THE ROLE OF MINING INFRASTRUCTURAL DEVELOPMENT ON ECONOMIC GROWTH IN SOUTH AFRICA FROM (1980-2013): AN ECONOMETRIC APPROACH

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DISSERTATION SUBMITTED IN FULFILLMENT OF THE REQUIREMENT OF A MASTERS OF COMMERCE DEGREE IN ECONOMICS AT THE NORTH WEST UNIVERSITY

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GRADUATION CEREMONY: OCTOBER 2017

STUDENT NUMBER : 22989048

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ABSTRACT

In the study we investigate the relationship between mining infrastructure and economic growth in South Africa from 1980-2013. The importance of the study is to examine if there is both short and long run significant relationship between mining infrastructure and economic growth in South Africa. The data mining was collected from South African Reserve Bank (SARB) covering the range from 1980-2013 of the study. Both Augmented Dickey Fuller (ADF) and Phillip Perron (PP) where used for stationarity tests. The study used 5% critical value to analyse the results obtained from the study. Johansen Cointegration test are employed in the study, also Vector Error Correction Model (VECM) are also employed in the study. In the results we obtained that there is a positive significant relationship between mining infrastructure and economic growth. There is also a causal relationship between mining infrastructure and economic growth, meaning the development of mining infrastructure does promote economic growth. In conclusion the policy makers should improve private infrastructure which will equip human capital to be more useful in contributing towards knowledge and innovation. This means South African government and mining industry should priorities the development of infrastructure as component that will be sufficient towards economic development.

DEDICATION

I would like to dedicate this study to both of my parents Mrs ChristinahTebogoMarutle and Mr. Modisaotsile John Marutle for supporting me spiritually and financially.

ACKNOWLEDGEMENTS

I would like to thank God for giving me guidance, strength and knowledge to complete this dissertation. I would like to express sincere appreciation to my supervisor Professor David Daw for contributing towards my dissertation and sustaining accuracy to the work. The techniques employed within the study were provided by my supervisor. Allow me also to thank Dr Gisele Mah for providing support and advice in the process of writing this dissertation. You have shown much that we are your priorities and conducting well research to me. Your contribution towards this dissertation is much appreciated. I am also dedicating the dissertation to my family because they saw and understood the importance of advancing my studies. Let me also acknowledge whoever has contributed in my dissertation because your advices kept me going to the last stage.

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LIST OF ABBRIVIATIONS

ADF	: Augmented Dickey Fuller
BEE	: Black Economic Empowerment
CLRF	: Classical Linear Regression Function
DF	: Dickey Fuller
EMPLY	: Employment
GDP	: Gross Domestic Product
INFRS	: Infrastructure
JB	: Jaque Bera
OECD	: Organisation for Economic Co-operation and Development
OLS	: Ordinary Least Square
PIT	: Personal Income Tax
PP	: Phillip Perron
RDP	: Reconstruction Development Programme
SARB	: South African Reserve Bank
USA	: United States of America
VAR	: Vector Autoregression
VAT	: Value Added Tax
VECM	: Vector Error Correction Model

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CHAPTER 1

INTRODUCTION

1.1 Background of the study

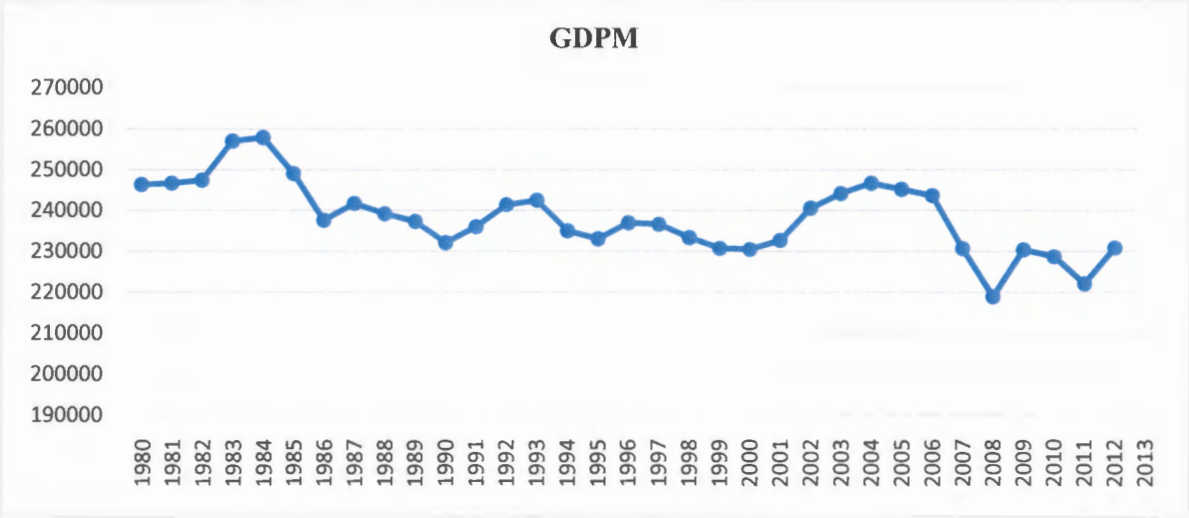
The relationship between infrastructure and economic growth has been one of the most important topics to be discussed in recent years both in academics and policy makers. There are much current International debate concerning ways of stimulating growth, reduce poverty and improve the quality of human life in emerging economies. It has centred the need to promote more spending in investments. Furthermore, investing prudently in mining infrastructure is critically important as over spending to large investments would to projects which are inefficiently large but with low marginal returns. Emerging economies transpires more dependently in infrastructure investments which are known to be efficiently in terms of their returns. The marginal returns of infrastructure investment are used to finance government coffers and standard of living conditions. As a result, the infrastructure investment in emerging economies remains to be the challenge where general public relies on mines to provide with employment and other basic needs.

Common argument is spending in large infrastructure may have significance in promoting productivity of both private and public sectors. In this regards infrastructure services may have a strong growth in expanding private inputs and also the rate of capital returns. Agenor and Dodson (2006) highlights that in Sub Saharian of Africa there are lacks of infrastructure services were 16% of the roads are paved, one of five has access of electricity, and transports costs are higher. The prospects of spending more in infrastructure would address the challenges which are faced by low income countries and the region. The role of human capital in production process would play a key role in establishing flexibility towards capital formation, output growth and minimising cost of inputs. A well designed mining infrastructure investment has long term economic benefits; they can increase economic growth, productivity while providing with significant spillovers.

After all most two decades of democracy, South Africa is still facing serious challenges to alleviate unemployment, inequality and poverty. The mining sector in South African economy has long been seen as an aggregate output, foreign exchange earner, employer and

generator of tax revenue. Furthermore, mining sector is also viewed as an engine behind South African economy. Historically, the significance of mining sector into the economy has carried much perception that makes it more validity. The shortage of infrastructure investment has brought various economic challenges such as low economic growth, investment, employment and capital accumulation.

Figure 1.1: Gross Domestic Product for Mining Sector.



Source: Authors own computation using data from SARB

It is evident in figure 1.1 that the performance of economic output has been deteriorating due to challenges occurred in mining sectors. Such challenges are conveyed by mining infrastructure investment and other macroeconomic challenges to oppress the performance of aggregate growth. In the first decade (1980-1990), economic output declined mainly in the gold and platinum sector. The instabilities of economic output were caused by global impacts and other variables. Although, other reasons concerning the decline in outputs were political instabilities such as apartheid. In the second decade (1991-2000), after political riots the new government introduced several policies together with mining sector to achieve growth.

The aggregate growth in the second decade continues to decline due to the gigantic production of gold sector. However, platinum sector continue to increase their production output. In the last decade (2001-2013), the recovery of aggregate growth occurred after 2001 and 2002 in the beginning of 2003. The establishment of mining charter in 2002 also contributed to the positive response of aggregate growth from mining and other sectors. Many opportunities did occur where the mining sector started to establish human capital and

contribute to corporate social responsibility to expand socio economic life style. In 2008, the world financial crises did have much impact in South African economy more especially in mining production. The South African economy was under attack by recession which influenced mining sectors to take radical actions in order to protect industry after the decline in production and price of minerals.

This is a clear picture of how South Africa has performed in 1994 and beyond it, particularly in economic terms. However, much are still to be done in terms of correcting challenges which are face by South Africa. When comparing the economic growth of South Africa and other countries like United States of America, Russia and United Kingdom, it's not satisfactory maybe it's due to forever escalating inflation rate, exchange rate and budget deficit caused by instabilities of economic performance. According to Chamber of mine (2016), though mining contributes greatest single part of South African export revenue and employs both direct and indirect of people compared to other sectors. Although, it faces the significant regulatory uncertainties when comparing with international peers and having vagary of tumbling commodity price.

Empirically, the relationship between mining infrastructure investment and economic output has been an essential question in many countries. However, the results obtained from various studies were found to be apparent that infrastructure and economic growth have positive relationship. Both investment in infrastructure and economic growth were found to have a strong positive relationship (Kumo, 2012). Infrastructure remains to be the central element of growth between nations as many studies shown how infrastructure leads to economic growth. Fedderke and Garlick (2008) articulate an argument on how growth can also result to infrastructure; however, in his study growth could lead to investment in infrastructure if firms produce more commodities. Investment in infrastructure can also be accelerated if firms directly build roads to transport their own output and providing necessary skills to employees to perform better.

The importance of conducting this study is to examine if whether the perception of the role of mining infrastructure in South African economy remains justified (Fedderke and Pirouz, 2002). The significance of mining sector in establishing investment on aggregate economy was of great and increasing of output growth primarily driven by capital accumulation. However, traditionally some essential roles of mining remain to be on the same position while others remain not to be on the same position. The main purpose of the study is to

answer the question: Is there a long run relationship between infrastructure of the mining sector and economic growth in South Africa. Is there a causal relationship between mining infrastructure and economic growth?

1.2 Problem Statement

The argument regarding the relationship between infrastructure and economic growth has been an on-going debate between economist and policy makers. In the case of South Africa, the level of mining infrastructure has not yet been significant and accompanied by a mute of economic growth. The decline in economic growth continues to be conspired by deficiency of infrastructure. The instability and uncertainty explains weak investment performance in Africa. In particular, currency and inflation are the cause of gigantic decline in economic growth while other macroeconomics challenges continue to grow. In this point of time, South African mining infrastructure doesn't resolve the current challenges which they are facing. Infrastructure is required to address issues such as mineral price and escalating of labour demand with excessive wage demand (Chamber of mines, 2016).

Binding of Infrastructure constrain is another issue following productivity of platinum, gold and coal that is declining and experiencing rapid escalating costs. "Rapid structural change caused by globalisation and technological change have increased the importance of human capital in the past years" (Deutsche Bank Research, 2005). In the industrialised economies, the structural change has put people with low level of education under pressure since physical work is replaced by capital. Some countries has realised the importance of human capital and they have acted accordingly. However, South Africa is still far to reach the level were industrialised economies are at. Even though it takes time to boost economic growth, human capital remains to be important both in public and private sectors. As the result, the mining infrastructure investment in South Africa is not yet adequate to address current challenges of high unemployment, inequality and poverty.

The challenges of which South Africa is facing requires immediate economic infrastructure from mining sector to boost level of productivity and capital accumulation. Therefore, the significance of mining infrastructure investment in South Africa should be more effective in correcting the aggregate growth in all different spheres. According to Statistics South Africa (2015), the unemployment rate was recorded at 25.5% together with the decline of economic growth. South Africa remains to have huge unemployment rate across the world.

Insufficiency of infrastructure in South Africa delays economic growth and other macroeconomic challenges.

1.3 Objective of the study

The primary objective of this study is to examine the nature of the relationship between the mining infrastructure and economic growth from (1980-2013). The specific objectives are to:

- Examine the short and long run relationship between mining infrastructure investment and economic output.
- Test causal relationship between mining infrastructure investment and economic output.

1.4 Statement of Hypothesis

H_0: The mining infrastructure investment has no impact on economic output in South Africa

H_1: The mining infrastructure investment has an impact on economic output in South Africa

1.5 Significance of the study

The study examines how the role of infrastructure in mining sector does contribute towards economic output. However, many researchers have made similar studies concerning the impact of mining to economic output. Fedderke and Pirouz (2002), in their study employed VECM methodology to examine the relationship between level of output and employment. The study obtained a negative relationship between the level of employment and level of output. This study goes further to investigate the relationship between mining infrastructure investment and employment focusing at the contribution of human capital. Furthermore, this study contributes towards literature particularly in South Africa were the effects of mining infrastructure investment are less studied. Basically, there is a famine of mining infrastructure investment in South Africa; therefore, the importance of this study is to introduce advanced econometric methods concerning the topic of mining infrastructure investment and economic growth.

The main importance of this study is to merge the role of mining infrastructure investment with human capital as the key role to enforce stability in economic growth. The South African government and mining sector can also utilize the study for policies in terms of sustaining infrastructure. The main focus of this study is based on mining industries which should provide services to communities as the mining charter has required. However, the

issue of infrastructure has been escalating from both private and public sectors but failing to address the challenges which the industry is facing. According to smith (2013), mining sector has been the backbone of South African economy for almost 150 years. However, this study will also assist to establish the effectiveness of mining infrastructure investment in promoting economic output and to merge the decline of labour market with high wage rate. Furthermore, this study continues to provide with more solutions on how mining infrastructure investment can expand its compensation to the citizens of South Africa.

1.6 Structure of the study

Chapter 1: introduces the topic and the historical background of the study. This chapter further outlines the problem of study which gives the inside of the study, the objective of the study, statement of hypothesis, significance of the study and the scope and limitations of the study.

Chapter 2: presents the South African overview of the study, the evolution of mining sector on economic growth, importance of mining sector on South African economy.

Chapter 3: presents the theoretical findings or theory as well as the empirical findings of the literature review which outlines the existing theory.

Chapter 4: the chapter is the presentation of data and methodology which are used in the study. The simple regression analysis is used to determine the relationship between the variable. Unitroot tests are used to determine the stationarity among variables. Cointegration is used to identify if there is a long run relationship; vector error correction model is a test used to identify if whether there is a short run relationship among variables; and granger causality is used to verify if there is any causality existing among the variables.

Chapter 5: presents the results obtained from the various tests and analysis the output of the results which are acquired within the tests.

Chapter 6: is the conclusion and summary of the whole study and the implication of the results obtained from the analysis. It provides with policy recommendations together with the future research.

CHAPTER 2

OVERVIEW OF THE STUDY

2.1 Introduction

In this chapter the evolution of the mining sector in South Africa is provided and the macroeconomic framework is presented. The evolution of the mining sector in South Africa is discussed first. The contribution of the mining sector to aggregate output will be firstly discussed including the role of value added, tax revenue, an open context to economy(export) and the distribution of output in the economy. Secondly, the contribution of labour market conditions in the aggregate mining sector including employment trends of three aggregate mining sectors, and the links between labour productivity and the real labour cost are discussed. The chapter closes by giving conclusions and options which the mining sector could use in order to expand the growth of an industry and participate in expanding community needs.

2.2 The development of mining sector in South Africa

The discovery of minerals in South Africa influenced the country's growth positively especially with regards to employment and attracting foreign investments. As Segal and Malherbe,2000) state the discovery of gold and diamond in the last half of the 19th century laid foundation for transformation of South Africa more basically from agricultural economy to a modern industrialised economy. The South African economy transformed after the discovery of diamond and gold which opened the opportunity for business to take place in terms of productivity and creating employment. In the 1980s the mining sector did operate even though politics was more into power where apartheid and racial discrimination was to oppress the rights of human being. According to Atin (2013), the discovery of Witwatersrand goldfields in 1886 was the turning point of South Africa. Even though South African people were sustaining themselves with agriculture by creating gardens in their back yards for their survival, its establishment encouraged job creation and reduced poverty.

People shifted from agriculture to mining as a form of improving their life style. However the mines did needed more people and more machinery to produce minerals. The De Beers Company came as a leading monopoly over the diamond industry and led to the installation of railways system. However, it was the labour and capital intensiveness of goldfield which impacted the economic trajectory of future South African (Malherbe, 2000). The second effect of the discovery of gold was brought by a rise of mining housing. The mining houses

where used as a form of investment to acquire capital and attract foreign investment to strengthen their case against government and global competition. Anglo gold, De Beers, Goldfields and harmony created the chamber of mines and also did dominate the economy until 1990s.

After the discovery of gold and diamond a number of challenges occurred such as low number of resources, high costs of production and massive of labour was required at the mines. South Africa's success in modern economy was supported by the growth of both gold and diamond. However the industrialization of the economy could not have been achieved by coal and ore. Although the industry is currently facing many challenges after 160 years of commercial enterprise in South Africa, it is still one of the diverse and important mining industries in the world and has an attractive resource base that holds promise to future mining activities.

2.3 The contribution of mining sector to total output of the South African economy

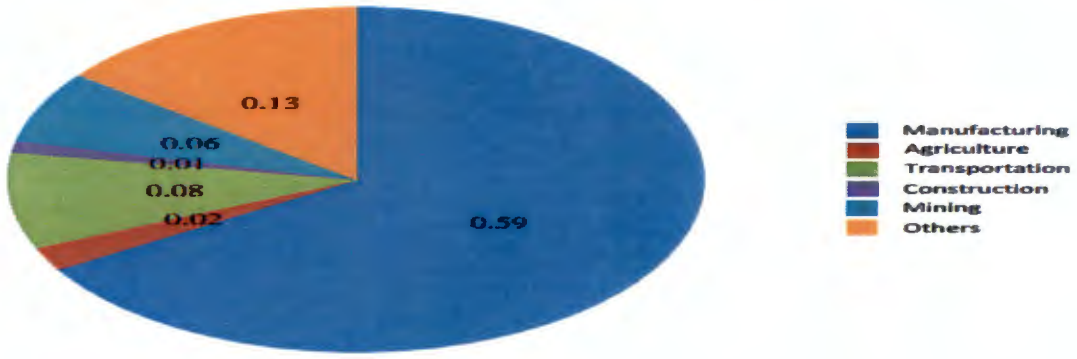
The mining sector continues to be a leading sector and holds the record of being the main contributor towards South Africa's growth. Gold and diamond have laid a solid foundation in transforming the history of South African economy. The industry has attracted various foreign investments and created the competitive environment for business within the scope of an industry and outside the industry. The study examines the value added of the output in mining sector towards South African economy. The tax revenue from the mining sector contributes to the government coffers. The contribution of mining sector in export performance. The distribution of output in Gold, Platinum and Coal.

2.3.1 The impact of mining in terms of its contribution to value added in the South African economy

In this section the impact of mining sector output in terms of real value added contributed by four mining sectors in South African is examined. The concern of the study is to focus in both net input of mining sector to total output in the South African economy and aggregate sales volume of the sector. The impact of the mining industry in South Africa plays a major role in influencing economic growth, investment, employment and foreign income. The contribution of the industry within the South African context did decline due to strikes which impacted performance of the industry since the beginning of 2007. According to Fedderke and Pirouz (2002) the mining sector contribution to value added has been declining ever since the year 1970 to 1998. The industry faced numerous challenges where employment and economic

growth have been declining. Rodrik (2008) also argues that South Africa has been going under remarkable transformation since democratic transition in 1994. However, South African mining industry has been experiencing high rate of unemployment and low economic growth. The contribution of the South African mining industry in the economy is been declining due to structural changes which occurred the beginning of 1994 and 2008. The following graphical illustration shows the different sectors contributing towards the South African economy.

Figure 1.2: The contribution of mining and other sectors in South African economy



Source: Author's own computation using data from South African Reserve Bank (SARB)

The manufacturing sector is the leading sector by contributing 59% towards South African economy. The linkage between the mining sector and the manufacturing sector has opened opportunities for manufacturing sector into a competitive environment. Other sectors do contribute only 13%. The transportation sector has also made a remarkable improvement by contributing 8% to the South African economy. The outsourcing of mining companies in terms of transportation and contractors also do contribute in the economic growth.

The mining sector in South Africa contributes about 6% towards the Gross Domestic Product (GDP). The reduction in commodity price, depreciation of rand against other currencies and labour strikes which cover the whole industry continue to reduce mining output. The South African mining industry, even though it is facing challenges, continues to be the leading minerals producer across world.

