The Impact of Transport Infrastructural Development on economic growth in South Africa

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By

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PLAGIARISM DECLARATION

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ABSTRACT

This study examines the impact of transport infrastructure on the economic growth of South Africa from the period 1970 to 2015. The researcher adopted a conceptual and theoretical framework related to infrastructure development and economic growth. The Johansen multivariate Co-integration and Granger causality test were adopted, consisting of stationary and directional causality of variables. The findings disclosed a strong unidirectional causality relationship in the long run between economic growth and gross domestic fixed capital formation, which runs from the former to the latter. The results also indicated a causal relationship between economic growth and transport infrastructure in both railway and ports transport. Moreover, there exist links between economic growth and railway transport, which run from the former to the latter. The findings further showed that the correlation between economic growth and ports transport runs from the former to the latter.

On the contrary, the findings revealed a non-existence of causal relationship between economic growth and transport infrastructure (roadways and airways), though the theoretical framework demonstrates a link between them. The findings also revealed a non-existence of a causality association between economic growth and transport infrastructure performance. The overall findings demonstrated the existence of a unidirectional causality relationship between economic growth and gross domestic fixed capital formation, and between economic growth and transport infrastructure (both railways and ports transport). Economic growth expands commercial and industrial sectors and as such, there is a need to suggest that transport infrastructure development policies align with it to maintain sustainable economic growth in South Africa.

ACRONYMS AND ABBREVIATIONS

ASGI-SA:	Accelerated and Shared Growth Initiative South Africa
CSSR:	Centre for Social Science Research
EG:	Economic growth
GDPGSA:	Gross domestic product growth South Africa
GDFCF:	Gross domestic fixed capital formation
MTEF:	Medium Term Expenditure Framework
NDP:	National development plan
SA:	South Africa
PFTISA:	Performance of transport infrastructure
TI:	Transport infrastructure
TINSA:	Transport infrastructure South Africa
Tr1:	Transport railway
Tr2:	Transport roadways
Ta3:	Transport airways
Tp4:	Transport ports

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CHAPTER ONE

INTRODUCTION

1.1 Background

A high-quality transportation network is vital for a top-performing economy and a pre-requisite for future growth. A well-performing transportation network allows businesses to manage inventories, transport them cheaply, access a variety of suppliers and markets for their products, and get employees reliably to work, as well as benefit a country's citizens by affording them better access to work (National Economic Council, 2014, p. 4). Governments around the globe rank framework arrangement related to infrastructure policy among their most prominent concerns. The modernisation of infrastructure is seen as being critical to future economic competitiveness and crucial to accommodating expanding populations in urbanising environments (Development Bank of Southern Africa [DBSA], 2012). South Africa (SA) is no exception: it has identified inadequate infrastructure as one of the six most important constraints to growth (Marie & Davies, 2008). In fact, National Treasury (Treasury) has allocated R813 billion to infrastructure spending, with transport and logistics allocated the bulk of that budget, at R339 billion over the next three years, which accounts for 42% of total spending on infrastructure (National Treasury, 2013). This paper seeks to investigate whether investment in transport infrastructure can assist the country in creating more jobs and thus stimulate growth, in turn improving the quality of life of its citizens, as well as to determine whether there is a relationship between transport infrastructure development and economic growth.

There are many macroeconomic studies that have linked investments in infrastructure to economic growth during the last decade. For instance, Fedderke and Garlick (2008) concluded that both theoretical and empirical evidence points to the existence of a robust positive relationship between infrastructure and economic growth. This finding is in line with that of Kumo (2012), who concluded that investment in economic infrastructure spurs economic growth. Kumo (2012) also said that it is expected to generate employment directly through the actual construction, operation and maintenance requirements. Kumo (2012) further argued that economic theory identifies five channels through which infrastructure can positively impact on economic growth: (i) as a direct input into the production process and hence as a factor of production; (ii) by complementing other inputs into the production process, in the sense of lowering or raising cost of production; (iii) a stimulating factor through providing facilities for human capital development; (iv) boosting aggregate demand through increased expenditure during construction and maintenance operations; and (v) serving as a tool to guide industrial policy.

An empirical study by Démurger (2001) provides evidence on the links between infrastructure investment and economic growth in China. Key to the findings was the role of transportation facilities in determining differentiating factors in explaining growth gaps. Démurger (2001) noted that telecommunications infrastructure has reduced gaps between isolations into linkages and connections. This implies that it reduces travel time for passenger and freight transport and consequently reduces cost, time and spending. Esfahani and Ramírez (2003) confirmed the positive impact that infrastructure development has on the gross domestic product (GDP) of a country and argued that the benefits of infrastructure development surpass the cost of services and the impact thereof on GDP.

Regarding the relationship between transportation infrastructure and economic growth, a study conducted by Pradhan and Bagchi (2013), which focused on the causal relationship between transportation infrastructure (road and rail), economic growth, and gross capital formation in India from 1970 to 2010, resulted in bidirectional causality. The researchers identified that bidirectional causality exists between road transport infrastructure and economic growth, as well as gross domestic capital formation, while a unidirectional causality exists from railway infrastructure to both economic growth and gross domestic capital formation. Transport infrastructure has imparted more in the economic growth of developed countries than developing countries, which explains the level of investment developed countries are willing to undertake to enhance their infrastructural development (Dinh & Dinh, 2016). The common factor among these studies is that they point to economic growth as a consequence of an accumulation of factors encouraging an environment to take off and seize the opportunities to increase the income of a country. Conversely, certain studies hold that infrastructure development has little impact on economic growth. This, based on government's approach to infrastructure development is questionable since the delays, capacities and capabilities often pose problems to the economy (Achour & Belloumi, 2016; Badalyan, Herzfeld, & Rajcaniova, 2014).

The Accelerated and Shared Growth Initiative South Africa (ASGI-SA), launched in 2006, has identified inadequate infrastructure as one of the six most important constraints to economic growth in South Africa. The aim of ASGI-SA is to initiate programmes to reduce poverty and unemployment, in addition to its mandate to improve economic growth (Kumo, 2012). Economic infrastructure investments have been put in place by public and private stakeholders in SA to achieve this. Indeed, Treasury has allocated R813 billion to infrastructure spending in SA, with transport and logistics prevailing, accounting for 42% of total spend on infrastructure three years in a row (National Treasury, 2016). Identification of economic growth remains central to the SA policy debate; however, the growth rate remains in limbo since the launch of ASGI-SA.

Plentiful reported contributions exist (Perkins, Fedderke, & Luiz, 2005) regarding the changing structure of economic growth in SA and the urgency to address a number of determinants that influence the economic growth of the country, including transport infrastructure. These contributions address transport infrastructure not as a complement factor into production processes, but as a complement of human needs and economic development. However, few studies have addressed the relationship between transport infrastructure and economic growth on long-term development (Agbigbe, 2016; Kumo, 2012; Zahra, 2016). Moreover, few have explored the linkages between transport infrastructure as a complement factor into production processes and economic growth in SA from 1970 to date. This motivated the researcher to explore the correlation between transport infrastructure and GDP.

1.2 Problem statement

The provision of infrastructure confers a number of benefits to the economy. There is a correlation between transport infrastructure and economic growth. Many studies conducted by (Knoeri, Steinberger, & Roelich, 2016), and Perkins, (2011) have been conducted on the local and international level regarding infrastructure development and economic growth, most of which focused on the contribution of infrastructure development and related services to the economy and end users at large. They also focused on the characteristics of infrastructure and the valued services these render to economies across countries (Prud'homme, 2004a). Without any controversy, the availability or absence of the right infrastructure expenditure can affect the decisions which producers and consumers make about where to live or work, what to produce and whether to produce (Ngandu, Garcia, &

Arndt, 2010). Whereas infrastructure growth is a dynamic constituent in enhancing the growth of a country, a good infrastructure expands productivity of a country, as its openness and quality make it desirable and attractive to foreign investors (Zahra, 2016, p. 298).

Theoretical and empirical literature has confirmed a correlation between infrastructure investment and economic growth. The first body of literature analysed the relationship between infrastructure development and its impact on GDP. These works evaluated the linkage hypothesis by primarily using time series data and the Granger test. Their results confirmed an empirical evidence of existing linkages between infrastructure development and economic growth (Estache & Garsous, 2012; Prud'homme, 2004b; Tong, Yu, & Roberts, 2014; Trimbath, 2011). The second body of literature examined the linkages between energy consumption and economic growth over a period. The results showed bidirectional causality (Achour & Belloumi, 2016; Estache & Garsous, 2012; Omri & Kahouli, 2014). Similarly, the third body confirmed the relationship between energy consumption and economic growth over a period, and the substantive findings maintained bidirectional causality (Achour & Belloumi, 2016; Estache & Garsous, 2012). Other literature analysed transport infrastructure, energy consumption, GDP and economic growth, with findings revealing a long-run association among these variables (Abbas & Choudhury, 2013; Phiri & Nyoni, 2015; Song & van Geenhuizen, 2014; Zahra, 2016). However, the most important study that considered transport infrastructure and economic growth is that of Pradhan and Bagchi (2013), conducted in India. Their findings point out bidirectional causality between road transportation and economic growth. This causality depicts the positive impact of infrastructure stock and services on the economy. Interestingly, the methods adopted by Pradhan and Bagchi (2013) included co-integration and the Granger test, as well as times period data. However, Pradhan and Bagchi's (2013) study differs from the above studies in that it addresses whether or not infrastructure investment connects or has a relationship with GDP or economic growth. This provided an aggregate estimate of the extent of the causal relationship and how much impact infrastructure had on a country's economic growth. In contrast, this study examines whether there is a relationship between transport infrastructure as a complement to other factors into production processes in SA and its economic growth from 1970 to 2015.

1.3 Research objective

This research investigates the potential embedded in transport infrastructures and their ability to boost the production and consumption of goods and services, which ultimately affect the economic growth of a country. Accordingly, exploratory sequential design objectives will explore the impact of transport infrastructural development in economic growth. Central to the impact of transport infrastructural development is a conducive economic environment, which helps promote a country's economic growth. Without doubt, transport infrastructures are a concern to most countries, as this facilitates economic growth and social energies of its economic base. Thus, the overall objective of this research is to examine the relationship between transport infrastructural development and economic growth using SA as the study area. The specific sub-objectives formulated are listed below:

- To examine the relationship between transport infrastructure and economic growth;
- To ascertain whether improved transport technology and networks accelerate economic growth and improve the quality of life of citizens; and
- To ascertain whether transport investment is a catalyst for economic growth or whether economic growth puts pressure on existing transport infrastructures and incites additional investment.

1.4 Research questions

Transport infrastructure projects have significantly impacted the development of many countries, which has called for the allocation of resources into transport infrastructure investments. SA, however, is faced with increasing constraints in financing transport infrastructure, hence the country's preference to allocate resources in a way that maximises the net return to society. To facilitate the allocation of such resources, it is important to understand all the wide-ranging impacts of investment in transport infrastructure. It is difficult to measure the exact relationship between transport infrastructure and economic growth, although some theoretical analyses (Kularatne, 2006, Moeketsi, 2017, and Vukeya, 2015) indicate the presence of significant impacts. This study seeks to contribute to the body of knowledge provided by previous scholars on the subject matter. It will complement empirical evidence in the existing studies.

This dissertation aims to address the impact dimension emanating from transport infrastructure by focusing on the following key questions, in order of importance:

- Is there a link between transport infrastructure development and economic growth?
- Do improved transport technology and networks accelerate economic growth and improve the quality of life of citizens?
- Is transport infrastructure investment a catalyst for economic growth or does economic growth put pressure on existing transport infrastructures and incites additional investment?

Identifying long-run economic growth remains central to the South Africa policy debate. As indicated, many studies have investigated the changing structure of economic growth in SA and addressed the impact of a number of its determinants (Kumo, 2012; Perkins et al., 2005). Few studies have however addressed the relationship between transport infrastructure and economic growth on long-run development. In considering these theories, this dissertation needs to study the following hypotheses:

- Hypothesis 1: There is a positive link between transport infrastructural development and economic growth.
- Hypothesis 2: A high-quality transportation network is vital for a top-performing economy and a prerequisite for future growth.
- Hypothesis 3: Transport investment is a catalyst for economic growth.

1.5 Significance of the study

The contribution of this study to the body of knowledge cannot be overemphasised. Firstly, very little literature has contributed to this discourse, which is the relationship between transportation infrastructure and economic growth. This dissertation will thus contribute to the existing body of knowledge on the topic and add value to it. Secondly, this study investigates the impact of transport infrastructural development as a complement to other factors of production and economic growth in SA. The existence of a constructive or undesirable relationship between variables will assist in policy direction by aiding transport planners, managers and economists in decision-making to boost transportation infrastructure and hence economic development in SA. Thirdly, this study will help clarify the links between transport infrastructure and economic growth in SA. Fourthly, SA is a developing country striving to become a developed country and hence, a stabilised economy is essential. Thus, understanding the consumption pattern of transport through import and export matters a great deal, to the economy. SA has remarkable transport infrastructure facilities; if consumption of transport services increases, there will be an equal increase in GDP growth of the country, which will boost the economy and lead to rapid growth. This research therefore uses the latest data from 1970 to 2015 to evaluate the relationship among variables.

1.6 Scope and delimitation of the study

The study examines the impact of transport infrastructural development on economic growth in SA. The period of the data is yearly observation from 1970 to 2015.

- The study was limited to South African macroeconomic indicators only.
- The study focused on 1970 to 2015 yearly observations only.

The examination of the impact of transport infrastructure on economic growth within South African provinces can be extended in a future study and would provide important information relevant to causal relationships.

1.7 Research assumptions

This study focused on and examined the impact of transport infrastructural development on the economic growth of SA. It used the co-integration method to test the relationship between transport infrastructure, including railways, airways, ports and roads, and economic growth in SA.

- The study considered transport infrastructure as a complement to other factors in the production process.
- The study did not consider other variables.
- Due to limited time, the study ran only partial regression.
- The study used secondary data from the World Bank yearbook only, along with extensive literature reviews.
- Due to lack of data on transport infrastructure and transport technology, this study considered performance of transport infrastructure (% of commercial service exports).

1.8 Outline of the study

This dissertation is divided into five chapters, with each focusing on a theme of significance. Chapter one presents the introduction and background, which elaborated on the research problem, objectives and questions, hypotheses, purpose, and significance. This chapter provides an overview of previous studies and presents gaps identified in the existing extensive literature on the infrastructure and economic growth. Chapter Two presents the literature review, which comprises the conceptual and theoretical framework on the impact of transport infrastructural development on economic growth in SA. Chapter Three covers literature related to the study, while Chapter Four addresses the methodology to the study. Chapter Four also presents the data sources and data collection process, including procedure and techniques, and data analysis. Chapter Five provides the analysis and discusses the results, while Chapter Six presents the conclusion and recommendations.

CHAPTER TWO

CONCEPTUAL AND THEORETICAL FRAMEWORK AND RELATED LITERATURE REVIEW TO THE STUDY

2.1 Introduction

This section covers the conceptual framework, which refers to an interconnected set of ideas on how a particular phenomenon functions (Svinicki, 2010). Concepts, meanwhile, provide an analytic frame, serving as a point of reference and a guide in the analysis of data with related theory (Bowen, 2008). Therefore, the conceptual framework for this study includes infrastructure development, transport, transport planning, and connectivity, while the theoretical framework adopted related theories, including growth theory and the basis of economic growth model. Both frameworks provide a systematic definition of various concepts and theories and their relevance to the study.

2.2 Conceptual framework

2.2.1 Infrastructure development

Several research studies confirm the importance of infrastructure service provision to economic development (Perkins, 2011, Srinivasu, & Rao, 2013 and Treasury, 2013). Infrastructure refers to all basic inputs into and requirements for the proper functioning of the economy (Jerome, 2011; United Nations, 2011, p. 5). Infrastructure development contributes to economic growth, as alluded to by the United Nations (UN) (United Nations, 2011). This implies a bidirectional relationship between infrastructure and GDP. Transport infrastructure plays an important part in the process of infrastructure development. It follows that the two concepts, in combination, can play a pivotal role in the development of the economy.

2.2.2 Infrastructure

The UN (2011, p. 5) indicated that infrastructure refers to all basic inputs into and requirements for the proper functioning of the economy. With specific reference to economics, infrastructure could be conceived as a capital good in the sense that its origin lies in investment expenditure and is characterised by its long duration, technical indivisibility and high capital-output ratio (Interaction, 2008, p. 8; Torrisi, 2009, p. 8). The latter definition refers to state-owned entities, which use the benefactor role to provide services to a country's citizens. The former definition of infrastructure as advocated by many scholars emphasises infrastructure as a part of the capital stock used to facilitate economic production, or as production inputs such as electricity, roads, bridges, tunnels, and harbours (Estache & Garsous, 2012; Garrison, 2000; Perkins et al., 2005; Torrisi, 2009; United Nations, 2011).

