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THE IMPACT OF TRANSPORT INFRASTRUCTURE INVESTMENT ON TRADE OPENNESS IN SOUTH AFRICA

A DISSERTATION SUBMITTED IN FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF COMMERCE

IN

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BY

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ALICE

SOUTH AFRICA

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ABSTRACT

South Africa’s economic growth and global competitiveness were reported to depend significantly on the quality of its transport infrastructure, which played a vital role in facilitating trade. This study was conducted to investigate the impact of transport infrastructure investment on trade openness in South Africa over the period 1992 to 2022. Using annual time series data, the study applied descriptive trend analysis, unit root testing (ADF and PP tests), and the Autoregressive Distributed Lag (ARDL) model to explore both the short-run and long-run dynamics between the variables. The results revealed a statistically significant and positive long-term relationship between transport infrastructure investment and trade openness, where a 1% increase in investment was associated with an estimated 4.5% increase in trade openness. In the short run, the Error Correction Model indicated a strong adjustment speed of 66%, suggesting a rapid return to equilibrium. Based on these findings, the study concluded that sustained and well-targeted transport infrastructure investment was essential for enhancing South Africa’s trade openness. It further offered policy recommendations, including improving rail and port systems, increasing public investment, and aligning infrastructure policy with trade and industrial strategies to promote economic integration and growth.

Keywords: Transport Infrastructure investment, Trade Openness, South Africa, ARDL, ECM.

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LIST OF ACRONYMS AND ABBREVIATIONS

ECM	Error Correction Model
PP	Philips–Perron
GDP	Growth Domestic Product
ADF	Augmented Dickey-Fuller
IMF	International Monetary Fund
SA	South Africa
SARB	South African Reserve Bank
ARDL	Autoregressive Distributive Lag
CUSUM	Cumulative Sums
CUSUMSQ	Cumulative Sum of Squares
OECD	Organisation for Economic Co-operation and Development
ACSA	Airports Companies South Africa
VECM	Vector Error Correction Model
EG	Engle and Granger
ECT	Error Correction Term

CHAPTER ONE

INTRODUCTION TO THE RESEARCH STUDY

1.1. INTRODUCTION AND BACKGROUND

The transport sector plays a pivotal role in supporting both domestic and global economic activities. According to Wang (2018), efficient transport systems are essential for facilitating the movement of goods and passengers, thereby contributing significantly to economic development. Hoffman et al. (2019) further assert that transportation supports the integration of regional markets and enhances international trade. For emerging economies such as South Africa, the availability and quality of sustainable transport infrastructure are critical in promoting economic growth and trade openness.

Transport infrastructure including roads, railways, airports, and ports serves as the backbone of the trade ecosystem. It enables firms to access input and output markets efficiently, reduces transaction costs, and promotes both imports and exports. As Cigu et al. (2019) highlight, strategic investment in transport infrastructure across European Union countries has not only stimulated sustainable economic growth but also become a key policy priority for both governments and private stakeholders.

Trade openness is widely recognized as a driver of economic development, particularly in developing economies. It facilitates access to international markets, enhances foreign exchange earnings through exports, and promotes the importation of capital goods and technologies, thereby increasing industrial productivity. In South Africa, empirical evidence by Malefane and Odhiambo (2018) using the ARDL bounds testing approach demonstrates that trade openness measured by the ratio of total trade (exports plus imports) to GDP has a positive and statistically significant long-run effect on economic growth. Similarly, the World Bank (2021/22) argues that trade liberalization enables developing countries to benefit from advanced technology, improved competitiveness, and greater integration into the global economy.

Furthermore, trade openness allows for the diversification of export products and trading partners, thereby reducing dependence on specific commodities and enhancing resilience to global economic shocks (Monyana & Saba, 2022). It also encourages more efficient resource allocation and facilitates the transfer of technological know-how and expertise. According to recent empirical studies (Recent Empirical Literature on Trade Openness and Institutional Quality, 2022), these dynamics support a more vibrant, innovative, and competitive domestic economy.

South Africa’s transport infrastructure consists of multiple modes, including road, rail, air, pipeline, and sea transport (Donaubauer et al., 2018). The country boasts approximately 750,000 kilometres of road network, 30,000 kilometres of railway (of which 20,900 kilometres are operational), eight commercial ports, and eleven major airports (Transnet, 2017). However, despite this expansive infrastructure, significant operational challenges persist. For instance, the World Bank’s 2022 Container Port Performance Index ranked the Port of Durban 341st and Cape Town 344th out of 348 global ports. In 2023, South Africa's liner shipping connectivity index declined by 21%, marking the second-largest drop globally after Russia.

infrastructure development, particularly in transport, is essential for improving a country's terms of trade and supporting economic modernization. Papi (2018) argues that infrastructure is instrumental in connecting producers to markets, both domestically and internationally. Luo and Xu (2018) emphasize that physical infrastructure such as roads, airports, and railways vital for enhancing market access and reducing transportation costs. The Organisation for Economic Co-operation and Development (OECD, 2021) supports this view, noting that the primary goal of transport infrastructure is to promote the efficient flow of goods and people while minimizing environmental and economic externalities.

South Africa remains one of the most advanced economies in Sub-Saharan Africa, ranking as the third-largest on the continent by GDP (International Monetary Fund, 2022). Its geographic position along key global shipping routes, such as the Cape of Good Hope, makes it a strategically important maritime trade hub (Statista, 2020). However, the country shares many infrastructure challenges with other Southern African nations, particularly concerning delays in the delivery and maintenance of municipal infrastructure (Matabane, 2019). Most transport infrastructure funding in South Africa is sourced from the national government, although significant portions are directed toward provincial budgets (DBSA, 2018).

Despite increased budgetary allocations, infrastructure performance remains suboptimal. According to Stats SA (2021), 75% of the road network is in poor condition and in need of maintenance. Half of South African households rely primarily on road transport, with usage patterns influenced by long travel distances, spatial inequality, and inadequate municipal resources. The World Economic Forum (2018) notes that South Africa is underperforming globally, ranking only 64th for overall infrastructure quality on the Global Competitiveness Index.

However, there have been noticeable improvements, especially in regions where transport investment has focused on improving connectivity and easing logistical constraints. According to the DBSA (2018), improved transport infrastructure has contributed to a rise in the global competitiveness of South African exports. Road, rail, and port networks are especially important for enabling trade within the Southern African Development Community (SADC) region.

In addition to enabling trade, infrastructure projects create employment opportunities and stimulate economic activity. Transport investments including the construction and maintenance of roads, airports, and railways have a multiplier effect on economic growth. The DBSA (2018) estimates that such projects contribute approximately 25% per year to economic growth, with the potential for even higher returns as infrastructure upgrades continue. These investments also drive innovation and industrial development by exposing domestic producers to international competition, thereby encouraging efficiency and technological upgrading (Carbaugh, 2021).

The outbreak of the COVID-19 pandemic further exposed the vulnerability of South Africa’s economy. Already in a technical recession, the economy experienced severe contractions due to nationwide lockdowns and supply chain disruptions. Many businesses were unable to meet contractual obligations, leading to job losses, salary reductions, bankruptcies, and a significant decline in household income (Wining, 2020). These impacts have heightened concerns over poverty and inequality, underscoring the urgent need for a comprehensive economic recovery plan that includes strategic investment in infrastructure as a tool for inclusive growth.

1.2. STATEMENT OF THE RESEARCH PROBLEM

South Africa’s ability to participate effectively in global trade has been increasingly undermined by challenges in its transport infrastructure, which significantly affects trade openness the ratio of exports and imports to GDP. Trade openness in South Africa has shown considerable fluctuation over the years, rising from a low of 34.3% in 1992 to a high of 65.9% in 2008, before stagnating around 56.1% in 2021 and recovering to 65.2% in 2023. However, this recovery still trails behind the global average of approximately 95%, indicating structural constraints in the country’s trade system (The Global Economy, 2024; Macrotrends, 2024). Despite this, limited scholarly attention has been paid specifically to the dynamics and determinants of trade openness within South Africa, particularly in relation to infrastructure investment.

The decline in transport infrastructure particularly in ports and rail has emerged as a major constraint on trade performance . Recent evidence suggests that South African ports are under severe strain. For example, the Durban port, a key trade hub, experienced severe congestion in late 2023, with over 61,000 containers and 79 vessels delayed at anchorage (Clyde & Co, 2024). Similarly, the Port of Cape Town ranked 399th out of 405 ports globally in the World Bank’s 2023 Container Port Performance Index. Rail freight volumes have dropped from over 226 million tonnes in 2017/18 to approximately 150 million tonnes by 2022/23, undermining the ability of industries to move goods cost-effectively (Reuters, 2024). Retailers like Pepkor reported losses exceeding R700 million in the final quarter of 2023 due to logistics bottlenecks, while Transnet alone lost an estimated R160 million in potential revenue (Clyde & Co, 2024).

These inefficiencies are not merely logistical issues; they directly impact trade openness by reducing export competitiveness, delaying imports, and increasing costs. According to Grossman (2020), high transport costs and delivery delays discourage both imports and exports, undermining South Africa's trade participation. Industry analysts like Ram (2021) and Fratila (2021) have similarly highlighted how aging infrastructure and underinvestment have eroded the country's logistics reputation. As Neus (2019) points out, global trade is increasingly competitive, and poor last-mile delivery performance leads international partners to seek more efficient alternatives, resulting in lost trade agreements and reduced foreign investment.

Despite numerous studies on infrastructure and economic growth, few have directly assessed the impact of transport infrastructure investment on trade openness in South Africa. This study addresses that gap by empirically investigating how investment in transport infrastructure influences the country's trade openness from 1992 to 2022. In doing so, it also responds to the broader need for informed, evidence-based policy that promotes integration into global markets through modern, reliable transport systems.

1.3 OBJECTIVES OF THE STUDY

The primary objective of this study is to investigate the impact of transport infrastructure investment on trade openness in South Africa for the period 1992-2022. More specifically, the sub-objectives of this study are to:

• To examine trends and provide an overview of transport infrastructure investment and trade openness in South Africa for the period.

• To econometrically examine the influence of transportation infrastructure on trade openness in South Africa for the period.

•To make policy recommendations and conclusions based on empirical results obtained during this research.

1.4 HYPOTHESIS TESTING

H_0: Transport infrastructure investment does not have impact on trade openness in South Africa.

H_1: Transport infrastructure has a significant impact on trade openness in South Africa

1.5 SIGNIFICANCE OF THE STUDY

The study is significant to the South African economy and the academic literature. Achieving a stable economy is crucial, especially for South Africa, an emerging economy working towards attaining the status of a developed nation. Understanding the contribution of transport infrastructure investment to trade openness is vital. Therefore, this study adds to the literature on the impact between investment in transport infrastructure and trade openness and helps to pinpoint areas that need further study. It is also essential to identify which type of transport infrastructure has the most significant impact on trade openness. The findings of this study are expected to serve as a key resource for policymakers in the public sector, particularly concerning transport infrastructure investment and trade facilitation.

Many studies in South Africa focused on economic growth, while this study will focus on transport infrastructure investment and trade openness. Matsolo (2019) and Chateni (2013), among others, conducted studies in South Africa to examine the relationship between transport infrastructure investment and economic growth. These researchers noted that investment in transport infrastructure contributes to development and economic growth, there is limited research on the impact of transport infrastructure investment on trade openness in the South African context. The critical part of the Matsolo (2019) study used trade openness as one of their variables and discovered a positive relationship between trade openness and transport infrastructure investment. Most of these similar studies used quantitative data and gravity models to analyse variables of interest. Also, given that there was not much done on trade openness, the chosen methodology (ARDL) would thus be an addition to the body of knowledge.

1.6 ETHICAL CLEARANCE

The ethical consideration requirements of the University of Fort Hare have been adhered to and respected prior to starting this research. All data and content used in the study will be properly acknowledged. Ethical clearance was obtained through the University of Fort Hare Inter-Faculty Research Ethics Committee (IFREC).

1.7 DELIMITATION OF THE STUDY

This study focused on the period from 1992 to 2022. Events occurring beyond this timeframe will not be considered, even if they could have influenced the relationship between the research variables.

1.6 ORGANISATION OF THE STUDY

The study will be organised into Six chapters. Chapter One will cover the study's introduction and background. Chapter Two will provide history of transport infrastructure in South Africa and trends of all variables of interest of the study. Chapter Three reviews literature to support the study and strengthen the credibility of its findings. The Chapter starts with theoretical literature, followed by empirical literature from developed countries, developing countries, and South Africa. It concludes with an evaluation of the literature, focusing on the relationship between transport infrastructure investment and trade openness, as well as their impact on South Africa, based on available studies. In Chapter Four the methodology was employed to evaluate the correlation between trade openness and transport infrastructure investment in South Africa. The Chapter is arranged as follows: following introduction is section 4.2 model specification or empirical model specification (the discussion include theories that underpin the study model), definition of variable, prior expectation, data sources. Section 4.3 discuss the estimation technique used to test unit root/stationarity and cointegration test. Section 4.4 deals with diagnostic and stability test. Chapter Five provides interpretation of regression results and the estimates using ARDL model. The final chapter of this study, Chapter Six, presents the findings, conclusions, and policy recommendations.

CHAPTER TWO

AN OVERVIEW OF TRANSPORT INFRASTRUCTURE ON TRADE OPPENNESS IN SOUTH AFRICA

2.1 INTRODUCTION

This chapter aims to provide an overview of transport infrastructure investment in trade openness in South Africa. In addition, this chapter analyses the considerable interest in transport efficiency and trade openness and the money, time, and energy invested in improving it. It is logical to provide a few facts and figures on transport's role globally, regionally, and locally. However, the picture needs to be completed because many of the implications and effects of transport lie outside the transport sector, including environmental effects.

2.2 HISTORICAL DEVELOPMENT OF TRANSPORT INFRASTRUCTURE IN SOUTH AFRICA

According to the 2023 report by the Automobile Association, approximately 7% of rural roads in South Africa were classified as being in poor condition in 1998, based on the Visual Condition Index. However, by 2021, nearly 20% of South Africa’s paved provincial and national roads were in poor or worse condition (SANRAL, 2021). Gravel roads show a varied pattern: while those in metropolitan areas are generally well-maintained, 30% of municipal gravel roads are in poor condition, and 50% under provincial management are in very poor condition.

One of the most visible challenges facing South Africa’s road infrastructure in recent years has been the proliferation of potholes. This deterioration is largely attributed to a decline in preventative maintenance and a substantial increase in the volume of heavy-duty vehicles. While the precise economic cost of potholes remains unquantified, the South African Road Federation estimates that pothole-related vehicle damage and associated injuries cost the country approximately R50 billion annually (SANRAL, 2021).

South Africa’s transport infrastructure also includes an extensive maritime system, managed by Transnet’s National Ports Authority. The country’s coastline stretches approximately 2,954 kilometres and encompasses eight commercial seaports. Durban port is the most critical for trade, handling over 60% of containerised cargo and serving as the primary trade gateway to the Southern African Development Community (SADC). Cape Town port is a crucial hub for agricultural exports, especially fruit, while East London and Port Elizabeth handle additional container traffic (Makgopa, 2023).

The development of rail and air infrastructure has historically played a foundational role in South Africa's transport sector. The first public railway line was inaugurated in Durban in 1860, and air transport infrastructure was formalised with the launch of Jan Smuts International Airport in 1952, now OR Tambo International Airport. These facilities have evolved to become key nodes in national and international trade (Transnet, 2017).

2.3 MODES OF TRANSPORT IN SOUTH AFRICA

Efficient, integrated transport systems are essential for linking producers to markets and enabling international trade. South Africa possesses the most extensive transport infrastructure on the African continent, encompassing road, rail, air, and maritime networks. These systems support domestic connectivity and global market access, with the Department of Transport identifying the sector as a cornerstone of South Africa's international competitiveness (Hertz, 2020).

2.3.1 MARITIME TRANSPORT

Maritime transport remains the primary conduit for South Africa's international trade. Approximately 95% of the country's imports and exports by volume are handled through ports including Durban, Cape Town, Port Elizabeth, and Richards Bay (Transnet, 2022). However, in recent years, South African ports have struggled with performance inefficiencies. For example, the World Bank's 2022 Container Port Performance Index ranked Durban and Cape Town at 341st and 344th out of 348 ports globally, citing equipment failures and insufficient investment in infrastructure as primary reasons (World Bank, 2022; Makgopa, 2023).