Table1: the contribution of seven private mining sectors

SA's share of world reserves & production

Mineral	Africa's % of World production	Africa's Rank Production	Africa's % of World Reserves	Africa's Rank Re-serves
Platinum	78%	1	88%	1
Gold	18%	3	55+%	1
Chrome	51%	1	95%	1
Manganese	28%	2	82%	1
Vanadium	40%	1	44%	1
Cobalt	18%	1	42%	1
Diamonds	54%	1	60+%	1

Source: Statistics South Africa, South African Reserve Bank

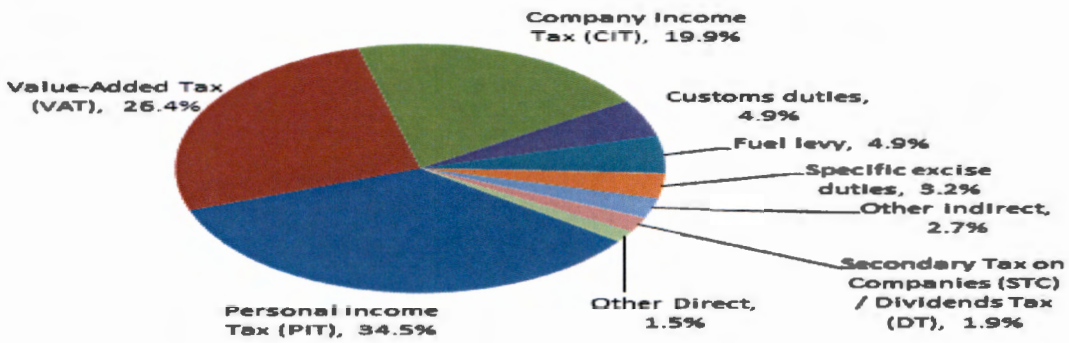
South Africa leads the world in the production of Platinum at 78% and it is also ranked number one in Africa's production. In Africa's world reserves platinum contributes 88% and also ranked number one in reserves. Diamond followed platinum by 54% in world production and contribute over 60% of Africa's reserve. Chrome was 51% after diamond and its reserves are amounted to 95% over platinum and diamond. Vanadium production and reserves are amounted to 40%. Manganese production is amounted to 28% and in the world reserves manganese contributes more than diamond with 82%. Gold and cobalt production are amounted to 18% but cobalt is ranked number one in world production while gold is ranked number three in world production, the cobalt contributes 42% of their reserves and gold contributes over 55% and both were ranked number one in Africa reserves. South Africa remains the leading country with the production of most important minerals across the world.

2.3.2 The impact of mining industry on taxation in South African economy.

In South Africa the government tax revenue is an important source of income used to address economic challenges of the country. Taxation is used as an instrument to reduce poverty, unemployment and to support other social infrastructure as a form of improving life styles and balance inequality. Mining companies in South Africa are paying tax under company income tax. In South Africa government uses two types of taxes which are corporate income tax system and royalty tax systems. According to Curtis(2009) the South Africa mining companies are enjoying generous tax treatment were they can be able to deduct 100 percent of their capital expenditure against tax, however gold mining companies do pay corporate income tax according to the formula which payments are lower to government. The government introduced royalty tax after conceding to the demands of the mining industries. Royalty tax system is another form of taxation which is used to compensate owners of factors of production (government) for extracting minerals in their land.

The mining industries in South Africa enjoy the treatment of tax system more especially in not paying tax for capital expenditure. Mining industries do not pay tax when purchasing equipment, office materials, expanding shafts, research and developments and other social needs. The gold mining companies pay corporate income tax according to the formula that keeps government payments low. When the economy is not stable companies are entitled to pay less than what is required by the South African government. The purpose of creating a formula is to create a life span for gold mining companies in South Africa after the decline in volume of gold output. Steenkamp (2012) argues that personal income tax in South Africa is higher and continues to remain constant since 1995. However, personal income tax has been high and constrained by companies' income tax. The personal income tax is a burden to wage earners and continues to discourage people from accumulating wealth because the more income increases the more tax increases. However, companies' income tax is less than personal income tax. Figure 1.3 below illustrates the contribution of companies to the South African economy:

Figure 1.3: Contribution of taxation in South African economy



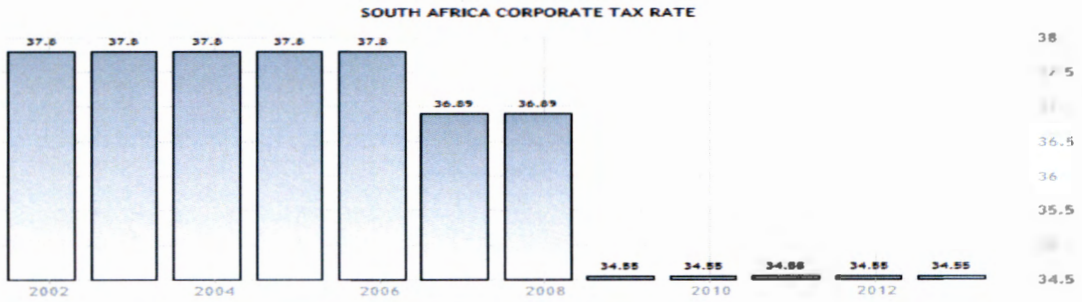
Source: Author's own computation using data from Chamber of Mines

Figure 1.3 shows the results of different tax system in South Africa and are reported as follows: personal income tax (PIT) to government is reported about 34.5%. The employees are ones who are carrying the burdens because in South Africa personal income tax is the first priority to finance government coffers. Value added tax (VAT) contributes 26.4% after the personal income tax and company income tax contributes 19.9% to government coffers. Custom duties and fuel levy both contribute 4.9% followed by specific excise duties with 3.2%, other indirect tax 2.7%, secondary tax on companies are amounted to 1.9% and other direct is 1.5%.

According to the South African Revenue Service (2015), corporate income tax is amounted to 28%. The mining companies in South Africa are given 100% capital expenditure against tax, this means if companies make low profit they will only pay less tax and if they did not make any profit then they would not pay any tax. Mining companies do pay many different taxes and contribute in addition to corporate income tax. In addition to corporate income tax, mining companies pay other different tax such as personal income tax, dividends tax, custom duties and property tax. Other industries can be able to pay such form of taxes, but royalties, fees and other contributions that are specifically to mining sector they effectively represent the payment to government in extracting mineral resources. The Mining industry contributes to government costs of infrastructure such as water, electricity and housing (Price Waters Coopers, 2009).

The study observation begins from 1980 to 2013 but the graphical illustration below does not cover the data range. The graph in this study is used to show performance of corporate tax in South Africa. Figure 1.4 depicts the graphical illustration of South African corporate tax rate from 2001 to 2014. The study employs the graph which does not cover study period. The corporate tax rates were implemented in the early 2000 hence the figure 1.4 begins with 2001.

Figure 1.4: The South African Corporate tax rate



Source: South African Revenue Services

In 2002 to 2006 corporate tax rate in South Africa was held constant at 37.8% for five years. The industry was performing well and generating large profit from their production output. The world financial crises which occurred in 2007 did affect the South African economy. South Africa did face recession were mining also was affected and was forced to cut jobs, mining companies had to pay less tax income at 36.89. In 2008 to 2014 corporate tax rate amounted to 34.55 in the period of 6years. Even though company income tax is less than the

personal income tax in South African, the mining companies do contribute to the government by paying different types of tax. Mining contributes to the government through building houses and infrastructure.

2.3.3 The impact of mining sector in export

The South African economy relies more on primary mineral export commodities which create sustainable development for local to national economies. South Africa is the leading country with regards to primary minerals and exports most important minerals to different countries across the world. Mangondo (2006) mentions that before 1997 gold producers in South Africa were forced to sell their commodity output of gold to South African Reserve Bank and they were paid with US dollars. In 997 the minister of finance announced that the gold producers are free in applying for exchange control regulations if they want to sell the output themselves. The gold sector did not leave the opportunity while they were waiting for such opportunities to occur and walk their business into such stimulating path. The gold producers used the opportunity in order to sell their gold output and used rand refinery as their mediator. The Reserve bank still purchases some of the gold and they make decisions about the reserves compositions (South African Reserve Bank, 2002).

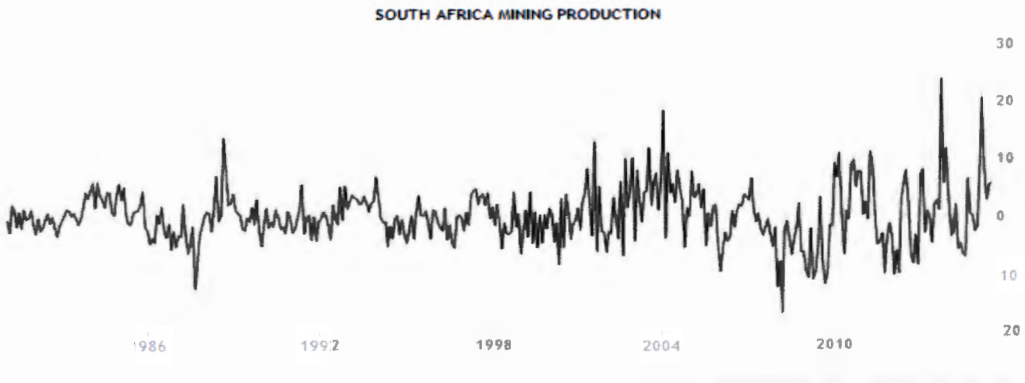
In the South African law, no individual can trade gold rather than gold coin, however individuals can be able to trade with Kruger rand because they are considered as authorized tenders. Maia (2013) proposes that the share of mining sector products in South African Merchandise exports has declined from 58% percent in 1994 to 31.4 % percent in 2003, largely the smaller growth of gold mining did contribute to the decline in mining sector. The rise of the platinum group metals, Iron -ore and other mineral exports has advanced by the proliferation of commodity price before the commencement of economic crises that occurred and boosted the mining exports declined to 48.6% percent in 2011. In 2012 mining exports declined to 44% after the downfall of the platinum group metals while the industry was facing difficult times. Gold exports appealed about 10.1 % percent of share contribution to export basket followed by platinum group metals 9.3% percent, iron–ore 8.8% percent and coal exports 8.2% percent (Industrial development Corporate, 2013).

The department of trade and industry has identified the need of export promotion and development through legislation. The legislation should lead to an increase in South African export volume, production and diversification of exports both in production and markets. The current export should be reserved and new exporters must be developed. The importance of

intensifying export will promote economic growth, increase net currency inflow, job creation, and improve equity and reducing poverty (Department of Trade and Industry, 2013). The intervention of mining on exports enables the mining sector to pave different opportunities and also influence the export growth that will enhance foreign income. In such manner, economic growth and infrastructural development will improve the countries condition.

Wise industrial actions are needed to intervene in order to promote labour by offering skills which will add contribution to technological change and expand production of output. The industry aggregate production output has been fluctuating due to political reasons which forced the industry to focus more on community needs. The ethnic, linguistic and national cleavage has overlapped the process which could have tended into industrialisation. The political and social structure dimensions have an impact in South Africa's mining production and cheap labour that don't have necessary skill and in such manner safety will continue to be the problem in mining sector. Figure 1.5 illustrates the South African mining production as:

Figure 1.5: Aggregate mining sector production



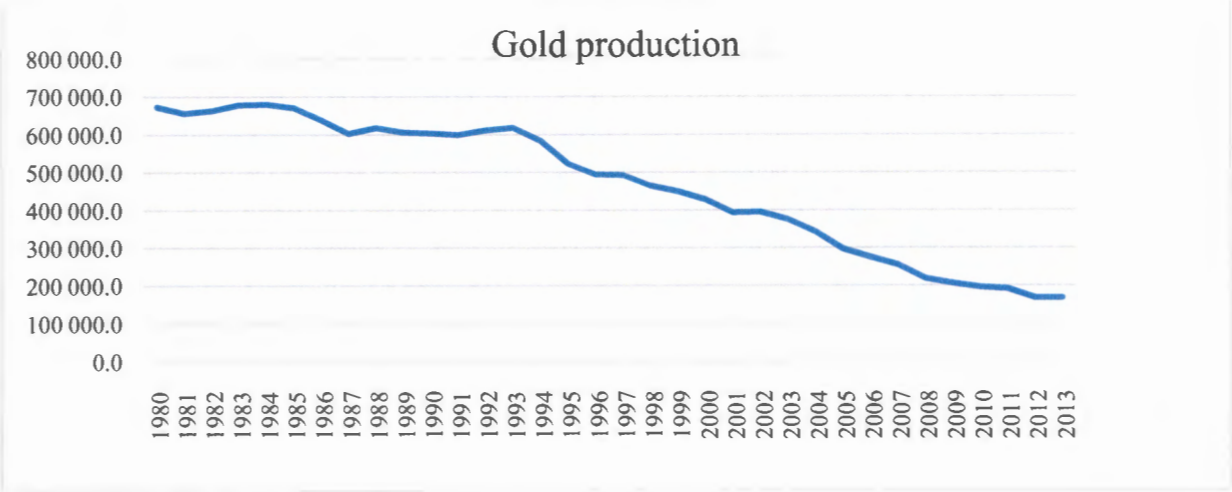
Source: Statistics South Africa

In 1980 to 1986 the production of mining sector was stable even though it did not increase by such values. The South African mining production in the period of 6 years after 1986 until 1992 did deteriorate due to the economic trade a sanction which was imposed by the former government of South Africa. The platinum industry was overtaking both gold and coal because the demand for platinum was increasing. In 1992 to 1998 mineral produced but they were constant due to mining laws and policies which where formulated which protected labour and decreased production of mining output. The mineral output did cover due to the stimulation of platinum and coal while gold production was continuing to decline until 2004. Platinum and gold sectors were facing difficult challenges due to the results of economic

global competitive market environment and world financial crises which occurred in 2007 during 2004 until 2010.

In 2010 to 2013 the labour unrest which occurred in 2012 did also take part in affecting the mining output negatively where industries were forced to use their reserves in order to survive. In figure 1.6 the study present declining trend of gold production in South Africa from 1980-2013. Gold production in South Africa has played the central role of maintaining economy however unforeseen challenges have been occurring which stumbles slow recovery of economic growth. According to Hartnedy (2009) argues that South Africa has fallen in the second country to of producing gold output after china took first place in world ranking of gold production. In large sector in South Africa remains to be gold, coal and other mining minerals .The mining sector have made average contribution -0.03 percentage to the average 3.3% of annual growth rate over period of the 1994-2012 exhibiting either negative or positive. The South African economy is more reliant with mining sector.

Figure 1.6: Production in gold



Source: South African Reserve Bank

The aggregate production of mining output in gold sector has been deteriorating from 1980 to 2013. In 1980 to 1994 gold production was held between 600 000 to 700 000 tons of output which shows productivity of both labour and capital was more productive and generated more revenue, investment and economic growth. In 1980 gold made up to 67 % of all mineral sales and continued to decline less than half of what is used to contribute in 1980. During 1994 until 2013 production of gold out declined from 600 000 to 200 000. Production of gold output decreased due to the structural breaks which occurred in 1994 and 2008. The gold

price did also decline were platinum started to take over gold. The gold metal contributed 3.8% in gross domestic product during 1993 to 1.7% in 2013. South Africa was the leading gold produced in 2007 (Statistics South Africa, 2015).

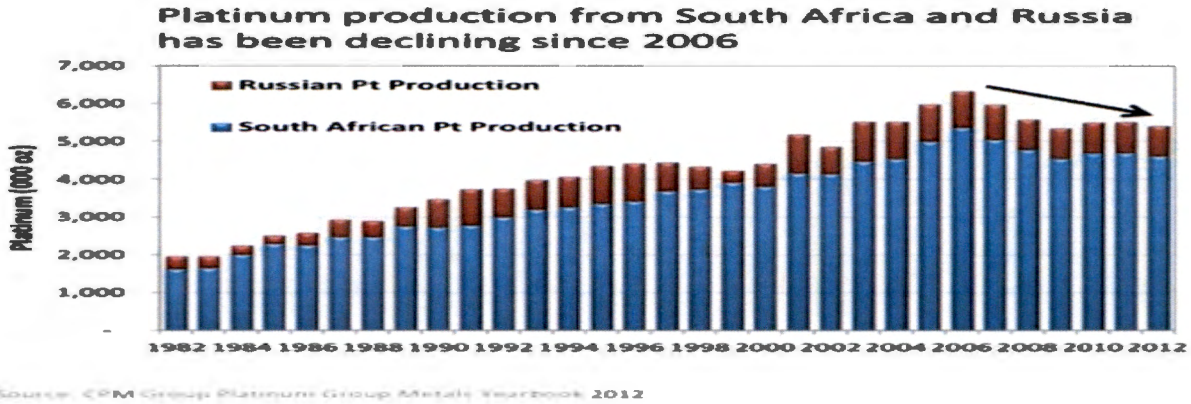
China is been the leading gold producer across world, mining production decreased 4.7% by 2015. The largest negative growth where captured as this manner gold -27, 5 %. The main contributor to negative growth of 4.7% decreases was gold contributing -4.3% and platinum group metal -2.3% (Statistics South Africa, 2015). The discovery of platinum production in South Africa did make another significance role after gold production was declining in the past decade. The Anglo American and Sibanye gold companies are known as the main gold producer. The South African companies are within top 10 which produce large volumes of gold in the world. According to Harvey and Shabalala (2015) argues that "the perfect storm of expanding costs, labour cost and weak metal price have affected South African platinum group metal (PGM) companies into restructure and eliminate production cost". The output of platinum production in South African mining industry does largely contribute direct and indirect to other sectors within the economic sphere.

Platinum is the rare commodity which is only found in South Africa or Russia. Platinum is known as one of the commodities which are exported in different countries to produce different goods and services. The performance of platinum in South Africa has been shrinking for more than two decades and has caused the volume of platinum output also to decline. Many companies have reduced their production output as the results of showing the effects within the market. South African mining industry has responded towards `market conditions which has covered the whole country. The labour strikes which took part in 2012 became main reason in affecting the platinum sector. Platinum sector became number one global reserve earner after gold experience the decline in prices. Even though both gold and platinum sectors have experienced challenges they remain to be largest sectors (Mc Kay, 2015).

Figure 1.7 shows both the performance of platinum production and total platinum group metal in South Africa. We begin by showing the comparison between South Africa and Russia platinum production. Platinum is the rarest commodity which is only extracted either in South Africa or Russia. Since mining sector is the backbone of South African economy the study will explore more in production performance of both nations. South Africa produces

more platinum than Russia. South Africa is known as the country which has various minerals across the world.

Figure 1.7: Production in platinum and total platinum production



Source: CPM Group Platinum Group Metals Yearbook 2012

In 1982 towards the end of 1989 production of platinum in South Africa was below 2 500 oz. 1990 until 1999 platinum production arose from 2 500 oz close to 4000 oz. In the first decade platinum was not in high demand, however platinum became the leading commodity in South Africa after gold price and output declined globally. Around 2000 to 2006 there was high demand in platinum which forced platinum sector to expand their production to almost double digits. The World financial crises which occurred in 2007 at United States of America (USA) caused a decline in price of platinum and also affected output of an industry together with exports commodities.

The weak price of platinum metals has affected the volume output of platinum in South Africa n mining output. South Africa platinum mining sector produce large volumes of platinum and they export platinum to different countries across world. According to Mc Kay (2015) propose that a cut in platinum production by impala platinum 180 000 once is further shows evidence that South African sector do respond to market conditions. The reaction of cutting 180 000 ounces is created by the slow global demand in platinum and producing large volume of output. The introduction of world financial crises which occurred in America around 2007, initially in South Africa which takes part in 2008 and 2009 did cause slow demand in both platinum price and volumes of platinum output. Labour unrest also did contribute to the decline of platinum value which affected the platinum production of South Africa as figure 1.5 has illustrated below.

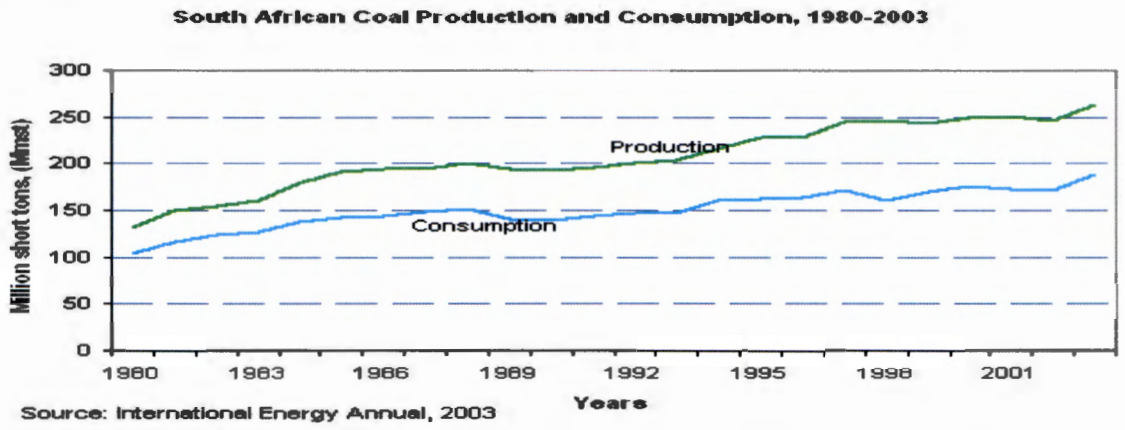
Figure 1.8: Production in platinum

The volume of platinum tons from 2003 to 2006 increased from 149 000 tons to 170 000 tons in 2006. The production of mining industry in platinum output gained value and increased by 21 000 tons. The volume of platinum output was highly demanded and price in platinum also was very high which took over gold sector in 2003. In 2007 world financial crises which affected many economies also affected South Africa. The recession which occurred in 2008 to 2009 in South Africa has affected many sectors and mining sector as well. Since South African economy is more relied in mining sector platinum production declined from 170 000 tons in 2006 to 145 000 tons in 2008. The recession which started in 2008 and gained strength around 2009 decreased tons of platinum to 140 000 tons. In 2008 to 2011 the platinum output increased to 148 000 tons and remained constant between 2010 and 2011. The labour unrest which occurred both in platinum and gold sectors in 2012 and 2013 resulted decline in mining production of output.