Torrisi (2009) categorised economic infrastructure into three groups. The first group relates to utilities such as power, piped gas, telecommunications, water and sanitation, sewerage and solid waste disposal; the second relates to public works such as roads and water catchments in dams, irrigation and drainage; while the third relates to transport sub-sectors such as railways, waterways and seaports, airports, and urban transport systems. Fedderke and Garlicky (2008) retorted that in economic terms, infrastructure could be considered as stock or variables. They further elaborated that being considered a stock means static, while, as a variable, it focuses on net infrastructure creation or loss over a given period. In general, infrastructure may include electricity, gas, telecoms, transport, water supply, sanitation, and sewerage (Estache & Garsous, 2012).

Other studies have broadly divided infrastructure into two categories: economic and social (Ghosh & Der, 2004; Torrisi, 2009). However, this dissertation focuses on infrastructure from the economic point of view, which may include transport, communications, power generation, water supply, and sanitation facilities. The particularity of this dissertation is that it looks at transport infrastructure including transit, highways, airports, railways, ports or waterways, tunnels, bridges, harbours, canals, subways, and tramways, as well as intermodal links.

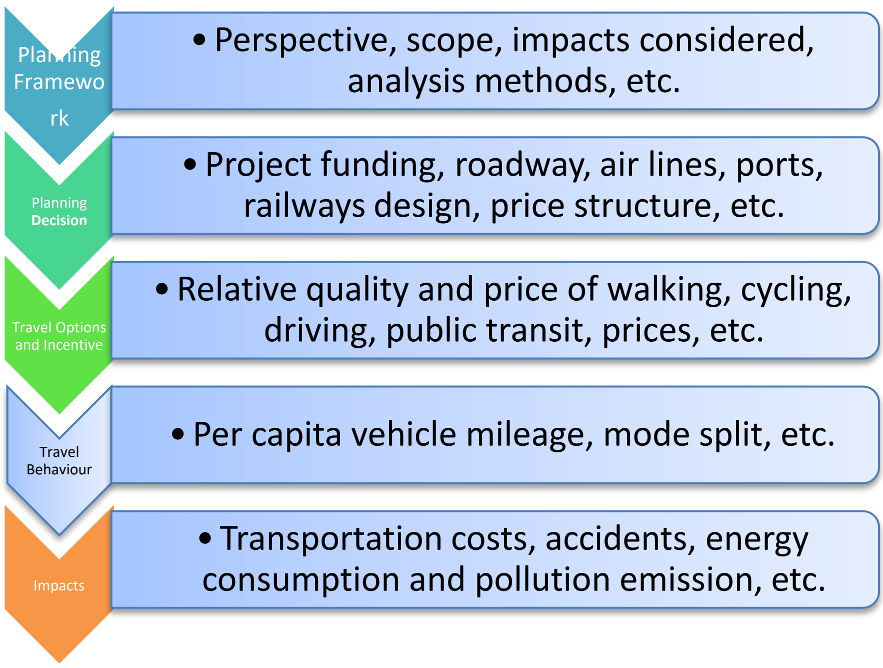
2.2.3 Transport planning

Transport planning is about making people, goods, services and opportunities more accessible to one another (Lyons & Davidson, 2016). To fulfil this role, governments take decisions which affect the economic, social and environmental aspects of a country. Poor planning impacts negatively on a transport system’s efficiency and obstructs its normal course (Litman, 2014; Republic, 2011). According to Lyons and Davidson (2016), transport systems are a key enabler of economic activity. The pair argued that transport systems not only enable economic activities to thrive, but also facilitate the movement of people, goods and services, while creating opportunities to make this variable more accessible to one another (Lyons & Davidson, 2016). Moreover, transport systems play a vital role in the development of a country's economy by determining overall productivity, quality of life of citizens, access to goods and services, and the pattern of distribution of economic activity (Everett, Ishawaran, Ansaloni, & Rubin, 2010; GIZ, 2016).

Transportation systems are partnerships between governments and users: a government's planning decisions determine the transport options available, from which users choose the combination that best meets their needs (Litman, 2014). It is the regard that studies present a transport-planning framework. (Litman, 2014) transportation planning framework defines the basic planning structure processes to include perspective, scope, impacts considered, and analysis methodologies. In addition, (Litman, 2014) was clear on the impact of planning decisions, which influence travel options and help shape travel behaviour and various impacts. This framework includes sequential steps to follows in decision processes, as indicated below.

Figure 1: Planning Framework and Impact

Steps between Planning Framework and Impacts



Source: Updated from (Litman, 2012)

The above framework outlines which options to consider and how they could be assessed. As noted, Litman (2014) emphasised that the decisions undertaken affect options and incentives, travel behaviours, and ultimate impacts.

2.2.4 Connectivity

According to Alstadt, Weisbrod and Cutler (2012, p. 3), connectivity, in the context of transportation planning, refers to the ease, time or cost of travelling between different transportation route systems or modal systems. Transport planning plays a pivotal role in planning how to connect goods, services and people from one point to another. Connectivity includes both physical connectivity and the associated soft infrastructure (Lyons & Davidson, 2016, p. 110; Song & van Geenhuizen, 2014). The physical aspect of connectivity relates to transport infrastructure (road, rail and ports) and energy infrastructure, while associated soft infrastructure includes the critical area of infrastructure financing. As previously indicated, this dissertation focuses on the physical aspect of transport infrastructure.

Increased investment in cross-border infrastructure is the primary strategy to improve connectivity between neighbouring countries and to promote trade and investment growth (Holzner, 2016; Jouanjean, Gachassin & Velde, 2015). A transport infrastructure system connects a country to the outside world, facilitates the movement of goods and services, and stimulates economic growth. It ensures expansion and cohesion between trade partners in any region (Holzner, 2016). Furthermore, transport's connection and interaction functions create many improvement opportunities, such as one road, one belt (Barisitz, & Radzyner, 2017 and Garrison, 2000).

Connectivity goes along with market access, which is defined as a surrounding area or region comprising the market. Therefore, connecting market access and connectivity leads to terminal linkages. Thus, both concepts can improve productivity and intermodal transportation connectivity improvements, which tend to extend the range of workers, materials and customers that, are accessible to a business.

2.2.4 Government approach to Infrastructure Development (ID) Economic Growth (EG)

SA's government provides an approach to transport infrastructure development based on the concept that transport and land use are inextricably linked. The government, in its National Development Plan (NDP), Vision 2030, has established a relationship between land use and transport. The government understands the role that transportation infrastructure plays in land use development that promotes high-quality integrated transport infrastructure and services (Stapelberg, 2006). This integrated transport infrastructure approach facilitates economic activity, which proves that government considers the impact of infrastructure investment on economic growth.

For the SA government to promote transport infrastructure development, this will require efficient decision-making and firmness, which will ultimately boost economic growth, since these infrastructures lower the cost of production and consumption, and make it easier for participants in the economy to enter into transactions (Ngandu et al., 2010). Increasing the efficiency of infrastructure will thus improve growth performance, service provisions and development outcomes.

However, it should be noted that challenges come along when conceptualising the delivery of transport planning. Important opportunities to address those challenges and even capitalise on them matter as much as alluded to by Lyons and Davidson (2016). This depends largely on the government's approach to infrastructure development. However, government's approach should always be to plan and determine the transport options available, from which users can then choose the combination that best suits their needs (Litman, 2014).

2.2.5 Approaches to measuring infrastructure development

Numerous studies have been conducted to measure the relationship between transport infrastructure and economic output (Esfahani and Ramírez 2003, Fedderke and Garlick 2008, Kumo, 2012, and Pradhan and Bagchi, 2013). This investigation started with Aschauer (1989), who emphasised the impact of transport infrastructure on economic output. Pradhan and Bagchi (2013) referred to two possible traditional methods that assist in examining the relationships between transport infrastructure and economic growth, including cost benefit analysis and macro econometric modelling on infrastructures. This study endorses the macro econometric modelling, which provides three approaches, namely production function approach, cost function approach, and causality approach. These have been studied by various scholars, including Esfahani and Ramírez (2003), Fedderke and Garlick (2008), Kumo (2012), and Pradhan and Bagchi (2013).

Production function and cost function approaches appear not to provide adequate consideration to the direction of causality, while the Granger causality approach pays attention to such, taking into account the formulation of effective policies (Abbas & Choudhury, 2013; Pradhan & Bagchi, 2013). The policies, in this regard, may be formulated relying on the directional patterns of transport infrastructure and economic growth (Badalyan et al., 2014; Fedderke & Garlick, 2008; Pradhan & Bagchi, 2013; Tong et al., 2014).

Scholars have categorised three ways of directional causality of the mentioned variable relations, including unidirectional causality between transport infrastructure and economic growth, bidirectional causality between transport infrastructure and economic growth, and no causality between transport infrastructure and economic growth. As Fedderke and Garlicky (2008) suggested in their review of infrastructure development and economic growth, to consider measuring infrastructure by taking into account associated aggregate economic performance. Kumo (2012) considers two levels of measurement, including micro and macro levels. Both Fedderke and Garlicky (2008) and Kumo (2012) asserted that micro-level analysis conditions provide accuracy more than macro as far as data are concerned. This dissertation attempts to ascertain the linkages between transport infrastructure and economic growth in SA, and to consider transport infrastructure in relation to economic growth at a national level.

Fedderke and Garlicky (2008) asserted that infrastructure measurement in terms of stock or flows requires association with an appropriate measure of aggregate economic performance. Their central argument focused on consideration of infrastructure stock and economic output as cumulative in nature while possessing time trends. The contrast to this argument would be to consider infrastructure flows and economic growth as cumulative. Therefore, the technicality of this argument leads to a general understanding of the need to compare GDP and infrastructure flows to GDP growth, which this dissertation has done.

2.2.6 Summary of this section

This chapter covered the conceptual framework related to the study under investigation, so to comprehend the relationship between infrastructure development and economic growth. The chapter reviewed infrastructure development, transport, transport infrastructure, transport planning, and connectivity. In addition, the importance of each one of the concepts in relation to the examination of causality association of economic growth and transport infrastructure in SA was revealed. Finally, the framework provided a better understanding of the research topic and a systematic definition of various concepts and their relevance to the study.

2.3 Theoretical framework to infrastructure and economic growth

Economic theory identifies five channels through which infrastructure can positively affect economic growth. This includes infrastructure as a factor of production, a complement to other factors, a stimulus to factor accumulation, a stimulus to aggregate demand, and a tool of industrial policy. This dissertation focuses on infrastructure as a complement to other factors involved in the production process.

2.3.1 Growth theory

The basic model of economic growth originated from Robert Solow, a Nobel Prize winner. Economists define economic growth as an increase in the amount of goods and services that an economy produces (Wolla, 2013, p. 1). In simplest terms, it can be referred to as an increase in the productive capacity of an economy compared from one period to another. In this model, mainstream economists usually think of capital, labour and land as the primary factors of production (Stern & Cleveland, 2004). For example, Fedderke and Garlick (2008), and Perkins et al. (2005) perceive the economic growth model principally in terms of factors of production such as capital stock, to include roads, bridges, factories, land, infrastructure, etcetera. In addition, land use changes dynamic population in the process of production for its transformation. The theory of growth and a focus on the primary inputs – particularly capital and land – appear more important.

2.3.2 The Basic Growth Model

Economic growth models examine the evolution of a hypothetical economy over time, as the quantities or qualities of various factors in the production process (Stern & Cleveland, 2004). They added as well the methods of using those inputs change. However, the procedures of using those factors change from one to another. Output or total production refers to a function of capital and labour, which can be represented by the following notation: $Y = F(K, L)$, where Y represents output, K is capital, and L is labour. Any increase in output depends on an increase in capital via investment and depreciation, and any increase in terms of labour will depend on supply through population growth. The model assumes that output increases at a decreasing rate, as the amount of capital employed rises (Stern & Cleveland, 2004, p. 38). In addition, this theory asserts on occurrence of the growth, as a complex phenomenon that depends on many factors. These factors are not limited to innovation and technology, potential to convergence, investment and institutional arrangement (Werle, 2012, p. 34).

The relevance of this theory to the dissertation, as expressed in economic theory, holds that an increase in one of the factors of production, such as the stock of infrastructure, would increase the output of the economy as a whole, directly inducing economic growth (Fedderke & Garlick, 2008). Many scholars refer to growth in terms of a production function for goods and services, which, in most cases, factors of production are positive determinants of aggregate output (Fedderke & Garlick, 2008; Jajri, 2007).

Accordingly, economic growth occurs when more factors of production are in use and are optimum. The tenets of neoclassical growth theory attribute continuous economic growth to technological progress or the increasing returns associated with new knowledge (Stern & Cleveland, 2004). The common ground of the argument views the ability to grow the economy by increasing knowledge rather than labour. Furthermore, the tenets of the neoclassical theory of growth underscore the importance of investing in new knowledge creation to sustain growth (Siraj, 2014 and Cortright, 2001).

According to Fedderke and Garlick (2008), results on infrastructure development and economic growth, both theoretical and empirical, point to the existence of robust positive relationships. The researchers argued that aggregate infrastructure stock and investment drives economic outputs, and the driving relationship between economic output and infrastructure varies significantly across. Moreover, different types of physical infrastructure and infrastructure impact on output both directly and indirectly, via increased private sector investment, improved productivity and rising exports. Economists prefer describing total factor productivity as an output growth over and above which can be attributed to the accumulation of factors of production (Daude, Fernández-Arias, & Pezzini, 2010; Jajri, 2007). As a consequence, the approach is probably to stimulate the economic growth, and impetus results. Literature related to transport infrastructure revealed, on one side, mixed results and positive and strong effects of infrastructure provision on economic growth, while on the other side, negative or negligible effects.

Evidence from the import and export of goods and services across countries indicates the importance of transport infrastructure as a complement to other factors of production (Hummels, 2009). He argued that this links into cross-border results in increased economic growth and reduced cost of production. For instance, Hummels (2009) indicated that trade specialists consider shipping cost as an impediment to trade based on the cost of transportation services, which fluctuate dollars at different small harbour points. Hummels (2009) further indicated that while trade is growing and growing lighter, exports are expanding primarily by reaching new markets with smaller flows, and fragmented production networks are becoming the norm.

Studies conducted on transport infrastructure as a stimulus to other factors of the production process found that it lowers the cost of production (Fedderke & Garlick, 2008, p. 5). In addition, transport infrastructure may also increase the productivity of other inputs in the production process. This view was also expressed by Brooks (2008, p. 1), who indicated that efficient infrastructure services lower transaction costs, raise value added, and increase potential profitability while increasing and expanding linkages to global supply chains and distribution networks for producers.

2.3.3 Summary of the section

This section covered the theoretical framework related to the study under investigation. This was to inform our thinking and assist in making research decisions in the real world. The section referred to economic growth as an increase in the amount of goods and services, and went further to focus on the primary inputs, as an increase in one of them (inputs) leads to an increase of output of the economy, directly inducing economic growth. Finally, the section systematically interrelated infrastructure factors and economic growth.

2.4 Literature review related to transport infrastructure and economic growth

2.4.1 An overview of developed countries' transport infrastructure (TI) and economic growth (EG)

Empirically, research on the impact of infrastructure started in the last two decades in the footsteps of Aschauer (1989). He attributed the private sector productivity slowdown of the 1970s and 1980s primarily to lower growth in public capital accumulation in the US. This implies that low investment in infrastructure impacts negatively on the economic growth of a country. Further, Aschauer (1989) indicated that public infrastructure such as mass transit, water and sewerage, highway and similar are to be considered as factors of production.

Transport performance presents, on the one hand, positive outcomes, and on the other, negative outcomes. For instance, in the US, one of these positive outcomes is that transport performance peaked in the 2010s, compared to the 1990s. This was due to an increase in US government spending on highways and roads. Generally, good infrastructure advances the productivity of other inputs in the production process (Trimbath, 2011). It also raises the productivity of other inputs in the production process.

Some of the negative outcomes include that the US lost its ranking at the international level as other countries began improving their transport infrastructure. One might recall China's transport infrastructure and "one road one belt" as refers to physical connectivity of road to facilitate movement of goods, services and people. Transportation infrastructure remains an obstacle to business in the US, as many companies make an effort to find ways to process production of goods and service to their customers around the country, as well as the world (Trimbath, 2011). However, Hummels (2009) indicated that fragmentations put a much larger strain on transport and trade infrastructure than other types of production arrangements.

The European Union (EU) has seized the opportunity provided by well-developed infrastructure to ensure better living conditions for its population. The EU has invested in infrastructure to connect European communities via transport modes of moving goods and services within member countries. The common benefit was to improve competitiveness among European countries and to facilitate private business to develop operations. This policy direction has accentuated the importance of connecting both new and old member states by bridges and other means of transport infrastructure (Feddersen & Zucatto, 2013; Kumo, 2012). Late entries into the EU have recognised the importance of construction infrastructures, since this creates economic expansion in the short term (Holzner, 2016). In the long term, it contributes largely to boosting the economy through industrialisation (Holzner, 2016).

A common benefit of infrastructural development to EU member states has been the overall decrease in the cost of production and the improvement of accessibility to markets. Assessing the state of transport infrastructure in some of the European countries and the significance thereof, Badalyan et al. (2014) posited that gross capital formation and road or rail goods transported have a positive and statistically significant impact on economic growth in the short term. The study covered the period 1982 to 2010. Estache and Garsous (2012) contend that improvement of transport accessibility is attributed to factors other than transport stock. They argued that the estimated growth effects of transport investments have been feeble. Indeed, common evidence spanning more than two decades confirms this trend.

