An evaluation of the impact of transport infrastructure investment on the economic performance of South Africa

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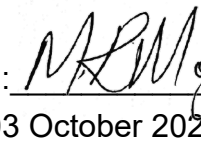
Masters in Management – Research Report

Wits School of Governance

September 2023

DECLARATION OF AUTHENTICITY

I, Mathapelo Refilwe Mogoiwa, Student No: 0413117P, declare that this submission is my work and that any sources consulted are duly acknowledged.

Signed: 

Date: 03 October 2023

ACKNOWLEDGEMENTS

When I embarked on this academic journey, I never thought that research was very challenging and I almost gave up at some point. Coming across one of the quotes by former President Thabo Mbeki inspired me: “Those who complete the course will do so only because they do not, as fatigue sets in, convince themselves that the road ahead is still too long, the inclines too steep, the loneliness impossible to bear and the prize itself of doubtful value.” I picked myself up with renewed strength. Several people, whose names I cannot all mention here because of limited time and space, kept encouraging me up to this point. I worked closely with my supervisor, Prof Pundy Pillay. He stands in an exceptional category, and I thank him for his support and guidance.

I also thank my family for their encouragement and support. I especially thank my son Reatlehile Mogoiwa who had to understand when I had to be away during my studies.

I consulted several friends and colleagues. They gave me their shoulders to lean on when I needed them. Dr Takesure Zhowa and Joseph Mudau gave me tremendous support, and I am so grateful for their involvement in my life and studies.

DEDICATION

This research paper is dedicated to my late mother Onkemetse Hilda Mogoiwa, who gave me the foundation of education she never enjoyed. Ever since then, I have appreciated the value of education and ultimate learning. Onkemetse Hilda Mogoiwa, you could not witness my success because death defeated you.

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LIST OF ABBREVIATIONS AND DESCRIPTIONS

ASGISA	Accelerated and Shared Growth Initiative for South Africa
FDI	Foreign direct investment
GDP	Gross Domestic Product
GEAR	Growth, Employment, and Redistribution program
GNI	Gross National Income
IDC	Industrial Development Corporation
ILO	International Labour Organisation
PRASA	Passanger Rail Agency of South Africa
RDP	Reconstruction and Development Program
SARB	South African Reserve Bank
SARS	South African Revenue Services
STATA	Statictical software
StatsSA	Statistics South Africa
VAR	Vector autoregression
VECM	Vector error-correction model
WEF	World Economic Forum

ABSTRACT

The decision to invest in economic infrastructure has far-reaching benefits for the South African economy, including innovation, economic growth, job creation, increased productivity, poverty alleviation, and an improvement in the standard of living. Therefore, the current study was conducted to determine the causal impact of selected critical economic variables for positive economic performance. The focus of the study was to evaluate how rail infrastructure investment impacts economic performance by assessing indicators such as economic growth, competitiveness, and unemployment rate using time series data from 1989 to 2018. As a quantitative study, the research employed correlational and causal-effect designs. Quantitative data was collected from credible secondary sources, including the websites and reports of Statistics South Africa, the South African Reserve Bank, the South African Revenue Services, and the World Economic Forum. Data analysis was conducted using descriptive analysis to identify the series of trends.

In contrast, multivariate time series analysis generated inferential statistics to assess the direction and significance of the relationship between the variables. The study discovered that rail infrastructure investment, competitiveness, and economic growth are significant causal relationships to unemployment and were found to have substantial causal relationships to economic growth. The study findings also confirmed the single-direction hypothesis that rail infrastructure investment Granger causes economic growth, competitiveness, and employment. Bidirectional Granger causal effects were proven between competitiveness and economic growth, competitiveness and unemployment, and economic growth and unemployment.

Keywords: Rail infrastructure investment; economic performance; economic growth, competitiveness, unemployment, vector autoregression, vector error-correction model.

CHAPTER 1: INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION

The South African economy is characterised by consistently poor performance, rising unemployment rates, and slow economic growth. These challenges make the country's economy unsustainable and ultimately unable to realise its full potential (Francis and Webster, 2019). While the South African government adopted strategies for stimulating economic growth and development, attaining the set economic goals has been beyond reach. These strategies include, among others, the Growth, Employment, and Redistribution program (GEAR), the Reconstruction and Development Program (RDP), and the Accelerated and Shared Growth Initiative for South Africa (ASGISA) (National Treasury, 2019). In 2004, the South African government was tasked to reduce unemployment and poverty by 50% through public investment initiatives. The South African economic stimulus included monetary and fiscal expansion policies. The South African National Treasury (2019) reports that for 1994 to 2012, the implemented economic initiatives raised the average economic growth rate to 3.3 per cent.

Lin, Dhakal and Wu (2021) contend that the transportation of essential commodities is a critical specialisation requirement since it promotes the effective production and consumption of goods and services in diverse areas. However, to foster effective transportation services and the movement of people, there is a need to invest in transport infrastructure to ensure economic growth, reduce unemployment, and ensure long-term sustainability (National Treasury, 2019). According to Lombard, Behrens and Viruly (2017), the transport infrastructure development backlog in the South African economy is exacerbated by limited government investment. Dwiatmoko, Hidayat, Supriyatno (2020) assert that transport infrastructure investment promotes sustainable competitive advantage, lowers production costs, and increases corporate and national revenue. The current study sought to determine the impact of rail transport infrastructure investment on the economic performance of South Africa. This chapter provides an overview of this study by discussing the research

background, research problem, purpose, research questions and research objectives, the significance of the study, and organisation of the study.

1.2 BACKGROUND OF THE STUDY

Dwiatmoko et al. (2020) contend that rail transport is a cost-effective mode of transportation and is projected to lower transportation costs, improve commuter safety and reliability of transportation services, and encourage economic growth and regional trade. However, several studies that focused on the impact of high-speed rail transport yielded mixed results (Blanquart and Koning, 2017; Chong, Chen & Qin, 2019). For instance, in the research conducted by Lin (2017) in Europe and Japan, the outcomes show that high-speed rail provides travel convenience between places with advanced local economic growth that offers multiple career choices to citizens. Albate (2016) found that high-speed rail infrastructure creates employment, promotes cost savings and boosts regional economic growth. Similarly, Li and Wang (2014) studied high-speed rail transport in Shanghai-Hangzhou and found a strong correlation between high-speed rail transport and economic growth.

Lombard et al. (2017) confirm that a functioning transportation network creates jobs, expands businesses, and lowers household appliance costs. Railway transport offers many returns, including moving persons and commodities in large quantities, energy efficiency, space efficiency, high safety and low pollution. Perkins (2011) submits that it is rational to predict that building a highway or railway connecting two formerly disconnected economic activity centres will boost economic growth. In 2011, the South African government launched the Gautrain Rapid Rail project which was aimed at increasing economic growth and creating job opportunities for citizens. The Gautrain project is Africa's first high-speed rail project that serves as a model for megaproject planning in the transportation sector. In analysing the outcomes of the Gautrain project, Thomas (2013) found that the rail infrastructure project created jobs and reduced traffic congestion. Reboredo (2019) reiterates that megaprojects are perceived to be vital politico-economic mechanisms that have provided answers to South Africa's continuing challenges, such as poverty and inequality.

In the third quarter of 2021, the unemployment level surpassed a previous record, an unprecedented high unemployment rate of 34.9 per cent (Smith, 2021). The labour market has been strained due to the increased COVID-19 lockdowns and the eruption of public unrest in July. This socio-economic crisis exacerbated the labour market's long-standing economic issues. The South African government's reform strategy to stimulate economic performance is critical to promote economic growth and job creation. The studies confirm that developed countries have thus far measured the impact of transport infrastructure investment in various dimensions, but limited research has examined the impact of transport infrastructure in South Africa (Hlotywa & Ndaguba, 2017; Pradhan, 2010).

The McKinsey Global Institute (2016) estimates yearly global infrastructure investments total $2.5 trillion (transport, power, water and telecommunication systems). However, this expenditure falls short of the full demand, especially in rural regions. The lack of adequate attention paid by many nations to developing and maintaining their infrastructure assets has led to growing global infrastructure gaps. The South African situation is no exception to the shortfall of transport infrastructure investment that has impacted the attainment of targeted national economic goals such as economic growth, redistribution of wealth, employment, and national economic competitiveness.

1.3 PROBLEM STATEMENT

South Africa's infrastructure investment accelerated in the years leading up to the 2010 FIFA World Cup, and it was expected to continue as the cornerstone of a national growth and development strategy. In the ten years ending 2020, South Africa's annual economic growth rate was about -0.4% from 1.5% in 2018, a worrying downward trajectory (World Bank, 2020). In the same period, South Africa's debt-to-GDP ratio rose from 56.7% to almost 60%, and more recently, the figure has reached close to 70%. Such a ratio signified that the country's debt capacity was reaching unsustainable levels.

Thomas (2013) contends that introducing transport infrastructure in South Africa was capital-intensive and envisioned to reduce traffic congestion and create employment for citizens. The inadequate allocation of resources for transport infrastructure investment, among other factors, has significantly slowed the growth and development of the South African economy and employment opportunities. Stupak (2017) notes that government expenditure on transport infrastructure as a percentage of GDP has declined in many countries over the past few decades. Matabane (2017) comments that despite expanding funding for the transport sector, over 75% of South Africa's current road network has deteriorated and requires maintenance. The lack of a symbiotic interaction between road and rail inhibits the advent of impulsive intermodal collaboration.

According to Das and Keeste (2016), traffic congestion is a significant issue in urban areas, and truck traffic on all types of roads is excessive. Increased traffic congestion, externalities, and upkeep of road infrastructure come at a considerable cost to the economy. Several studies, such as Blanquart et al. (2020) and Mitra et al. (2021), found that the advent of high-speed rail transport improves economic growth and creates job opportunities, while research by Gharehbaghi et al. (2020) and Chong et al. (2019) in Australia and China respectively yielded mixed results. Moreover, Diao (2018), Jia et al. (2017), and Perl et al. (2021) found that rail transport positively impacts economic geography, economic growth, urbanisation and destination accessibility, respectively. On the other hand, Tian et al. (2021) found that rail transport negatively impacts service industry agglomeration in peripheral cities in China. In light of limited studies on transport infrastructure investment, this study sought to determine the impact of road transport infrastructure investment on economic performance in South Africa.

1.4 RESEARCH PURPOSE

The transport sector is recognized as an essential catalyst for economic development. The primary purpose of this study is to evaluate the impact of rail transport infrastructure investment on South African economic performance. In particular, the study assessed the contributions of transport infrastructure

investment to economic performance in terms of the extent of the impact on economic growth measures.

1.5 RESEARCH OBJECTIVES

The primary objective of this research was to evaluate the impact of rail transport in South Africa on economic performance. To achieve the primary objective, the following secondary research objectives were investigated:

- To determine the state of rail transport infrastructure development in South Africa.
- To assess the effect of rail transport infrastructure investment on economic growth, competitiveness and employment.
- To recommend ways to promote rail infrastructure investment in the South African economy.

1.6 RESEARCH QUESTIONS

To investigate the research problem, the primary research question was formulated as follows: How does rail transport infrastructure investment impact the economic performance of South Africa?

The following sub-questions were answered to address the problem:

- What is the state of rail transport infrastructure investment in South Africa?
- What is the effect of rail infrastructure investment on economic growth, competitiveness and employment in South Africa?
- How can rail infrastructure investment be increased in the South African?

1.7 SIGNIFICANCE OF THE STUDY

The results will hopefully provide theoretical and practical contributions to academics, public policy makers and private actors. The study findings will contribute to the existing knowledge about the relationship between rail infrastructure investment and economic performance. The existing theories about transport infrastructure investment will be enriched by the theoretical model developed from the results of the current study. Research scholars will benefit

from the study's results through new knowledge about transport infrastructure investment and its influence on economic performance. They will be able to identify areas of future research direction for further research. From a practical perspective, the result will guide public actors such as policymakers and politicians in assessing the areas within the rail transport infrastructure investment requiring prioritisation. The South African policymakers will allocate sufficient funds for transport infrastructure development, particularly rail transport infrastructure investment. Private actors can also be influenced to invest in transport infrastructure for broad economic benefits. The investment in railways infrastructure will stimulate various economic objectives such as economic growth, job creation, redistribution of wealth and trade surplus. By making appropriate rail investment priorities, the movement of goods, services, and people in and outside the Republic of South Africa could be significantly improved.

1.8 STRUCTURE OF THE STUDY

The research study is organised into five chapters comprising:

Chapter 1 – *Introduction and research background* provides an overview of the current research study by narrowing the direction and focus of the present study. The research problem, questions and objectives are stipulated to provide the study direction.

Chapter 2 – *Literature review* provides empirical evidence relevant to this study to highlight applicable framework and theories, identify research gaps and position the study. Similar previous studies are critically discussed to understand the research strategies employed in the studies.

Chapter 3 – *Research methodology* outlines the research design and process selected to foster the data collection and ultimate analysis to test the research hypothesis.

Chapter 4 – *Research findings,* provide data, presentation, and interpretation to achieve the set research objectives. Statistical results were generated from the study and discussed and interpreted to solve the research problem.

Chapter 5 – *Conclusions and recommendations,* summarises the research findings and the respective conclusions to confirm the research hypothesis. The

study's conclusions confirm the accomplishment of the research objectives and proposed recommendations.

1.9 SUMMARY

Chapter 1 provided an overview of the nature of the problem under investigation. The study introduction highlighted the importance of rail infrastructure investment in promoting economic performance, while the background context provides the extent of the research problem from previous experiences. The research background helped to justify the current research study, indicating that related previous studies conducted in South Africa about rail transport infrastructure were limited. Therefore, the research problem was funnelled from the background of the study and narrowed to the research purpose, research questions and research objectives. The delimitation of this study streamlined the research problem, increasing the study's feasibility.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

The study focuses on assessing the impact of rail transport infrastructure investment in South Africa on economic performance. Several previous studies argue that infrastructure investment is directly associated with employment creation, poverty alleviation and economic growth and development (Kumo, 2012). This section reviews the literature on infrastructure development, transport infrastructure investment, road and rail transport, and the economic benefits of infrastructure investment in South Africa. The critical literature discussion assists in positioning this study based on the identified research gaps.