The South African platinum group metals mining is one of the largest sector components in South African mining sector on the foundation of gross domestic product, export foreign earner and significant role contributer to the economy. Despite the contribution and significance role to mining sector in south african economy the industry is facing difficult challenges. The industry has been hit by combined impact in slow global demand, market surplus and falling prices(Chamber of Mines, 2012). Anglo platinum and Impala are known as the major contributer of platinum in South African platinum industry. The platinum mining sector is another component which adds value to South African export and economic growth however the mining indusrty in platinum has experienced difficult challenges which cripled the aggrigate economy of South Africa. Other minerals in mining industry continues to growth while platinum and gold are still facing challenges in a market. The production of

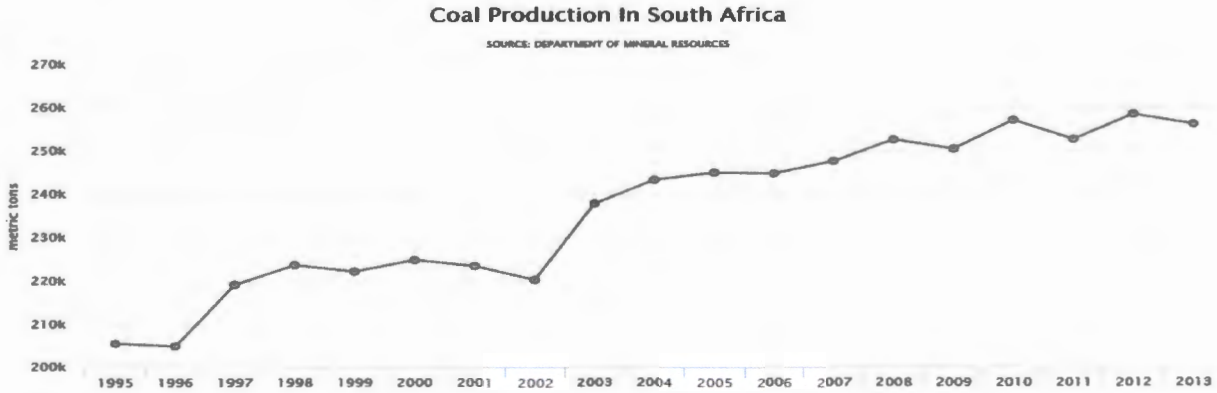
coal as another contributor of supply to energy sector also plays key role in energy sector to economic growth. Figure 1.9demonstrate production of coal in south africa as:

Figure: 1.9 production and Consumption of coal



South African coal in 1980 – 1989was estimated to be 200 million tons which was produced within the country from 125 million tons in 1980. Coal consumption was estimated to be 100 million tons in 1980 to 150 million tons in 1989. In 1990 coal productiom was 200 million tons and increased to 250 million tons of coal in 1999. Consumption of coal also increased during 1990 -1999 but not higher than the coal production. In 2000 towards 2003 coal production remained constant together with the coal consumption. Figure 1.10 is the continuation of coal production in South Africa demostrated above as figure 1.9.

Figure 1.10: Production in coal.



The coal mining is experiencing growth in producing output of coal from 1995 to 2002. In 2002 to 2013 coal production experienced growth even when recession is getting stronger coal mining continues to produce large commodity output. According to Ziramba (2009) conducts the study in South Africa and propose that South Africa has developed energy

supply and production system, the country has large endowments of coal resources. Coal production in South Africa is another important mineral used under energy supply and contributes towards economic growth. Coal mining in South Africa produces adequate coal amounted to 94% of its energy production and the industry contributes towards infrastructural development (Chamber of Mines, 2015).

2.4 Labour Market Conditions in the three aggregate mining sector of South African economy.

This section examines the employment trends in three aggregates of the mining sector from 1980 to 2013. This includes labour usage and providing an overview of changes in labour market concerning the South African economy. The study goes further to provide some explanatory factors that will support the development of employment in mining sector. Changes in the importance of mining industry as the relative employer to South Africa has essentially mirrored the predicament of output in past three decades (Fedderke and Pirouz, 2002). The importance of the mining sector as an employer has been relatively declining in comparison to other sectors and its absolute terms in giving employment within sector. The contribution of the mining sector in employment has been declining and it has affected the hiring of unskilled labour.

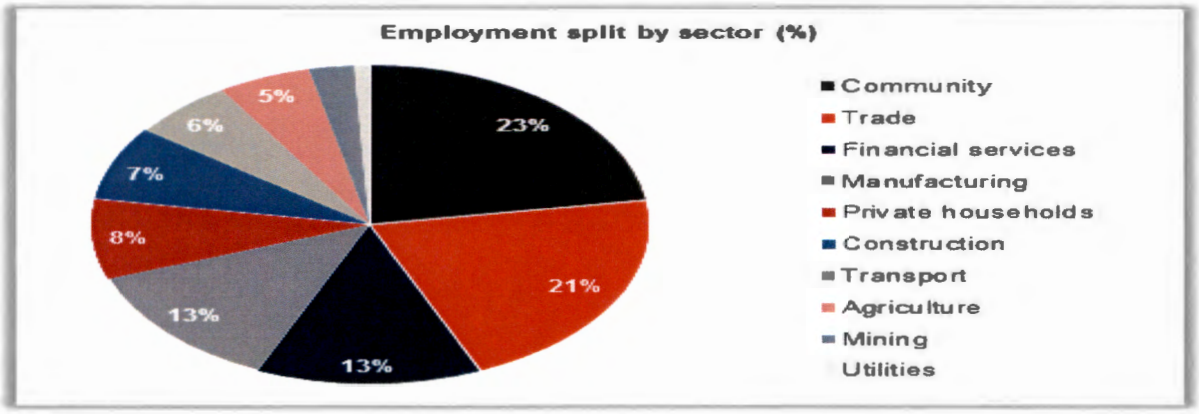
The reasons for causes of the decline in the mining sector are many. There are many reasons which impede employment in the mining sector; however, the study provides only two reasons. Firstly, the decline in value added generated by mining sector creates a decline in labour demand. Examining evidence suggests that best output levels are the clear reasons for decline in employment trends. The mining industry focus is to produce large volume of output with few employees and generate large profit. The change in share output of the mining sector employment is far worse than the whole share of aggregate changes in South African employment.

Secondly the possible reasons of employment trends in the South African mining sector are examined as: labour productive and labour cost. Examining evidence suggests that labour cost has a negative correlation with employment as the economic theory has predicted. According to Fedderke and Pirouz (2002), the increase in labour productivity has not been adequate in expanding labour cost in the mining sector. However they have been justified by skills in the mining sector labour force. The mining sector in South Africa provides employments to semi-skilled and unskilled labourers. Employment in South Africa is the

major challenge which needs to be addressed to alleviate poverty. Growth in the mining sector more especially in employment paves long term growth in the South African economy.

Different economic sectors do rely in the mining sector in terms of its contribution towards economic growth, investment and foreign income. The industry is facing difficult challenges which force the mining sector to reduce their employees and South Africa begins to experience slow growth. Figure 1.11 illustrates the sectors which contribute to South Africa employment.

Figure 1.11: Aggregate employment in South African economy



Source: stats SA, global sight

The community sector in terms of social services is the leading sector by 23%. Mining sector contributes to social services in terms of developing community projects in partnership with government. Trade sector contributes 21% after community sector by 23%. The majority of South Africa's export commodities are primary minerals extracted from the mines, so mining also contributes to trade sectors. Both mining and financial services are directly contributing to employment by 13% followed by private household 8%, construction 7%, transport 6% and agriculture is 5%. The mining industry is known as the leading sector and contributing more on economic growth however the diagram above depicts that when coming to employment they are the third sector when coming to job creation in first quarter of 2013.

2.4.1 Employment by the three aggregate mining sectors of the South African economy

This section examines the employment trend in South Africa from 1980 to 2013. The three aggregate mining sectors contribute more in generating in South African economic development. Mining industry has been sustaining the South African economy about a

century ago and still continues to be the leading sector in generating growth. The industry contributes largely in employment; however, all three aggregate mining sectors are facing challenges in global market. In 2012 mining sector contributed 16.7% in the gross domestic of the country. The mining sector helped to create 1 365 892 million jobs in South Africa economy. The mining sector contributed 14% of aggregate formal employment of non-agriculture. The industry created 524 632 thousand jobs directly and 841 260 jobs were indirectly formed from industries which supply goods and services or use mining commodities downstream value addition. These are industries which are related from spending multipliers of mining and mining employees in economy (Chamber of mines, 2013).

Table2: Contribution of Employment in three leading mining sectors

SECTORS	VALUES
Coal	83 240
Gold	142 201
Platinum Group Metal (PGM)	299 191
Total	**524 632**

Source: Chamber of Mine: 2013

The leading sector contributing to employment in the South African mining sector is platinum group metal (PGM) by 299 191 thousands, Gold mining becomes the second industry amounted to 142 201 of employment in South Africa. The coal mining industry contributes to employment at the rate 83240 people working within the industry and is ranked the third industry which contributes to employment. Platinum and gold industries in South Africa have created a solid foundation in changing South Africa from agriculture to modernized economy. The gold and platinum sector in South Africa still face challenges which affects employment growth within the sector and continues to affect other sectors which relies on mining. The decline in the mining industry goes simultaneous with other economic sectors. The Labour market currently fluctuating while unemployment continues to increase.

2.4.2 Links between Employment and Labour remuneration

The economic theory advocates that there is a tradeoff between employment and labour remuneration. However, when increasing labour, remuneration will improve productivity of the sector and employment opportunities will be created as the reason to expand business.

The aim of employers is to sustain employment by paying labour less remuneration. The trade unions on the other side will go further to enforce a rise in labour remunerations. Mining sector representatives and trade unions continue to create movement and shifts of employment and remunerations in labour markets. In a nutshell, it can be said that there is an excess demand or supply between employment and remuneration. The study investigates a link between employment and labour remuneration in South Africa for the gold, platinum and coal sector.

In the mining sector, wages account for a significant proportion in production cost. The wages in mining sector account more on the company's production costs. Gwatidzo and Benhura (2013) conducted a study in South Africa and discovered that an increase in labour cost and labour unrest would contribute to the decline in employment among the sector. An increase in labour cost and labour unrest does affect employment due to a decline in productivity as the sector would be forced to reduce their labour as a form of cutting costs. The study depicts a proportion of wages to total cost is higher in gold sector followed by platinum group metals and coal sector. According to Fedderke and Pirouz (2002), the most direct additional explanatory variable for employment trends in mining sector given by the economic theory is real labour cost.

The labour remunerations of mining employee are determined by employers looking at their cost production and to remain with large portion of platinum. In 1980 the establishment of the National Union Mine workers was formed. The first legal strike took part in 1984 after great decline in gold price. The reduction in gold price and output remained the burden until early 2000. The labour remunerations for unskilled labour improved due to the better labour representations. Global commodity price decreased and shareholders were putting pressure on companies. In 1988 massive jobs were lost more especially in the gold industries by 60% within a decade resulted by the crises which occurred in 1980 (Malherbe, 2000). The platinum and coal mining sector labour remuneration remained key focus area of labour representatives of national union mine works after it was formed in 1980. Since 1980 there has been a decline in the number of people hired within the coal sector in South Africa. The trend was largely driven by productive gains as the results of introducing labour saving technologies.

In 2009 -2010 employment in the gold mining sector declined from 159 925 to 157 019 in 2010 and the total remuneration increased by 14.4% in the very same period. Despite the

significant recovery in the platinum group metal sector, average employment in South Africa continues to decline from 1.2% to 182 003, while the total remuneration increased by 6.8% resulting in 8.1% increase in average remuneration per employee. The coal mining sector is the third largest sector in employing people after the Gold and Platinum mining sector. In 2009 the coal mining sector employed over 70 000 people and accounted to 14.4% of mining employment in South Africa. Coal mining industry compensated their employees R12 .8 billion in wages including contractors which constituted 14.4% of total wage income within the mining industry as a whole (Department of Mineral Resource, 2011).

In 2011 the gold companies increased their offers to their employees giving 5% to the lowest employees and 4.5% for the rest of employees. The mining sector contributes 6.2% of formal employment in 2012. The basic mining wage were amounted to be R6000 per month and was almost double average entry level wage paid in South Africa. In platinum companies wage cost are amounted to be 55% and 60%. The platinum sector employed 197847 compared to the total employment of mining as 524632 and represents 36.5%. The leading platinum sector saw the importance of increasing wages within an industry. The coal mining industry directly employs close to 90 000 people and paid almost 19 billion in wages. Coal mining industry offered employees with 8.5% for lowest employees and 7% was for rest of employees (Chamber of mines, 2011.

The striking of labour unions as a form of increasing their wages is the main cause of disruptions of the country's business and investment. Both centralised and non-centralised bargaining plays an important role in determining wages of mining sector. The chamber of mines plays an important role as a representative of mines and negotiates with other representatives from different sectors more in coal and gold mining sectors (Bhorat, Westhuizen, Coga, 2009). The mining sector in South Africa is going into difficult challenges which cause companies to close other operations and reduces thousands of employees. Remunerations in South African mining sector have increased due to the enforcement of better labour representatives which have hindered employment. There is a tradeoff between employment and labour remuneration so should the mining sector continue in promoting employment or remunerations. All those three mining sector should continue to enforce growth in employment and strengthen the sector to bring growth in South Africa.

2.5 The link between mining sector and infrastructure in South Africa

The infrastructural development in South Africa is an important factor to expand economic growth. The main importance of creating infrastructural development is to create a path for sustainable development which is aligned with national development plan however the development of both economic and social infrastructure has long troubled South African history. Social infrastructure directly affects growth such as health and education. They do add value in the production output such as human capital as a source of acquiring knowledge and skills to operate new technologies. Infrastructure is seen as an important factor that adds value to inputs within production and leads to economic growth (Fedderke and Garlick, 2008).

Barro's (1990) argument demonstrates that the important attribute to infrastructure expenditure in the public sector only increases the marginal product of other capital used to certain point. The infrastructure provided by the public sector also does persuade other capital used within production process. Public sector expenditure in infrastructure has a positive influence in other capital used within production although private sector expenditure in infrastructure continues to lead in expanding economic growth. The combination between both public and private sectors in terms of developing infrastructure brings development in expanding growth of a nation. Government should strengthen and create new paths by supporting mining industries as they are leading sector in South African economy.

The industry is at risk and well planned infrastructure should be developed based on insufficient skills and technologies to be produced. The mining industry should start by investing in their employees who have no skills and who are semi-skilled. The mining industry would not achieve this alone but also government should come with strategic investment that will enhance the industry forward. Once the investment is captivated, then the capital will improve which labour efficiency will be needed to expand productivity. Cawood (2011) argues that South Africa needs to consider the main threats of sustainable mining as a competitive industry. In terms of development, South Africa needs to put more focus on challenges which affects mining industry. More attention is needed in minimizing the threats as a stumble block of bringing development in South Africa.

Countries like Turkey, Portugal and China have experienced double digits in growth rates of research and development in recent years. Other OECD countries have successfully transformed their economies from resource based to knowledge based spending 4% of Gross

Domestic Product in Finland and Sweden research. The average spending of research and development in other OECD countries is estimated to 2.3% when comparing South Africa with those countries, it only spends 1% in research and development. South Africa does not significantly invest much in research and development which is still struggling in transforming from resource based economy to knowledge based economy (Organisation for Economic Cooperation and Development Facts book, 2010).

Cawood (2011) articulates that necessary skills, Knowledge, Research and Technologies are needed to open new reserves and develop necessary infrastructure that is optimal to minerals. It is in the industries' interest to produce high volume of output without compromising health and safety of workers, environment and delivering to the public benefits. This question will only be addressed by universities by producing students who are innovative and solving problems within industries. New skills, knowledge, research and technologies will only be obtained at institutions of higher learning which the industry should finance students to enroll for scares courses which can enhance expansion of development within the industry towards economic growth.

The standard of education and better facilities for health should be continued to be prioritized by both the industry and government. Securing health and education stimulates labour to be more intensified as the result of being productive. Investing in education as the form of training labour increases the marginal productivity and output will also increase. Establishing new infrastructure which results into productive of labour and total output will significantly proliferate investments. Acquiring new investments needs people who are fully skilled and being able to develop new technologies which will be operated by intensified labour. Government spends lot of money in both education and health but more intervention are needed in improving standard of education and health facilities in South Africa.

2.6 Conclusion

In this chapter the study stresses out the evolution of the mining sector in economic growth and how mining sector can expand infrastructural development to enforce economic growth in South Africa. The mining sector is playing the significant role in contributing to South African economy more in attracting investments, foreign income and employment. There are numerous challenges that have occurred and shifted the focus on mining sector in bringing development. The chapter shows the contribution of the mining sector to total output in South Africa, labour market conditions of three aggregate mining sectors and the link between

mining sector and infrastructure. The contribution of the mining sector for total output in South Africa shows total output value added, taxation, export and total distribution of output. Labour market conditions of contributions in three aggregate mining sectors entails employment and employment and labour remunerations have been discussed. The link between infrastructure and mining sectors explains the importance of education and health in expanding productivity. The well planned strategy is needed to formulate a comprehensive plan that will be aligned with national development plan, mining charter and new growth path.

CHAPTER 3

LITERATURE REVIEW

3.1 Introduction

Numerous empirics propose that mining infrastructure investment is associated with slow economic growth and the crowding out of private and public investment through their effect on high demand of real wages, decline in productivity output and high rate of unemployment. According to Fedderke and Garlick (2008), infrastructure investment is seen as an important factor that adds value to inputs of production to reach maximum output. As a result, various policies have been developed to address the challenge of infrastructure in emerging economies. However, several studies have conducted similar study were their argument are based on the demand and supply side of the economy. The first part of this chapter deliberates on the theoretical vagueness of the relationship between mining infrastructure investment and economic output. Secondly, it reviews the relevant empirical inputs to the debate on developed and developing countries and South Africa in particular.

3.2 Theoretical literature

The aim of this section is to review theoretical exposition of the mining infrastructure investment and its relationship with economic growth. The theoretical underpinnings are from Marxist, Keynesians and neoclassical economist who employed the production function in their study to formulate theories in economic growth. The theories are Marxist, Harrod Domar Model, Neoclassical, Rostow's growth theory, Neo-Marxist and Endogenous growth theory. In this section of the study, the above outlined school of thoughts referred to are discussed in detail and the attention is given to the implications, assumptions, arguments raised and critics.

3.2.1 Marxist theory

According to Ellman (1989), postulate that Marx argument emphasise the importance of social rational system. He further the study by explaining that only planned social economy will lead to the rational system when there two advantages are taken into consideration: firstly the absence of anarchy production and secondly in the absence of class conflict. Firstly the theory explains that in the capitalist system every firm is isolated from one another and producers make many commodities in the aim of making maximum profit. Under the socialist view, whether the firm produces and they do not make profit, still the workers will

continue to receive their remunerations. The central socialist view is to protect the resource and the interest of the people in order to bring equal opportunities for everyone.

Secondly, the class conflict as was outlines by the socialist means reaching rational objectives in an efficient way. Marx in his theory was to provide much of the inside in how to establish the rational objectives in an efficient way to bring development. Prychitko (2002) argues that Karl Marx criticised capitalism and explain capitalist as the system that exploit workers in the form of obtaining profit. The owners of production should privately enjoy, they should not be able to ruthlessly exploit workers. The owners of factors of production should enjoy their privileges and not to be exploited. The classical economist failed to adequately explain the capitalist profit. In his study he believed that capitalist does block the capacity of human to create human society.

Butgereight and Carden (2011) postulate that Marx in his theory of the communist manifesto argues that they should be the abolition of property right, once he could be able to remove the capitalist system people will move to the last stage which is communist. Socialism should eliminate inequality, and once the property right is eliminated, then the issue of inequality will be corrected. Sowell (1985) approve that Marx work will increasingly grow being sophisticated but his study will remain essential for the system. The work of Marx was trending and in such the way that it was very crucial in assisting the society within a socialist system. The study was needed to protect resource to the best interests of society and not to influence profit motive within capitalist system.

Butgereight and Carden (2011) also approve the theory of Marx and Engels were clear on their goals. However, they failed to provide with the link between the eradication of property rights and prosperity even though Marx was clear on eradicating property right in order to correct inequality and to address equality. Marx in his essay wrote an actual economic fact which is outlined as "the worker becomes poorer as the wealth he produced increases, the more his production increases I power and extent , the more he become cheaper commodity as more commodity produced" (Marx, 1844). In Marx's study all of factors of production go to the employer and the worker remains only with the small portion of income. The labourer's humanity is debased by private property right and most of capitalist production.