To buttress the assertion above, Holzner (2016) confirmed an estimation amount of 7.7 billion euros being invested in transport infrastructure by the European Commission in the Balkans region. Records show that these investments in transport infrastructure improved the economic growth of the western Balkan region by 1% per year, and boosted employment opportunities for about 200,000 people, equal to 4% of the active work force. In contrast, Estache and Garsous (2012) observed more dimensions of interest, such as bottlenecks, diseconomies of scale, network effects, and technological lags, than capital infrastructure. This was mainly because these countries already had stable infrastructure.

This therefore confirms that literature on infrastructure and economic growth is consistent with the findings of Terenteva, Vagizova, and Selivanova (2016), which in turn confirms that high transport accessibility of a region is a key contributor to attract investment, accelerate economic turnover, create jobs, and optimise to gain better access to markets. This view supports the ideas of Estache and Garsous (2012), who said that infrastructure investment ought to support varied growth across regions. In retrospect, the evidence on the impact of infrastructure focuses on macroeconomic indicators. This empirical evidence ardently evaluated the effects of infrastructure on broad aggregates such as GDP, economic growth and productivity, using a variety of data, empirical methodologies and infrastructure measures.

2.4.2 An overview of developing countries' transport infrastructure (TI) and economic growth (EG)

The linkage between infrastructure and economic growth, with specific reference to transport infrastructure, is well established in developing countries. Literature reviewed thus far demonstrates that infrastructure investment is one of the main preconditions for enabling developing countries to accelerate or sustain the pace of their development. Ekpo and Bassey (2016) analysed the economic consequences of an infrastructural deficit in developing economies, using electricity supply in Nigeria as a case study. Their findings indicated inefficient, unreliable and grossly inadequate electricity supply in Nigeria, which implies that the minimum requirement to meet the demand of consumers cannot be met. Prior to this study, Démurger (2001) conducted research on the role of economic and social infrastructure in economic development. He asserted that economic infrastructure plays a positive and significant role in the growth performance of many countries. Similarly, the Asia Development Bank (2012) and Jerome (2011) noted a strong association between electricity supply, telecommunications, surfaced roads, safe water and GDP per capita.

With a focus on transport infrastructure, Achour and Belloumi (2016) observed an empirical relationship between transport infrastructure and economic growth for India, using yearly data over the period 1999 to 2014. They established the existence of such a relationship only in the short term between the two variables concerned. They used the Granger causality test, which resulted in bidirectional causality between GDP and transport infrastructure.

Evidence from the most recent two decades reveals that India saw rapid economic growth thanks to investment and the development of critical infrastructure, namely transport systems (road, railways, ports and air transport). This investment also led to a decrease in economic disparity, poverty and social depreciation within the country. Pradhan and Bagchi (2013) also observed the influence of road and railway infrastructure on India's economic growth, from 1970 to 2010. Their findings presented bidirectional evidence, which means that road infrastructure facilitated economic growth, and that economic growth led to road and railway infrastructure development booming. In the cross neighbouring country of Pakistan, Zahra

(2016) explored the possible influences of electricity consumption and transport infrastructure on economic growth by using the Johansen co-integration test on data from 1971 to 2015. The results showed a long-term association between electricity consumption, transport infrastructure and economic growth. Abbas and Choudhury (2013) used Pakistan and India as a case study to assess the causal relationships between electricity consumption and economic growth, with a focus on the agricultural sector. The results indicated an increase in both variables in both countries, as electricity consumption increases the agricultural production and causes an increase in economic growth.

Vis-à-vis China, Chen, Yang, Li, and Chen (2017) conducted an interesting study on transportation infrastructure and economic growth and noted rapid development in China over the last two decades. This development resulted in average output elasticity in the Chinese transportation system to 0.13. In addition, variations in their estimation were attributed to different dependent variables. Prior to this study, Song and Van Geenhuizen (2014, p. 175) investigated the influence of port infrastructures on the economy of China, using yearly data over the period 1999 to 2010. By applying co-integration, the results revealed that port infrastructure investment positively affected the country's economic growth. Moreover, Shiu, Li, and Woo (2016) investigated the relationship between energy investment, transportation infrastructure expansion and economic growth in China's 30 different provinces, for the period 1991 to 2012, using Granger causality. The results showed an increase from transport infrastructures to economic growth, while economic growth expanded energy investment. Energy and transportation capacity imitated post-western development strategy, and as such, Shiu et al. (2016) advocated for continuous investment in energy and transportation infrastructure. This evidence seems to validate the view that infrastructure impacts economic growth.

Research conducted by Brida, Lanzilotta, Brindis, and Rodríguez (2014) undertook an analysis of the long-run effects between air transport demand and economic growth in Mexico. By means of Johansen co-integration, Granger causality and quarterly data from 1995qIII to 2013qIV, they found the existence of one co-integrated vector, where the corresponding elasticities were positive, while causality relationships were positive and bidirectional. This was an indication of expansion in air transport, coupled with positive results on economic growth. Transport infrastructure may influence growth indirectly by boosting the accumulation of other factors of production, or by boosting the productivity of the factors of production.

Moreover, Daude et al. (2010) conducted an econometric analysis in Latin America. They maintained that low productivity and slow productivity growth are measured by total factor productivity, rather than impediments to factor accumulation. In their view, the finding was the key to understanding Latin America's low income relative to developed economies and its stagnation relative to other developing countries. Estache and Garsous (2012) claim that many of these countries present a greater likelihood of a positive impact of infrastructure on the economy or economic growth; it is a claim supported by numerous scholars.

2.4.3 Types of transport infrastructure investments

Transportation investment encompasses two forms: capital expansion and capital enhancement. These two forms are defined by Eberts (2000, p. 2), who refers to e*xpansion* as the construction of additional highways (e.g. additional lanes, extension of an existing road), bridges (e.g. replacement or widening of bridges or building of new bridges), rail lines (e.g. upgrading branch lines, extension of existing rail lines), ports (e.g. additional ports, expanding existing ports), airports (e.g. lengthening of the runway, additional terminal gates), bus and taxi terminals (additional terminals); and e*nhancement* as new technologies that can enhance the efficiency of the existing systems, for example, intelligent highway systems (e-tolls), intermodal freight facilities, geographic positioning systems, instrument landing systems, etcetera. It is therefore important to understand the effects of these innovations on economic development through enhanced delivery of transportation services.

In considering investment in transport infrastructure, it is important to explore the broad economic consequences of these innovations by considering the direct social and economic effects of transport investment. South African transportation infrastructure is not yet mature and requires ongoing expansion and enhancement. However, a decision needs to be made within the transportation investment allocation of whether the funds should be devoted to highway expansion, road maintenance, intermodal facilities, bicycle paths, extending bus and taxi terminal capacity, or sidewalk expansions, among other things.

2.4.4 Transport infrastructure budget and spending in South Africa

Infrastructure investments have traditionally been viewed as a policy instrument for development in several developing countries. According to the New Growth Path that was launched in 2010 by the Department of Economic Development, infrastructure has been targeted as one of the job drivers in the economy. Presenting the Infrastructure Development Cluster (IDC) briefing in February 2012, the Minister of Transport highlighted the South African government's interest to invest in infrastructure and make it a central priority in addressing problems of inequality, poverty and unemployment. Therefore, the government is set to invest over R845 billion in implementing infrastructure projects meant to remedy the distortions of infrastructure, such as roads, hospitals, schools, electricity, ports and rail that were created by the apartheid system (Cheteni, 2013, p. 761).

Infrastructure spending was historically defined as consumption expenditure by either government or the private sector but is now near-universally defined as a capital expenditure, as infrastructure has been recognised as a capital good. Transport infrastructure includes roads, railways, ports, airports and waterways – all of which contribute to GDP. The South African government has prioritised infrastructure development and, in 2012, allocated a budget of R583 billion for transport infrastructure development projects. Within this, major infrastructure projects included (National Treasury, 2013):

- The acquisition of a new fleet of rolling stock over the next 20 years by PRASA: R80 billion.
- The maintenance, improvement and refurbishment of roads and construction of new roads by SANRAL: R45.4 billion.
- The acquisition of rolling stock for freight rail – 110 locomotives to be purchased by Transnet.
- Provincial road improvement – maintenance, improvement and refurbishment of roads and construction of new roads over the next three years: R25.5 billion.
- Ngqura container terminal – improvement of port capacity by 800k units by Transnet: R7.9 billion.

The following table illustrates budget allocation in transport infrastructure in South Africa.

Table 1: Transport Infrastructural Budget and Spending

No	Project name/ Implementing agent/ Cost	Project description	Finance
1	Rolling stock for passenger rail (PRASA) *R80bn*	Rolling stock fleet renewal over 20 years from 2012	Fully funded by fiscus
2	Rolling stock and locomotives for freight rail (Transnet) *R7.7bn*	Acquire rolling stock and locomotives	Corporate debt raised through market; users repay through tariffs
3	Nqgura container terminal (Transnet) *R7.9bn*	Increase port capacity by 800 000 units, first phase completed in 2012	
4	Manganese rail and terminal (Transnet) *R18bn*	Upgrade rail, port and terminal capacity	
5	Iron ore line (Transnet) *R13bn*	Expand Sishen Saldanha iron ore railway	
6	N2/R72 Port Elizabeth to East London (SANRAL) *R5.3bn*	Capacity upgrades, additional lanes and resurfacing	Bonds and corporate debt, possibly with government guarantees
7	N2 Richards Bay to Ermelo (SANRAL) *R6.2bn*	Capacity upgrades, additional lanes and resurfacing	
8	Gauteng Freeway Improvement Project (SANRAL) *R18.9bn*	Upgrade highways in Gauteng	
9	Public transport networks (municipalities) *R15.1bn*	Rollout of public transport in prioritised metropolitan areas	Mainly funded through fiscus, with user charges to cover operational costs

Source: Compiled from Treasury (2013)

As the above table indicates, there has been a steady increase from 2011/12 to 2015/16 in overall infrastructure expenditure by the public sector, including capital and maintenance spending. This has been allocated to national and provincial government and state-owned companies. This is to say that transport investment accounts for 27% of the public sector infrastructure budget over the Medium Term Expenditure Framework (MTEF). An additional R827 billion budget has been allocated to public sector infrastructure in 2013, to be spent for years to come. This makes up about 22.89% of the budget over MTEF. This budget is allocated towards the Transnet pipeline, port and rail investments. A portion of the budget is also allocated towards the investment in the bus rapid transport (BRT) system, national roads improvement and minor refurbishments, replacements and preparatory work by ACSA on runways in Cape Town, East London and OR Tambo International Airports (tunnels and remote aircraft stands).

PRASA has been allocated a budget of R4.2 billion for the next three years for the improvement of the quality and capacity of its commuter rail services (contract negotiations were underway, with the first coaches delivered in 2015). SANRAL spent R2.9 billion on non-toll roads and R1.1 billion on toll roads (National Treasury, 2013, p. 1). This, after a period from 1976 to 2002, when annual infrastructure investments fell from 8.1% to 2.6% of GDP, with per capita expenditure falling from R1 268 to R3560 (Fedderke & Garlick, 2008).

2.4.5 Importance of transport infrastructure development

Infrastructure in general and transport infrastructure specifically plays a major role in economic development as well as in social development. In addition, construction services form a significant part of a country’s GDP. Transport contributes about 4% towards the GDP of South Africa (Stats SA, 2014). Investment in social and economic infrastructure plays an important role in increasing productivity of labour and business.

The South African government recognised the importance of transport and transport infrastructure in policies such as the Reconstruction and Development Programme (RDP 1994), the Growth Employment and Redistribution and Development Programme (GEAR 1996), and Accelerated Shared Growth Initiative in South Africa (ASGISA, 2006). GEAR specifically stated the requirement for an “increase in infrastructural development and service delivery, making intensive use of labour-based techniques”. The South African government has also injected a significant amount of its budget towards infrastructure development, an equivalent of 7% of GDP (National Treasury, 2013).

Governments around the world rank infrastructure policy among their greatest concerns. The modernisation of infrastructure is seen as being critical to future economic competitiveness and crucial to accommodating expanding populations in urbanising environments. However, the state's ability to deliver and effectively maintain infrastructure is grounded on its ability to collect tax and user charge revenue, as this determines the quantum of resources available for infrastructure investment. It also relies on the efficacy with which programmes are implemented and delivered to the targeted beneficiaries (including the management of public finance, procurement processes, contract management and effective monitoring of the state-owned entities) (DBSA, 2012).

In justifying the importance of infrastructure, Fedderke and Garlick (2008) argue that infrastructure may be regarded as a complement to other inputs into the production process in two senses. In the first sense, improvement in infrastructure may lower the cost of production. Inadequate infrastructure creates a number of costs to organisations, which may have to develop contingency plans against infrastructure failure or even build infrastructure themselves. Inadequate transport infrastructure, for example, incurs potentially massive costs for organisations that must seek alternative means of transporting both their inputs and finished goods. Good infrastructure generally raises the productivity of other inputs in the production process. If a country invests in good infrastructure, transactions that were previously unprofitable become profitable. This results in the increase of a range of available profitable investment opportunities and may thus encourage both domestic and foreign investment, boosting aggregate economic activity in South Africa. A well-oiled transportation infrastructure expands the productive capacity of a nation, both by increasing the mobilisation of available resources and by enhancing the productivity of those resources (Pradhan & Bagchi, 2013, p. 139). Inadequate infrastructure may render some production processes nearly impossible. International trade, for example, is dependent on relatively sophisticated transport and communication infrastructure. Good infrastructure also boosts tourism in that the provision of tourism services to the international market is entirely dependent on transport infrastructure (Fedderke & Garlick, 2008, p. 5), while the provision to the local market is severely constrained by the absence of such infrastructure.

2.4.6 Impact of urban transportation infrastructure on quality of life in South Africa

Infrastructure contributes to economic development by increasing productivity, by providing amenities which enhance the quality of life, and by providing outputs which are valued in their own right. Infrastructure creates amenities such as bus stops, airport or passengers terminal facilities by providing spatial order to human settlements and public works of architectural appeal and civil pride. Improvements in infrastructure are central to the quality of life and enjoyment gained from both the natural and man-made (built) environment, especially in urban areas (Meeting, 2016). One important area of research is to explore the productivity enhancing innovations that have been introduced into existing transport systems, for example, the Gautrain and Reavaya buses.

Cities are locations that have a high level of accumulation and concentration of economic activities and are complex spatial structures that are supported by transport systems. The larger the city, the greater its complexity, and the potential for disruptions, particularly when this complexity is not effectively managed. The most important transport problems are often related to urban areas and take place when transport systems, for a variety of reasons, cannot satisfy the numerous requirements of urban mobility. Urban productivity is highly dependent on the efficiency of its transport system to move labour, consumers and freight between multiple origins and destinations.

High-quality rapid transit systems like the BRT and Gautrain impact the quality of life, productivity, health and safety of people living in the cities. These impacts have been explored in varying depth in the existing research in the form of travel time benefits, environmental impacts, public health, safety benefits, and urban development changes. The BRT system and Gautrain reduce travel time for passengers, as the BRT buses have an exclusive, segregated lane, while the Gautrain is a high-speed train. Prepaid boarding at stations, along with high-capacity buses and carriages with multiple boarding doors, help speed up passenger boarding. The BRT system and Gautrain also have positive environmental impacts, as they reduce emissions that contribute to global climate change, as well as local air pollutants. The other benefit covered in literature is that these systems provide valuable public health benefits by reducing road fatalities, crashes and injuries, and by reducing personal exposure to harmful air pollutants, as well as increasing physical activity – such as in the case of BRT users (Bel & Holst, 2015).

2.5 Empirical evidence on transport infrastructure and economic growth in South Africa

Theoretical and empirical literature suggests the existence of a positive relationship between infrastructure investment, poverty reduction, employment creation and sustainable growth and development. Labour-intensive infrastructure construction programmes, particularly in rural areas of developing economies, often lead to short and medium-term employment opportunities, thereby reducing rural poverty. Access to improved infrastructure in hitherto inaccessible areas in turn spurs private sector investment, leading to further job creation and economic growth (Kumo, 2012).

In the same line of research, Fedderke and Bogetic (2006) investigated the direct impact of infrastructure investment on labour productivity and the indirect impact of infrastructure on total factor productivity using the panel data analysis method and pooled mean group (PMG). Also, some other authors have employed unrestricted error correction in their estimation of infrastructure investment on factors of production (Pesaran, Shin and Smith, 1999). The panel data used is based on South Africa, from the period 1970 to 2000, and includes a range of 19 infrastructure measures. The researchers concluded that controlling for the possibility of endogeneity in the infrastructure measures renders the impact of infrastructure capital not only positive but of economically meaningful magnitudes (Fedderke & and Bogetic, 2006).

A similar study was conducted in South Africa by Perkins et al. (2005). Using the Pesaran, Shin and Smith (1996, 2001) F tests, these authors identified directions of association between economic infrastructure and economic growth. They identified long-run forcing relationships from public sector economic infrastructure investment and fixed capital stock to GDP, from roads to GDP and from GDP to a range of other types of infrastructure. They also found that the relationship between economic infrastructure and economic growth runs in both directions.

