The Impact of Electricity Supply on the Manufacturing Sector Output in South Africa

by

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DECLARATION

I declare that "***the impact of electricity supply on the manufacturing sector output in South Africa***" is my own work, that it has not been submitted for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged by complete references.

Full names... Date.................................

Signed..

Signature... Date.................................
Supervisor

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ABSTRACT

Uninterrupted and sufficient electricity supply is one of the most important determinants that boost manufacturing output in any economy. The availability of electricity plays a vital role in both the production and consumption of goods and services as well as in a country's growth prospects. It is against this background that the main objective of this dissertation is to determine the impact of electricity supply on manufacturing sector output in South Africa from 1985 to 2014.Cointegrated VAR methodology was implemented to test the impact of electricity supply on South Africa's manufactured output.

The analysis showed evidence of two cointegrating vectors. A positive long run relationship was found between manufactured output and manufacturing employment and between manufactured output and electricity supply. The results imply that electricity supply and manufacturing employment play a role in bringing manufactured output to equilibrium. In this study the error term is -0.135, which implies that the cointegration relationship is stable. The speed of adjustment is 13.5 percent. This is a speed at which manufacturing output returns to equilibrium after a shock in independent variables like electricity supply. This indicates that 13.5 percent of the gap between manufactured output and its equilibrium value is eliminated in the short run.

The policy implication of a positive relationship between electricity supply and manufactured output is that an expansion of the electricity sector will result in an increase in manufactured output. Policy makers in South Africa should continue to formulate and implement policies that are aimed at promoting and expanding the electricity sector. This will not only boost the manufacturing sector but will also create more jobs in the country. The results that have emerged from this analysis corroborate the theoretical predictions and are also supported by previous studies.

Keywords: Electricity Supply, Manufacturing sector output, Vector Autoregression, South Africa

LIST OF ACRONYMS

AAC	Anglo American Corporation
ADF	Augmented Dickey Fuller
ARDL	Autoregressive Distributed Lag
CES	Constant Elasticity of Substitution
CVAR	Cointegrated Vector Autoregression
CPI	Inflation rate
DE	Department of Energy
DME	Department of Minerals and Energy
DTI	Department of Trade and Industry
EIA	Energy Information Administration
Es	Electricity supply
GDP	Gross Domestic Products
GIRF	Generalized Impulse Response Function
Int	Real interest rate
IPAP	Industrial Policy Action Plan
JB	Jarque-Bera
K	Capital
KPSS	Kwiatkowski-Phillips-Schmidt-Shin
L	Labour
Me	Manufacturing employment
Mo	Manufactured output
MSI	Micro and Small scale Industries
NER	National Electricity Regulator

NERSA	National Energy Regulator of South Africa
NRR	National Nuclear Regulator
OLS	Ordinary Least Square
PDF	Probability Density Function
PP	Phillips-Peron
RBC	Real business cycle
RSA	Republic of South Africa
SME	Small and Medium Enterprises
SADC	Southern African Development Community
SCI	Standard Industrial Classification
Stats SA	Statistics South Africa
TFP	Total Factor Productivity
UNDP	United Nations Development Programme
VAR	Vector Autoregression
VECM	Vector Error Correction Model

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

Introduction

1.1 Background

Uninterrupted and ample electricity supply is one of the most important features that boost manufacturing output in any economy. Many developing countries are faced with power shortage problems. Almost all sectors in the economy depend on electricity for their day to day running. The availability of electricity has a very significant role in both the production and consumption of goods and services as well as in a country growth prospects (Ferguson, Wilkinson and Hill, (2000). The reliability of input factor and availability of resources including electricity are very vital for the firm productivity in developing countries.

Most African countries have monopolised power utilities resulting in low tariffs. Unfortunately, this is also associated with poor technical and financial management. The United Nations Development Programme (UNDP) (2004) is of a view that these state-owned power monopolies have resulted in little investment and poor maintenance of infrastructure leading to power shortages, brownout[1] and load-shedding[2] becoming common in most African countries. Poor infrastructure and improper financial mechanisms are some of the factors that affect Africa's electricity sector.

According to Oshikoya and Hussain (2001) most African countries have a problem of unreliable and a high disruption cost of power supply which leads to production inefficiency and affects long term growth and competitiveness. In most parts of East and West Africa, manufacturing companies use back up power system (diesel powered generators) as their main source of electricity. African manufacturing companies rely on high price electricity for their production processes which restrain them from competing effectively with Asian and developed world counterparts. South Africa, as is the case in the rest of the Southern Africa region, also has serious infrastructure and power supply challenges to support the manufacturing sector.

[1]Brownout is defined as an intentional or unintentional drop in voltage in an electric power supply system. Intentional brownouts are used to reduce power load in an emergency and can last for minutes or hours. They are used to prevent power outage known as Blackout (Blume, 2007).

[2]Load shedding refers to a situation when there is not enough electricity to meet the demand. Load shedding is used to interrupt the supply of electricity to certain areas in order to balance demand and supply. It is an effective way to avoid total collapse of the electricity supply grid (Siano, 2014)

Manufacturing is a wealth-trigger or wealth creating sector in the economy, while the service sector tends to be wealth-consuming (Friedman, 2006). South Africa has developed an established diversified manufacturing base that has shown its resilience and potential to compete in the global economy. Estimations have shown that South Africa produces more than half of the electricity generated in Africa. The country started experiencing a decrease in the electricity reserve margin in the recent years (Energy Information Administration (EIA) 2008).

The general public and companies in South Africa have since the 2008 load-shedding, experienced the reality of electricity shortages for the first time in the country. According to (EIA, 2008) the country experienced power shortages and load shedding in mid-January 2008 which lasted for about four weeks and leading to economic costs estimated at $253 million and $282 million. Roughly half of this amount represented losses in the country's key mining and manufacturing sector. The net effect of power demand surpassing its supply is a growing crisis that threatens to negatively affect the manufacturing sector.

The South African energy sector served major investments in heavy manufacturing industry and mining, the two of which build the economic and energy structure of the country (Department of Minerals and Energy (DME), 2001). Most of the products in the manufacturing industry are connected to mining activities through minerals beneficiation and metal production. The production of these activities consumes more electricity, as a result, relies on the availability of coal for the production of electricity. South Africa's consumption levels of electricity are significantly greater than those in many other developing countries predominantly because of its strong industrial base (National Electricity Regulator (NER), 2001a).

1.2 Problem statement

The South African manufacturing output is affected by electricity blackouts which force companies to limit their production. At the beginning of 2015, manufacturing fell by 1.5 percent compared to December 2014 and by 2.3 percent compared to January 2014. According to Isa (2015) the manufacturing output was mainly affected by electricity blackouts during the month of January 2015, forcing many companies to limit their production. Mining and manufacturing account for about a fifth of the gross domestic product in South Africa. A reduction in manufacturing output reflects the harm that electricity cuts cause on the South African economy. Isa (2015) also pointed out that the business confidence fell in the first quarter, mainly due to the situation in the manufacturing sector.

Strydom (2015) reported that the power situation in South Africa is being monitored by the World Bank as its effects on the economy are regarded as severe. The afflictions from the power supply are said to be one of the three major factors that will reduce growth in South Africa in 2015, and is expected to recover in 2016. Furthermore, the energy woes in South Africa are said to be self-inflicted, as a result the country would struggle to achieve a two percent growth.

Few studies such as Boqiang, Presely, and Wesseh (2014), Wolde-Rufael (2014), Ziramba (2009) and Odiambo (2009) among others, have examined the relationship between electricity consumption and economic growth or industry production in South Africa. Looking at the existing literature, a lacuna exists in the available research as there seems to be no studies that focused on the impact of electricity supply on the manufacturing sector output in South Africa. This study therefore, seeks to fill this gap.

Looking at the information provided above, questions which may arise are: (1) Does electricity supply have any impact on total output in South Africa`s manufacturing sector? (2) Is there any relationship between South Africa's manufacturing sector output and electricity? (3) How significant is this relationship if it exists? (4) Can manufacturing output be enhanced by increasing electricity supply? In this regard, this study attempts to empirically reveal the relationship between electricity supply and South Africa`s manufacturing sector output.

1.3 Importance of the study

It is very important to examine and find out how electricity supply affects the manufacturing sector in South Africa. This study will give policy makers a guide when formulating policies aimed at encouraging investors to use the available resources and means, in generating more electricity in South Africa. The findings of this study will contribute knowledge to the general public, policy makers, manufacturing sector regulatory authorities and economic planners on the impact of electricity supply on manufacturing sector in South Africa.

The results obtained in this study will also contribute to the available literature on the current situation of the manufacturing sector in South Africa. With the empirical findings and analysis, the results of this study will benefit the researchers who will use them for further research. This study will also benefit policy makers and economic planners in terms of using its findings in formulating and implementing appropriate policy measures towards accelerating economic growth through the manufacturing sector.

1.4 Aims and Objectives

The main aim of this study is to determine the impact of electricity supply on manufacturing sector output in South Africa from 1985 to 2014.

The study has the following specific objectives:

- test the relationship between electricity supply and manufactured output and
- ascertain the relationship between manufacturing output, electricity supply and manufacturing employment by means of Vector Autoregression (VAR) model.

1.5 Hypothesis of the study

This study has two hypotheses which are as follows:

- H0: Electricity supply does not have any impact on manufactured output in South Africa.
- H1: Electricity supply has an impact on manufactured output in South Africa.

1.6 Organisation of the study

The study is organised as follows: Chapter One provides a brief background to the study as well as aims and objectives of the study. Chapter Two provides an overview of South Africa's manufacturing sector and the electricity sector. Chapter three reviews literature of related theoretical and empirical studies, on the impact of electricity supply on the manufacturing sector output. This is then followed by a presentation of methodological framework in Chapter four. Chapter five discusses empirical results on the relationship between electricity supply and the manufacturing sector output, and lastly, the conclusion and policy implications are presented in Chapter six.

Chapter 2

Overview of South Africa's manufacturing sector and electricity sector

2.1 Introduction

The aim of this chapter is to discuss the overview of South Africa's manufacturing sector as well as the overview of South Africa's electricity sector. The chapter is divided in to four sections. Following this introduction is section 2.2, which discusses an overview of South Africa's manufacturing sector, while 2.3 discusses an overview of South Africa's electricity sector. Section 2.4 concludes the chapter.

2.2 An overview of South Africa's manufacturing sector

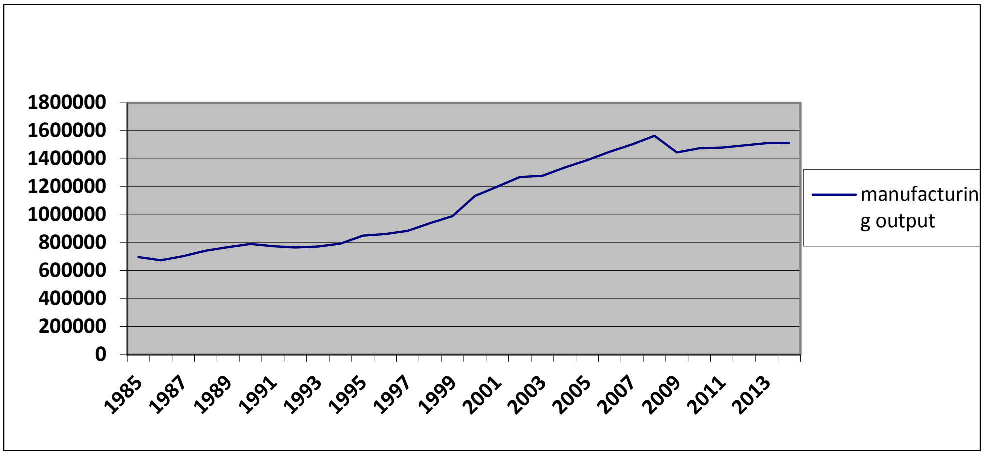
The establishment of South Africa's manufacturing sector traces back to the year 1917. This was the year when the Anglo American Corporation (AAC) was formed (Innes, 1984). AAC was registered as a South African firm and took advantage of its position as South African firm to work closely with the government. Innes (1984) went on to state that AAC and other foreign firms moved into manufacturing behind protective barriers, extending their control over the South African economy and increasing their profits. South Africa made use of the Tariff Act 1925 as a way to develop a viable manufacturing sector.

According to Innes (1984) the Tariff Act succeeded in bringing about a resurgence of foreign investment in South Africa and specifically a major increment in the level of both foreign and mining investment in manufacturing production. With the use of the Tariff Act of 1925, the manufacturing sector became an extremely profitable place to invest in South Africa. According to Clark (1994) the number of manufacturing firms increased by 7.7 percent between 1925 and the time of the Great Depression in 1929. In 1939South Africa's inwards-oriented program of industrialisation which began in 1925 had tripled the manufacturing output and doubled the number of white jobs in the manufacturing sector (Archer, 1981).

South Africa's manufacturing sector pulled along the rest of the economy as manufacturing output outstripped GDP growth from1946 to 1980. South Africa has developed an established, diversified manufacturing base that has shown its resilience and potential to compete in the global economy.

Figure 2.1 represents a trend of manufacturing output in million rand from the year 1985 to 2014. Downward swings prior to 1990s were mainly due to apartheid policies. Since 1994,the government of South Africa has been giving support to the manufacturing sector through implementation of various policy amendments and the development of new policies. This is indicated by an upward swing between 1990s and early 2000s which is due to democracy and associated to removal of sanctions and liberalisation. A downward swing experienced in 2009 was due to the world economic crisis and infrastructural bottlenecks in particular shortage of electricity which South Africa started experiencing in early 2008. From 2009 to 2014 there has not been that much improvement

Figure 2.1 Trends of manufacturing output from 1985 to 2014

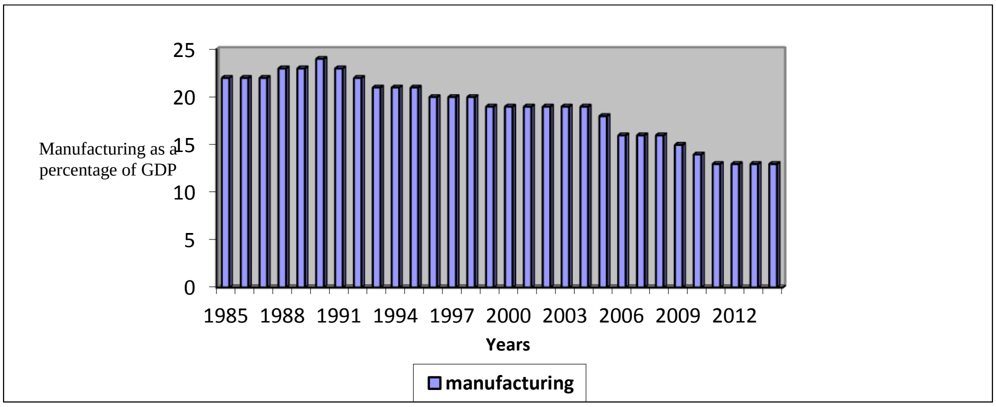


Source: Quantec (Stats SA)

Manufacturing appears as an important sector within the South African economy as it continues to appear among the top-three sectors with the highest multiplier effects in terms of output, employment, export earnings and fiscal revenue. According to Stats SA, manufacturing sector in South Africa forms part of the three major sectors that build up the country's economy. The sector also forms part of the largest power consuming sectors in the economy. Manufacturing has a substantial direct employment creation potential and is central the country's export strategy (Department of Trade and Industry (DTI)). DTI also stated that the sector has labour intensive traceable productions that generate revenues that have a significant positive impact on the balance of payment.

Following the world economic crisis of 2007-2009, South Africa's manufacturing sector has not recovered, and is also being affected by a range of domestic economic shocks mainly electricity price hikes as well as shortage of power supply in the country (DTI).