In order for the labour to survive under capitalist system, they should change exchange labour as component which they own with commodities because they are alienated from their own production output. Marx and Engels (1848) advocate that labour becomes the slaves of

"Bourgeois" and they must accept any rate which the capitalist offers. Marx in his study criticised the capitalist and supports that all resources should be centralised and controlled by the state. He believed that once the state takes controls of resources then labours will be not be exploited, land will not be destroyed in the form of not expecting profit. The capitalist system in Marx writings were taken as a system which is there to oppress the rights of society and stealing their resources for their own benefits.

The workers will form collective group and take their demand to the political sphere as a force to be reckon about (Marx and Engles, 1948). The labour will be joined by number of people from middle lower class who their entrepreneurial livelihoods are being destroyed by industrialised factories; all society will be going to the one side to support labour. People will move from capitalist system to socialist system. The theory of Marx, even though was very essential towards the socialist and communism, was criticised by many theorist.

3.2.2 Harrod Domar model

Harrod (1939) and Domar (1946) independently developed the identical growth model which was referred as Harrod Domar Model. The Harrod Domar model is known as one of the first model to be developed and being the best in the history of economic growth models. One of the assumption of Harrod Domar model is both capital and labour are constant and the condition is both labour and capital are fully employed (Hess and Ross, 1997). The level of output ratio to be produced will require some units of both labour and capital. In this model only capital and labour where used as input ratio to produce the level of output, however, both the rate of capital and labour should increase with the same rate level of output ratio.

The second condition is that investment and savings are equal at the one sector model where there is no government and foreign trade. According to Hess and Ross (1997), investment is a production national output which was not used in present consumption, while savings is the income which was generated from production of national output and was not used for present consumption. Investment is the sum of national income which was postponed for future consumption while savings is the income earned by labours during production process and was not spent. When investment is equal to savings, then the expenditure will also be equal to the output ratio produced. The savings rate is sad to be determined by external factors which are not included in the model.

They pointed out that investment changes the economic supply and demand side. Full employment can be reached only if the investment and other sources of aggregate demand grow as fast enough to absorb the increase output that the new investment made it possible. Once the investment and other sources of aggregate demand increase, then the economy will shift to the new level and employment will be maintained (Van De Berg, 2013). In the Harrod Domar model, the country is expected to growth only if they save some of their portion of income. According to Van De Berg (2013) presented both demand and supply side of Harrod Domar model and the study used the same models to explain the theory of Harrod Domar. In his study he firstly shows the supply side then secondly we will illustrate demand side of a model.

The supply side of Harrod Domar model is to capture the potential inconsistency between investment, dual effect and aggregate demand and the economic production capacity. Harrod and Domar separated their demand and supply model. They wanted to make a fundamental point to show potential consistency between aggregate demand and aggregate supply, not to give a general growth model. They hypnotized the simple model where investment has only one contributor to economic growth. In their study one of the assumptions was having a constant marginal product of capital in order to keep model linear. They wanted to show how investment contributes directly to increase productivity capacity and not to clutter their abstract model with features which are unrelated to the purpose at hand.

3.2.2.1 The supply side of Harrod Domar model

Firstly the constant marginal product of capital means the economy is exhibiting a constant ratio $K/Y_s - \gamma S$ and the supply of output Y_S is proportional to the stock of capital (K):

$$Y\sigma - (1/\gamma)K \tag{3.1}$$

The change in output is equally to the change in the capital stock

$$\Delta Y_S - (1/\gamma)\Delta K \tag{3.2}$$

If capital does not depreciate then the change in capital will be equal to the investment. Another assumption is savings rate is constant σ, all other savings are invested productively,

$$S - \sigma Y_S - I - \Delta K \tag{3.3}$$

Combining the equation (1), (2), (3) will give us the following equation as:

$$\Delta Y_S - (1/\gamma)\Delta K - (1/\gamma)\sigma Y_S - (\sigma/\gamma)Y_S \qquad (3.4)$$

We derive the equation (4) below by depicting an equation as follows:

$$GY_S - \Delta Y_S/Y_S - \sigma/\gamma \qquad (.35)$$

The supply side of Harrod Domar model does suggest the rate of economic growth is constant equals to the ratio of the savings to the capital output ratio.

3.2.2.2 The demand side of Harrod Domar model

In the demand side of Harrod Domar hypothesised that investment demand is a function of recent growth in the aggregate demand of output *YD:*

$$I = b(\Delta Y_D) \qquad (3.6)$$

The parameter *b* relates new investment to the change in aggregate, which Harrod Domar assumed aggregate demand consistent of just consumption and investment.

$$Y_d = C + I - (1 - \sigma)Y_S + b(\Delta Y_d) \qquad (3.7)$$

The economy is in equilibrium when the desired investment is equal to the actual savings or when:

$$b(\Delta Y_d) - \sigma Y_S \qquad (3.8)$$

When we manipulate the above equation then we have a new equation as:

$$\Delta Y_d/Y_S = \sigma/b \qquad (3.9)$$

It is difficult to maintain this equilibrium because dynamically the growth of aggregate demand is equal to the growth of aggregate supply only if,

$$\Delta Y_d/Y_S - \sigma/b - \Delta Y_S/Y_S - \sigma/\gamma \qquad (3.10)$$

In the formal sector when we combine the demand side and supply side we will start by a simple equation showing the economic output at the left hand side (Y) and two commodities as consumption (C) and investment (I) given as:

$$Y = C + I \qquad (3.11)$$

Harrod Domar represented investment with change in capital (Δk): the change in stock of capital is equal to the investment, the stock of existing capital is not affected by depreciation

$$Y = C + \Delta K \tag{3.12}$$

The Harrod Domar assumption is that existing capital stock never becomes absolute investment and always rise the total rate of capital stock. The constant capital ratio is shown as:

$$K/Y = \gamma \tag{3.13}$$

When we move both constant and income to the opposite side it becomes clearer that output is proportional to the change in capital stock given as:

$$\Delta y - (1/\gamma)k = AK \tag{3.14}$$

In the Harrod Domar model conclusion, we say the rate of growth in output is proportionally to the rate of savings. The constant capital output also implies the change in output will equally be to the change in capital stock as:

$$\Delta y = (1/\gamma)\Delta k - A\Delta \tag{3.15}$$

For the country to grow it must invest and we expect the investment to be equal to savings, it is assumed that savings are invested productively and generate output according to growth in capital stock as:

$$\Delta k = I - S - \sigma Y \tag{3.16}$$

The ratio of propensity to save to the capital output ratio provides with the warrant growth rate of output and both capital and labour are required to grow at the same rate. In this study, the natural growth rate of labour was considered as given, because it was considered by a number of factors which are population growth rates and labour force participation rates. The theory had its own shortcoming where various theorists criticized the Harrod Domar theory. In the Harrod Domar model the determinants of natural growth rate such as population growth rate and participation of labour force were not given, meaning the reasons why natural growth rate was considered to as an exogenous facto were not given. "There are many fixed parameters in the Harrod Domar model and no adjustment mechanism within the study" (Hess and Ross (1997).

In the Harrod Domar Model, every country is expected to save certain portion of its national income in order to grow. For the country to grow, new investments are needed in order to expand capital stock of the country.

3.2.3 Neoclassical Growth Theory

In 1956 an American economist Robert Solow developed the study of a contribution on the theory of economic growth. He developed this study after criticizing Harrod Domar that savings is not the only variable that could expand the growth. In his study he presented the coherent dynamic model with an explicit description of the process of capital accumulation in which savings and investment are being into new capital. In the Solow model, available suppliers of capital and labour used to produce output within a year are employed to clear factor markets. The savings and investment are assumed to be exogenous, while the labour force are expected or assumed to grow at the given rate. The essential need about Solow model is that it incorporates dynamic link between savings and investment and stock of capital (Solow, 1956).

According to Sorensen and Jacobsen (2005), Solow model accounts for two successive years, so the stock of capital will increase by the amount of capital minus depreciation which will be the net investment. The stock of capital is equal to the net investment after deducting depreciation. Fourie and Burger (2015) present the assumptions of which were applied by Solow growth model, firstly there is a constant return to scale and secondly diminishing marginal of returns of both labour and capital. The constant return to scale means factors of production when they increase by given percentage of 10% then the output will also increase by the same percentage. The diminishing marginal returns means when labour increases and other factors of production are held constant the output ratio will increase to a certain point and begin to decline. Solow (1956) originally he developed the basic model of income is a function of capital stock(k), labour usage in production(n) and an index of technological and institutional progress(A). Mathematically we can present the formula as:

$$Y = f(K, N, A) \tag{3.17}$$

In the Solow growth model, technology was considered as an exogenous variable and only capital and labour force were believed to expand output ratio. We can rewrite the formula in the following manner where;

$$\frac{Y}{N} = f(\frac{K}{N}; A) \tag{3.18}$$

$(\frac{y}{n})$ Represent output labour ratio, $(\frac{k}{n})$ capital labour ratio and (A) an index of labour ratio. According Fourie and Burger (2015), the output labour ratio towards economic growth could increase in the long run only when savings and investment, labour force growth, progress in terms of new technology and improvements in human capital are well financed. Once the investment and labour force and technology are being promoted then the national income will also arise and Gross Domestic Product will also advance. In the Solow growth model it is said to be only technology does improves the output ratio or economic growth. Technology was considered as an exogenous variable, labour and capital cannot only raise level of output without using technology.

At the steady state including savings, the required investment worker for capital stock to keep up with labour usage is illustrated as:

$$\frac{I_t}{N_t} = \delta\frac{K_t}{N_t} + n\frac{K_t}{N_t} - (\delta + n)\frac{K_t}{N_t} \tag{3.19}$$

This equation illustrates how required investment per worker ratio should keep both capital labour ratio and output ratio stable. The investment needs to be financed from the available savings rate within the economy. Since savings is the portion of income which was not spent then we denote equation as:

$$S_t = sY_t \tag{3.20}$$

(s) Is the average savings rate, the actual available investment is equals to the average saving rate. So actual available investment is given as:

$$I_t = sY_t \tag{3.21}$$

In the steady state or equilibrium, the actual available investment is equal to required investment per worker given as:

$$S\frac{Y_t}{N_t} = (\delta + n)\frac{K_t}{N_t} \tag{3.22}$$

In the Solow model, investment should ensure if capital stock grow to keep up with the labour efficiency or technological change. In this case the required investment will keep capital labour ratio output ratio stable or equal rates as:

$$\frac{I_t}{N_t} = (\delta + n + a)\frac{K_t}{N_t} \tag{3.23}$$

The balanced growth model at a steady state will be given as:

$$S\frac{Y_t}{N_t} = (\delta + n + a)\frac{K_t}{N_t} \quad (3.24)$$

The balanced growth equation can be can be deduced from the above equation as:

$$sY = (\delta + n + a)k_t \quad (3.25)$$

According to Solow (1956), "population growth is the drag to economic growth" Solow in his writings believed that economic growth will increase when there is technological advancement without having high number of population which will delay growth. In the steady state output ,labour ratio, capital ratio and technology are expected to grow at an equal rate then we could say convergence does exist between developed and developing country.

3.2.4 Rostow Growth Theory

Rostow (1956) developed the study of stages on economic growth which advices the traditional economies to progress towards industrial economies. Countries should pass all the stages as the transition towards economic growth or development in order to sustain their investment and total real output. Todaro and Smith (2009) introduced Rostow as the most prominent and outspoken intellectual in stages of economic growth. The American historian Rostow developed an influential study which all countries can be able to use in order to widen the economic progress that will lead towards to development. This study was also developed as an alternative to Marxist theory of non-communist manifesto.

Thriwall (1994) outlines Rostow's study as a political theory and descriptive economic study used as the pattern for growth and development within countries. The central theme of Rostow's development stages is logically and practically possible to identify the stages of development and to classify countries according to their stages. In his theory Rostow distinguished five stages of development which are traditional economies, transitional, take off, maturity and high mass consumption.

In the first stage known as traditional economies societies are meant to produce high proportion of work force in agricultural commodities, less social change with less great wealth and decentralised political power. In developing countries societies focus more on agricultural commodities were there are extensive of natural resources but less of technological advancement. In his theory he further explains that most societies who have

emerged from traditional societies are impacted by external challenges and nationalism. The primary stage influences much on agricultural activities and labour mobility contributes much to the economy. When labour mobility and social change improve, then the society moves to the next level.

The second stage is identified as transitional stage where the level of primary investment should be at its minimum with national income to sustain growth. Societies should have an investment which could create growth. The Infrastructural development is a key role for the country to create a path towards sustainable growth. The basic services such as roads, schools and other services are of importance to society's growth. Societies which are within transitional stage are to start by focusing in public investment for their infrastructure. For the investments to grow, people must be willing to take capital risks which are available for people to be entrepreneurs and also innovate the willingness of people at large to operate within economic system, moving from home to factories and the principle of division of labour. Societies are expected to take risks which are to advance them economically in terms of opening business and specialising based on your ability. The excess commodities should be taken into industries which would make a small profit and all the portion will be used as a form of investment.

Thriwall (1994) clarifies that Rostow's take off stage using the development literature as it is similar to transitional stage, however there are merits used to isolate both stages. The third stage is identified as take off stage starts off in private investment as it plays a crucial in expanding self-sustaining. He further developed the study of take off stage as an interval during the rate which investment increases in a way where real per capita output rises and initial increase promotes radical changes in production technique, the disposition of income flows which perpetuate or creates the new level of investment and also perpetuate the new rising scale of real output per capita. The investment should rise to an excess towards national income sufficiently to guarantee the future levels of savings and investment. Rostow on his study persists on explaining the leading growth sectors should maintain its establishment.

The initial change requires some groups who have the will and authority to set up or distribute new production techniques and continue the growth process. It requires that those who are the leading group should expand the authority and the society at large must respond direct to changes including potentials of external economies. Rostow (1960) advocates that any industry can play an important role in leading the sector but based on four conditions.

Firstly, the market of the product should be growing fast. Secondly, the leading sector generates a second expansion. Thirdly; the sector has an adequate and continual supply of capital from back profit and lastly the sector should have the scope of increasing in productivity.

Once the societies have reached technological innovation and political revolution then the sequence of take off stage is achieved. In the fourth stage, which is maturity stage, society changes as the economy converge. The growing economy drives to extend modern technology. The national income is invested and the real production output is increased in order to outstrip the increasing population. The make-up of the economy changes unnecessarily as techniques improves, new industries improve and older industries leave markets. The important goods are mostly produced domestically and new imports requirements are developed and export commodities which are to be matched.

The society makes requirements as the process of modern efficient production in terms of balancing the new against the older values and institution or revising the latter in such a way to support the new ideas in order to speed up the process. The process at this stage realises progressive technological advance and entrepreneurial skills but not to produce everything. The last stage known as high mass consumption citizens have variety of choices which they can choice on what they want and satisfies the utility of individuals. In this stage there is no need for government to intervene because the economy is at the peak. The level of employment, poverty and inequality are maintained at the lower rate.

3.2.5 Dependency theory

The dependency theory is explained as underdevelopment its transition start from capitalism to socialist. According to Coetzee and Graff (1996), developing countries will never reach development because the developed countries exploited the resources from developing countries during the colonisation. Their debate is that countries which are no longer colonised still depend on those industrialised ones. The North countries exploited South countries resources to be rich and leave developing countries to be poor. The developing countries are no longer colonised politically but economically they still depend on developed countries. In the dependency theory neo- colonialism is the central theme which they argue about.

The industrialised countries are the ones that set the laws through global competition while developing countries should engage into such agreement because of they don't have sectors

which will refine the raw material .The neo-colonialism does slower the growth of developing countries. In order to approach industrialisation, there are three aspects which needs to be followed firstly; capital, labour and resource. The European countries continued to exploit the poor countries in the form of neo colonisation. Mowlana and Wilson (1990) advocate that "dependency theory was not the new model of development but collection of criticism of the conventional approaches". The critiques dealt most with the underdevelopment rather than establishing new methods of development.

Their main argument was based more on criticising modernisation capitalist development in how developing countries will not be able to catch up with developed countries. White (1989) opposed capitalist system or modernisation theory as a dominant modernisation paradigm that saw development in terms of economic growth that needs supports in terms of foreign policy agenda, interest and adventures of western democracies in their diffusion of dominant political , social and cultural values. Modernisation paradigm is the system supporting foreign policy agenda in order to stimulate the growth of western countries and by not protecting the interest and growth of developing countries.

The Western countries influence developing countries by using modernisation policies adopted from western countries which will benefit them but leaving developing countries with a smaller growth. The insight of dependency theory is developing countries for them to grow should have to be independent from developed countries in terms of adopting their own policies and laws. Historically wealthy nations took many quantities of minerals and material to the poor countries. The agricultural commodities which were could have left in the poor countries where also taken to the manufacturing in wealthy countries.

Wealthy countries could not be rich if they could not take those materials from the poor countries and continue to expand their profit by using cheap labour. In the dependency theory, they emphasis's that in the third world developing countries are faced by poverty, unemployment, and inflation which caused by the modernisation countries. Their argument is developing countries would have been rich only if they could not exploit their land and other factors of production.

3.2.6 Endogenous growth theory

Mankiw, Romer and Weil (1992) in their study developed the model which is similar to the Solow Swan model. However in their study they added human capital and endogenous

technology contrary to Solow swan model where technology was given as exogenous. The theory focuses on positive externalities and spillover effects of knowledge based economy that will lead to economic development. In the endogenous growth theory, the spillover effects are disseminated indifferent investment as the results of human capital and reduce the diminishing of returns to capital accumulation. In their controversial study, the long run growth rate of the economy does holds into policy measures. This model is also seen similar because it assumes that there is constant return to scale beside human capital which is included in the model. Mankiw, Romer and Weil saw the gap in the Solow Swan model by including human capital in their production function as a form of expanding output per worker.

One of the assumptions used in the theory is that production function does not exhibit diminishing returns to scale that will lead to endogenous growth. Various rational assumptions are given such as positive spillovers where capital investment would lead to growth as economy as in the whole and improvement in technology leading to improvement in learning and various institution. In the production function, Agenor (2006) argues that an important way from Solow Swan model is the small changes in resources devoted to both physical and human capital accumulation which may lead to large changes in output per worker. In their study, human capital plays major role which they believe that introducing human capital may accelerate production output and also brings improvement in labours. Mankiw, Romer and Weil (1992) proposed their model as follows:

$$Y = AK^{\alpha} \tag{3.26}$$

Where Y stands for output ratio, K stock of human capital and A symbolises technological progress. The study applies decreasing return to scale in physical and human capital ratio but holds constant return to scale only in labour and capital. In their study technology is not given or taken as an exogenous factor, however it does not seen as the only factor that brings growth. Technology in endogenous growth theory is treated as an endogenous and do believe human capital and technological progress are the core answer or an agent to economic development. Mankiw, Romer and Weil assume both physical and human capital do follow the rate of depreciation. This means the rate of depreciation in human capital is assumed the same as physical capital. Mathematically it can be expressed in the following manner:

$$H = S_H Y - \delta H \tag{3.27}$$

The investment in human capital can also be depreciated when the productivity of labour have begun to diminish. Human capital can be defined as the contribution of individual skills, experience and knowledge for the whole economy to improve both social and economic development. The qualification obtained by various individuals and knowledge are mainly known as components of human capital but contributing directly to growth. This really reflects Human capital continues to be potential engine of growth. The Technological progress are driven by high intensive individuals who have skills and knowledge being able to apply both into particular commodity. Romer (1990) regarded human capital as economic efficiency. Human capital can also be efficient because once the firm has labour who are highly educated they will apply their knowledge, experience and skills to produces efficient but aiming for maximizing the profit.

Baztosan, Aksoylu and Ulucak (2016) acknowledge that Romer regarded technology as outcome from individual abilities to create new commodities, ideas and including human capital accordingly. In the endogenous growth model population was never seen as a negative factor towards growth. The availability of population is seen as a direct input within the economy because once those populations are technologically advanced then they are knowledgably with necessary skills and the economy will grow. In the endogenous growth theory the marginal product of capital does not diminish to zero, this means large firms will be productive than small firms because they still diminishing.

3.3 Review of Empirical literature

The role of mining infrastructure investment on economic growth studies has been conducted but leaving other important concepts behind. Many studies have shown how mining does contribute towards infrastructural development and economic growth. As a result, mining infrastructure investment has showed both negative and positive impacts towards economic output. However, there are a small number of studies which has used econometrics to analyse the similar study. The purpose of this section is to review related empirical studies on the role of mining infrastructure investment and economic growth. The study reviews closely related studies of the role of mining on economic output, literature in infrastructure is employed to support the basis of a study.