Furthermore, a number of studies have examined the contribution of aggregate investment expenditure to economic growth, yet few have addressed the distinction between public and private investment expenditure and the impact of infrastructure investment on long-run development in particular (Kumo, 2012; Perkins et al., 2005). To date, little attention has been paid to the determinants of infrastructural investment in South Africa. Kumo, and

Perkins et al, indicated in conclusion that the relationship between economic infrastructure and economic growth appears to run in both directions.

From the above, the literature suggests that the majority of transport infrastructure investments mainly rail and road accounted respectively for 43,3% and 31,4% as a contribution to the total infrastructure in South Africa (Africa, 2010; Treasury, 2013). A study by Kumo (2012) focused on the macroeconomic impact of public economic infrastructure investment in the country for the period 1960 to 2009, using pairwise Granger causality and bounds test approaches (co-integration test). The main finding of the study indicated a strong causality between economic infrastructure investment and GDP growth that runs bidirectional. In other words, economic infrastructure investment drives long-term economic growth in South Africa and improves growth feedback into more public infrastructure investments. Kumo's (2012) findings project transport infrastructure as a complement to other factors of production. Most of these factors of production as indicated by Fedderke and Garlick (2008) are positive determinants of aggregate output of which an increase in one of them, like stock of physical capital, can result in an increase in production of goods and services. This implies that an increase in capital investment such as transport infrastructure or its related services causes growth in production. A planned infrastructure programme has the potential to offset the contradictory effects of the global downturn (Ngandu et al., 2010). An emphasis on construction serves as an income generator for stakeholders involved therein.

Omri and Kahouli (2014) examined interrelationships between energy consumption and economic growth using data of a panel comprising 65 countries, by taking data from 1990 to 2011. Applying econometrics models, the researchers established bidirectional results related to the interrelationship between energy consumption and economic growth. The bidirectional results suggested two causality relationships with regard to the variables predictors. Similarly, Boopen (2006) conducted a study which focused on African countries and island states by analysing transport capital and economic growth, over the period 1980 to 2000, using Cross section, pooled OLS and panel data analysis. Empirical evidence from the study indicated the importance of transport capital as an element of these countries' development. More importantly, transport capital appeared more productive than the overall investment.

More recently, Phiri and Nyoni (2015) revisited multivariate co-integration and causality relationships between electricity consumption and economic growth in the South African context, based on the period from 1994 to 2014. The results concluded were twofold: firstly, the results showed significant multivariate long-run co-integration relationships between electricity consumption and economic growth. Secondly, empirical analysis held that neutrality hypothesis existed between electricity consumption and economic growth in the long run.

If one considers transport infrastructure as complement to factor of production, it implies that improvements in transport infrastructure may lower the cost of production and increase economic growth of that particular country. However, inadequate transport infrastructure impacts negatively on firms and enterprises to operate at their optimum in the process of creating goods and services and as far as transporting to final consumers is concerned (Fedderke & Garlick, 2008; Harris, Wang, & Wang, 2015).

2.6 Summary of the chapter

This chapter commenced by analysing the conceptual and theoretical framework in relation to the study. It highlighted the transport infrastructure development inputs and economic growth, and reviewed literature on transport infrastructure and economic growth. It was ascertained from the review that there is a linkage between transport infrastructure and economic growth based on the empirical evidence from different scholarships worldwide. It was noted that correlation and regression analysis does not imply automatic causality from one variable to another. Further, the review of literature indicated that much of this empirical evidence employs the econometric notions of Granger causality and co-integration to test the presence and direction of causality between the variables related to the mentioned subject.

Most of the studies conducted by Harris, Wang, & Wang, 2015, Kumo 2012, Pradhan & Bagchi, 2013 dealt with the growth and productivity effects of infrastructure development, which are consistent with the work of Estache and Garsous (2012). The main result was that infrastructure development in Africa promotes a significant long-term economic growth. Similarly, it was ascertained that infrastructure stocks and services affect economic growth positively in developing countries. Overall, the findings indicated that economic growth has a correlation with infrastructure stocks and the quality of infrastructure services. In the developed world, less growth caused by infrastructure was noticed, while the policy implications in developing countries suggest an increased investment in infrastructure while avoiding spending cuts and negligence on capital stock, which boost economic growth. In the developed world, more funds are channelled into innovation and technology related to infrastructure development.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter presents the methodology used to explore the relationship between transport infrastructure and GDP in the South African context. First of all, Le Roux, (2011) research methodology referred to a method, techniques, and procedures that are employed in the process of implementing the research design or research plan. Within a methodology, there is a method which Bhattacherjee (2012) refers to as a standardised set of techniques for building scientific knowledge, such as how to make valid observations, how to interpret results, and how to generalise these results.

To conduct a successful quantitative data analysis, Bhattacherjee (2012) introduced researchers to twofold statistic tools: the first relates to descriptive analysis, which statistically, describes, aggregates and presents the variables of interest. The second talks to inferential analysis, which in turn, statistically tests the hypothesis. This dissertation used both descriptive analysis and inferential analysis techniques to test the relationship between transport infrastructure and economic growth or GDP. The researcher conducted a test using software programs such as STATA. The author understood this fundamental and has made use of it in this analysis.

3.2 Research data

Quantitative research methodology is typically considered more scientific, as such, the focus is on using specific definitions and taking into account operating concepts and variables mean (Tewksbury, 2009). Quantitative research methodology relies primarily on the collection of quantitative data or observable variables. It is the numerical representation and manipulation of observations for the purpose of describing and explaining the phenomena that those observations reflect (Creswell, 2009). Creswell refers quantitative research to the numerical representation and manipulation of observations for the purpose of describing and explaining the phenomena that those observations reflect. Quantitative research explains phenomena by collecting numerical data that are analysed using mathematically based methods. In this study, the author considered a yearly time line period from 1970 to 2015. The data were collected from the World Bank database website, and extracted and converted in Excel format for computation using the STATA program. The data were analysed and synthesised following meticulous steps as the methodological assumption cause and effect, all of which offer responses to the inquisitorial question of what the objective and process of the research are.

The Granger test of causality was applied to explore the linkage between transport infrastructures as a complement of other factors into the process of production in South Africa. However, while the ability to predict what is to come is suggested as central to the supposedly superior value of quantitative research, Tewksbury (2009) claims that prediction is based on theoretical grounds, and the testing of theoretical concepts, propositions and relationships.

3.3 Specification of the Regression Model

This study defines economic growth in the aggregate demand economic model, made up of the components of demand by GDP South Africa. The author symbolises investment by Gross Domestic Fixed Capital Formation South Africa (GDFCFSA). This study symbolises transport infrastructure by Transport Infrastructure South Africa (TINSA), which, for the sake of this study, can be split into railway (Tr1), Roads (Tr2), Airways (Ta3), and ports (Tp4), and the preformation of transport infrastructure by PFTISA. A key emphasis here is that infrastructure stock is generally compared to GDP and infrastructure flows to GDP growth (Fedderke & Garlick, 2008). The author considered this assumption before estimating the model.

This is expressed in the following equation 1 as:

$$\boldsymbol{GDPGSA_t = \beta_0 + \beta_1 GDFCFSA_t + \beta_2 TINFSA_t + \beta_3 PFTISA_t + \mu} \ldots\ldots\ldots\ldots\ldots 1$$

Where t denotes period in years and the coefficients$\boldsymbol{\beta_1}$; $\boldsymbol{\beta_2}$ and $\boldsymbol{\beta_3}$ are known as the coefficients respectively defined as:

- GDFCFSA: Gross Domestic Fixed Capital Formation South Africa (annual percentage growth)
- TINFSA: Transport Infrastructure South Africa

- PFTISA: Performance of Transport Infrastructure (percentage of commercial services)

$GDPGSA$ represents Gross Domestic Product Growth South Africa (annual % of growth).

The **TINFSA** variable is composed of Tr1: Railways (Km) Tr2: Roads (Km), Ta3: Airways (Km) and Tp4: Ports (TEU: 20 foot equivalent units).

Replacing the **TINFSA** variable in equation 1 with the four components will generate equation 2:

$$GDPGSA_t = \beta_0 + \beta_1 GDFCFSA_t + \beta_2 Tr1_t + \beta_3 Tr2_t + \beta_4 Ta3_t + \beta_5 Tp4_t + \beta_6 PFTISA_t + \mu$$

All variables are as define before.

3.4 Description and measurement of variables

Gross domestic capital formation includes all expenses made by households, business people and government, adding new durable goods to the fixed capital stock of a country. These assets are in the form of infrastructure such as buildings, roads, canals, bridges, means of transport, machinery and other equipment. For the present empirical analysis, the study uses GDP growth as a proxy for economic growth.

Transport infrastructure

In this study, transport infrastructure is defined to include road transport, rail transport, port transport, and railway transport, gross domestic capital formation as a proxy for transport infrastructure investment. For the lack of data, the researcher replaced Roadways by Rail lines (total route – km) and Performance of transport infrastructure by Transport services (% of commercial service exports). Therefore, the above equation expresses the annual data on the GDP growth, airways transport, which represents freight (million ton-km), while Railways, goods transported (million ton-km) and port represents Container port traffic (TEU: 20-foot equivalent units). The researcher used the South Africa real GDP and real GDP growth rates to derive the real GDP series.

3.5 Estimation approach

In this dissertation, the author applied the Granger causality test based on the Vector auto-regression (VAR) as suggested by Granger (1988). Under econometric conditions, the test requires stationary of time series data I to achieve desirable results. However, non-stationary implies non-adequacy of the results and the stability condition is not met. Further, Granger (1988) indicated in the case of non-stationary that the researcher performs a co-integration analysis to assess the linkages between variables of concerns. In another word, co-integration test is meant to reveal the existence of a long-run equilibrium relationship between the variables (Pradhan & Bagchi, 2013); in this case, transport infrastructure and economic growth.

According to Bhattacherjee (2012), hypotheses refers to relationships between variables, including independents and dependent, and is an empirical formulation of propositions. Bhattacherjee (2012) also underlines that cause-effect relationships can be tested empirically as either true or false. There are many phenomena that a researcher might want to consider when analysing transport infrastructure and economic growth. However, in this study, the researcher selected one dependent variable and two independents variables, this being economic growth, transport infrastructure (roads, railways, airways, and ports) and stock capital investment. The transition from one variable to other shows the dependence and independence of variables.

3.5.1 Unit root test

Unit root tests are used to examine the degree of integration between the variables and assess their stationarity properties. There are three Dickey-Fuller models, which include intercept, trend and intercept, and no trend and no intercept. All three models come to the same decision as to whether the variables of concern, have unit root or not. This means that all these three models must comply that the variables of concern, have unit root or not. In the case of the Dickey-Fuller Test, this may create a problem of autocorrelation. Therefore, to solve this problem, a test called and Augmented Dickey-Fuller Test is in place. This test goes as follows:

Null hypothesis H0: variable is not stationary or got unit root

Alternative hypothesis H1: stationary

This test is referred to as a test of a time series variables with the presence of a non-stationary, whilst possessing a unit root (Mahadeva & Robinson, 2004). In general terms, the hypothesis has a unit root, whereas the alternative does not possess that trend of a unit root. In this dissertation, the author refers to the test of Granger (1988), who posited that any vector auto-regression model requires an Augmented Dickey-Fuller Test for unit root test (ADF). Many economic variables present a non-stationary trend (Stock & Watson, 1988). Therefore, this test is meant to check on the degree of integration between variables, hence times series stationarity or stability is needed. In the case of this study, the variables considered include GDP growth, Gross Domestic Fixed Capital Formation, transport infrastructure and performance of transport infrastructure.

3.5.2 Co-integration analysis

Co-integration analysis provides a framework for estimation, inference and interpretation when the variables are not covariance stationary (Achour & Belloumi, 2016; Johansen, 1988). The analysis of co-integration is based on certain fundamentals, such as the vector error correction (VEC) model specification; assumptions that economic theory characterises the long-run behaviour (Johansen, 1988, p. 232). Therefore, the co-integrating VAR approach is described as the use of economic theory to impose restrictions to identify power of explanation represented by alpha (*A)* and beta (B) (Garratt, Robertson, & Wright, 2006). It is in this regard that the researcher has considered these principles to undertake a co-integration analysis.

3.5.3 Short run and long-run estimation

According to Johansen (1988), short run and long-run estimation identifies alpha and beta by imposing coefficient of determination R^2 theoretical restrictions. Inference on the parameters depends crucially on the stationarity of the co-integrating equations. The short-run fluctuations represent deviations from the equilibrium – the short-run and long-run economic concepts are linked to the statistical concept of stationarity (Achour & Belloumi, 2016; Badalyan et al., 2014). These economic concepts, in the case of this study, related to GDP, capital infrastructure and transport infrastructure development, which one has to estimate respective causes and effects. This means that it is about which one of these variables causes the other, and verse-versa in the short run, as well as in the long run.

3.6 Summary of the chapter

This chapter has dealt with the research methodology that informs the study. It succeeded in providing methodological steps undertaken to investigate transport infrastructure development impact on economic growth in South Africa. Descriptive analysis and inferential analysis were used as techniques in this study to quantify the impact of transport infrastructure development on economic growth in South Africa. This was tested and analysed by the use of statistic software package STATA 14.

CHAPTER FOUR
EMPIRICAL RESULTS AND DISCUSSIONS

4.1 Introduction

Empirical results are generated from the analysis of infrastructure and economic growth of South Africa. To get these results, the researcher has referred to Gujarati (2006) econometric analysis procedures. These include creating a statement of a theory or hypothesis, collecting data, specifying mathematical model of the theory. These three were dealt with in previous chapters, but in this chapter, the researcher emphasises on parameters. The fourth step calls for specification of econometric or model of theory. The fifth, estimates the parameters of the chosen econometric model. The sixth step checks on the adequacy of the model or model specification test. The seventh step refers to testing the hypothesis derived from the model and the final step uses the model for prediction. This dissertation considers the mentioned steps for better results which are presented respectively, descriptive statistics, unit root, co-integration, and short and long run results.

4.2 Descriptive statistics

In terms of description of variables interest, this was based on the annual time series on South African macroeconomic indicators. These include GDPGSA, which represents GDP growth South Africa (annual % of growth) and GDFCFSA, also represents Gross Domestic Fixed Capital Formation South Africa (annual percentage growth). Transport infrastructure is presented in this study by the availability of and quality of roads, railways, airways and ports. tr_1= Railways transport data; replace tr2= Roads transport data.

The following table, Table 2, presents a summary of descriptive statistics on overall variables.

Table 2: Summary of Variables Descriptions

Variables	Min	Max	Mean	SD	Obs
GDPGSA	-2.137	6.621	2.570	2.241	46
GDFCFSA	-17.506	16.276	3.473	7.562	46
tr_1	1.000	29.000	14.600	7.781	35
tr2	1.000	29.000	14.600	7.781	35
ta_3	1	46	23.5	13.4226	46
tp4	1801610	4831462	3383227	1030686	15
pftisa_1	1	46	23.5	13.4226	46

Notes: Gross Domestic Product Growth South Africa; GDFCFSA= Gross Domestic Fixed Capital formation South; tr_1= Railways transport; tr2= Roads transport; ta_3= Airways transport, tp4= Ports transport; pftisa= Performance of transport infrastructure

4.3 Results

4.3.1 Unit root results

In this model, the study included time trend as the observation trends up and down. At the same time, the author included the constant, as the series did not fluctuate around the average of the sample. Therefore, the study considered the variable GDP of South Africa to test the unit root. The following results are demonstrated in table 3:

Table 3: Unit root test results: ADF Test statistic

Variables	**Lag Difference (0) 5% critical value**		**Decision**		**Lag Difference (1) 5% critical value**		**Decision**
	Test Statistic	Critical Value			Test Statistic	Critical Value	
GDPGSA	-4.686	-3.52	Stationary		-4.484	-3.524	Stationary
GDFCFSA	-3.741	-3.52	Stationary		-5.044	-3.524	Stationary
tr_1	-4.045	-3.564	Stationary		-3.437	-3.568	Not Stationary
tr2	-4.045	-3.564	Stationary		-3.437	-3.568	Not Stationary
ta_3	-3.551	-3.52	Stationary		-2.986	-3.524	Not Stationary
tp4	-2.046/	-3.6	Not Stationary		-1.716	-3.6	Not Stationary
pftisa_1	-3.786	-3.52	Stationary		-4.28	-3.524	Stationary

NB: Notes: Gross Domestic Product Growth South Africa; GDFCFSA= Gross Domestic Fixed Capital formation South Africa; tr_1= Railways transport; tr2= Roads transport; ta_3= Airways transport, tp4= Ports transport; pftisa= Performance of transport infrastructure; 5% Critical value for the rejecting of hypothesis of unit root

The purpose was to see if the data was stationary or non-stationary, with stationary meaning that the series revolves around a constant means. The hypothesis stipulates that if the absolute value of test statistic is more than critical value, we can reject null hypothesis and can accept alternative hypothesis. Secondly, if the absolute value of test statistics is less than critical value, we cannot reject null hypothesis, rather we accept null hypothesis.