2.2 INFRASTRUCTURE DEVELOPMENT

Joynt (2019) describes infrastructure as new assets, renewals, maintenance costs, renovations and expansions, and asset regeneration, remodelling, and refurbishing. In scholarly papers, an appropriate provision of public infrastructure has long been considered a vital factor for economic success (Calderón, Cantú & Chuhan-Pole, 2018). Wentworth and Cloete (2022) highlight that a sustainable influence on improving economic well-being could be provided by infrastructure investment, which also has a sizeable potential multiplier effect. To promote interconnection, competitiveness, and intra-African commerce toward sustained socioeconomic wellbeing, regional infrastructure development should be prioritised.

The International Labour Organisation's (2016) data reveal that, worldwide, about one billion people have no access to proper roads; one billion have no all-weather roads, and four billion lack modern communication services. This signals national governments and policymakers need to prioritise infrastructure investment to change the narrative. Wentworth and Cloete (2022) emphasise that an economically viable, socially responsible, and environmentally sound recovery from the COVID-19 crisis can be achieved in SADC by leveraging transformative infrastructure.

The European Commission (2010) emphasises that high-quality infrastructure investment is crucial for sustainable development that promotes achieving various economic goals. Kumo (2012) reiterates that the fundamental economic strategy to achieve fast economic growth and income redistribution should be through expedient infrastructure investment to satisfy citizens' needs. Substantial evidence suggests that most developing countries with poor infrastructure experience slow economic growth and global trade.

Rapid investment in infrastructure is imperative to attain sustainable investment that contributes to poverty alleviation and employment creation. In 2008 and 2009, South Africa's infrastructure investment was 6.1% and 7.6% of the GDP, respectively (Kumo, 2012). The South African government's strategic plan was progressive after the 2008 global recession. According to Calderón and Servén (2010), the quantity and quality of infrastructure in Sub-Saharan Africa positively impact growth and income distribution. The results from Perkins, Fedderke and Luiz's (2005) study concluded that there is a positive effect between infrastructure investment and economic growth using the Perasan, Shin and Smith's (2001) F-tests. An f-test is statistical test in which the test statistic has an f-distribution under the null hypothesis. It is used when comparing statistical models fitted to a data set, to identify a model that best fits the population from which the data were sampled.

Perkins et al. (2005) observe that the link between economic infrastructure and economic growth is two-directional. In another study, Fedderke and Bogeti (2006) confirm the direct causal relationship between infrastructure investment and labour productivity and the inverse causal relationship with total labour productivity. The data analysis method used in the study was panel data analysis and Pooled Mean Group estimator of Pesaran. The next section discusses the transport infrastructure investment.

2.3 TRANSPORT INFRASTRUCTURE INVESTMENT

The Department of Transport (2020) reports that South Africa has Africa's most extensive transportation infrastructure network, with roughly 750 000 km of roads, 30 000 km of rail lines, 20 900 km of route kilometres, eight commercial ports,

and eleven major airports. Transport infrastructure, which is the focus of the current study, is one of the four categories of infrastructure investment, communication networks, energy, and water and sanitation essential for driving national economic development.

According to Jia, Zhou and Qin (2017) and Shi (2018), building transportation networks such as roads and railways could directly stimulate positive economic performance through job creation and economic growth. The findings from a study such as this could reveal a robust link between road infrastructure improvement and poverty reduction. South Africa's air, rail and road networks are of the highest quality on the African continent. The Republic also provides Africa's largest and arguably best seaports for shipping from Asia, the Americas, Europe, Australasia and other African countries (Shi, 2018). The South African National Department of Transport is responsible for formulating rules and regulations that control roads, trains, ports, airports, pipelines, and freight and public transportation multimodal operations (South African Government, 2020).

Sahoo, Dash, and Nataraji's (2010) study on China concludes that transport infrastructure investment impacts the growth of the economy. In a similar study conducted by Chen, Salike and Luan (2014) using panel data from 2009 to 2010, the results confirm that transportation infrastructure positively affected economic growth in 28 Chinese provinces. However, Chen and associates' findings are based on the benefits of transport infrastructure, not infrastructure investment. In Côte d'Ivoire, Echui (2013) evaluated the association between transport infrastructure investment and output using panel data for 1970 – 2002. The results generated by the Granger causality test reveal that public investment in transport has no causal impact on economic growth. The Granger causality test is a statistical hypothesis test for determining whether one time series is a factor and offer useful information in forecasting another time series. Yet, economic growth has a causal impact on transport infrastructure investment. Results from Tong, Yu, and Roberts (2014) confirm that highway development in the United States indirectly affects economic growth by improving the capital stock of non-transport infrastructure investment.

The South African government has identified the transport sector has identified the transport sector as a catalyst for economic growth and social development. The Government unveiled strategic economic development plans and allocated billions of rands to improve road, railway and port infrastructures (South African Government, 2020). In the long run, public policymakers will be expected to allocate sufficient budgets to the Department of Transport to stimulate improved economic performance through efficient employee movement of people, goods, and services. South Africa should strive to increase government expenditure on transport infrastructure as a percentage of GDP and avoid a declined in investment in this sector, as pointed out by Stupak (2017).

2.3.1 Rail Infrastructure Development

In London, high-speed rail expansion in 2009 was presented as a national strategy to meet the expanding inter-urban capacity needs (United Kindom Department for Transport, 2010). The expansion of the rail organization was expected to continue expanding travel needs within the cities due to economic growth (Shi, 2018). Transportation projects like the high-speed rail system are presented as activities with associated costs and substantial social and economic benefits (Department of Transport, 2010). Blanquart and Koning (2017) in France reviewed the academic and grey literature on the economic influence of high-speed railways. Based on this review, they found a consensus in the existing literature on the construction effects associated with expanding high-speed railways. However, they concluded that researchers have seen the existence and absence of economic influences of high-speed railways on the economy.

However, it is important to note that the only high-speed railway currently in development in South Africa is the Gautrain Rapid Rail. Thus, literature specific to South Africa is limited, suggesting further research is required to explore the impact of high-speed railway development on the South African economy. In addition to the direct factors such as city size, industry structure, amenities, and distance from the urban core, associated factors must be considered in estimating the economic impact (Blanquart & Koning, 2017).

In another study in South Africa, Gamede et al. (2019) noted that energy efficiency must also be considered in the railcar manufacturing industry due to the impact of energy efficiency on economic factors like productivity, competitive advantage, costs, and sustainability. Similarly, in addition to construction costs, impacts and costs associated with the expansion of high-speed railways include the upkeep and operation costs of associated transport safety bearings, transport facilities, direct user benefits, congestion and overcapacity effects, exhaust emissions, and strategic environmental and sustainability considerations (World Bank, 2014). The following section outlines the specific literature on methods for approximating the economic results of high-speed rail systems. According to Granelli and Tervala (2016), public infrastructure investment is expected to increase output and boost economic growth in the short and long run.

2.3.2 Rail Infrastructure in South Africa

Gruhn (2019) investigated localization challenges associated with the rail industry in South Africa. Gruhn (2019) explained evidence of government corruption and unethical business practices related to the railway system, such as the improper extension of contracts by the Passenger Rail Agency South Africa (PRASA). This finding is that such unethical practices and corruption are damaging this finding is important because unethical practices and corruption damage industrial growth (Gruhn, 2019). The National Development Plan includes plans for developing the transportation sector to achieve the following: a) improve entry to commercial opportunities, public spaces, and facilities by connecting geographic distances in an affordable, reliable, and safe way; and b) improve the flexibility of people and goods using eco-friendly transport changes (Alloggio & Thomas, 2013; Chaka, 2015).

Fourie and Loncan (2015) explain that the rail infrastructure in South Africa impacted both growth and segregation in South Africa's Cape Colony during the initial globalisation era. An estimated 46 to 51 per cent of the increase in labour output in the years 1873-1905 was attributed to the railway either due to investment in the rail network or a reduction in transportation costs associated with the railway. The railway system was also associated with changes in the

economic geography of South Africa, with the economy restructured based on the railway lines between diamond mines and ports (Fourie & Loncan, 2015).

In addition to the economic growth and restructuring associated with the railway system, the social impacts associated with developments in railway systems have also been noted by other researchers, such as Lingaitis and Sinkevičiu (2014), confirming that both social and economic impacts are associated with developments in railway transport.

The first high-speed railway in South Africa was the Gautrain project, which created citizens' jobs and decreased traffic congestion between Johannesburg and Pretoria. According to Thomas (2013), congestion issues would be alleviated if the train reached an anticipated ridership of 120,000 people per day and about 20 per cent of current Ben Schoeman drivers converted to the rail system. Since the Gautrain operates in the big metros of Johannesburg and Pretoria, it benefits the wealthy citizens instead of the poor citizens. The impact of the Gautrain project on the economy of South Africa can be contested, for the construction costs were higher than the project's benefits (Thomas, 2013).

2.3.3 Road Infrastructure in South Africa

Road infrastructure development is, by nature, a public good that cannot always be monetised, depending on the conditions in which a country finds itself. Bayes (2014) states that public investment in road infrastructure attracts additional investment from the private sector in the form of investment in trade and business, transport services and enabled mobility of the factors of production. In a Mexican study, Gonzalez-Navarro and Quintana-Domeque (2010:2) found that investing in paving roadways resulted in greater investment in housing upgrades, well-developed road infrastructure, and purchases of automobiles. The standard of living of the local people and employment creation opportunities associated with the housing projects along with the road-paved areas. Joynt (2019) posits that there is considerable underinvesting in transport infrastructure investment and the multiplier effect of bad economic performance. Maintenance programs for transportation infrastructure improvements should be prioritised to derive meaningful gains.

South Africa has a total road network of 153,719 paved roads and 593,259 gravel roads (Development Bank of Southern Africa, 2014). In 2013, the South African road maintenance program included the maintenance of 21,000 kilometres of roads, resulting in thousands of jobs. This factor positively influences poverty by creating economic opportunities.

According to research conducted by Govender (2015) and Mayekiso (2015), South Africa is experiencing a significant unemployment rate, which triggers government authorities to focus on policies that lead to establishing work possibilities for South Africans such as road network and railways infrastructure investment. According to Joynt (2019), transportation and logistics infrastructure finance accounted for roughly 28 per cent (2016/2017) to 38 per cent (2021/2022) of the government's total infrastructure expenditure. The multiplier effect of infrastructure investment of the South African government should generate substantial benefits to the economy. The South African National Roads Agency Limited (SANRAL) oversees the funding, engineering, upkeep, repair, and rebuilding of the country's toll and non-toll roads. At the same time, provincial transport agencies control the paved road network 49 000 kilometres. The South African Government (2020) recommend that increased transport infrastructure maintenance spending could help to ensure that transportation infrastructure endures life expectancy to derive maximum economic benefits.

2.4 ECONOMIC BENEFITS OF INFRASTRUCTURE DEVELOPMENT

Kumo (2012) alludes that infrastructure investment impact is measurable at the micro (project) and macro (national) levels. According to the latter researcher, the accelerated economic infrastructure investment prior to the 2010 World Cup arguably cushioned the South African economy from the worst global downturn or recession.

The design of innovative railway systems is associated with economic growth (Department for Transport, 2010; Chong et al., 2019). However, estimating the specific economic results of rail manufacturing and systems is complex. Moreover, research regarding the economic benefits of developments in

transportation infrastructures has yielded mixed results (Diao, 2018; Chong et al., 2019). The approaches that have been applied in evaluating the economic results of innovative rail systems include benefit-cost analysis and econometric analysis (Ansar et al., 2016; Chen & Hayes, 2015; Chong et al., 2019; Lin, 2017; Qin, 2017). Chong et al. (2019) aimed to estimate the commercial results of a high-speed rail system in China and analyzed a dataset of 268 cities in China from 2008 to 2015. Based on an analysis that included consideration of mixed effects, endogeneity and spatial necessity in a three-dimensional panel modelling process, Chong et al. (2019) determined that the high-speed rail system in China contributed to 11% of economic growth. However, Chong et al. (2019) noted that this economic progress was because of the local influence instead of an expected spillover effect of the high-speed rail system.

In another study, Li et al. (2020) found that economic development in municipalities with a high-speed railway was more advanced than in those without an operational system. Noting the importance of city size, Li et al. (2020) identified a siphoning effect in which there was a more pronounced impact on economic development associated with introducing a high-speed railway in urban areas compared to other areas.

Contrary to the findings of Chong et al. (2019) and Li et al. (2020), Shi (2018) found that in China, the results of the high-speed railway on regional development were negative when considering per capita GDP. However, Shi (2018) found that high-speed railways did have a positive influence on the population. Specifically, a high-speed rail system helped to further develop large municipalities but was not conducive to the growth of medium-sized and small municipalities (Shi, 2018). The findings hold value in South Africa due to population dispersal. Considering the regional layout and population density of different regions of South Africa, high-speed rail may have mixed results for the economy. However, an analysis of this is not available in academic literature.

Based on Shi's (2018) findings, China's infrastructure investment focuses on the distribution effects of the high-speed railway system. Despite finding a negative economic impact in association with the high-speed railway system, Shi (2018)

supports the Department for Transport (2010) suggestion that high-speed railways support the growth of large municipalities. The next section outlines the specific impacts of rail manufacturing in South Africa. Kumo (2012) observes that there are few studies on causal relationships conducted between infrastructure investment variables and dependent variables using the Granger-causality test and bound test approaches. The next section presents the study's conceptual framework based on the literature review.

2.5 MEASURING ECONOMIC PERFORMANCE

Economic indicators cover stability and macroeconomic performance measurements, such as gross domestic product (GDP), consumption, investment, and international commerce (World Bank, 2019). A metric used to gauge the macroeconomy's overall health is known as an economic indicator. These measures are intended to address the entire nation's challenges, including unemployment, poor infrastructure, and crime (Alexander, 2017). The International Labour Organisation (ILO) acknowledges that a lack of adequate infrastructure significantly hinders efforts to advance inclusive growth, decent work goals, and many other sustainable development goals and that infrastructure improvements directly affect the quality of life of individuals (International Labour Organisation (ILO), 2018).