Figure 2.2 Manufacturing, value added (% of GDP)



Source: World Bank

Figure 2.2 shows that since 1991, the contribution of the manufacturing sector toward the South African GDP has been declining. In 1990, manufacturing sector contributed to about 25 percent of total GDP, which was the highest contribution between 1985 and 2014. Over the years more mines were discovered and that led to a decline in the share of the manufacturing sector. Another factor which led to a decline in the share of the manufacturing sector towards GDP was the world economic crises in 2009. This has resulted in the manufacturing sector contributing less than 15 percent to total GDP up until 2014.

2.2.1 South Africa's manufacturing sector divisions

According to Stats SA, the standard industrial classification (SCI) system classifies manufacturing activities in under three major divisions ranging from the manufacturing of food products, beverages and tobacco and ending with the manufacturing of furniture. The manufacturing sector is dominated by industries such as agro-processing, automotive, chemicals, information technology and communications, textile, clothing and footwear. A brief discussion of these industries follows.

2.2.1.1 Agro-Processing

The agro-processing sector is defined in statistics terms by the food processing and beverage manufacturing sub sectors. These subsectors deal with the processing of fresh water, aquaculture and mariculture, exotic and indigenous meat, nuts, herbs and fruits. The sectors are also involved in the production and export of deciduous fruits; production and exportation of wines and confectionary manufacturing and export. In 2013, the sector had 207 893 jobs.

Since 2008 the food processing sector grew by over 2%, more than the manufacturing sector as a whole (IPAP, 2015).

2.2.1.2 Automotive

The automotive industry is regarded as one of the vital industries in South Africa. The sector assembles vehicles for both the national and global markets. Vehicle manufacturers such as BMW, Ford, Volkswagen, Daimler-Chrysler and Toyota have their production plants in South Africa. The components manufacturers (Arvin Exhust, Bloxwitch, Corning and Senior Flexonics) have established their production bases in the country. At the beginning of 1995, only a few vehicles were exported. In 2011 vehicle export amounted to 239465 (IPAP, 2013).

2.2.1.3 Chemicals

The chemical industry of South Africa is the largest in Africa. The primary and secondary sectors are dominated by Sasol, AECI and Dow Sentrachem. These companies have diversified and expanded their interests in tertiary products especially those with export potential. In 2013 the sector was the fourth largest employer in South Africa with 200 000jobs and contributed about 5% of the country's GDP (IPAP 2015).

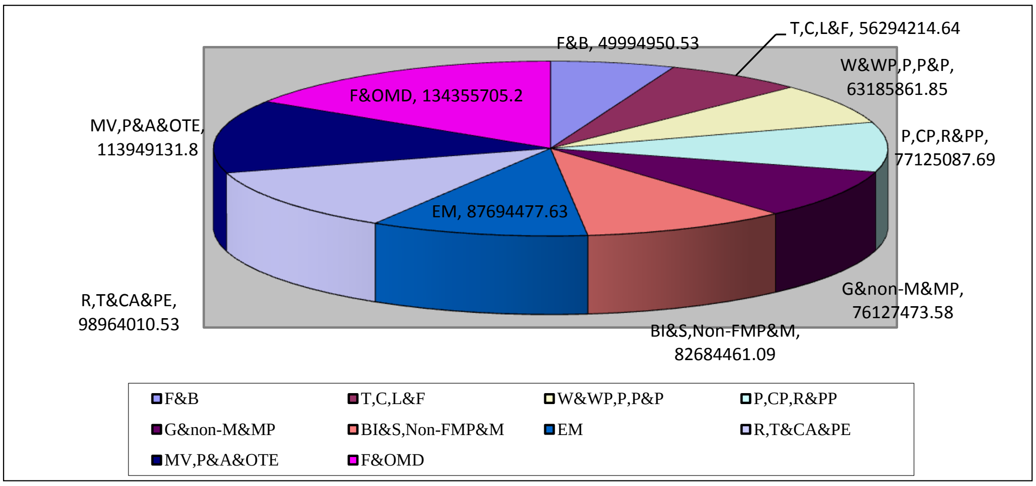
2.2.1.4 Information Technology and Communications

The South African Information Technology and Communication industry is the largest and most advanced in Africa. The sector is characterised by technology leadership especially in the field of mobile software and electronic banking services. According to Stats SA (2013) ICT contributed 4.3% to total GDP and 3% to total exports.

2.2.1.5Textile, Clothing and Footwear

The textile industry is one of the smallest in South Africa. In 2009, South Africa introduced the Clothing and Textile Competitiveness Programme, and through this programme companies were able to invest in new technology and skill development. Because of the technological development, the sector has evolved into a capital intensive industry, producing synthetic fibres in ever-increasing proportions. Clothing textile and footwear industry contribute about 4.36% to GDP, 8.2% in terms of employment 5.58%of total manufacturing output (Quantec, Stats SA).

Figure 2.3 Average Manufacturing output by sector from 1998 to 2014

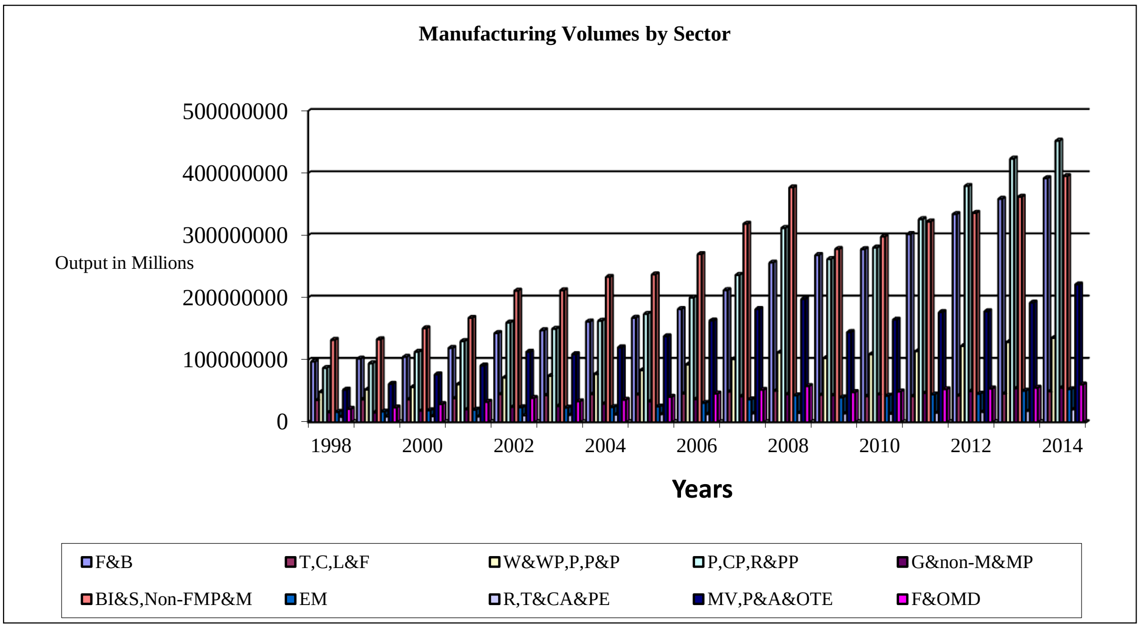


Source: Quantec (Stats SA)

Textile, clothing, leather and footwear (TCL&F) Food and beverages (F&B) Electrical machinery (EM)
Wood and wood products, paper, publishing and printing (W&WP, P, P&P)
Glass and non-metallic mineral products (G&non-M&MP)
Petroleum, chemical products, rubber and plastic products (P, CP, R&P)
Basic iron and steel, non-ferrous metal products, metal products and machinery (BI&S, Non-FMP&M)
Radio, television and communication apparatus and professional equipment (R, T &C&PE)
Motor vehicles, parts and accessories and other transport equipment (MV, P&A&OTE)
Furniture and other manufacturing division (F&OMD)

Figure 2.3 indicates that on average from 1998 to 2014, motor vehicles, parts and accessories and other transport equipment (MV, P&A&OTE) was the highest contributor to total manufacturing output with an average of 113949131.9 million rands as an individual sector. According to IPAP 2013motor vehicles, parts and accessories and other transport equipment output increased massively in 2011 and the vehicles exported by this sector amounted to about 239465 million rand. This could be the reason why on average the sector is the largest contributor to total manufacturing. Following motor vehicles, parts and accessories and other transport equipment is radio, television and communication apparatus and professional equipment (R, T &C&PE) sector with 98964010.53 million rands. This sector is said to be the largest and most advanced not only in South Africa but in the whole of Africa.

Figure 2.4 Total manufacturedoutput by sector from 1998 to 2014



Source: Quantec (Stats SA)

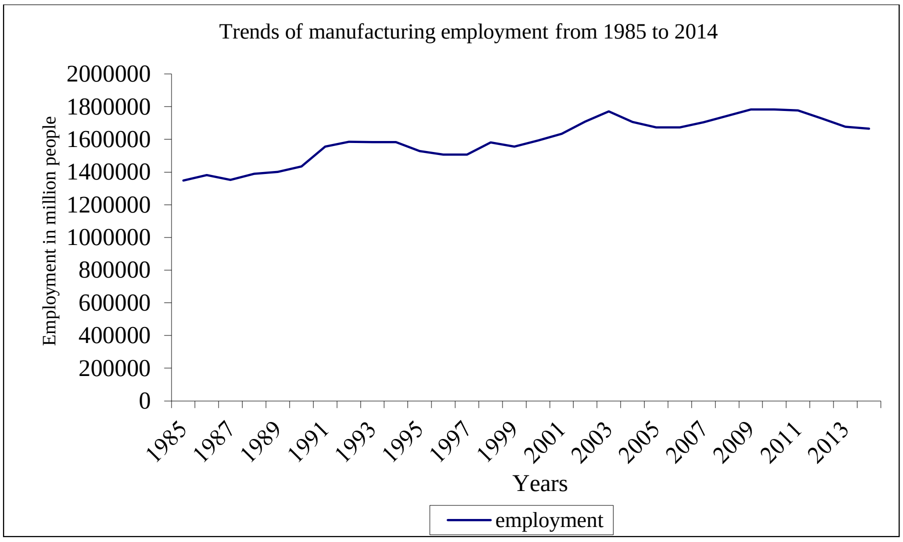
Textile, clothing, leather and footwear (TCL&F)Food and beverages (F&B)Electrical machinery (EM)
Wood and wood products, paper, publishing and printing (W&WP, P, P&P)
Glass and non-metallic mineral products (G&non-M&MP)
Petroleum, chemical products, rubber and plastic products (P, CP, R&P)
Basic iron and steel, non-ferrous metal products, metal products and machinery (BI&S, Non-FMP&M)
Radio, television and communication apparatus and professional equipment (R, T &C&PE)
Motor vehicles, parts and accessories and other transport equipment (MV, P&A&OTE)
Furniture and other manufacturing division (F&OMD)

2.2.2 Manufacturing Employment in South Africa

According to the Department of Trade and Industry, South Africa's manufacturing sector has a substantial direct employment creation potential and is central to the export strategy. The sector has labour intensive tradable productions that generate revenues that have a significant positive impact on the balance of trade. According to Manufacturing Circle, more than 440 000 shops were closed down between 2006 and 2011. This could be because in the early 2000s, South Africa opened the local markets to compete globally. According to IPAP 2015 this was in line with the World Trade Organisation rules.

The strong global competition from legitimate manufactures put local markets under pressure. Some manufacturers were forced to close down and people lost their jobs. IPAP, 2015 has also stated that South African manufacturers were also faced with cheap and illegal imports from Far East, as a result they were forced to close down their operations. Figure 2.5 shows a downward swing in the number of employment between 2004 and 2007. Manufacturing Circle has shown that more than 300 000 South African jobs were lost or exported to other countries since 2008 and most of them went to China. This is clearly indicated by a downward swing of the curve in figure 2.5

Figure 2.5 Trends of Manufacturing Employment from 1985-2014



Source: Quantec (Stats SA)

2.2.3 Policies that regulate South Africa's manufacturing sector.

The government of South Africa has since 1994 been trying to provide support to the manufacturing sector through various policy amendments and the development of new policies. There are a number of economic policies in South Africa but only a few are used in the manufacturing sector in relation to growth and development. The two main policies used in the manufacturing sector are Industrial Policy Action Plan (IPAP) and the New Growth Path.

2.2.3.1 Industrial Policy Action Plan (IPAP) 2015

Industrial Policy Action Plan (IPAP) 2015 is a special section on support for the black industrialist, which sets out the first practical steps towards realising government commitment to transformation and empowerment in the manufacturing sector (IPAP, 2015). The IPAP 2015/16 – 17/18 is the seventh annual Industrial Policy Action Plan. It sets out time-bound transversal and sector specific plans, lists lead and supporting departments and provides for continuous monitoring, evaluation and improvement of all the key interventions it makes to secure industrial development in South Africa (IPAP, 2015).

The Industrial Policy Action Plan is guided by the National Industrial Policy framework which aims to implement government approach to industrialisation through the following objectives:

- Increasing exports in key sectors such as mining, construction, labour-intensive manufacturing and agriculture.
- Infrastructure development to facilitate economic activity and job creation.
- Reducing the cost of regulatory compliance, especially for small- and medium-sized firms
- Developing a more comprehensive and effective innovation system.
- Stimulating a higher rate of industrial investment, with public sector investment crowding in private investment.
- A strong commitment to public and private procurement that supports domestic industry and job creation.

There are a number of programmes that have been set with a view to stimulate and promote growth and development in the manufacturing industry and include among others the following:

- Automotive Production and Development Programme (APDP)

This programme includes Regulatory amendments and implementation of the tariff regime, production incentives and volume assembly allowance elements of the APDP; and it ismore involved with the policies relating to production and development within the automotive manufacturing sector.

- Clothing, Textiles, Footwear and Leather Competitiveness Programme

This programme was established with the aim to allow the sector as a whole to compete effectively with foreign competitors, both in national and the foreign markets. The programme also helps improve competition among the local manufacturing companies.

- Furniture Sector Strategy

Furniture industry is facing constraints that are holding back development and affect its competitiveness. This programme was formed in order to deal with the constraints regarding skills transfer and the lack of appropriate institutional framework including the potential for clusters. The benefits of cluster formation include economies of scale, shared infrastructure, shared transport costs, sharing of information and reduced input costs.

- Skills development

This programme's main focus is to improve skills within the textile sector. The programme will involve the finalisation of funding agreements with the National Skills Fund (NSF). The strategy is implemented through the Textiles and Clothing Centre of Excellence.

2.2.3.2 The New Growth Path

The new growth path is a framework that was established in order to deal with issues that have to do with unemployment, inequality, and poverty, through strategy implementation relating to job creation. The objective of the new growth path is to create 5 million jobs by 2020 by attempting to restructure the South African economy, to improve performance in relation to labour intensive and an improved growth rate. The success of the new growth path depends on strategies to be implemented to improve local economies and established economic sectors as well as emerging economies with the view of creating more jobs.

The New Growth Path identifies key job drivers which are:

- Substantial public investment in infrastructure to create employment directly and indirectly by improving efficiency across the economy.
- The targeting of labour absorbing activities in the main economic sectors such as agriculture, mining value chains, manufacturing and services.
- Taking advantage of new opportunities in emerging economies, e.g. Green Economies
- Nurturing rural development and regional integration.

Efforts are prioritised in creating employment in the following key sectors:

The agricultural value chain, the mining value chain, the Green economy, Manufacturing sectors and Tourism and services.