The above results indicate, for example, that GDP growth South Africa, absolute value of test statistic (4,686) is more than critical value (3,520). In this regard, we reject the null hypothesis and accept the alternative hypothesis. This is to say that the variable GDP is stationary or does not have unit root. This result is consistent with the nature of stationarity due to the findings by vector auto-regression and co-integration as presented in the next subsection. The next subsection presents co-integration test results of the variables.

4.3.2 Co-integration results

The co-integration test examines the existence or otherwise of a long-run equilibrium relationship between the variables (Pradhan & Bagchi, 2013). It implies the existence of a long-run association between economic variables. This dissertation examines this relationship among economic growth, transport infrastructure, preformation of transport infrastructure and capital investment in South Africa. The hypothesis that tests this is the null of no co-integration, whereas the alternative hypothesis indicates that co-integration exists.

To perform the Johansen test of co-integration, the process as follows condition in this way: In the Johansen test, variables must be non-stationary at level, but convert into first difference, they must be stationary. Therefore, the study assumes that the variables such as GDPGSA, GDFCFSA, tr_1, tr2, ta_3, tp4, and pftisa_1 are co-integrated. Hence, let us consider a South Africa economic growth and transport infrastructure sample from 1982 to 2014. A co-integration test results in Trace test and Max test statistics, presented in the following table 4:

Table 4: Economic Growth and Transport Infrastructure South Africa

	Rank test (Trace)			**Rank test (Max)**		
Maximum rank	eigen value	**Trace statistic**	5% Critical value	eigen value	**Max statistic**	5% Critical value
0	.	122.8961	94.15	·	52.4886	39.37
1	0.79619	70.4075	68.52	0.79619	35.2140	33.46
2	**0.65599**	**35.1935***	**47.21**	**0.65599**	**15.2890***	**27.07**
3	0.37080	19.9045	29.68	0.37080	13.8911	20.97
4	.34357	6.0134	15.41	0.34357	3.5618	14.07
5	0.10231	2.4515	3.76	0.10231	2.4515	3.76
6	0.07160			0.07160		

None (0) Denotes a rejection of the null hypothesis at the 5% level.

Star (*): Indicates number of co-integration related to the maximum rank: two (2).

GDPGSA = Gross Domestic Product Growth South Africa; GDFCFSA = Gross Domestic Fixed Capital formation South Africa; tr_1 = Railways transport; tr2= Roads transport; ta_3 = Airways transport; pftisa = Performance of transport infrastructure.

If trace statistic is more than critical value (0.05), we can reject the null hypothesis and accept the alternative hypothesis, meaning that there is co-integration. But, if trace statistic is less than critical value (0.05), we accept the null hypothesis. The same apply to Max statistic.

The highest lag presented in Table 4 is six (6). At lag 2, the six variables are co-integrated, meaning that, in the long run, these variables are moving together, and have long-run association. The decision is based on trace and max test statistic. The trace statistic of 35.1935 is less than the critical value of 47.21; hence the null hypothesis of no co-integration cannot be rejected (see annexure 4). This is to say that we can accept the null hypothesis, meaning that there is two co-integration among variables economic growth and transport infrastructure South Africa. The Max statistic of 15.2890 is less than the critical value of 27.07; hence the null hypothesis of no co-integration cannot be rejected (see annexure 4). The second model Max statistic results in the same results as on trace statistic, showing that there is co-integration (See Table 4). Max statistics present a co-integration among variables at different ranks. This means that in the long run, economic growth and transport infrastructure will be moving together in an association's relation, which will stimulate the South African economy. Based on the above results, our six variables are co-integrated or have long-run association. This means that they are moving together in the long run. Therefore, when the variables are co-integrated, we can run a vector error correction model (VECM).

Hence, when one considers economic growth, capital formation, airways transport and performance of transport infrastructure, there is an indication of one co-integration. The trace statistic of 19.7319 is less than the critical value of 29.68, and the Max statistic of 12.9445 is less than the critical value of 20.97 (See annexure 2A). Subsequently, when considering economic growth, capital formation, railways transport and roads transport, the results show the existence of two co-integration. The trace statistic of 14.4261 is less than the critical value of 15.41(See annexure 2B); hence the null hypothesis of no co-integration cannot be rejected. This to say that we can accept the null hypothesis, meaning that there is two co-integration among the aforementioned variables.

Therefore, in South Africa, a long-run equilibrium relationship among roads, airways, port ways and rail transportation infrastructure, GDP, gross capital formation, and performance of transport infrastructure may exist. In another words, the dependent (GDPGSA) and independent variables (airways, the preformation of transport infrastructure, GDFCFSA, railway and roads) in this study have a long-run association, or, in the long run, may move together. The following section presents lag selection, thereafter VECM.

4.3.3 Selection of lag length

The question here was how many lags should be used in the system equation? To respond to this question, we ran VAR and VECM diagnostics tests. The results have been reported in the following table, Table 5.

Table 5: Selection of Lag length

Models	Nº of lag	LR	P	FPE	AIC	HQIC	SBIC
Vector Auto Regression Model (1)	4	296.07*	0.000	1.519*	57.4759*	59.7378*	64.4146*
Vector Error Correction model (2)	4	296.07*	0.000	1.519*	57.4759*	59.7378*	64.4146*

*Star(*****):Indicates lag order selected by the criterion:**LR**:sequential modified LR test statistic (each test at 5% level); **FPE**:Final prediction error; **AIC:**Akaike information criterion; **SC**: Schwarz information criterion, as **lowest value of each criteria(See annexure 1)***

***VARM**: Vector auto Regression Model and **VECM**: vector error correction model present same Outcomes. Four out of four criteria are talking the same language of four lags. All criteria are good and efficient.*

The guideline here was that the lower the value, the better the models. The above table shows that all criteria presented lower value, at four (4) lag. This means four lag should be used and also that all criterion are good to be chosen as they suggest taking four lags. Therefore, four lags will be chosen for the future model.

Both tests from the two models showed the same results. Thus, we should be using four lags in the Johansen test of co-integration model and in the VAR or VECM, because all models are system equation models, and the lag selection criteria is also a system equation model. We can therefore select four lags in all systems equation models. Therefore, optimum lag is four.

4.3.4 Long run and short run results

The vector error correction model (VECM) is employed to detect the long and short run relationships among the variables, and can identify sources of causation. VECM refers to the error correction terms derived from the long run co-integrating relationships, while the short run dynamics are captured through the coefficients βi of the explanatory variables.

The coefficients δ of the Error Correction Terms detect the deviation of the dependent variables from the long run equilibrium in the equation (1). To check causality among variables, we used the standard Granger test in terms of the long run as well as short run. This was based respectively on appropriated tests. We considered the target model as GDP Growth South Africa (dependent variable) on Gross Domestic Fixed Capital Formation South Africa, railways transport, roads transport, airways transport, ports transport, performance of transport infrastructure. In this regard, there are two tests to run, including long run causality and short run causality.

4.3.4.1 Long run causality

The long run causality is based on the error correction term or speed of adjustment towards equilibrium (CE1), which, if negative in sign and significant, means there is a long run causality, running from independent variables (Gross Domestic Fixed Capital Formation South Africa: railways transport, roads transport, airways transport, ports transport, performance of transport infrastructure), to dependent variable (GDP Growth South Africa). Hence, in this case, there is a positive coefficient 5.602879 of error correction term (CE1) and p-value of 0.239 (not significant) (see Annexure 3). The decision therefore is that there is no long run causality running from independent variables (Gross Domestic Fixed Capital Formation South Africa: railways transport, roads transport, airways transport, ports transport, performance of transport infrastructure) to dependent variable (GDP Growth South Africa). See result extracted from Annexure 2 in the following table, Table 7:

Table 7: Target Model to consider for Long Run Causality

	Coefficient	**Standard. Err.**	**Z**	**P>|z|**	**95% Conf. Interval**
D_GDPGSA _ce1					
L1.	5.602879	4.760269	1.18	0.239	14.93283

D_GDPGSA: Conversion of South Africa gross domestic product in first difference.
CE1: Error Correction Model or speed of adjustment towards equilibrium

4.3.4.2 Short run causality

It was stated that a null hypothesis: 0 refers to non-existence of short run causality running from independent variables (Gross Domestic Fixed Capital Formation South Africa: railways transport, roads transport, airways transport, ports transport, performance of transport infrastructure) to dependent variable (Gross Domestic Product Growth South Africa). This was based from lag 1 to 4, means lag 1 to lag 4 of all independent variables jointly can cause or not the dependent variable. The following table, Table 8, presents the results.

Table 8: Short Run Causality

Variables		Chi^2	$Prob>Chi^2$	P-value
Dependent	**Independent**			
D_GDPGSA	L_{1-4} GDFCFSA	1.88	**0.7569**	0.05
	L_{1-4} tr_1	1.69	0.7924	0.05
	L_{1-4} tr2	2.33	0.6746	0.05
	L_{1-4} ta_3	2.11	0.7153	0.05
	L_{1-4} pftisa_1	2.30	0.6809	0.05

NB: L_{1-4} : lag 1 to lag 4 of each independent variable.

The results from the table above show that all probabilities are more than 0.05, meaning that we cannot reject null hypothesis, rather than accept null hypothesis. This means that there is no short run causality from all independent variables to dependent variable. As a consequence, there is no long run or short run causality running from Gross Domestic Fixed Capital Formation South Africa: railways transport; roads transport; airways transport, ports transport; performance of transport infrastructure to Gross Domestic Product Growth South Africa.

4.3.5 Causality Analysis Results

To start, the researcher considers the first of two variables, such as Gross Domestic Product Growth South Africa (GDPGSA) and Gross Domestic Fixed Capital Formation of South Africa (GDFCFSA). The researcher assumes without checking that these two variables are stationary or do not have any a unit root. This is due to the fact that, in the Granger causality test, the variables must be stationary. The researcher considers, as indicated, GDPGSA, which is Gross Domestic Product Growth of South Africa and GDFCFSA, which is Gross Domestic Fixed Capital Formation of South Africa as stationary. If not, there is a need to make them stationary before testing Granger causality test. Also, assume assumption on $\mathbf{u}_1$ and $\mathbf{u}_2$ terms of error as uncorrelated.

Time period: 1971 to 2015

Causality results between GDPGSA and GDFCFSA

Table 9: GDPGSA and GDFCFSA

	South Africa	
Hypotheses tested	0.05	Decision
Gross Domestic Product growth SA causes Gross Domestic Fixed Capital Formation SA	0.03	yes
Gross Domestic Fixed Capital Formation SA causes Gross Domestic Product growth SA	0.967	No

Gross Domestic Product growth SA; GDFCFSA: Gross Domestic Fixed Capital Formation SA at 5% level of significance both in the short run and in the long run and not vice versa.

4.3.5.1 Interpretation of statistic results

Null hypothesis: Lagged GDFCFSA does not cause GDPGSA, alternative hypothesis: Lagged GDFCFSA does cause GDPGSA. The probability value is (0.03) less than 0.05, therefore we can reject null hypothesis, meaning we can accept the alternative hypothesis. This implies that GDPGSA causes GDFCFSA.

4.3.5.2 Economical interpretation of Granger causality test

The Granger causality test revealed that an economic variable such as GDP growth causes gross domestic capital fixed formation in South Africa. It follows the interpretation posits of many previous studies on GDP and gross capital fixed formation worldwide. This implies an increase of economic growth, which means that an amount of goods and services produced in South Africa over a period of time has increased (Wolla, 2013). As consequence of economic growth increase, implies causes increase into capital investment related to infrastructure development. The emphasis in this regard is that there is an increase in the productive capacity or potential output, of the South African economy which results in the net return to society in terms of job creation. Economic growth appears to be one of the main drivers of gross domestic fixed capital formation but not the other way around. This result is consistent with the findings of Kumo (2012), who pointed out a strong bidirectional relationship between GDP and transport infrastructure. The only difference appears that the current study shows a unidirectional causality between economic growth and gross domestic fixed capital formation that runs from the former to the later.

This dissertation has considered as causal variable result as GDP or economic growth and the effect variable result as gross domestic fixed capital formation. The effect variable, which is capital infrastructure investment, will also be known as a sufficient condition for growth in the country. This means that the country's economic growth in the gross domestic fixed capital formation sector determines the investment in infrastructure and related services in the long run and not vice versa in the short term.

Further, the author tested the causality relationship between GDP and railways transport. The findings revealed that we can reject the null hypothesis as the probability value is (0.01) less than 0.05. This means that we accept that GDP growth causes railways transport. The following table, Table 10, presents the results.

Causality results between GDPGSA and Railways Transport SA

Table10: Economic Growth and Railways Transport

	South Africa	
Hypotheses tested	0.05	Decision
GDP growth SA causes Railways Transport SA	0.0151	yes
Railways Transport SA causes GDP growth SA	0.1644	No

4.3.5.3 Economic interpretation on ED and Tr1

Economic interstation holds that there is a causal link between railways transport and economic growth that runs from the latter to the former. This is to indicate that when there is an increase in economic growth of a country, it motivates the government to invest or improve railways transportation system. In addition, this analysis seems consistent with the results of previous studies, which assume economic growth of the country in the transport sector determines railways transport and related services in the long run, and not vice versa in the short run (Achour & Belloumi, 2016).

Moreover, the author tested the link between GDP growth and roadway transport. The results indicated that probability value is more than 0.05; therefore we cannot reject the null hypothesis. The following table, Table 11, displays the results.

Causality results between GDPGSA and Roadways Transport SA

Table 11: Economic Growth and Roadways Transport

	South Africa	
Hypotheses tested	0.05	Decision
GDP growth SA causes Roadways Transport SA	0.0810	No
Roadways Transport SA causes GDP growth SA	0.7680	No

However, since rail lines (Tr1 replace roadways (Tr2) as specified in previous section, the result appeared the same. Thus regression results on the impact of roadways can be interpreted or be the same as those for the impact of railroads.

4.3.5.4 Economic interpretation on EG and Tr2

The economic interpretation shows that we accept that there is no-link between GDP and roads transport. This result is justified, as the author replaced roadways transport data by rail lines total root-km, due to the lack of data in this regard. It could have been better off if we had had available roadways transport data under the time period of the study.

However, this result is contrary and inconsistent with the expectation, as one could have liked to see roadways transport impacting positively on economic growth in South Africa, due to its quality and services. Many studies support the view that roadways transport as a basic factor into production process would be predicted to have a positive impact on economic growth (Fedderke & Garlick, 2008).

Ceteris paribus, to say all things being equal, roadways transport cause economic growth in the transport sector. Therefore, causality relationship is more supportive than likewise. However, the problem can be attributed to the data a concern specific to roadways in South Africa.

Further, the author tested the relationship between GDP and air transport in South Africa. The findings indicated probability value more than 0.05, therefore, we accept hull hypothesis. The following table, Table 12, presents the results.

Causality results between GDPGSA and Airways Transport SA

Table 52: Economic Growth and Airways Transport

	South Africa	
Hypotheses tested	0.05	Decision
GDP growth SA causes Airways Transport SA	0.6986	No
Airways Transport SA causes GDP growth SA	0.2136	No

4.3.5.5 Economic Interpretation on EG and Ta3

The above results indicate non-link between GDP and airways transport. Although airways transport presents full indicators, the causal relations between airways transport and GDP appears non-existent. In addition, the author assessed the link between GDP and ports transport. The statistic result shows a probability value of 0.04 less than 0.05; therefore, we reject null hypothesis. This means that we accept linkage between GDP and ports transport in South Africa.

The following table, Table 13, shows the result.

Causality results between GDPGSA and Ports Transport SA

Table 13: Economic Growth and Ports Transport

	South Africa	
Hypotheses tested	0.05	Decision
GDP growth SA causes Airways Transport SA	0.0403	yes
Airways Transport SA causes GDP growth SA	0.2373	No

4.3.5.6 Economic interpretation on EG and Tp4

Economically, there is a strong relationship between GDP and ports transport that runs from the former to the latter. This is to indicate the extent to which GDP causes movement of goods and services though ports or harbours in South Africa. These ports or harbours include the Port of Cape Town, Port of Durban, Port of Ngqura (Port Elizabeth) and Richards Bay

Harbour. It is also consistent to indicate that the economic growth in the transport sector determines ports transport in the long run, while not vice versa in the short term.

In addition, some evidence demonstrates that economic growth stimulates ports transport in South Africa. This includes increase in goods and services produced by the manufacturing, industrial and commercial sectors. These products need facilities to move them from one point to another, and that is ports transport facilities.

Finally, the author tested the relationship between GDP and performance of transport infrastructure. The results showed that probability value is more than 0.05; therefore, we cannot reject the null hypothesis. The following table, Table 14, demonstrates.
Causality results between GDPGSA and Transport Performance SA.

Table 14: Economic Growth and Transport Performance

	South Africa	
Hypotheses tested	0.05	Decision
GDP growth SA causes Transport performance SA	0.2140	No
Transport performance SA causes GDP growth SA	0.8934	No

4.3.5.7 Economic interpretation on EG and Tftisa1

The results show non-existence of relationship between GDP and transport infrastructure permanence, represented by transport services of export in South Africa. This suggests in normal circumstance that the export-led growth theory considers exports to be a driver of economic growth in the exporting counties (Belloc, 2012; and Felipe, & Fisher 2003). Indirectly, the services related will increase as exports increase. As a consequence, improvement of the services related to transport infrastructure occurs as long as performance is concerned. This view contradicts the current findings, as there is a no-causal relationship between GDP and transport services.