Pasara and Garidzirai (2020) conducted a time series study about causality effect of gross capital formation, unemployment, and economic growth in the Republic of South Africa. The research data was analysed using a time series test (Granger causality test) and multivariate time series analysis (Vector autoregression). The results from the study by Pasara and Garidzirai (2020) revealed that capital formation and economic growth had a strong long-term causal relationship. The findings further confirmed that unemployment did not cause short-term economic growth. An inverse causal relationship was established between unemployment an economic growth (Pasara & Garidzirai, 2020). In another study, Makaringa and Khobai (2018) evaluated the effects of unemployment on economic growth in South Africa using time series data from the 1994 1st quarter to the 2016 4th quarter. The results from the study concluded

that there is a negative casual influence between unemployment and economic growth in the short-run and long-run.

2.5.1 Economic growth

The overall gross value added by the nation's resident producers is measured by the widely used metric known as the gross domestic product (GDP). GDP change at constant prices is used to gauge economic growth. As a lagging indicator, GDP is used to assess an economy's strength. It reflects economic output and expansion, or the size of the economy. Gross National Income (GNI) per capita, which is calculated by dividing the total domestic and international value-added claimed by a country's citizens by the country's population, is another important metric for evaluating a nation's wealth and ability to support its citizens. According to ILO (2018), adequate infrastructure is the cornerstone for sustainable economic growth and social development, which raises living standards.

The Industrial Development Corporation (IDC) (2013) reports that South Africa experienced the highest economic growth rate of 5.2 per cent between 2004 and 2007. The major contributors to the high economic growth during the period were competitive markets, flourishing commodity prices of commodities, and gross local capital creation. During the 1995-2004 period, gross capital formation increased by 5.1 per cent, making it one of the most significant stimulators of economic growth (du Plessis & Smit (2006). According to Makris and Stavros (2019), many previous findings are ambiguous as to whether foreign direct investment (FDI) and gross domestic product (GDP) have a relationship is bidirectional or not. Makris and Stavros' findings (2019) confirm a unidirectional short-run and long-run causal relationship between FDI and GDP using the vector error correction model (VECM) in the United States of America.

Osinubi (2005) observes that although economic growth plays a pivotal role in lowering unemployment and reducing poverty, it is insufficient because it cannot eliminate all the causes of poverty and unemployment. Makaringe and Khobai (2018) suggest implementing better economic policies that aid in deploying investment programs to facilitate job creation, speed up economic growth, and eliminate poverty and unemployment.

2.5.2 Employment

South Africa's two biggest economic and social problems are generating jobs and lowering unemployment. A favourable job climate is the principal link between economic growth and improving living standards and is the primary prerequisite for long-term social change. Employment-intensive investment programme supports International Labour Organisation (lLO) member states in designing, formulating, implementing, and evaluating policies and programmes aiming to address unemployment and underemployment through public investment, typically in infrastructure development (ILO, 2018). While labour-based construction activities create temporary jobs, the excellent infrastructure they develop boosts economic performance in many other industries, creating a ripple effect that positively affects employment and revenue across the economy (ILO, 2018).

The study by Li and Lui (2012) found that in China, unemployment has a negative impact on growth, while inflation has a positive causal influence. The study used multivariate time series analysis, particularly vector autoregression (VAR) and vector error-correction model (VECM), to test the significance of the variable causal relationships. In another similar study, Shahid (2014) investigated the impact of inflation and unemployment on Pakistani economic growth and discovered an inverse relationship between economic growth and unemployment. According to Banda (2016), improving the gross domestic product will likely boost employment levels, lowering unemployment. Kareem (2015) reiterates the need to create jobs and increase Nigeria's GDP growth rate. The latter researcher states that one of the world's most pressing economic concerns is creating jobs.

Unemployment, economic growth, and gross capital formation are all linked by the balanced theory of capital formation (Taraki & Arslan, 2019). Jhingan (2012) points out that investment in capital goods should be spread across all economic sectors to foster balanced economic growth. According to Taraki and Arslan (2019), investors believe economies with high unemployment offer better opportunities for cheap labour. Therefore, economic investment is bound to increase when the levels of unemployment are high in an economy. Boianovsky

(2015) supports that capital accumulation that stimulates economic performance boosts production capacity, creating more job opportunities, resulting in a lower unemployment rate. Banda et al. (2016) discovered a positive association between economic growth and unemployment using a Johansen cointegration and VECM. Makaringa and Khobai (2018) state that the most prevalent type of unemployment in South Africa is structural and technology advances where output tends to rise, as well as unemployment.

2.5.3 Economic competitiveness

The World Economic Forum (WEF) (2017) defines competitiveness as the collection of structures, guidelines, and other elements that determine an economy's degree of productivity, establishing the prosperity level an economy can achieve. Klaus and Xavier (2018) point out that competitiveness can be defined as the capacity of an organization, industry, region, or geographic area to have comparatively high income levels and sustainable employment sustainably. The competitive productivity model, put forth by Baumann and Pintado (2013), attempts to postulate a clear relationship between the two ideas and links attitudes and actions intended to outperform the competition. The complexity of a firm's strategy and operations, coupled with the calibre of the microeconomic business environment in which enterprises compete, are the foundations of competitiveness in a nation (Porter, 1991). In keeping with this view, Labarca (2007) states that competitiveness determines how simple it is for corporations to use the opportunities provided by the global economy. From the views discussed, competitiveness is triggered by micro and macroeconomic factors.

Melara-Gálvez and Morales-Fernández (2022) contend that the ability of a nation to compete globally is a critical factor in explaining why some countries produce so much wealth compared to others and have more robust sustainable sources of revenue. The study by Melara-Galvez and Morales-Fernandez (2022) conducted in Central America confirms that the critical Global Competitiveness Index includes macro-economic stability, information technology adaptation and infrastructure development. International economic competitiveness hinges on a nation's ability to generate knowledge, education, and innovation, vital

development signals and globalisation (Mohamed, Liu & Nie, 2022). The nation's efforts to foster sustainable development, which affects the citizenry's well-being, heavily rely on how competitive a country thrives. Voinescu and Moisoiu (2015) emphasise that economic competitiveness aids in formulating economic national policies which impact enterprising activities, particularly strategy formulation to devise plans to raise a country's micro and macro-economic levels.

Xia, Liang, Zhang, and Wu (2012) suggest that economic competitiveness is determined by the availability of factors comprising institutions, policies and technological attributes that directly impact the country's economic productivity. Results from a study by Podobnik, Horvatic´, Kenett and Stanley (2012) confirm that institutions' integrity significantly affects economic competitiveness and growth. The rate of return on economic investment affects the economic growth rate. Favourable economic competitiveness will likely attract a wide range of investments promoting national wealth creation (Xia et al., 2012). Podobnik et al. (2012) opine that when a nation fights public corruption, the chances are high that competitiveness will increase.

2.5 CONCEPTUAL FRAMEWORK

Based on the critical discussion of research evidence and abstracts, the framework for the current study was modelled on two main variables, namely rail infrastructure investment and economic performance. The study’s conceptual framework was based on the premise that rail transport infrastructure investment affects economic performance.

Figure 1: Conceptual framework

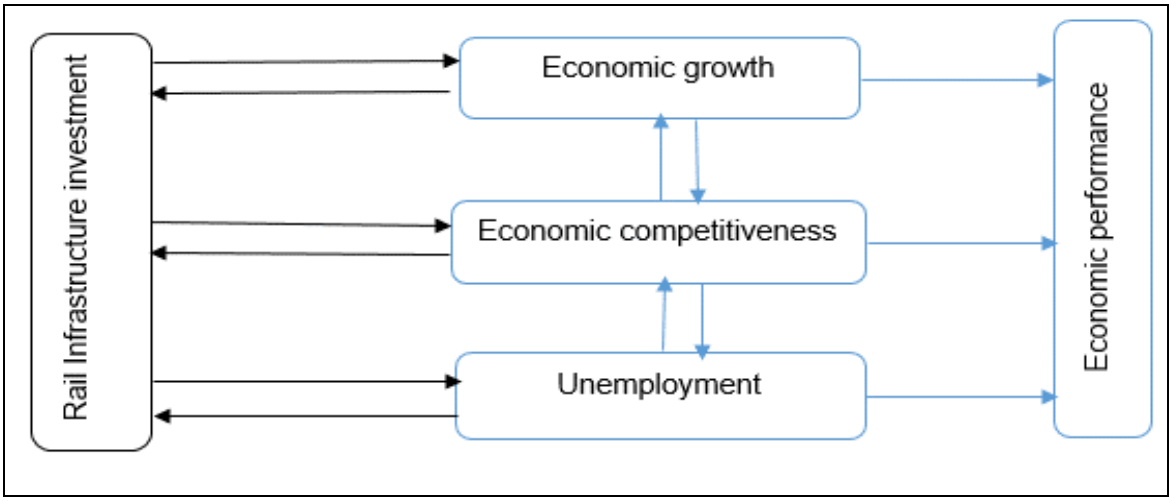


Figure 1: Proposed conceptual framework

Source: Own

From the conceptual framework, rail transport infrastructure investment (independent variable) is perceived to significantly influence economic performance (dependent variable) as illustrated by the following research hypotheses:

- Rail infrastructure investment Granger causes economic growth and vice-versa.
- Rail infrastructure investment Granger causes unemployment growth and vice-versa.
- Rail infrastructure investment Granger causes global competitiveness and vice-versa.
- Global competitiveness Granger causes economic growth and vice-versa.
- Global competitiveness Granger causes unemployment and vice-versa.

2.6 SUMMARY

This chapter provided a detailed discussion of the related literature to reveal previous theories and concepts relevant to this study. The detailed discussion of infrastructure investment, transport infrastructure investment and economic performance was made. The rigorous discourse assisted in identifying research gaps that facilitated the positioning of the current research study. The conceptual

framework was developed based on concepts in the literature discussion from previous studies that aligned to infrastructure investment and economic performance. The next chapter provides a detailed outline of the research methodology applied to collect the data to address the research problem.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 INTRODUCTION

The methodology that was applied to obtain the research data to answer the research questions is selected, discussed and justified in this section (Creswell and Creswell, 2017). The methodological aspects include the research approach, research design, research tools, population and sampling, data collection and analysis processes, research rigour, research limitations and ethical considerations.

3.2 RESEARCH APPROACH

The three research approaches that are deployed in research are qualitative research, quantitative research, and mixed methods (Saunders et al., 2019). The quantitative approach examines testable hypotheses through numerical data to analyse the relationship between examined variables (Ghauri et al., 2020). In other words, it collects observable data to address a research problem using statistical techniques. In contrast, qualitative approaches focus on examining data about a specific phenomenon through participants' reflections and collecting and analysing textual data (Mertens, 2017). According to Creswell and Clark (2017), the mixed-methods approach is a blend of qualitative and quantitative approaches where numerical and textual data are collected and analysed to understand phenomena. The quantitative approach was used in this study to collect and analyse numerical data to determine the relationship between rail transport infrastructure investment and economic performance in South Africa. To measure the effect of rail transport infrastructure on selected economic indicators, quantitative data gathered were statistically analysed.

3.3 RESEARCH DESIGN

The term research design is defined as the comprehensive plan that the research adopts to combine the different parts of a study into a comprehensible and logical manner (Coolican, 2017; Saunders et al., 2015). The latter scholars identified the types of research design as descriptive, correlational, causal-comparative, and

experimental research (Mertens, 2017). Although there are several research designs, this study used correlational and causal-effect research designs. The correlational design and causal design were used to determine the relationship between the two variables: rail infrastructure investment and economic performance (Mertens et al., 2017). In using the latter research design, previous data were considered for testing the posed research hypotheses to address the cause and effect of research phenomena (Mertens et al., 2017). As such, a casual comparative design was chosen for its suitability to apply numerical secondary data to explore and evaluate the relationship between rail transport infrastructure investment and economic growth, competitiveness and employment in South Africa.

3.4 RESEARCH TOOLS AND THEIR APPLICATION

The time series data methods are deployed to facilitate the study data collection for the prescribed period. This project drew from secondary data for 1989 and 2018, inclusive, regarding rail transport infrastructure investment and economic performance in South Africa. For this purpose, data from 1989 to 2018 was collected from the South African databases (Statistics South Africa (SSA), the South African Revenue Services (SARS), the South African Reserve Bank (SARB), and the World Economic Forum which include economic growth data for the selected timeline. For this study, the dependent variable for this data component was economic performance measured by GDP growth and employment percentages and competitiveness indices. The independent variable was rail transport infrastructure investment in South Africa for 30 years (1988 – 2018).

3.5 INCLUSION AND EXCLUSION OF DATA SOURCES

The time series data was readily available from different national and international databases. However, the secondary sources considered for this study were bwtween 1989 to 2018. Time series concentrates on a single person or institution at various points, whereas panel data (also known as longitudinal data) focuses on several people or institutions at different points in time. Panel data is

a subset of longitudinal data in which the same subjects are observed repeatedly. The panel dataset is a type of multi-dimensional data typically consisting of measurements collected over a specified time. The study did not track a group of people through time series but endogenous factors of a single nation in Africa. The researcher used annual data series that pertain to observations of phenomena, particularly rail transport infrastructure investment and economic growth, competitiveness and unemployment on times series from 1989 to 2018. Any data sources from 1998 and below and 2019 and above were not considered for securing data for the current study.

3.6 DATA COLLECTION PROCESS

Time-series research data from 1989 to 2018 were collected annually containing information about national income accounts that provide GDP and national employment figures. A similar study by Badalyan, Herzfeld and Rajcaniova (2014) on transport infrastructure and economic growth used the panel data approach. The secondary data was accessed from the SARB, StatsSA and SARS publications and databases. Complementary data was collected from the Word Bank Atlas and Global Competitiveness Reports.

3.7 DATA RIGOUR

This study obtained secondary data from credible online sources such as SARS Atlas, StatsSA and SARB databases that experts prepare to reflect the quarterly GDP growth and employment rate from 1998 to 2018. The data was gathered from the databases, which signifies an empirically based methodology for ensuring the accuracy and validity of the data. Experts in the field of national governance, and economic development creates the database. The national reports have credibility due to the auditing performed by public auditors.