3.4.1 The role of mining sector in Australia

Hajkowiez, Heyenga and Moffat (2011) presents the study in Australia examining the relationship between quantity of life indicators and gross value materials, using 71 local government arrears containing mining activities of household income, housing affordability, and access to communication services, educational attainment, life expectation and unemployment. The cross tabulation of correlation coefficients used the statistical significance of Fishers test and the results were found that there is no negative relationship between quantity of life and gross value of minerals produced. There is positive correlation between the quantity of life and gross value of minerals produced. This means the gross value of minerals produced also causes the quantity of life because people will have opportunities to create employment, their level of education will improve and other communication facilities. The effectiveness and efficiency of labour in productivity within the mines would enhance opportunities for the economy as a whole.

Tonts, Plumber and Lawrie (2012) examined the relationship between socio economic wellbeing and resource dependence in mining towns. They also used cross sectional analysis of socio economic performance in 385 small mining towns in the Western Australia. The results of social economic wellbeing are said to be highly on variable and contingent on the range of factor particular in commodities, company structure and location. The socio economic wellbeing is not supposed to be improved or to increase based on merits such as location of mine company structure and the value of commodity. The socio economic wellbeing should improve in all different angles not only in the availability of resources but such resources can also be used to generate opportunities for other towns to grow.

The availability of resources in towns creates urbanization and people will move from one town to another to seek of opportunities and social wellbeing on people would be affected negatively because of availability of crime and other health risks. Contrary, Solomon, Katz and Lovel (2008) mention that social dimensions of mines are increasingly acknowledged as critical towards business success but yet remain to be the least of business concept of sustainable development, economy environment and society. They presented their study using current debates, research and contemporary issues on Australian mining industry. The social dimensions of mines are critically taken as business success but their effort in social development is not seen adequate.

The study used debate, research and contemporary issue in order to address the issues of communities, also adopting policies and practicing such policies to emerge both industry and society. Esteves (2008) addresses the study by questioning how mining companies can access social investment as a project that can add value more companies and communities in which they can operate and being aware of practical hazards in order to facilitate local development. The study utilized the case study method to address the key issue of social investment projects and the results obtained was there are eight principles underpinning social investment strategy and great value for both business and affected communities. Many companies increasingly avoid methods which they should undertake to assist local and national government. The mining industry should take full responsibility in implementing policies effectively to expand social investment and monitoring such policies in an ongoing process.

Chestrie (2010) conducted the study and found that mining companies have positioned themselves as a central actor in governing or intervening as voluntary partnerships to assist those communities who are affected as by sustaining among business, government and community, the study goes further by being analytical on asking government how can mining sector be the leading actor in determining the future of local mine communities who are affected. The government should utilise the mining companies as an instrument to add value on social investment. The mines intervene by securing their operational license in contributing positive to affect communities. According to Fernandez (2008), a country has achieved much in expanding economic development in terms of mining. The Australian industry has built a national infrastructure for more than century. Their results shows that both the mining technology services and mining industry suggest innovation to the point where interactions of firms through knowledge intensive services activities.

The innovation within the mining industry plays the major role where people in Australia have decided to develop capital accumulation to assist mining industry in terms of productivity output. The mining industry in Australia has been booming in producing minerals which have brought much of development in infrastructure. The country produces mining technology commodities which are used by mining industry and they continue to produce knowledge economy which will contribute to the economy in a near future. Wright and Crelusta (2004) also agree that Australian minerals have produced wealth more than it have depleted. The mineral of the country has generated much in countries economic activities. The mining companies are providing services delivery which government did not

put into implementation and they just being there not as a form of partnership but potranage. It raises the question of what will happen to the future generations of those communities once the mines close and the new challenges arises for corporate actors.

Stoeckel (1999) agrees that the mining sector capital stock increased by 40% in the same period, The research and development of mining sector accounted by 20% same as all the research and development of all other industries. The mining sector in Australia contributes the biggest share in their economy and their mining sector research and development also continued to growth and expanding human capital to speed up their productivity. The Australian minerals can go hand in hand with expansion of both economic growth and technological progress of technological advancement (Wright and Crelusta, 2004). The industry in Australia invests lot of money in their employees as a form of infrastructural development. The more employees improve their productivity, level of income also increases, new job opportunities are created as level of unemployment and poverty decreases, while firms generate profit then economic growth of the country expands and the path for economic development also increases.

3.4.2 The role of mining sector in Ghana

Akabzana and Darimani (2001) developed the study in Ghana explaining that the mining sector has attracted 3billion of foreign direct investment and representing more than 60% of all the investments in the country. However most of the funds are used in order to rehabilitate, expansion of existing mines and developing new projects that will enhance towards economic and social dimension. The benefit of improving the mining investment on Ghanaian economy are mining is the leading earner of foreign direct investment ,promoting government revenue, providing capital and social infrastructure ,creating direct and indirect employment and developing communities around mining arears.

Aryee (2001) also developed the study in Ghana using survey of contribution large scale of twelve to sixteen mines and also reviewing the contribution of a key factor towards the national economic indicator, however the country does not depend on mining sector since other national commodities and Gross Domestic Product are considerable. The study concludes that mining sector should sustain policy initiatives, diversifying the sector and strengthening of linkages rather than fiscal and improving productivity through training and appropriate technology then they will meet development. The mining industry should diversify the sector by increasing opportunities for people and expands technological

advancement for productivity to grow and in such manner they will reach development. Blosh and Owusu (2012) also declare that in Ghana the gold mining was ranked the second best after South Africa and became the ninth largest producer of gold at some 3.8% of global producer from 2.6%. The gold production volumes and revenue significantly increased around the year 2000 however in Ghana the mining industry was negatively related to the improvements of an economy such as public revenue, employment skills development and localise economic development. The gold mining in Ghana should strive to promote investment and strengthen their growth by promoting socio-economic life. In such manner they will no longer view gold mines negatively.

Amankwah and Sackey (2003) propose their study by looking at the development in small scale of gold and diamond mining industry in Ghana and propose the strategies that can be implemented towards sustainable development within an industry and improve sustainable development within an industry. The gold and diamond mining industries should develop a strategy that will improve the community's ability and enhance them to provide intensive skills. This is to create opportunities for people and expand their knowledge through education to maintain them in the long run. People will be able to diversify, produce different commodities and they will reduce their import commodities as the produce variety of commodities domestically.

Anamah and Amponsah (2007) developed the study in Ghana of construction using time series data of 1968 to 2004. Granger causality test was used to determine if whether construction industry does cause economic growth and the conclusion was found that the contraction industry also must be considered as a major drive of economic growth in Ghana. The construction industry should take part in driving the economic growth of Ghana because the also generate more income just like mining. Construction is the large partnership of mining industry and both industries could improve the economic growth of Ghana through human development.

3.4.3 The role of mining sector on South Africa

Hope (2014) conducted a study in South Africa by explaining the importance of mining sector in being crucial behind success of the South African economy. However the issue of labour, commodity price, infrastructure and foreign direct investment, continue to affect the mining industry negatively. The South African mining industry is facing the challenges of labour unrest between direct and indirect employees, commodity prices also continue to

decline against the foreign currencies and not being able to attract formal investment. Abraham (2015) articulates that the community wants the mining operations to be immobile after they have submitted their application; the argument arises when communities express their emotions in how mining disturbs top soil, blasting and also construction of road. The community is taking full responsibility for the mine not to operate and continue to secure their land. Government, communities and other stakeholders should continue to work together in order to strengthen both societies and business that will maintain economic growth.

Fedderke and Pirouz (2002) derived the study in South Africa using an annual time series data from 1970-1997, examining the contribution of mining sectors in South African economy in output and employment, They employed vector error correction model using cointegration analysis. Their results were that output has no long run relationship towards contributing to Gross Domestic Product, and cointegration confirmed that a loss in employment causes real wage cost to increase. The South African mining industry has declined since 1970 more especially in gold and Uranium other sectors are contributing constantly towards value added. The decline in total value added causes total tax revenue of the state also to decline. Employment also continues to decline which causes unskilled labour to lose their jobs. According to Moncur and Jones (1999), the mining sector in South Africa around 1970 did experience the decline in volume of gold output but the industry also did recover and start to grow again. The mining industry went into dramatic changes for the composition of output and composition of labour force.

The industry plays a major role in the South African economy. However the challenge has affected the other parts of the economy and the real wages have increased. The industry did recover after the mining policies and labour law were changed to support industries to expand their productive output, profit and create sustainable development for communities who are living near the mines. The industry is facing crises such as job losses and decline in commodities prices which creates an economy to be unstable. The decline in mineral export does affect foreign currency, investments also declines and firms will be forced to retrench their employees. Hope (2014) and Teke (2015) argue that mining sector is still facing challenges of commodity price which is not expected to recover anytime soon. South Africa should apply carbon tax and carbon tax as it will be a developing country to do so, this will prejudice the survival and competitiveness of carbon intensive mining industry. The South African economy was ever since negatively affected by recession which occurred in 2008.

The industry passed into difficulties which make the volume of commodity of output and losing employees in three biggest sectors which is gold, platinum and diamond.

Mining industry in South Africa continues to be leading sector behind the country's success. However even though short term challenges are continuing to hindering the mining growth. All leaders of different stakeholders should seat down together to assist the industry to realise their potential from up until in the near future. Jones (2003) developed the study in South Africa from 1990 to 2000, in his findings the gold mining in 1990 was a leading industry but the volume of output in gold did declined and the platinum group metals did take over, the direct contribution of mining declined to 6.5% and indirectly contributed about 10%. In the previous year's mining sector has been performing badly in terms of their productive real output and productive labour force but still continuing to contribute towards Gross Domestic Product. The industry should promote the rate of productivity output towards the rate of capital ratio in that case the volume of output increase and begin to strengthen the economy. The increase in size of population is good only when their marginal of productivity keeps on increasing. However the labour unions and company management also did contribute to the downfall of an economy and less sustainable.

The mining industry has negatively affected the South African economy losing 40% of global production in previous companies losing revenues of 9.2 billion and current account deficit is already in a key weakness in South Africa and forecasting South African rand currency under pressure (Reuters, 2014). The mining strikes have affected the South African economy where foreign investments, currency, level of employment have been declining. The South African mining industry also takes part in adding towards current challenges which South Africa is facing today. The level of unemployment is still continuing to increase, poverty and weak rand currency against foreign currency. Moncur and Jones (1999), Jones (2003) and Kantor (2013) argue that South African mining is in crisis more especially gold and platinum having a negative impact on Gross Domestic Product and the value of rand. Investors are not confident about the prospects of an industry share performance. The level of employment opportunities continue to decline. The labour unions should focus more on protecting their members by resisting retrenchment and not focusing on unrealistic demand improved benefits.

Fedderke and Bogetic (2002) developed the study in South Africa of infrastructure based on public investment and how does it contributes towards productivity growth, using panel data

in manufacturing data from 1970-2000, the study develops an "instrumentation strategy generable to other context." However in their findings the direct impact of infrastructure on labour productivity and indirect impact of infrastructure on total productivity are invariant. Infrastructure increases the investment and economic growth of the country, however the public investment do expand labour productivity but not at a rate which firms are expecting their productive to increase. Infrastructural investment does improve the economic turn down of a country. Smit (2013) proposes that mining industry spend about 78 billion in wages and salaries, continues to be largest contributor in black economic empowerment. The mining job opportunities are based in unskilled and semi-skilled labour.

The role of industry in employment is that it creates large opportunities for those who are unskilled and expands local economies within communities. People will want to improve their skills and acquire knowledge which will sustain people in the long term. Once people have acquired knowledge, productivity of output within the industry will improve and will create competitiveness within the environment. The industry will influence other sectors and people living near the mines will create business expecting mining companies to support them. Kumo (2012) also made the study in South Africa about infrastructure and economic growth, granger causality test was employed in a study using annual data from (1960-2009). The results were found to be that there is a causal relationship between economic infrastructure and investment on economic growth. The investment in infrastructure was found to be positively related with economic growth. South Africa still needs to build more of their infrastructure to expand export commodities, attract foreign investment and improve sustainable development from local regions towards national level.

3.4 Limitations of Reviewed Literature

Some of the reviewed studies have been criticized from theoretical and empirical background. Some doubts have been on the fitness of economic theories employed under econometric modeling. For example, According to Nafziger (1997), in the theory of socialism and communist Marx did not develop the theory very well, holding into the absence of anarchy and the class conflict. Even Marx interpretation of capitalist and the transition of socialism had number of flaws. He theorised the worker revolt in the industrialised west, however the first revolution began in Russia and is known as one of the least developed countries in Europe. Marx overlooked the possibility that the interest of workers and capitalist might not conflict. Workers in the western countries would have gained the constant

relative rapid growth share in the long run rather than having large higher share of output growing at the slower rate under the alternative system.

Many studies did criticize the study of Harrod Domar model emphasising that the model is simple. The exposition of Harrod tended to rest on incomplete specified behavioral and expectations hypothesis while Domar was more interested in the straightforward demand factors at the growth rate (Solow, 1956). This study was criticised because of its logic focused more at the growth rate hence their explanation was incomplete when coming to other factors. Empirically, if the nation cannot reach the growth rate, then this theory will not be applicable. Furthermore, Filho, Silva and Diniz (2005) argue that the theory of Solow was based on the close economy. The convergence hypothesis of supposed group countries had no interaction, meaning that, countries where isolated from one another. The second limitation is the implicit share of income that comes from capital does not match the national accounting information. The last limitation is estimated convergence is to low even attempts by modifying Solow model have impacts on this rate. This failure of the model extends into two dimensions; firstly, Harrod Domar model failed to provide other factors except the demand factor at the growth rate, while it tended to rest in incomplete specified behavioral and expected hypothesis. Secondly, the version of the model cannot account for important role played by technology, population and human capital.

Rostow's theory was also under attend by many theorist specifying that the conditions which developing countries are facing today are not identical to the past conditions so there is no guarantee that what happened on the past will repeat again in future. Many countries tried to adopt growth path, but they did not make it as the industrialised countries e.g. Brazil, Ghana and Nigeria (IGCSE, 1999). In his theory he advocates that once the country is industrialised then growth will better everyone. However, in reality countries continued to divide among themselves according to their wealth who is rich and poor. In short the theory is subjective but in reality it doesn't exist. Itagaki (2007) criticised Rostow's theory emphasising that there is no mathematical model as an interaction variable explaining each stage to prove theory, furthermore the theory does provokes but it cannot answer the question of what comes next.

3.5 Conclusion

In macroeconomic studies, various theoretical models are developed to conduct the study of mining on economic growth. Different schools of thoughts are used to explain their theoretical models. The argument was generated from the development of classical theory. Marx's (1844) central theme was to criticize the capitalist system and fight for social and economic justice. Harrod and Domar (1946) and Solow (1956) mention that in the supply side of the economy, endogenous growth models were developed and their argument were based on productivity of firms in how they can promote economic growth. Rostow (1960) also developed five stages of economic growth and argued that countries will converge with developed countries only if they pass through those stages. Once level of savings and investment are available then we expect the economy to growth.

Various studies have shown that the role of mining sector and infrastructure investment are positively related to economic growth. Once the mining sector produces large export quantity of output, financing infrastructure investment and sustainable development then economic growth and development will be achieved. Few studies did apply vector error correction model (VECM) using cointegration analysis and granger causality. The results approved that there is long run relationship between public infrastructural investments and economic growth. In Australia, mining companies invest more in their employees and continues to take the major role on giving back to the people. In other countries it was found that the mining sector does contribute towards technological advancement. In Africa and South Africa the study reviewed other studies outlining the challenges which they are facing in financing infrastructure to promote economic development. In these terms the study reviewed the empirical studies at aggregate terms.

CHAPTER 4

METHODOLOGY

4.1 Introduction

The study in chapter three reviewed the literature of a role in mining infrastructure and economic output in South Africa. However, it has become a tradition in economics to make use of econometrics techniques to approve or disapprove a particular economic propositions and models. According to Asteriou and Hall (2011), the first task in applying econometrics is by developing a model that can be verified empirically. Therefore, this study developed the regression model to examine short run and long run relationship between mining infrastructure and economic output in South Africa using Vector Error Correction Model quantified under VAR framework. The VECM was choosen under this study due to its appropriateness of working with multivariate time series data. Granger causality in this study is used to examine then causality between mining infrastructure and economic output.

4.2 Data source and definition of variables

The study employed annual time series data to examine the true nature relationship between mining infrastructure and economic output in South Africa from 1980-2013.The Data range expressed in this study are collected in millions while others are in percentages. The utilisation of annual time series data has given this study several advantages over studies that have employed quarterly and monthly data. Time series data is more concerned with the order and listing of observation as the dependency and changing order could the meaning of data (Asteriou and Hall, 2011). Furthermore, the variables are transformed into stationarity since macroeconomic variables are normally carrying a random walk or being non stationary. The study does apply maximum likelihood estimation towards vector error correction model to simultaneously determine long and short run effects of dependent variable in the model.

Table: Data type and Sources

Variables (s)	Indicator Name	Measurement	Sourced from
LGDP	Gross Domestic Product	Millions	Reserve Bank
LINFRS	Infrastructure	Millions	Reserve Bank
LGRENL	Gross enrolment	Millions	World Bank
LEMPLY	Mining employment	Percentage	Reserve Bank
LCAPITAL	Fixed capital formation	Millions	Reserve Bank

Economic output

It can also be defined as the achievement of improving the standard of living in time bounds. When the welfare of people has increased, then we could conclude by saying economic growth has been achieved. Economic growth is one of the most important economic objectives between nations.

Infrastructure

Infrastructure was historically defined as consumption expenditure by both government and private sector and generally was considered as current expenditure and also as capital good. Infrastructure may also be considered as both public and private goods because other facilities can be used by everyone without excluding people from utilising it, on the other hand certain commodities are rival and excludable, meaning people can be excluded from using those goods. In economic terms infrastructure can be examined both as a stock or flow variable (Fedderke and Garlick, 2008).

Employment

Employment is defined as an aggregate of population who are economically active to work or are searching for work. Employment is seen as an important factor to be dealt with mostly in developing countries. In South Africa employment creation is been very slow for the period of time (Fedderke and Mariotti, 2002). Employment can be considered as one of the most important production input to maximise total output.

Fixed Capital Stock

Fixed capital formations are assets used during production process but they are not directly related to the commodity produced. It can be further defined as commodities used to by producers of which their duration is more than a year.

Human Capital

Human capital is defined as the role of acquiring knowledge, skills, competences and other attributes embodied individually who are relevant to economic activities. Furthermore, the definition of human capital can be regarded as an apparatus that includes all investments which are directly related to individual skills (Schutt, 2003).

4.3 Methodology

When choosing and applying methodology of econometrics analysis, it is much essential to link the objective of the study with time series data. There are various methodologies in econometrics carrying both advantages and disadvantages; it becomes a challenge to choose an appropriate methodology. However, The VECM under Vector Auto Regressive framework was taken as an outstanding estimation technique under the nature of this study. According to Enders (1995), time series data are very dynamic in nature and they require methodologies that take into consideration of inherent setbacks. For instance, data trends and feedback effects between historical and current values.

The VECM technique has more advantages over Ordinary Least Square (OLS) and General Methods of movements (GMM) when modelling time series data more especially macroeconomic time series data Johansen (1980). There are several econometrics techniques used in this nature of study to analyse the results. The study followed Johannsen (1988) and Johansen and Juselius (1990) cointegration technique. The techniques used within the study establish a long run relationship between variables. Before we make any test, the data should be integrated at same order. This is done by using unitroot test to examine the stationary data. The variables will employ Dickey Fuller (DF), Augment Dickey Fuller (ADF) and Phillip Perron (PP) unit roots. Vector Error Correction Model (VECM) is used to examine both the long and short relationship between variables. Residuals and stability Diagnostic test are employed in the study to confirm the test used within a study.

4.4 Model specification

The neoclassical growth model by Solow (1956) and endogenous growth model by Romer (1990) are employed under the study. The model provides with useful framework on the analysis of historical development. It continues to be useful framework as the guidance to correct historical disadvantage of development. It is also important for econometric evaluation for certain alternative strategies for both mining sector and government could employ in the basis of decision making. The purpose of using both neoclassical and endogenous growth model is to establish the significance of mining infrastructure as a contributor towards economic output. The hypothetical model used as the representative model is as follows:

$$Y = K^{\alpha}(AL)^{1-\alpha}$$

Where

Y – Output ratio

K – Stock of Human capital

A – Technological Progress

L – Labour

The above model is modified by employing the variables of Fedderke and Pirouz (2002) and was converted into estimable form as:

$$LGDP = \beta_0 + \beta_1 LGRENL + \beta_2 LCAPITAL + \beta_3 LEMPLY + \beta_4 LINFRS + \mu$$

Where

LGDP - Gross Domestic Product

LGRENL - Gross Enrolment

LCAPITAL - Fixed Capital Formation

LEMPLY - Mining Employment

LINFRS - Infrastructure

Using the VAR Framework stochastic model of regression fundamental in the regression analysis is specified as follows:

$$LGDP = \delta_0 + \delta_1 LINFRS + \delta_2 + \delta_3 LGRENL + \delta_4 LEMPLY + \delta_5 LCAPITAL + \mu_t$$

The multivariate cointegration methodology advanced by Johansen following the VAR framework process will specify the model as follows: '

$$LGDP_t = \delta_0 + \delta_1 LINFRS + \delta_2 LGRENL_t + \delta_3 LEMPLY + \delta_4 LCAPITAL + \mu_t$$

The equation above can be transformed to VEC as follows:

$$\Delta LGDP_t = \delta_0 + \delta_1 \Delta LINFRS_{t-1} + \delta_2 \Delta LGRENL_{t-1} + \delta_3 \Delta LEMPLY_{t-1} + \delta_4 \Delta LCAPITAL_{t-1} + \xi_{t-1} + \mu_t$$

The symbol Δ is used to illustrate difference operator while ξ_{t-1} is presented to illustrate lagged significance of error term derived from the long-run Cointegration relationship and it utilised to capture the short-run dynamics.