2.3 *An overview of South Africa's electricity sector*

The government of South Africa established the Electricity Supply Commission (ESCOM) in 1923 using the Electricity Act of 1922. The company was also known by its Afrikaans name Elektristeits Voorsienings Kommissie (EVKOM). ESCOM and EVKOM were merged in 1986 and now the company is known as ESKOM (Conradie and Messerschmidt, 2010). According to the Department of Energy (DE), Eskom was converted into a public company on the 1st July 2002. Eskom does not have exclusive generation rights but it has a practical monopoly on bulk electricity.

Eskom forms part of the South African Power Pool. This power pool consists of a group of utilities in the region that aims to create a common market for electricity in the region. The South African Power Pool is made up of South Africa, Botswana, Lesotho, Mozambique, Namibia, Swaziland, Zambia and Zimbabwe (Eskom). According to Stats SA (2010) Eskom exports about 12000 gigawatt-hour of electricity to SADC countries participating in the power pool. South Africa also imports electricity from SADC countries. The country imports around 9000 gigawatt-hour on average per year, from the Cahora Bassa hydroelectric generation station in Mozambique through the 1000MV Cabora Bassa high voltage direct transmission system (Stats SA, 2010).

According to Eskom SA, South Africa has been having excess supply capacity until the mid-1990s. The situation changed after 1994 as more households started having access to electricity. Due to rising demand of electricity and inadequate investment in additional supply of electricity, South Africa started experiencing shortages in power supply. Because of these shortages, in 2008 the Department of Minerals and Energy (DME) together with Eskom jointly released a policy named National response to South Africa electricity shortages (DME). The plan of this policy was to increase power supply by re-opening three power stations that were closed in 1990 and open two new coal-fired power stations. In 2009, the electricity sector was further hit by the global economic crisis and experienced a further decrease in the supply of electricity.

Eskom operates 23 power stations with a total nominal capacity of 42 090MW. About 95 percent of electricity used in South Africa is generated by Eskom while approximately 45 percent of the electricity used in Africa is from Eskom. Eskom produces high voltages of electricity and supplies directly to large consumers such as mines, mineral beneficiaries and other large industries (Eskom).

2.3.1 South Africa's primary energy supply by source

According to the Department of Energy, 92.6 percent of electricity is coal fired, while the only nuclear station in the South Africa produces about 5.7 percent of electricity. Pumped electricity contributes 1.2 percent, hydroelectric 0.5 percent, while gas turbine contributes only 0.1 percent.

2.3.3.1Coal-Fired Power Stations

Coal is the main source of electricity supply in South Africa. According to the Department of Energy, coal is the most widely used primary fuel accounting for about 36 percent of the total fuel consumption of the world's electricity production. In South Africa 77 percent of energy needs are provided by coal. Most of coal-fired stations in South Africa have 6 generating units each of which has a boiler, a turbine that drives a generator as well as a control and auxiliary support system (Eskom Fact Sheets, 2014).

For electricity to be produced, combustion of fuel, a chemical conversion process which generates heat to turn water into steam at very high temperature and pressure. The heat energy contained in the steam drives the huge turbines, converting heat energy into rotating mechanical energy. Connected to a turbine shaft is a generator where electricity is produced.

2.3.3.1Conventional Hydroelectric Power Station

In conventional hydroelectric power stations, electricity is produced by converting the potential energy of water stored in the dam or river. This is done by conveying water through waterway to hydro turbines. The electricity produced is then transmitted to the electricity grid through the transmission lines (Eskom Fact Sheets). Electricity produced from conventional hydroelectricity stations is cheaper than that produced from coal. With the limited water resources and unpredictable rainfalls in South Africa it is not achievable to make greater use of conventional hydroelectric power stations. These stations are useful only during peak periods.

.3.3.2 Pumped Storage power Station

Pumped storage power schemes are used as substitutes for conventional hydroelectricity to provide electricity during peak periods. Under this system, the water is rather retained in the system for re-use than being discharged, as is done under hydroelectric power stations. Since there is a need to re-pump the water back after use, pump storage systems can only provide electricity for limited periods of time. The pumping costs of these systems make them more expensive to operate than conventional hydroelectric power stations (Eskom, 2014).

2.3.3.4Gas Turbines

In gas turbines stations electricity is generated through three primary units, the gas turbines, generator and control. Gas turbines have rapid run-up capability which makes them perfect for meeting relatively short peaks in load demand. They are also of beneficial use as standby plants to supplement reserve generating capacity on the nation system and can be used as synchronising condensers for voltage regulations. Gas turbines can also be used to re-energise the network due to their ability to restart without power from network (Eskom 2014).

2.3.3.5 Nuclear Energy Power Station

According to Eskom (2015) nuclear energy currently provides approximately 11% of the world's electricity needs. Koeberg Nuclear Power Station situated in the Western Cape is the only nuclear power station in South Africa providing 4.4 percent of South Africa's electricity needs. Under this system electricity is produced through the following process:

- Primary loop

This system takes heat away from the water and nuclear fuel in the reactor to the tubes in the steam generators. The water is then returned to the reactor by means of a pump. This system is closed and water from it does not come into direct contact with the secondary or tertiary loop.

- Secondary loop

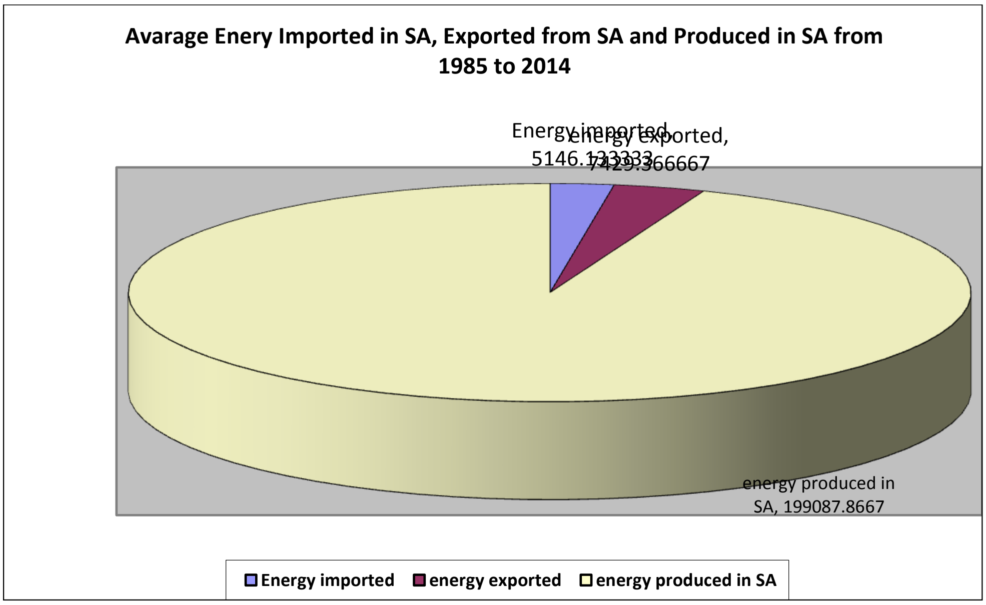
The secondary system is also closed. Water is pumped into the steam generator where it is allowed to boil and form steam, which drives one high-pressure turbine and three low-pressure turbines which in turn drive the generator. The generator produces 930 MW (sent out) of electricity. Once the steam has driven the turbines, it flows to the condensers where it is cooled back to water and circulated back to the steam generator.

- Tertiary loop

This system is used in the condensers. The cooling water system for the condensers uses seawater at the rate of 80 tons/sec to cool the steam in the two condensers, 40 tons/sec for each unit. Once it has cooled the steam it is returned to the sea.

Figure 2.6 shows that on average South Africa has been generating more electricity and exporting more to other countries than it is importing from 1985 to 2014.

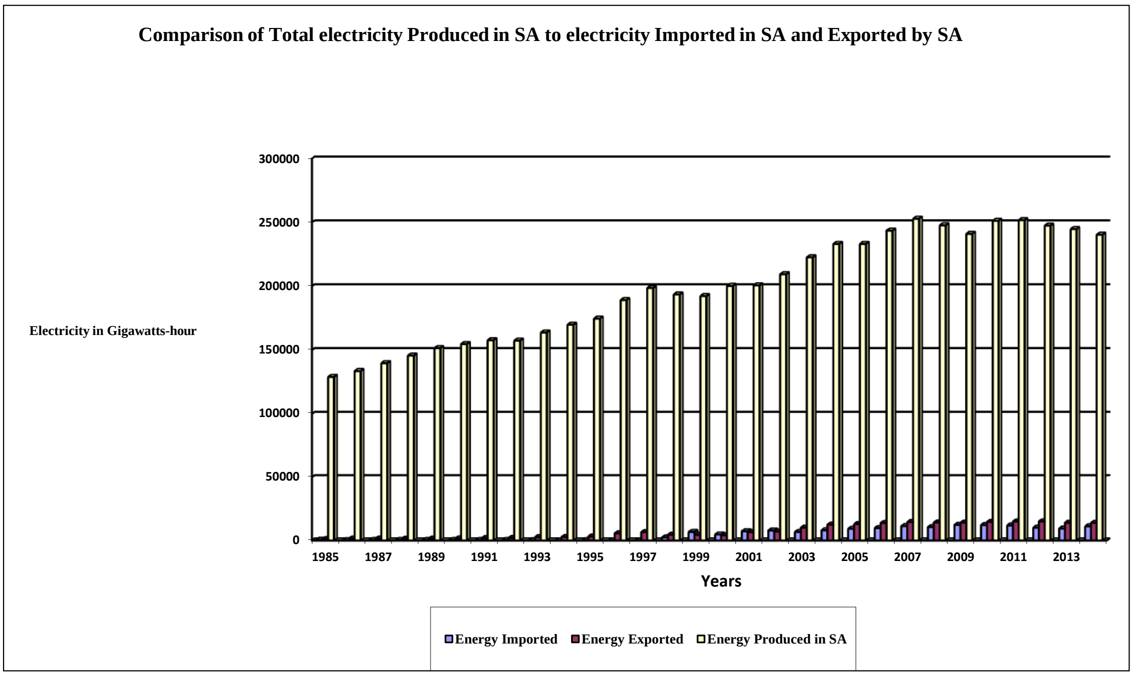
Figure 2.6 Average Energy Imported, Exported and Produced in South Africa



Source: Eskom

Figure 2.7 shows that from 1985, electricity produced in South Africa was increasing up until in 1992 when it went down a bit. In 1994 production went up and kept on increasing until in 1997. In 1998 and 1999 productions were lower but then increased in 2001 and reached its peak in 2007. South Africa started experiencing shortages of electricity at the beginning of 2008 which resulted in load shedding and some brownouts. During this time electricity demanded outstripped electricity supplied and the sector was forced to deliberately cut power supply in some areas so as to balance demand and supply. In 2009 South Africa was hit by the global financial crisis which affected almost all sectors including the electricity sector. Because of this crisis, we see a downward swing in the electricity produced. South Africa still continued exporting more electricity to the power pools members and imported less than what it was exporting. In South Africa the sector recovered from the financial crisis and in 2010 production improved until in 2011. From 2012, production declined until in 2014.

Figure 2.7 Comparison of total electricity produced in RSA to electricity imported in RSA and exported by RSA



Source: Quantec (Stats SA)

2.3.2 Policies that regulate South Africa's electricity sector

There are a few policies used to regulate the South African electricity sector and they include among others Electricity Regulation Act 2006 (Act No 4 of 2006) and the Nuclear Energy Act 1999 (Act No 46 of 1999).

2.3.2.1 Electricity Regulation Act 2006 (Act No 4 of 2006)

The Electricity Regulation Act 2006 was formed with a view to establish a national regulatory framework for the electricity supply industry. Through this Act the National Energy Regulator was made the custodian and enforcer of the electricity regulatory framework. The Act provides the guidelines for licences and registration and the manner on how generation, transmission distribution, trading and the import and export of electricity are regulated. According to the Government Gazette (2006) the Electricity Regulation Act has the following objectives:

- to succeed with efficient, effective, sustainable and orderly development andoperation of electricity supply infrastructure in South Africa;

- to ensure that the interests and needs of present and future electricity customers and end users are safeguarded and met with regard to the governance efficiency, effectiveness and long-term sustainability of the electricity supply industry within the broader context of economic energy regulation in the republic.
- to facilitate investment in the electricity supply industry;
- to facilitate universal access to electricity;
- to promote the use of diverse energy sources and energy efficiency;
- to promote competitiveness and customer and end user choice; and
- to facilitate a fair balance between the interests of customers and end users, licensees, investors in the electricity supply industry and the public.

The licensing of the electricity industry is done by the National Energy Regulator of South Africa (NERSA) through the use of the Electricity Regulation Act 2006 (Act No 4 of 2006). NERSA issues new licences, amends the existing licences, renews the existing licences and also withdraws licences (NERSA, 2007/2008).

2.3.2.2 Nuclear Energy Act 1999 (Act No 46 of 1999)

The Nuclear Energy Act 1999 (Act No 46 of 1999) is used to regulate the nuclear sector in South Africa. The Act is used together with National Nuclear Regulator (NRR) Act 1999 (Act 47 of 1999) and they are implemented by the Department of Energy**.**

2.4 Conclusion

The purpose of this chapter was to present an overview of South Africa's manufacturing sector and the electricity sector. The manufacturing sector was established in 1917 and managed to pull along the rest of the economy from1946 to 1980. This was mainly because manufacturing output outstripped GDP growth during those years. South Africa has developed an established, diversified manufacturing base that has shown its resilience and potential to compete in the global economy. Electricity has always been one of the determinants of manufactured output. South Africa has been having excess electricity supply capacity until in the mid-1990s. The situation changed after 1994 as more and more households started having access to electricity. Due to rising demand of electricity and inadequate investment in additional supply of electricity, South Africa started experiencing shortages in power supply.

CHAPTER 3

Literature Review

3.1 Introduction

The main purpose of this chapter is to discuss both theoretical and empirical literature on the issues surrounding electricity and manufacturing sector. The chapter is categorised into four sections. Following this introduction sub-section 3.2 discusses theoretical review while section 3.3 discusses the empirical literature on the impact of electricity on the manufacturing sector. Section 3.4 concludes the chapter.

3.2 Theoretical Review

This section discusses the production theories, namely; the Cobb-Douglas production function, Real Business Cycle Theory and the Constant Elasticity of Substitution (CES) production function..

3.2.1 Cobb-Douglas Production Function

Cobb-Douglas production function is one of the widely used production functions in presenting how two or more inputs (capital and labour) can be used to produce a certain amount of output. The function was introduced by Wicksteed (1894) and was put to test by Cobb and Douglas (1928) when modelling the growth of the American economy for the period 1899 to 1922. Cobb and Douglass (1928) wanted to find out the amount of labour and capital that are used to produce the volumes of goods and to determine the relationship between labour capital and product.

The authors were of a view that production output can best be measured by the amount of labour used and the capital investment. Capital and labour were found to be the key determinants of production output. Production was measured as the total monetary value of all goods produced in a year, labour as the total number of people per hours worked in a year and capital as the monetary value of all machinery, equipment and buildings.

The function used by Cobb and Douglas (1928) was modelled as follows:

$$Y^{t} = AL^{\alpha}K^{\beta} \quad \text{...}(3.1)$$

Where *Y* represented total production, *K* was capital and *L* was labour. *A* represented the level of technology while α and β represented the ratios of capital and labour to total output .*A*, α and β are positive constants. The assumption was that α <1 and $\beta < 1$so that the firm has decreasing marginal product of labour and capital. According to the function, if $\alpha + \beta = 1$, the firm has constant returns to scale meaning that if K and L are each increased by for example 10%; P will also increase by 10%.