4.4 Summary chapter Four: Empirical Results and Discussion

This chapter was about estimation of empirical model, related to the relationship between infrastructure development and economic growth in South Africa. The empirical analysis via unit root test confirmed stationary of the variable (GDP). Also, the empirical analysis showed existence of two co-integration among variables economic growth and transport infrastructure South Africa. Finally, the short and long run analysis indicated that Gross Domestic Product growth South Africa causes Gross Domestic Fixed Capital Formation South Africa. However, there is no long run or short run causality running from Gross Domestic Fixed Capital Formation South Africa: railways transport; roads transport; airways transport, ports transport; performance of transport infrastructure to Gross Domestic Product Growth South Africa. This implies unidirectional causality between economic growth and gross domestic fixed capital formation that runs from the former to the later.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The focus of this dissertation is an examination of the impact of transport infrastructure and economic growth in South Africa from 1970 to 2015. The purpose was to investigate whether there is a positive link between transport infrastructure development and economic growth. A quantitative method was required for an effective examination of the relationship between transport infrastructure development and economic growth in South Africa. This method was based on empirical analysis for the period 1970 to 2015.

Chapter One introduced the background and purpose of the study, the problem statement and research objective. It also presented the significance of the study, scope and delimitation; research assumption and outline of the study. Chapter Two provided a conceptual and theoretical framework related to the infrastructure and economic growth, as well as a literature review on transport infrastructure and economic growth. Chapter Three focused on methodology, while Chapter Four presented the results and discussions. Chapter Five presents the conclusions and recommendations.

5.2 Re-visitation of objectives

The general objective, as indicated in section 1.5, was to examine whether there is a link between transport infrastructure development and economic growth in South Africa. This was covered in Chapters Four and Five. Prior to this result, Chapter Two covered an extensive literature review, concepts and theories related to comprehend transport infrastructure and economic growth under investigation. Chapter Three executed methodology to examine the link between transport infrastructure and economic growth. Chapters Four and Five responded to the second and third objectives of the study.

Chapter one captured the following objectives:

- To find out whether there is a positive link between transport infrastructure and economic growth.

- To find out whether improved transport technology and networks accelerate economic growth and improve the quality of life of citizens.
- To find out whether transport investment is a catalyst for economic growth or whether economic growth puts pressure on existing transport infrastructures and incites additional investment.

From the above, the findings responded to the question of whether there is a link between transport infrastructure and economic growth, which was covered in Chapter Four, section 4.5 – such a link exists unidirectional between economic growth and transport infrastructure (railways and ports), that runs from the former to the latter. Whether improved technology and networks accelerate economic growth was also covered in section 4.5 – such link was non- existent. Finally, as to whether economic growth puts pressure on existing transport infrastructure, it was indeed found that economic growth causes transport infrastructure.

5.3 Summary of the study

A review of an intensive literature on economic growth and infrastructure development indicated that infrastructure development causes economic growth and vice versa; that economic growth causes infrastructure development. This substantiates the bidirectional causality association between economic growth and infrastructure investment.

The review also indicated that transport infrastructure facilitates economic activities. The infrastructure stocks or flows need to be associated with a correct measure of aggregate economic performance. The review further indicated that government consideration to intervene in the infrastructure development sector enhances infrastructure potential as far as connectivity is concerned. In addition, theoretically, an increase in one of factors of production stock or flows of infrastructure would increase the total output of the economy. This results in an impact of infrastructure on macroeconomic indicators. An empirical analysis associated with these indicators covers the long run association of variables of concerns across countries, to test the presence and direction of causality. Thus, the empirical findings on the long-term link between transport infrastructure and economic growth in the current study are consistent with previous empirical studies across countries.

This dissertation examined the link between transport infrastructure and economic growth in South Africa using data for the 1970 to 2015 periods. For this purpose, co-integration and Granger causality tests were applied. These tests attested to the existence of more than one co-integration vector, indicating that the system under investigation is stationary in more than one direction. This study found that there is a strong unidirectional causality relationship between economic growth and gross domestic fixed capital formation. Also, the findings revealed a directional causality relationship between economic growth and transport infrastructure (railways transport and port transport), that runs from the former to the latter. It should be indicated that economic growth causes transport infrastructure.

However, the results showed a sign of non-link between economic growth and transport infrastructure (roadways and airways). In contrast, the theoretical foundation revealed that transport infrastructure such as railways and airways cause economic growth and vice versa. In general, there is the existence of a unidirectional causality relationship between economic growth and gross domestic fixed capital formation, and between economic growth and transport infrastructure (both railways and ports transport).

5.4 Conclusion

This dissertation explored the possibility of linkages between transport infrastructure and economic growth in South Africa in the period 1970 to 2015, using co-integration and causality tests. The findings showed that much evidence demonstrates that economic growth stimulates ports transport in South Africa. This includes an increase in goods and services produced by the manufacturing, industrial and commercial sectors. Products need transport to move them from one point to another, which can be easily achieved through ports transport facilities.

The results also indicated a unidirectional relationship between GDP or economic growth and gross domestic fixed capital formation. This means that an increase in economic growth increases household income, which ultimately results in a tax revenue increase. This consequently increases contribution of gross domestic fixed capital formation, within which transport infrastructure has a big portion.

The results further indicated that a unidirectional causality exists from GDP to railway transport in South Africa. This result shows that an increase in economic growth results in the use of railways transport. This is because primary sector industries produce raw materials, which need to be transported. Further, manufacturing industries produce raw and semi-raw material, which needs to be transported to the centre of consumption or export-based destination. In this regard, export of products is more accurate in South Africa, as the country is export orientated and import penetration. Railways play a pivotal role in developing countries such as South Africa. It was observed that an increase in economic growth impacts on railways, which then call for government-led infrastructure policies to guide expected trends.

In conclusion, the link between economic growth gross domestic fixed capital formation and transport infrastructure (railways, roadway, airways and ports) is expected to be a causal relationship in the long run. This will reverse the unidirectional or add bidirectional causality trend to economic growth and transport infrastructure (railways and ports transport), and to economic growth and gross domestic fixed capital formation. This will occur due to the long-run co-integration patterns over the variables under investigation. The influence of railways and port transport facilitates the movement of goods and people, but its impact appears statistically negligible. For instance, railways records 0.01, while ports transport is 0.04. As a result, policy makers need to promote and enhance the services.

5.5 Recommendations

The examination of transport infrastructure and economic growth in South Africa revealed interesting results; results which should be considered in the process of initiating and implementing transport policies in relation to the economic growth of South Africa.

It is recommended that the process of determining and formulating macroeconomic indicators considers the transport sector, specifically railways, roadways, airways and port transport. It is also recommended that policymakers ensure the promotion and enhancement of existing infrastructure. In addition, it is recommended that they increase investment in transport infrastructure development.

These recommendations are consistent with previous studies on transport infrastructure and economic growth.

Future studies could analyse the indirect and direct relationship between transport infrastructure development and economic growth. Future studies could further include South African government and other South African sources of data to analyse the above relationship.

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APPENDIX: RESULTS

OBS	GDPGSA	GDFCFSA	Tr1	Tr2	Ta3	Tp4	PFTISA
1970	5,248543	14,28362			56,8		20
1971	4,279002	11,65997			63,9		20,67361
1972	1,654788	6,810433			75,8		22,39796
1973	4,572026	3,838788			112,7		24,4848
1974	6,111071	6,155282			143,6		24,59434
1975	1,695372	9,680008			142,3		20,3598
1976	2,249987	-0,47204			146,3		23,24955
1977	-0,0941	-6,96082			173,8		23,74392
1978	3,014508	-3,90088			222,1		25,03429
1979	3,790545	4,04135			237		27,59494
1980	6,62059	16,27615	99556	23596	251,2		26,34389
1981	5,360741	9,572802	99170	23596	311,4		24,38999
1982	-0,38335	-2,12277	103890	23581	318,2		24,0155
1983	-1,84655	-4,45884	84100	23664	367,3		21,93456
1984	5,099075	-1,3732	85220	23720	442,9		21,92028
1985	-1,21144	-6,978	91860	23821	391,8		26,2871
1986	0,017787	-17,5061	91960	23790	308,2		25,53639
1987	2,100778	-2,92316	90570	23607	268,1		23,10258
1988	4,200043	10,48731	87080	23507	238,3		23,98502
1989	2,39486	6,6436	93980	21244	205,6		23,87444
1990	-0,31778	-2,41101	101746	21617,06	179,2		21,99633
1991	-1,01831	-7,31821	85569	21635	191		21,38732
1992	-2,13704	-4,74132	89248	21635	263,2		25,69484
1993	1,233613	-0,73689	91359	22233	332,9		24,692
1994	3,2	8,264972	93487	22621	276,5		24,55458
1995	3,1	10,09924	96559	20319	263,1		23,66607
1996	4,3	12,89345	99687	20319	328,5		20,25988
1997	2,6	6,086008	104632,1	20189	420,4		20,48443
1998	0,5	0,811578	102286,8	20189	535,6		20,5484
1999	2,4	-7,51874	102800	20070	688,4		21,03797
2000	4,2	3,94283	106605	22657	687,569	1846944	23,57445
2001	2,7	3,218048	105393	22657	755,516	2021183	24,13932
2002	3,700374	4,29897	103717	22657	783,844	1801610	22,57046
2003	2,949075	10,18937	106538	20041	891,465	2378881	17,19784
2004	4,55456	12,9096	108503	20247	928,987	2614577	17,22722
2005	5,277052	10,97814	108513	20047	923,383	3111121	17,08309
2006	5,585046	12,10147	108513	20047	1232,995	3552198	17,11426
2007	5,360474	13,75871	108513	24487	939,199	3734165	18,46796
2008	3,191044	12,82252	106014	24487	760,889	3875952	18,83698
2009	-1,53809	-6,67675	113342	22051	676,413	3726313	17,94872
2010	3,039747	-3,91225	113342	22051	1025,562	3806427	19,29738
2011	3,212452	5,724448	113342	20500	1072,915	4392975	19,2629
2012	2,219824	3,604901	113342	20500	1174,667	4360100	17,78273
2013	2,212354	7,62369	113342	20500	1122,986	4694500	18,62501
2014	1,548701	-0,38646	134600	20500	1042,736	4831462	18,01874
2015	1,283296	1,382145			885,278		16,40993

ANNEXURE 1: OUTPUT SELECTION OF LAG LENGTH

. varsoc GDPGSA GDFCFSA tr_1 tr2 ta_3 pftisa_1

Selection-order criteria

Sample: 1984 - 2014 Number of obs = 31

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-1014.11				1.5e+21	65.8139	65.9043	66.0914
1	-966.36	95.509	36	0.000	7.6e+20	65.0555	65.6888	66.9983
2	-931.292	70.136	36	0.001	1.1e+21	65.1156	66.2918	68.7237
3	-888.912	84.761	36	0.000	1.7e+21	64.704	66.423	69.9774
4	-740.877	296.07*	36	0.000	1.5e+19*	57.4759*	59.7378*	64.4146*

Endogenous: GDPGSA GDFCFSA tr_1 tr2 ta_3 pftisa_1

Exogenous: _cons

. varsoc GDPGSA GDFCFSA tr_1 tr2 ta_3 pftisa_1

Selection-order criteria

Sample: 1984 - 2014 Number of obs = 31

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-1014.11				1.5e+21	65.8139	65.9043	66.0914
1	-966.36	95.509	36	0.000	7.6e+20	65.0555	65.6888	66.9983
2	-931.292	70.136	36	0.001	1.1e+21	65.1156	66.2918	68.7237
3	-888.912	84.761	36	0.000	1.7e+21	64.704	66.423	69.9774
4	-740.877	296.07*	36	0.000	1.5e+19*	57.4759*	59.7378*	64.4146*

Endogenous: GDPGSA GDFCFSA tr_1 tr2 ta_3 pftisa_1

Exogenous: _cons

ANNEXURE 2: OUTPUTS JOHANSEN TEST OF CO-INTEGRATION

```
. corrgram GDPGSA

                          -1       0       1 -1       0       1
 LAG       AC       PAC      Q     Prob>Q  [Autocorrelation]  [Partial Autocor]
-------------------------------------------------------------------------------
1      0.3228   0.3256    5.113  0.0237          |--                |--
2     -0.0570  -0.1764   5.2762  0.0715           |                -|
3     -0.0578   0.0203    5.448  0.1418          |                |
4     -0.0347  -0.0224   5.5112  0.2387           |                |
5      0.0046   0.0265   5.5124  0.3566          |                |
6      0.1547   0.1536   6.8341  0.3365          |-               |-
7      0.1252   0.0349   7.7219  0.3578          |-               |
8      0.0889   0.0691   8.1814  0.4159          |                |
9     -0.0528  -0.1080   8.3478  0.4995           |                |
10     0.0241   0.1456   8.3833  0.5915           |               |-
11    -0.1480  -0.3171   9.7649  0.5517          -|              --|
12    -0.3144  -0.3244   16.183  0.1830         --|              --|
13    -0.2237  -0.2197   19.532  0.1075          -|               -|
14    -0.1293  -0.3033   20.686  0.1099          -|              --|
15    -0.0939  -0.2430   21.314  0.1271           |               -|
16    -0.0314  -0.2172   21.387  0.1641           |               -|
17    -0.0675  -0.2572   21.733  0.1952           |              --|
18    -0.1056  -0.1473   22.612  0.2059           |               -|
19    -0.1391  -0.2025   24.195  0.1888          -|               -|
20    -0.1134  -0.0872   25.288  0.1906           |                |
21    -0.1359  -0.3017   26.919  0.1736          -|              --|
```

```
. corrgram D.GDPGSA

                          -1       0       1 -1       0       1
 LAG       AC       PAC      Q     Prob>Q  [Autocorrelation]  [Partial Autocor]
-------------------------------------------------------------------------------
1     -0.2173  -0.2173   2.2692  0.1320          -|               -|
2     -0.2618  -0.3271   5.6414  0.0596         --|              --|
3     -0.0453  -0.2210   5.7448  0.1247           |               -|
4     -0.0229  -0.2310   5.7717  0.2169           |               -|
5     -0.0450  -0.2783   5.8787  0.3182           |              --|
6      0.1106  -0.1371   6.5421  0.3653           |               -|
7      0.0476  -0.1370   6.6682  0.4642           |               -|
8      0.0621   0.0412   6.8886  0.5487           |                |
9     -0.1721  -0.2094   8.6289  0.4722          -|               -|
10     0.1619   0.2399   10.213  0.4220           |-               |-
11     0.0034   0.1685   10.214  0.5113           |               |-
12    -0.1501   0.0033   11.658  0.4735          -|                |
13     0.0149   0.0186   11.673  0.5546           |                |
14    -0.0233  -0.1376    11.71  0.6296           |               -|
15     0.0441  -0.1217   11.847  0.6906           |                |
16     0.0564  -0.1310   12.079  0.7385           |               -|
17    -0.0264  -0.2488   12.132  0.7921           |               -|
18    -0.0142  -0.2131   12.148  0.8395           |               -|
19    -0.0214  -0.2748   12.185  0.8776           |              --|
20     0.0564  -0.0541   12.454  0.8996           |                |
```

```
. corrgram GDFCFSA

                                  -1       0       1 -1       0       1
 LAG       AC       PAC      Q     Prob>Q  [Autocorrelation]  [Partial Autocor]
-------------------------------------------------------------------------------
1       0.5320   0.5331   13.885  0.0002          |----             |----
2      -0.0161  -0.4167   13.898  0.0010          |              ---|
3      -0.1865   0.0898   15.684  0.0013         -|                 |
4      -0.0960  -0.0014   16.168  0.0028          |                 |
5      -0.0347  -0.0787   16.233  0.0062          |                 |
6      -0.0398   0.0042   16.321  0.0121          |                 |
7       0.0957   0.2149   16.839  0.0185          |                 |-
8       0.2230   0.0300   19.729  0.0114          |-                |
9       0.1587  -0.0399   21.232  0.0117          |-                |
10     -0.0028   0.0165   21.233  0.0195          |                 |
11     -0.1976  -0.3135   23.697  0.0141         -|               --|
12     -0.1780   0.1259   25.756  0.0116         -|                 |-
13     -0.0622  -0.1035   26.014  0.0169          |                 |
14     -0.0727  -0.3313   26.378  0.0232          |               --|
15     -0.0785   0.1016   26.817  0.0303          |                 |
16     -0.0757  -0.3139   27.239  0.0389          |               --|
17     -0.0834  -0.1920   27.768  0.0477          |                -|
18     -0.1410   0.1590   29.335  0.0444         -|                 |-
19     -0.1825  -0.4465    32.06  0.0308         -|              ---|
20     -0.2335  -0.7809   36.688  0.0128         -|           ------|
21     -0.2608  -0.4943   42.696  0.0034        --|              ---|
```

```
. corrgram D.GDFCFSA

                                  -1       0       1 -1       0       1
 LAG       AC       PAC      Q     Prob>Q  [Autocorrelation]  [Partial Autocor]
-------------------------------------------------------------------------------
1       0.0994   0.0997   .47532  0.4906          |                 |
2      -0.3953  -0.4225   8.1594  0.0169       ---|              ---|
3      -0.2837  -0.2310   12.213  0.0067        --|                -|
4       0.0237  -0.1302   12.242  0.0156          |                -|
5       0.0475  -0.2057   12.361  0.0302          |                -|
6      -0.1140  -0.3336   13.066  0.0420          |               --|
7       0.0601  -0.1109   13.268  0.0658          |                 |
8       0.2041  -0.0324   15.649  0.0477          |-                |
9       0.0711  -0.0900   15.947  0.0680          |                 |
10     -0.0223   0.2104   15.977  0.1003          |                 |-
11     -0.2081  -0.2502   18.672  0.0672         -|               --|
12     -0.0545   0.0080   18.862  0.0919          |                 |
13      0.1487   0.1903   20.324  0.0874          |-                |-
14     -0.0208  -0.2536   20.353  0.1194          |               --|
15      0.0183   0.1925   20.377  0.1579          |                 |-
16      0.0518   0.0722   20.572  0.1955          |                 |
17     -0.0052  -0.2730   20.574  0.2459          |               --|
18     -0.0779   0.3195    21.05  0.2769          |                 |--
19      0.0351   0.4315    21.15  0.3286          |                 |---
20      0.0146  -0.4154   21.168  0.3873          |              ---|
```

```
. corrgram tr_1, lags(1)
```

```
                                          -1       0       1 -1       0       1
 LAG       AC       PAC      Q     Prob>Q  [Autocorrelation]  [Partial Autocor]
-------------------------------------------------------------------------------
1        0.4141   0.4143   6.5322  0.0106          |---              |---

. corrgram D.tr_1, lags(1)

                                          -1       0       1 -1       0       1
 LAG       AC       PAC      Q     Prob>Q  [Autocorrelation]  [Partial Autocor]
-------------------------------------------------------------------------------
1       -0.3144  -0.3147   3.6664  0.0555        --|               --|

. corrgram tr2, lags(1)

                                          -1       0       1 -1       0       1
 LAG       AC       PAC      Q     Prob>Q  [Autocorrelation]  [Partial Autocor]
-------------------------------------------------------------------------------
1       -0.0303  -0.0304   .03497  0.8517          |                 |

. corrgram D.tr2, lags(1)

                                          -1       0       1 -1       0       1
 LAG       AC       PAC      Q     Prob>Q  [Autocorrelation]  [Partial Autocor]
-------------------------------------------------------------------------------
1       -0.5001  -0.5001   9.2747  0.0023      ----|             ----|

. corrgram ta_3, lags(1)

                                          -1       0       1 -1       0       1
 LAG       AC       PAC      Q     Prob>Q  [Autocorrelation]  [Partial Autocor]
-------------------------------------------------------------------------------
1        0.5211   0.5441   13.323  0.0003          |----             |----

. corrgram D.ta_3, lags(1)

                                          -1       0       1 -1       0       1
 LAG       AC       PAC      Q     Prob>Q  [Autocorrelation]  [Partial Autocor]
-------------------------------------------------------------------------------
1       -0.2422  -0.3110   2.8198  0.0931         -|               --|

. corrgram tp4, lags(1)

                                          -1       0       1 -1       0       1
 LAG       AC       PAC      Q     Prob>Q  [Autocorrelation]  [Partial Autocor]
-------------------------------------------------------------------------------
1        0.8008   0.9560   11.682  0.0006          |------           |-------

. corrgram D.tp4, lags(1)

                                          -1       0       1 -1       0       1
 LAG       AC       PAC      Q     Prob>Q  [Autocorrelation]  [Partial Autocor]
-------------------------------------------------------------------------------
1       -0.2083  -0.2102   .74757  0.3872         -|                -|

. corrgram pftisa_1, lags(1)
```

```
                              -1       0       1 -1       0       1
 LAG       AC       PAC      Q     Prob>Q  [Autocorrelation]  [Partial Autocor]
-------------------------------------------------------------------------------
1        0.7330   0.7823   26.363  0.0000          |-----             |------
```