4.5 Estimation technique

As mentioned above, the study employed VECM econometric approach to examine the nature of relationship between mining infrastructure investment and economic growth in South Africa. The VECM comprises the following steps below:

4.5.1 Testing for stationary

The classical linear regression function assumptions necessitate that independent and dependent variable must not correlate with one another, zero mean and constant variance (Steward). In the presences of non-stationary the results obtained from regression are kindly known spurious regression. According to Granger and Newbold (1974) argue that spurious regression are detected by high R^2 `and low Durbin Watson statistics, T and F statistics appear to be significant but the variables does not provide with economic sense. According to Nelson and Plosser (1982) argues that macro time series data are defined by non-stationary data instead of deterministic trend.

The importance of unitroot test is to examine stationarity because the presence of non-stationary regressor misleads many standard hypothesis tests which give wrong estimations. Authors contribute that F statistics which is calculated from regression and occurred in non-stationary time series data does not follow standard distribution. The temporal dependence is said to be dependent on the number of lags not a point in time. The value of a given time is expected to be equal to the previous given time together with the stochastic error term then time series data is said to be stationary. Macroeconomic variables are not stationary in nature so it is for the main purpose to employ unitroot test as a case for finding the existence of unitroot. Ramanathan (1995) argues that if variance of the explanator and the stochastic error term goes to infinite then there is a unit root problem. If the problem is ignored then we continue to estimate with a non-stationary time series data then the study will experience spurious results.

4.5.1.1 Dickey Fuller and Augmented Dickey Fuller test

Dickey fuller (1979, 1981) developed simple formal procedure to test for non-stationary. The key insight of their study was to test for non-stationary if is equivalent to the test of existence in unitroot. In simple terms their argument is based on testing for non-stationary same as testing for existence of unitroot. The simple model of dickey and fuller (1979) is illustrated below as:

$$Y_t = \emptyset Y_{t-1} + \mu_t \qquad (4.1)$$

In this study we adopt the same model developed by Dickey and Fuller to explain unitroot test. $\emptyset$ In the simple model explains stationarity if whether is equals to one according to the hypothesis or less than one as an alternative to hypothesis testing. Dickey and Fuller (1979) developed an alternative regression equation that can be used to test for presence of unitroot. The first equation shows constant in the random walk below as:

$$\Delta Y_t = \alpha_0 + \gamma Y_{t-1} + \mu_t \qquad (4.2)$$

It is an important case because such process does exhibit a definite trend when the random walk is equal to zero. The first equation which shows constant in random walk was developed as an extremely important case to identify if macroeconomic variables are not used definite trend and random walk is equal to zero. The second equation also shows how non-stochastic trend obtained and illustrated as:

$$\Delta Y_t = \alpha_0 + a_2 + \gamma Y_{t-1} + \mu_t \qquad (4.3)$$

Dickey fuller test for stationary is then the simple normal t- test on the coefficient of the lagged dependent variable. The test does not have a conventional t distribution (Asteriou and Hall, 2011).

According to Asteriou and Hall (2011) argues that Dickey and Fuller extended their test procedure suggesting an augmented version form their previous procedure. Their augmented version includes extra lagged terms of the dependent variable in order to remove or eliminate auto-correlation. The Lag lengths are determined either by Akaike Information Criterion (AIC) or the Schwartz Bayesian Criterion (SBC) or more usefully lag length which will whiten residuals:

$$\Delta Y_t = \gamma Y_{t-1} + \sum_{j=1}^{P} \beta_i \Delta Y_{t-1} + \mu_t \quad (4.4)$$

One way to test for stationarity is to examine the value of γ is equal to one or less or less than one in that case we examine if stationarity does exist within the time series data. In the augmented level version both Engle and Granger (1987) extended their study by including another regression equation as constant with no trend. The equation is shown below as:

$$\Delta Y_t = \alpha_0 + \gamma Y_{t-1} + \sum_{j=1}^{P} \beta_i \Delta Y_{t-1} + \mu_t \quad (4.5)$$

The second test include constant but without including trend. In their last regression they did include both constant and trend which is shown below as:

$$\Delta Y_t = \alpha_0 + \gamma Y_{t-1} + a_2 + \sum_{j=1}^{P} \beta_i \Delta Y_{t-1} + \mu_t \quad (4.6)$$

The test which are shown above do follow the same procedure where Gamma (γ) is expected to be one or less than one when testing for stationarity. When the variables are no stationary we at levels we difference them to order of integration (1) to be stationary. If the variables are not stationary at first difference then we difference the variables to order of integration (2) to be stationary. To conclude on the matter of stationarity the error term represented by (μ) should not be correlated to each other and the mean is expected to be zero while variance is expected to be constant over the period of time.

4.5.1.2The Phillips- Perron (PP) test

Phillips and Perron (1988) developed a generalised of the Augmented Dickey Fuller test procedure that impartially corrects unimportant assumptions concerning the distribution of errors. The Phillip Perron test was developed to correct the previous mistakes made by the Augmented Dickey Fuller test concerning the distribution of errors. The generalised regression method developed by Phillips and Perron in 1988 is shown below as:

$$\Delta Y_{t-1} = \alpha_0 + \gamma Y_{t-1} + \varepsilon_t \quad (4.7)$$

The Augment Dickey fuller corrects high order of serial correlation by adding a lagged differenced on the righted side while Phillip Perron test corrects t- statistics of the coefficient from Autoregression AR(1) to account for serial correlation in error term. The Phillips Perron are only the modification of the Augmented Dickey Fuller test statistics that takes into account less restrictive nature of error process (Asteriou and Hall, 2011).

4.5.2 Lag order selection criteria

The lag length can be determined by some of many information criteria's. It is important to avoid too many lags, since the numbers of parameters and lag length grow very fast. The information criteria strike to compromise between lag length and number of parameters by minimising linear combination of residual sum of square. However if the lag length is required one can be able to add another important variable. The selection of lag order is based on the information criteria as a direction to choose which lag length to be used. A selection of lag length permits adjustments in the model and accomplish well behaved residuals (Murwirapachena, Maredza, Choga, 2013). However Liew (2004) and Mah (2013) state that Akaike information Criteria and Final prediction Error are superior when having less than 60 observations.

4.5.3 Cointegration

When the variables are non-stationary at levels but stationary at first difference are sad to be integrated at I (1), then there is the possibility of a linear relationship between the variables at I(1), and all the series of variables should be integrated at order I(1). The variables that satisfy the requirements are considered to be cointegrated or both having the long run relationship. The cointegration among the variables exist only when residual from regression are stationary at levels. These cointegrated variables must have an error correction representative by incorporating error correction term in the model. Ang and Mckibbin (2006) Vector Error Correction Model is formulated to reintroduce the information lost in the differencing process and by allowing long run equilibrium and short run dynamics. The next stage is estimating vector error correction model which contains both long and short run effects.

Engle and Granger (1987) approach can be used to combine both short and long run properties, and maintains stationarity at all variables. The Engle and Granger techniques can consider both short and long run properties, and maintaining all variables in the study are stationary. The Engle Granger procedure approach is valid for only bivariate analysis, meaning it measures only two relationships of variables if the long run relationship does exist. One of the best advantage of using Engle and Granger approach is, it is very simple to understand and implement. Kleiber and Zeilels (2008) also agree that Engle and Granger is the simple method to apply. However, There are shortcomings which are associated with it, the approach cannot tell about the arrangements of variables of which should be a given

regressor and why. It cannot treat the possibilities of more than two cointegrating vectors. The last one is, the mistake occurred in the first step is being carried to the second step. In addition one of the models has more two variables and there is a possibility of having more than one cointegrating vector.

This happens when variables in the model have several equilibrium relationships to govern long term behaviour of variables (Chicheke, 2009). When variables are cointegrated there should be at least one or more relationships among the variables. The problem arises if there is one cointegration relationship when there is more than one. In this case the Engle and Granger approach cannot be implemented to solve the problem. In this instance we employ Johansen cointegration technique.

4.5.3.1 Johansen cointegration

Johansen (1988) developed the maximum likelihood estimation procedure focusing in testing more than one cointegrating vectors. The procedure was built because the Engle and Granger cannot determine more than two cointegration vectors. The Johansen procedure relies on the relationship between ranks of matrix and characters of roots. His method was used as the reinvention of Engle and Granger or secondary generation approach which directly builds on maximum likelihood rather than focusing on the least square (Sekuma, 2011). The Engle and Granger focus more on bivariate however the development of Johansen is focusing more on multivariate generalisation of Augmented Dickey Fuller test. Johansen in his study presented two likelihood ratios which are trace test and maximum eigenvalue test. The vector cointegration method has more advantage than Engle and Granger cointegration because it determines the number of cointegration vectors.

The first step in the Johansen approach is to test if all variables are stationary and are integrated at the same order either at levels, first difference and second difference I (0), I (1) and I (2). The aim is not to have non-stationary variables that will make the results spurious and detecting stationary cointegration relationships with meaningless result. It is known that variables should integrate at same order of integration in order to test for cointegration test. However, it is not always the case that variables should be integrate at the same level of integration, even though they integrate at different levels cointegration relationships might still exist. The inclusion of such variables might affect the results and such considerations should be applied when same problems occurs time and again.

The second step as Asteriou and Hall (2007) and Enders (2013) have stressed, when determining order of *(K)* should be appropriate because Johansen test can be affected by the lag length employed in the vector error correction model. However, it is important to appoint and select lag length in the appropriate way. Finding the appropriate lag length will assist the study for having standard normal error terms which will not suffer from stationarity and diagnostic tests. Chicheke (2009) saw the importance of inspecting data before estimating and finding the functional relationships in order to decide if there should include an important variable. The importance of inspecting data before estimating a model is minimising the risk of obtaining spurious results and obtaining variables which will make economic sense. When the results seems not to make economic sense there are various remedies that should be taken into consideration, adding a dummy variable will account for short run effects that have important effects on macroeconomics.

In the third step we decide whether an interceptor trend should be included in the model. In choosing the dynamic model the study employs Puntula principles which involve the estimation of models and presenting high restrictive hypothesis to least restrictive hypothesis. In the model selection procedure it comprises of moving from the most restrictive model and in its stage comparing trace test with critical values up until we reject the null hypothesis.

The fourth step involves determining the number of cointegrating vectors. However, there are two methods and crossponding statistics for determining the number of cointegration relations and all involve estimations of cointegration relationships based on matrix of ***(Π)***:

Both Trace (λ_{trace}) test and Maximum eigenvalue (λ_{max}) test, are specified as follows:

$$\lambda trace(r_0) = -T \sum_{j=r_0+1}^{k} \log(1 - \hat{\lambda}) \qquad (4.9)$$

And,

$$\lambda \max(r_0) = -T \log(1 - \lambda_{r_0+1}) \qquad (4.10)$$

Where r is the number of cointegration vectors under the null hypothesis, and λ_i is the estimated value for the *ith* order in eigenvalue from **Π** matrix. The trace statistics considers whether trace is increased by adding more eigenvalues beyond the *rth* eigenvalue. The null hypothesis is that the number of cointegrating vectors are less than or equals to *r*. On the other hand, the null hypothesis of rank **Π**= r against the alternative hypothesis that the rank isr_0+1 is considered under the maximum eigenvalue method test. The test considers largest

eigenvalues in descending orders and considers whether they are significantly different from zero. Finally, after determining the cointegration vectors obtained from two Johansen methods, we estimate the vector error correction model (VECM). The vector error correction model can be estimated by specifying the number of cointegration vectors, lag length and by normalising the model from the true cointegrating vectors (Chicheke, 2009).

4.5.4 Vector Error Correction Model

The vector error correction model (VECM) is an economic technique under vector autoregression (VAR) model used for variables which are stationary in their differences. The vector error correction model can be taken into consideration for any cointegrating relationships among the variables. The vector error correction model is illustrated as:

$$\Delta Y_{t-1} = \emptyset + \pi y_{t-1} + \alpha_t + \sum_{j=1}^{p-1} r_i \Delta y_{t-1} + \varepsilon_t \qquad (4.11)$$

When the variables are not stationary at levels integrated I (0), but are stationary at first and second difference I (1) and I (2) and being cointegrated the vector error correction model can be used to estimate the model. The advantage of using the VECM is it can determine both long and short run relationships of variables.

4.5.5 Residual Diagnostic test

The diagnostic and stability test are employed in this study to detect whether the model is specified correctly or not. The diagnostic tests used in this study are illustrated as follows:

4.5.5.1 Normality test

One of the most Classical Linear Regression Function (CLRF) assumes that the residuals are normally distributed with a zero mean and constant variance. Gujarati and Porter (2009) propose that histogram residual is the simple graphical devices that can be used learn population density function of the random variable. For the diagram to be normally distributed the skewness should be zero and kurtisis must be three. The Jaque Bera (JB) normal test is known as an asymptotic or large sample test. However, Abadir and Paruolo (1997) point out that if the normality error terms are rejected for some reasons (kurtises) then there is no need to worry because the Johansen results are not affected. If the results of the skewness are fine then there is no need to correct normality estimations.

4.5.5.2 White test

White (1980) developed a more generalised test for heteroscedasticity used to eliminate the problem that occurs on the previous test. The White test is also a LM test and the advantages are firstly it doesn't depend on normality distribution and it propose a particular choice for explanators in a regression. Seddighi, Lawler and Kato (2000) explain the white test as a popular test for heteroscedasticity, it examines if the variance of the error term is a function of a regressor.

4.5.5.3 Serial correlation test

Durbin Watson (1950) developed the most frequently test which is used as a presence of serial correlation. The Durbin Watson test is only valid when certain assumptions are met, however one limitation of the Durbin Watson statistics is it depends on the number of observation and the preferred test which is used under serial correlation is Lagrange Multiplier test (Asteriou and hall, 2011). Breusch (1978) and Godfrey (1978) developed the LM test that can accept the drawbacks of Durbin Watson. The results of serial correlation test are applicable when the lagged dependent variable is used and conclusive. Serial correlation test is another method included in the paper to explore the true reflection of the results. Serial correlation test can take into higher order of error residuals. Wooldridge (2009) suggested that when the variables correlate one another we can use AR (1) to the dependent variable should be lagged into q times to correct serial correlation.

4.5.6 Stability test

In the study the stability test will be used to examine and confirms if whether there is a long run relationship within the variables when using cointegration test. We also use one common test which demonstrates if the variables are stable or unstable. The inverse root of AR characteristics of polynomial graph is used in the study to examine the true specification and stability of the variables. The aim of the test is to examine the true nature of a model. The property of AR roots is, if all roots have modulus less than one and falls within unit circle then we could say the VAR is stable or stationary.

4.5.7 Granger causality test

Causality test is known as one of the major important studies under Vector Autoregression (VAR). Causality in econometrics is known as a way of predicting one variable for another (Asteriou and Hall, 2011). Under causality test it is possible to capture various relationships

among variables. One variable can granger cause another variable, having bio directional relationship between variables and both variables can be independent from one another. Granger (1969) developed relative simple study emphasising that a variable cause's only one variable which can be predicted with a greater accuracy using past values of another variable.

Sims (1980) introduced one of the important most studies under the vector autoregression (VAR) which is causality as an alternative study of granger causality. Causality is taken as one of the most influential study under the VAR model. Sims in his study criticised that it is not possible for the future to estimate or determine current. In the regression analysis we are provided with the relationship among variables but it does not give causality of which variable is more influential to another. According to Pindyck and Rubinfeld (1991) advocate granger causality as the test which explains one exogenous variable as a cause towards the endogenous variable and significantly can be used to predict endogenous average mean. In their theory they clarify that there are two conditions which needs to be met firstly: The past values of exogenous variables should help to predict the past values of endogenous variables, past values as the exogenous variables should significantly contribute to the power of the regression. We present mathematically the granger causality as follows:

$$Y = \sum_{j=1}^{M} \alpha_i Y_{t-1} + \sum_{i=1}^{M} BX_{t-1} + \varepsilon_t \qquad (4.12)$$

The second condition, endogenous estimator, must not predict the exogenous variable .the average mean of the exogenous variables are expected to predict the average mean of the endogenous variable without the assistance of the endogenous estimators. If the endogenous variables does predict the values of exogenous variables then it shows there are some other variables which causes both endogenous variables and exogenous variables .The results of having such model is spurious of results, biasness and inconsistency.

4.6 Conclusion

In conclusion we have provided necessary econometric tools and techniques used within the study. The models and techniques are relevant and appropriate to be used within the role of mining infrastructure investment and economic growth in South Africa. The techniques provided above are given as theoretical background to the analysis of data. In the next chapter the study analysis data by using all tools and techniques specifies in this chapter.

CHAPTER 5

RESULTS AND ANALYSIS

5.1 Introduction

The methods and measures which were followed in the study have already been elucidated. In this chapter the results obtained from various test used to answer the research questions and achieved the objectives of a study are reviewed. This chapter presents all the testing methods used to mineral growth output for the period 1980-2013. The interpretation and analysis of the results are based on the relationship between the mining infrastructure investment and economic growth.

5.2. Unitroot results

The Augmented Dickey Fuller and Phillip Perron unitroot test are performed to obtain stationarity. Macroeconomic variables at levels seem to be non-stationary and the Augmented Dickey Fuller (ADF) and Phillip Perron (PP) are common tests to obtain stationarity.The Augmented Dickey Fuller stationarity test starts by testing variables at levels then if the presence of non-stationary test is observed then the study will further test the variables at first and second difference. The stationarity is determined by comparing the t-statistics with the critical values. However, Phillip Perron test does not use the lag length but rather the band width to determine or confirm the stationarity of variables. In this section the (*) asterix sign will be employed as a representation of stationarity within the variables.

5.2.1 Augmented Dickey Fuller Test

The ADF test begins by testing variables at levels to check if they are non-stationary or stationary. However, if non stationary is observed among variables then the study will go further to test variables at first difference and second difference if stationarity is not reached at first difference.