Cobb-Douglas production function was made under the following assumptions:

- Y^l represent actual production Y
- Y^l approaches zero as either labour or capital approaches zero.
- The marginal productivity of labour is proportional to the amount of production per unit of labour
- The marginal productivity of capital is proportional to the amount of production per unit of capital.

When performing the mathematical analysis, Cobb and Douglas (1928) presented their function as:

$$Y = bL^{\alpha} K^{1-\alpha} \qquad (3.2)$$

Where b is independent of labour and capital while α is constant.

When formulating this function, the assumptions were that capital values grew from year to year as the money value of goods produced, and that the physical volume of production is proportional production due to manufacturing alone.

Cobb-Douglas production function was made under the assumption that production output vanishes as either labour or capital vanishes. In real terms, a decrease in labour does not necessarily mean production will decrease as that decrease may be due to machinery that has been found to produce more goods than when done by people. It has also been assumed that if either labour or capital is doubled, production output will also double. This could not be the case in real world. Capital may be doubled but not result in a double increase in output. There are other factors like electricity which is required for continuous operation of the machines. Because electricity supply is not consistent, load-shedding and brownouts may lead to insufficient use of this machines and as a result production output may not be as much as it was expected.

The second assumption of the Cobb-Douglas production function is that the ratios of labour and capital to total output are constant. This assumption does not hold, mainly because labour and capital can be substituted for each other in the production of one good. There are goods that require more labour than machinery while others need more machinery than labour.

Because of the rapid change in technology, firms use advanced machines and equipment which are operated by two or three people for the production of their goods resulting in less labour required.

3.2.2 Constant Elasticity of Substitution (CES) production function

Solow (1956) introduced the constant elasticity of substitution (CES) production function and was later made popular by Arrow, Chenery, Minhas and Solow (1961). Under the CES production function, production technology is characterised by constant percentage change in factors of production (labour and capital) due to a percentage change in marginal rate of substitution. Two or more inputs are combined into an aggregate quantity. According to Gujarati and Porter (2009) the CES production function can be modelled as follows:

$$P_r = A\left[\delta K_r^{-\beta} + (1-\delta)L_r^{-\beta}\right]^{-1/\beta} \qquad (3.4)$$

Where P=output, K=capital input, L=labour input, A=scale parameter, δ=distribution parameter $(0 \le \delta \le 1)$ and β=substitution parameter $(\beta \ge -1)$.

The CES function has similar properties as Cobb-Douglas production function. The CES function is standardised of degree one and just like Cobb-Douglas it displays constant returns to scale.. If L and K are substitutable (infinity) for each other an increase in K will require less of L for a given productivity. As a consequent, the MP of L will increase. Thus the MP of an input will increase when the other input is increased.

The CES production function considers only two inputs. When used to explain the production of the firm, it cannot be used to explain aggregate production function of all firms in the industry.

3.2.3 Real Business Cycle (RBC) Theory

Real business cycle theory was developed by a group of researchers in the 1980s. Kydland and Prescott (1982) were the first authors to contribute to RBC theory followed by Long and Plosser (1983). It was further expanded by Mankiw (1989). The main objective of these authors was to explain the business cycle by fluctuations in the rate of technological progress (Gujarati and Porter, 2009). In the basic version of RBC theory, the impulse initiating the business cycle is a shock to productivity which is propagated through the economy via its impact on capital accumulation and the resulting effect on productive capacity. According to this view, the employment fluctuations found during business cycle reflect voluntary movements along individual labour supply curves. This occurs when workers choose to enter the labour market or to work extra hours when real wages are unusually high due to a high level of productivity. On the other hand it could happen where labour supply is reduced when productivity and real wages are unusually low relative to their underlying growth trends.

The real business cycle theory is modelled as:

$$P_t = K_t^{\alpha}(A_t L_t)^{1-\alpha}, \ldots\ldots\ldots 0 < \alpha < 1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.3)$$

Where P is total output, K is the capital stock at the start of the period t, L is total labour input during that period measured in hours worked and the parameter. At captures labour-augmenting technical progress increasing the productivity of labour over time.

As the term indicates, the RBC model is indeed real and contains no nominal values. The model can only be used to simulate fluctuations in the cyclical components of output and labour input. The RBC theory has a problem explaining the observed fluctuations in aggregate employment as the outcome of intertemporal substitution in labour. The theory assumes that workers voluntarily choose to work less when real wages are relatively low and vice versa. In real terms, not everyone will work less when real wages are low, some employees may choose to be more productive with the hope that they will get promotions or increase in wages.

3.3 Empirical Literature

Empirical literature on electricity and manufacturing sector is categorised as follows: 3.3.1 focus on empirical literature from developing countries, 3.3.2 on empirical literature from developed countries, 3.3.3 empirical literature on grouped countries, 3.3.4 empirical literature on studies that used questionnaires as an estimation technique and lastly 3.3.5 empirical literature on studies which focused in South Africa.

3.3.1 Empirical literature from developing countries

Among studies which conducted a research on the relationship between electricity supply and manufacturing output, is a study that was done by Yakubu, Manu and Bala (2015). The study examined the relationship between electricity supply and manufacturing output in Nigeria and employed autoregressive distributed lag (ARDL) as a research technique. Annual time series data covering the period 1971 to 2010 was used. A long run relationship between the variables was observed. Manufacturing output was found to be possibly depending on electricity supply both in the short run and long run but only significant in the long run.

Still in Nigeria, Mojekwu and Iwuji (2012) conducted a study examining the impact of some macroeconomic variables and power supply on the performance of the manufacturing sector using the ex-post facto design method. A time series data analysis was carried out from 1981 to 2009 using ordinary least square OLS multiple regression technique. The results obtained revealed that power supply had a positive and significant impact on capacity utilisation while inflation and interest rates had negative impact on capacity utilisation.

The study done by Yakubu et al (2015) is more related to this study except for the methodology that was used. The results obtained are favourably comparable to the literature. In terms of methodology, Yakubu et al (2015) employed ARDL model while this study is going to use cointegrated VAR. ARDL model is said to be more efficient for small samples or limited observations especially in developing countries. Nigeria is a developing country but the sample size that was used by Yakub et al (2015) is not small (1971-2010) which makes the ARDL model to be unfit for their study. There exists a gap in terms of methodology used by Yakub et al (2015), and therefore this study seeks to close this gap by using cointegrated vector autoregressive (VAR) model.

Allcott, Collard-Wexler and O`Conell (2015) conducted a study estimating the effect of electricity shortages on Indian manufacturing using Cobb-Douglas production function model. A time series data from1992 to 2010 on weather, power sector and manufacturing production was used.

The results obtained revealed that power shortages slowed down production in the manufacturing sector. This resulted in revenue reduction of 5.6 to 8.6 percent for the average plant in a short run. The results have also shown that producer's surplus dropped 9.5 percent for the average plant, of which 3.9 percent was due to capital costs incurred for backup generators. It was also discovered that in the short run plants reduced their inputs in response to electricity shortages and that led to a decrease in total production.

Alkott, Collard-Wexler and O`Conell (2015) focused on the shortage of electricity and how it affects manufactured output while this study focuses on how electricity supply affect manufactured output.

In Pakistan, Tang and Shahbaz (2013) conducted a study to assess the causal relationship between electricity consumption and real output at the aggregate and sectoral levels. The study focused mainly on agriculture sector, manufacturing sector and service sector. Johansen and Juselius cointegration test as well as Granger causality test were used to determine the order of integration. The study used annual time series data from 1972 to 2010. Cointegration was observed both at aggregate and sectoral level. A unidirectional causality running from electricity consumption to real output was found at aggregate level while at sectoral level electricity consumption granger causes real output in the manufacturing sector. In agricultural sector, there was no evidence of causality between electricity consumption and real output.

Still in Pakistan, Qazi, Ahmed and Mudassar (2012) used Johansen cointegration approach based on VAR to conduct a study on the relationship between disaggregate energy consumption and industrial output. The study covered the period 1972 to 2010. There were three results obtained from the analysis. The results showed a positive long run relationship between disaggregate energy consumption and industrial output. Bidirectional causality was observed running from oil consumption to industrial output. On the other hand, evidence of a unidirectional causality was observed running from electricity consumption to industrial output. Unidirectional causality was also found from industrial output to coal consumption. However no causality was observed between gas consumption and industrial output. In the short run, bidirectional causality was found between industrial output and oil. Still in the short run, there was evidence of unidirectional causality from electricity consumption to industrial output.

Even though Qazi et al (2015), used the same methodology as the one that is used in this study (VAR), the focus was on how electricity consumption affect industrial output and this study focus on the supply of electricity and how it affects output.

In another study, Husain and Lean (2015) used a demand function to investigate the relationship between electricity consumption, output and price in the Malaysian manufacturing sector. The study employed annual time series data and covered the period 1978 to 2011. In the long run, electricity consumption, output and price were found to be cointegrated. Evidence of a positive relationship was found between electricity consumption and manufactured output. A long run, a unidirectional relationship from manufacturing output to electricity consumption was also obtained. Results obtained for the short run showed a unidirectional relationship running from electricity consumption to output. This indicates that in the short run, a decrease of energy usage in production might lead to a reduction in output growth.

Soytas and Sari (2007) conducted a research in which they investigated the relationship between energy and production with evidence from Turkey manufacturing sector. A multivariate framework was used in examining electricity consumption and value added relation while also taking into account labour and fixed investment. Annual time series data from 1968 to 2002 was employed. A three cointegration vector was obtained between the variables showing evidence of a long run relationship among the variables. . Evidence of a unidirectional causality running from electricity consumption to manufacturing value added was found. The study also discovered manufacturing output positively responded to positive shocks electricity consumption through the use of generalised impulse response and variance decomposition.

In all the studies that have been discussed, a positive relationship between electricity and manufactured output was observed though the focus was more on the consumption side of electricity.

3.3.2 Empirical literature from developed countries

Among studies which focused on the relationship between electricity and output in the manufacturing sector is a study that was done by Sari, Ewing and Soytas (2008). Using autoregressive distribution lag (ARDL) approach, Sari et al (2008) examined the relationship between aggregate energy consumption and industrial output in the United States. Employment was used as one of the variables. Monthly data covering the period from January 2001 to June 2006 was employed in the study. The main results of the study showed evidence of a positive long run relationship between industrial production and energy consumption while a negative impact was only found on solar energy. In the short-run, analyses revealed that the results obtained were found to be consistent with the long run findings and statistically significant between employment, industrial production and energy sources except for gas.

Sari et al (2008) used monthly data which gave a lot of observations, but used ARDL model which is more efficient in small samples or limited observations. Focus was still on electricity consumption and industrial output which present a gap that this study wants to feel by focusing on electricity supply and its impact on manufactured output.

Fisher-Vanden, Mansur and Wang (2015) conducted a study on electricity shortages and firm productivity with evidence from China's industrial firms. The study applied econometric techniques to an unbalanced panel of firm level data consisting of approximately 23000 of the most energy consuming firms in China covering the period from 1999 to 2004.For this study, it was discovered that firms in regions with greater shortages decreased factor share of electricity and increased shares of materials. No evidence was found on an increase of self-generation of electricity. From 1999 to 2004, firm costs rose by eight percent and was primarily due to input factor substitution.

In another study, Sun and Anwar (2015) used a tri-variate vector autoregressive framework that includes entrepreneurship to examine the relationship between electricity consumption and industrial production in Singapore's manufacturing sector. Using monthly data, the study was done starting from January 1983 to February 2014. Evidence of cointegration among the variables was observed meaning that a long run relationship exists between electricity consumption, manufactured output and entrepreneurship in Singapore. It was also observed that entrepreneurship granger causes electricity consumption which causes industrial production. Sun and Anwar (2015) employed the autoregressive distributed lag (ARLD) testing approach to confirm the results obtained from the Johansen cointegration approach.

Bernstein and Madlener (2015) used a cointegrated VAR approach to estimate electricity demand elasticities for eight subsectors of the German manufacturing sector. The study used annual data covering the period 1970 to 2007. In this study, a long run relationship was found in five of the eight subsectors namely food and tobacco, pulp and paper, chemicals, non-metallic minerals and transport equipment sectors. Tests on granger causality revealed evidence for the feedback hypothesis in food and tobacco and pulp and paper industries. As for chemicals, non-metallic minerals and transport equipment sectors the conservation hypothesis was observed. In the short run, the elasticity estimates were found to be economically reasonable in terms of the sign and magnitude. The impulse response function was applied in this study to trace out the dynamic behaviour of electricity demand in response to shocks in other variables. A plausible behaviour was observed as electricity demand responded positively to shocks in value added and negatively to electricity prices.

3.3.3 Empirical Literature from grouped countries

Among studies which focused on the impact of electricity on manufacturing sector is a study that was conducted by Scott, Darko, Lemma and Rud (2014). Scott et al (2014) examined how electricity insecurities affect businesses in low and middle income countries. The main aim was to assess and quantify the impact of electricity insecurities on firm productivity and competitiveness and how it affects their investment decisions for start-up and expansion. Data was sourced from the World Bank Enterprise Survey and the countries involved were Bangladesh, Nepal, Nigeria, Pakistan, Tanzania and Uganda. The results obtained by Scott et al (2014) revealed that electricity insecurity negatively affect total factor productivity and labour productivity of manufacturing SMEs. However this was not the case in all manufacturing SMEs as some had higher productivity. Variations in the findings between countries is associated with differences in geography, structure of the economy and business environment.

Moyo (2013) conducted a study on which the impact of the quality of power infrastructure on productivity in African manufacturing firms was examined. Data was sourced from the World Bank enterprise surveys covering the period 2002-2005. Five Sub-Saharan African countries namely South Africa, Zambia, Uganda, Mauritius and Tanzania were used in this study. The firms were drawn from six International Standards Industrial Classification (ISI) industries in 28 towns and cities. Moyo (2013) employed the Cobb-Douglas production function to measure plant level total factor productivity (TFP) while estimates were done using Ordinary Least Square methods. Power infrastructure quality was measured by using the number of hours per day without electricity and the percentage of output lost due to outages. A cross-sectional model was estimated and the study also accounted for individual country and sector heterogeneity by using country and sector dummies.

The results obtained showed that the impact of power outages on productivity differed from one country or sector to another depending on the experiences on electricity problems that each country had. A high number of hours without electricity as well as high percentages of output lost due to power disruptions were expected to negatively affect productivity. Negative and significant results were obtained in Uganda, Zambia and Tanzania as well as in the food and agricultural sector implying that poor quality infrastructure negatively affect productivity in these countries.

Miketa and Mulder (2005) conducted a study analysing energy-productivity convergence across 56 developed and developing countries and 10 manufacturing sectors. Under developing countries, 24 countries were drawn from OECD countries of North America, the Pacific and Western Europe while under developing countries 32 countries were drawn from non-OCED countries. The manufacturing sectors involved were selected using the International Standards Industrial Classification (ISI). The period of the study was from 1971 to 1995. Miketa and Mulder (2005) employed a cross-country method. The study calculated average annual growth rates of energy productivity and conducted a convergence analysis in order to examine patterns of international energy productivity developments at sectoral level. Energy production was measured as output per final energy use. The results obtained revealed that cross-country differences in energy tend to decline more especially with the less energy-intensive sectors except for the non-ferrous metal sector. Energy productivity growth was found to be higher in all manufacturing sectors particularly in countries that initially lagged behind in terms of energy productivity levels. Evidence of countries converging to different steady states was observed while several others failed to catch-up.