These inefficiencies have substantial economic consequences. For instance, 60,000 containers were delayed at the Port of Durban in 2023 due to outdated handling equipment and poor maintenance. The fruit export sector alone lost approximately R2.5 billion during the 2021/2022 peak season due to shipping delays.

The maritime sector's performance is directly linked to trade openness and economic growth. Investment in port infrastructure has the potential to significantly boost trade efficiency and international competitiveness (Fedorenko, 2021).

2.3.2 AIR TRANSPORT

South Africa's air transport network is the largest and most developed on the African continent, anchored by international airports in Johannesburg (OR Tambo), Cape Town, and Durban (King Shaka). Additional regional airports further enhance connectivity (DoT, 2022).

Air transport is particularly important for high-value, time-sensitive goods. While it accounts for a small proportion of cargo volume (less than 1% globally), its role in enabling just-in-time supply chains and global production networks is critical (Van den Brosche et al., 2017). However, the high cost of air freight and its limited capacity for bulk goods constrain its broader application (Button et al., 2015; Tsiaotso et al., 2019).

In the South African context, air transport infrastructure investment contributes to trade openness by facilitating international commerce, despite cost-related limitations.

2.3.3 ROAD TRANSPORT

South Africa's road network spans approximately 750,000 kilometres, with 618,081 kilometres formally proclaimed (DoT, 2023). The South African National Roads Agency (SANRAL) manages only 3.6% of this network, yet it accommodates nearly 34.5% of vehicle kilometres travelled and 70% of long-distance freight.

Road transport remains the most dominant and versatile mode of transportation in the country, linking manufacturing hubs, ports, and airports (Mtizi, 2017). However, the sector faces considerable challenges, especially in rural areas, where poor road conditions reduce access to employment and basic services (Sewella et al., 2019).

Too little investment and disagreements about how to fund road projects have slowed down progress in improving roads. One of the main problems is the use of tolls and user-pay systems, which many people in the public do not support (Van Rensburg & Krygsman, 2019).

2.3.4 RAILWAY NETWORKS

South Africa's railway network is the eleventh largest globally, extending over 30,400 kilometres. It is operated primarily by Transnet Freight Rail (TFR), alongside the Passenger Rail Agency of South Africa (PRASA) and the Gautrain Management Agency (Transnet, 2023).

Rail offers cost-effective transportation of bulk commodities over long distances and has the potential to ease congestion on roads. However, underinvestment and operational inefficiencies have reduced its effectiveness. A significant volume of freight that should be transported by rail, such as timber, is instead moved by road, leading to higher costs and road degradation (Kelly, 2024).

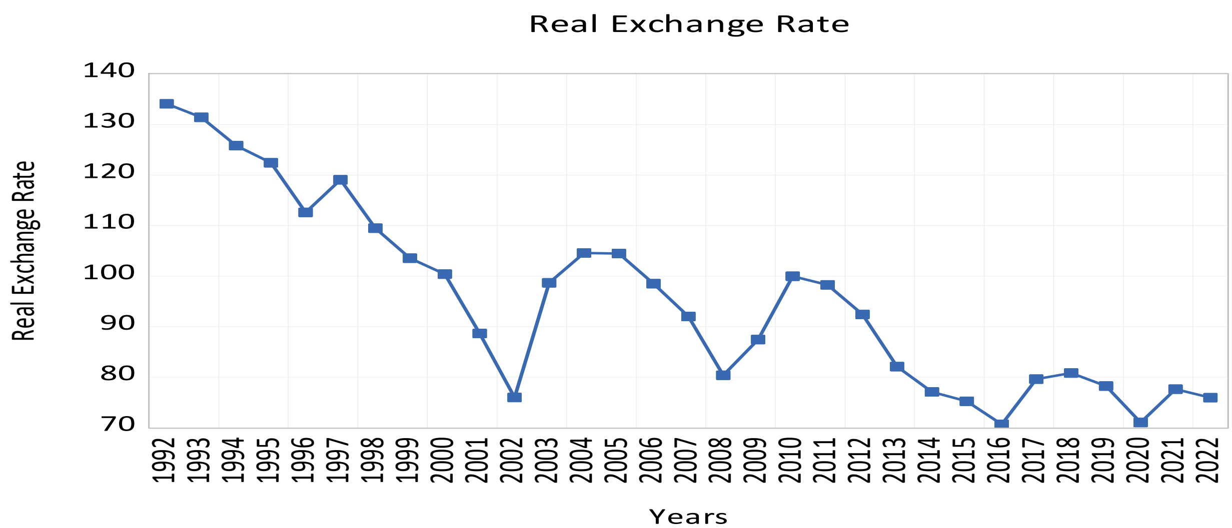
2.4 HISTORICAL TRENDS OF REAL EFFECTIVE EXCHANGE RATE IN SOUTH AFRICA (1992-2022)

Most of studies noted an inverse relationship between trade openness and real effective exchange rate volatility. That is when the degree of trade openness is higher, the real effective exchange rate volatility is lower (Bleaney & Francisco, 2010; Curran & Velic, 2019). This inverse relationship is explained in three ways. In the event of a significant macroeconomic shock, such as a reduction in capital flows, countries with greater trade openness may absorb shocks by adjusting the current account balances, moving back to equilibrium swiftly (Romelli et al., 2018). Bleaney (2008) showed that current account balances are sustainable if the real effective exchange rate is stable. Therefore, under free market conditions, countries with high trade openness have a low chance of being plunged into a currency crisis, leading to less real effective exchange rate volatility (Cavallo & Frankel, 2008).

Also, a greater degree of trade openness captured by a massive amount of tradables increases real effective exchange rate pass-through, which is how the prices respond to real effective exchange rate changes. The relative price of domestic goods adjusts to offset the effect of the shocks should unplanned monetary and natural shocks hit the economy. Even though the pass-through might be incomplete in the short term, adjustments of this nature reduce aggregate price rigidity in the local market, reducing the volatility of the real effective exchange rate (Hau, 2002). This entails that trade openness has the potential to stimulate economic growth (Sakyi et al., 2015). When the economy of the country is stable, the treasury tends to allow free foreign exchange, leading to lower exchange rate volatility (Krol, 2014).

The previous studies asserted that higher trade openness does not result in lower real effective exchange rate volatility. Calderon & Kubota (2018) noted that manufacturing trade decreases real effective exchange rate (REER) volatility, whereas non-manufacturing trade might cause heightened REER volatility. Moreover, trade openness has a different mitigating effect in different countries (Mpofu, 2021).

Figure 4: Historical Trends of Real Effective Exchange Rate in SA (level)



Source: Author's compilation from (SARB, 2023)

Between 1992 and 1994, South Africa's REER was marked by depreciation driven by capital controls, political uncertainty, and sanctions. However, between 1986 and 1993, the REER index rose from 81 to 111.04 due to declining inflation (Stats-SA, 2022). A sharp decline followed from 1993 to 2001, partly due to the Asian financial crisis and speculative attacks on the rand.

The currency appreciated significantly between 2002 and 2007, supported by falling inflation and favourable global conditions. However, the 2008 global financial crisis led to a sudden drop in the REER index from 90.78 to 77.55. The index recovered to 106.76 in

2010 because of FIFA World Cup before ,declining again amid global uncertainty and sluggish growth.

Recent volatility has sparked debates about the extent to which exchange rate fluctuations reflect fundamental macroeconomic conditions.

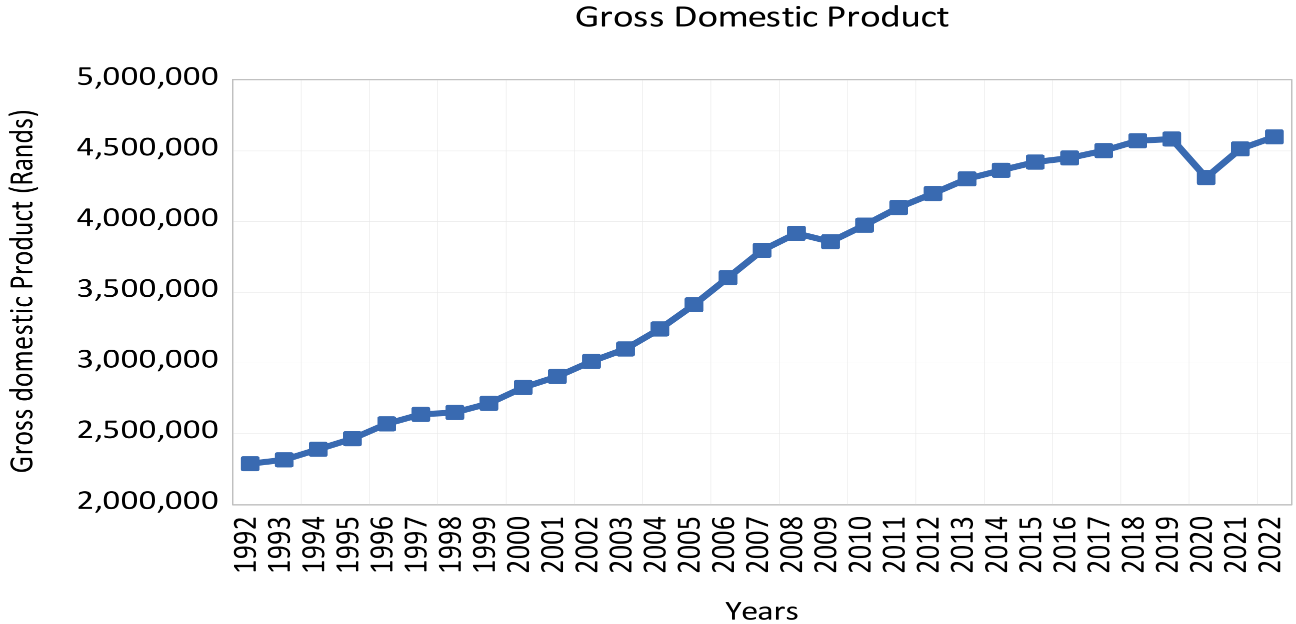
2.5 HISTORICAL TRENDS OF GROSS DOMESTIC PRODUCT IN SOUTH AFRICA (1992-2022)

The non-linear relationship between trade openness and GDP growth when considering the quality of the exports, trade has adverse effect on the growth of the GDP especially for countries that specializes in poor quality goods (Bourdon et al., 2018). To ensure international competitiveness the country must trade a diversity of high-quality products (Choi & Cho, 2021; Vissak et al., 2018).

The ocean transport accounted for about R54 billion to the South African GDP and created more than 310, 000 jobs (DoT, 2023). The Study by Fedorenko (2021) suggested that the ocean/sea transport can account for R177 billion to the GDP and can create about 1 million jobs if the government of South Africa invest in infrastructure development. The ocean transport has contribution in trade openness in South Africa because most of the exports is transported by sea.

Currently, about 70% of the South African long-distance road freight uses road network and biggest issue is the maintenance of roads (SANRAL,2024). The road network is very important in South Africa because of all goods in transported by road from different industries around South Africa to ports and airports to be transported around the world. The transport and logistics sector in South Africa is responsible for about R270 billion to the GDP and provide crucial services to other key sectors such as mining, agriculture and manufacturing (Stats-SA, 2022).

Figure 5: Historical Trends of Gross Domestic Product in SA (In Millions)



Source: Author's compilation from (SARB, 2023)

The graph indicate that highest fall was in 1992 when the GDP fell by 2,1 percent. The economy was going through a two-year recession as a result of global economic decline. The economy contracted by 1.5 percent during the period of 2008/09 as the world was facing global financial crisis (Stats-SA, 2020). In 2010 GDP rose due massive transport infrastructure investment in preparing for the World Cup. SARB (2011) highlighted that the increase in real GDP growth rate in 2010 was largely driven by a steady rise in consumer spending, partly due to the FIFA World Cup hosted by South Africa, along with factors such as faster global economic growth, lower interest rates, and strong commodity prices. Between 2015 and 2016, an upward revision of national accounts indicated that the economy was recovering from challenges, including the end of the super commodity cycle and a severe drought. The World Bank (2018) projected GDP growth to rise from 1.3% in 2017 to 1.8% by 2021, contributing to a broader recovery among developing economies, commodity exporters, and global growth.

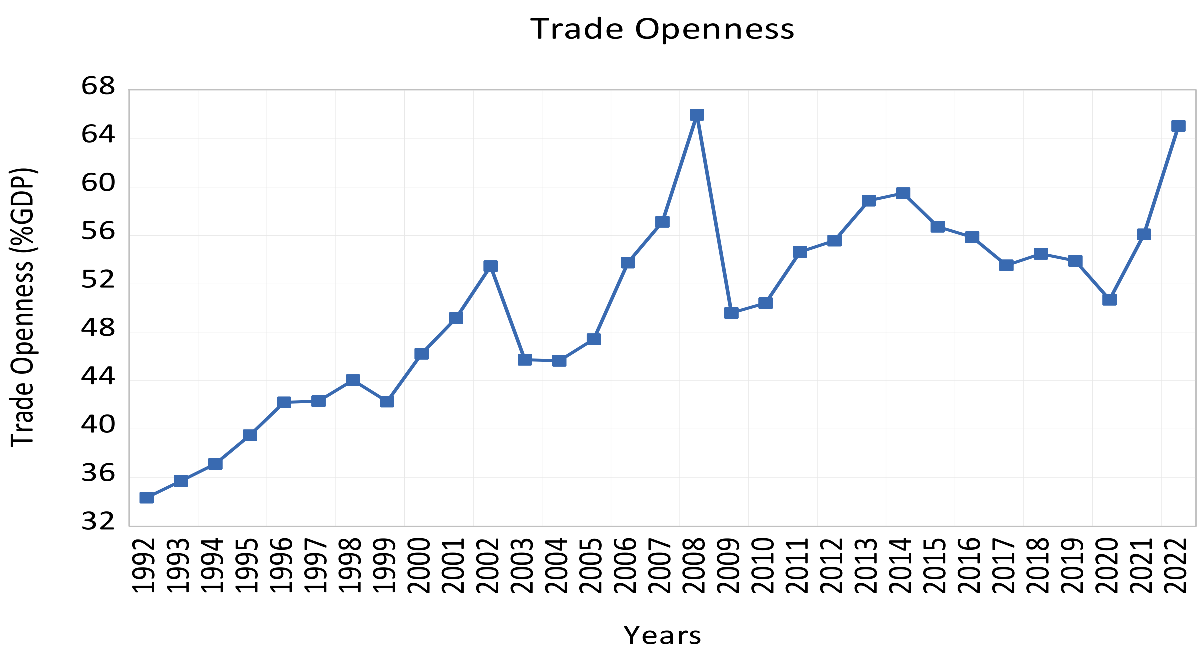
The Covid-19 pandemic caused significant decline in GDP in 2020 as many economic activities were brought to a complete halt (Rebecca,2021). In 2020, the country experienced a significant 7% decline in economic activity. This downturn was primarily attributed to the COVID-19 pandemic and the associated lockdown restrictions. According to Stats SA (2021), this marked the largest annual drop-in economic activity since 1946. For context, the second-largest decline occurred in 1992 when the economy contracted by 2.1%, as illustrated in Figure 2. During that period, the country was grappling with a two-year recession caused by a global economic downturn.

The agricultural sector showed so much resilience in the face of the pandemic as indicated by its growth in 2020 -21 while other sectors of the economy performed badly. The South African economy grew for a second consecutive year, expanding by 2,0% between 2021 and 2022, from R4,50 trillion to R4,60 trillion. Although GDP reached an all-time high in 2022, the economy has only grown by 0,3% from the 2019 pre-pandemic reading of R4,58 trillion (Stats SA,2022).

2.6 HISTORICAL TRENDS IN TRADE OPENNES IN SOUTH AFRICA (1992-2022)

Trade openness provide a wide range of benefits such as better use of countries resources because of improved production conditions, attaining a comparative advantage and it allows economies of scale optimization leading to a rise in levels of income and efficient allocation of resource (WTO, 2022).

