9.773063 | 6.493520 | 3.310827 | 6.443493 |
| 6 | 2.606520 | 67.33936 | 3.962819 | 9.672325 | 6.345675 | 2.243976 | 7.435842 |
| 7 | 2.613509 | 67.02498 | 4.017349 | 9.716236 | 6.340596 | 3.226568 | 7.674269 |
| 8 | 2.619337 | 66.75225 | 4.005051 | 9.870608 | 6.444228 | 4.214552 | 7.713309 |
| 9 | 2.628160 | 66.35754 | 3.979126 | 9.817159 | 6.927200 | 4.186135 | 7.732836 |
| 10 | 2.639733 | 65.78585 | 4.061281 | 9.731343 | 7.517392 | 3.167427 | 7.736707 |
| Cholesky Ordering: GDP LnFDI LnENE LnHEA LnTRA LnEDU | | | | | | | |

Source: Author (Compiled from E-Views)

The results of the ten-year variance decomposition from the Vector Auto-Regression (VAR) model are displayed in Table 5.7. These findings illustrate that in the first year, economic growth is primarily influenced by its own inventions, accounting for 100%; however, the influence decreases steadily, from period 1 to 65.78% in period 10. This suggests that as the duration of the forecast extends, the historical impacts of infrastructure investments and foreign direct investment (FDI) become progressively more significant in accounting for variations in GDP. Starting from the second year, investment in energy infrastructure emerges as a vital element for economic development, reaching a peak of 10.60% in the second period, before experiencing a slight decline and stabilizing at approximately 9.73% by the tenth period. Subsequently, the education sector ranks next with a contribution of 7.73% in the tenth period, followed closely by the health sector at 7.51% during the same period. This suggests that energy, education, and health are significant factors in explaining growth over both the short and long-term. The results further demonstrate that transportation infrastructure and foreign direct investment do not significantly contribute to the variations observed in economic growth, based on the average percentages of 2.97 and 2.98, respectively, over the ten-year forecasting period. These results are in accordance with the economic theory, which asserts that a considerable share of the variations in GDP can be attributed to shocks in the explanatory variables. Furthermore, the findings are consistent with the results obtained from the impulse response analysis, with the exception of LnEDU, where the impulse response function indicates that educational infrastructure negatively affects growth in the short term.

#### *5.3.3.5 Results for Diagnostic Analysis*

To validate the results obtained, four diagnostic tests were conducted on the growth model. The serial correlation LM test was utilised to assess the presence of serial correlation, with the null hypothesis positing that no serial correlation exists in the model at a 5% significance level. The P-value of 0.75 exceeds 0.05, indicating that the null hypothesis will not be rejected, thus confirming the lack of serial correlation in the model. The Breusch-Pagan-Godfrey (BPG) test for heteroscedasticity indicated that the model is homoscedastic, as evidenced by the probability value of 0.99. Furthermore, the p-value derived from the Jarque-Bera normality test is 0.20, which exceeds the 5% significance threshold. Therefore, the results suggest that the series adheres to a normal distribution.

**Table 5.8: Diagnostic Tests**

| | Null Hypothesis | P-Value |
|---|---|---|
| LM Test | No serial correlation | 0.7487 |
| BPG Test | No conditional heteroscedasticity | 0.9983 |
| JB Test | The model's residuals are normally distributed | 0.2060 |

Source: Author (Compiled from E-views)

The performance and goodness-of-fit of the underlying model suggest robust estimation outcomes. The model as a whole demonstrates high statistical significance and adheres to Gaussian conditions, successfully passing tests for 'serial correlation, functional form misspecification, and heteroscedasticity.' Additionally, the model is determined to be normally distributed, as illustrated in Table 5.8 above.

**Table 5.8.1: Variance Inflation Factors (VIF)**

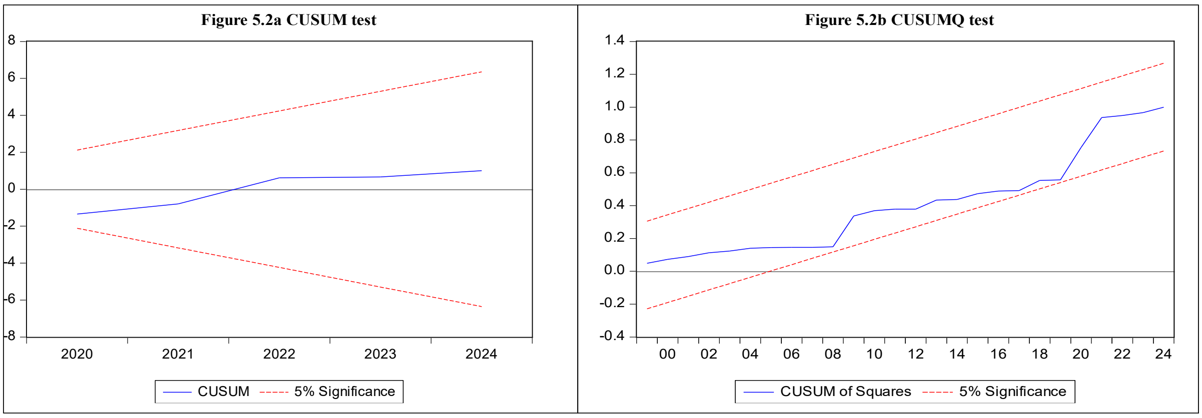
| Variable | Coefficient Variance | Uncentered VIF | Centered VIF |
|---|---|---|---|
| LINFEDU | 0.215287 | 424.4802 | 3.536177 |
| LFDI | 0.044067 | 39.77485 | 2.116235 |
| LINFENE | 0.781820 | 153.7896 | 2.767408 |
| LINFHE | 0.246428 | 216.7190 | 4.162643 |
| LINFTRAN | 1.948162 | 300.0143 | 3.109150 |
| C | 7.072566 | 105.5713 | NA |

Source: Author (Compiled from E-views)

Table 5.8.1 indicates the variance inflation factor results, which detect the existence and severity of multicollinearity amongst explanatory variables. A rule of thumb for assessing multicollinearity based on the VIF is that, if the centered VIF is less than 5 or 10, it indicates that multicollinearity is not a concern. Conversely, if the VIF is greater than 5 or 10, this suggests that significant multicollinearity exists, which may require corrective measures. The results illustrate no evidence of multicollinearity amongst the explanatory variables.

The estimated growth model was also tested for stability using recursive residuals (CUSUM) and cumulative sum of squares residuals (CUSUMSQ).

**Figure 5.2: Plots for the CUSUM Test (a) and CUSUM of Squares Test (b).**




Source: Author (Compiled from E-views)

The findings outlined above in Figures 5.2a and 5.2b demonstrate that the recursive residuals and the cumulative sum of squares curves are trending within the established boundaries. This serves as a positive indication that the model is stable, and its relationships remain relatively unchanged throughout the analysis period.

### *5.3.3.6 Estimation Results for Employment Model*

The Bounds testing approach of the ARDL methodology is employed to identify co-integration between variables, and the findings are presented in Table 5.9 below.

**Table 5.9: Bounds test for co-integration**

| F-Bounds Test | | Null Hypothesis: No levels relationship | | |
|---|---|---|---|---|
| Test Statistic | Value | Signif. | I(0) | I(1) |
| | | | Asymptotic: n=1000 | |
| F-statistic | 5.806087 | 10% | 2.08 | 3 |
| k | 5 | 5% | 2.39 | 3.38 |
| | | 2.5% | 2.7 | 3.73 |
| | | 1% | 3.06 | 4.15 |
| Actual Sample Size | 31 | | Finite Sample: n=35 | |
| | | 10% | 2.331 | 3.417 |
| | | 5% | 2.804 | 4.013 |
| | | 1% | 3.9 | 5.419 |
| | | | Finite Sample: n=30 | |
| | | 10% | 2.407 | 3.517 |
| | | 5% | 2.91 | 4.193 |
| | | 1% | 4.134 | 5.761 |

Source: Author (compiled from E-Views)

The bounds test for cointegration was employed to determine whether a long-run relationship exists between employment and its explanatory variables: energy infrastructure investment, transport infrastructure investment, health infrastructure investment, education infrastructure investment, and foreign direct investment. The null hypothesis, asserting the absence of a long-run relationship between the variables, was examined. Table 5.9 indicates that the calculated F-statistic of 5.80 exceeds the upper critical values of 4.15, 3.38, and 3 at the 1%, 5%, and 10% significance levels, respectively. Thus, the null hypothesis of no cointegration was rejected, leading to the conclusion that a long-run relationship exists between employment and its explanatory variables. The study proceeded with the ARDL analysis.

**Table 5.10: Long Run Coefficients (1, 1, 2, 1, 1)**

| Variable | Coefficient | Std. Error | t-Statistic | Prob. * |
|---|---|---|---|---|
| LNFDI | -1.194896** | 0.506529 | -2.358991 | 0.0298 |
| LNEDU | 2.025357** | 0.749517 | 2.702216 | 0.0146 |
| LNENE | 3.760363** | 1.660322 | 2.264840 | 0.0361 |
| LNHEA | -3.925992*** | 0.864573 | -4.540962 | 0.0003 |
| LNTRA | 7.988555** | 3.417440 | 2.337584 | 0.0312 |
| C | 28.93469 | 3.285199 | 8.807590 | 0.0000 |

EC = LNEMP - (-1.1949*LNFDI + 2.0254*LNEDU +3.7604*LNENE
- 3.9260*LNHEA + 7.9886*LNTRA + 28.9347)

'Notes: *** Statistically significant at 1% level
** Statistically significant at 5% level
* Statistically significant at 10% level'
Source: Author (Compiled from E-views)

The long-run estimates illustrated in the table above examine the dependent variable (log(formal employment)), which is experiencing a prolonged crisis characterised by structural unemployment, high informality, and growing inequality. The independent variables examine the roles of foreign direct investment and key pillars of public infrastructure. There is a significant positive long-term effect on formal employment for the following infrastructural investments: education, energy, and transportation. This suggests that a 1% increase in educational infrastructure investment is correlated with a substantial 2,03% increase in formal employment at 5% significance level. This aligns with human capital theory, which suggests that improved education infrastructure (schools, universities, and training colleges) enhances the quality and quantity of the skilled workforce. Additionally, a more skilled labour force increases productivity and makes the economy more competitive, thereby stimulating demand for formal labour (Leoni, 2025). Furthermore, an elasticity greater than 1 suggests a highly responsive and multiplicative effect.