The hypothesis of this study is specified as follows:

H_0: Time series is non stationary

H_1: Time series is stationary

Table 4: Augmented Dickey Fuller test for all variables at levels

Series	Model	Lag length	ADF stats	Critical value	Conclusion
LGDP	Intercept	1	1.371	-2.957	No stationary
	Trend+intercept	1	-2.096	-3.557	No stationary
	None	1	2.873	-1.951	No stationary
LINFRS	Intercept	2	-0.011	-2.960	No stationary
	Trend+intercept	1	-3.931	-3.557	Stationary
	None	2	3.732	-1.952	No stationary
LCAPITAL	Intercept	2	-0.007	-2.960	No stationary
	Trend+intercept	2	-1.741	-3.562	No Stationary
	None	2	1.561	-1.952	No stationary
INEMPLY	Intercept	1	-0.609	-2.957	No stationary
	Trend+intercept	1	-1.873	-3.557	No stationary
	None	1	-0.777	-1.951	No stationary
LGRENL	Intercept	0	-1.284	-2.954	No stationary
	Trend+intercept	0	-1.063	-3.552	No stationary
	None	0	0.442	-1.951	No stationary
*Note: *5% significance level and **1% significance level*					

In table 4, when applying ADF test variables at levels under the model of intercept, trend and intercept and none of the variables were found to be stationary at 1%, 5 % and 10% significance level. Therefore, we fail to reject our null hypothesis of non-stationary and conclude that at levels variables are non-stationary. In table 5 we proceed by testing the same variables at first difference and the results are prearranged as follows:

Table 5: Augmented Dickey Fuller Test for all variables at first difference

Series	Model	Lag length	ADF stats	Critical value	Conclusion
ΔLGDP	Intercept	0	-2.550	-2.957	No stationary
	Trend+intercept	0	-3.532	-3.557	No stationary
	None	0	-2.444*	-1.951	Stationary
ΔLINFRS	Intercept	0	-3.794**	-2.957	Stationary
	Trend+intercept	0	-3.717*	-3.557	Stationary
	None	0	-2.006*	-1.951	Stationary
ΔLCAPITAL	Intercept	1	-2.232	-2.960	No stationary
	Trend intercept	1	-2.188	-3.562	No stationary
	None	1	-1.560	-1.952	No stationary
ΔLEMPLY	Intercept	0	-3.036*	-2.957	Stationary
	Trend+intercept	0	-3.207	-3.557	No stationary
	None	0	-2.940**	-1.951	Stationary
ΔLGRENL	Intercept	0	-4.917**	-2.957	Stationary
	Trend+intercept	0	-4.960	-3.557	Stationary
	None	0	-4.947	-1.951	Stationary
Note: Reject at 5% (*) significance level and 1% (**) significance level					

In table 5, when applying ADF test variables at first difference under the model of intercept, trend and intercept and none some of the variables were found to be stationary at 1%, 5 % and 10% significance level. Therefore, we fail to reject our null hypothesis of non-stationary and conclude that at first difference variables are non-stationary. In table 6, we proceed by testing the same variables at second difference and the results are prearranged as follows:

Table 6: Augmented Dickey Fuller Test for all variables at second difference

Series	Model	Lag length	ADF test	Critical value	Conclusion
ΔΔINGDP	Intercept	0	-5.659**	-2.960	Stationary
	Trend+intercept	0	-5.550**	-3.562	Stationary
	None	0	-5.662**	-1.952	Stationary
ΔΔLINFRS	Intercept	0	-5.611**	-2.960	Stationary
	Trend+intercept	0	-5.520**	-3.562	Stationary
	None	0	-5.714**	-1.952	Stationary
ΔΔLCAPITAL	Intercept	0	-3.516**	-2.960	Stationary
	Trend+intercept	1	-4.226**	-3.568	Stationary
	None	0	-3.575**	-1.952	Stationary
ΔΔLEMPLY	Intercept	1	-6.005**	-2.963	Stationary
	Trend+intercept	1	-5.893**	-3.568	Stationary
	None	1	-6.114**	-1.952	Stationary
ΔΔLGRENL	Intercept	0	-9.433**	-2.960	Stationary
	Trend+intercept	0	-9.283**	-3.562	Stationary
	None	0	-9.587**	-1.952	Stationary
Note: Reject at 5% (*) significance level and 1%(**) significance level					

In table 6, when applying ADF test variables at second difference under the model of intercept, trend and intercept and none all of the variables were found to be stationary at 1%, 5 % and 10% significance level. Therefore, we reject our null hypothesis of non-stationary and conclude that at second difference variables are stationary. As a result, all variables are integrated at order I (2).

5.2.2 Phillip Perron test

The study also employ PP test in order to correct the robustness of ADF test. Phillip Perron test is applied to determine stationarity and it presented as follows:

H_0: Time series is non stationary

H_1: time series is Stationary

Table 7: Phillip Perron test for all variables at levels

Series	Model	Band width	PP test	Critical value	Conclusion
LGDP	Intercept	3	0.648	-2.954	No stationary
	Trend+intercept	0	-0.726	-3.552	No stationary
	None	3	-1.311	-1.951	No stationary
ININFRS	Intercept	7	-0.324	-2.954	No stationary
	Trend+intercept	4	-2.325	-3.552	No stationary
	None	6	10.338	-1.951	No stationary
LCAPITAL	Intercept	4	-0.825	-2.954	No stationary
	Trend+intercept	4	-1.859	-3.552	No stationary
	None	4	3.269	-1.951	No stationary
LEMPLY	Intercept	3	-0.353	-2.954	No stationary
	Trend+intercept	3	-1.343	-3.552	No stationary
	None	3	1.140	-1.951	No stationary
LGRENL	Intercept	4	-1.513	-2.954	No stationary
	Trend+intercept	4	-1.410	-3.552	No stationary
	None	4	0.337	-1.951	No Stationary
Note: Reject at 5%(*) significance level and 1%(**) significance level					

According to Phillip Perron test, it is evident in table 7 that all variables are non-stationary at 1%, 5% and 10% significance level. Therefore, the study fails to reject null hypothesis of time series has no stationarity. The study proceeds by testing the same variables at first difference and the results are prearranged below as follows.

Table 8: Phillip Perron Test for all variables at first difference

Series	Model	Band Width	PP test	Critical value	Conclusion
ΔLGDP	Intercept	4	-2.517	-2.957	No stationary
	Trend+intercept	7	-3.395	-3.557	No stationary
	None	4	-2.414*	-1.951	Stationary
ΔLINFRS	Intercept	10	-3.681**	-2.957	Stationary
	Trend+intercept	10	-3.599*	-3.557	Stationary
	None	4	-1.852	-1.951	No-stationary
ΔLCAPITAL	Intercept	0	-1.805	-2.957	No stationary
	Trend+intercept	4	-1.780	-3.557	No stationary
	None	1	-1.573	-1.951	No stationary
ΔLEMPLY	Intercept	0	-3.036*	-2.957	Stationary
	Trend+intercept	0	-3.207	-3.557	No stationary
	None	0	-2.940	-1.951	Stationary
ΔLGRENL	Intercept	4	-5.014**	-2.957	Stationary
	Trend+intercept	3	-4.999**	-3.557	Stationary
	None	4	-5.056**	-1.951	Stationary
Note: Reject at 5%(*) significance level and 1%(**) significance level					

In table 8 it is evident that not all variables were obtained to be non-stationary. Variables like gross enrollment, mining employment and mining infrastructure investment are stationary at 1%, 5% and 10% significance level. However, the study fails to reject the null hypothesis and conclude that at first difference variables has no unitroot. The non-stationarity was removed when we test with the same variables at second difference and the following table yields the results presented as follows.

Table 9: Phillip Perron Test for all variables at second difference

Series	Model	Band Width	PP test	Critical value	Conclusion
ΔΔLGDP	Intercept	29	-11.468**	-2.960	Stationary
	Trend+intercept	26	-11.273**	-3.562	Stationary
	None	30	-8.888**	-1.952	Stationary
ΔΔLINFRS	Intercept	23	-11.189**	-2.960	Stationary
	Trend+intercept	22	-10.543**	-3.562	Stationary
	None	23	-11.539**	-1.952	Stationary
ΔΔLCAPITAL	Intercept	7	-3.239**	-2.960	Stationary
	Trend+intercept	9	-3.065	-3.562	No stationary
	None	7	-3.315**	-1.952	Stationary
ΔΔLEMPLY	Intercept	9	-7.559**	-2.960	Stationary
	Trend+intercept	9	-7.327**	-3.562	Stationary
	None	9	-7.733**	-1.952	Stationary
ΔΔLGRENL	Intercept	3	-11.682**	-2.960	Stationary
	Trend+intercept	3	-11.557**	-3.562	Stationary
	None	3	-11.870**	-1.952	Stationary
Note : Reject at 5%(*) significance level and 1%(**) significance level					

According to PP test, all the variables at second difference are stationary at 1%, 5% and 10 significance level. The variables were tested at the same model of intercept, trend and intercept and none. Therefore, the study rejects the null hypothesis of time series has no unitroot and concludes that all variables are integrated at order I (2). Since there was an evidence of stationarity in all variables then the study proceeds by estimating a spurious nonlinear model of mining infrastructure investment and economic growth for South Africa.

5.3 Lag order of selection criterion

The lag order of selection model is presented below as follows:

Table 10: Lag order of selection criterion

lag	logL	LR	FPE	AIC	SC	HQ
0	121.486	N/A	4.74	-7.280	-7,051	-7,204
1	339.011	353.47	2.88	-19.313	-17.939	-18.857
2	396.036	74.845*	4.41*	-21.314*	-18.795*	-20.479*

Note: asterix (*) indicates lag order selection of criterion, LR: Sequencial modified LR test statistics (each test at 5% level).FPE: Final Prediction Error. AIC: Akaike Information Criterion. SC: Schwarz Information Criterion. HQ: Hannan Quinn Information Criterion

It is very essential under Johannsen methodology to conduct lag order of selection criterion in order to establish the number of lag to be employed. Furthermore, the lag order selection criterion can be based on Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC) and Hannan Quinn Information Criterion (HQ).The test was conducted and lag 2 was selected based on all selection criterions. The agreement of lag length selection method agreed with two so the study will carry lag order of two throughout the study.

5.4 Johansen Cointegration

When estimating the model which includes time series variables, the first thing to be done is to test for cointegration to check if time series variables are cointegrated or stationary at same order of integration. When do we say the variables define cointegration or have a long run relationship? There are two steps which are used when estimating for cointegration; the first step is to run a unitroot for every variable to determine if variables are integrated at same order of integration. If the variables are integrated at the same order then we go to another step to estimate cointegration equation and to examine if residual of the model is stationary. When the variables are not stationary the can be a possibility that they can be cointegrated. In the table below the study shows Johansen cointegration to find out if whether there is more than one cointegration vector.

Table 11: Johansen cointegration results

Hypothesised no of CE(S)	Eigen value	Trace statistics	Critical value (5%)	Maximum Eigen statistics	Critical value (5%)
None	0.832	126.540	69.818	55.404	33.876
At most 1	0.719	71.135	47.856	39.405	27.584
At most 2	0.401	31.729	29.797	19.215	21.131
At most 3	0.331	12.513	15.494	12.487	14.264
At most 4	0.000	0.026	3.841	0.026	3.841

The study has employed Johansen cointegration and do confirm if there is cointegration between the variables. In Table 11 Johansen cointegration is estimated were both trace test and maximum eigenvalue test are employed to determine number of cointegrating vectors in the study. The results obtained show that in the case of trace test the null hypothesis of no cointegration was rejected since the test statistics of 126.540 was greater than the critical value of 69.818, hence long run relationship exists at none. Furthermore, going to another test of null hypothesis at most one the test statistics was 71.135 greater than the critical value of 47.856 so in this case we reject the null hypothesis of no cointegration, hence the long run relationship also exist at most one. The results obtained show that at most two the null hypothesis of no cointegration was rejected since the test statistic of 31.729 was greater than the critical value of 29.797, hence long run relationship exist at most two. In most 3 the test statistics was less than the critical value, hence we stopped and conclude by saying there are only three cointegration relationship under trace test.

The results of maximum eigenvalue test also show that in none the maximum Eigen value statistics of 36.704 is greater than the critical value of 33.876. The null hypothesis of no cointegration is also rejected and concludes by saying there is a long run relationship at none. The results obtained show that at most 1 the null hypothesis of no cointegration was rejected since the test statistics of 39.405 is greater than the critical value of 27.584, hence long relationship exist at most 1. At most 2, 3 and 4 their maximum Eigen values statistics where less than the critical values and failed to reject the null hypothesis of no cointegration. The maximum Eigen value probability was significant at none and at most 1, hence the maximum Eigen test also confirms one cointegrating vector. Both the trace and maximum eigenvalue

tests do confirm the long run relationship of mining sector and economic growth in South Africa. Our normalised cointegration coefficients are:

$$LGDP = 6.618C + 0.004LEMPLY + 0.509\ LCAPITAL + 0.109LINFRS$$

In the next stage we estimate the vector error correction model. The vector error correction model (VECM) is reintroduced to acquire the information which was lost during the difference process, this is done by estimating the long run equilibrium and short and short run dynamics (Ang and Mc Kibben, 2006).

The Vector Error Correction Model (VECM) allows us to distinguish the impact of both long and short run effect and also to establish the influence of explanatory variables on economic growth Murwipachena, Maredza and Choga (2013). The Vector Error Correction Model also permits to separate between the long and short run effect of the model. The long run model shows the change of explanatory variables and also the behaviour of economic growth in South Africa over years. The normalised coefficients will be discussed in the vector error correction model because it provide with the same coefficients.

5.5 Vector Error Correction Model

The vector error correction model is estimated in the study and some of their properties are discussed in the following manner. The vector error correction model includes both long run and short run among the variables. Johansen (1998) and Juselius (1990) approach can be used to combine both long and short run properties and also maintain if all variables are stationary. To check for the existence of long run relationship cointegration test is used to determine the lags intervals and deterministic trend assumptions are all used to determine the vector error correction model (VECM).

5.5.1 The long run relationship

Table 12: Long run estimate

Variable s	Coefficients	Standard Errors	T statistics
LINFRS	0.109	0.020	-5.315
LEMPLY	0.004	0.032	-0.127
LCAPITAL	0.509	0.113	4.475

The relationship reflected in table 11 can be presented in a formula form as follows:

$$LGDP_t = 6.618 + 0.004LEMPLY_t + 0.509LCAPITAL_t + 0.109LINFRS_t + \varepsilon_t$$

The long run relationship between variables as described by the equation above suggest that there is positive significant relationship between mining infrastructure and economic output in South Africa. The results obtained in a model are consistent with the study conducted by Fedderke and Garlick (2008) and Cawood (2011). However, the mining industry has been experiencing share decline of commodities together with high demand of real wages. Furthermore, the study has approved a positive insignificant relationship between mining employment and economic output in South Africa. There is also positive significant relationship between fixed capital stock and economic output. In the nutshell, the results confirmed that mining infrastructure is imperative when coming to economic output towards South Africa.

The implication of positive relationship between mining infrastructure and economic output was that 1% increase in mining infrastructure will increase economic output by 0.10 % in South Africa. Furthermore, 1% increase in fixed capital stock and mining employment will increase economic output by 0.50% and 0.004%.

5.5.2 The Short run relationship

The short run results are illustrated below as follows:

Table13: short run estimates

Variables	coefficients	Standard Errors	T statistics
CointEq(1)	-0.053	0.188	-2.281
D(LINFRS(-1))	0.039	0.081	-0.487
D(LINFRS(-2))	-0.075	0.063	-1.173
D(LEMPLY(-1))	-0.017	0.065	-0.265
D(LEMPLY(-2))	0.036	0.069	0.526
D(LCAPITAL(-1))	-0.855	0.466	-1.831
D(LCAPITAL(-2))	-0.070	0.493	-0.143
D(LGRENL(-1)	0.156	0.079	1.960
D(LGRENL(-2))	0.101	0.075	-1.337

The coefficient of dependent variable is 0.05% and it is statistically significant with t- value of -2.281. The model will go back to its normal trend with a coefficient of 0.05%. The coefficient of 0.5% represents a discrepancy to be corrected in a year. After estimating the model we conduct both diagnostic and stability tests to confirm if our model was stable and good.

5.6 Diagnostic and Stability test

There are eight classical linear regression model assumptions that should be taken into consideration when developing a regression model. These assumptions are required to show for the estimation techniques of VECM properties as they have number of properties and hypothesis test regarding coefficient estimates are to be conducted. According to Gujarati and Porter (2009), when estimating a model it is very imperative to test for stability and diagnostic test to examine if whether the model is of good fit. Furthermore, the main objective of diagnostic test is to build test statistics in order to correct specifications from an estimated model. The diagnostic test performed here are the one elucidated in chapter 4 and they are subjective to their own hypothesis.

5.6.1 Jaque Bera Results

The importance of performing Jaque Bera test is to ensure if estimated residuals are normally distributed. The model with residuals which are not normally distributed provides with spurious results which cannot be used for predictions. Table 13 below presents the results and the hypothesis as follows:

H_0: Residuals are multivariate normal

H_1: Residuals are not multivariate normal

Table 14: Jaque Bera test

Component	Jarque-Bera	df	Prob.
1	0.367480	2	0.8322
2	7.162701	2	0.0278
3	2.610979	2	0.2710
4	2.959719	2	0.2277
5	0.432967	2	0.8053
Joint	**13.10088**	**10**	**0.1084**

Based on the results reflected in table 14, it is evident that the estimated model is normally distributed with the probability of 0.1084. As a results, the study fails to reject the null hypothesis of residuals are multivariate normal. Therefore, the estimated residuals were developed at the basis of being normally distributed.

5.6.2 White Heteroscedasticity Test

The hypothesis of heteroscedasticity is presented as follows:

H_0: Homoscedasticity

H_1: Heteroscedasticity

Table: 15: Heteroscedasticity

Chi – squared	df	Prob.
375.2463	360	0.2792

Heteroscedasticity is used to examine if whether the variance is zero and the mean is constant. In this case, the chi squared was obtained to be 375.246 with the probability value of 0.2792. The study fails to reject null hypothesis and conclude by saying there is homoscedasticity.

5.6.3 Breusch –Godfrey Serial Correlation

When employing time series data, Serial correlation becomes a challenge by resulting into under estimation of standard errors by making t- values to be overestimated. According to Asteriou and Ha11 (2011), serial correlation occurs mostly when the estimated model has omitted an essential variable. Table 15 below presents LM test together with the hypothesis as follows:

H_0: No serial correlation

H_1: There is serial correlation

Table 16: VEC Residual Serial Correlation LM Test

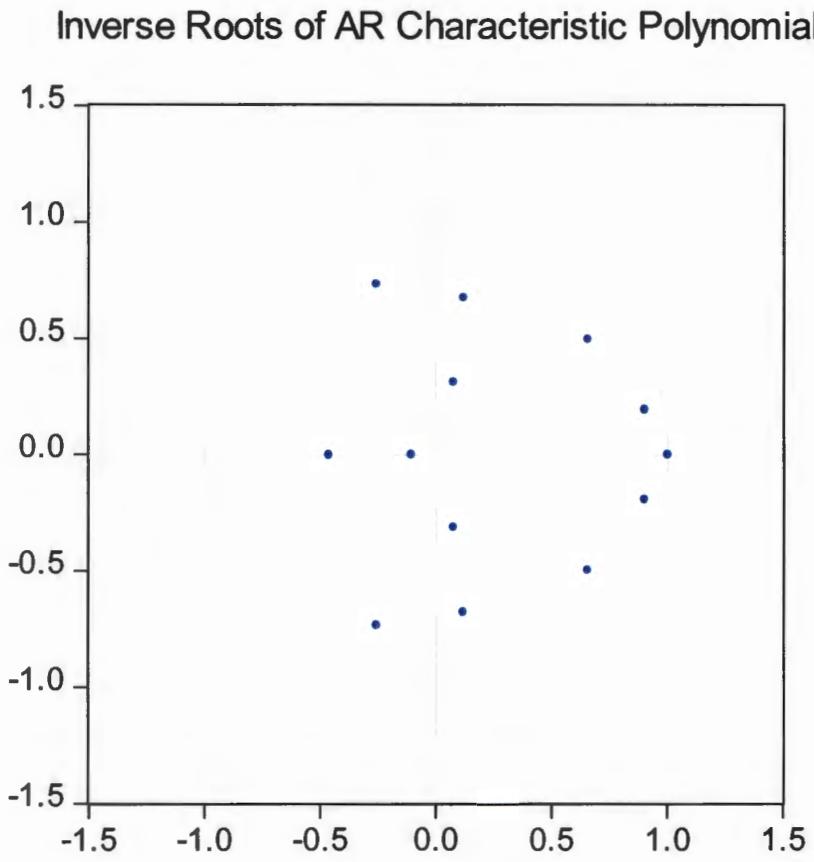
Lags	LM Stat	Prob.
1	23.11109	0.5711
2	25.77340	0.4198

Based on the results obtained from table 15 above, it is evident that the estimated model doesn't suffer from serial correlation with the probability of more than 5%. As a result, the study fails to reject the null hypothesis and conclude that there is no serial correlation.

5.6.4 Inverse Roots of AR Characteristic Polynomial

To test for stability test, the study employed the AR roots to examine if whether the estimated model is consistent or not. Figure 5.1 below illustrate the inverse roots of AR characteristic polynomial in the following manner:

Figure 5.1: Inverse Roots of AR characteristic Polynomial



It is evident from figure our model is stable and it approve the classical linear regression model assumptions. The estimated VAR is stationary because the roots are less than one and they fall within the unit circle.

5.7 Pairwise Granger Causality Test

The cointegration does exist between mining infrastructure and economic output in South Africa from 1980-2013 and the study continues to examine if there is a direction between mining infrastructure and economic output. In this instance, we determine if our endogenous

variable can have an influence in other variables, all the variables are given the chance to explain itself towards each and every variable within a model. According to Asteriou and Hall (2011) in their theory describe Vector Autoregression (VAR) causality method as one of the most important study in economic theory. Granger (1969) developed the study of granger causality and defines as follows, the causality exist when variable y_t does granger cause the x_t and variable x_t can be predicted with a greater accuracy of past values in y_t holding other constant. Granger causality is presented below by using tables to give each and every variable a chance to be an explanator. The null hypothesis of granger causality is indicated in the following way:

$$H_0: X_t \text{ does not cause } Y_t$$

$$H_1: Y_t \text{does not cause } X_t$$

Table 17: Granger Causality Test

Null hypothesis	Obs	Fstats	Prob	Conclusion
LINFRS does not granger cause LGDP	32	1.735	0.195	No-causality
LGDP does not granger cause LINFRS	32	8.197	0.001	Causality
LEMPLY does not granger cause LGDP	32	1.225	0.309	No-causality
LGDP does not granger cause LEMPLY	32	2.947	0.069	No-causality
LCAPITAL does not granger cause LGDP	32	6.772	0.004	Causality
LGDP does not granger cause LCAPITAL	32	8.562	0.001	Causality
LGRENL does not granger cause LGDP	32	0.334	0.001	Causality
LGDP does not granger cause LGRENL	32	0.053	0.718	No-causality

Based on the results obtained in table 16 above, it is evident that mining Infrastructure does not granger cause economic output but rather economic output does granger cause mining infrastructure. This simply implies that the economic output is not affected by the changes of mining infrastructure but rather the changes of economic output influences mining infrastructure and it makes economic sense. The level of mining infrastructure turns out to be significant only when output growth respond positively and generates more income. Furthermore, the causal relationship between mining infrastructure and economic output is found to be uni-directional since it runs from one direction. The rest of the results are presented in table 16 above.