Figure 6: Historical Trends in Trade Openness in SA (%GDP)



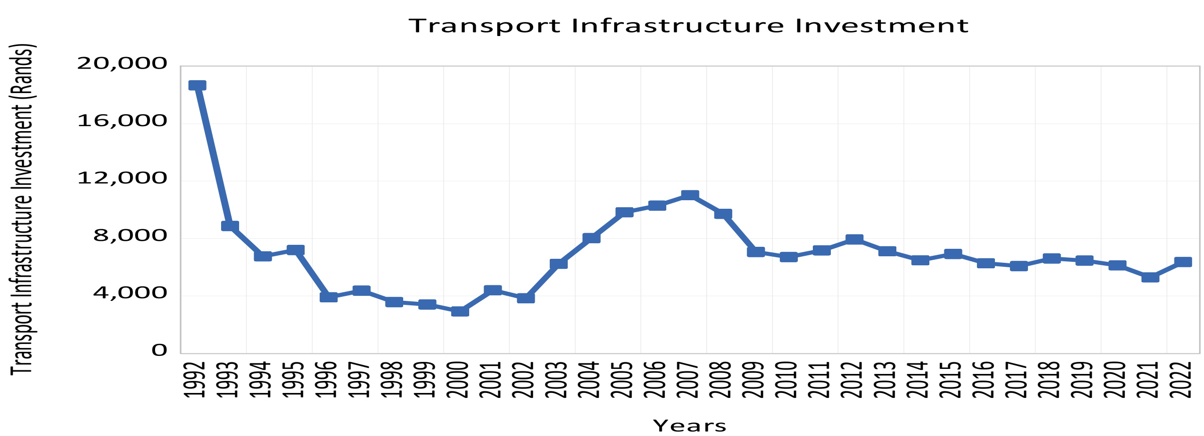
Source: Constructed from World Bank World Development Indicators (2023)

South Africa experienced a substantial decline in trade openness in early 1980s and between 1990 and 1992. However, trade openness entered an upward trajectory from 1993 reaching a peak of 72.9 percent in 2008. Due to 2007/08 global economic recession the trade openness of South Africa declined to 55.4 percent in 2009, before it rose again in 2010 because of FIFA world cup in South Africa. According to World Bank (2016) South Africa's trade openness remained steadily above 60 percent Between 2011 and 2016. Trade openness shows declined from 2019 to 2020 because of the coronavirus pandemic that hit South Africa at the end of March, many businesses were closed, and many economic activities stopped. After 2020 to 2022 the trade openness showed a steady upward trend because of decrease spread of coronavirus pandemic and economic activities opened again.

2.7 HISTORICAL TRENDS IN TRANSPORT INFRASTRUCTURE INVESTMENT IN SOUTH AFRICA (1992-2022)

Investing in transport infrastructure is essential for development in any country. Poor transport infrastructure reduces productivity, hinders market integration, and negatively affects trade openness (Garcia et al., 2015). Previous studies illustrated the economic importance of transport infrastructure. That results in high productivity, labour reallocation, and promote reorganization of global production networks (Hummels, 2007).

Figure 7: Historical Trends in Transport Infrastructure Investment in SA (In Millions)



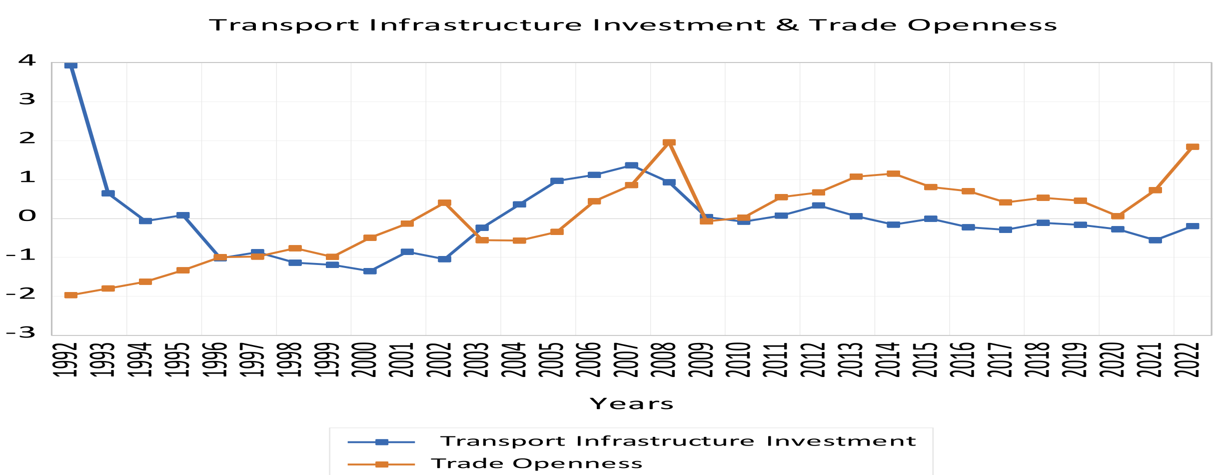
Source: Author's compilation from (SARB, 2023)

From 1994 to 2019 transport infrastructure investment in South Africa experienced significant changes. There was an increase in investment on transport infrastructure due to the growing economy, then in 1994, Since there was a democratic transaction, there was even a minor decline in investment due to a change in political stances. Since South Africa was becoming a democratic nation, the state was spending more in infrastructure improvements, and the country's economy was recovering, there was a minor increase of 29% in 1995. In 2005, transportation infrastructure investment started to recover, and as a result, investment in transportation infrastructure increased to its greatest level in 2007.In 2008, there was a sharp drop in transportation infrastructure investment because of the severe global economic crisis, which hampered transportation infrastructure investment and resulted in negative values. The 2010 World Cup, which was held in South Africa, caused a slow recovery of the infrastructure, particularly in transportation, in 2009.

Investment in transport infrastructure happened between 2011 and 2014 however, in 2012 it slightly fell and recovered in 2013. The large proportion of the infrastructure budget 28% between 2016/17 and 38% in 2021/2022 was channelled towards transport infrastructure investment. This is the biggest budgetary allocation compared to other sectors. The transport industry must ensure that transport infrastructure is adequately implemented and maintained (Joynt,2022).

2.8 LINK BETWEEN TRANSPORT INFRASTRUCTURE INVESTMENT AND TRADE OPENNES IN SOUTH AFRICA (1992-2022)

Figure 8: Link Between Transport Infrastructure Investment and Trade Openness in SA (1992-2022)



Source: Author's compilation from (SARB, 2023)

Figure 5 shows the relationship between the transport infrastructure investment and trade openness in South Africa between 1992 to 2022. In 1992 to 1996 the transport infrastructure investment was decreasing and trade openness decreasing, since there was a democratic transaction, there was even a minor decline in investment due to a change in political stances on other hand investors attracted in South Africa and trade with other countries improve, with trade openness increased.

From 2002 to 2004 we see a sharp drop in trade openness because real GDP was growing by 3.1/2 percent rate per year in the 2nd quarter of 2000. However, to the spillover effect of weak global demand to the South African economy caused 2.1/2 fall in the annualised growth rate in 1st quarter of 2001. The rand depreciation during the same period reduced the effect of the weak global economy on the local economy, leading to export and import decline (SARB, 2001).

From 2000-2002 both transport infrastructure investment and trade openness were increasing, because transport infrastructure investment and trade openness are following the same trend since an increase in infrastructure could lead to the general increase trade openness. The factors that affect both the transport infrastructure investment and trade openness has led to similar shift or a change .Hence, it is evident from the illustration if transport infrastructure and trade openness performance have both been affected by major external shocks such as the 2007-2008 global financial crisis(declined) and they followed the same trend from 2010-2018 by looking at this data we can see that the two variables' trade openness and transport infrastructure are following the same trend. South Africa has attracted relatively high investors, and this is partially due to the 2010 Soccer World Cup which was played in South Africa, whilst at the same time trade was observed to be rising (Strauss, 2019).

From 2019 to 2020 transport infrastructure investment and trade openness are following the same trend(decline) because of covid-19 pandemic in South Africa which stopped all economic activities around the world (Winkler,2021). From 2021 to 2022 the graph showed the increasing both transport infrastructure investment and trade openness variable because of opened economic activities around the world again.

2.9 CHAPTER SUMMARY

This chapter explored the evolution of South Africa's transport infrastructure and trade openness from 1992 to 2022. It examined the country's transport modes maritime, air, road, and rail and their economic significance. Empirical trends in the real effective exchange rate, GDP, and transport investment were also assessed.

The descriptive analysis highlights a recurring pattern: external shocks (e.g., the global financial crisis and COVID-19) and domestic policy initiatives (e.g., the 2010 World Cup) significantly influence the trajectory of both transport infrastructure investment and trade openness. However, while trends suggest a positive association, causal relationships require empirical testing using econometric methods.

CHAPTER THREE

LITERATURE REVIEW

3.1 INTRODUCTION

This chapter commences with a theoretical framework which presents neoclassical economic growth theory, optimal transport theory and new trade theories which underpinned the study. This is followed by empirical literature conducted in developing and developed countries. This chapter concludes with an assessment of the literature on the relationship between transport infrastructure investment and trade openness, as well as their impact on South Africa, based on the available findings from various studies.

3.2 THEORETICAL LITERATURE

3.2.1 THEORETICAL FRAMEWORK

This study is grounded in three interrelated theoretical perspectives: the Neoclassical Economic Growth Theory, the New Trade Theory, and the Optimal Transport Theory. Each of these frameworks captures a vital component of the relationship between transport infrastructure investment and trade openness. While they address distinct economic dynamics, they are theoretically complementary and collectively provide a comprehensive lens through which the study's variables and causal pathways can be examined.

3.2.2 NEOCLASSICAL ECONOMIC GROWTH THEORY

The Neoclassical Economic Growth Theory, originally developed by Solow (1956) and Swan (1956), provides a foundational basis for understanding how investment in physical capital including transport infrastructure drives economic growth. According to this theory, economic output is determined by capital accumulation, labour force expansion, and technological progress. Infrastructure investment enhances productivity by reducing transaction costs, improving the efficiency of production, and enabling the movement of goods and services. In the South African context, improvements in transport infrastructure are expected to contribute to long-run economic growth by increasing the efficiency and competitiveness of local industries.

3.2.3 NEW TRADE THEORY

Building on this, the New Trade Theory , pioneered by Krugman (1979, 1980), explains international trade patterns by introducing increasing returns to scale and network effects into traditional trade models. New Trade Theory emphasizes the role of economies of scale, product differentiation, and imperfect competition in driving trade, particularly among similar countries. Transport infrastructure plays a pivotal role in this framework by reducing the cost of trade and enabling firms to access larger markets. As infrastructure expands, it facilitates specialization and export diversification, thereby increasing trade openness. In this way, the New Trade Theory connects improvements in transport systems to enhanced international competitiveness and greater integration into global markets.

3.2.4 OPTIMAL TRANSPORT THEORY: Chronological Development and Relevance

Optimal Transport Theory provides the theoretical foundation for understanding how resources such as goods, services, or labour can be moved in the most efficient way from one location to another. The theory traces its origin to Gaspard Monge (1781), who introduced the problem of determining the most cost-effective way to move mass from one distribution to another. This initial formulation, however, lacked mathematical tractability. In the 1940s, Leonid Kantorovich reformulated Monge’s problem using linear programming, thereby providing the analytical tools necessary to solve real-world transport allocation challenges. Kantorovich’s contributions later earned him the Nobel Prize in Economics, underscoring the importance of efficient transport in economic planning.

Throughout the 20th century, Optimal Transport Theory evolved significantly with contributions from mathematics, operations research, and computational economics. In the 1970s–1990s, it gained relevance in urban planning and logistics as computational tools improved. By the early 2000s, the theory began to be applied in economic geography and trade modelling. Post-2010 developments have seen its integration into large-scale infrastructure evaluation, especially in studies seeking to optimize trade flows, reduce logistical bottlenecks, and assess the spatial efficiency of transport networks. In this study, Optimal Transport Theory serves as the analytical framework for linking infrastructure development to the efficient movement of goods, which ultimately influences trade openness.

3.2.5 INTEGRATION OF THEORETICAL FRAMEWORKS

Rather than viewing these theories in isolation, this study treats them as part of an interconnected theoretical structure. The Neoclassical Economic Growth Theory explains how infrastructure investment contributes to productivity and growth. The New Trade Theory builds on this by linking that growth and productivity to increased trade through scale economies and reduced costs. Optimal Transport Theory serves as the bridge between the two, showing how improved transport networks enable efficient allocation of goods and services, thereby operationalizing the productivity gains and trade cost reductions predicted by the other two theories.

In the context of South Africa, where trade openness is both a development goal and a policy challenge, the integration of these theories provides a coherent foundation for analysing how transport infrastructure investment can catalyse economic transformation. Together, they support the hypothesis that transport infrastructure investment is not only a driver of domestic growth but also a facilitator of global trade participation.

3.3 EMPIRICAL LITERATURE

3.3.1 DEVELOPED COUNTRIES

Studies in developed economies broadly agree that transport infrastructure significantly contributes to trade openness. For instance, Ferrari (2018) and Borchert (2022) found a strong positive link between transport infrastructure investment and trade openness in the USA and UK. Both studies emphasize the role of efficient infrastructure in reducing trade costs and facilitating international competitiveness. Similarly, Roshan (2020)**,** using advanced econometric techniques (Johansen cointegration and vector error correction models), identified long-term interdependence between infrastructure investment and trade openness in Saudi Arabia, reinforcing the importance of sustained investment in transport systems.

However, differences emerge based on regional and methodological focus. Bougheas (2022) analysed economic corridors across China, Russia, and Mongolia, concluding that while infrastructure enhances trade broadly, geographic barriers diminish its effects in some regions (e.g., Northeast Asia). In contrast, Persyn (2020) stressed the impact of fuel prices and shorter transport routes on trade costs, but was criticized for neglecting crucial factors like access to oceans and border connectivity key determinants of trade for port-based economies like South Africa.

Lin (2020) and Chukwuma (2018) emphasize the transformational role of infrastructure and openness in driving technological growth and economic performance. Banerjee et al. (2020) further support this with evidence from China, showing that infrastructure investments significantly boosted GDP per capita.

Despite their merits, many of these studies such as Fan et al. (2021), who focused on expressways in China, and Cavallo et al. (2021), who examined domestic trade margins tend to overlook other critical modes like rail and air. These gaps are particularly relevant for South Africa, where diversified transport modes are vital to trade logistics.

Cigu et al. (2019) and Felbermayr & Tarasov (2022), using panel data across the EU, found long-term causality between transport infrastructure and trade openness. These findings, while compelling, largely reflect contexts with consistent public infrastructure funding conditions that differ from those in South Africa.

In the Indian context, Donaldson (2018) reported that improvements in road and rail systems reduced price gaps and enhanced trade flows. However, the study excluded maritime infrastructure, a mode central to South Africa's export-led sectors.

Taken together, these studies support the idea that infrastructure investment enhances trade openness but highlight that context matters. Developed countries typically benefit from strong institutions and financing, while developing economies may not achieve the same outcomes due to structural constraints.

3.3.2 DEVELOPING COUNTRIES

Empirical findings from developing countries present a more complex picture. Lawin and Dossa (2022) used Granger causality testing on 36 African nations and confirmed a causal link between infrastructure growth and intra-African trade openness.

Similarly, Ibrahim (2022) found that trade openness in 38 African countries increased with improvements in transportation infrastructure, though he noted that rapid urbanization could limit these benefits.

In Pakistan, Gupta & Zahra (2022) used a non-linear ARDL model and found that while transport infrastructure contributes to trade openness, it also has ecological impacts, particularly under asymmetric shocks. Their study raises important concerns about negative externalities that might be overlooked in purely economic analyses.

Sarania (2021), focusing on India, employed the ARDL bounds test and found both short- and long-run causality between transport investment and trade openness. Similarly, Roy (2017) emphasized that trade liberalization enhances infrastructure and connectivity in low- and middle-income countries aligning with this study's context in South Africa.

Studies from Latin America also support this relationship. Santamaria et al. (2020) showed that transport infrastructure significantly improves trade openness in Colombia, Peru, and Argentina. In Fiji, Rao (2017) observed that infrastructure investments not only promote trade but also generate widespread social benefits.

However, contradictory findings exist. Christopher (2020), examining 14 COMESA member states, found that while infrastructure enhances trade flow, trade openness can dampen the link between transport and output development. Jiya et al. (2020) reached similar conclusions, suggesting that trade liberalization may not always amplify the benefits of infrastructure.

Collectively, these studies show that in developing economies, the effect of infrastructure on trade openness is highly context-dependent. Factors like urbanization, environmental impacts, and regional integration influence outcomes. This reinforces the need for a localized study such as this one on South Africa that reflects unique institutional, financial, and geographic realities.

3.3.3 SOUTH AFRICA

Limited studies have specifically addressed the transport infrastructure trade openness nexus in South Africa. Selamolela (2018) employed Johansen cointegration and Granger causality tests to assess long-term links between infrastructure and trade openness from 1970 to 2015. The results showed strong long-run relationships between railway and port infrastructure but no significant influence from road and air transport highlighting mode-specific dynamics in the country.