Table 5.10 further indicates that a 1% growth in the energy infrastructure investment is linked to a substantial 3,76% increase in formal employment at 5% significance level. This finding is consistent with Chapters 2 and 3 of the study, as reliable energy is a fundamental input for all modern economic activities. It reduces operational costs, enables industrial expansion, and attracts new businesses (Eberhard et al., 2020). In addition, Dirma et al. (2024) found that the energy sector plays a vital role in job creation, as emerging technologies and initiatives require experts across various fields, ranging from engineering to installation. Large-scale energy infrastructure projects, whether based on fossil fuels or renewable sources, generate employment opportunities across numerous sectors, particularly during the construction stages. Likewise, a 1% surge in transport infrastructure investment will result in a substantial 7,99% growth in formal employment in South Africa, also at 5% significance level. The findings align with those presented by Kumo (2012), which identified a robust bidirectional causal link between investments in economic infrastructure and employment within the public sector. This relationship underscores the impact of such investments on employment opportunities via construction, maintenance, and operational activities. Furthermore, the rise in employment may subsequently foster additional infrastructure investments indirectly by enhancing total demand and stimulating economic growth in South Africa. Mbanda and Chitiga-Mabugu (2017) found similar results.

Table 5.10 further illustrates that a 1% increase in health infrastructure investment is linked to a substantial decline of 3,93% in formal employment, highly significant at 1% level. This result contradicts the expected assumption that a positive relationship exists between employment and health infrastructure investment. However, Boeri & Van Ours (2021) indicate that policies raising the costs of formal employment, such as non-wage labour costs, tend to informalize various sectors and favour substituting capital for labour. Foreign direct investment demonstrated a statistically significant negative correlation with employment levels in South Africa, with a coefficient of -1.19 at 5% significance level. The findings align with the scholarly perspective that employment benefits of FDI are not guaranteed; rather, they depend on the attributes of the host country, including the degree of human capital and the ability of the local economy to accommodate investments (Flores, 2022). Strauss (2013) argued that sectors characterized by capital-intensive FDI do not yield significant prospects for job creation through investments in human capital. Therefore, it is essential to allocate resources towards enhancing human capital, equipping individuals with pertinent training and skills to enhance their employability and subsequently amplify employment impacts through FDI.

The research thus concludes that investment in economic infrastructure exhibits a substantial positive long-term correlation with employment, whereas investment in social infrastructure demonstrates both positive and negative associations with employment in South Africa.

**Table 5.11: Short Run Coefficients (1, 1, 2, 1, 1)**

| | Coint Eq (-1) | LNFDI | LNEDU | LNENE | LNTRA | LNHEA |
|---|---|---|---|---|---|---|
| Coefficient | -0.4556*** | -0.5444*** | 0.9229** | 1.7135** | 3.6402*** | -1.7889*** |
| P-value | 0.0000 | 0.0095 | 0.0146 | 0.0100 | 0.0054 | 0.0005 |

Notes: *** Statistically significant at 1% level
** Statistically significant at 5% level
* Statistically significant at 10% level
Source: Author (Compiled from E-views)

The cointegration equation (-1) is an error correction term (ECT) that indicates the rate at which equilibrium is restored within the employment model. It shows the speed at which a disequilibrium from the past cycle is adjusted. Table 5.11 above shows the highly significant cointegration equation (-1) value of -0.46, which suggests that the model is indeed adjusting towards its long-run equilibrium at approximately 46%. This indicates a rapid adjustment from short-term deviations to long-term equilibrium in response to disturbances within the model. Moreover, this validates the existence of a steady long-term correlation between the variables. Findings further demonstrate that, in the short-run, investment in economic infrastructure (LNENE and LNTRA) exerts a statistically significant impact on employment, quantified at 1.71, significant at 5% level, and 3.64, statistically significant at 1% level, respectively. This suggests that economic infrastructure investment plays a crucial part in driving short-term employment growth. Similarly, a 1% rise in government spending on social infrastructure (LNEDU) leads to a rise in job creation, specifically by 0.92% significant at 5% level. While health infrastructure and foreign direct investment show a negative correlation with employment in the short-run, both are highly significant at 1% level. The study, therefore, concludes that LNENE, LNTRA, and LNEDU have a substantial positive effect on employment in the short run.

*5.3.3.7 Impulse Response Function of Employment*

The findings from the impulse response analysis are illustrated in Figure 5.3a-e. As noted earlier, the solid blue line denotes the impulse response function, while the dotted red lines signify the 95% confidence interval, and the zero line indicates the threshold for significance. If the red dotted lines encompass the zero line, the effect is deemed statistically insignificant. Conversely, if both red bands are completely above and below the zero line, the effect is considered statistically significant.

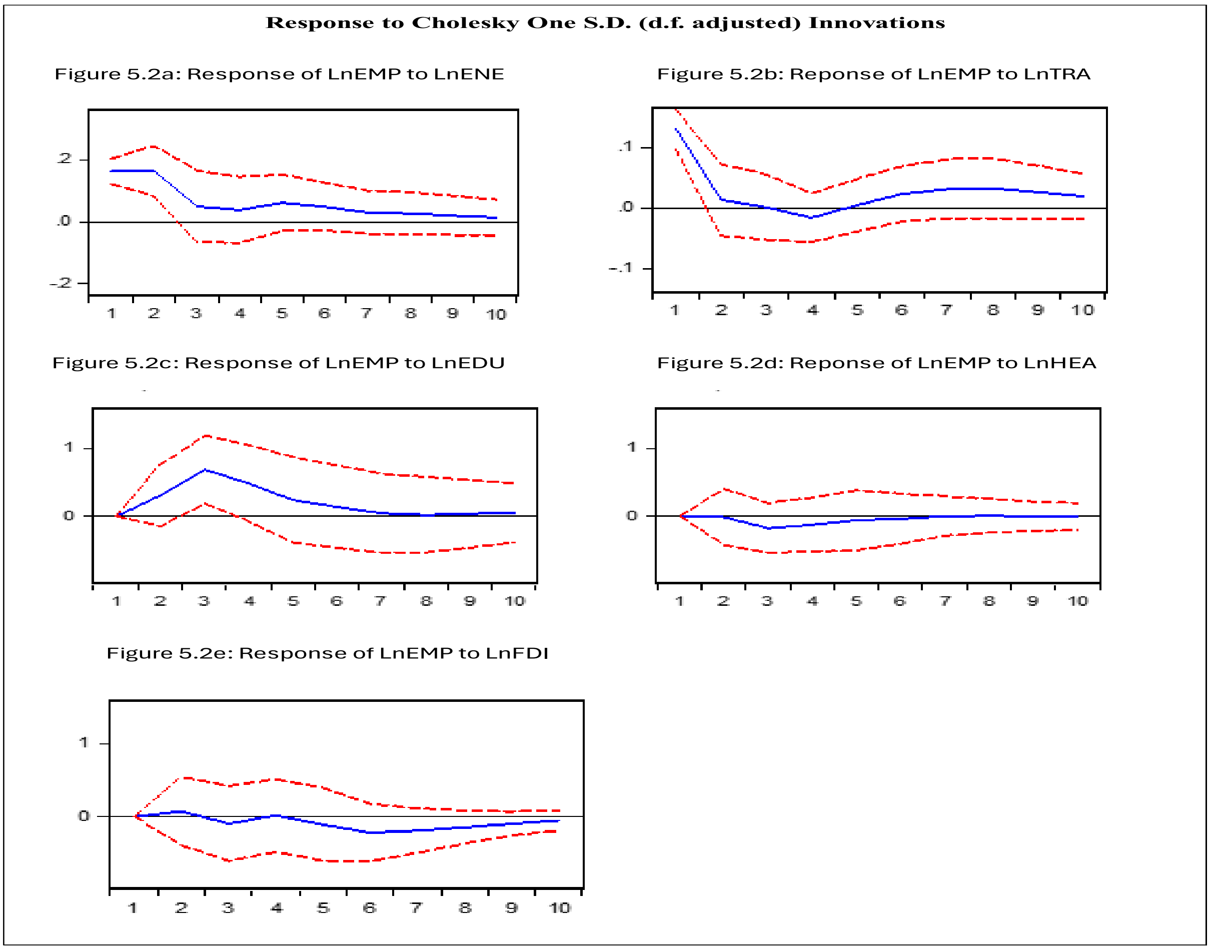
The response of LnEMP to LnENE is depicted in Figure 5.3a, demonstrating that employment exhibits a highly positive response to energy shocks during the early stages, specifically in periods 1-2, at a variation of approximately 1.8%, and is statistically significant. Subsequent to period 2, the impact drops significantly and stabilises closer to zero for the remaining periods. This indicates that the effects of energy infrastructure shocks have a favourable impact on employment in both the short and long-term.

LnEMP's response to LnTRA is shown in Figure 5.3b. Employment responds positively to transport infrastructure shocks during the early stages, from period 1-3, at a variation of approximately 0.12%. The response to employment slightly drops at period 4, then gradually rises again above the zero line up to the 10$^{th}$ period. This indicates that the positive effect of transport infrastructure shocks has a positive impact on employment in both the short and long-term, similar to the energy sector.