3.3.4 Empirical literature from studies that used questionnaires as a research technique

Using a three-interval Likert scale, Braimah and Amponsah (2012) conducted a study examining the causes and effects of the unannounced electricity blackout on the operations of micro and small scale industries (MSI) in Kumasi, Ghana. The data used was sourced from a sample of 320 MSI in 3 industrial clusters from Kumasi metropolis. The results obtained showed a 5.3 % deficit in the quantity electricity required for continuous operations of the MSI. The deficit was caused by frequent and unannounced blackouts which were estimated to last for an average of 10.3 hours per month. Due to blackouts, about 44% of the MSI spent that duration in redundancy as they did not have backup or alternative sources of electricity but had to maintain the same labour cost. On the other hand, the remaining 56% of the SMI incurred more costs as they used alternative power sources which needed an average of GH15 per month to operate.

Wijayatunga and Jayalath (2008) conducted a study examining the economic impact of the quality of electricity delivered to the industrial installations in Bangladesh. The study covered a period from 2001 to 2003 using a questionnaire that was developed in association with all the stake holders. The questionnaire was given to 208 industry installations through personal visits so as to have an adequate number of installations in the final analysis. The number was then reduced to 188 after eliminating unreliable and inaccurate records. The study included analysing power supply interruptions and their economic impact on a sample of industrial consumers. An estimation of self-generation costs and environmental impact was also performed. When analysing the results, (Wijayatunga & Jayalath, 2008) discovered that the industrial losses attributable to unplanned electric power interruptions averaged 0.83US$/kWh while there were only 0.34US$/kWh for planned outages. It was also discovered that 94 percent of the total energy not served resulting inform interruptions was due to unplanned outages while only 6 percent could be attributable to planned outages. Due to these interruptions, approximately 13.6 percent of the industrial sector demand could not be met by these utilities which had a significant effect in the economy of Bangladesh.

Ketelhodt and Wocke (2008) did a study on the impact of electricity crisis on the consumption behaviour of small and medium enterprises in Cape Town, South Africa. The study used a Likert type questionnaire which was developed from the literature review. The questionnaire was randomly given to 2900 out of 4000 SME's who were members of the Cape Town Chamber of Commerce. Only 250 responses were received which makes 9percent of the response rate. According to Harzing (1997) the 9 percent response rate falls within the acceptable range of mail survey. The findings of the study revealed that most businesses were seriously affected by the electricity crisis and reported loss of production as they could not trade. 89 percent of the SME heavily depend on a stable supply of electricity and as a result electricity interruption lead to lower production.

Another study which used a questionnaire survey is a study that was done by Adenikinju (2003) examining the cost of electricity shortages on the Nigerian Manufacturing sector. The analysis was based on data that was obtained from a nationwide survey conducted in 1998. The paper outlined the various costs from power outages and examined the response of manufacturers to the infrastructure problem. The results showed a high impact of electricity failures costs on the manufacturing sector. The costs were due to expensive back-up systems put in place to minimise the expected outage costs. The costs on average were about 3 times the costs of publicly supplied electricity.

Braimah and Amponsah (2012) Ketelhodt and Wocke (2008), Wajiyatunga and Jayalath (2008) and Adenikinju (2003) used questionnaires as their research technique which could give biased results. There is a research gap with regard to the methodology that was used by the authors. According to Ackroyd and Hughes (1981) the process of coding in the case of an open ended questionnaire brings a great possibility of subjectivity by the researcher. The authors argued that there is no way to tell how truthful a respondent is being. Ackroyd and Hughes (1981) also pointed out that there is a level of researcher imposition. The argument is that when formulating the questionnaire, the researchers make their own decisions and assumptions as to what is and what is not important which may result in important things left out. This study therefore seeks to feel this methodology gap by employing cointegrated VAR.

3.3.5 Empirical literature from studies which focused on South Africa

Little or no studies have been done on the impact of electricity supply on the manufacturing sector output in South Africa and only a few were done on electricity consumption and industrial production/economic growth. Studies which focused in South Africa include among othersBoqiang, Presrly and Wesser (2014), Odhiambo (2009), Ziramba (2009) and Ketelhodt and Wocke (2008).

Boqiang, Presrly and Wesser (2014) conducted a study on energy consumption and economic growth in South Africa. The study investigated claims concerning Granger causality relationship from energy consumption to economic growth in South Africa. Boqiang et al

(2014) adopted nonparametric bootstrap method to reassess evidence supporting Granger causality and unravel finding of long-run unidirectional causality running from energy consumption to economic growth. The study covered the period from 1970 to 2010. The results for the analysis of electricity consumption and economic growth in South Africa showed evidence of a unidirectional short-run and long-run Granger causality running from electricity consumption to economic growth in all tests periods. The long-run estimates reinforced the granger causality tests by showing that energy consumption positively correlated with economic I the long-run.

Boqiang et al (2014) were mainly interested in finding out how electricity consumption affects economic growth rather than manufactured output. Engle-Granger causality was also used. The difference between this study and Boqiang et al (2014) is in terms of methodology and targeted variables and as a result this study will feel this gap. Another study which focused in South Africa was conducted by Odhiambo (2009), examining the causal relationship between electricity consumption and economic growth. For this study, a dynamic Granger Causality test was used to examine the direction of causality between electricity consumption and economic growth in South Africa. The study used annual time series data covering the period 1970 to 2006.The results obtained showed a short-run causality from electricity consumption to economic growth. The findings also revealed a positive long-run relationship between electricity consumption and economic growth as supported by the coefficient of the lagged error-correction term which was negative and statistically significant.

In another study, Ziramba (2009) employed a cointegration analysis to assess the relationship between disaggregated energy consumption and industrial output in South Africa. The study used annual time series covering the period 1980 to 2005. Ziramba (2009) applied Toda H.Y Yamamoto T (1995) Statistical Inference in vector autoregression. Employment was used as one of the variables to allow for substitution possibilities between energy use and labour. The results obtained in this study revealed that both industrial production and employment have a long run relationship with electricity consumption. Bidirectional causality was found between oil consumption and industrial production. In other forms of energy consumption, there was evidence in support of energy neutrality hypothesis.

As opposed to Odhiambo (2009) and Boqiang et al (2014),Ziramba (2009) focused on electricity consumption and industrial output rather than economic growth. The results have also shown to be favourably comparable to literature.

Ketelhodt and Wocke (2008) did a study on the impact of electricity crisis on the consumption behaviour of small and medium enterprises in Cape Town, South Africa. The study used a Likert type questionnaire which was developed from the literature review. The questionnaire was randomly given to 2900 out of 4000 SME's who were members of the Cape Town Chamber of Commerce. Only 250 responses were received which makes 9 percent of the response rate. According to Harzing (1997) the 9 percent response rate falls within the acceptable range of mail survey. The findings of the study revealed that most businesses were seriously affected by the electricity crisis and reported loss of production as they could not trade. The results also showed that 89 percent of the SME heavily depend on a stable supply of electricity and as a result electricity interruption lead to lower production.

The empirical literature on studies which focused on South Africa poses a research gap in terms of methodology used, and their main focus was on electricity consumption and industry output and or GDP. This study therefore seeks to close this gap by using cointegrated VAR and focus on the supply side of electricity and how it affects the manufactured output.

3.4 Conclusion

The study discussed some of production theories including the Cobb-Douglas production function, Real Business Cycle Theory and the Constant Elasticity of Substitution (CES) production function. In addition to these theories, a number of studies on electricity and manufactured output were reviewed. Although most of these studies focused on electricity consumption, most of the results obtained revealed positive relationship between electricity and manufactured output. The researchers used different estimation techniques ranging from VAR, ARDL and Engle-Granger while some carried out surveys.

Chapter 4

Research Methodology

4.1 Introduction

Chapter 3 of this study sheds some light on the relationship between electricity supply and manufacturing output. This chapter specifies the model and the estimation technique used to determine the impact of electricity supply on South Africa's manufacturing sector's output. The chapter also identifies the data to be used in the models. The chapter is divided into six sections. Following this introduction is section 4.2 which develops a model that links electricity supply and manufacturing output. Data follows in section 4.3 while a research method is covered in section 4.4.Review of the estimation of procedures follows in section 4.5. Section 4.6 concludes the chapter.

4.2 Model Specification

To determine the impact of electricity supply on manufacturing sector in South Africa, the study adopts and modifies the multivariate framework that was used by Ziramba (2009). Industry production was modelled as a function of disaggregated electricity consumption and manufacturing employment. Ziramba (2009) included employment in a framework to allow for substitution possibilities between energy use and labour. This study substitutes disaggregated energy consumption with electricity supply and includes manufacturing employment and other variables (interest rate and inflation rate) in the model. Interest rate and inflation rate are included in the model so as to avoid under fitting a model or omitting relevant variables which according to Gujarati and Porter (2009) may result in biased results. Manufactured output (in million Rands) is modelled as a function of interest rate, manufacturing employment, inflation rate and electricity supply. The model used in this study is based on the Cobb Douglas Production Function as modified by Ziramba (2009). The common link between the model used in this study and the theoretical review is that labour is included as one of the explanatory variables. The empirical model can be specified by the model below:

$$MO_t = f(\overset{-/+}{INT}, \overset{+}{\mathrm{ME}}, \overset{-/+}{CPI_t}\ \overset{+}{ES}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where Mo = Manufactured output in million rands

INT = Real interest rate

ME = Manufacturing employment

CPI = Inflation rate

ES = Electricity supply in gigawatts-hour

The effect of electricity supply and manufacturing employment on manufacturing output is expected to be positive. However, as for real interest rate and inflation rate it is an empirical question. In a linear form, equation 1 can be presented as:

$$MO_t = \alpha + \beta_1 INT_t + \beta_2 ME_t + \beta_3 CPI_t + \beta_4 ES_t + \mu_t \text{ ……………………………….. (2)}$$

Where $\alpha =$ Intercept

$\beta s =$ Slope coefficients

$\mu =$ Error term

All the variables are converted to logarithms except for real interest rate and inflation rate, as they are already in percentages. This is done to obtain elasticity coefficients on the variables and minimising the impact of outliers. However, for INT and CPI the βs won't be elastic. The model is thus of the form:

$$\ln MO_t = \alpha + \beta_1 \ln ME_t + \beta_2 INT_t + \beta_3 CPI_t + \beta_4 \ln ES_t + \mu_t \text{ …………………………….. (3)}$$

Where:

lnMO is a logarithm of manufacturing output in million rands

lnME is a logarithm of manufacturing employment in million people

lnES is a logarithm of electricity production from all producers in South Africa in gigawatts-hour

According to Hossain (2008) the target variable is placed last in the ordering so that its impact on the dependent variable can be observed when performing the General Impulse response Function (GIRF). The variables that are not caused by other variables in the model are placed first in the list of ordering.

4.3 Data type and sources

The data used in this study is obtained from Eskom, Stats SA and World Bank under Quantec website. The study uses annual time series data covering the period 1985 to 2014 depending on the availability of data on the variables. The data is based on five variables namely; manufactured output, manufacturing employment, real interest rate, inflation rate and lastly electricity supply.

4.4 Estimation Technique

This study uses Cointegrated Vector Autoregression (CVAR) as an estimation technique. According to Gujarati and Porter (2009), the term autoregressive is due to the appearance of the lagged value of the dependent variable on the right-hand side, and the term vector is due to the fact that one is dealing with a vector of two or more variables. VAR methodology appears to be similar to simultaneous equation modelling where several endogenous variables are considered together. Each endogenous variable is explained by its lagged or past values and the lagged values of all other endogenous variables in the model. Usually there are no exogenous variables in the model. According to Sims (1980) if there is a true simultaneity among a set of variables, they should all be treated on an equal footing; there should not be any priori distinction between endogenous and exogenous variables. VAR model is one of the most successful and easy to use for the analysis of the multivariate time series.

In this study Augmented Dickey-Fuller (ADF), Philip-Perron and KPSS unit root or stationarity tests are implemented to examine whether the variables are stationarity or non-stationarity and test their order of integration. After testing for stationarity in the variables, the next step would be to test cointegration. According to Granger (1987), cointegration can be thought of as a pre-test to avoid spurious regression situations. Cointegration means that despite being individually non stationary, a linear combination of two or more time series can be stationary. If the variables are stationary, the system cannot be modelled using variables in levels and a simple F-statistics will be sufficient to test the causal relationship between electricity supply and manufacturing output.

If cointegration is established amongst the variables the vector error correction model (VECM) will be used instead of VAR. The diagnostic tests will then be performed to assist in checking the appropriateness of the VAR model and they include heteroskedasticity, residual normality test and autocorrelation LM test among others. Finally the Generalized Impulse Response Function (GIRF) and the variance decomposition will be performed to check the robustness on the cointegration results.

4.5 Steps followed in the CVAR Technique

Section 4.5 discusses the steps that will be followed in finding out the impact of electricity supply on manufacturing sector's output in South Africa through the use of VECM technique.

Different techniques are available for parameter estimation, and they range from classical regression to cointegration based techniques. The traditional regression models assume that all variables to included are stationary and that the errors have mean zero and constant variance. Most economic time series are non-stationary which brings a concern in standard regression models.

4.5.1 Unit root/Testing for stationarity

Over the years researchers have been using unit root test to test for stationarity and non-stationarity in variables. Brooks (2008) defines a stationary series as one with a constant mean, constant variance and constant autocovariance for each given lag. The stationarity or otherwise of a series can strongly influence its behaviour and properties. With evidence of unit roots, the series must be differenced *d* times before it becomes stationary. The series are said to be integrated of order *d*and will be written as I (*d*). Applying the difference operator more than *d* times to an I (*d*) will result in a stationary series. A time series is said to be stationary if it does not change over time. A stationary series is signified as I (0) while an I (1) contains 1 unit root. Differencing a time series twice to induce stationarity is denoted as I (2), meaning that the series has two unit roots.

A time series which is not stationary is said to be non-stationary (Gujarati and Porter, 2009). The mean and variance of a non-stationary series do not fluctuate around zero. Evidence of non-stationary variables can result in spurious regressions. In order to avoid the spurious regression problem that may arise from regressing a non-stationary series, the non-stationary series have to be transformed from non-stationary to stationary. The transformation method depends on whether the time series are difference stationary (DSP) or trend stationary (TSP). If a time series is non-stationary it must be differenced k times until it becomes stationary, and it will be said to be integrated of order k. Before performing any tests, all the variables must be tested for unit root and after that, estimating the parameters and testing for cointegration will follow. This study uses the Augmented Dickey-Fuller (ADF) test, Phillips-Perron (PP) test and the Kwiatkowski-Phillips-Schmidt-Shin KPSS test to test for stationarity.

4.5.1.1 Augmented Dickey-Fuller Test (ADF)

According to Brooks (2008) the early and pioneering work on testing for a unit root in a time series was done by Dickey and Fuller (Fuller, 1976; Dickey and Fuller, 1979).Dickey and Fuller (1979) established a test known as the Augmented Dicky- Fuller (ADF) Test. This test is performed by augmenting the test by adding the lagged values of the dependent variable. The model can be written as

$$\Delta y_t = \beta_1 + \beta_2 + \delta y_{t-1} + \sum_{i-1}^{m} \alpha_i \Delta y_{t-i} + \varepsilon_t \text{..4}$$

where ε_t is a pure white nose error term and where $\Delta y_{t-1} = (y_{t-1} - y_{t-2}), \Delta y_{t-2} = (y_{t-2} - y_{t-3})$ ………………………………………..(5)

The number of lagged difference terms to include is often determined empirically, the idea being to include enough terms so that the error term in the equation is serially uncorrelated of δ which is the coefficient of Y_{t-1}.

The null hypothesis of a unit root is rejected in a case where the T statistics is more negative than the critical value, in other words when the T statistics is smaller than the critical value. We fail to reject the hypothesis when the T statistics is greater than the critical value.