Newbery (2012) used cost-benefit analysis and found a long-term positive association between transport infrastructure investment and trade openness. However, the study was more focused on economic growth outcomes and did not isolate the effects of different infrastructure types.

Kumo (2012), using Granger causality tests between 1960 and 2009, reported a strong causal relationship between trade openness and infrastructure investment. Yet, like the other studies, his work did not deeply explore how infrastructure investment influences trade dynamics specifically particularly in light of recent issues like port congestion, rail failures, and underinvestment.

While these studies provide preliminary insights, they do not sufficiently explain the causal mechanisms between infrastructure investment and trade openness in the current South African context. Most of the focus has been on broader economic growth rather than on trade-specific outcomes. Moreover, they fail to address current infrastructure challenges such as Transnet delays, port inefficiencies, and logistical backlogs.

3.3.4 ASSESSMENT OF LITERATURE

Theoretical literature review on the impact of transport infrastructure investment as asserted by the neoclassical economic growth and optimal transport theory indicated that high quality infrastructure promotes the performance of the country’s logistics in the international trade leading to the expansion of the markets. New trade theory explained the advantage of trade because of available of variety of goods to different countries in the world.

The empirical literature provides a solid foundation suggesting that transport infrastructure contributes to trade openness. However, key gaps remain especially in the South African context. Existing studies often**:**

- Focus on developed countries with robust infrastructure funding.
- Use panel data that overlook country-specific conditions.
- Emphasize economic growth more than trade openness.
- Ignore mode-specific transport issues (e.g., seaport , rail, road)

While panel data are useful for broader comparisons, this study uses time series analysis, which better captures the long-run relationship between transport infrastructure investment and trade openness in a single country context. The ARDL model is selected due to its suitability for small samples and its flexibility with mixed integration orders (I(0) and I(1)).

Moreover, previous South African studies did not adequately incorporate recent trade challenges (e.g., port congestion, equipment failures, declining rail volumes) or consider trade-specific outcomes. Therefore, this study fills a significant gap by examining how transport infrastructure investment impacts trade openness in South Africa over time addressing both economic theory and practical realities.

3.4 CHAPTER SUMMARY

The essence of this chapter was to review theoretical framework with respect to transport infrastructure and trade openness and the empirical studies that have been conducted. The chapter focused on the new trade theory, the neoclassical theory and the optimum transport theory. The results from the theories and empirical studies revealed that investing in the development of transport infrastructure leads to trade openness, welfare gains and economic growth.

CHAPTER FOUR

RESEARCH METHOLODY

4.1 INTRODUCTION

The previous chapter discussed both theoretical and empirical literature terms related to trade openness and transport infrastructure investment. These concepts provided the guidance on variables to be used in the regression analysis the study to undertake. This chapter provides the methodology to employed to evaluate the correlation between trade openness and transport infrastructure investment in South Africa. The chapter is arranged as follows: following introduction is section 4.2 model specification or empirical model specification (the discussion include theories that underpin the study model), definition of variable, prior expectation, data sources. Section 4.3 discuss the estimation technique used to test unit root/stationarity and cointegration test. Section 4.4 deals with diagnostic and stability test. Lastly, section 4.5 provides chapter conclusion.

4.2 MODEL SPECIFICATION AND ESTIMATION AND DATA COLLECTION

The present study adopts and modifies the model proposed by Rehman et al. (2020), who examined the short- and long-run causal relationships between infrastructure development and trade openness in Pakistan. Their study was grounded in the new growth theory**,** which posits that trade openness enhances productivity through increased access to larger markets, technology diffusion, and economies of scale. In turn, this promotes further investment in transport infrastructure to reduce trade costs and improve competitiveness.

The original Rehman et al. (2020) model is specified as**:**

Equation 1= $\mathbf{INF}t\mathbf{=}\ \beta 0 + \mathbf{FDI}t + \beta 2OPENTt + \beta 3REXCHt + \beta 4C\mathbf{P}t + \mu t.$

Where **INF** represents infrastructure development, **FDI** is foreign direct investment, **OPEN** is trade openness, **REEXCH** is the real exchange rate, and **CAPEX** is capital expenditure**.** While this model provides a useful foundation, the current study focuses specifically on the impact of transport infrastructure investment on trade openness in South Africa. Therefore, the model is modified to better reflect this objective and the local context. Specifically**:**

- **FDI**, **CAPEX**, and the general infrastructure index are excluded, as they are either overly broad or outside the immediate scope of transport-specific investment.
- New variables are introduced:
  - **Transport Infrastructure Investment (TRANS_INFRA)**, which directly captures government spending on roads, ports, and related logistics infrastructure.
  - **GDP**, representing the size of the economy and used as a control variable.
  - **Real Effective Exchange Rate (REER)**, retained from the original model, as it influences trade competitiveness.

To ensure consistency in interpreting coefficients and to linearise any potential exponential growth in time series data, natural logarithms are applied to all variables, following the guidance of Brooks (2008). The modified model is thus specified as:

$$\textbf{Equation 2} = logTrade\_\textbf{openn} = \beta 0 + \beta 1 logTrans\_Infrast + \beta 2 logGDPt + \beta 3 logReal\_exchanget + \mu t$$

Where:

β0: The intercept

Trade_openn= Trade openness, measured as the ratio of total trade (exports + imports) to GDP.

LTrans_infrast = Transport Infrastructure investment

REER = Real Effective Exchange Rate, capturing competitiveness in international markets.

GDP = Gross Domestic Product at constant prices, capturing economic size and growth.

β1, **β2** and **β3**=Show the independent variables' coefficients

μ = demonstrates the stochastic error term, which includes variables not included in the model's specification.

t: Stands for time series.

The parameters **β1**, **β2**, and **β3** are the long-term elasticity of Trade_openn for LTrans_infrast, REER, and GDP, respectively. Since improved transport infrastructure led to more imports and exports as well as improved economic activity therefore signs of **β1**, **β2**, and **β3** are expected be positive.

4.2.1 VARIABLES AND PRIORI EXPECTATIONS

Table 4.1 Description of variables and Expectations

Variables	**Description of variables**	**Expectations**
Trade_openn	Trade openness	Dependent variable
LTrans_infrast	Transport infrastructure investment	+ (positive)
REER	Real effective exchange rate	+/- (positive)
LGDP	Gross domestic product	+ positive

Source: Own compilation 2024

4.2.2 DEFINATION OF VARIABLES

Given the empirical literature found in most of the research (Nidugala,2019; Bharat, 2015; Murthi, 2015; Molefe, 2011; Nurudeen & Usman, 2010), it is anticipated that the independent variables included in this analysis will have a significant impact on trade openness's long-term impact on economic growth. This is because there are several business cycles and shocks that have an impact on trade openness over an extended period. Therefore, there is a link between increase in GDP and an increase in trade openness. Access to infrastructure development and the amount spent on transport infrastructure are found to be exogenous, and they may positively affect investment, which is going to increase trade openness.

REAL EFFECTIVE EXCHANGE RATE(REER)

The real exchange rate represents the value of the South African Rand compared to other major currencies. This data is collected by Statistics South Africa and the South African Reserve Bank. According to the study by Wondemu and Potts (2016), the REER coefficient is expected to have a negative sign. Major currencies like the euro (€), pound sterling (£), US dollar ($), and Japanese yen (¥) are used to facilitate international trade. South African importers need this currency therefore, they are required to convert Rands into other currency such as dollar, leading to high demand for foreign currency. On the other hand, importers from other countries such as the USA need to convert their dollars into rand to purchase South African exports again the demand for the rand increases (Pettinger, 2017).

GROSS DOMESTIC PRODUCT

Gross domestic product (GDP) serves as the independent variable, influenced by changes in explanatory variables, and a country's economic growth is driven by fluctuations in its GDP. This study focuses on analyzing the annual market value of products, including imports and exports, in and out of South Africa. As noted by Fedderke (2018), GDP refers to the total market value of goods and services produced within a country's borders during a specific period. South Africa is the most developed country in Africa. The service sector contributes significantly to economy as it accounts for about 73% to the GDP. A closer look at the service industry the most vital are finance, real estate and business services (21.6 percent); government services (17 percent); wholesale, retail and motor trade, catering and accommodation (15 percent); and transport, storage and communication (9.3 percent). Manufacturing accounts for (13.9 percent); mining and quarrying for around (8.3 percent) and agriculture for only 2.6 percent (Stats SA, 2024).

TRANSPORT INFRASTRUCTURE INVESTMENT

Transport infrastructure development is measured by the total length of roads in kilometres, rail lines in kilometres, container port traffic in tons, air transport, registered carrier departures, and the cost of capital goods. The World Bank is mandated for collecting this data. Infrastructure investment includes spending both new development and the extension of existing framework. It is anticipated that increased investment in transport infrastructure will lead to greater trade openness. This is in line with a study by Banister and Berechman (2015), who argue that improving networks allows businesses to use the transport system to reduce expenses effectively. Accessibility to world markets is important for manufactured exports.

Infrastructural development involves investing in physical structures such as clinics, power systems, highways, state connectivity, airports, and educational facilities, all of which are crucial for the efficient operation of the economy. It is widely acknowledged to be a capital-intensive, long-term system accompanied by various facilities (Stupak, 2018). According to the World Bank, a 10% increase in infrastructure investment results in a 1% rise in gross domestic product.

TRADE OPENNESS

In this study, trade openness is defined as the ratio of trade to GDP. The data is sourced from the World Bank indicators. One argument supporting trade openness is that a more open economy is more likely to experience an increase in national per capita income. This occurs because greater trade openness stimulates investment, which subsequently drives long-term economic growth (Klasra, 2011). Trade openness assesses the extent of an economy's integration with global trade and serves as an indicator of its economic condition. It is argued that trade openness offers numerous economic advantages, such as enhanced skill transfer, technology diffusion, improved labour and total factor productivity, as well as accelerated economic growth and development (Economics Online, 2019).

4.2.3 DATA SOURCES

The study utilized secondary data from 1992 to 2022 is based on an annual basis from the World Bank indicators and South African Reserve Bank. The study covers the period from 1992 to 2022, and this timeframe was chosen for several reasons. Firstly, 1992 marks a significant turning point in South Africa’s political and economic history, as the country began transitioning away from apartheid, leading to the reintegration of South Africa into global markets. This period coincides with major policy reforms aimed at liberalizing trade and expanding infrastructure investment under democratic governance.

Secondly, the 1990s onwards saw the introduction of key economic strategies such as the Growth, Employment and Redistribution (GEAR) policy (1996), followed by the National Development Plan (NDP) in 2012, both of which emphasized transport infrastructure as a means of stimulating trade and economic growth. The post-2010 period also witnessed several large-scale government-funded transport projects aimed at enhancing logistics and reducing trade costs.

Lastly, the availability and consistency of reliable annual data on trade openness, transport infrastructure investment, GDP, and real exchange rates for South Africa are only available from 1990 onwards in international databases such as the World Bank and South African Reserve Bank (SARB). The end year, 2022, represents the most recent year with complete and verified data at the time of this study.

I was aware that although both institutions provide similar macroeconomic indicators, their methodologies and reporting periods can differ. To address this, I carefully cross checked variables such as trade openness, real effective exchange rate ,GDP, and transport infrastructure investment for consistency in definitions, units, and timeframes. Where overlapping data existed, I prioritized one source based on data completeness and alignment with the study's scope typically relying on the Reserve Bank for country specific indicators and the World Bank for internationally standardized data. I also conducted a preliminary data cleaning process to ensure uniformity before proceeding with analysis. This helped minimize the impact of any discrepancies and allowed for more reliable results.

Table 4.2 Data Sources

VARIABLES	**DATA SOURCES**
Trade_openn	World Bank Indicators
LTrans_infrast	World Bank Indicators
REER	South African Reserve Bank

LGDP	South African Reserve Bank

4.3 ESTIMATION TECHNIQUES

It was important to understand the dynamics of variables and their interactions over time in the context of time series data. Even a straightforward regression analysis in a time series study provided insights into relationships among variables, especially when the characteristics of the series data were properly accounted for. This study employed a three-step approach to assess the relationship between transport infrastructure investment and trade openness, along with other control variables.

The first step involved examining the stationarity of the variables through unit root testing. Secondly, the long-run relationship between the variables was assessed using the Autoregressive Distributed Lag (ARDL) Bounds test. Lastly, an error correction model was estimated to capture short-run dynamics.

The study employed the Autoregressive Distributed Lag (ARDL) model, as developed by Pesaran and Shin (1999), to estimate both the short-run and long-run relationships between transport infrastructure investment and trade openness in South Africa. The ARDL approach was selected due to its flexibility and appropriateness for analysing timeseries data that may be integrated at different levels, specifically I(0) and I(1), but not I(2). This suitability was confirmed by the results of the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests conducted in the study, which indicated a mixed order of integration among the variables.

In addition, the ARDL method was considered advantageous for small sample sizes, which was applicable to this study as it relied on annual data from 1992 to 2022. Unlike traditional cointegration techniques such as Johansen's method, the ARDL model allowed for reliable estimation with a relatively limited number of observations, making it particularly suitable for case studies in developing countries such as South Africa.

The model also enabled the simultaneous estimation of both short-run dynamics and long-run relationships within a single reduced-form equation. This was particularly important given the study's objective of identifying both the immediate and sustained effects of transport infrastructure investment on trade openness. Furthermore, the ARDL Bounds testing approach allowed for the examination of cointegration among the variables without the need for pre-testing them to be integrated at the same order. Therefore, based on its theoretical robustness and empirical relevance, the ARDL model was deemed the most appropriate method for the study.

To test for stationarity, the study employed the Phillips-Perron (PP) and Augmented Dickey-Fuller (ADF) unit root tests using EViews software. These formal tests helped to determine the order of integration of each variable. The ARDL co-integration approach was applied to investigate whether a long-run relationship existed between the variables using the Bound F-statistic. If the computed F-value exceeded the upper bound values at the 1%, 5%, and 10% significance levels, the variables were considered co-integrated. Once cointegration was confirmed, short-run and long-run tests were conducted.

The optimal lag length of the ARDL model was selected using the Akaike Information Criterion (AIC). After estimating both long-run and short-run models, diagnostic tests were performed to check the fitness of the model, including tests for serial correlation and heteroskedasticity. Finally, the CUSUM and CUSUM of Squares tests were applied to assess the stability of the model.

4.3.1 STATIONARY TEST

The first stage of the analysis aimed to determine the stationarity of the time series variables. This test examined the characteristics of each variable over time. Stationarity referred to a condition where the distribution of a time series variable did not change over time (Dawn, 2017). When a series was stationary, it implied that the future statistical behaviour of the data was similar to the past. The objective of these stationarity tests was to determine the order of integration of the variables and identify how many times each variable had to be differenced to achieve stationarity (Brooks, 2018). This step was crucial in preventing the risk of misleading regression results.

A stationary stochastic process was one with a constant mean and variance over time, and with covariance depending only on the lag, not the actual time period. A non-stationary time series, in contrast, exhibited a fluctuating mean or variance, or both (Gujarati, 2017). The assumptions of the classical regression model required both dependent and independent variables to be stationary, and the errors to have a zero mean and finite variance. Using non-stationary variables could lead to spurious regressions, which presented artificially high $\mathbf{R^2}$ values and misleading statistical significance (Verbeek, 2000:281; Granger & Newbold, 1974; Enders, 1995:215).

A series was considered integrated and denoted as I(d), where **"d"** represented the order of integration. This indicated how many unit roots a series had, or how many differences were needed to make it stationary (Takaendesa, 2004). As Phillips (1986) noted, non-stationary variables caused OLS estimators to lose consistency, and typical test statistics became invalid. Enders (1995) described several cases of spurious regression, including situations where regressions involving variables integrated at different or same orders yielded unreliable results unless their residuals were stationary, indicating cointegration.

4.3.1.1 UNIT ROOT TESTS

Unit root tests could be performed through informal and formal methods. Informal methods involved visual inspection using graphs and correlograms, while formal methods relied on statistical tests such as the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. This study used both informal and formal tests to determine stationarity.

The informal tests included plotting the time series and visually examining trends in the mean, variance, autocorrelation, and seasonality. Although these methods provided preliminary insight, formal tests were used to statistically confirm the presence or absence of unit roots (Gujarati, 2004). Because of their precision and wide acceptance in econometric research, formal tests were preferred in this study.