3.7 DATA ANALYSIS

The data analysis entails applying econometric techniques to summarise the time series data, conduct multivariate time series analysis and perform hypothesis testing. Using computerised statistical software such as Microsoft Excel and

STATA assisted in generating accurate statistical output to answer the research questions and test the research hypothesis. Stock and Mark (2007) highlight that by employing both statistical techniques and economic models, the econometric methods assess the economic indicators and predict the desired parameters. The three primary econometric methods applicable to the current study include descriptive statistics and multivariate time series analysis (Mahbubul, 2020). Descriptive statistics results of rail transport infrastructure investment and South African economic performance data provide time series trend charts.

Granger (1976) states that multivariate time series are for assessing the causality between economic variables. The trend analysis was conducted on the time series data collected using observations of the investment and economic performance outcome variables. Data analysis was done using time series analysis that compares two sets of observational data across a series of times. The independent variable was rail infrastructure investment (rail network investment), and the dependent variable was economic performance (economic growth, unemployment and economic competitiveness).

Bose, Hravnack and Sereika (2017) point out that one of the most adaptable methods to uncover inherent causative factors in panel data is vector autoregressive (VAR) modelling with Granger causality testing. The Granger causality test was conducted to test the causality between rail infrastructure investment and economic performance variables in a bidirectional manner. According to Wei (2016), if a researcher wants to establish if one time series may be used to predict another, the Granger causality test, a statistical hypothesis test, is appropriate. Since the study tested the Granger causality of three economic variables, the pairwise causality test was conducted based on the vector autoregression (VAR) model (Kumo, 2012). VARs are commonly employed for predictive purposes and frequently prove to be as effective as elaborate structural models (Olanrewaju, Oguntade & Zubair, 2015). The VAR model for the current study was expressed as:

$$Y = \beta_0 + \beta_1 y_{t-i} + \beta_1 y_{t-2} + \cdots + \beta_p y_{t-p} + \varepsilon_t$$

Y stands for the vector of endogeneous variables at time t, β_1,(1,2 …p) is the number of coefficient vectors, p is the number of lags, ε_t is the residual vector, β_0

is the vector of the intercept term. The endogeneous variables for the current study are economic competitiveness (*cindex*), economic growth (*gdp*), and unemployment (*unrate*). The independent variable is rail infrastructure investment (*railii*).

Therefore, the equations of the VAR model would be structured as follows:

$$\boldsymbol{gdp_{t-i}} = \alpha + \sum_{t=1}^{k} \boldsymbol{\beta_i}\, \boldsymbol{gdp_{t-i}} + \sum_{t=1}^{k} \phi_j\, railii_{t-j} + \sum_{t=1}^{k} \Psi_m\, cindex_{t-m} + \sum_{t=1}^{k} \theta_k\, unrate_{t-k} + \mathrm{n}_{1t}$$

$$\boldsymbol{railii_{t-i}} = \alpha + \sum_{t=1}^{k} \beta_i\, gdp_{t-i} + \sum_{t=1}^{k} \boldsymbol{\phi_j}\, \boldsymbol{railii_{t-j}} + \sum_{t=1}^{k} \Psi_m\, cindex_{t-m} + \sum_{t=1}^{k} \theta_k\, unrate_{t-k} + \mathrm{n}_{2t}$$

$$\boldsymbol{cindex_{t-i}} = \alpha + \sum_{t=1}^{k} \beta_i\, gdp_{t-i} + \sum_{t=1}^{k} \phi_j\, railii_{t-j} + \sum_{t=1}^{k} \boldsymbol{\Psi_m}\, \boldsymbol{cindex_{t-m}} + \sum_{t=1}^{k} \theta_k\, unrate_{t-k} + \mathrm{n}_{3t}$$

$$\boldsymbol{unrate_{t-i}} = \alpha + \sum_{t=1}^{k} \beta_i\, gdp_{t-i} + \sum_{t=1}^{k} \phi_j\, railii_{t-j} + \sum_{t=1}^{k} \Psi_m\, cindex_{t-m} + \sum_{t=1}^{k} \boldsymbol{\theta_k}\, \boldsymbol{unrate_{t-k}} + \mathrm{n}_{4t}$$

As alluded to by Atmadja (2005), the Granger causality test was conducted as:

- The unit root test was conducted to ascertain whether each series is stationary or non-stationary. As applied in the study by Olanrewaju et al. (2015), the Augmented Dickey-Fuller (ADF) test is used to determine the unit root. The stationarity test for investment in rail transport infrastructure was tested against economic performance indicators and vice-versa.
- Johansen cointegration test to check the existence of cointegration among the series (variables);
- If there is no cointegration in the series, the data variables are perceived to be unintegrated, triggering the VAR model analysis to determine the relationship of the series in the short run and
- VAR analysis is performed when the stationary test is in the first difference *I*(1) and not *I*(2). When the stationary test series are in the I(2) and the series are cointegrated, a vector error correction model (VECM) for the bivariate system was applied after the VAR model.

The VECM was formulated according to the following structure:

- $\Delta Y_t = \sigma + \sum_{i=1}^{k-1} \beta_i \Delta Y_{t-i} + \sum_{j=1}^{k-1} \eta_j \Delta X_{j-1} + \sum_{m=1}^{k-1} \Phi_m \Delta Z_{t-m} + \sum_{z=1}^{k-1} \Psi_z \Delta W_{t-z} + \lambda ECT_{t-1} + \varepsilon_t$

Where:

- k-1 = the lag length is reduced by 1;
- β_i, η_j, Φ_m, Ψ_z= short-run dynamic coefficients of the model's adjustment long-run equalibrium
- λ_t = speed of adjustment parameter
- ECT_{t-1} = the error correction term is the lagged value of the residuals obtained from the cointegrating regression of the dependent variable on the repressors.
- ε_t = residuals (stochastic error terms often called impulses, innovations or shocks)

When the economic variables were factored into the VECM equation, it was modelled as follows:

$$\Delta gdp_t = \sigma + \sum_{t=1}^{k-1} \beta_t \Delta Ygdp_{t-1} + \sum_{j=1}^{k-1} \eta_j \Delta railii_{j-1} + \sum_{t=1}^{k-1} \Phi_t \Delta cindex_{t-1} + \sum_{t=1}^{k-1} \Psi_t \Delta unrate_{t-1} + \lambda ECT_{t-1} + \varepsilon_{t-1}$$

In the current study, bivariate regression analysis was conducted to assess the co-integration of the time series variables: rail infrastructure investment explains the dependent variable; economic performance was measured by economic growth, competitiveness and unemployment. The statistical significance of regression coefficients was tested at a 5% critical value for the formulated research hypothesis. The findings were used to reject or accept the bidirectional proposed hypotheses.

The hypothesis was formulated as bidirectional as follows:

H_{01}: Rail infrastructure investment has no significant effect on economic performance and vice-versa.

H_{a1}: Rail infrastructure investment significantly affects economic performance and vice versa.

3.8 LIMITATIONS, FEASIBILITY AND POSITIONALITY

Project limitations are elements that could potentially impact the study's results, and delimitations refer to the limits placed within a study to ensure a reasonable scope of analysis (Tracy, 2019). The key limitation of this study is the reliance on secondary data, which did not permit an experimental assessment of the rail transport infrastructure investment relationship with economic indicators in South Africa. However, this constituted a limitation because the researcher could not collect primary data country-wide. This study focused on the South Africa data for a 30 year-period, which overlapped with the pre-democracy era. In addition, the critical variable examined the change in economic performance indicators and rail infrastructure investment. As such, the delimitations offered context to the difference the rail infrastructure investment has on economic performance in South Africa. Lastly, secondary data collection was limited to 1989-2018. The period was chosen as rail infrastructure investment accelerated from 1998 in South Africa. In addition, economic activities past 2018 were affected by the COVID-19 pandemic, and therefore, 1989 to 2018 was an ideal focus period for this study.

3.9 ETHICAL CONSIDERATIONS

This study complied with Wits University’s general research ethical requirements, including the application for research ethical clearance. Permission was sought to conduct the study and granted by the Wits School of Governance Research Ethics Committee. Research ethics stress respect for the rights of human research participants (Kumar, 2011). The data for this study did not use human participants. Hence, the rights to voluntary confidentiality and anonymity were not compromised. However, ethical issues are also considered in secondary research projects. The identities of individuals, private companies, and organisations were not disclosed; therefore, permission to conduct the study from human participants was unnecessary. Furthermore, seeking permission to use statistical data gathered from public databases such as SARS Atlas, Stats South Africa, South African Reserve Bank, and World Economic Forum was unnecessary.

3.10 SUMMARY

This chapter provided the research methodology employed to collect the time series data analysed in the next chapter. Using a quantitative approach, numerical time series data pertaining to rail infrastructure investment and economic performance variables were collected from secondary sources to test the postulated research hypothesis. Data was collected from secondary data sources, including SARS Atlas, Stats South Africa, South African Reserve, and World Economic Forum databases. The correlational and causal design were deemed appropriate to establish the Granger causality relationship between the economic research variables. The multivariate time series analysis was used to establish the causality effect between rail infrastructure investment and economic performance indicators. The unit root, cointegration, and Granger causality tests were selected to test this study's hypothesis.

CHAPTER 4: DATA ANALYSIS

4.1 INTRODUCTION

This chapter presents and analyses the time series dataset (1989-2018) collected from various secondary sources, including Statistics South Africa, the Reserve Bank of South Africa websites, the South African Revenue Services Atlas and World Economic Forum reports. The dataset was presented in mainly descriptive and inferential statistical results that provided series trends, and the causal-effect relationships between rail infrastructure investment and economic performance measured by economic growth (GDP growth), unemployment rate, and global competitiveness.

4.2 DESCRIPTIVE STATISTICS

The dataset descriptive statistics was used to summarise the time series data results to ensure a better interpretation of the findings. The trend charts of the variables were generated using Microsoft Excel software. The statistics for rail infrastructure investment (RII), economic growth, unemployment growth and global competitiveness are presented in charts labelled Figure 1, 2, 3, and 4, respectively. The composite chart summarises the trends of all the series economic variables in Figure 5.

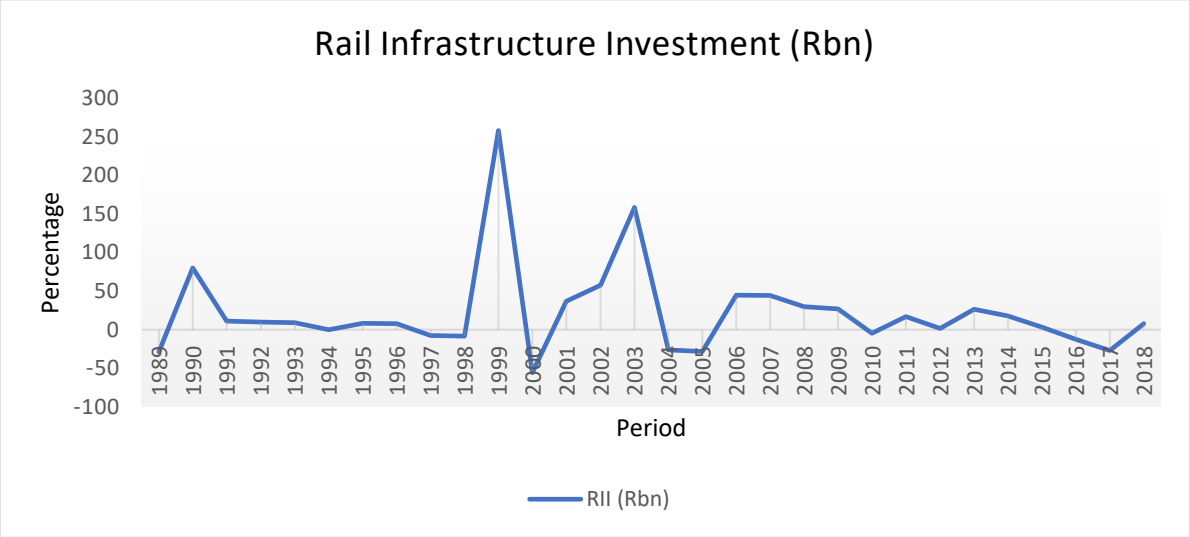
4.2.1 Rail infrastructure investment

The rail infrastructure investment chart in Figure 1 depicts the trend of the RII growth rate in the South Africa over 30 years (1989-2018). The years 1990, 1999 and 2003 had the highest rail infrastructure investment growth while 2000 had the lowest investment growth and grow the highest rail infrastructure investment growth, and 2000 had the lowest unemployment growth rate, followed by 1989, 2004, and 2005, respectively. The rail infrastructure investment allocated during the Apartheid era was insignificant because public transport was not prioritised.

The discrepancies between rail investment and economic growth are confirmed by Thomas (2013) and Joynt (2019). Thomas (2013) concludes that the Gautrain project that started in 2006 in South Africa had high transport costs compared to

the benefits gained. Joynt (2019) also points out that underinvesting in transport infrastructure investment had a multiplier effect or poor economic performance.