Figure 5.3c illustrates the impact of a one standard deviation shock in LnEDU on employment across a 10-period horizon. The findings indicate that employment reacts positively to the shock in educational infrastructure, attaining its peak value at period 3 with a variation of almost 0.7%. This positive reaction gradually diminishes and reaches a steady state from period 8 to 10. This implies that shocks to LnEDU will certainly impact employment positively in the short to long-term. As discovered in Figure 5.3d, a one standard deviation shock to LnHEA has a negative effect on employment, as evidenced by a sharp decline from period 2 to 4, then from period 5 onwards, the line reaches the steady state and remains there up to the 10$^{th}$ period. This implies that shocks to health infrastructure investment will negatively impact employment in the short-run.

Figure 5.3e depicts the effect of a one standard deviation shock in LnFDI on employment along a 10-period horizon. The findings reveal that during the initial phases, specifically from period 1 to 4, the response remains at the zero line, indicating minimal reaction to the FDI shock. However, from period 5 to the 10th period, a slight downward trend emerges, where the response turns negative, implying a potential minor decline in employment in the long term. Nonetheless, the findings indicate that the overall effect lacks statistical significance, implying that, in accordance with the study's employment model, an unexpected shock in foreign direct investment does not lead to a substantial change in the path of employment. Since the confidence interval covers the zero line, the results are consequently deemed insignificant.

**Figure 5.3: The Cholesky Impulse Response Function (Employment).**




Source: Author (Compiled from E-views)

*5.3.3.8 The Variance Decomposition of Employment*

The variance decomposition analysis illustrated in Table 5.12 covers a duration of up to 10 years, with the objective of assessing the impact of the independent variables on employment as they are permitted to exert their effects over an extended timeframe.

**Table 5.12: Variance Decomposition**

| **Variance Decomposition of LnEMP** | | | | | | | |
|---|---|---|---|---|---|---|---|
| Period | S.E. | LnEMP | LnENE | LnTRA | LnEDU | LnHEA | LnFDI |
| 1 | 1.136558 | 100.0000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| 2 | 1.415256 | 88.59665 | 5.112616 | 3.39E-05 | 5.946109 | 0.047781 | 0.296815 |
| 3 | 1.740429 | 70.46422 | 7.984503 | 0.592818 | 18.62730 | 0.503689 | 1.827478 |
| 4 | 2.041033 | 67.92061 | 6.102958 | 4.748739 | 18.96012 | 0.569278 | 1.698288 |
| 5 | 2.176870 | 66.95395 | 5.531251 | 7.400199 | 17.53475 | 0.505719 | 2.074136 |
| 6 | 2.228544 | 65.99225 | 5.588866 | 8.044260 | 16.85552 | 0.494446 | 3.024649 |
| 7 | 2.249424 | 65.57361 | 5.659625 | 8.151517 | 16.54444 | 0.530464 | 3.540344 |
| 8 | 2.258369 | 65.34191 | 5.756663 | 8.127244 | 16.41778 | 0.559389 | 3.797011 |
| 9 | 2.263257 | 65.23973 | 5.842890 | 8.099680 | 16.35181 | 0.564881 | 3.901006 |
| 10 | 2.267127 | 65.20621 | 5.890964 | 8.084674 | 16.32386 | 0.563528 | 3.930760 |
| Cholesky Ordering: LnEMP LnENE LnTRA LnEDU LnHEA LnFDI | | | | | | | |

Source: Author (Compiled from E-views)

The results of the ten-year variance decomposition from the Vector Auto-Regression (VAR) model are displayed in Table 5.12. These findings suggest that employment is primarily influenced by its own innovations, which constituted 100% in the initial year; however, the influence decreases steadily, from 100% in period 1 to 65.21% in period 10. This suggests that most future changes in employment are influenced by its own internal dynamics and shocks. Nevertheless, the drop to 65.21% implies that the remaining 34.79% of the long-term variation is accounted for by external shocks, specifically the five independent variables.

Starting from the second year, investment in education infrastructure surfaces as the most crucial factor in accounting for employment fluctuations, reaching a peak of 16.32% by the tenth period. Subsequently, the transport sector ranks next with a contribution of 8.08% in the tenth period, followed by the energy sector at 5.89% during the same period. The findings additionally suggest that the unpredictable shocks in foreign direct investment and health infrastructure do not significantly contribute to the overall changes in employment when compared to other influencing factors. This suggests that education, transport, and energy infrastructure are the most significant factors in explaining short to long-term labour market fluctuations. The results are consistent with the outcomes derived from the impulse response analysis.

*5.3.3.9 Results for Diagnostic Analysis*

To ensure that the results obtained are valid, four diagnostic tests were performed for the employment model. The serial correlation LM test was employed to evaluate the existence of serial correlation, with the null hypothesis asserting that no serial correlation is present in the model at a 5% significance level. The P-value of 0.64 surpasses 0.05, suggesting that the null hypothesis will not be rejected, thus affirming the lack of serial correlation in the model. Additionally, the Breusch-Pagan-Godfrey (BPG) test for heteroscedasticity indicated that the model is homoscedastic, as evidenced by the probability value of 0.11. Furthermore, the p-value derived from the Jarque-Bera normality test is 0.28, which is above the 5% significance threshold. Therefore, the results suggest that the series adheres to a normal distribution.

**Table 5.13: Diagnostic Tests**

| | Null Hypothesis | P-Value |
|---|---|---|
| LM Test | No serial correlation | 0.6443 |
| BPG Test | No conditional heteroscedasticity | 0.1141 |
| JB Test | The model's residuals are normally distributed | 0.2823 |

Source: Author (Compiled from E-views)

The overall model demonstrates a high level of statistical significance and adheres to Gaussian assumptions, successfully passing assessments for 'serial correlation, functional form misspecification, and heteroscedasticity'. furthermore, the model exhibits a normal distribution, as illustrated in Table 5.13 above.

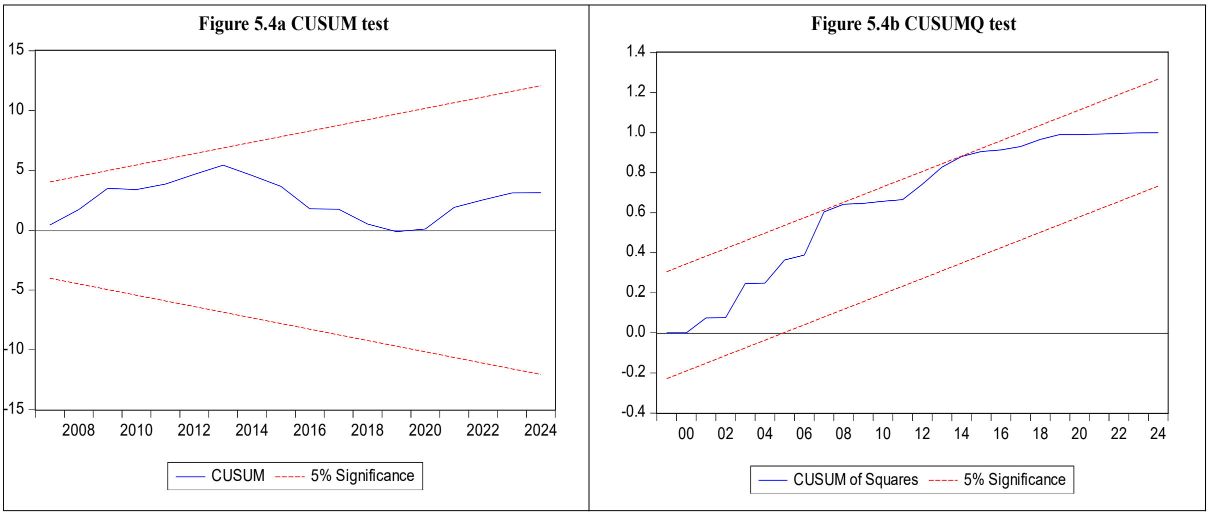
**Table 5.13.1: Variance Inflation Factors (VIF)**

| Variable | Coefficient Variance | Uncentered VIF | Centered VIF |
|---|---|---|---|
| LFDI | 0.081086 | 36.50667 | 1.942350 |
| LINFENE | 1.295109 | 127.0740 | 2.286667 |
| LINFHE | 0.626020 | 103.4906 | 1.161045 |
| LFOEMPLO | 0.074239 | 71.37021 | 4.735235 |
| LINFEDU | 0.460976 | 173.7790 | 3.048993 |
| C | 95.67825 | 712.3812 | NA |

Source: Author (Compiled from E-views)

Table 5.13.1 results illustrate that there is no indication of multicollinearity amongst the explanatory variables, as the values of the centered VIF, which range between 1.16 and 4.74, are below the common thresholds of 5 and 10. This demonstrates that the regression model's coefficients are reliable and not affected by collinearity issues. The estimated growth model was also tested for stability using recursive residuals (CUSUM) and cumulative sum of squares residuals (CUSUMSQ).

**Figure 5.4: Plots for the CUSUM Test (a) and CUSUM of Squares Test (b).**




Source: Author (Compiled from E-views)

In terms of model stability, the CUSUM and CUSUM of square residuals tests were used to assess the stability and consistency of the error term. The CUSUM of squares identifies systematic variations in parameters, whereas the CUSUM test evaluates the stability of the model. Both tests indicated stability in the model parameters and constancy of the error terms, as evidenced by the blue lines remaining within the 5% significance threshold.

### 5.3.4 Summary of Empirical Results

This research was intended to deliver an evaluation of how investing in public infrastructure (both economic and social) affects the South African growth and employment levels. Secondly, it seeks to compare the differences in the impact of these infrastructure factors on economic growth and employment between the general government and public corporations. In alignment with this goal, the research will evaluate the extent to which investments in public infrastructure influence economic growth and employment rates in the short and long term within South Africa. Additionally, it is essential to determine the role of the supporting variable FDI in the regression model in promoting sustainable growth and employment levels.