The unit root testing process used the ADF and PP tests, following recommendations from Brooks (2008), who stated that trending data needed to be regressed on deterministic functions of time to assess stationarity. Testing began with identifying the order of integration for each variable to validate the suitability of the chosen econometric model. Nason (2006) warned that ignoring non-stationarity in time series could result in spurious regression outcomes. Therefore, testing for stationarity was a necessary precondition.

4.3.1.2 AUGMENTED DICKEY FULLER UNIT ROOT TEST

The Dickey-Fuller test was designed to address the potential non-stationarity of time series data (Asteriou & Hall, 2011). Stationarity meant that the mean, variance, and autocovariance of the data remained constant over time. Gujarati (2004) defined a purely random series as one with a zero mean, constant variance, and no autocorrelation.

Brooks (2008) explained that non-stationary time series could only be analysed meaningfully within the observed period. Due to the low power of the basic Dickey-Fuller test in distinguishing between a unit root and a near-unit root process, the Augmented Dickey-Fuller (ADF) test was developed by including lagged dependent variables (Fomby, 2006). The ADF test also had limitations, including a tendency to reject true null hypotheses. In this study, the null hypothesis stated that the time series followed a random walk (i.e., non-stationary), while the alternative suggested the series was stationary.

The Schwartz Bayesian Information Criterion (SBIC) and Akaike Information Criterion (AIC) were used to select the optimal number of lags. The process continued until the last lag was statistically insignificant. The t-test was used to decide whether to include a time trend in the regression model or to difference the data. For series with exponential trends, the data were logged before differencing (Brooks, 2008). Accordingly, the ADF test in this study used the logged series. The ADF t-statistic helped determine whether a time series followed a random walk, with I(1) series requiring one differencing to achieve stationarity (Rosca, 2011).

4.3.1.3 PHILIPS- PERRON (PP) UNIT ROOT TEST

The Phillips-Perron (PP) test provided an alternative method to detect unit roots. Unlike the ADF test, the PP test was non-parametric and did not require a specific form of serial correlation under the null hypothesis (Shrestha & Bhatta, 2018). It also corrected for autocorrelation and heteroskedasticity in the error terms.

Gujarati (2008) noted that the PP test used non-parametric methods to address serial correlation without adding lagged difference terms. Although the PP and ADF tests shared the same null hypothesis and had similar asymptotic distributions, the PP test offered an advantage by automatically adjusting for autocorrelated residuals (Brooks, 2008).

However, both tests suffered from reduced power in small samples, making it difficult to detect stationarity, especially when the unit root was near one. To address this limitation, this study employed both ADF and PP tests for confirmation of stationarity, in line with Brooks (2008), who recommended using both for robust results.

4.3.2 COINTEGRATION AND ERROR CORRECTION MODEL TEST

Granger (1981) introduced the concept of cointegration, which was later extended by Engle and Granger (1987). Their work allowed for regression analysis involving I(1) variables to yield meaningful results, provided the residuals were stationary.

Sorensen (2008) emphasized that most unit root tests tested for the presence of unit roots (non-stationarity), while most cointegration tests evaluated the null hypothesis of no cointegration. Although cointegration tests used a similar distribution to the ADF test, they required their own critical values. The Engle-Granger approach determined whether residuals from a single equation regression were stationary.

According to Greene (2012), it was standard to assess dynamics in residuals through a version of the ADF test, also referred to as the Cointegration ADF (CADF) test. Cointegration indicated that although individual series were non-stationary, their linear combination was stationary, suggesting a long-term relationship. Mukherjee et al. (1998) warned that visually appealing regressions involving trending series could be misleading. Hence, the study confirmed that the residuals were stationary before drawing long-run conclusions. When cointegration was present, the error correction model (ECM) was applied to represent short-term dynamics and adjust for long-run equilibrium.

4.3.2.1 AUTOREGRESSIVE DISTRIBUTION LAG MODEL (ARDL)

The ARDL model was used to examine the relationship between explanatory variables and trade openness. As noted by Nkoro and Aham (2016), ARDL was suitable for testing long-run relationships when variables were integrated at different orders (I(0) and I(1)). It was particularly effective in small samples and when only a single cointegration relationship was present.

This study applied the ARDL model developed by Pesaran, Shin, and Smith (2001) using EViews 11. The model allowed current values of variables to depend on their past values. According to Brooks (2008), including lags helped to capture dynamic adjustments due to institutional or behavioural delays. The ARDL method focused on detecting long-term relationships, not just short-run effects (Moeketsi, 2017).

Haug(2002) noted that the ARDL approach was especially effective in small-sample contexts, and Schneider (2018) stressed its ability to model economic relationships in a single equation framework. The model was estimated using ordinary least squares (OLS).

ARDL Cointegration Procedure Followed in the study:

- **Step 1:** The study tested for long-run relationships using the Bounds F-test, following Pesaran et al. (2001). The null hypothesis of no cointegration was rejected if the calculated F-statistic exceeded the upper bound critical value. If the statistic fell below the lower bound, the null could not be rejected. Values within the bounds were inconclusive.
- **Step 2:** The optimal lag length was selected using AIC, SBC, and HQC, based on Burke (1993). The lag length ensured that model errors were well-behaved (i.e., not autocorrelated, heteroscedastic, or non-normally distributed).
- **Step 3:** The study estimated error correction terms to evaluate both short-run adjustments and long-run equilibrium. Diagnostic tests including tests for serial

correlation, heteroskedasticity, and normality were conducted, followed by CUSUM and CUSUM-squared tests to verify model stability.

4.4 DIAGNOSTIC TEST

The study performed different diagnostic test such as the White test, BG Serial Correlation LM Test and Jarque Bera statistics test to identify the stochastic properties of the model. Conducting diagnostics analysis on the residuals is important as one should assess the robustness of the model that has been specified. The robustness of the specified model is examined by testing for serial correlation, normality and heteroscedasticity.

4.4.1 SERIAL CORRELATION

Serial correlation occurs when past values of a variable influence its future values, creating repeating patterns over time. While serial correlation does not impact the consistency of the OLS estimator, it does reduce the efficiency of the estimates. Specifically, positive serial correlation causes the OLS estimates of standard errors to be underestimated, making the parameter estimates appear more precise than they are. This can lead to misleading conclusions about the significance of the estimates.

4.4.2 NORMALITY TEST

The Jarque-Berra test is used to test for the normality of the residuals to detect any misspecification in the model. Asteriou & Hall (2007) posit that if the JB statistic appears to be bigger than the critical value or the p-value appears to be below 0.05, corresponding to a 95 per cent significance level, the null hypothesis of normality is rejected. Most statistical procedures assume that the data follows a normal distribution, meaning the population from which the sample is drawn is normally distributed. This assumption is crucial for drawing accurate and reliable conclusions about the population. However, when the sample size is large (typically >30 or 40), violations of the normality assumption do not pose significant problems. In such cases, parametric methods can still be used even if the data is not perfectly normally distributed. The null hypothesis is as follow**:**

H_0: Residuals are normally distributed

The null hypothesis will be rejected if the probability value from the Jarque-Bera test is below 0.05.

4.4.3 HETEROSCEDASTICITY

Heteroskedasticity refers to the situation where the variances of the regression errors are not constant across different observations. This condition can occur in both cross-sectional and time-series data (Greene, 2012). In this study, we utilize the White heteroskedasticity test to identify this problem. Heteroskedasticity occurs when the error terms have unequal variances across observations, although they remain uncorrelated with each other.

According to Gujarati (2003), ignoring heteroskedasticity when conducting statistical tests can lead to misleading conclusions. While ordinary least squares (OLS) remain a consistent estimator of $\boldsymbol{\beta}$ even in the presence of heteroskedasticity, the OLS residuals will reflect, albeit imperfectly, the heteroskedastic nature of the disturbances. As a result, tests for heteroskedasticity are typically applied to the OLS residuals (Greene, 2012).

The White test for heteroskedasticity is beneficial because it does not depend on the assumption of normality and is straightforward to apply (Gujarati, 2003). This test evaluates the null hypothesis that heteroskedasticity is not present. If there is no heteroskedasticity, the statistic should not show significant results. The test examines whether there is any systematic relationship between the squared residuals and the explanatory variables.

Asteriou & Hall (2007) explain that there are two methods for detecting heteroskedasticity. The first is an informal approach that involves visually inspecting various graphs. This method is referred to as the visual or informal way. The second method involves applying specific tests designed to detect heteroskedasticity and providing a more formal and objective assessment. In the informal approach, as we have observed in the case of two variables, heteroskedasticity can be readily detected by visually examining the scatter plot. However, in multiple regression cases, this visual inspection becomes more challenging. Instead, valuable insights regarding the potential presence of heteroskedasticity can be gained by plotting the squared residuals against the dependent variable and/or the explanatory variables. These plots provide useful information for identifying heteroskedasticity in multiple regression analysis. There are several tests to identify heteroskedasticity, including the Breusch-Pagan LM test, the Glesjer LM test, the Harvey-Godfrey LM test, the Park LM test, and White’s test. In this study, we will use the Breusch-Pagan LM test.

This study employed White's (1980) general test for heteroscedasticity, which offers several advantages as it accounts for multiple assumptions. The test assumes linearity in the regression model, with the acceptance of the null hypothesis indicating no heteroscedasticity, while its rejection signals the presence of heteroscedasticity.

4.4.4 STABILITY TEST

The cumulative sum of recursive residuals derived on the first (n) observations is used in the CUSUM test, which is updated recursively and shown against the break point (Dawn,2017). The CUSUMSQ utilizes the same approach and employs squared recursive residuals. This indicates that although the structural failure point is uncertain, CUSUM tests can be used. The null hypothesis that all coefficients are stable cannot be rejected if the CUSUM and CUSUMQ plots stay within the 5% critical constraint. Furthermore, when one of the parallel lines crosses, then null hypothesis of parameter stability must always be rejected at a level of significance of 5% (Khadaroo,2010). The results indicate that both the CUSUM and CUSUMSQ plots are inside the 5% critical bound, indicating that the model's parameters are not structurally unstable for the period under consideration (Armah,2016).

4.5 CONCLUSION

The chapter provided the methodology employed by the study and the major emphasis of the chapter was to illustrate how the impact of transport infrastructure investment on trade openness was going to be estimated. The model is expected to perform all the F-bound test including the CUSUM test, heteroskedasticity and unit root analyses. The augmented Dickey-Fuller and Phillips-Perron test was adopted to test stationarity and for estimation purposes unit root test was used to see if the model is good enough. The Autoregressive Distributed Lag Model is important for analyzing the cointegration among the variables under consideration. However, the series must be stationary to obtain meaningful results from the regression model. Formal unit root tests are conducted to check if the model's variables are stationary.

CHAPTER FIVE

PRESENTATION AND INTERPRETATION OF EMPIRICAL RESULTS

5.1 INTRODUCTION

This chapter discusses and highlights the empirical analysis of the ARDL model discussed in chapter 4. The empirical results were generated from several tests which were very important to investigate the impact of transport infrastructure investment on trade openness in South Africa. The study used EViews 12 econometric package to conduct the empirical analysis. The chapter is divided into Seven subsections. Following the introduction is section 5.2 descriptive statistics, 5.3 covariance analysis. Section 5.4 shall discuss stationarity tests (graphical presentation of series at levels) 5.4.1 Informal stationarity at levels (graphical presentation of series at first difference) 5.4.1.1 informal stationarity at first difference) 5.4.2 Formal stationarity test (wherein you will conduct Phillip Perron Stationarity Test and Augmented Dickey Fuller Stationarity Test). Section 5.5 illustrates F-bound cointegration results (ARDL F-Bounds Test, Lag Selection Criteria, Lag Selection (AIC)). Section 5.6 analyses the findings and interprets the results (ARDL regression results, the long run results as well as ARDL-ECM short run results). Section 5.7 discusses reliability and validity of the ARDL technique through different diagnostic i.e. fitness check, serial correlation, heteroskedasticity and normality tests and stability tests conducted (Ramsey reset test, CUSUM and CUSUM of squares). The last section discusses the conclusion of the chapter.

5.2 DESCRIPTIVE STATISTICS

The summary of descriptive statistics in Table 5.1 presents the behavior of both the dependent and independent variables, including indicators such as the mean, standard deviation, maximum, and minimum values, kurtosis, and skewness of the data.

Table 5.1 Descriptive Statistics

	TRADE_OPENN	LTRAN_INFRAST	LGDP	REAL_EXCHANGE
Mean	50.22109	8.772718	15.05981	95.12849
Median	50.68684	8.796036	15.14938	92.42164

Maximum	65.97452	9.834780	15.34141	134.1044
Minimum	34.32135	7.978654	14.64273	70.67382
Std. Dev.	8.053937	0.386509	0.242150	18.36294
Skewness	-0.162795	0.166426	-0.365030	0.556881
Kurtosis	2.434753	3.626654	1.614679	2.289460
Jarque-Bera	0.549621	0.650336	3.167300	2.254387
Probability	0.759716	0.722406	0.205225	0.323941
Sum	1556.854	271.9543	466.8542	2948.983
Sum Sq. Dev.	1945.977	4.481686	1.759097	10115.93
Observations	31	31	31	31

Source: Authors own computation using Eviews12

Table 5.1 presents a summary of the descriptive statistics for the study. The dataset contains 31 observations. The results show that the variables exhibit relatively low dispersion, with the mean and median values closely aligned across the sample. However, the negative skewness of the trade openness variable (TRADE_OPENN), which is the key variable of interest, explains why the median (50.686) is higher than the mean (50.221). This indicates a high possibility of outliers in the sample. Additionally, the trade openness variable appears to represent a normal distribution, with a kurtosis value of 2.434. However, there are more values below the mean of trade openness in the sample. The standard deviation reveals some degree of dispersion across all the variables.

Furthermore, Table 5.1 reveals that transport infrastructure investment (LTRAN_INFRAST), another key variable of interest, has a relatively low standard deviation of 0.386, suggesting little variation, with a minimum value of 7.978 and a maximum value of 9.834. The standard deviations of the variables indicate low volatility, particularly for REAL_EXCHANGE, LTRAN_INFRAST, and LGDP, as they are all below their respective means.

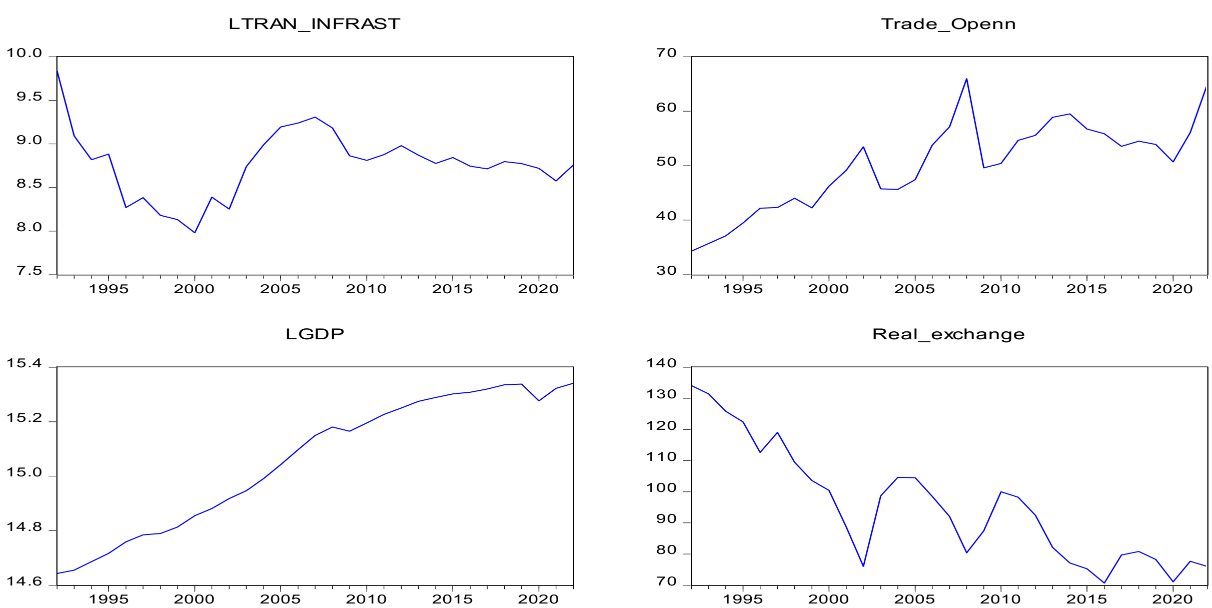
5.3 INFORMAL UNIT ROOT TESTS

5.3.1 GRAPHICAL DISPLAYS

The graphical analysis of the series is a commonly used informal method for testing stationarity. It is a visually representation of the series, which would be crucial stage in time series analysis before moving on to formal tests. This preliminary evaluation of the data is essential as it helps identify any issues with data collection or structural breaks, while also providing insight into the trends and stationarity of the dataset. The variables such as transport infrastructure investment (LTRAN_INFRAST) and gross domestic product (LGDP)was logged. Brooks (2008) states that when logarithms are being introduced into the model the exponential trend in the time series data is linearised.