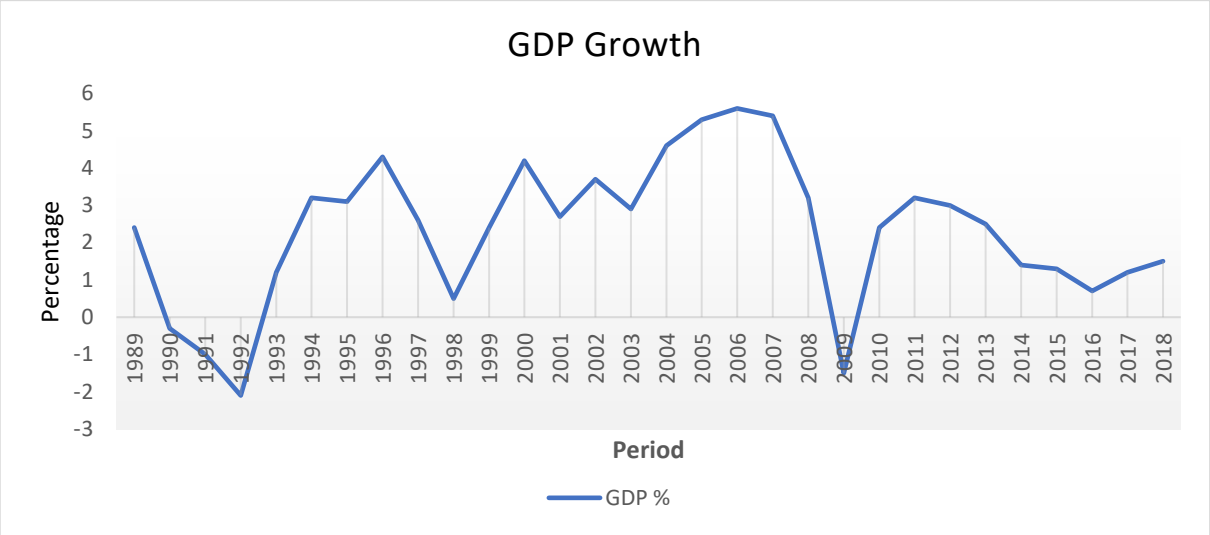
Figure 2: Rail infrastructure investment trend



4.2.2 Economic growth

The data analysed for economic growth was the GDP growth rate to the time series data. The economic growth rate chart in Figure 2 depicts the trend of the economic growth of the South Africa economy over 30-years (1989-2018). The chart shows economic growth peaks in 1994, 1996, 2000, 2002, 2006, and 2011. The trends paint a picture what has been happening over the years to inform the assumptions that can be made in this study. There was significant negative economic growth in 1992, 1998, and 2009. Generally, the GDP trend shows fluctuations on annual intervals and in some instances, the growth rates turn negative before recovery to positive rates. The results were consistent with South African National Treasury (2019) reports that for the years 1994 to 2012, the average economic growth rate was 3.3 percent. Industrial Development Corporation (2013) confirms the growth peaks in the chart with the highest economic growth rate of 5.2 per cent between 2004 and 2007.

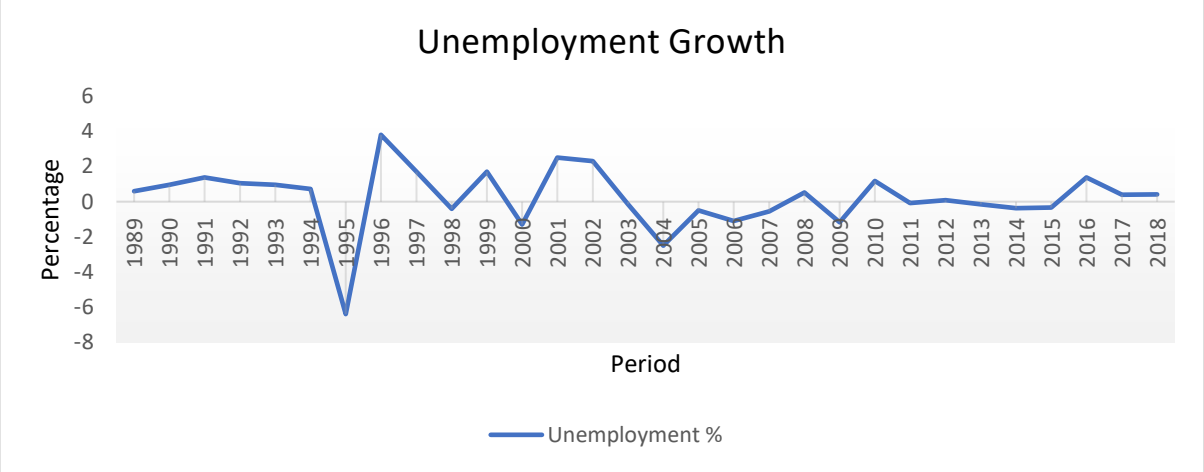
Figure 3: GDP growth



4.2.3 Unemployment Rate

The unemployment growth rate chart in Figure 3 depicts the trend of the unemployment growth rate in the South Africa over 30 years (1989-2018). The years 1996, 2001 and 2003 show that highest unemployment rates, while 1995 shows the lowest unemployment growth rate, followed by 2004, 2009, 2000, respectively.

Figure 4: Unemployment rate

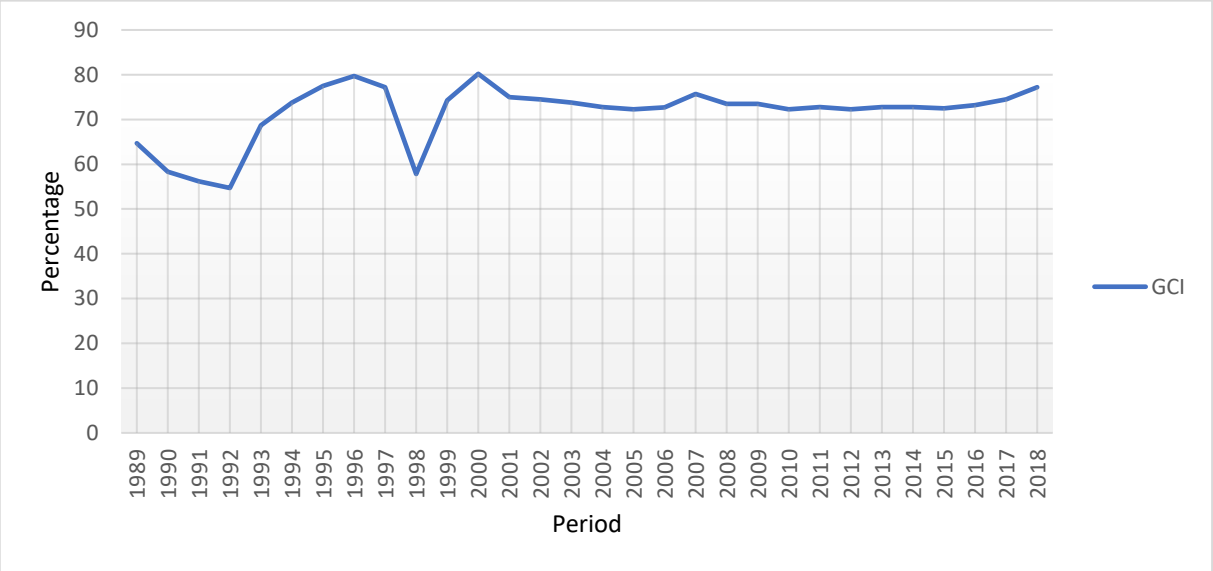


4.2.4 Economic Competitiveness

The South African global competitiveness time series is expressed as a percentage using 6 as the denominator, representing the best economic competitiveness for the highest-performing nations. The global competitiveness

index chart depicted in Figure 4, displays the trend of the Republic of South Africa's GCI over 30 years (1989-2018). There are three distinct years (1992, 1998 and 2004) when the GCIs show deficient conditions for favourable economic performance. The GCI was measured using macroeconomic and micro economic variables, including economic infrastructure investment.

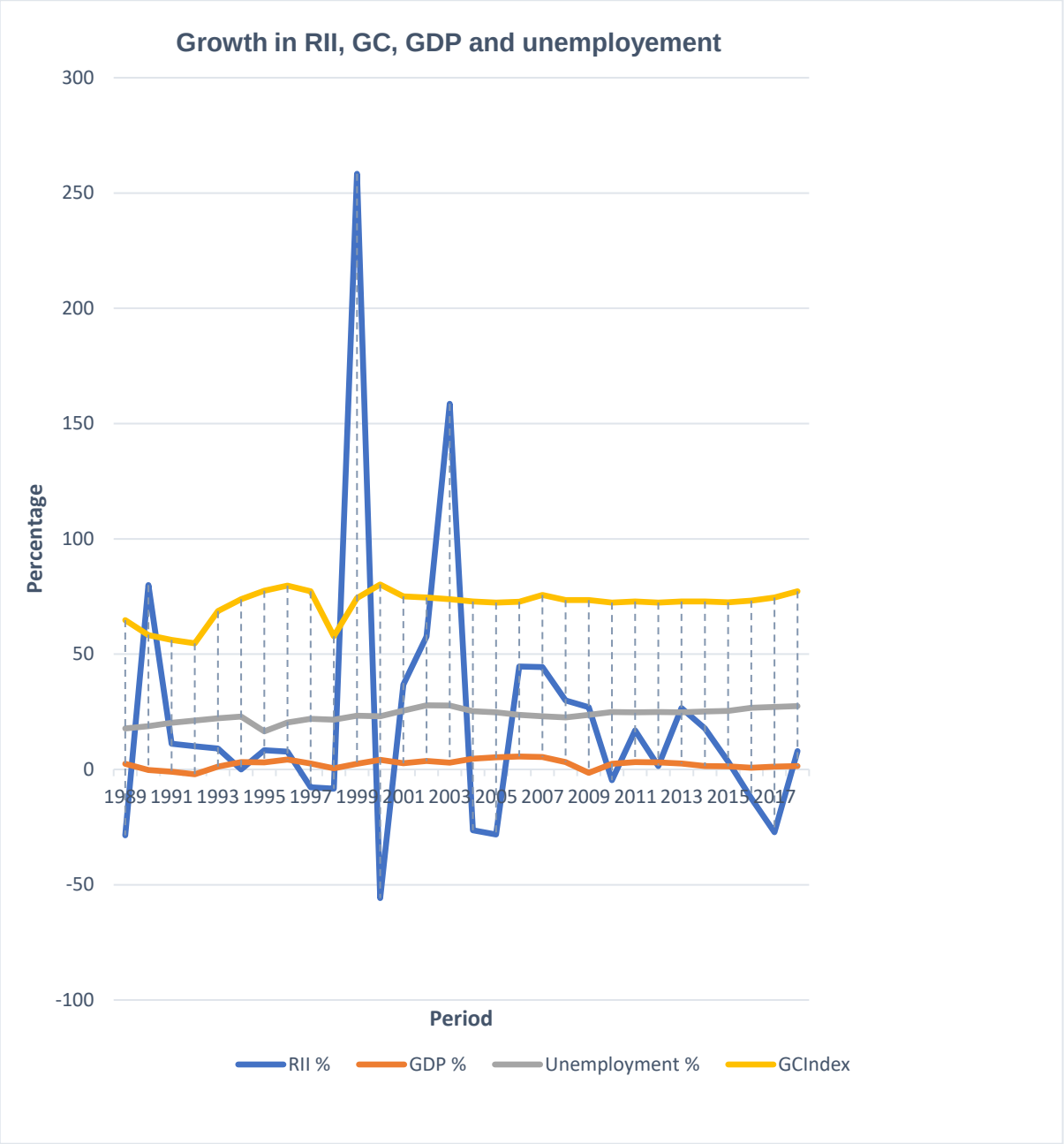
Figure 5: Economic competitiveness



4.2.5 Composite analysis of RII, GC, GDP and unemployment

In Figure 5, the RII, GDP and GC trend charts depict some relationships in some years of the time series. In 1999, when the RII showed significant growth, the country's global competitiveness improved, as well as the economic growth measured by the GDP change. In 2000, when the RII significantly declined, the GDP and GC followed the trend in 2001. However, the unemployment rate does not show a clear trend in the composite chart that could be directly related to other economic variables such as inflation and interest rates.

Figure 6: Composite trend series chart



The South African government endeavours to eradicate unemployment and stimulating economic growth stagnation by implementing different investment policies. The Industrial Development Corporation (IDC) (2013) reported an average economic growth improvement of 1.5 percent from 1980 to 1993. According to the South African National Treasury (2019), an average of 3.3 economic growth rate was achieved from 1994 to 2012. The IDC (2013) records that the South African economic growth was significant between 2004 and 2007.

4.3 MULTIVARIATE TIME SERIES ANALYSIS

The study's time series test and multivariate time series analysis were rigorously conducted using STATA statistical software. The statistics generated include lag-order selection, unit root tests, Granger's causality test, cointegration analysis, and vector autoregression modelling.

4.3.1 Unit root tests (URT)

The URTs were conducted in STATA using the Augmented-Decker-Fuller and Phillips-Perron tests to determine whether the time series data was stationary or non-stationary. The test results determined the predictive ability of the data to estimate series behaviours in the long term. Non-stationary series data result in spurious correlations and meaningless causality effects for predicting long-run series.

Augmented-Decker-Fuller unit root test

This method was used to test time series data stationality to ascertain the predictive power of the series in the long run. The decision criterion applied to interpret the ADF test results is based on comparing the test statistic with the 5% critical value. The absolute values of the two statistics are compared, ignoring the signs of the values. The null hypothesis of non-stationality is the reject test statistic value is greater than the 5% critical value, and accepted the 5% critical value is greater than the test statistic value.

In Table 1, the rail infrastructure investment (rail) series has stationality since the test statistic (-6.755) is greater than the 5% critical value (-3.584). Therefore, the null hypothesis that the series is non-stationary was rejected, and the alternative hypothesis accepted. The results confirm that the series can be used to develop a statsitical model critical for measuring linear relationships with economic variables including economic growth, rail infrastructure investment, economic competitiveness and unemployment under consideration.

Table 1: ADF unit root test of rail infrastructure investment

```
. dfuller railii, trend regress lags(0)

Dickey-Fuller test for unit root                  Number of obs   =        29

                                 ------------ Interpolated Dickey-Fuller ------------
                 Test         1% Critical       5% Critical      10% Critical
               Statistic         Value             Value            Value
------------------------------------------------------------------------------
 Z(t)            -6.755           -4.343            -3.584           -3.230
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000
```

In Table 2, the economic growth (ecogro) series has stationality since the test statistic (-2.897) is greater than the 5% critical value (-1.708). Therefore, the null hypothesis that the series is non-stationary was rejected, and the alternative hypothesis accepted.

Table 2: ADF unit root test of economic growth

```
. dfuller gdp, drift regress lags(1)

Augmented Dickey-Fuller test for unit root        Number of obs   =        28

                                 ------------ Z(t) has t-distribution ------------
                 Test         1% Critical       5% Critical      10% Critical
               Statistic         Value             Value            Value
------------------------------------------------------------------------------
 Z(t)            -3.025           -2.485            -1.708           -1.316
------------------------------------------------------------------------------
p-value for Z(t) = 0.0028
```

In Table 3, the global competitiveness index (cindex) series has stationality since the test statistic (-3.025) is greater than the 5% critical value (-1.708). Therefore, the null hypothesis that the series is non-stationary was rejected, and the alternative hypothesis accepted.