**Table 5.14: Summary of Short and Long-Run Relationships between General Government and Public Corporations.**

| GROWTH MODEL | | | | | EMPLOYMENT MODEL | | | |
|---|---|---|---|---|---|---|---|---|
| Variables | *General Government* | | *Public Corporations* | | *General Government* | | *Public Corporations* | |
| | LR | SR | LR | SR | LR | SR | LR | SR |
| LNTRA | | | - | - | | | 7.988** [0.031] | 3.640*** [0.005] |
| LNENE | | | 2.701* [0.054] | 4.077** [0.020] | | | 3.760** [0.036] | 1.713** [0.010] |
| LNEDU | 1.322** [0.048] | 1.996** [0.042] | | | 2.025** [0.014] | 0.922** [0.014 | | |
| LNHEA | 1.142* [0.070] | 1.725* [0.052] | | | -3.925*** [0.000] | -1.788*** [0.000] | | |
| LNFDI | -0.551 [0.142] | -0.832 [0.143] | -0.551 [0.142] | -0.832 [0.143] | -1.194 [0.298] | -0.544*** [0.009] | -1.194 [0.298] | -0.544*** [0.009] |

'Notes: SR and LR denote short and long-run, respectively; P-value represented by [].'

*** Statistically significant at 1% level
** Statistically significant at 5% level
* Statistically significant at 10% level
'The VAR results are presented as the IRF and Variance Decomposition, and as such, they could not be included in the table.
Source: Author (compiled from e-views)'

The above estimated results of the ARDL indicate the presence of both long-term and short-term co-integrating relationships among public infrastructure investment, both economic and social, economic growth, and employment. These empirical results visibly illustrate that, within the framework of the growth model, economic and social infrastructure have a markedly positive impact on economic growth. This indicates that the General Government's spending in the areas of education and health significantly influences economic growth. The high elasticity of the coefficients LnEDU (1.99) and LnHEA (1.72) in the short-run implies that these investments serve as strong and effective catalysts for economic expansion, which are statistically significant at the 5% and 10% significance levels, respectively. This suggests that a prompt injection of capital into these sectors produces a robust growth multiplier, rendering them highly effective instruments for fiscal stimulus. Furthermore, in the short term, the pronounced elasticity is primarily driven by the demand-side effects of the investment; as the government constructs new schools, hospitals, and clinics, or upgrades existing facilities, this activity generates immediate economic engagement, which encompasses heightened demand for construction materials, equipment, labour, and associated services, thereby directly boosting economic growth (DBSA, 2024). These results are consistent with the variance decomposition findings, which suggest that Education and Health infrastructure are the most influential factors in explaining the fluctuations in growth at a magnitude of 7.73% and 7.51% respectively.

Spending by Public Corporations also indicates a significant positive impact on the South African economy. The highest elasticity for the energy sector (LnENE) at 4.07 and statistically significant at

5% level, indicates that investing in the energy sector by Public Corporations is the most efficient way to boost short-term growth in South Africa. Considering the persistent electricity supply crisis in South Africa (such as load-shedding and load-reduction), the results strongly indicate that addressing the energy sector is the most urgent lever for economic recovery. A reliable and adequate energy supply alleviates the primary constraint on business productivity, enabling businesses to function at full capacity and leading to rapid and substantial growth (Dall'Omo, 2024), as evidenced by the 4.07% short-run elasticity. Furthermore, the high elasticity carries significant policy implications for the South African government, especially given the country's persistent challenges with economic growth and unemployment. The results align with the impulse response analysis and variance decomposition, which found shocks in the energy sector to have a positive effect on economic growth in both the short and long-term. The coefficients of LNFDI and LNTRA were found to be statistically insignificant in explaining growth.

Table 5.14 also displays the empirical results of the employment model, indicating that investment in economic infrastructure (LNTRA and LNENE) has a statistically significant effect on employment in both the long and short term. The substantially high elasticity of 7.98 at 5% significance level observed in the long term suggests that investments made by Public Corporations in the transport sector have a substantial, influential, as well as essential effect on job creation within the South African economy. This implies that when state-owned entities such as Transnet and SANRAL invest in and enhance transport networks, they not only generate construction jobs but also trigger significant productivity gains throughout the entire economy (Rodrigue, 2024). Similarly, investment in the energy sector has been proven to be essential for job creation, exhibiting a high elasticity of 3.76 in the long-run and statistically significant at 5% level. This indicates that when businesses, particularly those in energy-concentrated sectors such as mining and manufacturing, can operate at full capacity, they are motivated to invest, expand their output, and, in turn, increase their demand for labour (Rodrigue, 2024). Furthermore, a positive and substantial relationship between educational infrastructure and employment confirms that the formation of human capital serves as a vital and influential long-term driver of job creation, suggesting that investing in education is not merely a social expenditure but a key economic catalyst. Enhanced education and training facilities result in a positive impact on the development of a more skilled and productive workforce (Dall'Omo, 2024).

The negative high coefficient of -3.92 observed in the health sector, which is highly substantial at 1% significance level, indicates that the investment may be significantly capital-intensive yet poorly managed, resulting in an inability to achieve the anticipated productivity improvements in health. The highly negative LnHEA coefficient necessitates an urgent reassessment of the allocation and management of government health infrastructure funds. The empirical results of this research indicate that foreign direct investment (LNFDI) exerts a negative and statistically significant influence on employment levels in South Africa. The results are consistent with those of Mathebula (2023), who stated that the negative relationship may be attributed to the type of FDI that is drawn to South Africa, which is generally more 'capital-intensive rather than labour-intensive', thereby creating job opportunities for a limited number of skilful workers and consequently resulting in a detrimental effect on job creation. These findings are consistent with the impulse response and variance decomposition analysis.

In light of the comprehensive assessment of the findings from this study, the following conclusions are drawn regarding the hypotheses of this study:

- In terms of hypothesis 1 of the study, the null hypothesis (Ho) is rejected, and the alternative hypothesis (H1) is accepted as the results have revealed that investment in social and economic infrastructure exhibits a significantly positive impact on economic growth and employment in South Africa.
- In terms of hypothesis 2 of the study, the null hypothesis (Ho) is rejected, and the alternative hypothesis (H1) is accepted as the findings have revealed a significant difference in the impact that both social and economic infrastructure investment has on economic growth and employment between the general government and public corporations.

## 5.4 Conclusion

This chapter concentrated on the interpretation of the results derived from the models estimated in Chapter 4 of the study. The analysis commenced with an examination of the time series characteristics of the data, employing two methods to test for a unit root. These approaches validated that the variables are integrated at different orders, specifically, I(0) and I(1). Following the determination of the integration order for the variables, the lag length used in the estimation of the ARDL co-integration was identified, with most information criteria indicating a lag of 1 for the growth model and a lag of 2 for the employment model. These two identified lag lengths were then applied in the estimation procedure. The bound F test for co-integration was conducted to assess the presence of a long-term relationship among the variables. The findings revealed that a long-term relationship exists between economic growth and its explanatory variables, in addition to the relationship between employment and its independent variables. Following this, the ARDL-ECM model was estimated to investigate both the long-term and short-term interactions among the variables. To complement findings obtained from the ARDL-ECM model, the impulse response function alongside the variance decomposition analysis was utilised to assess the behaviour of shocks within the model and to ascertain the significance of these shocks in explaining variations in the variables of interest. Additionally, a range of statistical diagnostics was performed to verify the robustness and statistical integrity of the model. The findings substantiated that investment in public infrastructure exerts a considerable influence on economic growth and employment in South Africa, aligning with the study's primary objective.

The subsequent chapter offers a concise overview of the research, including policy recommendations, identified limitations, and proposals for future research.

# CHAPTER 6

## STUDY SUMMARY, CONCLUSIONS, POLICY IMPLICATIONS, AND RECOMMENDATIONS

### 6.1 Introduction

The focus of this study has been to provide a comprehensive assessment of how investments in public infrastructure influence economic growth and employment within the South African economy. This chapter summarizes the study, outlines the conclusions derived from the findings, and suggests recommendations for future policy formulation. The chapter concludes with a discussion of the study's limitations and potential avenues for future research.

### 6.2 Summary of the Study

The purpose of this research was to ascertain whether investing in public infrastructure could assist the nation in generating additional employment opportunities, thereby fostering economic growth and enhancing the quality of life for its citizens. Additionally, the study sought to explore the correlation between infrastructure investment, economic growth, and employment in South Africa. The research is structured into six chapters. The first chapter provided the introduction and context of the study. The focus was to analyse the effect of infrastructure from economic and social viewpoints and further examine their contribution to growth and the ability to create more jobs through upgrading, refurbishment, maintenance, or construction of new assets from a public sector perspective, i.e., general government and public corporations.

Chapter two reviewed the trends in social and economic infrastructure spending, economic growth, and employment from 1992-2024. The literature reviewed in this chapter reveals that, from 1994, the democratic government prioritized investing in social infrastructure and developed policies aimed at addressing issues such as low growth rates, inadequately positioned infrastructure, unemployment, and poverty resulting from Apartheid. In the early 2000s, the democratic government began investing more in projects of economic value as a way of stimulating economic activities and dealing with the demands of the growing economy by increasing spending on public corporations such as Eskom, Transnet, SAA, and many more. However, despite this investment, South Africa has, over the years, experienced significantly high levels of unemployment and low growth rates driven by a mixture of structural, economic, and social factors. The country's economy has struggled to produce adequate employment opportunities to match the growing labour force, resulting in what is referred to as "jobless growth". The South African growth rate continues to deteriorate even further, with recent stats showing that GDP decreased to 0,1% in the first quarter of 2024 from 0,3 in quarter 4 of 2023, while unemployment increased to 32,9% from 32,1% respectively (Statistics SA, 2024). In the South African context, the downward trend in growth could be as a result of insufficient infrastructure funding due to fiscal consolidation, poor implementation of projects, which resulted in underperformance of the overall infrastructure spending, inadequate maintenance of existing facilities, unreliable power supplies, and operational difficulties in ports, freight, and rail, continuing to plague South Africa's transport industry. All these challenges have proven to be a substantial barrier to economic growth and social progress.