Figure 5. 1: Graphical unit root tests (1992-2022)

5.1.1 Stationarity test: levels

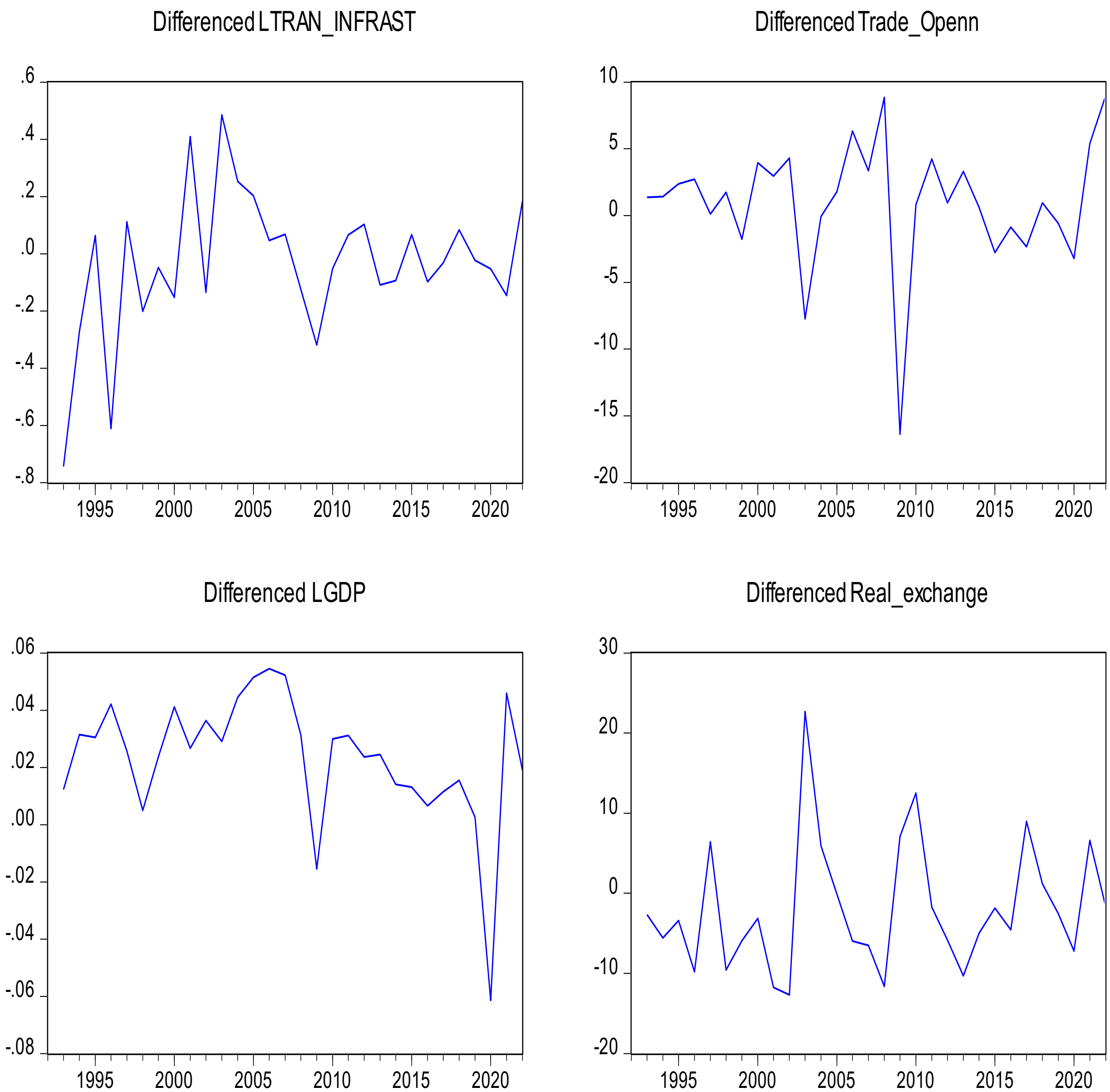


Source: Authors own computation using Eviews12

Based on the analysis above, we cannot definitively conclude whether the variables are stationary, particularly for those that do not exhibit a clear trend, like the real effective exchange rate in this research. Hence, further analysis is needed.

Figure 5.2: Graphical unit root tests (1992-2022)

Stationarity test: Differenced



Source: Authors own computation using Eviews12

The visual inspection of the graphical plots above shows that LGDP graph fluctuates partly away from the mean value that means that LGDP is likely not stationary. If the time series is nonstationary and a unit root is present, the null hypothesis cannot be rejected. However, if the t-statistic is smaller than the critical values, the time series data are considered stationary and do not contain a unit root, leading to the rejection of the null hypothesis. In contrast, as shown in the graphs above, all other variables deviate partially from the mean, indicating they are non-stationary. Granger and Newbold (1974) suggested that when both the dependent and independent variables exhibit unit roots, traditional estimation techniques based on the levels of these variables are likely to identify a statistically significant relationship, even if there is no meaningful economic link between them.

For a comprehensive analysis of policies, it is essential to differentiate between a correlation driven by a common trend and one that indicates a true causal relationship. To make this distinction, the study used two tests to examine the univariate time series behaviour of the data and determine the appropriate unit of observation. These tests are the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test.

5.4 UNIT ROOT ANALYSIS

In this study, the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests were adopted. The findings, revealed in the tables below, indicate that differencing the variables once is sufficient to achieve stationarity. These tests were conducted under various deterministic trend assumptions, including models with no constant and trend, as well as those with both trend and intercept. The results were "explosive" for both the no constant and no trend specifications, particularly under the ADF test.

Table 5.2 UNIT ROOT TESTS (LEVEL SERIES)

	"Augmented Dickey Fuller Test"			**"Phillips Perron"**		
Variable	**"Intercept and Trend**	**Intercept**	**None**	**"Intercept and Trend**	**Intercept**	**None**
Trade_Openn	-3.163	-2.225	0.888	-2.923	-1.425	3.239
LTrans_infrast	-2.898	-3.102**	0.079	-3.413*	-3.351**	-0.793
LGDP	-0.062	-2.012	5.541***	-0.063	-1.948	4.544***
Real_exchange	-3.454*	-2.031	-1.257	-2.347	-2.231	-3.347***

Source: Authors own computation using Eviews12

(*) (**) (***) statically significant at (10%) (5%) (1%) level

Table 5.3 UNIT ROOT TESTS (FIRST DIFFERENCE SERIES)

	"Augmented Dickey Fuller Test"			**"Phillips Perron"**		
Variable	**"Intercept and Trend**	**Intercept**	**None**	**"Intercept and Trend**	**Intercept**	**None**
Trade_Openn	-4.457***	-3.927***	-5.465***	-9.572***	-9.638***	-5.538***
LTrans_infrast	-3.425***	-3.489***	-2.556**	-5.653***	-5.762***	-6.087***
LGDP	-4.957***	-4.275***	-1.175	-4.949***	-4.292***	-2.384**
Real exchange	-4.524***	-1.957	-1.795*	-8.828***	-6.079***	-4.713***

Source: Authors own computation using Eviews12

(*) (**) (***) statically significant at (10%) (5%) (1%) level

Tables 5.2 and **5.3** display the results for the variables at both their levels and first differences. None of the series show second-order integration, which confirms the stationarity of the data. To avoid spurious regressions, all tests include both intercept and trend for the level and first difference series (applying Phillips-Perron tests and Augmented Dickey-Fuller). The Akaike Information Criterion (AIC), which serves as an estimator for prediction error and a model quality check, was used to determine the appropriate lag length for the unit root tests. When applying the PP and ADF tests, the failure to reject the null hypothesis of a unit root at the 1%, 5%, and 10% significance levels, along with the computed t-statistic being less than the critical value in absolute terms, suggests that the series is non-stationary. However, after differencing the series once, stationarity is achieved.

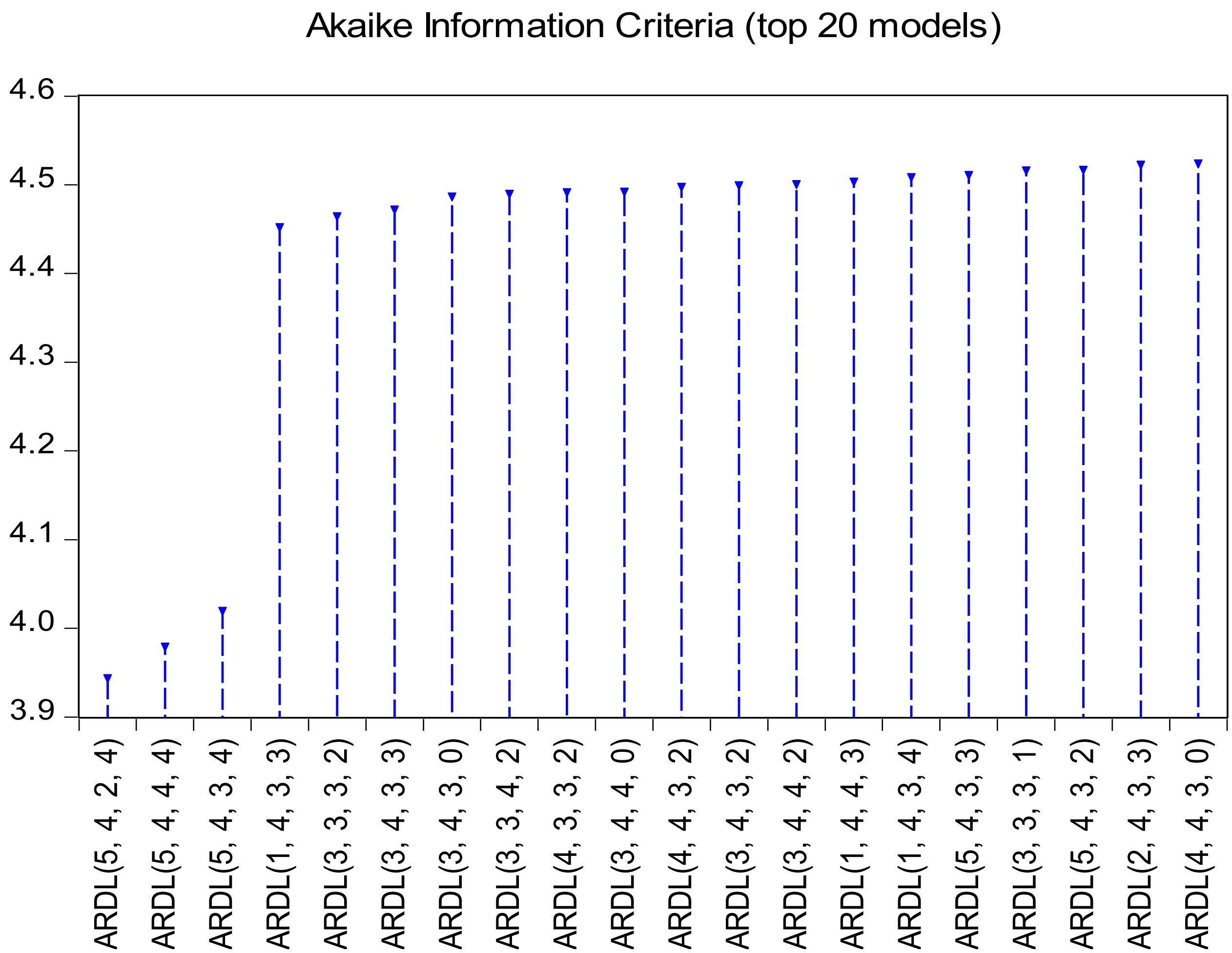
5.5 ARDL MODEL RESULTS AND ANALYSIS

5.5.1 Lag length selection criteria

Hall and Dimitrious (2001) argued that determining the correct lag length is crucial, as a model must produce standard normal error terms that are free from issues such as heteroskedasticity, autocorrelation and non-normality.

Choosing the correct lag length is essential when using the ARDL model to obtain reliable results. In this study, the lag order was determined by applying two information criteria: the Akaike Information Criterion (AIC) and the Schwartz Information Criterion (SIC). The ARDL model (5, 4, 2, 4) was selected, with AIC being the preferred model over SIC. After determining the appropriate lag length, the following step was to perform the F-bound test to check for the presence of cointegration. This lag length was chosen because it helps mitigate issues like heteroskedasticity, non-normality, and autocorrelation. The general rule is to select the criterion with the lowest value, which, in this case, was AIC, as a lower value indicates a better-fitting model. Based on this, we conclude that the optimal lag length for the model is 3.45, and the best criterion to use is AIC. According to Brooks (2008), the Akaike Information Criterion (AIC) is particularly favourable for larger sample sizes.

Figure 5. 3 Akaike information criterion (AIC)



Source: Authors own computation using Eviews12

5.5.2 Cointegration Results

The ARDL bound test is applied in this study to determine whether cointegration exists between the variables of interest (Trans_infrast, Real_exchange, GDP) and trade openness. According to Bellourmi (2014), the ARDL bound test can be used to series that have a mix of I(0) and I(1), where I(0) represents the lower critical values and I(1) represents the upper critical values. If the computed *F-statistic* exceeds the upper critical value, the null hypothesis of no cointegration is rejected. Conversely, if the test statistic falls below the lower bound, the null hypothesis is not rejected. As shown in Table 5.4, the calculated *F-statistic* value (11.328) exceeds both the I(0) and I(1) critical values and is significant at all levels (1%, 5%, and 10%). This suggests that cointegration exists between the variables and trade openness, confirming the results of Pradhan et al. (2013) for India and Samir et al. (2018) for MENA countries

Table 5.4: ARDL Bound Test

Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	11.32806	10%	2.37	3.2
K	3	5%	2.79	3.67
		2.5%	3.15	4.08
		1%	3.65	4.66

Source: Authors own computation using Eviews12

5.5.3 Short run, Long run and Strength Discussions and Analysis

Table 5.5: ARDL Error Correction Model results

ARDL Error Correction Regression				
Dependent Variable: D(TRADE_OPENN)				
Selected Model: ARDL (5, 4, 2, 4)				
Case 2: Restricted Constant and No Trend				
Sample: 1992 2022				
ECM Regression				
Case 2: Restricted Constant and No Trend				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
D(TRADE_OPENN(-1))	1.078915	0.178783	6.034769	0.0005

D(TRADE_OPENN(-2))	1.120925	0.200479	5.591229	0.0008
D(TRADE_OPENN(-3))	1.211451	0.211406	5.730454	0.0007
D(TRADE_OPENN(-4))	0.598244	0.116531	5.133798	0.0013
D(LTRAN_INFRAST)	8.716726	2.978712	2.926341	0.0221
D(LTRAN_INFRAST(-1))	-1.122405	1.897669	-0.591465	0.5728
D(LTRAN_INFRAST(-2))	-15.18017	3.690881	-4.112885	0.0045
D(LTRAN_INFRAST(-3))	-18.49632	3.492549	-5.295939	0.0011
D(LGDP)	175.1226	14.83098	11.80789	0.0000
D(LGDP(-1))	81.98030	21.68315	3.780830	0.0069
D(REAL_EXCHANGE)	-0.361736	0.051959	-6.961969	0.0002
D(REAL_EXCHANGE(-1))	0.156004	0.080712	1.932842	0.0945
D(REAL_EXCHANGE(-2))	0.053771	0.092296	0.582592	0.5784
D(REAL_EXCHANGE(-3))	0.496127	0.090898	5.458036	0.0009
CointEq(-1)*	- 0.661987	0.236749	-9.434309	0.0000
R-squared	0.972227	Mean dependent var		0.879288
Adjusted R-squared	0.936879	S.D. dependent var		5.123132
S.E. of regression	1.287128	Akaike info criterion		3.636348
Sum squared resid	18.22368	Schwarz criterion		4.362173
Log likelihood	-32.27253	Hannan-Quinn criter.		3.845360
Durbin-Watson stat	1.845983			

* p-value incompatible with t-Bounds distribution.