Table 3: ADF unit root test of global competitiveness

```
. dfuller cindex, drift regress lags(1)

Augmented Dickey-Fuller test for unit root         Number of obs   =        28

                                 ------------ Z(t) has t-distribution ------------
                      Test       1% Critical       5% Critical      10% Critical
                    Statistic       Value             Value            Value
--------------------------------------------------------------------------------
 Z(t)                -3.152          -2.485            -1.708           -1.316
--------------------------------------------------------------------------------

p-value for Z(t) = 0.0021
```

In Table 4, the unemployment rate (unrate) series has stationality since the test statistic (-4.503) is greater than the 5% critical value (-1.708). Therefore, the null hypothesis that the series is non-stationary was rejected, and the alternative hypothesis accepted.

Table 4: ADF unit root test of unemployment rate

```
. dfuller unrate, drift regress lags(1)

Augmented Dickey-Fuller test for unit root         Number of obs   =        28

                                 ------------ Z(t) has t-distribution ------------
                      Test       1% Critical       5% Critical      10% Critical
                    Statistic       Value             Value            Value
--------------------------------------------------------------------------------
 Z(t)                -4.503          -2.485            -1.708           -1.316
--------------------------------------------------------------------------------

p-value for Z(t) = 0.0001
```

Table 5: Summary of the ADF results

Variable	T-Statistic	ADF Critical Value 5%	Null hypothesis: Series has a unit limit
railii	-6.755	-3.584	Rejected
gdp	-2.897	-1.708	Rejected
cindex	-3.025	-1.708	Rejected
unrate	-4.503	-1.708	Rejected

According to the ADF model, all the economic time series in this study satisfied the stationality test, as confirmed by the statistics in Table 5. The outcome

qualified the series for vector autoregression and vector error-correction model analyses.

Phillips-Perron unit root test

The Phillips-Perron unit root test was run to confirm the ADF test results of stationality using the same criterion of accepting the null hypothesis when the test statistic is less than the 5% critical value and rejecting the null hypothesis that the series is non-stationary when the 5% critical value is greater than the test statistic value. Like the ADF test, the series data were tested on original series values.

In Table 6, the rail infrastructure (rail) series has stationality since the test statistic (-36.004) is greater than the 5% critical values (-18.204), respectively. Therefore, the null hypothesis that the series is non-stationary was rejected, and the alternative hypothesis accepted.

Table 6: Phillips-Perron unit root test of rail infrastructure investment

```
. pperron railii, lags(1) trend regress

Phillips-Perron test for unit root                Number of obs   =        29
                                                  Newey-West lags =         1

                                        ———— Interpolated Dickey-Fuller ————
                 Test                 1% Critical       5% Critical      10% Critical
               Statistic                 Value             Value            Value
———————————————————————————————————————————————————————————————————————————————
 Z(rho)         -36.004                -23.012           -18.204          -15.792
 Z(t)            -6.777                 -4.343            -3.584           -3.230
———————————————————————————————————————————————————————————————————————————————
MacKinnon approximate p-value for Z(t) = 0.0000
```

In Table 7, the global competitiveness index (cindex) series has non-stationality since the test statistic (-10.335) is less than the 5% critical values (-12.628), respectively. Therefore, the null hypothesis that the series is non-stationary was accepted, and the alternative hypothesis rejected.

Table 7: Phillips-Perron unit root test of global competitiveness

```
. pperron cindex, lags(2) noconstant regress

Phillips-Perron test for unit root                  Number of obs   =        29
                                                    Newey-West lags =         2
```

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(rho)	-10.798	-12.060	-7.364	-5.332
Z(t)	-2.556	-2.654	-1.950	-1.602

cindex	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
cindex						
L1.	.6055473	.1508612	4.01	0.000	.2965221	.9145724

In Table 8, the unemployment rate (unrate) series has stationality since the test statistic (-34.362) is greater than the 5% critical values (-18.204), respectively. Therefore, the null hypothesis that the series is non-stationary was rejected, and the alternative hypothesis accepted.

Table 8: Phillips-Perron unit root unit of unemployment rate

```
. pperron unrate, lags(1) trend regress

Phillips-Perron test for unit root                  Number of obs   =        29
                                                    Newey-West lags =         1
```

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(rho)	-34.362	-23.012	-18.204	-15.792
Z(t)	-6.261	-4.343	-3.584	-3.230

MacKinnon approximate p-value for Z(t) = 0.0000

In Table 9, the economic growth (ecogro) series has stationality since the test statistic (12.911) is greater than the 5% critical values (12.628), respectively. Therefore, the null hypothesis that the series is non-stationary was rejected, and the alternative hypothesis accepted.

Table 9: Phillips--Perron unit root test of economic growth

```
. pperron gdp, trend regress

Phillips-Perron test for unit root                Number of obs   =        29
                                                  Newey-West lags =         3

                                                  ---------- Interpolated Dickey-Fuller ----------
                 Test                 1% Critical          5% Critical          10% Critical
               Statistic                 Value                Value                Value
------------------------------------------------------------------------------------------
 Z(rho)         -22.867                  -23.012              -18.204              -15.792
 Z(t)            -4.096                   -4.343               -3.584               -3.230
------------------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0064
```

Table 10: Summary of the Phillips-Perron results

Variable	T-Statistic	ADF Critical Value 5%	Null hypothesis: Series has a unit limit
railii	-36.004	-18.204	Rejected
gdp	-22.867	-18.205	Rejected
cindex	-10.798	-7.364	Rejected
unrate	-12.911	-12.628	Rejected

According to the Phillips-Perron model results, all the economic time series datasets for the current study satisfied the stationality test, as confirmed by the statistics in Table 10. Since all the series data had stationary data, they qualified for vector autoregression and vector error correction model analyses.

4.3.2 Co-integration analysis

The results of the unit root tests confirmed the stationality of the economic variable series, paving the way for the cointegration analysis. The cointegration test was conducted using the Johansen cointegration test to determine if the series of rail infrastructure investments, economic growth, competitiveness, and unemployment were related and could be integrated to establish a linear model or equation. The Trace statistic and Max statistic results were tested against the 5% critical value to accept or reject the null hypothesis regarding series cointegration.

Table 11: Co-integration analysis

```
. vecrank railii cindex ecogro unrate, trend(constant) lags(1) max

                    Johansen tests for cointegration
Trend: constant                                      Number of obs =      29
Sample:  1990 - 2018                                       Lags =       1
```

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	4	-386.35841	.	85.2815	47.21
1	11	-366.77253	0.74095	46.1098	29.68
2	16	-350.927	0.66472	14.4187*	15.41
3	19	-346.63588	0.25617	5.8365	3.76
4	20	-343.71763	0.18230		

maximum rank	parms	LL	eigenvalue	max statistic	5% critical value
0	4	-386.35841	.	39.1717	27.07
1	11	-366.77253	0.74095	31.6911	20.97
2	16	-350.927	0.66472	8.5822	14.07
3	19	-346.63588	0.25617	5.8365	3.76
4	20	-343.71763	0.18230		

From the Trace statistic, at maximum rank 0, we rejected the null hypothesis since the Trace statistic (85.2815) was greater than 5% critical value (47.21); at rank 1, we rejected the null hypothesis since the Trace statistic (46.1098) was greater than 5% critical value (29.68); at rank 2, we accepted the null hypothesis and rejected the alternative hypothesis that the series had cointegration. The series variables were related and able to formulate two linear models. From the Max statistic, at maximum rank 0, we rejected the null hypothesis since the Trace statistic (39.1717) was greater than 5% critical value (27.07); at rank 1, we rejected the null hypothesis since the Trace statistic (31.6911) was greater than 5% critical value (20.97); at rank 2, we accepted the null hypothesis and rejected the alternative hypothesis (Max statistic, 8.5822; 5% critical value, 14.07) that the series had cointegration. The series variables were related and able to formulate two linear models.

Based on the results, we reject the null hypothesis that there is no cointegration in the series and accept the alternative hypothesis that there is cointegration in the series. Therefore, the Johansen cointegration test results confirm that the series in the current study are indeed linked and can be combined in linear

predictive models. Even if the South African economy could experience shocks in the short run that could affect series movement, would converge in the long run. The series could estimate short-run and long run models.

4.3.3 Lag-order selection criteria (preestimation)

Table 10 provides the lag estimation for the current time series data based on the STATA output. The lag was a preestimation result prior to a detailed time series test and multivariate time series analysis.

Table 12: Lag order selected by the criteria

Selection-order criteria (lutstats)
Sample: 1993 - 2018 Number of obs = 26

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-100.068				.702103	-.816128	-.816128	-.816128*
1	-92.1387	15.858	9	0.070	.772872	-.733729	-.608322	-.298234
2	-79.7003	24.877	9	0.003	.621962	-.998227	-.747413	-.127237
3	-67.9328	23.535*	9	0.005	.560218*	-1.21111*	-.834889*	.095376
4	-67.0097	1.8462	9	0.994	1.28773	-.58981	-.088182	1.15217

Endogenous: gci egr ugr
Exogenous: rii _cons

The lag-order selection for the current study was based on the Alkaike information criterion (AIC); Hinnan-Quinn information criterion (HQIC), and Schwarz's-Bayes information criterion (SBIC). The asterisked values are aligned to the optimal lag result essential for application when processing vector autoregression in the next section, 4.3.4. The SBIC selects a 0 lag, which could cause low error specification, whereas the AIC and HQIC select lag 3 as the optimal lag appropriate for the current study.

4.3.4 Vector autoregression (VAR)

The testing of regression significance for the estimation models in the short run from the series was developed using the vector autoregression analysis. The decision criteria was based on the probability value (p-value) The models were derived from the vector autoregression STATA output presented in Tables 13 – 17.

Table 13 depicts the four-vector autoregression equation generated from the series regarding the economic variable including gdp railii, cindex, and unrate. The ensuing presentations test the regression significance in the short run, thus, the variable causal effect in the short run. The p-values for all the equations indicate that the equations are statistically significant.

Table 13: Vector autoregression equation output

Equation	Parms	RMSE	R-sq	chi2	P>chi2
gdp	9	2.61711	0.5849	39.44604	0.0000
railii	9	49.3934	0.5195	30.27343	0.0002
cindex	9	7.06272	0.4708	24.91187	0.0016
unrate	9	1.76945	0.3525	15.24073	0.0546

The decision criteria for interpreting the relationship between the variables was based on the probability value (p-value) measured at a 5% level of significance. In Tables 14–15, the outcome variable was regressed against three regression endogenous variables. In Table 14, the outcome variable (*gdp*) was regressed against three regression endogenous variables: *railii, cindex, and unrate*.

Table 14: Vector autoregression gdp output

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
gdp						
gdp						
L1.	.2757386	.3125486	0.88	0.378	-.3368453	.8883225
L2.	.2701585	.2694427	1.00	0.316	-.2579394	.7982565
railii						
L1.	-.0304816	.0173781	-1.75	0.079	-.064542	.0035788
L2.	-.032484	.0142259	-2.28	0.022	-.0603663	-.0046017
cindex						
L1.	.2547378	.0984663	2.59	0.010	.0617475	.4477281
L2.	.0108722	.1073214	0.10	0.919	-.1994739	.2212182
unrate						
L1.	.0350539	.3172528	0.11	0.912	-.5867503	.656858
L2.	.3065587	.306115	1.00	0.317	-.2934157	.9065332
_cons	1.58331	.928369	1.71	0.088	-.2362598	3.40288

In Table 14, lag 1 of the competitiveness (*cindex*) variable shows that the *cindex* has a 1% statistical significance (p= 0.010) causal effect on economic growth in the short run. Rail infrastructure investment (railii) has a significant causal effect (p = 0.022), on economic growth (*gdp*), in lag 2. Unemployment (*unrate*) has no statistically significant causal relationship with economic growth (*gdp)*. The coefficients in lag 1 and lag 2 fall outside the acceptable decision criteria of 1%, or 5% significance levels (p = 0.912) and (p= 0.317), respectively (see Table 14).

In Table 15, in lags 1 and 2, the economic growth (*gdp*) has no statistically significant relationship with rail infrastructure investment (*railii*). With a probability value of (p = 0.777) and (p = 219), an inference is made that economic growth has no causal effect on rail infrastructure investment at a 5% significance level. Competitiveness (*cindex*) has no significant casual effect on rail infrastructure investment (*railii*), in lags 1 and 2, (p = 0.200) and (p =885), respectively. The economic variable has no short-run causal effect on rail infrastructure investment.

Table 15: Vector autoregression railii output

railii						
gdp						
L1.	-1.681491	5.94691	-0.28	0.777	-13.33722	9.974237
L2.	6.303415	5.126728	1.23	0.219	-3.744786	16.35162
railii						
L1.	-.4060962	.3306551	-1.23	0.219	-1.054168	.2419758
L2.	-.5123627	.2706792	-1.89	0.058	-1.042884	.0181587
cindex						
L1.	2.398751	1.873533	1.28	0.200	-1.273305	6.070808
L2.	.2950172	2.042021	0.14	0.885	-3.70727	4.297304
unrate						
L1.	5.504011	6.036419	0.91	0.362	-6.327152	17.33517
L2.	8.961231	5.824498	1.54	0.124	-2.454575	20.37704
_cons	11.69987	17.66422	0.66	0.508	-22.92136	46.32111

In Table 15, the unemployment (*unrate*) variable in lags 1 and 2 regression has no significant causal effect on rail infrastructure investment (railii). In the two lags, (p = 0.669) and (p = 0.108), respectively. From the results, an inference can be made that unemployment growth has no short-run causal effect on rail

infrastructure investment. Therefore, the results implied that employment growth has a causal effect on rail infrastructure investment.