4.5.1.2 Phillips-Perron (PP) test

Phillips and Perron (1988) developed a more comprehensive theory of unit root non-stationarity. Phillips-Perron test is similar to the ADF test and is the modification and generalisation of the DF procedures to allow for autocorrelated residuals. The PP test considers less restriction on the distribution of the disturbance term. Phillips and Perron use nonparametric statistical methods to take care of the serial correlation in the error terms without adding lagged difference terms. The test often gives similar conclusions and suffers from most of the same limitations as the ADF test.

The Augmented Dicky-Fuller test and Phillips-Perron test have both been criticized on their low power. According to Gujarati and Porter (2009) these two tests tend to accept the null of the unit root more frequently than is warranted. That is, these tests may find a unit root even when there is none. There are several reasons for this. First the power depends on the time span of the data more than the mere size of the sample. For a given sample size *n*, the power is greater when the span is large. These types of tests assume a single unit root; that is, they assume that the given time series is I (1) but if a time series is integrated of order higher than 1, I(2) there will be more than one unit root.

4.5.1.3 Kwiatkowski-Phillips-Schmidt-Shin (KPSS)Test

With the critics on the ADF and PP tests, this study finds it fit to include a third unit root test using the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) Test. The Kwiatkowski-Phillips-Schmidt-Shin is also used to test for stationarity in the time series. ADF and PP test use the null hypothesis of non stationarity in variables while under KPSS the null hypothesis is that the variables are stationary. The results of the KPSS test will be compared with those obtained from the ADF and the PP procedure to see if the same conclusion is obtained.

The null and alternative hypotheses under each testing approach are presented as follows:

ADF/PP	**KPSS**
$H_{0:}y_t \sim I\ (1)$	H_0: $y_t \sim I\ (0)$
H_1: $y_t \sim I\ (0)$	H_1: $y_t \sim I\ (1)$

There are four possible outcomes:

(1) Reject $H_0$and Do not reject H_0

(2) Do not Reject $H_0$and Reject H_0

(3) Reject $H_0$and Reject H_0

(4) Do not reject $H_0$and Do not reject H_0

For the conclusions to be robust, the results should fall under outcomes 1 or 2, which would be the case when both tests concluded that the series is stationary or non-stationary, respectively. Outcomes 3 or 4 imply conflicting results. The joint use of stationarity and unit root tests is known as confirmatory data analysis.

4.5.2 Cointegration

Granger (1969) introduced the concept of cointegration and was later extended by Engle-Granger (1986) and Johansen (1988, 1991 and 1995). Cointegration test is applied mainly to determine whether the variables in the model are cointegrating or not. According to Gujarati and Porter (2009), variables are cointegrated if there exists a long term or equilibrium relationship between them. Cointegration deals with the relationship among a group of variables where unconditionally each has a unit root. In most cases, if two variables that are I (1) are linearly combined, the combination will also be I (1), (Brooks, 2008). A number of methods for testing cointegration have been proposed in the literature and include Engle-Granger, Engle Yoo and Johansen among others. The Engle-Granger approach is based on residuals while the Johansen technique is based on the maximum likelihood estimation on a VAR system. Most of the available techniques have problems when applied to multivariate models. These problems can be normalised by using a technique known as Vector Autoregressive (VAR).

This study is going to use the cointegrated vector autoregressive (CVAR) based cointegration test using Johansen (1991, 1995).

4.5.2.1 Johansen Technique Based on VARS

The Johansen technique is one of the techniques that provide estimates of all cointegrating relationships that may exist within a vector of non-stationary variables or a mixture of stationary or non-stationary variables. The Johansen setup allows the testing of the hypothesis about the equilibrium relationships between the variables. The Johansen technique allows for the existence of more than one cointegrating vectors and can help to eliminate simultaneous equation bias as opposed to single equation methods. There are two test statistics for cointegration under the Johansen approach which are formulated as:

$$\lambda_{trace}(r) = -T\sum_{i=r+1}^{g}\ln(1-\lambda_i) \quad \text{..} (6)$$

$$\lambda_{\max}(r, r+1) = -T\ln(1-\lambda_{r+1}) \text{..}(7)$$

Where r is the number of cointegrating vectors under the null hypothesis and λ is the estimated value of the *i*th ordered eigenvalue from the Π matrix. Intuitively, the larger is the λ the more large and negative will be in (1-λ) and hence, the larger the test statistic. Each eigenvalue will have associated with it a different cointegrating vector which will be eigenvectors. A significantly non-zero eigenvalue indicates a significant cointegration vector.

λ_{trace} is a joint test where the null is that the number of cointegrating vectors is less than or equal to r against an unspecified or general alternative that there are more than r. it starts with p eigenvalues and then successively the largest is removed. The λ_{trace} =0 when all λ=0 for

i=1…..g. λ_{max} conducts separate tests on each eigenvalue and has its null hypothesis that the number of cointegrating vectors is r against an alternative of r+1.

When conducting Johansen procedure the following steps are followed:

- Examining the order of integration

The order of integration must be examined in all the variables. When all the variables are integrated of the same order then we can proceed with the cointegration test.

- Setting the appropriate lag length of the model

Estimate the model and determine the rank of the II. The lag structure tests assist in determining the appropriate lags for the VAR.

- Choosing of the appropriate model regarding the deterministic components in the multivariate system.

Analyse the normalised cointegrating vectors and speed of adjustment coefficients.

- Determine the number of cointegrating vectors

Apply causality test on the error correction model to identify a structural model and establish whether the estimated model is reasonable.

Supposing that we have a set of g variables (g≥2) and that the variables are I(1) and thought to be cointegrated, a VAR with k lags containing these variables could be set up as

$$y_t = \beta_1 y_{t-1} + \beta_2 y_{t-2} + ... + \beta_k y_k + \mu_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(8)$$

In order to use the Johansen test, the VAR needs to be turned into a vector error correction model (VECM) of the form

$$\Delta y_t = \Pi y_{t-k} + \Gamma_1 \Delta y_{t-2} + \Gamma_2 \Delta y_{t-2} + ... + \Gamma_{k-1} \Delta y_{t-(k-1)} + \mu_t \ldots\ldots\ldots\ldots\ldots\ldots(9)$$

Where $\Pi = (\sum_{i=1}^{k} \beta_i) - Ig$ and $\Gamma_i = (\sum_{j-1}^{i} \beta_j) - Ig$

This VAR contains g variables in first differenced form on the HLS and k-1 lags of the dependent variable (differences) on the RHS each with a Γ coefficient matrix attached to it.

The Johansen test can be affected by the lag length used in the VECM and as a result it is useful to try to select the lag length optimally. The Johansen test centres on an examination of theπ matrix. Πcan be interpreted as a long run coefficient matrix.

4.5.3 Vector Error Correction Model (VECM)

When a unit root exists in the series, the best approach is to use the standard Johansen test and model a VECM. In this context the parameters of interest will have standard distributions. If the variables are I (1) and there is no cointegration using Johansen method, then the VAR in differences imposes the appropriate restrictions, that there are *n* different trends in the system. If the variables are I (1) and there is at least one cointegrating vector, then, we need to construct a VECM and do structural analysis in the context of VECM. If the variables are stationary then we can specify the VAR in levels and perform structural analysis.

The vector error correction model (VECM) is a restricted VAR inverted for use with non-stationary series that are known to be cointegrated. It limits the long run behaviour of the endogenous variables to come together to their cointegrating relationships while permitting for short run adjustment dynamics. It is vital because it is an appropriate model measuring the correction from disequilibrium of previous periods. When the two variables are cointegrated, it means that there is some adjustment process, which prevents the errors in the long run relationship becoming larger.

If cointegration has been detected between the series it means that there exists a long-run equilibrium between them and as a result VECM is applied to evaluate the short-run properties of the cointegrated series. In VECM the cointegration rank shows the number of cointegrating vectors. A negative and significant coefficient of the ECM indicates that any short-run fluctuations between the will give rise to a stable long run relationship between them.

4.5.4 Diagnostic Tests

After estimating VAR it is necessary to perform various diagnostic tests. The diagnostic tests help in checking the appropriateness of the estimated VAR and they include residual normality test ,heteroskedasticity and autocorrelation LM test among others. These multivariate extensions of the residuals will be implemented in this study and as a result they are briefly discussed below.

4.5.4.1 Residual Normality Test

There is a number of normality tests discussed in the literature. This study discusses the histogram of residuals and Jarque-Bera (JB) test.

4.5.4.1.1 Histogram of Residuals

According to Gujarati and Porter (2009) a histogram of residuals is a simple graphic device that is used to learn something about the shape of the probability density function (PDF) of a random variable. On the horizontal axis of a histogram, the values of the variable of interest are divided into suitable intervals. In each class interval we erect rectangles equal in height to the number of observations in that class of intervals. If one mentally superimposes the bell shaped normal distribution curve on the histogram, one will get some ideas as to whether normal PDF approximation may be appropriate. For a normally distributed variable, the skewness (a measure of symmetry) should be zero and the kurtosis (which measures how tall or squatty the normal distribution is) should be three. It is always good practice to plot the histogram of residuals from any regression as a rough and ready method of testing for the normality assumption.

4.5.4.1.2 Jarque-Bera Test of Normality

The JB test of normality is an asymptotic or large sample test. It is also based on the OLS residuals. This test computes the skweness and the kurtosis measures of the OLS residuals and uses the following test statistic:

$$JB = n[\frac{S^2}{6} + \frac{(k-3)^2}{24}] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(10)$$

Where n is sample size, S is skweness coefficient and K is kurtosis coefficient. For a normally distributed variable S=0 and K=3. Therefore, the JB test of normality is a test of the joint hypothesis that S and K are 0 and 3 respectively. In that case the value of the JB statistic is expected to be zero. The probability value of the JB should be more than five percent for variables to be normally distributed. If it is less than five percent it means that the variables are not normally distributed.

For the purpose of this study, the Jarque-Bera normality test is used to test whether the variables are normally distributed.

4.5.4.2 Heteroskedasticity Test

White (1980) is one of the most used formal tests for the heteroskedasticity. The test is particularly useful because it makes few assumptions about the likely form of the heteroskedasticity. The test regression is run by regressing each cross product of the residuals on the cross product of the regressions and testing the joint significance of the regression. The No Cross Terms option employs only the levels and squares of the original regressors while the With Cross Terms option involves all non-redundant cross product of the original regressors in the test equation. Using of OLS with the presence of heteroskedasticity may result in wrong standard errors and hence any inferences made could be misleading.

4.5.4.3 Autocorrelation LM Test

The autocorrelation L M test reveals the multivariate LM statistics for residuals serial correlation up to specified order. The test statistics for lag order is computed by running an auxiliary regression of the residualsμ, on the original on the right hand regressors and the lagged residuals $\mu_{t-h}$where the missing first values of u are filled with zeros.

4.5.5 Generalized Impulse Response Function (GIRF)

Impulse responses trace out the responsiveness of the dependent variables in the VAR to shocks from each variable. For each of the variables from each equation separately, a unit shock is applied to the error and the effects upon the VAR system over time are noted. If there are g variables in a system, a total of g^2 impulse responses could be generated. In practice this is done by expressing the VAR model as a vector moving average model (VMA) (Brooks, 2008).

4.5.6 Variance Decomposition

Variance decompositions provide the proportion of the movements in the dependent variables that are due to their own shocks, versus shocks to the other variables. Under variance decomposition, a shock to the *i*th variable will directly affect that variable, but it will also be transmitted to all of the other variables in the system through the dynamic structure of the VAR. Variance decompositions determine how much of the *s*-step-ahead forecast error variance of a given variable is explained by innovations to each explanatory variables (Brooks, 2008).

To some extent, impulse response and variance decomposition offer very similar information and suffer the same critics. According to Runkle (1987) both impulse responses and variance decompositions are notoriously difficult to interpret accurately. Runkle (1987) argues that confidence bands around impulse responses and variance decompositions should always be constructed. The author further states that the confidence intervals are typically so wide that sharp inferences are impossible.

4.6 Conclusion

The chapter specified the model that is used to determine the impact of electricity supply on South Africa manufacturing sector output. The variables which are used in the tests are manufacturing output, manufacturing employment, real interest rate, inflation rate and electricity supply. The model uses the Augmented Dickey-Fuller test, Phillips-Perron test and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test for unit root. Johansen (1991, 1995) cointegration technique based on VAR is employed in this study to determine the long-run relationship between manufacturing output and its explanatory variables. Diagnostictests will be done to test whether the residuals are normally distributed, have no heteroskedasticity and are not serial correlated.

Chapter 5

Empirical Results of Electricity Supply and Manufacturing Sector Output

5.1 Introduction

The purpose of this chapter is to provide answers to questions which were raised in chapter one of this study. The questions are as follows: How does electricity supply affect total output in South Africa`s manufacturing sector? Can manufacturing output be enhanced by increasing electricity supply? The results of the unit root tests and the graphical analysis for the variables used in the model are presented in this chapter. In order to establish the long run relationship among the variables, Johansen (1991, 1995) cointegration test is conducted. This is followed by the estimation of the vector error correction model, diagnostic tests, impulse response and lastly variance decomposition. The next section of this chapter presents the findings while the last section concludes the chapter.

5.2 Empirical Findings

This section is divided into five categories. The first category presents the results of stationarity/unit root test. The second category presents and discusses the results of the cointegration test, while the third category looks at the long run relationship between the manufacturing sector output and its explanatory variables. This is then followed by diagnostic tests, impulse response and variance decomposition in the last category.

5.2.1. Unit root/stationarity test results

As specified in chapter four of the study, the first step in the procedure is to test whether the time series are stationary. Augmented Dickey-Fuller (ADF) test, Phillips-Perron (PP) test and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test are used to find the order of integration. These tests show how many times a variable needs to be differenced to become stationary. The null hypothesis of the unit root is rejected if the test statistic is more negative than the critical value. This will mean that the series do not have a unit root.