Chapter three examined both theoretical and empirical literature, focusing on the general theory of employment, interest, and money; the Solow growth model; and the Cobb-Douglas production function theory. These theories complement one another, as the shortcomings of one are addressed by the strengths of the other. Furthermore, these theories offer distinct viewpoints on the same fundamental inquiry: (what influences the level and growth of a nation's income). Several empirical studies reviewed in this study have substantiated the theoretical premise that a positive relationship exists between infrastructure developments, employment, and economic growth. The body of literature aimed at assessing the economic effects of both 'economic and social infrastructure' remains constrained, as most researchers have predominantly concentrated on the effect of economic infrastructure on growth. Furthermore, the latest empirical research has primarily focused on the relationship between transport infrastructure investment and economic growth, specifically within the context of South Africa.

Chapter four outlined the research methodology along with all the data analysis techniques employed in the study. The study's objective revolves around two hypotheses, designed to investigate how significant macroeconomic variables, including economic growth and employment, have responded to the effects of investing in both economic and social infrastructure from 1992 to 2024. Furthermore, this study identified the primary factors influencing growth and employment in South Africa in the short and long term. To fulfil the study's primary aim and address the corresponding hypotheses, initial assessments of data were performed using a unit root test, revealing that two variables (GDPG and LnFDI) were stationary at level I(0); conversely, all other variables, LnEMP, LnENE, LnTRA, LnHEA, and LnEDU, exhibited stationarity at the first difference 1(1). This mixture of integration orders 1(0) and 1(1) makes the Autoregressive Distributed Lag (ARDL) model the most appropriate choice for further analysis, based on its ability to handle variables with different orders of integration. The bounds test for cointegration was subsequently utilised to ascertain the existence of a long-term relationship among the variables. The results indicated that there is a level of co-integration that exists between economic growth and its independent variables, as well as between employment and its explanatory variables. The identification of co-integration enabled the estimation of the ARDL models, which concurrently generated parameter estimates for both the long-term and short-term. To validate the results derived from the ARDL-ECM model, the variables were additionally analysed using the impulse response function along with the variance decomposition analysis, which corroborated the findings of the ARDL. In both instances, the estimated models exhibited robustness and successfully fulfilled all relevant diagnostic assessments discussed in chapter five of the research. These results are aligned with the theoretical literature reviewed in the study. The current chapter six presents the summary of the study, policy recommendations, limitations, and suggestions for future research.

## 6.3 Literature Findings and Conclusion of the Study

According to Barro's (1990) theoretical model, along with various economic growth theories and the majority of empirical research, investing in both economic and social infrastructure are anticipated to be crucial factors influencing economic growth, thereby yielding positive coefficients. This research confirmed the validity of this concept for both the economic and social infrastructure within the growth model. The results align with economic theory and the inferences derived from numerous empirical studies conducted in South Africa, including those by Kumo (2012), Gadinabokao and Daw (2013), More and Aye (2017), and, more recently, DBSA (2024). These findings suggest that an immediate injection of capital into both economic and social infrastructure sectors generates a strong growth multiplier, both in the short and long term, making them exceptionally effective tools for fiscal stimulus. Conversely, in the employment model, economic infrastructure showed a statistically significant positive correlation with employment, whereas social infrastructure showed both significant positive and negative associations with employment. The negative correlation was particularly evident in the health sector, with a high level of significance at the 1% level. This outcome challenges the theoretical assumption that a healthier population would lead to increased productivity and, consequently, higher employment levels. Nevertheless, this finding does not imply that the health sector is unimportant in the employment process.

There may be several explanations for this observation:

- First of all, the negative effects might suggest that government funding for health infrastructure is displacing more efficient private investments or that alternative government expenditures, such as those in energy or transportation infrastructure, are more crucial.
- Secondly, the investment could be highly capital-intensive but inadequately managed, leading to a failure in realizing the expected productivity gains in health.
- Thirdly, while infrastructure projects in health, including the construction of new hospitals or the upgrading of community health centres, may be completed, the long-term operational employment generated in relation to the substantial costs is inadequate (cost-benefit analysis) to counterbalance the negative economic repercussions of the necessary financing required.

The findings align with the conclusions of empirical studies, including those by Vukeya (2015) and Boeri & Van Ours (2021). The current study, therefore, concludes that investments in public infrastructure by both the General Government and Public Corporations significantly enhance economic growth in both the short and long-term. Furthermore, within the employment model, it was observed that all other explanatory variables (LnTRA, LnENE, and LnEDU) positively influence employment.

At the same time, the health sector (LnHEA) was found to have an unfavourable impact on employment levels in South Africa. This negative impact necessitates an urgent reassessment of the allocation and management of government health infrastructure funds. Moreover, the empirical findings of this study indicate that the control variable, foreign direct investment (LnFDI), has a negative and statistically significant impact on employment, and it was also found to be statistically insignificant in accounting for growth in South Africa. This finding is consistent with that of Mathebula (2023), who stated that the negative correlation may be attributed to the type of FDI attracted to our country, which tends to be more capital-focused rather than labour-intensive.

## 6.4 Policy Recommendations

The findings of this research provide valuable insights into the correlation among infrastructure development, economic growth, and employment in South Africa. The findings reveal a strong and positive correlation between infrastructure (as measured by investments in energy, transport, education, and health), economic growth, and employment levels. This emphasizes the importance of continuous investment in physical capital to achieve productivity gains and sustain economic well-being. The analysis further reveals an adverse correlation between health infrastructure and employment, highlighting the urgent need for an immediate policy review of how health infrastructure funds are allocated and managed by the government. Furthermore, the analysis indicates that there is no substantial relationship between foreign direct investment and economic growth, alongside a notable negative correlation between foreign direct investment and employment. This implies that complementary factors may have a bigger effect on the economic dynamics within South Africa.

Based on the findings obtained from this research, the following recommendations are put forth for policymakers:

- Efforts should be made to prioritize funding for infrastructure developments by both the general government and public corporations, as the results indicate that these sectors (Energy, Transport, Education, and Health) are the most effective fiscal levers for stimulating short-term growth and generating long-term employment. These projects should be given precedence, expedited, and protected from corruption and mismanagement to maximize their potential for growth and job creation.
- The research further suggests that the government ought to restore efficiency and capacity of the State-Owned Enterprises (SOEs), such as the unbundling of Eskom and the modernization of Transnet, which will result in significant employment benefits.
- Policymakers are urged to reconsider their strategies for health investment, given the significant negative correlation with employment, which necessitates an urgent reassessment of the allocation and management of health infrastructure funds. The focus of policy should transition from merely building new facilities to guaranteeing that expenditures lead to enhanced public

health results and increased productivity within the workforce. Additionally, measures must be implemented to tackle the risks of corruption and mismanagement of financial resources.

- Authorities ought to devise strategies that effectively draw foreign direct investment while ensuring that the nation's affairs are well-managed. This includes addressing issues of corruption and crime, as well as maintaining political stability, since investors are drawn to a conducive environment.
- The National Growth Path (NGP) and the National Development Plan (NDP) emphasize the essential role of infrastructure investment in fostering economic growth, generating job opportunities, and enticing investment by the private sector. The findings of this research validate and reinforce these strategic approaches.

## 6.5 Limitations of the Study and Areas for Future Research

This research investigated the effects of public infrastructure investment on economic growth and employment within South Africa. The analysis covered annual data from 1992 to 2024. The scope of the study is confined to specific macroeconomic variables that influence growth and employment levels in South Africa, which can be integrated into the model. Additionally, the research concentrated on public infrastructure projects initiated by either the general government (national, provincial, and local) or public corporations. Regarding social infrastructure investment, this study concentrated solely on expenditures related to the health and education sectors. In terms of investment in economic infrastructure, the study exclusively examined spending from the energy and transport sectors. Furthermore, the research is confined to the ‘South African economy’, which implies that the findings may not be directly relevant to other economies. Nonetheless, the study holds considerable importance as the conclusions drawn could provide valuable insights within the South African context. It is essential to exercise caution when applying these results to other economies, given the differences in economic structures and the nature of monetary policies.

Future research endeavours should explore archives for significantly larger data sets to implement VAR/VECM-type models, which demonstrate optimal effectiveness with substantial sample sizes. Moreover, future studies should seek alternative proxies for both social and economic infrastructure expenditures, encompassing additional sectors such as housing, social development, and any pertinent economic domain beyond transportation and energy. Furthermore, it is essential for upcoming researchers to examine the role of the private sector in contributing to infrastructure financing and the associated return on investment.

## 6.6 Conclusion

The objective of this chapter was to define the fundamental proposition of the entire research, summarize the results of the study conducted, provide policy recommendations, detail the study's limitations, and suggest potential avenues for future research. Based on the comprehensive assessment of the results from this research, which indicates that public infrastructure investment plays a crucial role in fostering economic growth and employment in South Africa, the following conclusions can be drawn regarding the study's hypotheses; Ho: for hypothesis 1 of the study is rejected because the results revealed that investment in social and economic infrastructure exhibits a significantly positive impact on economic growth and employment in South Africa. This finding is corroborated by Kumo (2012), who identified a bidirectional correlation between investments in economic infrastructure and economic growth, as well as a reciprocal causal relationship between economic infrastructure investment and employment within the public sector. The findings are also aligned with the conclusions drawn from Mbanda and Chitiga-Mabugu (2017). Ho: for hypothesis 2 of the study is also rejected, as the results have revealed a significant difference in the impact that both social and economic infrastructure investment has on growth and employment between the general government and public corporations.