In Table 16, the outcome variable, competitiveness (*cindex*) was regressed against three regression endogenous variables, including *railii, gdp*, and *unrate*. Rail infrastructure investment in lag 1 and lag 2 with (p=0.881) and (p = 0.425) had no short-run causal effect on global competitiveness. In lags 1 and 2, economic growth (*gdp*) no statistically significant, (p = 0.716); (p = 0.426) causal effect on competitiveness. The unemployment (*unrate*) variable has a statistically significant causal relationship with global competitiveness (*cindex*). The coefficient in lag 2 is within the acceptable decision criteria of 1% p-value (p = 0.000) (see Table 16).

Table 16: Vector autoregression cindex output

cindex						
gdp						
L1.	.2145794	.589525	0.36	0.716	-.9408684	1.370027
L2.	.4043312	.5082193	0.80	0.426	-.5917603	1.400423
railii						
L1.	-.043764	.0327783	-1.34	0.182	-.1080083	.0204802
L2.	-.0280931	.0268328	-1.05	0.295	-.0806844	.0244982
cindex						
L1.	.5530426	.1857258	2.98	0.003	.1890267	.9170584
L2.	-.1677109	.2024282	-0.83	0.407	-.564463	.2290411
unrate						
L1.	1.03859	.5983982	1.74	0.083	-.1342487	2.211429
L2.	2.291855	.5773902	3.97	0.000	1.160191	3.423519
_cons	2.331451	1.751078	1.33	0.183	-1.100598	5.7635

In Table 17, the unemployment (unrate) outcome variable was regressed against three regression endogenous variables, including *railii, cindex*, and *gdp*. Economic growth in lag 1 has a 1% regression significance (p= 0.001), implying that the regressor has a short-run causal effect on unemployment (*unrate*). Lag 2 with (p= 0.544) satisfies that *gdp* has no significant causal relationship with *unrate* in the short term.

Table 17: Vector autoregression unrate output

unrate						
gdp						
L1.	-.5233291	.1621412	-3.23	0.001	-.84112	-.2055383
L2.	.0848246	.1397791	0.61	0.544	-.1891374	.3587866
railii						
L1.	.0203038	.0090152	2.25	0.024	.0026342	.0379733
L2.	-.0030544	.00738	-0.41	0.679	-.017519	.0114101
cindex						
L1.	-.0704654	.0510815	-1.38	0.168	-.1705832	.0296524
L2.	.1429167	.0556752	2.57	0.010	.0337952	.2520382
unrate						
L1.	-.1134069	.1645816	-0.69	0.491	-.435981	.2091672
L2.	-.1653909	.1588037	-1.04	0.298	-.4766404	.1458585
_cons	.8748914	.4816111	1.82	0.069	-.069049	1.818832

Rail infrastructure investment (*railii*) had a statistically significant causal relationship with unemployment (*unrate*). The coefficient in lag 1 is within the acceptable decision criteria of 5% significance levels (p = 0.024). Lag 2 statistic show no significant causal relationship; (p= 0.151) (see Table 17). In lag 2. competitiveness (*cindex*) shows a 1% statistical significance (p= 0.010) of causal effectt on unemployment growth. However, lag 1, with coefficient (p= 0.168) shows no significant causal effect on unemployment in the short run.

4.3.5 Granger's Causality Test

The unit root test results from the ADF and Phillips-Perron models indicate that the variables are *I*(0). Hence, the VAR model used to conduct the Granger causality test was conducted between rail infrastructure investment (*railii*) and economic performance indicators (*ecogro; cindex; unrate*) and generated the results in Table 12. The results show the direction of the Granger causality between and among the series variables in the model equation. Based on the output in Table 1 the hypothesis are concluded as follows:

Gdp equation

Rail infrastructure investment (*railii*) does Granger cause economic growth (*gdp*), since p= (0.021) < (0.05), the null hypothesis is rejected that there is no causality of *railii* to *gdp*. The result corroborates Sahoo et al.'s (2010) whose findings were that transport infrastructure investment impacts the economy's growth. Global competitiveness (*cindex*) Granger cause economic growth (*gdp*), since p= (0.019) < (0.05), the null hypothesis is rejected that there is no causality from *cindex* to *gdp*. The results were consistent with Podobnick et al. (2012) who conclude that institutional integrity impacts economic growth and competitiveness.

The results show that Unemployment rate (*unrate*) does not Granger cause economic growth (*gdp*) since p= (0.603)> (0.05), the null hypothesis is accepted that there is no causality from *unrate* to *gdp.* The three variables (*railii; cindex; unrate*) combined, Granger cause economic growth (*gdp*), based on p= (0.046) < (0.05), the null hypothesis is rejected (see Table 18).

Railii equation

The results of this study show that blobal competitiveness (*cindex*) does not Granger cause rail infrastructure investment (railii), since p= (0.359) < (0.05), the null hypothesis is accepted that there is no causality of *cindex* to *railii*. GDP growth (*gdp*) does not Granger cause rail infrastructure investment (*railii*), since p= (0.466)> (0.05), the null hypothesis is accepted that there is no causality of from *gdp* to *railii*. The results concur with Edin's (2013) findings that trapsort infrastructure investment has no causal effect to economic growth. However, Sahoo et al. (2010) and Chen et al. (2014) conclude that transport infrastructure investment impacts the growth of the economy.

The results of this study show that unemployment rate (*unrate*) does not Granger cause rail infrastructure investment (*railii*) since p= (0.255)> (0.05), the null hypothesis is accepted that there is no causality from *unrate* to *railii.* The three variables (*gdp; cindex; unrate*) that do not Granger cause rail infrastructure investment (*railii*), based on p= (0.431) > (0.05), the null hypothesis is accepted (see Table 18).

Cindex equation

Economic growth (*gdp*) does not Granger cause global competitiveness (*cindex*), since p= (0.589) > (0.05), the null hypothesis is accepted that there is no causality from *gdp* to *cindex*. Rail infrastructure investment (*railii*) does not Granger cause global competitiveness (*cindex*); since p= (0.263) > (0.05), the null hypothesis is accepted that there is no causality of *railii* to *cindex*.

Unemployment rate (*unrate*) does Granger cause competitiveness (*cindex*) since p= (0.000) < (0.05), the null hypothesis is accepted that there is no causality from *unrate* to cindex. The three variables (*railii; gdp; unrate*) combined, Granger cause global competitiveness (*cindex*), based on p= (0.014) < (0.05), the null hypothesis is rejected (see Table 18).

Table 18: Granger casualty Wald tests output

Equation	Excluded	chi2	df	Prob > chi2
gdp	railii	7.6906	2	0.021
gdp	cindex	7.8873	2	0.019
gdp	unrate	1.0132	2	0.603
gdp	ALL	12.83	6	0.046
railii	gdp	1.5253	2	0.466
railii	cindex	2.0512	2	0.359
railii	unrate	2.7307	2	0.255
railii	ALL	5.9308	6	0.431
cindex	gdp	1.0591	2	0.589
cindex	railii	2.6692	2	0.263
cindex	unrate	16.611	2	0.000
cindex	ALL	18.866	6	0.004
unrate	gdp	10.619	2	0.005
unrate	railii	5.4309	2	0.066
unrate	cindex	6.8384	2	0.033
unrate	ALL	15.974	6	0.014

Unrate equation

Economic growth (*gdp*) does Granger cause unemployment (*unrate*), since p= (0.005) < (0.05), the null hypothesis is rejected that there is no causality from *gdp* to *unrate*. The results confirm Banda et al.'s (2016) conclusion that economic

growth has a significant causal relationship with unemployment using a Johansen cointegration and VECM.

Rail infrastructure investment (*railii*) does not Granger cause unemployment (*unrate*), since p= (0.066) > (0.05), the null hypothesis is accepted that there is no causality of *railii* to *unrate*.

Global competitiveness (*cindex*) does Granger cause unemployment growth (*unrate*) since p= (0.033) < (0.05), the null hypothesis is rejected that there is no causality from *cindex* to *unrate.* The three variables (*railii; cindex; gdp*) combined, Granger cause unemployment growth (*unrate*), based on p= (0.047) < (0.05), the null hypothesis is rejected.

Findings from previous studies and economic theory suggest that economic infrastructure investment stimulates economic growth. Infrastructure investment helps to create jobs directly through building projects, operation, and maintenance, as well as indirectly through multiplier effects throughout the economy (Kumo, 2012). In Chong et al.'s (2019) study, conclusions were made that China's high-speed train network contributed 11 per cent of economic growth using a three-dimensional panel modelling process. Similarly, the current study results confirm that rail infrastructure investment in Granger cause economic growth and the causal effect was strong.

4.3.6 Vector error-correction model (VECM)

The modelling of estimation models in the long run from the series were developed using the vector error correction model analysis. The models were generated from the VECM STATA output presented in Tables 19 and 20.

Table 19: Vector error-correction model equations

Equation	Parms	RMSE	R-sq	chi2	P>chi2
D_gdp	6	2.83337	0.6401	39.1349	0.0000
D_railii	6	53.5624	0.7350	61.02233	0.0000
D_cindex	6	7.76607	0.4201	15.93469	0.0141
D_unrate	6	1.93917	0.6226	36.30005	0.0000

The vector error-correction model generated four equations of the time series variables including the gdp, railii, cindex, and unrate. All the equations are statistically significant at 1% and 5% significant levels. The p-values in Table 19 include *gdp* (0.000); *railii* – (0.000); *cindex* – (0.041); *unrate* – (0.000), respectively.

In Table 20, the Johansen normalisation restriction-imposed statistics generated the long-run predictive model of the series variables for the current study. The probability values are statistically significant at 1% and 5%, respectively. For the *railii* (p = 0.014), *unrate* (p = 0.000), and *cindex* (p = 0.000).

The *gdp* - the target variable statistics in Table 20 was used to formulate the VECM equation critical for the causality relationship with other economic variables. The gdp is a function of the lag, which explains why the VAR model did not contain exogenous variables.

Table 20: Vector error-correction gdp output

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_gdp						
_cel						
L1.	.0114793	.1437276	0.08	0.936	-.2702216	.2931801
gdp						
LD.	.3380411	.3124433	1.08	0.279	-.2743365	.9504188
railii						
LD.	.008729	.0128844	0.68	0.498	-.016524	.0339819
cindex						
LD.	-.5116697	.1015772	-5.04	0.000	-.7107573	-.312582
unrate						
LD.	-.2019878	.3014444	-0.67	0.503	-.7928079	.3888324
_cons	.4055261	.5679504	0.71	0.475	-.7076363	1.518688

The equation of *gdp* as the target variable:

$$\Delta gdp_t = 0.406 + 0.338\Delta gdp_{t-1} + 0.009\Delta railii_{t-1} - 0.512\Delta cindex_{t-1}$$

$$- 0.202\Delta unrate_t + 0.015\Delta ECT_{t-1}$$

The error-correction term (ECT) coefficient describes the convergence speed of the time series. The adjustment term (0.015) is statistically significant at the 5% level. The result suggested that the previous year's errors (or deviation from the long-run equilibrium) are corrected within the current year at a convergence speed of 1.5%.

Table 21: Johansen normalisation output

Cointegrating equations

Equation	Parms	chi2	P>chi2
_ce1	3	128.98	0.0000

Identification: beta is exactly identified

Johansen normalization restriction imposed

beta	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_ce1						
gdp	1	.	.	.	.	.
railii	-.0393685	.0160004	-2.46	0.014	-.0707287	-.0080083
cindex	-.4520844	.094962	-4.76	0.000	-.6382066	-.2659623
unrate	3.101132	.4126966	7.51	0.000	2.292261	3.910003
_cons	-1.226333	.	.	.	.	.

Based on the statistics in Table 21, the cointegrating eaquation was extracted as:

$$ECT_{t-1} = [1.000gpd_{t-1} - 0.039railii_{t-1} - 3.101cindex_{t-1} - 1.226$$

In the beta statistics column, the *gdp* is positioned as a dependent variable explained by the other variables such as *railii, cindex, and unrate*. Based on the coefficients, the long run *railii* (-0.0393685) and *cindex* (-0.4520844) have a positive impact. At the same time, *unrate* (3.101132) could have a negative impact on *gdp* in the future on average *ceteris peribus*. Therefore, the *railii, cindex, and unrate* have asymmetry (opposing impacts) effects on the gdp in the long run. The findings revealed that when there was considerable investment in rail infrastucture and high competitiveness, there was a positive economic response leading to *gdp* growth that would be sustainable in the long run. On the other hand, there was an inverse relationship between *gdp* growth and

unemployment. The results suggest that the unemployment rate would decrease when economic growth is achieved in the South African economy.

The Jarque-Bera test was used to test the null hypothesis that the VECM model errors (residuals) are normally distributed. The null hypothesis was not disproved if the p-value (0.05) was less than the value of Chi2. As a result, the residuals were interpreted as a normal distribution.

Table 22: Jarque-Bera test for normally distributed disturbances

Jarque-Bera test

Equation	chi2	df	Prob > chi2
D_gdp	0.811	2	0.66679
D_railii	0.038	2	0.98121
D_cindex	2.151	2	0.34115
D_unrate	0.811	2	0.66679
ALL	3.810	8	0.87385

In Table 22, the chi2 values of the model economic variables: D_gdp (0.811); D_cindex (2.151), and D_unrate (0.811) are greater than 0.05, except D_raillii (0.038). The chi2 for the four combined economic variables (3.810 > p=0.05). Therefore, the null hypothesis is accepted that the residuals are normal, and the normal distribution assumption of the error terms were not violated.

The eigenvalue output in Table 23 was used to check the stability of the condition of the VECM model.

Table 23: Check condition stability of VEC estimates

Eigenvalue stability condition

Eigenvalue	Modulus
1	1
1	1
1	1
-.386426 + .5869412i	.702727
-.386426 - .5869412i	.702727
-.05158861 + .5573738i	.559756
-.05158861 - .5573738i	.559756
-.4807871	.480787

The decision criteria for checking the condition stability of the model was interpreted from the modulus of each eigenvalue that should be less than 1. All the modulus output estimates in Table 23 satisfy the eigenvalue stability condition. The stability criteria are met by VECM.