Table 5.1 Unit root/stationarity test results

Variables	Model	ADF		PP		KPSS	
		LEVELS	DIFFERENCES	LEVELS	DIFFERENCES	LEVELS	DIFFERENCES
lnMo	Intercept	0.005	-3.779^{abc}	-0.119	-3.779^{abc}	0.676***	0.168
	Trend & intercept	1.748	-3.626^{bc}	-1.929	-3.626^{bc}	0.098***	0.157***
lnInt	Intercept	-2.184	-6.784^{abc}	-2.28	-7.073^{abc}	0.183	0.168
	Trend & intercept	-2.135	-6.892^{abc}	-2.24	-10.324^{abc}	0.169***	0.193
lnMe	Intercept	-1.940	-3.957^{abc}	-1.916	-3.944^{abc}	0.631***	0.190
	Trend & intercept	-2.197	-4.090^{bc}	-1.664	-3.943^{bc}	0.123	0.091
lnCPI	Intercept	-1.254	-3.506^{bc}	-1.586	-3.504^{bc}	0.312	0.085
	Trend & intercept	-1.566	-3.445^{bc}	-2.044	-3.351^{c}	0.129	0.089
lnEs	Intercept	2.739	0.037	-0.819	-6.626^{abc}	0.685***	0.166
	Trend & intercept	-0.505	-1.306	-3.948^{bc}	-7.345^{abc}	0.197***	0.120

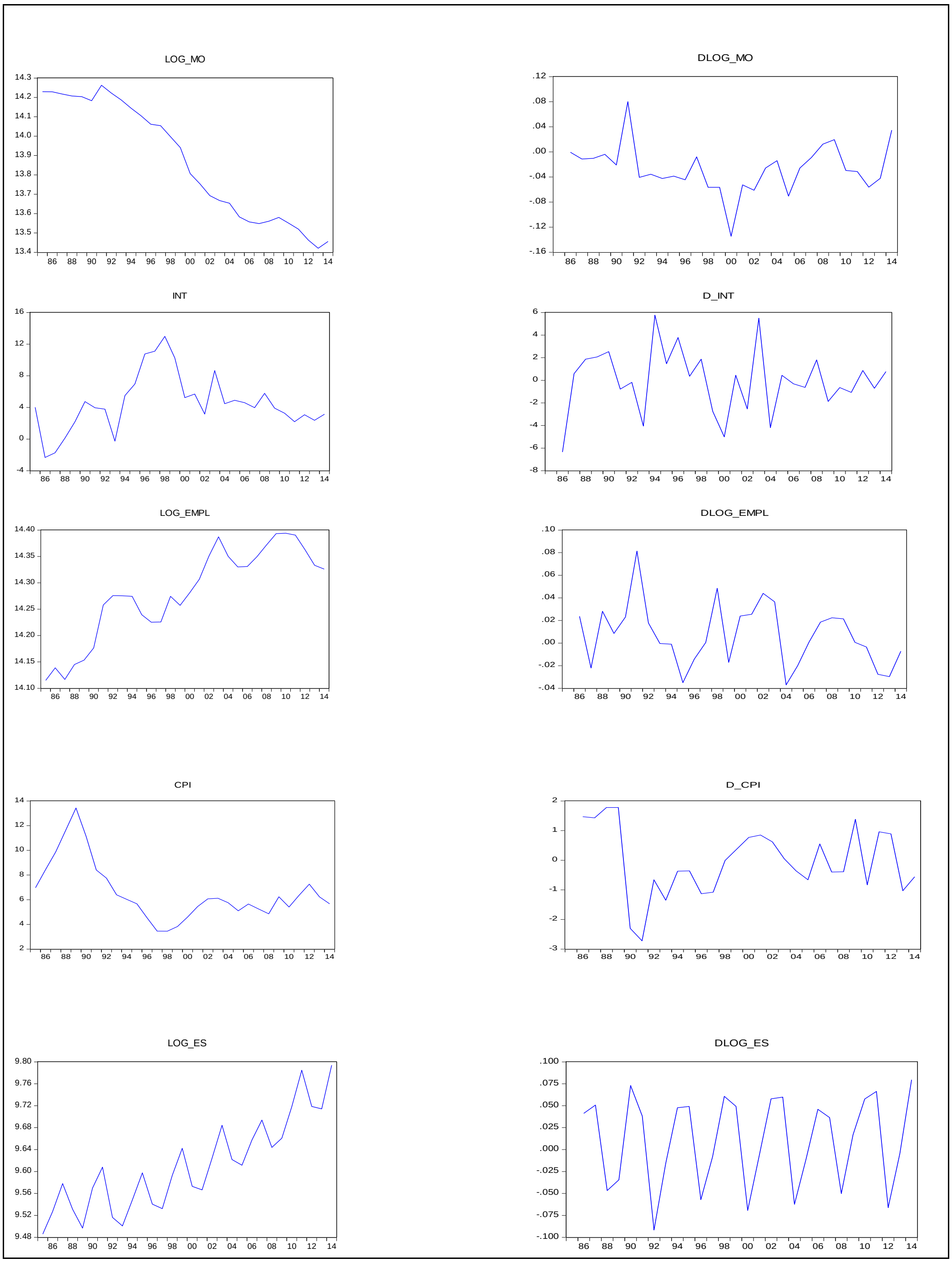
a, b, cdenotes stationarity of variables at 1%, 5% and 10% respectively
*** denotes rejection of the null hypothesis of stationarity at 5%
ln represents logarithms of variables

The unit root/stationary tests presented in table 5.1 show that the variables are I (1). They are non-stationary in levels but become stationary after being differenced once except for lnEs, which is not stationary at first difference under ADF test. Under Phillips-Perron and KPSS tests, lnEs became stationary after being differenced once.

Under KPSS test, variables are I(1) which means that the study rejects the null hypothesis that the variables are I(0) except for lnCPI which is I(0).

The results from the ADF, PP and KPSS tests are more in line with those from the graphical analysis. Figure 5.1 shows that all the variables have a time variant mean and variance which means that they are not stationary. None of the graphs (on the left) fluctuate around a zero mean in levels. After being differenced once, the variables become stationary as they fluctuate around the zero mean indicating stationarity as shown by graphs on the right. It is therefore necessary to conclude that all the series are first difference stationary I (1), which means that the variables are integrated of the same order, so we move forward to cointegration test.

Figure 5.1 Plots of manufacturing output and its explanatory variables



5.2.2. Lag length selection

Before testing for cointegration, it is very important to choose the lag length to be used when performing the tests. The lag length used in VECM can have an impact on the Johansen test and as a result it is necessary to try to select the lag length optimally. Table 5.2 below shows that one lag can be used as selected by Schwarz Information Criterion while Final Prediction Error, Akaike Information Criterion and Human-Quinn Information selected two lags. For this study, one lag was chosen because the use of two lags gave results which made no sense.

Table 5.2 Lag length selection

Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	-30.10064	NA	8.44e-06	2.507189	2.745082	2.579915
1	79.37664	172.035	2.09e-08	-3.526903	-2.099541*	-3.090544
2	115.7917	44.2186	1.12e-08	-4.342263	-1.725432	-3.542272

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

5.2.3. Johansen Cointegration test results

After finding out that all the variables are stationary and integrated of the same order, cointegration test follows. This test is done in order to determine whether the variables have a long run relationship among themselves. Cointegration shows the existence of an equilibrium or stationarity relationship between two or more time series which are individually non-stationary. There are conditions to be met for variables to be cointegrated and they are as follows: the variables should be cointegrated of the same order and the linear combinations of the variables from the regression of the non-stationary variables must be stationary.

If the null hypothesis of at most zero cointegrating relation is rejected in favour of at most one cointegrating relationship, it means in the next step the null hypothesis of at most one cointegrating relationship is tested against the alternative of at most two cointegrating relationships. We fail to reject the null hypothesis when the test statistics is smaller than the critical values for both the trace and maximum eigenvalue tests.

The cointegration test was done at lag length one, and the deterministic trend assumption of the test was (allow for linear deterministic trend in data) at trend 4, Intercept and trend in CE-no intercept in VAR. Table 5.3 A and B show the results of the cointegration test with one lag length.

Table 5.3(A) Trace Test Cointegration

	Trace Test			
Hypothesized No of CE(s)	Eigenvalue	Trace test	0.05 critical value	Probability
None *	0.924	150.395	88.803	0.000
At most 1*	0.787	78.385	63.876	0.002
At most 2	0.528	35.054	42.915	0.242
At most 3	0.281	14.029	25.872	0.655
At most 4	0.157	4.793	12.5179	0.626

Trace test indicate 2 cointegrating eng(s) at the 0.05 level
*denotes rejection of the hypothesis at 0.05 level

Table 5.3(B) Max-Eigenvalue Test Cointegartion

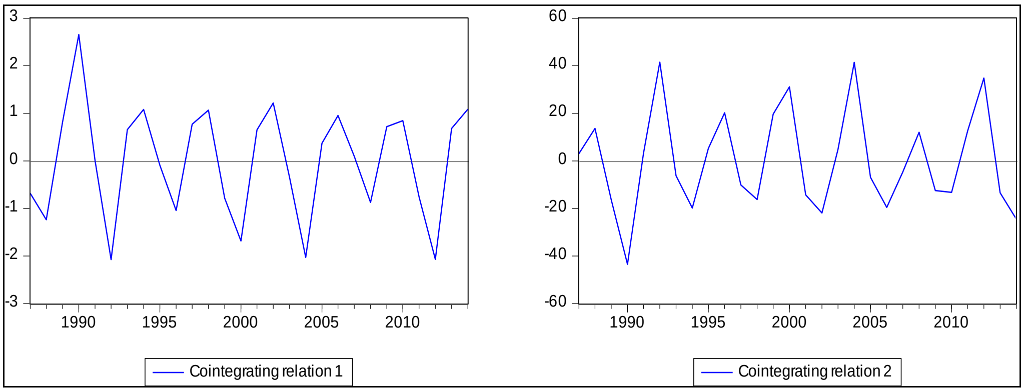
	Max-Eigen			
Hypothesized No of CE(s)	Eigenvalue	Max-Eigen statistics	0.05 critical value	Probability
None *	0.924	72.010	38.331	0.000
At most 1*	0.787	43.331	32.118	0.001
At most 2	0.528	21.025	25.823	0.189
At most 3	0.281	9.236	19.387	0.699
At most 4	0.157	4.793	12.518	0.626

Max-Eigenvalue test indicate 2 cointegrating eng(s) at the 0.05 level
*denotes rejection of the hypothesis at 0.05 level

Table 5.3 A and B show that the results for both the Trace and Maximum Eigenvalue tests reject the null hypothesis in favour of at least two cointegration vectors. These results are significant at 5 percent level. It could therefore be concluded that there are two cointegrating relationships in this model. In this test, a long-run relationship has been established between manufacturing output and its explanatory variables. The short-run and long-run dynamics of the model can be established in a vector error correction model.

The results of cointegration tests can be proved by plotting the graphs of cointegration vectors as presented in figure 5.2.The results of the first cointegrating vector (manufactured output equation) are of great importance as the focus of this study is on manufactured output. Cointegration graphs in figure 5.2 show stationarity in residuals as in both graphs they fluctuate around the zero mean.

Figure 5.2 Cointegration Graphs



5.2.4. Vector Error Correction Mode results

Since the existence of the long run relationship was established between manufacturing output, interest rate, manufacturing employment, inflation rate and electricity supply, the next step is to establish the short-run and long-run relationship dynamics using the Vector Error Correction Model. VECM restricts the long run behaviour of the endogenous variables to converge to their cointegrating relationships while permitting for short run adjustment dynamics. VECM is necessary because it is an appropriate model in measuring the correction from disequilibrium of previous periods. A negative and significant coefficient of the VECM indicates that any short-run fluctuations between the variables will give rise to a stable long run relationship between them.

Table 5.4 presents the long-run causality between variables used in the study. Cointegrating equation 1, present the long run relationship between manufactured output and the explanatory variables (lnCPI, lnME and lnES) while cointegration equation 2 presents the long run relationship between lnINT and lnCPI, lnME and lnES. The coefficients with negative numbers indicate a positive long run relationship between the dependant variable and its explanatory variables. Under cointegration equation 1, a positive long run relationship is revealed between manufactured output and manufacturing employment and electricity supply. As for inflation rate the relationship is negative. The results imply that electricity supply and manufacturing employment play a role in bringing manufactured output to equilibrium, while inflation rate on the other hand, does not play any role in bringing manufactured output to equilibrium. The second cointegration vector shows how real interest rate relates to other variables. Even though cointegration equation 2 is not of great concern in this study, manufacturing employment and electricity supply were found to have a negative relationship with real interest rate while inflation rate has a positive long run relationship with real interest rate.

The significant error correction term between zero and negative two indicates a stable long run equilibrium. In this study, the error term is -0.135010, which implies that cointegration relationship is stable. The speed of adjustment is 13.5 percent. This is a speed at which manufacturing output returns to equilibrium after a shock in independent variables like electricity supply. It shows that 13.5 percent of the gap between manufactured output and its equilibrium value is eliminated in the short run.

VECM was conducted at one lag length order with two cointegrating vectorsand the deterministic trend assumption of the test was (allow for linear deterministic trend in data) at trend 4, Intercept and trend in CE-no intercept in VAR. the results are shown in table 5.4.

Table 5.4 Vector Error Correction Model Results

Cointegarating Equations	Cointegartion Equation 1	Cointegration Equation 2			
Log_MO(-1)	1.000	0.000			
Int(-1)	0.000	1.000			
Log_Empl(-1)	-7.719 (1.815) [-4.253]	190.798 (34.429) [5.542]			
CPI (-1)	0.287 (0.034) [8.503]	-3.786 (0.639) [-5. 917]			
Log_ES	-29.636 (2.0145) [-14.709]	513.285 (38.215) [13.432]			
@Trend(85)	0.3797 (0.026) [14.491]	-6.434 (0.497) [-12.948]			
C	373.409	-7537.648			
Error correction model	**Δ(Log_Mo)**	**Δ(INT)**	**Δ(Log_Empl)**	**Δ(CPI)**	**Δ(Log_Es)**
Cointegration Equation 1	-0.135 (0.036) [-3.776]	-2.406 (3.421) [-0.703]	-0.009 (1.173) [-0.250]	-3.715 (1.173) [-3.166]	0.042 (0.036) [1.161]
Cointegrating Equation 2	-0.008 (0.002) [-4.279]	-0.196 (0.188) [-1.038]	-0.001 (0.003) [-0.666]	-0.184 (0.065) [-2.853]	-0.001 (0.002) [-0.349]

Standard errors() and t-statistics in []

5.2.5. Diagnostic tests results

To assess if the model used in this study reasonably fit the data, the diagnostic tests were performed and they include testing for normality, heteroscedasticity and serial correlation. Conducting diagnostic tests is very crucial in the analysis since it reveals whether there exists a problem in the estimation of a model or not. If a problem is detected it means that the model is not efficient and this can also mean that the results are biased.

For this study, the diagnostic tests carried out showed that the model is reasonably well specified. As indicated in table 5.5, the residuals are normally distributed with a joint probability of the Jarque-Bera at 94.96 percent. The residuals are not serially correlated as indicated by LM-Stat probability of 74.29 percent. It has also been observed that there is no heteroskedasticity as shown by a joint Chi-sq probability of 76.54 percent.