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# APPENDICES

## Appendix A: DATA

| YEARS | GDP | EMP | ENE | TRA | EDU | HEA | FDI |
|---|---|---|---|---|---|---|---|
| 1992 | -2,1 | 7 800 | 18,2 | 18,0 | 3,2 | 2,3 | 4 |
| 1993 | 1,2 | 6 914 | 16,7 | 23,9 | 3 | 2,1 | 10 |
| 1994 | 3,2 | 6 848 | 19,0 | 23,5 | 3,9 | 3,5 | 380 |
| 1995 | 3,1 | 6 813 | 22,9 | 25,1 | 4,5 | 4,0 | 1 241 |
| 1996 | 4,3 | 6 848 | 25,9 | 27,4 | 4,9 | 4,5 | 818 |
| 1997 | 2,6 | 6 794 | 25,0 | 33,4 | 5,4 | 5,6 | 3 817 |
| 1998 | 0,5 | 6 601 | 19,0 | 53,5 | 6,5 | 6,2 | 561 |
| 1999 | 2,4 | 6 564 | 15,5 | 40,0 | 7,4 | 6,5 | 1 503 |
| 2000 | 4,2 | 7 509 | 29,6 | 38,5 | 6,2 | 5,0 | 887 |
| 2001 | 2,7 | 7 194 | 43,7 | 40,4 | 6,5 | 6,2 | 6 784 |
| 2002 | 3,7 | 7 410 | 13,7 | 41,1 | 7,2 | 6,0 | 1 569 |
| 2003 | 2,9 | 7 725 | 27,2 | 48,6 | 8,5 | 6,5 | 734 |
| 2004 | 4,6 | 8 039 | 35,1 | 55,5 | 9,1 | 6,7 | 798 |
| 2005 | 5,3 | 8 336 | 59,7 | 70,6 | 9,1 | 7,0 | 6 647 |
| 2006 | 5,6 | 8 675 | 41,8 | 68,5 | 9,5 | 8,2 | 311 |
| 2007 | 5,4 | 9 147 | 53,6 | 77,6 | 7,2 | 8,7 | 6 538 |
| 2008 | 3,2 | 10 083 | 43,6 | 98,6 | 6,2 | 5,5 | 9 209 |
| 2009 | -1,5 | 9 967 | 47,5 | 91,3 | 6,2 | 6,2 | 7 502 |
| 2010 | 3,0 | 9 627 | 52,2 | 86,6 | 7,3 | 6,7 | 3 636 |
| 2011 | 3,2 | 9 942 | 67,1 | 89,2 | 8,8 | 7,7 | 4 243 |
| 2012 | 2,4 | 10 222 | 75,2 | 106,5 | 11,3 | 9,7 | 4 559 |
| 2013 | 2,5 | 10 524 | 69,6 | 98,9 | 13,7 | 10,0 | 8 300 |
| 2014 | 1,4 | 10 822 | 67,8 | 99,0 | 15,4 | 8,7 | 5 771 |
| 2015 | 1,3 | 10 935 | 65,9 | 111,7 | 18 | 10,3 | 1 729 |
| 2016 | 0,7 | 11 021 | 67,0 | 102,5 | 17,8 | 10,4 | 2 235 |
| 2017 | 1,2 | 11 288 | 55,1 | 91,2 | 17,6 | 9,7 | 2 008 |
| 2018 | 1,6 | 11 319 | 39,9 | 92,1 | 17,2 | 11,3 | 5 450 |
| 2019 | 0,3 | 11 234 | 26,2 | 89,9 | 17,4 | 12,2 | 5 125 |
| 2020 | -6,0 | 10 537 | 30,0 | 74,1 | 14,2 | 14,7 | 3 062 |
| 2021 | 4,9 | 10 043 | 35,5 | 77,7 | 14,5 | 16,4 | 40 215 |
| 2022 | 1,9 | 10 648 | 38,7 | 85,3 | 21,1 | 11,9 | 9 231 |
| 2023 | 0,7 | 10 806 | 46,1 | 75,1 | 14,4 | 13,1 | 5 233 |
| 2024 | 0,6 | 11 550 | 50,7 | 118,3 | 20,8 | 14,5 | 2 469 |

*Note: All the infrastructure values are in R billion, while formal employment is in thousands ('000)*

# Appendix B: Unit Root Test

## Appendix B1: Augmented Dickey Fuller (ADF)

### Variable 1: Gross Domestic Product

Null Hypothesis: GDP has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -4.629170 | 0.0008 |
| Test critical values: | 1% level | -3.653730 | |
| | 5% level | -2.957110 | |
| | 10% level | -2.617434 | |

Null Hypothesis: D(GDP) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=8)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -6.430587 | 0.0000 |
| Test critical values: | 1% level | -3.670170 | |
| | 5% level | -2.963972 | |
| | 10% level | -2.621007 | |

Null Hypothesis: D(GDP) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=8)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -6.346508 | 0.0001 |
| Test critical values: | 1% level | -4.296729 | |
| | 5% level | -3.568379 | |
| | 10% level | -3.218382 | |

### Variable 2: Formal Employment

Null Hypothesis: LnEMP has a unit root
Exogenous: Constant
Lag Length: 6 (Automatic - based on SIC, maxlag=8)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -2.763916 | 0.0774 |
| Test critical values: | 1% level | -3.711457 | |
| | 5% level | -2.981038 | |
| | 10% level | -2.629906 | |

Null Hypothesis: LnEMP has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 6 (Automatic - based on SIC, maxlag=8)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -1.902892 | 0.6242 |
| Test critical values: | 1% level | -4.356068 | |
| | 5% level | -3.595026 | |
| | 10% level | -3.233456 | |

Null Hypothesis: D(LnEMP) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -5.731890 | 0.0003 |
| Test critical values: | 1% level | -4.284580 | |
| | 5% level | -3.562882 | |
| | 10% level | -3.215267 | |

**Variable 3: Energy Infrastructure Investment**

Null Hypothesis: LnENE has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -2.249886 | 0.1937 |
| Test critical values: | 1% level | -3.653730 | |
| | 5% level | -2.957110 | |
| | 10% level | -2.617434 | |

Null Hypothesis: LnENE has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -2.624926 | 0.2725 |
| Test critical values: | 1% level | -4.273277 | |
| | 5% level | -3.557759 | |
| | 10% level | -3.212361 | |

Null Hypothesis: D(LnENE) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -6.762203 | 0.0000 |
| Test critical values: | 1% level | -4.284580 | |
| | 5% level | -3.562882 | |
| | 10% level | -3.215267 | |

**Variable 4: Transport Infrastructure Investment**

Null Hypothesis: LnTRA has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -2.083708 | 0.2521 |
| Test critical values: | 1% level | -3.653730 | |
| | 5% level | -2.957110 | |
| | 10% level | -2.617434 | |

Null Hypothesis: LnTRA has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -2.210445 | 0.4681 |
| Test critical values: | 1% level | -4.273277 | |
| | 5% level | -3.557759 | |
| | 10% level | -3.212361 | |

Null Hypothesis: D(LnTRA) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -5.837850 | 0.0002 |
| Test critical values: | 1% level | -4.284580 | |
| | 5% level | -3.562882 | |
| | 10% level | -3.215267 | |

**Variable 5: Education Infrastructure Investment**

Null Hypothesis: LnEDU has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=8)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -0.961678 | 0.7542 |
| Test critical values: | 1% level | -3.661661 | |
| | 5% level | -2.960411 | |
| | 10% level | -2.619160 | |

Null Hypothesis: LnEDU has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -3.415469 | 0.0670 |
| Test critical values: | 1% level | -4.273277 | |
| | 5% level | -3.557759 | |
| | 10% level | -3.212361 | |

Null Hypothesis: D(LnEDU) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -8.123637 | 0.0000 |
| Test critical values: | 1% level | -4.284580 | |
| | 5% level | -3.562882 | |
| | 10% level | -3.215267 | |

**Variable 6: Health Infrastructure Investment**

Null Hypothesis: LnHEA has a unit root
Exogenous: Constant
Lag Length: 4 (Automatic - based on SIC, maxlag=8)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -4.298952 | 0.0023 |
| Test critical values: | 1% level | -3.689194 | |
| | 5% level | -2.971853 | |
| | 10% level | -2.625121 | |

Null Hypothesis: LnHEA has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 4 (Automatic - based on SIC, maxlag=8)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -1.402985 | 0.8378 |
| Test critical values: | 1% level | -4.323979 | |
| | 5% level | -3.580623 | |
| | 10% level | -3.225334 | |

Null Hypothesis: D(LnHEA) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -5.577573 | 0.0004 |
| Test critical values: | 1% level | -4.284580 | |
| | 5% level | -3.562882 | |
| | 10% level | -3.215267 | |

**Variable 7: Foreign Direct Investment**

Null Hypothesis: LnFDI has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -4.425824 | 0.0014 |
| Test critical values: | 1% level | -3.653730 | |
| | 5% level | -2.957110 | |
| | 10% level | -2.617434 | |

Null Hypothesis: LFDI has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -4.616184 | 0.0044 |
| Test critical values: | 1% level | -4.273277 | |
| | 5% level | -3.557759 | |
| | 10% level | -3.212361 | |

Null Hypothesis: D(LnFDI) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -7.634648 | 0.0000 |
| Test critical values: | 1% level | -3.661661 | |
| | 5% level | -2.960411 | |
| | 10% level | -2.619160 | |

## Phillips – Perron (PP) Test

**Gross Domestic Product**

Null Hypothesis: GDP has a unit root
Exogenous: Constant
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -4.630466 | 0.0008 |
| Test critical values: | 1% level | -3.653730 | |
| | 5% level | -2.957110 | |
| | 10% level | -2.617434 | |

Null Hypothesis: GDP has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -5.274686 | 0.0008 |
| Test critical values: | 1% level | -4.273277 | |
| | 5% level | -3.557759 | |
| | 10% level | -3.212361 | |

Null Hypothesis: D(GDP) has a unit root
Exogenous: Constant
Bandwidth: 30 (Newey-West automatic) using Bartlett kernel

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -16.84774 | 0.0001 |
| Test critical values: | 1% level | -3.661661 | |
| | 5% level | -2.960411 | |
| | 10% level | -2.619160 | |