3.5 SUMMARY

Data collected for the time series period (1989-2018) was presented, analysed and interpreted in this chapter to answer the research questions and test the hypothesis. Series trends were depicted in descriptive graphs to establish the nature of the economic variables over the period. Multiple regression time series analysis was conducted to generate statistics to infer the findings to the broader context. The Augmented Dickey-Fuller and Phillips-Perron unit root tests confirmed the stationality of the series dataset. Co-integration analysis, vector autoregression, Granger causality test and vector error-correction model test were conducted to determine the existence of variable relationships, direction of relationships, and the significance of the regression. The next chapter summarises the findings, conclusions and recommendations of the study.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

This study aimed to determine the impact of rail infrastructure investment on economic performance using 30 years (1989–2018) of time series data for the Republic of South Africa. This chapter summarises the research findings, conclusions, and recommendations. The conclusions of the study determine whether the research objectives formulated in Chapter 1 were achieved. The recommendations of the study were made to improve the current and future performance of South Africa's economy through the formulation and implementation of appropriate economic policies and strategies. The suggestions for future research are based on the research gaps identified in the current study.

5.2 SUMMARY OF THE FINDINGS

The results presented, analysed and interpreted in Chapter 4 pertaining to the time series data collected to determine the effect of rail infrastructure investment on economic performance indicators, including economic growth, global competitiveness, and unemployment growth. The results were validated by relevant literature from previous studies discussed in Chapter 2.

5.2.1 Literature findings

The literature review discussion revealed different findings about the causal relationships between various economic factors. In a study by Sahoo et al. (2010), it was concluded that transportation infrastructure investment impacts the growth of the economy. According to Khumo (2012), economic infrastructure investment supports the creation of employment from construction projects, resulting in a multiplier effect on an entire economy. Lombard et al. (2017) confirm that a properly functioning transport network promotes business expansion that creates jobs in the economy. Thomas (2013) further corroborates that rail infrastructure projects create employment and reduce traffic congestion. This view is also shared by Mitra et al. (2021), who argue that investment in high-speed rail transport promotes economic growth and job opportunities.

Perl et al. (2021) point out that rail transport affects economic geography, economic growth, urbanisation, and destination accessibility. Fourie and Loncan (2015) confirm that the economic geography of South Africa is affected by the country's railway system. In China, Tian et al. (2021) reiterate that rail transport has a negative impact on service industry agglomeration in remote areas. According to the ILO (2018), adequate infrastructure is a pillar of sustainable economic and economic development, but no specific type of infrastructure is specified. The ILO (2018) further reports that unemployment and underemployment can be mitigated through public investment. Mohamed et al. (2022) suggest that a nation's competitiveness directly impacts sustainable development.

5.2.2 Research findings

After rigorous statistical analysis, the previous chapter analysed and interpreted the study's findings. The multivariate time series analysis produced the results summarised in sections that include unit root tests, vector autoregression analysis, Granger causality test, and the vector error-correction model.

5.2.2.1 Unit root tests

Based on the Augmented Dickery-Fuller and Phillips-Perron stationality tests in Chapter 4, the time series datasets for rail infrastructure investment, economic growth, global competitiveness, and unemployment growth can be used to generate significant results to explain bidirectional and unidirectional causal relationships (see Tables 9 and 10). Using a critical value of 5%, all the variables had positive stationarity results; therefore, the null hypotheses were rejected that the series were non-stationary.

5.2.2.2 Vector autoregression model results

The vector autoregression analysis provided the test of each outcome variable against the regression variables; *gdp, railii, cindex, and unrate.* Unemployment (*unrate*) had no causal effect on economic growth (*gdp*) in the short-run based on coefficients in lags 1 (P = 0.912) and 2 (P = 0.317) (see Table 14). However, Rail infrastructure investment (*railii*), in lag 2 (p = 0.022) and competitiveness

(cindex), in lag 1 (p = 0.010), showed significant causal effect on economic growth (gdp) in the short run.

Economic growth (*gdp*), in lag 1 (p = 0.777) and Lag 2 (p = 0.219) had no significant causal effect on rail infrastructure investment (*railii*). Similalry, competitiveness (*cindex*) with (p = 0.200) and (p = 0.885), in lags 1 and 2, respectively, showed no significant causal effect on rail infrastructure investment in the short run. Unemployment growth (*unrate*) had no causal effect on rail infrastructure investment in lags 1 and 2; (p = 0.362) and (p = 0.124), respectively (see Table 15).

Economic growth (*gdp*), (p=0.716) and (p=0.426) and rail infrastructure investment (*railii*) (p = 0.182) and (p= 0.295) had no causal effect on global competitiveness (*cindex*), in lags 1 and 2, in the short run. However, unemployment (*unrate*) showed a significant causal relationship with economic competitiveness in lags 2 (p = 0.000) (see Table 16).

Economic growth (*gdp*), with (p = 0.001), and rail infrastructure investment (*railii*), with (p =0.024), had significant causal-effect on unemployment in the short-run. Similarly, competitiveness (*cindex*) with coefficient (p= 0.010) in lag 2 had a significant causal relationship with unemployment in the short run (see Table 17).

5.2.2.3 Granger causality test results

In the ***gdp equation***, *railii*; p= (0.021) < (0.05) Granger causes economic growth; hence, the null hypothesis is rejected that there is no causality of *railii* to *gdp*. The *cindex* variable; p= (0.019) < (0.05), Granger causes economic growth (*gdp*), rejecting the null hypothesis there is no causality from *cindex* to *gdp.* The three variables (*railii; cindex; unrate*) combined, Granger cause economic growth, based on p= (0.046) < (0.05), the null hypothesis is rejected (see Table 18).

In the ***railii equation***, *gdp*; p= (0.466) > (0.05), *cindex*; p= (359) > (0.05), and *unrate*; p= (0.255) > (0.05), do not Granger cause rail infrastructure investment, hence the null hypothesis is accepted that there is no causality of *gdp, cindex and unrate* to *railii*. The three variables (*gdp; cindex; unrate*) combined do not

Granger cause rail infrastructure investment, based on p= (0.431) > (0.05), the null hypothesis is accepted (see Table 18).

In the ***cindex equation***, *gdp*; p= (0.589) > (0.05), and *railii*; p= (0.262)> (0.05), do not Granger cause competitiveness. Hence, the null hypothesis is accepted that there is no causality of *railii and unrate* to *cindex*. The *unrate* variable, p= (0.000) < (0.05), Granger causes economic competitiveness, rejecting the null hypothesis there is no causality from *unrate* to *cindex*. The three variables (*gdp; railii; unrate*) combined Granger cause global competitiveness, based on p= (0.004) < (0.05), the null hypothesis is rejected (see Table 18).

In the ***unrate equation****, gdp;* p= (0.005) < (0.05), and *cindex*; p= (0.033) < (0.05) Granger causes unemployment. Hence the null hypothesis is rejected that there is no causality of *gdpi and cindex t*o *unrate.* The three variables (*gdp; railii; cindex*) combined Granger cause employment, based on p= (0.014) < (0.05), the null hypothesis is rejected (see Table 18).

5.2.2.4 Vector error-correction model results

The vector error-correction model (VECM) statistical analysis was conducted to estimate models that would be used to predict the long-run causal-effect of the series variables. The fact that the series data had stationality facilitated the VECM analysis to test the long-run causal-effect relationship of the study's economic variables. The VECM model coefficients were identified as: *railii* (-0.0393685) and *cindex* (-9.4520844) with a positive impact on *gdp*. At the same time, *unrate* (3.101132) could negatively impact *gdp* in the long run on average cetetris peribus.

5.3 CONCLUSIONS

The summarised research findings in section 5.2 provide the basis for confirming the achievement of the research objectives. The hypothesis was tested based on the study results of the pairwise bivariate Granger causality between the four economic variables. The bidirectional alternative hypotheses proved were:

- *Rail infrastructure investment Granger causes economic growth.*

The findings confirmed that investment in railway infrastructure contributed to South Africa's economic growth from 1989 to 2018. The investment improved the speed and reliability of commodities in and outside South Africa. Transnet purchased new passenger coaches to enhance passenger services across the country. The Gautrain speed train was another stimulating investment that triggered national output in the various sectors of the economy. The speed train project was a significant source of job creation for many employment seekers.

- *Competitiveness Granger causes economic growth.*
  South Africa's competitive factors that characterised the southern African nation's improved economic performance during the time series included information technology adaptation, infrastructure development and a robust financial sector. These economic factors contributed to the economic productivity of South Africa. The national wealth creation was inevitable as the country attracted a wide range of investments through economic competitiveness.

- *Economic growth Granger causes economic competitiveness*.
  The growth of South Africa's economy was a source of the country's positive commitment to developing an attractive investment environment. A series of growth reforms, such as the National Development Plan and Economic Reconstruction and Recovery Plan, contributed to the country's economic sustainability and trade competitiveness. Economic growth increases income generated by the factors of production reinvested to improve the efficiency and effectiveness or the productive factors, including technology and infrastructure.

- *Economic competitiveness Granger causes employment.*
  The national competitiveness of South Africa is described in terms of the strength of economic institutions, national policies and other economic factors that measure the productivity levels of the Republic. The formation of most competitiveness factors such as infrastructure development and information technology innovation in South Africa was a crucial source of

mainly specialised employment opportunities. South Africa's competitiveness at the macroeconomic level increased the supply of horticulture and beef products to the European market, increasing opportunities for seasonal jobs in agriculture.

- *Economic growth Granger causes employment.*
  Economic growth entails rapid economic expansion, increasing national production output, creating employment opportunities, and improving the living standards of the citizens. When South African citizens experienced increased income, there was a positive rate of unemployment levels. As the economic growth rate increased, unemployment decreased as job creation showed an upward trajectory. During the short-run period, the processes of economic growth were effectively transposed into economic and social development.

The findings proved the initial direction of the formulated hypotheses, where rail infrastructure investment was postulated as the causal factor of other economic variables. Rail infrastructure investment and economic competitiveness had a strong causal effect on economic growth in South Africa during the time series period in the short run, on average ceteris peribus. Unemployment showed causal effect on economic competitiveness in the short term. Rail infrastructure investment, economic growth and competitiveness had significant inverse causal on unemployment in a time series period. However, economic growth, competitiveness and unemployment had no significant causal effect on rail infrastructure investment in the same period.

Based on the multivariate causality among the four economic variables, the composite single-directional hypotheses proved were:

- Rail infrastructure investment, competitiveness and unemployment combined Granger cause economic growth.
- Rail infrastructure investment, economic growth and unemployment growth combined Granger cause competitiveness.
- Economic growth, competitiveness, and unemployment do not Granger rail infrastructure investment.

The proved composite hypothesis confirmed investment in rail infrastructure, creating economic competitiveness, and improved employment had a causal effect on economic growth in South Africa. Another confirmed composite premise was that investing in rail infrastructure, improved economic growth, and reduced unemployment had a causal effect on economic competitiveness in South Africa. However, economic growth, competitiveness and unemployment do not influence rail infrastructure investment. The findings were consistent with Podobnik et al.'s (2012) conclusion that for a country to achieve substantial economic wealth, policymakers should adopt a collective approach to improve investment in relevant economic variables.

The bidirectional null hypotheses proved were:

- Unemployment does not Granger cause economic growth.
- Competitiveness does not Granger cause rail infrastructure investment.
- Unemployment does not Granger cause rail infrastructure investment.

The findings disproved other bidirectional causal-effect relationships: unemployment, economic growth, and unemployment to rail infrastructure investment. However, economic growth, rail infrastructure investment, and competitiveness presented opportunities for employment in South Africa's rail transport, trade, and energy sectors. During the time series, the lack of job opportunities did not cause rail infrastructure investment, economic growth, and macroeconomic competitiveness.

The equation of *gdp* as the target variable:

- $\Delta gdp_t = 0.406 + 0.338\Delta gdp_{t-1} + 0.009\Delta railii_{t-1} + 0.512\Delta cindex_{t-1} - 0.202\Delta unrate_t + 0.015\Delta ECT_{t-1}$

The model confirmed the endogenous economic variables combined causal effect (*gpd, railii, coindex, unrate*) on economic growth tested by the VECM stataistics. The model explained that economic growth was positively predicted by economic growth, rail infrastructure investment, and economic competitiveness, and negatively affected by unemployment during the time series period investigated. The model explained the long-run effect of the tested

economic variables using economic growth as the target variable. There was a sustained period of rising prosperity for the South African economy and economic growth driven by rail infrastructure investment.

5.4 RECOMMENDATIONS

Based on the research conclusions in section 5.3, recommendations are made to improve the country's long-term economic performance. Therefore, recommendations are made as follows:

- Public policymakers should allocate a budget to implement an expansionary fiscal policy to foster rail infrastructure investment to stimulate economic growth, employment, and sustainable economic development.
- The government and private investors should increase economic competitiveness by accelerating digital technology investment to improve rail transport efficiency and effectiveness.
- Public policymakers should broaden economic investment to promote rail infrastructure development and economic competitiveness to eradicate unemployment.
- The government should establish partnerships with private companies and invest in sustainable rail infrastructure projects that lead to meaningful economic growth and create more employment opportunities.
- Public policymakers should adopt a holistic approach and invest in microeconomic and macroeconomic development programs through the public and private sectors to stimulate global competitiveness.

5.5 DIRECTION FOR FUTURE STUDIES

The current study's research process had limitations that opened opportunities for further research studies in related areas. Although appropriate measures were taken to minimise the impact of limitations, the strategies were not ideal. The research findings, methodology applied, and variables investigated created gaps for future researchers in the suggested areas:

- Replicate the study using economic data from another African country for the same time series period for benchmarking.

- Broaden the transport infrastructure to include road, water, and air infrastructure investment to measure economic performance.
- Conduct a similar study with the same economic variables considering the effect of economic shocks or impulse responses.
- Assess the impact of economic infrastructure investment in energy and communication networks on economic performance.

5.6 SUMMARY

The findings from the study provided answers to the formulated research questions and the research hypotheses postulated. The results showed causal direction between and among the studied economic variables disapproving of the initial premise where rail infrastructure investment was postulated as the explanatory variable. The vector autoregression showed a significant causal relationship between the economic variables in the short-run, and vector error-correction model confirmed the long-run relationship between the variables. Therefore, to provide meaningful macroeconomic strategies, policymakers should apply an integrated approach to stimulate the economic variables instead of focusing on one economic variable to generate economic success.

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