Source: Authors own computation using Eviews12

Table 5.5 reveals that the error correction coefficient, cointEq(-1), is negative (-0.661987) as expected, and it is statistically significant at the 1% level. According to the rule of thumb, the error correction term should be negative and statistically significant, in line with economic theory. This shows the presence of short-run effects through the adjustment process. Specifically, it suggests that more than 60% of the previous disequilibrium is corrected in the current period, helping the system move towards long-run equilibrium.

TABLE 5.6 ARDL LONG RUN MODEL

Levels Equation				
Case 2: Restricted Constant and No Trend				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
LTRAN_INFRAST	4.460560	1.796259	2.483250	0.0420
LGDP	17.90899	5.459972	3.280051	0.0135
REAL_EXCHANGE	-0.221440	0.082643	-2.679491	0.0316
C	-240.7951	78.20796	-3.078908	0.0178
EC = TRADE_OPENN - (4.4606*LTRAN_INFRAST + 17.9090*LGDP -0.2214				
*REAL_EXCHANGE -240.7951)				

Source: Authors own computation using Eviews12

According to Table 5.6 in South Africa, transport infrastructure investment (LTran_infrast) has a positive impact on trade openness in the long run. Specifically, a 1% increase in transport infrastructure investment is linked with a 4.460560 increase in trade openness, and this effect is statistically significant at the 5% level (0.0420). These findings align with those of Selamola (2018), which show that investment in railways and ports significantly influences trade openness in South Africa in the long term. This supports the theoretical framework, as a positive relationship was anticipated.

These results address the main objective of the study, clearly indicating that improvements in transport infrastructure are essential to boosting trade openness. In 2017/18, the South African government was the largest investor in transport infrastructure, spending nearly R93 billion, which contributed to the positive outcomes observed (Gala, 2019). The 2010 FIFA World Cup served as a significant catalyst for investment in transport infrastructure and public transport services. As a result, South Africa is currently experiencing one of the most substantial infrastructure development and spending programs since the early 1980s (Bussière et al., 2015).

The long-run relationship between trade openness and gross domestic product (LGDP) reveals a positive correlation, suggesting that an increase in LGDP would lead to a 17.90899 rise in trade openness, with the result being significant at the 5% level (0.0135). This supports the findings of Al-Sharif and Bino Rietveld (2019), who demonstrated that LGDP influences trade openness in South Africa. Although South Africa's GDP declined by approximately 5% by the end of 2020 due to the impact of COVID-19, this has had only a minimal effect on the observed results (Stats SA, 2020).

The ARDL results further indicate a significant negative long-run relationship between the real effective exchange rate and trade openness in South Africa, suggesting that an increase in the real effective exchange rate leads to a decrease of -0.22140 in trade openness. This aligns with the expected outcome, as a negative sign was anticipated for the coefficient of the real exchange rate. The adoption of an inflation-targeting monetary policy framework in 2001, which introduced a freely floating exchange rate determined by market forces, has had a negative impact on trade openness in South Africa (Saayman, 2020).

After obtaining the co-integration results, diagnostic tests are conducted on the models to ensure their validity and confirm that the co-integration results are not misleading. Testing the model for robustness involves ensuring that it is free from issues like correlation and heteroscedasticity (Pesaran et al., 1999; 2001). To verify that the ECM satisfies all econometric assumptions, the following diagnostic tests were performed: the Heteroscedasticity Test, Ramsey RESET, Breusch-Godfrey Serial Correlation LM Test and Jarque-Bera Test.

Table 5.7: Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.295298	Prob. F(18,7)	0.9826
Obs*R-squared	11.22171	Prob. Chi-Square(18)	0.8847
Scaled explained SS	0.987357	Prob. Chi-Square(18)	1.0000

Source: Authors own computation using Eviews12

The results in **Table 5.7** show that the model from heteroscedasticity is free, as the null hypothesis of homoscedasticity was not rejected. This is confirmed by the R-squared probability value of 0.8847, which is greater than the 5% significance level.

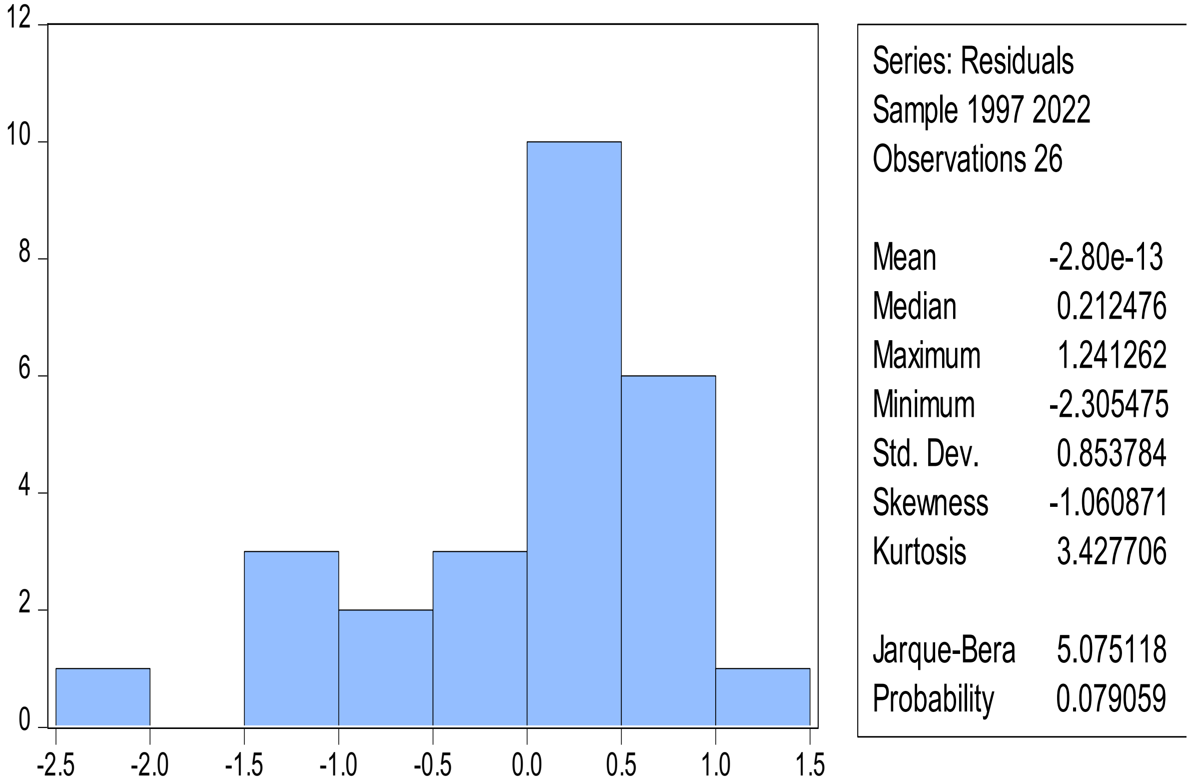
Table 5.8: Breusch-Godfrey Serial Correlation LM Test

F-statistic	0.083220	Prob. F(1,6)	0.7827
Obs*R-squared	0.355685	Prob. Chi-Square(1)	0.0609

Source: Authors own computation using Eviews12

Table 5.8 indicates from serial correlation the model is free, as the null hypothesis of no serial correlation was not rejected. This is evidenced by the R-squared probability value of 6.09%, which is higher than the 5% significance level.

Figure 5.4: Normality test



Source: Authors own computation using Eviews12

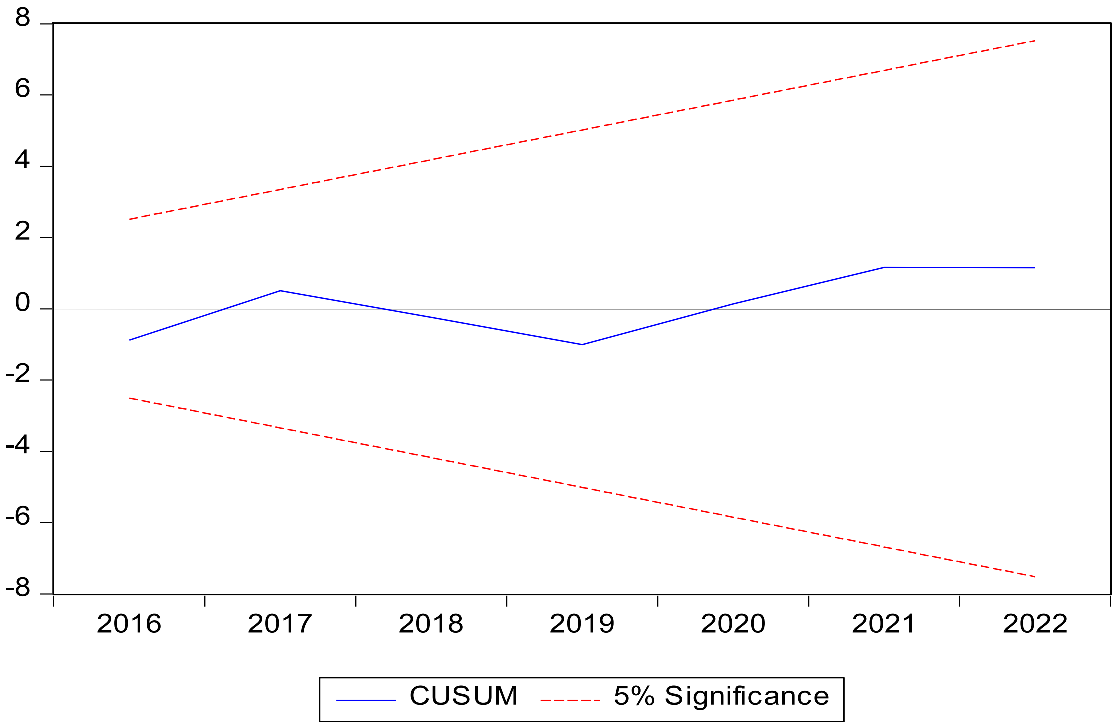
Figure 5.4 indicates that the Jarque-Bera test statistic is 5.0751, with a probability value of 0.0790, which is greater than the 0.05 significance level. As a result, in favour of the alternative hypothesis the null hypothesis of no normality is rejected, suggesting that the residuals are normally distributed. The findings illustrated on the table above shows that the model has a normal distribution, no autocorrelation in the mode and the model can be relied on because it cannot suffer from misspecifications.

CUSUM FOR STABILITY TEST

Pesaran (1997) recommends conducting the stability test for parameters using the cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMSQ) plots after estimating the model. This test helps eliminate any potential bias in the estimated model caused by excessive parameters. Moreover, in time series data, the stability test is crucial, especially when the researcher is uncertain about when structural changes may occur.

The results for testing structural stability, the values must fall inside the critical bounds at the 5% significance level, indicating parameter stability by using the cumulative sum of recursive residuals (CUSUM). The result in figure 5.5 shows that the model is normally distributed, there is homoscedastic, and it cannot suffer from misspecification also there is autocorrelation.

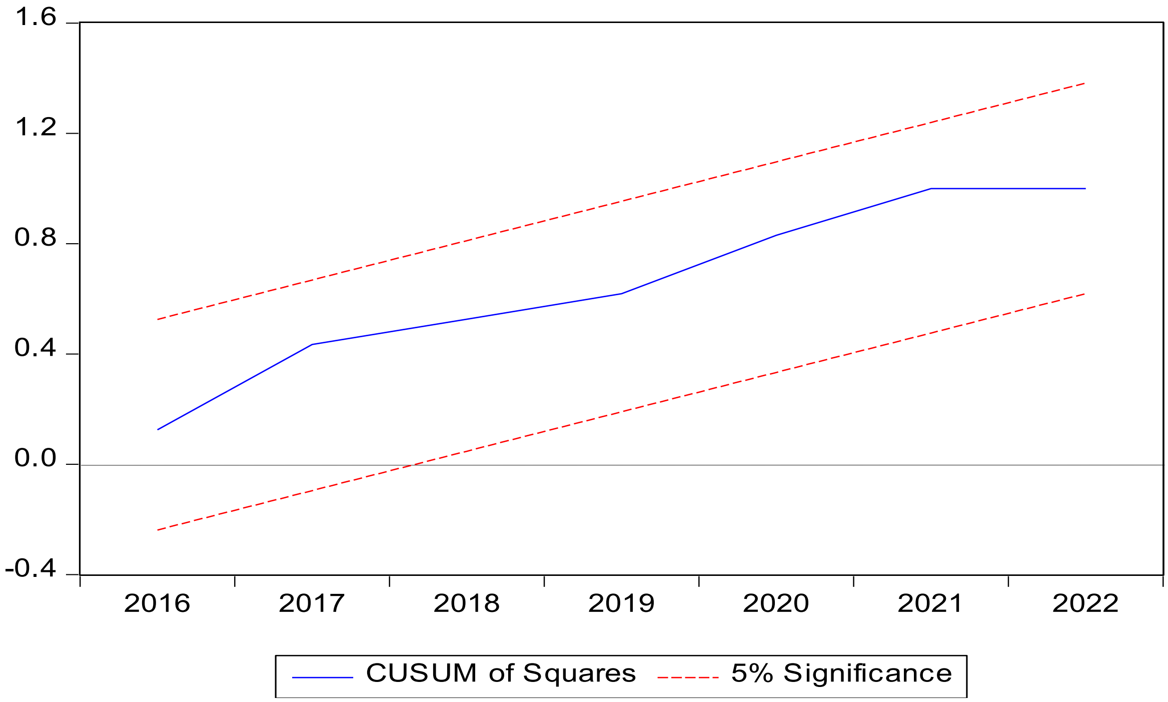
Figure 5.5 Cusum Stability test



Source: Authors own computation using Eviews12

CUSUM SQUARES TEST

Figure 5.6 Cusum Squares test



Source: Authors own computation using Eviews12

It is crucial that the errors in this model are serially independent; otherwise, the parameter estimates may not be consistent, due to the inclusion of lagged values of the dependent variable as regressors. According to Bahmani-Oskooee and Nasir (2004), if the plot stays within the critical bounds at a 5% significance level, the null hypothesis is accepted, indicating that the coefficients are stable. The model is considered stable if the plots do not exceed the critical value. From Figures 5.5 and 5.6, it can be observed that both the CUSUM of squares and CUSUM fall within the lower and upper bounds at the 5% significance level. This indicates that the residual variance is stable, confirming the stability of the model.

Table 5.9 Q-STATISTIC

Sample: 1992 2022						
Q-statistic probabilities adjusted for 5 dynamic regressors						
Autocorrelation	**Partial Correlation**		**AC**	**PAC**	**Q-Stat**	**Prob***
. |* . |	. |* . |	1	0.076	0.076	0.1701	0.680
***| . |	***| . |	2	-0.355	-0.363	3.9912	0.136
. |* . |	. |* . |	3	0.092	0.181	4.2583	0.235
. *| . |	.**| . |	4	-0.069	-0.280	4.4162	0.353
.**| . |	. *| . |	5	-0.286	-0.159	7.2424	0.203
. *| . |	.**| . |	6	-0.124	-0.258	7.7993	0.253
. | . |	. *| . |	7	-0.012	-0.167	7.8051	0.350
. | . |	. *| . |	8	0.002	-0.149	7.8052	0.453
. |**. |	. |* . |	9	0.216	0.130	9.8010	0.367
. |* . |	. | . |	10	0.142	-0.055	10.724	0.379
. *| . |	. *| . |	11	-0.172	-0.186	12.155	0.352
. |* . |	. |* . |	12	0.124	0.144	12.952	0.373

*Probabilities may not be valid for this equation specification.

Source: Authors own computation using Eviews12

The Q-statistic above was also examined to see if the faults of this model are serially independent. While the p-values are approximate, they provide strong evidence suggesting that there is no autocorrelation present in the model's residuals. This is a positive result.

5.6 CONCLUSION

The analysis in this chapter concludes in South Africa there is a strong positive relationship between trade openness and transport infrastructure investment, both in the long run and the short run. The findings are aligned with the research objectives, and the estimated coefficients of the significant variables meet the expected signs. The model demonstrates a good fit, as indicated by the Adjusted R-squared value. Diagnostic and stability tests confirm the reliability and validity of the ARDL model. The following section provides the conclusion and policy recommendations based on the study's findings.

CHAPTER SIX

SUMMARY, CONCLUSIONS AND POLICY RECOMMENDATIONS BASED ON THE FINDINGS

6.1. INTRODUCTION

This chapter presents a structured summary of the study's findings in relation to its three key objectives and hypotheses. It also provides clear conclusions based on empirical evidence, policy recommendations, study limitations, and suggestions for future research.