. corrgram D.pftisa_1, lags(1)

```
                              -1       0       1 -1       0       1
 LAG       AC       PAC      Q     Prob>Q  [Autocorrelation]  [Partial Autocor]
-------------------------------------------------------------------------------
1        0.0031   0.0034   .00048  0.9826          |                  |
```

Annexure 2A

. vecrank GDPGSA GDFCFSA ta_3 pftisa_1, trend(constant) lags(5) max

```
                Johansen tests for cointegration
Trend: constant                            Number of obs =      41
Sample:  1975 - 2015                              Lags =       5
-------------------------------------------------------------------------------
                                         5%
maximum                              trace    critical
 rank   parms      LL      eigenvalue  statistic    value
   0     68     -467.27226          .    55.8890    47.21
   1     75     -449.19371     0.58600     19.7319*   29.68
   2     80     -442.72145     0.27074      6.7874    15.41
   3     83     -439.67054     0.13828      0.6856     3.76
   4     84     -439.32775     0.01658
-------------------------------------------------------------------------------
                                         5%
maximum                              max     critical
 rank   parms      LL      eigenvalue  statistic    value
   0     68     -467.27226          .    36.1571    27.07
   1     75     -449.19371     0.58600     12.9445    20.97
   2     80     -442.72145     0.27074      6.1018    14.07
   3     83     -439.67054     0.13828      0.6856     3.76
   4     84     -439.32775     0.01658
-------------------------------------------------------------------------------
```

Annexure2B

. vecrank GDPGSA GDFCFSA tr_1 tr2, trend(constant) lags(5) max

```
                Johansen tests for cointegration
Trend: constant                            Number of obs =      30
Sample:  1985 - 2014                              Lags =       5
-------------------------------------------------------------------------------
                                         5%
maximum                              trace    critical
 rank   parms      LL      eigenvalue  statistic    value
   0     68     -694.60574          .    65.3298    47.21
   1     75      -680.0199     0.62182     36.1581    29.68
   2     80     -669.15389     0.51539     14.4261*   15.41
   3     83     -663.52385     0.31294      3.1660     3.76
   4     84     -661.94085     0.10016
```

```
-------------------------------------------------------------------------------
                                              5%
maximum                                  max     critical
 rank    parms      LL       eigenvalue  statistic    value
   0     68     -694.60574          .    29.1717    27.07
   1     75      -680.0199     0.62182    21.7320    20.97
   2     80     -669.15389     0.51539    11.2601    14.07
   3     83     -663.52385     0.31294     3.1660     3.76
   4     84     -661.94085     0.10016
-------------------------------------------------------------------------------
```

TARGET MODEL TO CONSIDER GDPGSA

. vec GDPGSA GDFCFSA tr_1 tr2 ta_3 pftisa_1, trend(constant) lags(5)

```
Vector error-correction model

Sample:  1985 - 2014                     No. of obs     =       30
                                       AIC            = -1.381512
Log likelihood =  181.7227               HQIC           =  1.024123
Det(Sigma_ml)  =  2.21e-13               SBIC           =  6.138247

Equation          Parms     RMSE     R-sq     chi2     P>chi2
----------------------------------------------------------------
D_GDPGSA           26     2.73663   0.8000   16.00361   0.9361
D_GDFCFSA          26     8.91003   0.8091   16.95188   0.9105
D_tr_1             26     10.391    0.7376   11.24454   0.9947
D_tr2              26     3.7e+06   0.9408   63.59614   0.0001
D_ta_3             26     15.1374   0.7942   15.43337   0.9489
D_pftisa_1         26     9.34335   0.8581   24.17927   0.5657
----------------------------------------------------------------


-------------------------------------------------------------------------------
             |     Coef.  Std. Err.    z    P>|z|     [95% Conf. Interval]
-------------+-----------------------------------------------------------------
D_GDPGSA     |
        _ce1 |
         L1. |  5.602879   4.760269    1.18   0.239    -3.727076    14.93283
             |
      GDPGSA |
         LD. | -3.168429   2.838696   -1.12   0.264    -8.732171    2.395313
        L2D. |  2.020644   1.975609    1.02   0.306     -1.85148    5.892767
        L3D. |  3.476059   2.751472    1.26   0.206    -1.916726    8.868845
        L4D. |  4.009314   3.393107    1.18   0.237    -2.641055    10.65968
             |
     GDFCFSA |
         LD. | -1.123831   .9567739   -1.17   0.240    -2.999073    .7514119
        L2D. |  -1.86866    1.56823   -1.19   0.233    -4.942334    1.205014
        L3D. | -1.871887   1.497059   -1.25   0.211    -4.806069    1.062295
        L4D. | -1.409003   1.230222   -1.15   0.252    -3.820194    1.002188
             |
        tr_1 |
         LD. |  .9114319     .71746    1.27   0.204    -.4947639    2.317628
        L2D. |  .2462724   .3367936    0.73   0.465     -.413831    .9063757
        L3D. |  .2451369   .2425374    1.01   0.312    -.2302276    .7205014
        L4D. |  .7432912    .698394    1.06   0.287     -.625536    2.112118
             |
```

```
         tr2 |
         LD. |  -2.83e-06   2.44e-06    -1.16   0.246    -7.62e-06    1.95e-06
        L2D. |  -3.29e-06   2.54e-06    -1.30   0.195    -8.27e-06    1.69e-06
        L3D. |  -2.94e-06   2.52e-06    -1.17   0.243    -7.87e-06    1.99e-06
        L4D. |  -5.60e-07   6.24e-07    -0.90   0.370    -1.78e-06    6.63e-07
             |
        ta_3 |
         LD. |   -.311371   .2618698    -1.19   0.234    -.8246263    .2018843
        L2D. |  -.0243165   .0850997    -0.29   0.775    -.1911089    .1424759
        L3D. |  -.0853265   .1698529    -0.50   0.615    -.4182321    .2475791
        L4D. |  -.2563468    .249304    -1.03   0.304    -.7449737    .2322801
             |
    pftisa_1 |
         LD. |  -.5383198   .4465894    -1.21   0.228    -1.413619    .3369793
        L2D. |  -.9058642   .7403594    -1.22   0.221    -2.356942    .5452135
        L3D. |  -.6505961   .6300081    -1.03   0.302    -1.885389    .5841971
        L4D. |   .4757965   .4147875     1.15   0.251     -.337172    1.288765
             |
       _cons |   1.701236   1.475428     1.15   0.249     -1.19055    4.593023
-------------+----------------------------------------------------------------
D_GDFCFSA    |
        _ce1 |
         L1. |   15.60072   15.49867     1.01   0.314    -14.77611    45.97755
             |
      GDPGSA |
         LD. |  -7.368519   9.242336    -0.80   0.425    -25.48317    10.74613
        L2D. |   6.693148   6.432266     1.04   0.298    -5.913862    19.30016
        L3D. |   9.544273   8.958349     1.07   0.287    -8.013768    27.10231
        L4D. |   10.28369   11.04741     0.93   0.352    -11.36884    31.93621
             |
     GDFCFSA |
         LD. |   -3.01937   3.115102    -0.97   0.332    -9.124857    3.086117
        L2D. |  -5.503419   5.105904    -1.08   0.281    -15.51081    4.503968
        L3D. |  -4.772818   4.874183    -0.98   0.327    -14.32604    4.780405
        L4D. |  -4.061095   4.005405    -1.01   0.311    -11.91154    3.789354
             |
        tr_1 |
         LD. |   2.118866   2.335934     0.91   0.364    -2.459481    6.697213
        L2D. |   1.021664   1.096546     0.93   0.351    -1.127526    3.170854
        L3D. |   .3721891   .7896626     0.47   0.637    -1.175521    1.919899
        L4D. |   2.342709   2.273858     1.03   0.303    -2.113971     6.79939
             |
         tr2 |
         LD. |  -8.48e-06   7.95e-06    -1.07   0.286    -.0000241    7.09e-06
        L2D. |  -8.23e-06   8.27e-06    -1.00   0.319    -.0000244    7.97e-06
        L3D. |  -7.84e-06   8.19e-06    -0.96   0.338    -.0000239    8.21e-06
        L4D. |  -9.67e-07   2.03e-06    -0.48   0.634    -4.95e-06    3.01e-06
             |
        ta_3 |
         LD. |  -.7981063   .8526057    -0.94   0.349    -2.469183    .8729702
        L2D. |  -.1835271    .277071    -0.66   0.508    -.7265762     .359522
        L3D. |  -.1836013   .5530137    -0.33   0.740    -1.267488    .9002856
        L4D. |  -.6637182   .8116936    -0.82   0.414    -2.254609     .927172
             |
    pftisa_1 |
```

```
         LD. |  -1.572068   1.454023    -1.08   0.280    -4.421901    1.277765
        L2D. |  -2.261282   2.410491    -0.94   0.348    -6.985757    2.463193
        L3D. |  -1.602114   2.051205    -0.78   0.435    -5.622401    2.418174
        L4D. |   1.291318   1.350481     0.96   0.339    -1.355576    3.938213
             |
       _cons |   4.935733   4.803757     1.03   0.304    -4.479458    14.35092
-------------+----------------------------------------------------------------
D_tr_1       |
        _ce1 |
         L1. |   3.785661   18.07477     0.21   0.834    -31.64024    39.21156
             |
      GDPGSA |
         LD. |   1.588551   10.77855     0.15   0.883    -19.53701    22.71411
        L2D. |   3.531805   7.501401     0.47   0.638    -11.17067    18.23428
        L3D. |   1.028077   10.44736     0.10   0.922    -19.44836    21.50452
        L4D. |   .1480043   12.88365     0.01   0.991    -25.10349    25.39949
             |
     GDFCFSA |
         LD. |  -1.480818   3.632876    -0.41   0.684    -8.601125    5.639489
        L2D. |  -1.623933   5.954578    -0.27   0.785    -13.29469    10.04683
        L3D. |  -.9710223   5.684343    -0.17   0.864    -12.11213    10.17008
        L4D. |  -.3795379   4.671161    -0.08   0.935    -9.534845    8.775769
             |
        tr_1 |
         LD. |   .6740472     2.7242     0.25   0.805    -4.665287    6.013381
        L2D. |  -.1053108   1.278807    -0.08   0.934    -2.611727    2.401105
        L3D. |   .5140544   .9209159     0.56   0.577    -1.290908    2.319016
        L4D. |   1.034111   2.651806     0.39   0.697    -4.163334    6.231556
             |
         tr2 |
         LD. |  -5.80e-07   9.27e-06    -0.06   0.950    -.0000187    .0000176
        L2D. |  -1.20e-06   9.64e-06    -0.12   0.901    -.0000201    .0000177
        L3D. |  -7.96e-07   9.55e-06    -0.08   0.934    -.0000195    .0000179
        L4D. |   6.69e-07   2.37e-06     0.28   0.778    -3.97e-06    5.31e-06
             |
        ta_3 |
         LD. |   .0276456   .9943211     0.03   0.978    -1.921188    1.976479
        L2D. |   .3212999   .3231241     0.99   0.320    -.3120118    .9546115
        L3D. |  -.1327162   .6449325    -0.21   0.837    -1.396761    1.131328
        L4D. |    -.38241   .9466088    -0.40   0.686    -2.237729    1.472909
             |
   pftisa_1 |
         LD. |   .0386655   1.695703     0.02   0.982    -3.284851    3.362181
        L2D. |  -.4043588   2.811149    -0.14   0.886     -5.91411    5.105392
        L3D. |   -.009161   2.392145    -0.00   0.997    -4.697678    4.679356
        L4D. |   .5427149   1.574951     0.34   0.730    -2.544132    3.629561
             |
       _cons |   2.531587   5.602211     0.45   0.651    -8.448544    13.51172
-------------+----------------------------------------------------------------
D_tr2        |
        _ce1 |
         L1. |    2781427    6461522     0.43   0.667     -9882922    1.54e+07
             |
      GDPGSA |
         LD. |   -4884062    3853206    -1.27   0.205    -1.24e+07     2668082
```

```
     L2D. |  -5085.423    2681664    -0.00   0.998     -5261051     5250880
     L3D. |    1200183    3734809     0.32   0.748     -6119908     8520274
     L4D. |    2904976    4605756     0.63   0.528     -6122140    1.19e+07
          |
  GDFCFSA |
      LD. |   412978.2    1298711     0.32   0.750     -2132449     2958406
     L2D. |  -793267.9    2128693    -0.37   0.709     -4965429     3378894
     L3D. |  -659819.8    2032087    -0.32   0.745     -4642637     3322997
     L4D. |   -1419785    1669886    -0.85   0.395     -4692702     1853131
          |
     tr_1 |
      LD. |   163060.4   973870.1     0.17   0.867     -1745690     2071811
     L2D. |   416340.3   457158.8     0.91   0.362    -479674.6     1312355
     L3D. |  -623197.8   329216.8    -1.89   0.058     -1268451    22055.26
     L4D. |   656974.1   947990.1     0.69   0.488     -1201052     2515001
          |
      tr2 |
      LD. |  -2.466719    3.31294    -0.74   0.457    -8.959961    4.026523
     L2D. |  -1.336462   3.446556    -0.39   0.698    -8.091588    5.418663
     L3D. |  -2.562519   3.413969    -0.75   0.453    -9.253775    4.128738
     L4D. |  -.4766142   .8467444    -0.56   0.574    -2.136203    1.182974
          |
     ta_3 |
      LD. |  -312298.6   355458.3    -0.88   0.380     -1008984    384386.9
     L2D. |  -147798.7   115513.1    -1.28   0.201    -374200.3    78602.88
     L3D. |   98435.51   230555.9     0.43   0.669    -353445.8    550316.8
     L4D. |  -4406.418   338401.7    -0.01   0.990    -667661.6    658848.7
          |
 pftisa_1 |
      LD. |  -351131.4   606194.1    -0.58   0.562     -1539250    836987.1
     L2D. |  -324594.4    1004953    -0.32   0.747     -2294267     1645078
     L3D. |  -780857.2   855164.1    -0.91   0.361     -2456948    895233.6
     L4D. |   220076.7   563026.6     0.39   0.696    -883435.3     1323589
          |
    _cons |  -.0000256    2002726    -0.00   1.000     -3925270     3925270
-------------+----------------------------------------------------------------
D_ta_3       |
     _ce1 |
      L1. |   6.721434     26.331     0.26   0.799    -44.88637    58.32924
          |
   GDPGSA |
      LD. |  -8.516176   15.70199    -0.54   0.588    -39.29151    22.25916
     L2D. |   2.043322    10.9279     0.19   0.852    -19.37498    23.46162
     L3D. |   5.922418   15.21952     0.39   0.697    -23.90729    35.75212
     L4D. |   2.181349   18.76867     0.12   0.907    -34.60456    38.96726
          |
  GDFCFSA |
      LD. |   1.392342   5.292308     0.26   0.792    -8.980392    11.76508
     L2D. |  -2.245496   8.674522    -0.26   0.796    -19.24725    14.75625
     L3D. |  -1.032946   8.280847    -0.12   0.901    -17.26311    15.19722
     L4D. |   -1.17875   6.804863    -0.17   0.862    -14.51604    12.15854
          |
     tr_1 |
      LD. |  -.3300986   3.968565    -0.08   0.934    -8.108344    7.448146
     L2D. |   .4128197   1.862943     0.22   0.825    -3.238482    4.064121
```

```
L3D. |  -1.539811   1.341574    -1.15   0.251    -4.169247    1.089625
L4D. |   .6371387   3.863103     0.16   0.869    -6.934405    8.208682
     |
 tr2 |
 LD. |  -6.19e-06   .0000135    -0.46   0.647    -.0000326    .0000203
L2D. |  -3.42e-06    .000014    -0.24   0.808    -.0000309    .0000241
L3D. |  -4.26e-06   .0000139    -0.31   0.760    -.0000315     .000023
L4D. |  -1.31e-07   3.45e-06    -0.04   0.970    -6.89e-06    6.63e-06
     |
ta_3 |
 LD. |  -.7164069   1.448509    -0.49   0.621    -3.555432    2.122618
L2D. |  -.4605615   .4707214    -0.98   0.328    -1.383158    .4620355
L3D. |  -.0058989    .939526    -0.01   0.995    -1.847336    1.835538
L4D. |    -.10535   1.379003    -0.08   0.939    -2.808145    2.597445
     |
pftisa_1 |
 LD. |  -.7160076   2.470269    -0.29   0.772    -5.557645     4.12563
L2D. |  -.9183925   4.095231    -0.22   0.823    -8.944898    7.108113
L3D. |   -.435797   3.484833    -0.13   0.900    -7.265944     6.39435
L4D. |  -.1987117   2.294359    -0.09   0.931    -4.695574     4.29815
     |
_cons |  -.7862577   8.161199    -0.10   0.923    -16.78191     15.2094
-------------+----------------------------------------------------------------
D_pftisa_1   |
_ce1 |
 L1. |  -4.457484   16.25241    -0.27   0.784    -36.31161    27.39664
     |
GDPGSA |
 LD. |   2.475615   9.691813     0.26   0.798    -16.51999    21.47122
L2D. |  -.4936357   6.745082    -0.07   0.942    -13.71375    12.72648
L3D. |  -2.821613   9.394015    -0.30   0.764    -21.23354    15.59032
L4D. |  -3.517018   11.58467    -0.30   0.761    -26.22256    19.18852
     |
GDFCFSA |
 LD. |   .7549039   3.266596     0.23   0.817    -5.647507    7.157315
L2D. |    .811946   5.354216     0.15   0.879    -9.682124    11.30602
L3D. |   1.164036   5.111226     0.23   0.820    -8.853784    11.18186
L4D. |   1.008707   4.200197     0.24   0.810    -7.223528    9.240943
     |
tr_1 |
 LD. |  -.3194058   2.449536    -0.13   0.896    -5.120409    4.481597
L2D. |   -.205751   1.149873    -0.18   0.858    -2.459461    2.047959
L3D. |  -.3915161   .8280658    -0.47   0.636    -2.014495    1.231463
L4D. |  -.2590306   2.384442    -0.11   0.913     -4.93245    4.414389
     |
 tr2 |
 LD. |   2.49e-06   8.33e-06     0.30   0.765    -.0000138    .0000188
L2D. |   3.36e-06   8.67e-06     0.39   0.698    -.0000136    .0000204
L3D. |   2.31e-06   8.59e-06     0.27   0.788    -.0000145    .0000191
L4D. |   1.29e-06   2.13e-06     0.61   0.545    -2.89e-06    5.46e-06
     |
ta_3 |
 LD. |    .358665     .89407     0.40   0.688     -1.39368     2.11101
L2D. |   .0874538   .2905456     0.30   0.763     -.482005    .6569127
L3D. |   .1158452   .5799081     0.20   0.842    -1.020754    1.252444
```

```
      L4D. |   .0520644   .8511682     0.06   0.951    -1.616195    1.720323
           |
   pftisa_1 |
       LD. |   .4152226   1.524736     0.27   0.785    -2.573204    3.403649
      L2D. |   .1217031   2.527719     0.05   0.962    -4.832534    5.075941
      L3D. |   .5830996    2.15096     0.27   0.786    -3.632704    4.798903
      L4D. |  -.7829019   1.416158    -0.55   0.580    -3.558521    1.992717
           |
     _cons |  -2.743957   5.037375    -0.54   0.586    -12.61703    7.129117
------------------------------------------------------------------------------
```