5.8 Conclusion

This study carried out in this chapter was in order to test for research hypothesis: mining infrastructure has no impact on economic output in South Africa as null hypothesis. The alternative, in the other hand, is specified as mining infrastructure has an impact on economic output in South Africa.The study examined annual time series data in South Africa from 1980-2013 focusing in mining infrastructure and economic output. The econometric tools and techniques where employed within the study. In the first test the study used Augmented Dickey Fuller (ADF) and Phillip Perron (PP) test to obtain stationarity within variables which are non-stationary. The results of the unitroot are rejected and do confirm if the variables are stationary after differencing them at second order of integration.

The second test was cointegration as it was used to examine the relationship between variables. The study employed Johansen cointegration to determine if there is a long run relationship. Johansen Cointegration was estimated and the study also obtained there is an existence of cointegration between variables. Johansen test technique using both trace and maximum Eigen value confirms that variables are cointegrated. The Vector Error Correction Model (VECM) was employed in the study to determine the short and long run effect. The ECT which measures the speed of adjustment have the negative sign and is statistically significant, this shows the economic output will promptly adjust slowly to its normal trend.

Granger causality test does reflect causality between mining infrastructure and economic output. Based on the results above, it is evident that the economic output and mining infrastructure remains to be imperative in terms of promoting production output and skilled labours. Therefore, the study concludes that mining infrastructure has a positive effect on economic output, meaning that the influence of mining infrastructure will bring along cost efficiency of productivity and skilled labours.

CHAPTER 6

SUMMARY, CONCLUSION AND POLICY RECOMMENDATIONS

6.1 Introduction

The main objective of this study was to examine the true nature of the relationship between mining infrastructure and economic output in South Africa using annual time series data from (1980-2013). The study incorporated the variables such as mining employment, gross enrolment and fixed capital stock to assist in explaining behavarial model between mining infrastructure and economic output. The study employed Vector Error Correction Model to examine the relationship of both long run and short run. The Vector Error Correction Model comprise procedures such as ADF and PP test which are utilised to test for stationarity, lag order of selection method used to select appropriate lag order, Johansen cointegration technique and estimating long run and short run. Furthermore, the study performed diagnostic and stability test. Lastly, the study performed Granger Causality to examine the cause and effects amongst the variables.

6.2 Key findings

The study started by asking the true nature of the relationship between mining infrastructure and economic output in South Africa. To respond at this question, the study employed Vector Error Correction Model techniques. The first part of the study employed empirical model of production output for South Africa and regressive gross enrolment a proxy for human capital as an independent variable. The variable included in the model is used to verify if the basis of endogenous growth model can be applied to contribute in the economic growth of both emerging and industrialised nations. The study examined behavioural of variables such as mining infrastructure, mining employment, fixed capital stock and gross enrolment towards economic output in South Africa. The cointegration test confirmed 2 cointegrating vector and suggest that there is cointegration among variables. Positive significant relationship between mining infrastructure and economic output was discovered. This implies that, increase in mining infrastructure will promote economic output in South Africa. The results obtained from the study supports endogenous growth theory that output increases through the effectiveness of labour, capital and human capital.

The study also discovered insignificant relationship between mining employment and economic Output in South Africa. Based on the results 1% increase in labour will increase economic output by 0.004 %. Although, the study has discovered a positive relationship between employment and output, a decline in share growth of mining sectors is accompanied by lack of skills with huge technological advancement from industrialised economies. The study captured another case by reporting positive and significant relationship between capital and economic out in South Africa. Furthermore, 1% increase in capital will increase economic output by 0.50%, Hence the combination between labour and capital are been regarded as main drivers in economic activities both in emerging and industrialised economies. In this instance, the results are consistent with Cobb Doughlas production function. All the variables where reported to be significant except for labour.

In the short run the estimated model reported that there is a convergence towards equilibrium in the long run but although in the short run the adjustment is weak at 0.05%. Diagnostic and stability test where employed by the study to examine if the model doesn't suffer from got fit. However, the study reports that the model does not suffer from heteroscedasticity, serial correlation and normality error. The polynomial characteristic AR roots was reported to be stable since AR polynomial was less than one and they fall within the unit cycle.

This study further analysed Granger Causality to test for causal relationship between mining infrastructure and economic output in South Africa. The granger causality indicated that mining infrastructure does not granger cause economic output. Instead, economic output does granger cause mining infrastructure. The causal link between mining infrastructure and economic output is found to be uni directional since there is only one causal relationship which runs from economic output to mining infrastructure.

Based on the results above, this study concludes that mining infrastructure in economic output is more accurate in addressing current challenges which the mining sector is facing. The results given in this study are efficient and consistent which are undertaken by diagnostic and stability test.

6.3 Policy recommendations

As it was outlined from the previous chapter that mining infrastructure has an influence on economic output, it is therefore recommended that the mining sector should focus more in intensifying mining infrastructure. Infrastructure remains to be critically important for South

African output by enforce productivity growth and addressing the burning issue of high demand wages. Mining sector should not focus only in promoting physical capital but also human capital to improve productivity, skills development and contributing towards knowledge. Improving infrastructure will boost South African into emerging markets and creating opportunities for investors, business people and not forgetting to provide the need to the people. Mining infrastructure will be more appropriate only when more money is spend into education, however employees would still move from one industry to another.

Secondly, it was evident from the study that mining employment is essential in South Africa since large portion of employment is created by mining sector. However, the escalating unemployed rate was increased by decline in mining output and international commodity price. South African mining industry should equip labours in terms of introducing human capital that will intensify their skills, Knowledge and lessen costs of production. The contribution of human capital in South African mining industry will speed up the process of mining output and allows employees to work high value added tasks more efficiently and quickly. As the results, the influence of human capital in employees will expand more output per hour than those who spend more money in physical capital.

Lastly, the findings concerning the study are in line with current literature. The mining infrastructure has an effect on economic output both in short and long run. In the theory of Solow both labour and capital remains to be key objective of growth. Introducing human capital and technology continues to demonstrate the significance importance of the study concerning the problem. The mining industries should consider expanding their form of investments from economic to social infrastructure. The study denotes this because in the findings both economic output and mining infrastructure does have long term growth. Promoting private infrastructure opens opportunity and diversity in trade, employment and economic output. The policy makers should improve private infrastructure which will equip human capital to be more useful in contributing towards knowledge and innovation. This means South African government and mining industry should priorities the development of infrastructure as component that will be sufficient towards to economic development.

6.4 Limitation of the study

The limitation of the study concerns on an unavailability of the data suggested by theoretical model on the effect of infrastructure. In the empirical model some of the variables were excluded and proxies where used to replace such variables. The risk involved in this proxy

might not replace actual variables and provide with inconsistent results however these problems did not affect the findings outlined in the study. The findings do also support theoretical and empirical insights between mining infrastructure development and economic output. Another limitation is there is only limited information concerning the exact study; most of such studies are conducted using primary data.

6.5 Area of further research

The study left out other variables which are seems to be important regarding the relationship between mining infrastructure development and economic output. Working hours for labours, real average wages per worker, population and foreign direct investment are variables which are significantly important regarding the study. In further research such variables should be incorporated in the empirical model to determine the influence of population regarding mining infrastructure and economic growth.

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LIST OF APPENDIX

Appendix1: Data employed in the study

DATE	GDP	GRENL	EMPLY	CAPITAL	INFRS
1980	1404900	84.07949	57.8	241678	17962
1981	1480213	81.2444	60.7	258696	21840
1982	1474538	78.40931	61	273817	24687
1983	1447310	75.57422	59.6	285870	27197
1984	1521110	72.73913	60.3	298405	28937
1985	1502682	69.90404	60.1	311908	32377
1986	1502950	78.09113	60.5	324027	33509
1987	1534523	79.80717	61.3	335527	35309
1988	1598975	80.60243	62.7	348558	45268
1989	1637267	105.7798	63.1	363085	58041
1990	1632064	106.7091	62.6	374283	62617
1991	1615446	108.8224	60.5	381934	65208
1992	1580923	110.9356	58.4	383287	67087
1993	1600424	113.0489	57	378465	69368
1994	1652184	115.3226	56.5	376656	79857
1995	1703660	117.3399	56.8	375444	95632
1996	1777032	119.3572	55.3	373864	109126
1997	1824067	114.1296	53.9	375260	123437
1998	1833504	112.9235	51.5	377766	137762
1999	1876740	111.2959	50.8	378125	134668
2000	1954710	103.7282	49.8	380664	147779
2001	2008181	102.8547	49.2	383983	162257
2002	2081837	103.1637	64.5	389924	184419
2003	2143232	102.7178	77.8	396237	211877
2004	2240847	101.8114	81.8	395215	243052
2005	2359099	99.59099	88.4	391006	282713
2006	2491295	98.18671	100.1	399078	348105
2007	2624840	98.6489	105.5	416731	435548
2008	2708600	97.71826	106.6	445086	556997
2009	2666939	96.87596	101.6	474542	539440
2010	2748008	96.25382	100	499753	529431
2011	2836286	96.31583	101.4	527592	566676
2012	2899248	97.62976	102.3	555125	614505
2013	2963389	98.50156	108.3	580202	708357

Appendix2: Cointegration test

Date: 03/02/17 Time: 17:37

Sample (adjusted): 1983 2013

Included observations: 31 after adjustments

Trend assumption: Linear deterministic trend

Series: LGDP LCAPITAL LINFRS LEMPLY LGRENL

Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.832581	126.5400	69.81889	0.0000
At most 1 *	0.719489	71.13504	47.85613	0.0001
At most 2 *	0.461983	31.72966	29.79707	0.0296
At most 3	0.331564	12.51382	15.49471	0.1339
At most 4	0.000856	0.026542	3.841466	0.8705

Trace test indicates 3 cointegratingeqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.832581	55.40494	33.87687	0.0000
At most 1 *	0.719489	39.40537	27.58434	0.0010
At most 2	0.461983	19.21585	21.13162	0.0908
At most 3	0.331564	12.48728	14.26460	0.0937
At most 4	0.000856	0.026542	3.841466	0.8705

Max-eigenvalue test indicates 2 cointegratingeqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Appendix 3: Vector Error Correction Model

Vector Error Correction Estimates
Date: 03/02/17 Time: 17:50
Sample (adjusted): 1983 2013
Included observations: 31 after adjustments
Standard errors in ( ) & t-statistics in [ ]

CointegratingEq:	CointEq1	CointEq2
LGDP(-1)	1.000000	0.000000
LGRENL(-1)	0.000000	1.000000
LEMPLY(-1)	-0.004188	0.207064
	(0.03279)	(0.08140)
	[-0.12773]	[2.54372]
LCAPITAL(-1)	-0.509429	1.054405
	(0.11382)	(0.28258)
	[-4.47573]	[3.73130]
LINFRS(-1)	-0.109744	-0.368875
	(0.02065)	(0.05126)
	[-5.31540]	[-7.19625]
C	-6.618799	-14.69068

Error Correction:	D(LGDP)	D(LGRENL)	D(LEMPLY)	D(LCAPITAL)	D(LINFRS)
CointEq1	-0.053130	-1.108476	-0.029535	0.245939	1.324721
	(0.18876)	(0.52563)	(0.61265)	(0.06673)	(0.63981)
	[- 2.28147]	[-2.10884]	[-0.04821]	[3.68542]	[2.07049]
CointEq2	-0.124062	-0.291339	-0.256966	0.004877	0.403253
	(0.06225)	(0.17335)	(0.20205)	(0.02201)	(0.21100)
	[-1.99293]	[-1.68065]	[-1.27180]	[0.22158]	[1.91111]
D(LGDP(-1))	-0.325586	0.008471	-0.280964	-0.087882	0.959737
	(0.29879)	(0.83203)	(0.96978)	(0.10563)	(1.01276)
	[-1.08969]	[0.01018]	[-0.28972]	[-0.83196]	[0.94764]
D(LGDP(-2))	-0.303536	0.054325	0.755515	-0.180980	-0.039833
	(0.25099)	(0.69892)	(0.81463)	(0.08873)	(0.85074)
	[-1.20936]	[0.07773]	[0.92743]	[-2.03960]	[-0.04682]
D(LGRENL(-1))	0.156412	-0.059324	0.357049	0.041789	0.055974
	(0.07978)	(0.22217)	(0.25895)	(0.02821)	(0.27043)
	[1.96046]	[-0.26702]	[1.37883]	[1.48158]	[0.20698]
D(LGRENL(-2))	0.101119	0.148323	-0.026476	0.063473	0.244094
	(0.07559)	(0.21051)	(0.24536)	(0.02673)	(0.25623)
	[1.33765]	[0.70461]	[-0.10791]	[2.37503]	[0.95263]
D(LEMPLY(-1))	-0.017363	0.090103	0.541929	-0.040281	0.038201
	(0.06544)	(0.18222)	(0.21238)	(0.02313)	(0.22180)
	[-0.26534]	[0.49448]	[2.55164]	[-1.74123]	[0.17223]
D(LEMPLY(-2))	0.036599	-0.033271	-0.360951	-0.085560	0.125268
	(0.06956)	(0.19369)	(0.22576)	(0.02459)	(0.23577)
	[0.52617]	[-0.17177]	[-1.59882]	[-3.47933]	[0.53132]
D(LCAPITAL(-1))	-0.855372	-0.352955	-3.512504	0.874779	-0.137440
	(0.46696)	(1.30033)	(1.51561)	(0.16509)	(1.58279)
	[-1.83179]	[-0.27143]	[-2.31755]	[5.29893]	[-0.08683]
D(LCAPITAL(-2))	-0.070788	1.699549	2.294260	-0.371732	-0.911716

	(0.49327)	(1.37358)	(1.60099)	(0.17439)	(1.67196)
	[-0.14351]	[1.23731]	[1.43302]	[-2.13166]	[-0.54530]
D(LINFRS(-1))	0.039687	0.648344	0.045572	0.047092	0.100126
	(0.08140)	(0.22666)	(0.26418)	(0.02878)	(0.27589)
	[0.48759]	[2.86045]	[0.17250]	[1.63651]	[0.36291]
D(LINFRS(-2))	-0.075007	-0.302059	-0.137440	-0.017105	-0.431585
	(0.06391)	(0.17798)	(0.20745)	(0.02260)	(0.21664)
	[-1.17354]	[-1.69714]	[-0.66253]	[-0.75700]	[-1.99215]
C	0.061644	-0.065538	0.042040	0.016585	0.147674
	(0.01718)	(0.04783)	(0.05575)	(0.00607)	(0.05822)
	[3.58908]	[-1.37031]	[0.75413]	[2.73136]	[2.53662]
R-squared	0.621952	0.573298	0.583541	0.958190	0.644124
Adj. R-squared	0.369920	0.288830	0.305902	0.930316	0.406874
Sum sq. resids	0.005518	0.042785	0.058125	0.000690	0.063392
S.E. equation	0.017508	0.048754	0.056826	0.006190	0.059345
F-statistic	2.467752	2.015335	2.101799	34.37628	2.714954
Log likelihood	89.83695	58.08896	53.33976	122.0700	51.99520
Akaike AIC	-4.957223	-2.908965	-2.602565	-7.036776	-2.515820
Schwarz SC	-4.355873	-2.307615	-2.001216	-6.435426	-1.914470
Mean dependent	0.022516	0.007359	0.018517	0.024223	0.108280
S.D. dependent	0.022057	0.057813	0.068208	0.023448	0.077056

Appendix 4: VEC Residual Normality Test

VEC Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: residuals are multivariate normal
Date: 03/02/17 Time: 18:05
Sample: 1980 2013
Included observations: 31

Component	Skewness	Chi-sq	df	Prob.
1	-0.093590	0.045256	1	0.8315
2	-0.353596	0.645991	1	0.4215
3	-0.401077	0.831125	1	0.3619
4	0.505974	1.322718	1	0.2501
5	0.090651	0.042458	1	0.8367
Joint		2.887547	5	0.7173

Component	Kurtosis	Chi-sq	df	Prob.
1	3.327108	0.138208	1	0.7101
2	2.253665	0.719478	1	0.3963
3	3.926302	1.108296	1	0.2925
4	3.075905	0.007442	1	0.9313
5	2.847364	0.030093	1	0.8623
Joint		2.003517	5	0.8487

Component	Jarque-Bera	df	Prob.
1	0.183464	2	0.9123
2	1.365469	2	0.5052
3	1.939421	2	0.3792
4	1.330160	2	0.5142
5	0.072551	2	0.9644
Joint	4.891064	10	0.8983

Appendix 5:VEC Residual Correlation LM Test

VEC Residual Serial Correlation LM Tests

Null Hypothesis: no serial correlation at lag order h

Date: 03/02/17 Time: 17:40

Sample: 1980 2013

Included observations: 31

Lags	LM-Stat	Prob
1	23.11109	0.5711
2	25.77340	0.4198
3	15.73993	0.9224
4	14.04406	0.9610
5	34.92045	0.0897
6	19.70191	0.7623
7	30.72186	0.1984
8	34.09169	0.1060
9	18.28311	0.8301
10	32.64560	0.1402
11	23.99487	0.5197
12	16.41757	0.9018

Probs from chi-square with 25 df.

Appendix 6: White Heteroscedasticity

VEC Residual Heteroscedasticity Tests: No Cross Terms (only levels and squares)

Date: 03/02/17 Time: 17:39

Sample: 1980 2013

Included observations: 31

Joint test:

Chi-sq	df	Prob.
375.2463	360	0.2792

Individual components:

Dependent	R-squared	F(24,6)	Prob.	Chi-sq(24)	Prob.
res1*res1	0.900546	2.263724	0.1565	27.91693	0.2636
res2*res2	0.933350	3.500915	0.0620	28.93384	0.2226
res3*res3	0.949053	4.657098	0.0315	29.42066	0.2047
res4*res4	0.637076	0.438850	0.9301	19.74937	0.7109
res5*res5	0.877217	1.786117	0.2423	27.19373	0.2955
res2*res1	0.861296	1.552395	0.3059	26.70017	0.3186
res3*res1	0.975691	10.03428	0.0043	30.24642	0.1767
res3*res2	0.927507	3.198621	0.0759	28.75273	0.2296
res4*res1	0.870761	1.684403	0.2677	26.99360	0.3048
res4*res2	0.804496	1.028745	0.5349	24.93937	0.4091
res4*res3	0.707535	0.604804	0.8240	21.93359	0.5832
res5*res1	0.825247	1.180593	0.4533	25.58267	0.3747
res5*res2	0.898193	2.205615	0.1646	27.84397	0.2667
res5*res3	0.881401	1.857952	0.2261	27.32345	0.2896
res5*res4	0.840049	1.312979	0.3930	26.04152	0.3511

Appendix7: Granger Causality

Pairwise Granger Causality Tests

Date: 03/02/17 Time: 17:44

Sample: 1980 2013

Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
LINFRS does not Granger Cause LGDP	32	1.73553	0.1954
LGDP does not Granger Cause LINFRS		8.19707	0.0017
LGRENL does not Granger Cause LGDP	32	0.33434	0.7187
LGDP does not Granger Cause LGRENL		0.05319	0.9483
LEMPLY does not Granger Cause LGDP	32	1.22573	0.3094
LGDP does not Granger Cause LEMPLY		2.94736	0.0695
LCAPITAL does not Granger Cause LGDP	32	6.77281	0.0041
LGDP does not Granger Cause LCAPITAL		8.56241	0.0013
LGRENL does not Granger Cause LINFRS	32	0.21997	0.8040
LINFRS does not Granger Cause LGRENL		0.94752	0.4002
LEMPLY does not Granger Cause LINFRS	32	1.79622	0.1852
LINFRS does not Granger Cause LEMPLY		1.85051	0.1765
LCAPITAL does not Granger Cause LINFRS	32	1.41057	0.2614
LINFRS does not Granger Cause LCAPITAL		4.27198	0.0244
LEMPLY does not Granger Cause LGRENL	32	0.02669	0.9737
LGRENL does not Granger Cause LEMPLY		0.03347	0.9671
LCAPITAL does not Granger Cause LGRENL	32	1.20224	0.3161
LGRENL does not Granger Cause LCAPITAL		1.83609	0.1788
LCAPITAL does not Granger Cause LEMPLY	32	0.95287	0.3982
LEMPLY does not Granger Cause LCAPITAL		3.85707	0.0336