6.2. SUMMARY AND CONCLUSIONS OF THE STUDY

The main objective of this study was to investigate the impact of transport infrastructure investment on trade openness in South Africa between 1992 and 2022. The analysis was guided by three specific objectives:

Objective 1: To examine trends and provide an overview of transport infrastructure investment and trade openness in South Africa.

This objective was addressed through time-series trend analysis and descriptive statistics. The results showed that transport infrastructure investment has grown gradually but unevenly since 1992, with a notable slowdown after 2010, largely due to public budget constraints and inefficiencies (OECD, 2020; World Bank, 2021). Simultaneously, trade openness in South Africa has shown fluctuations, particularly during global economic shocks such as the 2008 financial crisis and the COVID-19 pandemic (SARB, 2022).

Objective 2: To econometrically examine the influence of transport infrastructure on trade openness in South Africa.

This was accomplished using the ARDL Bounds Testing approach to estimate both long-run and short-run relationships. The study found that transport infrastructure investment has a statistically significant and positive impact on trade openness. Specifically, a 1% increase in investment leads to an approximate 4.5% increase in trade openness over the long run. The short-run dynamics, measured using an Error Correction Model, showed a 66% speed of adjustment toward long-run equilibrium, suggesting a strong correcting mechanism within the system.

These findings are consistent with previous studies such as Rehman (2020) and Wondemu & Potts (2016), which found a positive correlation between infrastructure development and trade openness in emerging economies. However, in contrast to some studies reporting no significant relationship (e.g., Ali & Cantore, 2019), this study confirms a robust link in the South African context.

Hypothesis Testing:

H_0: Transport infrastructure investment does not impact trade openness.

H_1: Transport infrastructure investment has a significant impact on trade openness.

Based on the ARDL results, the null hypothesis (***H_0***) is rejected, and the alternative hypothesis (***H_1***) is accepted.

Objective 3: To make policy recommendations and conclusions based on empirical results.

The results support the need for evidence-based policies aimed at improving the quality and reach of transport infrastructure in South Africa. Based on this, the study proposes several policy interventions (detailed in Section 6.3 below) that can enhance trade openness and economic growth through infrastructure investment.

6.3 POLICY RECOMMENDATIONS

Based on the empirical findings and literature (e.g., UNCTAD, 2021; AfDB, 2022), the following policy recommendations are proposed:

1. Increase Public Investment in Transport Infrastructure

The government should expand its budget allocation to transport infrastructure particularly rail, road, and port systems as these are key enablers of trade. Investment in national roads used by logistics firms will reduce transport costs and delays, enhancing trade competitiveness (Department of Transport, 2021).

2 .Improve Infrastructure in Rural and Underdeveloped Areas

The empirical results indicate that overall investment boosts trade openness, but a focus on rural connectivity is necessary. Extending paved roads and logistics support to rural areas will integrate them into broader trade networks and improve access to markets (World Bank, 2020).

3. Promote Infrastructure Governance and Budget Transparency

Implementing a national transport infrastructure monitoring system can reduce corruption and misallocation of funds. Transparent reporting of public infrastructure budgets and project progress can ensure that investment translates into actual improvements (Transparency International, 2022).

4. Enhance Rail and Port Infrastructure to Reduce Logistical Constraints

South Africa's port and rail systems face bottlenecks that hinder trade efficiency. Targeted investment in these area such as expanding rail corridors and modernizing port facilities will reduce trade friction and improve international competitiveness (AfDB, 2022).

5. Align Infrastructure Policy with Industrial and Trade Policy

Policies on infrastructure development should be coordinated with trade promotion and industrial development strategies. For example, aligning with the goals of the African Continental Free Trade Area (AfCFTA) could enhance regional integration (UNCTAD, 2021).

6. Address Power Supply Challenges

Although not a core variable in this study, findings and economic context suggest that energy constraints (e.g., ESKOM challenges) indirectly affect trade by undermining logistics, manufacturing, and small business operations. Accelerated energy sector reform is needed to support infrastructure and trade development.

6.4. CONSTRAINTS OF THE STUDY AND AVENUES FOR FUTURE RESEARCH

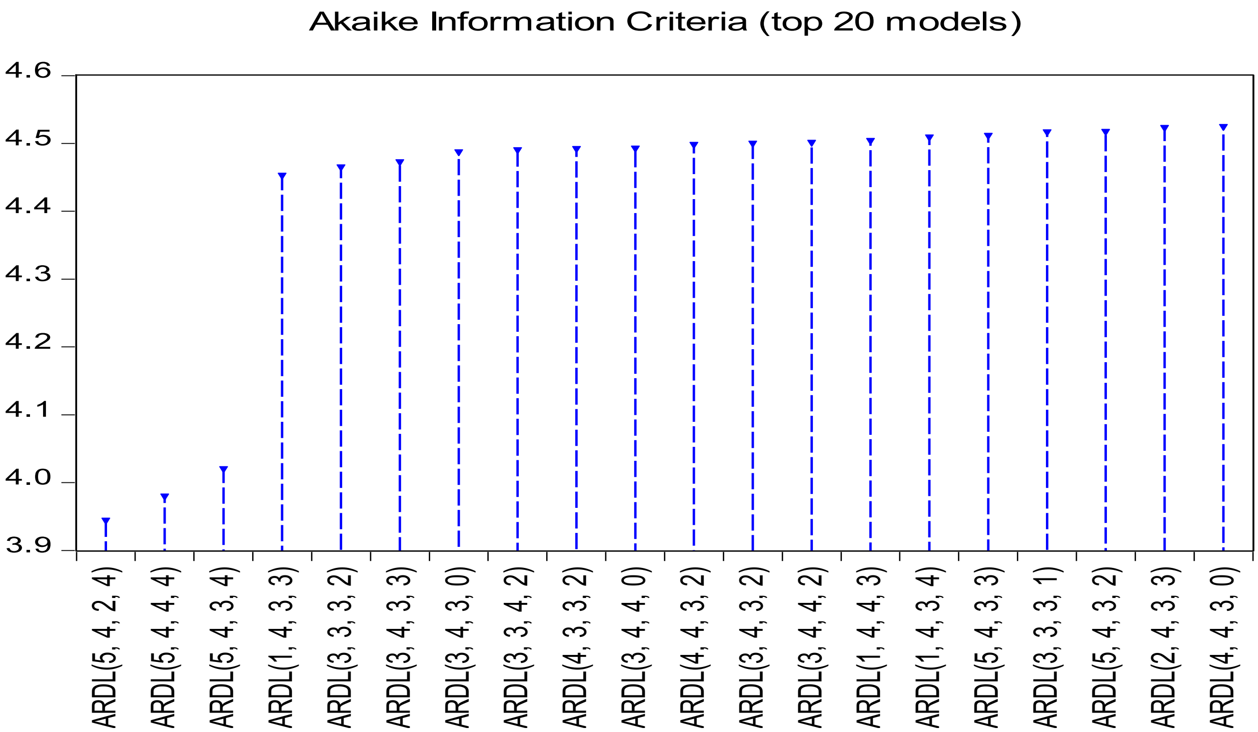
The study focused solely on the selected macroeconomic variables that determine the impact of transport infrastructure investment on trade openness in South Africa, within the scope of the models used. It considered data only from the period 1992-2022. The study is limited to the South African economy, meaning that the results may not be directly applicable to other economies. However, the study remains valuable, as the conclusions drawn could be insightful for the South African context. Regarding further areas for research, there are various ways in which trade openness can be examined in South Africa. This study used the annual time series data to investigate the impact between transport infrastructure investment on trade openness and the other controlling variables. Monthly data can be used for future studies in investigating the impact of investment on transport infrastructure in South Africa as this will increase the sample size and allow for greater degrees of freedom. Furthermore, to expand the analysis, additional variables can be added to the model or can be substituted for those examined in this study. Finally, different econometric techniques can be applied to examine the impact between trade openness and transport infrastructure investment as well as the other variables.

6.4 CONCLUSION

This study has empirically confirmed that transport infrastructure investment significantly influences trade openness in South Africa. The results strongly suggest that continued and targeted infrastructure investment is essential for enhancing South Africa’s participation in global trade. The study contributes to policy, theory, and practice, offering both immediate recommendations and longer-term research directions.

APPENDICES

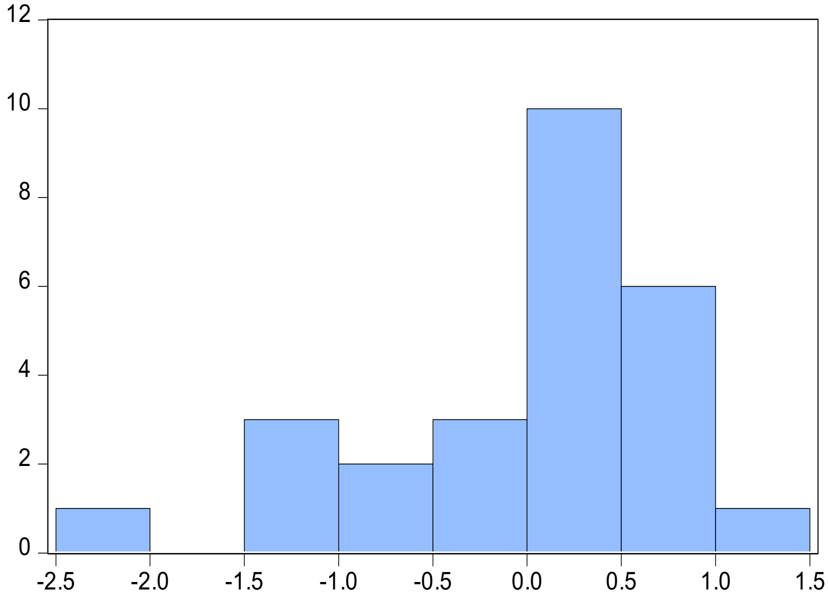
APPENDIX 1



APPENDIX 2

Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	11.32806	10%	2.37	3.2
K	3	5%	2.79	3.67
		2.5%	3.15	4.08
		1%	3.65	4.66

APPENDIX 3



Series: Residuals
Sample 1997 2022
Observations 26

Mean	-2.80e-13
Median	0.212476
Maximum	1.241262
Minimum	-2.305475
Std. Dev.	0.853784
Skewness	-1.060871
Kurtosis	3.427706
Jarque-Bera	5.075118
Probability	0.079059

APPENDIX 4

Levels Equation				
Case 2: Restricted Constant and No Trend				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
LTRAN_INFRAST	4.460560	1.796259	2.483250	0.0420
LGDP	17.90899	5.459972	3.280051	0.0135
REAL_EXCHANGE	-0.221440	0.082643	-2.679491	0.0316
C	-240.7951	78.20796	-3.078908	0.0178
EC = TRADE_OPENN - (4.4606*LTRAN_INFRAST + 17.9090*LGDP -0.2214				
*REAL_EXCHANGE -240.7951)				

APPENDIX 5

	TRADE_OPEN N	LTRAN_INFRAST	LGDP	REAL_EXCHAN GE
Mean	50.22109	8.772718	15.05981	95.12849
Median	50.68684	8.796036	15.14938	92.42164
Maximum	65.97452	9.834780	15.34141	134.1044
Minimum	34.32135	7.978654	14.64273	70.67382
Std. Dev.	8.053937	0.386509	0.242150	18.36294
Skewness	-0.162795	0.166426	-0.365030	0.556881
Kurtosis	2.434753	3.626654	1.614679	2.289460
Jarque-Bera	0.549621	0.650336	3.167300	2.254387
Probability	0.759716	0.722406	0.205225	0.323941
Sum	1556.854	271.9543	466.8542	2948.983
Sum Sq. Dev.	1945.977	4.481686	1.759097	10115.93
Observations	31	31	31	31

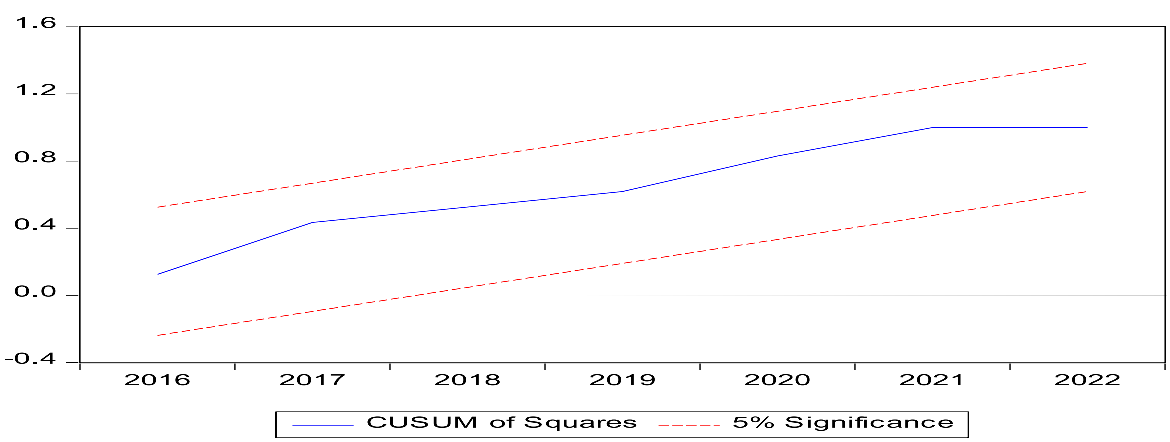
APPENDIX 6

F-statistic	0.295298	Prob. F(18,7)	0.9826
Obs*R-squared	11.22171	Prob. Chi-Square(18)	0.8847
Scaled explained SS	0.987357	Prob. Chi-Square(18)	1.0000

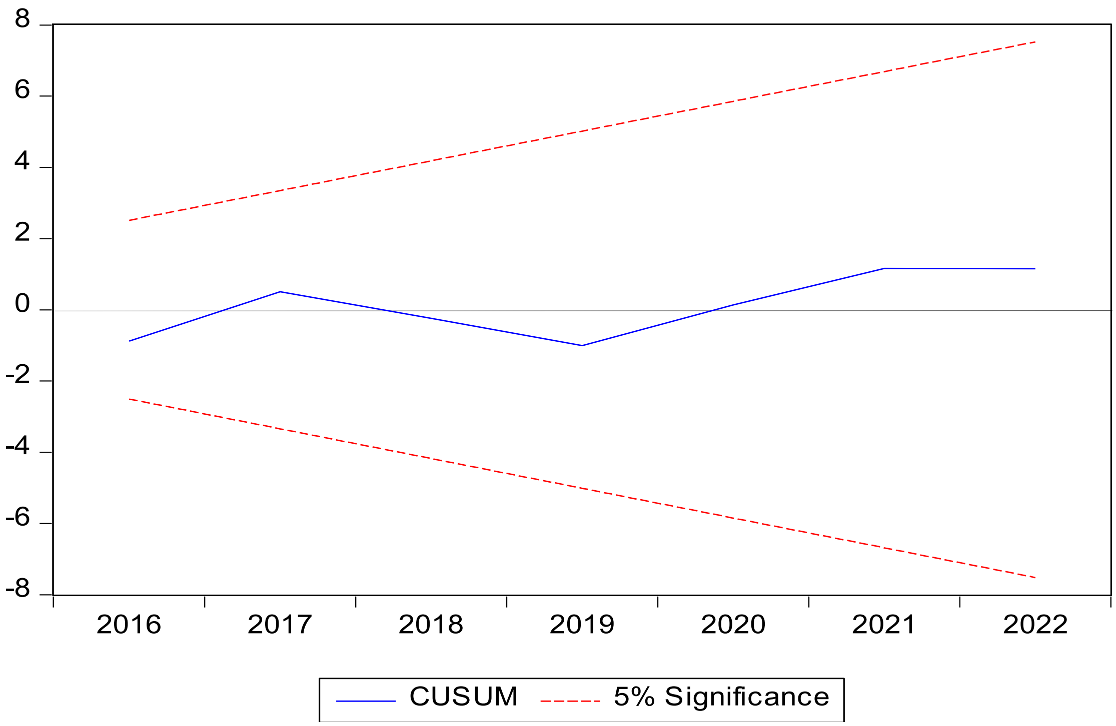
APPENDIX 7

Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	11.32806	10%	2.37	3.2
K	3	5%	2.79	3.67
		2.5%	3.15	4.08
		1%	3.65	4.66

APPENDIX 7



APPENDIX 8


8
6
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2
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-2
-4
-6
-8
2016
2017
2018
2019
2020
2021
2022
CUSUM
5% Significance

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