We consider GDPGSA as our target model as dependent.

ANNEXURE 3: OUTPUT VECM

. test ([D_GDPGSA]: LD.GDFCFSA L2D.GDFCFSA L3D.GDFCFSA L4D.GDFCFSA)

(1) [D_GDPGSA]LD.GDFCFSA = 0
(2) [D_GDPGSA]L2D.GDFCFSA = 0
(3) [D_GDPGSA]L3D.GDFCFSA = 0
(4) [D_GDPGSA]L4D.GDFCFSA = 0

chi2(4) = 1.88
Prob > chi2 = 0.7569

. test ([D_GDPGSA]: LD.tr_1 L2D.tr_1 L3D.tr_1 L4D.tr_1)

(1) [D_GDPGSA]LD.tr_1 = 0
(2) [D_GDPGSA]L2D.tr_1 = 0
(3) [D_GDPGSA]L3D.tr_1 = 0
(4) [D_GDPGSA]L4D.tr_1 = 0

chi2(4) = 1.69
Prob > chi2 = 0.7924

. test ([D_GDPGSA]: LD.tr2 L2D.tr2 L3D.tr2 L4D.tr2)

(1) [D_GDPGSA]LD.tr2 = 0
(2) [D_GDPGSA]L2D.tr2 = 0
(3) [D_GDPGSA]L3D.tr2 = 0
(4) [D_GDPGSA]L4D.tr2 = 0

chi2(4) = 2.33
Prob > chi2 = 0.6746

. test ([D_GDPGSA]: LD.ta_3 L2D.ta_3 L3D.ta_3 L4D.ta_3)

(1) [D_GDPGSA]LD.ta_3 = 0
(2) [D_GDPGSA]L2D.ta_3 = 0
(3) [D_GDPGSA]L3D.ta_3 = 0
(4) [D_GDPGSA]L4D.ta_3 = 0

chi2(4) = 2.11
Prob > chi2 = 0.7153

. test ([D_GDPGSA]: LD.pftisa_1 L2D.pftisa_1 L3D.pftisa_1 L4D.pftisa_1)

(1) [D_GDPGSA]LD.pftisa_1 = 0
(2) [D_GDPGSA]L2D.pftisa_1 = 0
(3) [D_GDPGSA]L3D.pftisa_1 = 0
(4) [D_GDPGSA]L4D.pftisa_1 = 0

chi2(4) = 2.30
Prob > chi2 = 0.6809

ANNEXURE 4: Economic Growth & Transport Infrstructure Output

vecrank GDPGSA GDFCFSA tr_1 tr2 pftisa_1 ta_3, trend(constant) max

Johansen tests for cointegration

Trend: constant Number of obs = 33

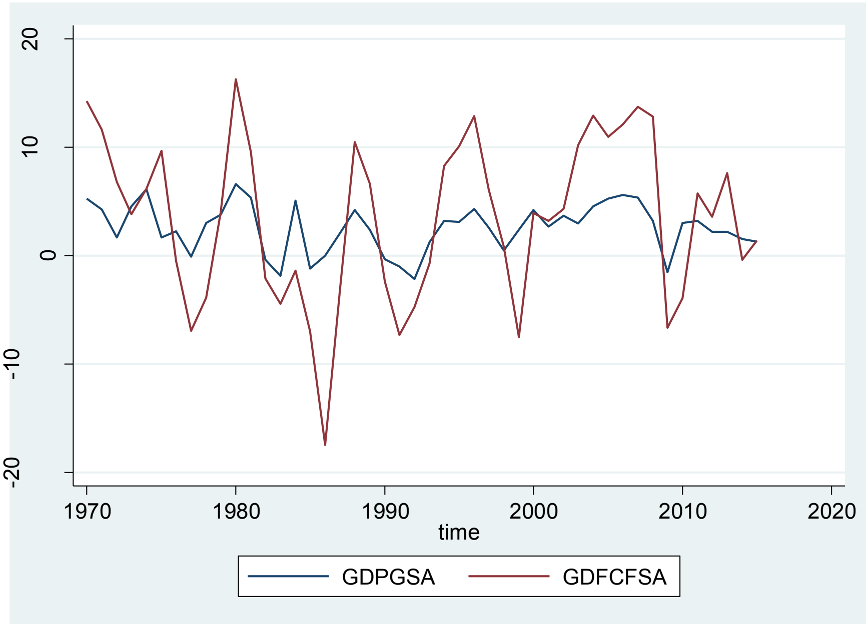
Sample: 1982 - 2014 Lags = 2

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	42	-1058.4361	.	122.8961	94.15
1	53	-1032.1918	0.79619	70.4075	68.52
2	**62**	**-1014.5848**	**0.65599**	**35.1935***	**47.21**
3	69	-1006.9403	0.37080	19.9045	29.68
4	74	-999.99475	0.34357	6.0134	15.41
5	77	-998.21383	0.10231	2.4515	3.76
6	78	-996.98805	0.07160		

maximum rank	parms	LL	eigenvalue	max statistic	5% critical value
0	42	-1058.4361	.	52.4886	39.37
1	53	-1032.1918	0.79619	35.2140	33.46
2	**62**	**-1014.5848**	**0.65599**	**15.2890**	**27.07**
3	69	-1006.9403	0.37080	13.8911	20.97
4	74	-999.99475	0.34357	3.5618	14.07
5	77	-998.21383	0.10231	2.4515	3.76
6	78	-996.98805	0.07160		

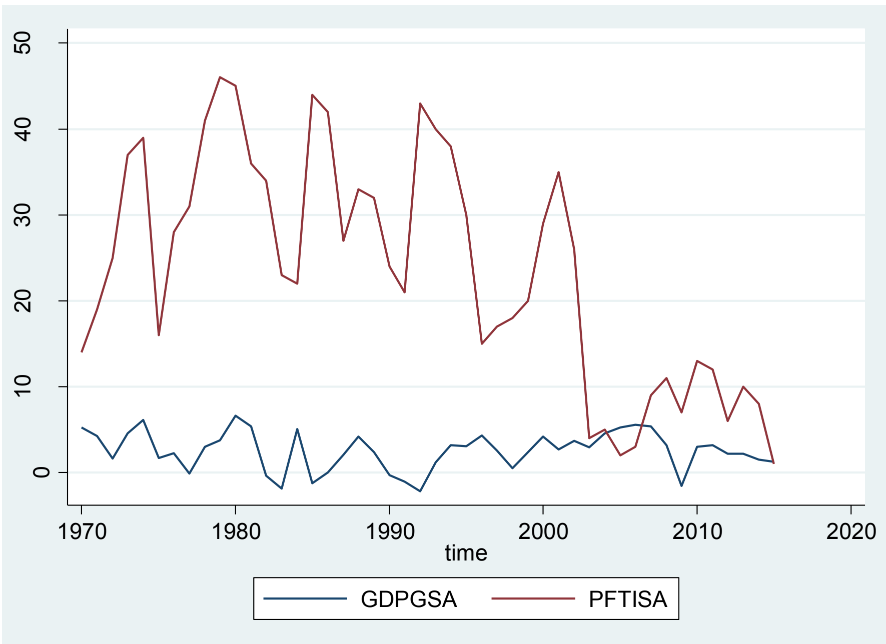
Trend of economic growth and transport infrastructure over time

Figure 2:A Trend of Economic Growth and Capital Formation



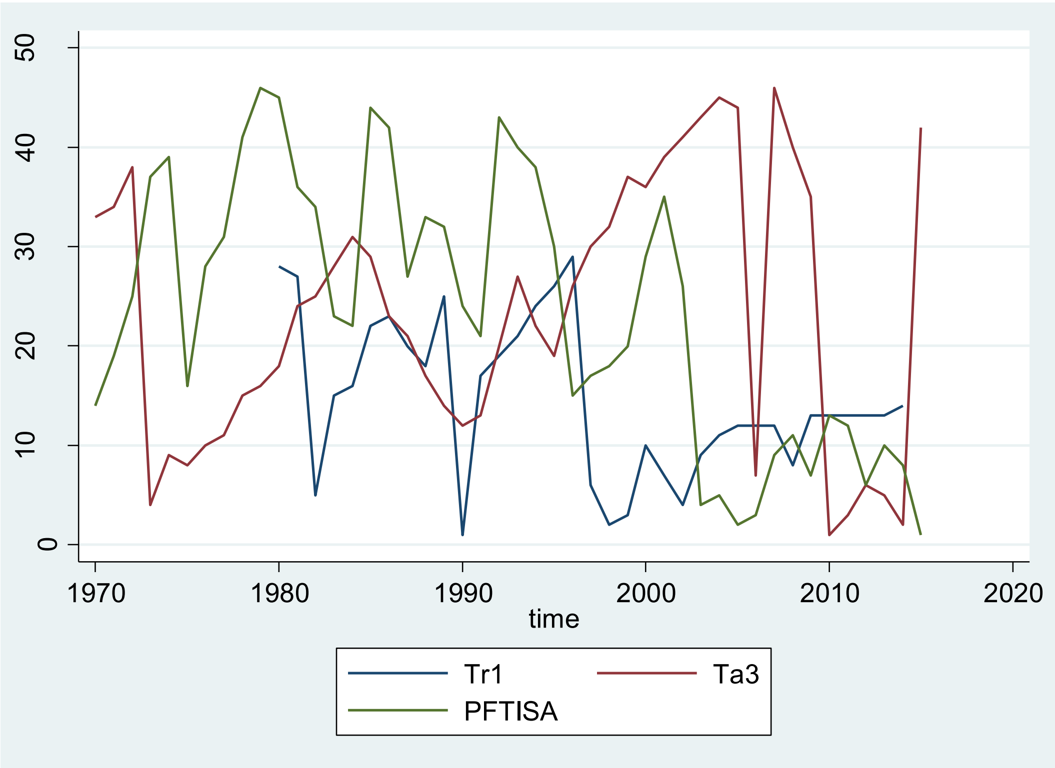
The above graph shows that in the long run, equilibrium association will come to pass among economic growth and gross domestic fixed capital formation. This is to say that there is a linkage among macroeconomic indicators, mainly economic growth and capital formation, over time.

Figure 3:A trend of Economic Growth and Transport Performance



The above model predicts that the changes in transport services toward export will perform and impact the projection horizon, although they decrease toward zero. There is a linkage among macroeconomic indicators – mainly economic growth and transport performance. Hence, transport infrastructure may complement other factors in the production process over time. It shows that the time periods of economic growth and transport performance exists among them.

Figure 4: A Trend of Transport Infrastructure Variables



The above graph reveals the potential of the infrastructure association among transport variables. Any service related to moving goods, services and people from one point to another will always, in the long-run equilibrium, influence the economy of the country. The transport services related to export indicate a relationship between air transport and railways transport in South Africa.