### Employment

Null Hypothesis: LnEMP has a unit root
Exogenous: Constant
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -1.713158 | 0.4153 |
| Test critical values: | 1% level | -3.653730 | |
| | 5% level | -2.957110 | |
| | 10% level | -2.617434 | |

Null Hypothesis: LnEMP has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 0 (Newey-West automatic) using Bartlett kernel

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -1.627715 | 0.7592 |
| Test critical values: | 1% level | -4.273277 | |
| | 5% level | -3.557759 | |
| | 10% level | -3.212361 | |

Null Hypothesis: D(LnEMP) has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -5.793938 | 0.0002 |
| Test critical values: | 1% level | -4.284580 | |
| | 5% level | -3.562882 | |
| | 10% level | -3.215267 | |

## Energy Infrastructure Investment

Null Hypothesis: LnENE has a unit root
Exogenous: Constant
Bandwidth: 6 (Newey-West automatic) using Bartlett kernel

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -2.122793 | 0.2375 |
| Test critical values: | 1% level | -3.653730 | |
| | 5% level | -2.957110 | |
| | 10% level | -2.617434 | |

Null Hypothesis: LnENE has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -2.555947 | 0.3013 |
| Test critical values: | 1% level | -4.273277 | |
| | 5% level | -3.557759 | |
| | 10% level | -3.212361 | |

Null Hypothesis: D(LnENE) has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 30 (Newey-West automatic) using Bartlett kernel

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -14.76964 | 0.0000 |
| Test critical values: | 1% level | -4.284580 | |
| | 5% level | -3.562882 | |
| | 10% level | -3.215267 | |

## Transport Infrastructure Investment

Null Hypothesis: LnTRA has a unit root
Exogenous: Constant
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -2.192730 | 0.2126 |
| Test critical values: | 1% level | -3.653730 | |
| | 5% level | -2.957110 | |
| | 10% level | -2.617434 | |

Null Hypothesis: LnTRA has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 1 (Newey-West automatic) using Bartlett kernel

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -2.181297 | 0.4833 |
| Test critical values: | 1% level | -4.273277 | |
| | 5% level | -3.557759 | |
| | 10% level | -3.212361 | |

Null Hypothesis: D(LnTRA) has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -5.822476 | 0.0002 |
| Test critical values: | 1% level | -4.284580 | |
| | 5% level | -3.562882 | |
| | 10% level | -3.215267 | |

**Education Infrastructure Investment**

Null Hypothesis: LnEDU has a unit root
Exogenous: Constant
Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -1.142237 | 0.6865 |
| Test critical values: | 1% level | -3.653730 | |
| | 5% level | -2.957110 | |
| | 10% level | -2.617434 | |

Null Hypothesis: LnEDU has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -3.420650 | 0.0663 |
| Test critical values: | 1% level | -4.273277 | |
| | 5% level | -3.557759 | |
| | 10% level | -3.212361 | |

Null Hypothesis: D(LnEDU) has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 6 (Newey-West automatic) using Bartlett kernel

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -9.555842 | 0.0000 |
| Test critical values: | 1% level | -4.284580 | |
| | 5% level | -3.562882 | |
| | 10% level | -3.215267 | |

### Health Infrastructure Investment

Null Hypothesis: LHEA has a unit root
Exogenous: Constant
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -0.765049 | 0.8154 |
| Test critical values: | 1% level | -3.653730 | |
| | 5% level | -2.957110 | |
| | 10% level | -2.617434 | |

Null Hypothesis: D(LHEA) has a unit root
Exogenous: Constant
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -5.689559 | 0.0000 |
| Test critical values: | 1% level | -3.661661 | |
| | 5% level | -2.960411 | |
| | 10% level | -2.619160 | |

Null Hypothesis: D(LHEA) has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -5.598830 | 0.0004 |
| Test critical values: | 1% level | -4.284580 | |
| | 5% level | -3.562882 | |
| | 10% level | -3.215267 | |

### Foreign Direct Investment

Null Hypothesis: LnFDI has a unit root
Exogenous: Constant
Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -4.966136 | 0.0003 |
| Test critical values: | 1% level | -3.653730 | |
| | 5% level | -2.957110 | |
| | 10% level | -2.617434 | |

Null Hypothesis: LnFDI has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 12 (Newey-West automatic) using Bartlett kernel

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -6.179380 | 0.0001 |
| Test critical values: | 1% level | -4.273277 | |
| | 5% level | -3.557759 | |
| | 10% level | -3.212361 | |

Null Hypothesis: D(LFDI) has a unit root
Exogenous: Constant
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -7.781722 | 0.0000 |
| Test critical values: | 1% level | -3.661661 | |
| | 5% level | -2.960411 | |
| | 10% level | -2.619160 | |

# Appendix C: ARDL Cointegration Test Results – Growth Model

## Appendix C1: Lag Order Selection Criteria

VAR Lag Order Selection Criteria
Endogenous variables: GDP LNFDI LNEDU LNENE LNHEA LNTRA
Exogenous variables: C
Date: 09/05/25 Time: 09:20
Sample: 1992 2024
Included observations: 31

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | -189.5538 | NA | 0.012146 | 12.61637 | 12.89392 | 12.70685 |
| 1 | -110.7029 | 122.0917* | 0.000802* | 9.851799* | 11.79462* | 10.48511* |
| 2 | -79.06202 | 36.74422 | 0.001411 | 10.13303 | 13.74113 | 11.30918 |

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

## Appendix C2: ARDL - Bounds Test

ARDL Long Run Form and Bounds Test
Dependent Variable: D(GDP)
Selected Model: ARDL(4, 4, 4, 4, 3)
Case 2: Restricted Constant and No Trend
Date: 09/05/25 Time: 09:40
Sample: 1992 2024
Included observations: 29

Conditional Error Correction Regression

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 30.13660 | 3.326030 | 9.060832 | 0.0003 |

| | | | | |
|---|---|---|---|---|
| GDP(-1)* | -1.509482 | 0.201560 | -7.488996 | 0.0007 |
| LNFDI(-1) | -0.832351 | 0.479776 | -1.734874 | 0.1433 |
| LNEDU(-1) | 1.996998 | 0.738190 | 2.705264 | 0.0425 |
| LNENE(-1) | 4.077364 | 1.224452 | 3.329951 | 0.0208 |
| LNHEA(-1) | 1.725270 | 0.680201 | 2.536414 | 0.0521 |
| D(GDP(-1)) | -0.007470 | 0.170836 | -0.043725 | 0.9668 |
| D(GDP(-2)) | -0.432439 | 0.136141 | -3.176412 | 0.0246 |
| D(GDP(-3)) | -0.342135 | 0.090805 | -3.767779 | 0.0131 |
| D(LNFDI) | 1.047451 | 0.230053 | 4.553084 | 0.0061 |
| D(LNFDI(-1)) | -0.169073 | 0.360134 | -0.469473 | 0.6585 |
| D(LNFDI(-2)) | -0.662641 | 0.336877 | -1.967013 | 0.1063 |
| D(LNFDI(-3)) | -0.583557 | 0.283943 | -2.055189 | 0.0950 |
| D(LNEDU) | -1.315248 | 0.375914 | -3.498801 | 0.0173 |
| D(LNEDU(-1)) | 0.429867 | 0.469422 | 0.915737 | 0.4018 |
| D(LNEDU(-2)) | 1.249730 | 0.346284 | 3.608969 | 0.0154 |
| D(LNEDU(-3)) | 1.333566 | 0.289855 | 4.600812 | 0.0058 |
| D(LNENE) | -1.320810 | 1.035879 | -1.275062 | 0.2583 |
| D(LNENE(-1)) | 8.520356 | 1.002956 | 8.495244 | 0.0004 |
| D(LNENE(-2)) | 7.406784 | 0.874504 | 8.469700 | 0.0004 |
| D(LNENE(-3)) | 7.322117 | 0.891924 | 8.209347 | 0.0004 |
| D(LNHEA) | -5.487546 | 1.179311 | -4.653181 | 0.0056 |
| D(LNHEA(-1)) | -3.545997 | 1.181504 | -3.001256 | 0.0301 |
| D(LNHEA(-2)) | 1.416706 | 1.158255 | 1.223138 | 0.2758 |

* p-value incompatible with t-Bounds distribution.

Levels Equation
Case 2: Restricted Constant and No Trend

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| LNFDI | -0.551415 | 0.316607 | -1.741641 | 0.1420 |
| LNEDU | 1.322969 | 0.509153 | 2.598375 | 0.0483 |
| LNENE | 2.701168 | 1.080552 | 2.499803 | 0.0545 |
| LNHEA | 1.142955 | 0.499212 | 2.289518 | 0.0707 |
| C | 19.96486 | 3.334921 | 5.986608 | 0.0019 |

EC = GDP - (-0.5514*LFDI +1.3230*LNEDU +2.7012*LNENE + 1.1430
*LNHEA + 19.9649 )

| F-Bounds Test | | Null Hypothesis: No levels relationship | | |
|---|---|---|---|---|
| Test Statistic | Value | Signif. | I(0) | I(1) |
| | | | Asymptotic: n=1000 | |
| F-statistic | 31.71020 | 10% | 2.2 | 3.09 |
| k | 4 | 5% | 2.56 | 3.49 |
| | | 2.5% | 2.88 | 3.87 |
| | | 1% | 3.29 | 4.37 |

### Appendix C4: Breusch-Godfrey LM Test:

Breusch-Godfrey Serial Correlation LM Test:

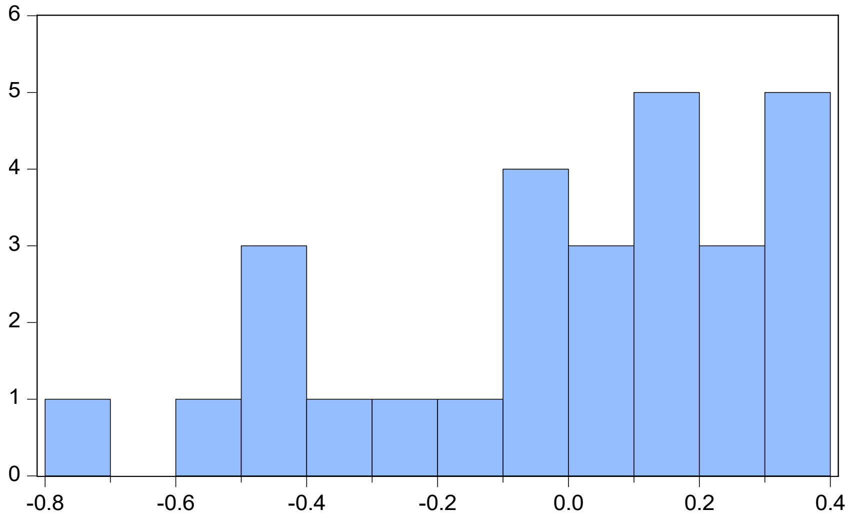
| | | | |
|---|---|---|---|
| F-statistic | 0.319183 | Prob. F(2,3) | 0.7487 |
| Obs*R-squared | 5.088166 | Prob. Chi-Square(2) | 0.0785 |

### Appendix C5: Breusch-Pagan-Godfrey - Heteroskedasticity Test

Heteroskedasticity Test: Breusch-Pagan-Godfrey

| | | | |
|---|---|---|---|
| F-statistic | 0.179325 | Prob. F(23,5) | 0.9983 |
| Obs*R-squared | 13.10867 | Prob. Chi-Square(23) | 0.9496 |
| Scaled explained SS | 0.989814 | Prob. Chi-Square(23) | 1.0000 |

### Appendix C6: JB Normality Test




Series: Residuals
Sample 1996 2023
Observations 28

| | |
|---|---|
| Mean | 1.33e-15 |
| Median | 0.064306 |
| Maximum | 0.386673 |
| Minimum | -0.756373 |
| Std. Dev. | 0.304985 |
| Skewness | -0.805487 |
| Kurtosis | 2.664662 |
| Jarque-Bera | 3.158967 |
| Probability | 0.206082 |

## Appendix D: ARDL Cointegration Test Results – Employment Model

### Appendix D1: Lag Order Selection Criteria

**VAR Lag Order Selection Criteria**
Endogenous variables: LnEMP LnFDI LnEDU LnENE LnHEA LnTRA
Exogenous variables: C
Date: 05/09/25 Time: 08:48
Sample: 1992 2024
Included observations: 31

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | -177.8359 | NA | 0.005703 | 11.86038 | 12.13792 | 11.95085 |
| 1 | -76.41146 | 157.0442 | 8.78e-05 | 7.639449 | 9.582270* | 8.272760 |
| 2 | -26.25599 | 58.24506* | 4.68e-05* | 6.726193* | 10.33429 | 7.902343* |

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

## Appendix D2: ARDL – Bounds Test

ARDL Long Run Form and Bounds Test
Dependent Variable: D(LNEMP)
Selected Model: ARDL (1, 1, 2, 1, 1)
Case 2: Restricted Constant and No Trend
Date: 05/09/25 Time: 08:50
Sample: 1992 2024
Included observations: 31

Conditional Error Correction Regression

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 13.18490 | 3.997518 | 3.298273 | 0.0040 |
| LNEMP(-1)* | -0.455678 | 0.113817 | -4.003586 | 0.0008 |
| LNFDI(-1) | -0.544488 | 0.187628 | -2.901960 | 0.0095 |
| LNEDU(-1) | 0.922911 | 0.341672 | 2.701164 | 0.0146 |
| LNENE(-1) | 1.713515 | 0.595259 | 2.878606 | 0.0100 |
| LNHEA(-1) | -1.788989 | 0.422368 | -4.235618 | 0.0005 |
| LNTRA(-1) | 3.640210 | 1.151003 | 3.162641 | 0.0054 |
| D(LNFDI) | -0.254252 | 0.155937 | -1.630475 | 0.1204 |
| D(LNEDU) | 0.012087 | 0.292613 | 0.041307 | 0.9675 |
| D(LNEDU(-1)) | -0.537881 | 0.271388 | -1.981959 | 0.0630 |
| D(LNENE) | 0.851146 | 0.505037 | 1.685316 | 0.1092 |
| D(LNHEA) | -2.807751 | 0.454403 | -6.178985 | 0.0000 |
| D(LNTRA) | 1.485187 | 1.135871 | 1.307531 | 0.2075 |

* p-value incompatible with t-Bounds distribution.

Levels Equation
Case 2: Restricted Constant and No Trend

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| LNFDI | -1.194896 | 0.506529 | -2.358991 | 0.0298 |
| LNEDU | 2.025357 | 0.749517 | 2.702216 | 0.0146 |
| LNENE | 3.760363 | 1.660322 | 2.264840 | 0.0361 |
| LNHEA | -3.925992 | 0.864573 | -4.540962 | 0.0003 |
| LNTRA | 7.988555 | 3.417440 | 2.337584 | 0.0312 |
| C | 28.93469 | 3.285199 | 8.807590 | 0.0000 |

EC = LNEMP - (-1.1949*LNFDI + 2.0254*LNEDU +3.7604*LNENE

- 3.9260*LNHEA + 7.9886*LNTRA + 28.9347 )

F-Bounds Test — Null Hypothesis: No levels relationship

| Test Statistic | Value | Signif. | I(0) | I(1) |
|---|---|---|---|---|
| | | | Asymptotic: n=1000 | |
| F-statistic | 5.806087 | 10% | 2.08 | 3 |
| k | 5 | 5% | 2.39 | 3.38 |
| | | 2.5% | 2.7 | 3.73 |
| | | 1% | 3.06 | 4.15 |

## Appendix D3: ARDL – ECM Regression Results

ARDL Error Correction Regression
Dependent Variable: D(LNEMP)
Selected Model: ARDL(1, 1, 2, 1, 1)
Case 2: Restricted Constant and No Trend
Date: 09/05/25 Time: 08:57
Sample: 1992 2024
Included observations: 31

**ECM Regression**
Case 2: Restricted Constant and No Trend

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| D(LNFDI) | -0.254252 | 0.083726 | -3.036723 | 0.0071 |
| D(LNEDU) | 0.012087 | 0.194397 | 0.062176 | 0.9511 |
| D(LNEDU(-1)) | -0.537881 | 0.196414 | -2.738508 | 0.0135 |
| D(LNENE) | 0.851146 | 0.362373 | 2.348811 | 0.0305 |
| D(LNHEA) | -2.807751 | 0.324403 | -8.655137 | 0.0000 |
| D(LNTRA) | 1.485187 | 0.699783 | 2.122355 | 0.0479 |
| CointEq(-1)* | -0.455678 | 0.061901 | -7.361395 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.799657 | Mean dependent var | -0.206278 |
| Adjusted R-squared | 0.749571 | S.D. dependent var | 1.252345 |
| S.E. of regression | 0.626710 | Akaike info criterion | 2.099013 |
| Sum squared resid | 9.426357 | Schwarz criterion | 2.422816 |
| Log likelihood | -25.53469 | Hannan-Quinn criter. | 2.204564 |
| Durbin-Watson stat | 2.241697 | | |

## Appendix D4: Breusch-Godfrey LM Test

Breusch-Godfrey Serial Correlation LM Test:

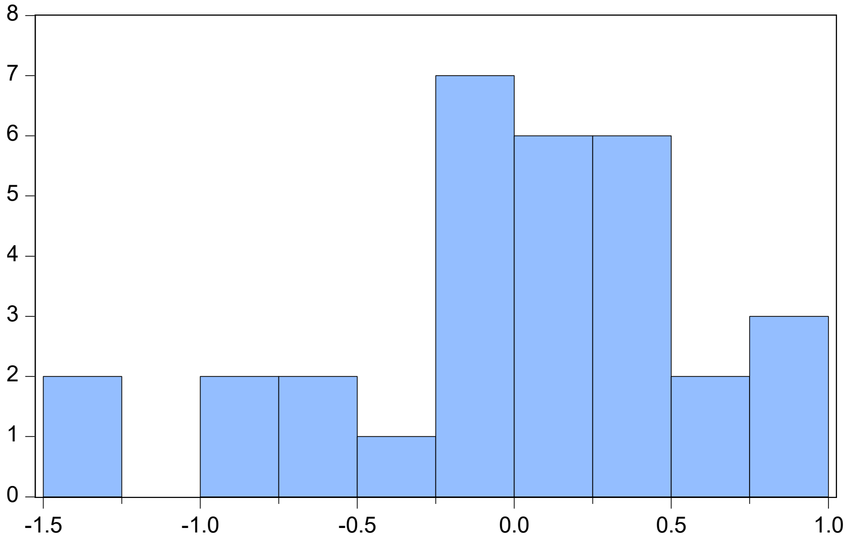
| | | | |
|---|---|---|---|
| F-statistic | 0.451947 | Prob. F(2,16) | 0.6443 |
| Obs*R-squared | 1.657648 | Prob. Chi-Square(2) | 0.4366 |

## Appendix D5: Breusch-Godfrey

Heteroskedasticity Test: Breusch-Pagan-Godfrey

| | | | |
|---|---|---|---|
| F-statistic | 1.857066 | Prob. F(12,18) | 0.1141 |
| Obs*R-squared | 17.14862 | Prob. Chi-Square(12) | 0.1441 |
| Scaled explained SS | 6.327095 | Prob. Chi-Square(12) | 0.8987 |

**Appendix D6: JB Normality Test**




Series: Residuals
Sample 1994 2024
Observations 31

| | |
|---|---|
| Mean | 6.99e-15 |
| Median | 0.014862 |
| Maximum | 0.866413 |
| Minimum | -1.331791 |
| Std. Dev. | 0.560546 |
| Skewness | -0.693260 |
| Kurtosis | 3.188686 |
| Jarque-Bera | 2.529132 |
| Probability | 0.282362 |