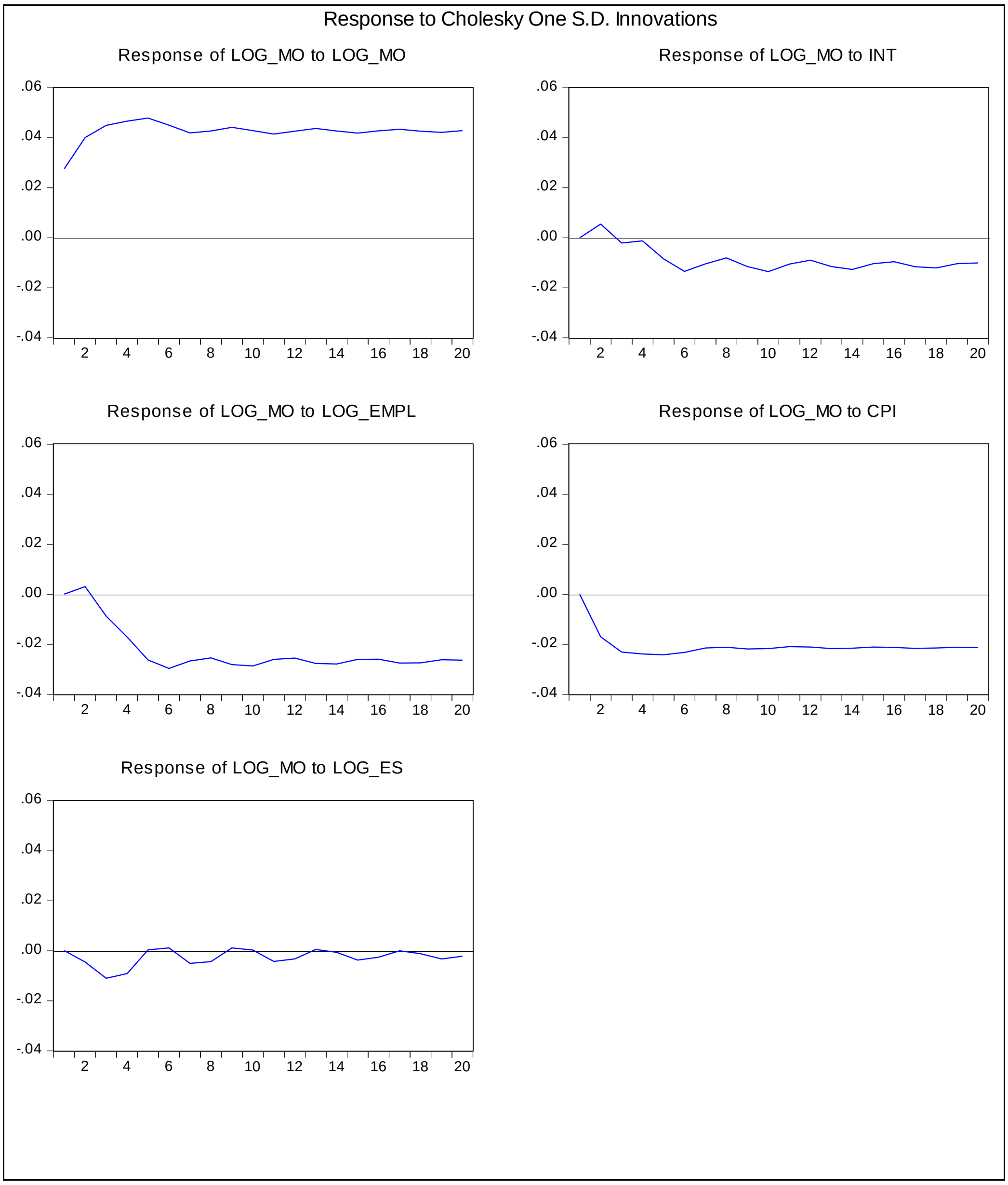
Table 5.5 Diagnostic tests

Test	Null Hypothesis	t-statistics	Probability
Jarque-Bera (JB)	There is a normal distribution	3.949	0.950
Langrage Multiplier (LM)	No serial correlation	20.075	0.743
White (CH-sq)	No conditional heteroskedesticity	194.878	0.7654

5.2.6. General Impulse response Function (GIRF) results

The impulse response functions trace the time paths of the effect of structural shocks on manufacturing output in response to a unit shock to its explanatory variables. Impulse response identifies the responsiveness of the dependent variables (endogenousvariable) in the VAR when a shock is put to the error term. Figure 5.3 shows that manufacturing sector output responds positively to its own shocks and negative to shocks in interest rate, inflation rate and manufacturing employment. As for shocks in electricity supply, there is evidence of positive and negative reactions. The response of manufactured output to the variable of interest (electricity supply) is almost in line with the theory and for other variables (interest rate and inflation rate) the results are in accordance with theoretical prediction. The negative response of manufactured output to shocks in manufacturing employment contradicts the predictions of the theory.

Figure 5.3 Plots of General Impulse response Function (GIRF) results



5.2.7 Variance Decomposition test results

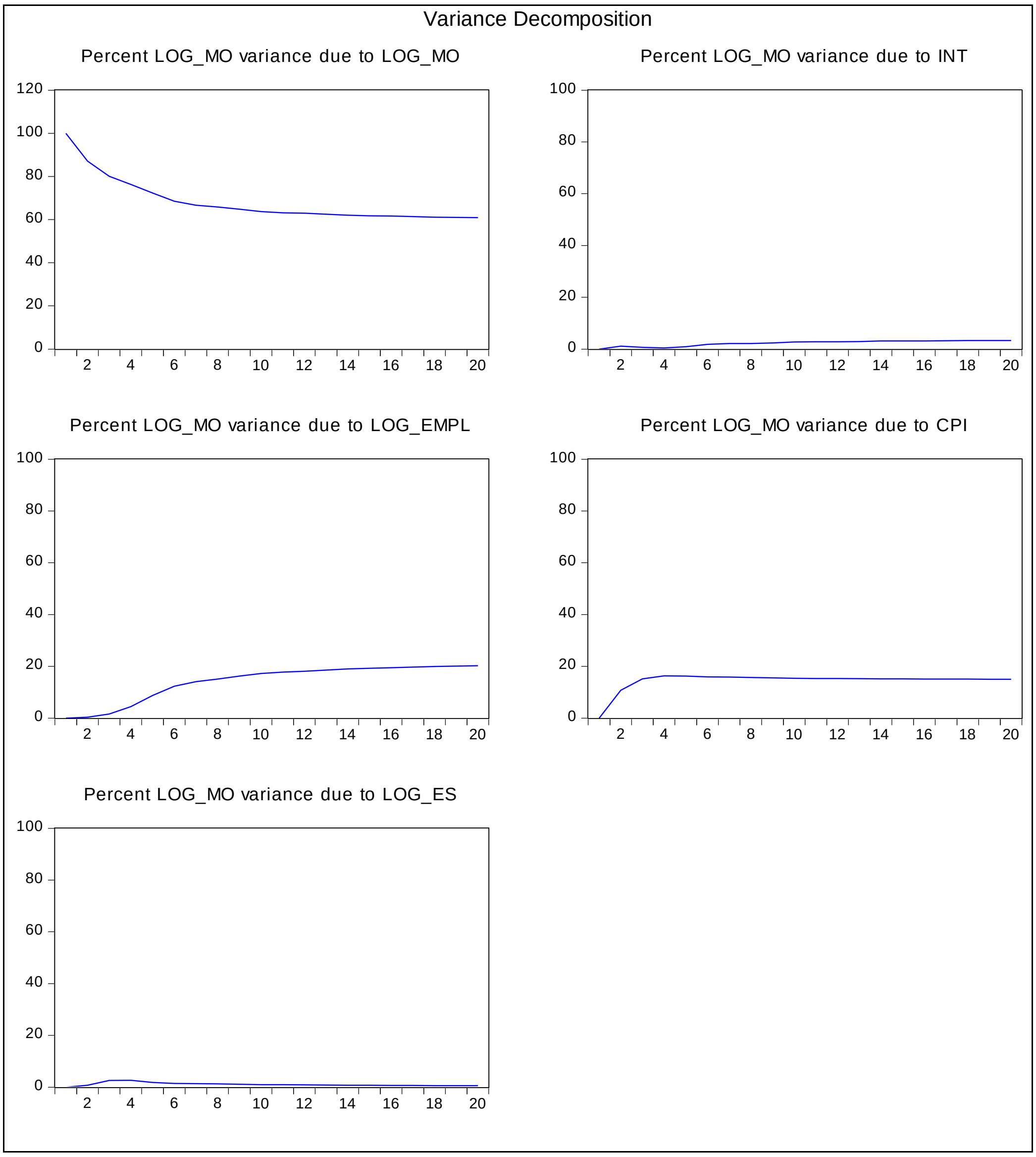
Table 5.6Variance Decomposition of LOG_MO:

Period	S.E	LOG_MO	INT	LOG_EMPL	CPI	LOG_ES
1	0.027503	100.0000	0.000000	0.000000	0.000000	0.000000
2	0.052039	87.07472	1.097827	0.344869	10.73364	0.748939
3	0.073905	80.07526	0.624474	1.582848	15.11929	2.598133
4	0.092650	76.26453	0.416596	4.400110	16.28655	2.632213
5	0.110543	72.29633	0.875632	8.733304	16.24463	1.850113
6	0.125880	68.50458	1.816825	12.28599	15.95751	1.435094
7	0.137520	66.66739	2.105404	14.06513	15.82469	1.337385
8	0.148036	65.84303	2.115351	15.09837	15.70096	1.242291
9	0.158964	64.80949	2.360623	16.23092	15.51638	1.082579
10	0.169064	63.70430	2.731128	17.23129	15.37586	0.957427
11	0.177620	63.15611	2.826948	17.76607	15.32472	0.926147
12	0.185883	62.91540	2.814951	18.11238	15.27997	0.877298
13	0.194501	62.50086	2.925507	18.56586	15.20591	0.801862
14	0.202615	62.02116	3.086719	19.00177	15.15037	0.739977
15	0.209876	61.77504	3.121491	19.25189	15.12958	0.721995
16	0.217033	61.64984	3.115304	19.43885	15.10639	0.689609
17	0.224383	61.41428	3.181319	19.69244	15.06678	0.645178
18	0.231354	61.15174	3.265757	19.93483	15.03796	0.609714
19	0.237801	61.01353	3.282208	20.08231	15.02575	0.596199
20	0.244209	60.92815	3.283010	20.20546	15.01022	0.573168

Table 5.6and figure 5.4 both present the forecast variance decomposition to assess how real interest rate, inflation rate, manufacturing employment and electricity supply account for variations in measures of manufactured output at various time horizons. The results from both table 5.6 and figure 5.4 show that in the short-run, manufactured output accounts for 100 percent of variation in manufactured output (own shock) and about 60% of the variation in the long run. Real interest rate accounts for a small variation in manufactured output in the short run and for less than 5 percent variations in the long run. Manufacturing employment accounts for less than 5 percent of the variations in manufactured output in the short run and about 20 percent of the variations in the long run. In the short run, inflation rate accounts for

less than 10 percent of variations in manufactured output and about 15 percent in the long run. Electricity supply accounts for about 1 percent of variations in manufactured output in the short run and for less than 1 percent in the long run. These results can be interpreted that real interest rate, inflation rate, manufacturing employment and electricity supply account for approximately 1 to 20 percent of the long run variation in manufactured output in South Africa.

Figure 5.4 Plots of Variance Decomposition results



5.3 Conclusion

The purpose of this chapter was to analyse the relationship between South Africa's manufacturing output and its explanatory variables being electricity supply, manufacturing employment, real interest rate and inflation rate. The first procedure was to test for stationarity in the variables and the series were found to be I (1). The Johansen cointegration test showed that there were two cointegrating vectors and these were between manufacturing output and its explanatory variables. The variables that have a positive long run relationship with manufacturing output are electricity supply and manufacturing employment. The error term was negative and significant as expected. The results obtained for VECM revealed that about 13.5 percent of the variations in manufacturing output from its equilibrium level is corrected within a year. The diagnostic tests revealed that our model is normally distributed; there is no serial correlation and no heteroskedasticity. The General Impulse response Function (GIRF) results showed that manufacturing sector output responds positively to its own shocks and negative to shocks in interest rate, inflation rate and manufacturing employment. As for shocks in electricity supply, there is evidence of positive and negative reactions. These results from Variance Decomposition showed that all the variables (real interest rate, inflation rate, manufacturing employment and electricity supply) account for approximately 1 to 20 percent of the long run variation in manufactured output in South Africa. The results are favourably comparable to those in the literature and they are also supported by the previous studies.

Chapter 6

Conclusion and Policy Implementations

6.1 Conclusion

This chapter draws conclusions of the study and suggests recommendations for future policy formulation. The relationship between electricity and manufacturing sector's output has long been debated, but mostly focused on the consumption of electricity by the manufacturing sector. It is against this particular background that it was necessary to determine and document the impact of electricity supply on the manufacturing sector output in South Africa. This study also wanted to test the relationship between electricity supply and manufactured output by using VAR methodology.

The study discussed some of production theories including the Cobb-Douglas production function, Real Business Cycle Theory and the Constant Elasticity of Substitution (CES) production function. In addition to these theories, a number of studies on electricity and manufactured sector were reviewed. Even though most of these studies focused on electricity consumption, most of the results obtained revealed positive relationship between electricity and manufactured output. The researchers used different estimation techniques ranging from VAR, ARDL and Engle-Granger while some carried out surveys.

After an extensive review of the literature on electricity and manufactured output, an empirical model that links manufactured output to its explanatory variables was specified. The variables that were identified as manufactured output's explanatory variables included real interest rate, manufacturing employment, inflation rate and electricity supply. The study relied on Johansen cointegration and VECM to determine the impact of electricity supply on manufactured output in South Africa.

Stationarity in the variables was tested by using ADF, PP test and KPSS and the variables were found to be integrated of the same order and they all became stationary at first difference I(1). Johansen cointegration showed evidence of two cointegrating vectors. A positive long run relationship was found between manufactured output and manufacturing employment and between manufactured output and electricity supply. Evidence of these results is consistent with a priori expectation.

Cointegration allowed for the estimation of VECM. The correction error term of -0.135 which indicatesa stable long run equilibrium was obtained. The speed of adjustment showed that 13.5 percent of the gap between manufactured output and its equilibrium value is eliminated in the short run. The model passed the entire diagnostic tests and the residuals were found to be normally distributed, homoscedasticity and not serially correlated. The results have shown that South Africa's manufacturing sector output can be enhanced by increasing electricity supply. These results are favourably comparable to those in the literature.

6.2 Policy Implications

South Africa's manufacturing sector has been experiencing a decline in its output due to shortages of electricity which led to load-shedding and brownouts. The empirical results of this study have found a long run positive relationship between electricity supply and manufactured output. The policy implication of this positive relationship is that an expansion of electricity sector will lead to an increase in manufactured output. Policy makers in South Africa should continue to formulate and implement policies that are aimed at promoting and expanding electricity sector. The Electricity Regulation Act 2006, which is aimed at maintaining the power infrastructure and building new power stations is an example of the policies that can be used to expand the electricity sector. This will not only boost the manufacturing sector but will also create more jobs in the country.

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Appendix Tables

Lag Length Selection

VAR Lag Order Selection Criteria
Endogenous variables: LOG_MO INT LOG_EMPL CPI LOG_ES
Exogenous variables: C
Date: 08/19/15 Time: 21:29
Sample: 1985 2014
Included observations: 28

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-30.10064	NA	8.44e-06	2.507189	2.745082	2.579915
1	79.37664	172.0357	2.09e-08	-3.526903	-2.099541*	-3.090544
2	115.7917	44.21826*	1.12e-08*	-4.342263*	-1.725432	-3.542272*

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

Cointegration Tests

Date: 08/19/15 Time: 21:33
Sample (adjusted): 1987 2014
Included observations: 28 after adjustments
Trend assumption: Linear deterministic trend (restricted)
Series: LOG_MO INT LOG_EMPL CPI LOG_ES
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.923601	150.3951	88.80380	0.0000
At most 1 *	0.787227	78.38510	63.87610	0.0019
At most 2	0.528054	35.05421	42.91525	0.2429
At most 3	0.280979	14.02924	25.87211	0.6552
At most 4	0.157330	4.793029	12.51798	0.6263

Trace test indicates 2 cointegrating eqn(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 *	0.923601	72.01000	38.33101	0.0000
At most 1 *	0.787227	43.33089	32.11832	0.0014
At most 2	0.528054	21.02497	25.82321	0.1896
At most 3	0.280979	9.236215	19.38704	0.6999
At most 4	0.157330	4.793029	12.51798	0.6263

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Vector Error Correction Estimates

Vector Error Correction Estimates
Date: 08/19/15 Time: 21:34
Sample (adjusted): 1987 2014
Included observations: 28 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	CointEq2
LOG_MO(-1)	1.000000	0.000000
INT(-1)	0.000000	1.000000
LOG_EMPL(-1)	-7.719866	190.7977
	(1.81523)	(34.4288)
	[-4.25284]	[5.54181]
CPI(-1)	0.286817	-3.786003
	(0.03373)	(0.63975)
	[8.50323]	[-5.91792]
LOG_ES(-1)	-29.63624	513.2853
	(2.01483)	(38.2145)
	[-14.7091]	[13.4317]
@TREND(85)	0.379651	-6.434281
	(0.02620)	(0.49693)
	[14.4905]	[-12.9482]
C	373.4094	-7537.648

Error Correction:	D(LOG_MO)	D(INT)	D(LOG_EMPL)	D(CPI)	D(LOG_ES)
CointEq1	-0.135010	-2.406304	-0.008824	-3.714631	0.041960
	(0.03576)	(3.42068)	(0.03524)	(1.17324)	(0.03614)
	[-3.77567]	[-0.70346]	[-0.25041]	[-3.16613]	[1.16112]
CointEq2	-0.008425	-0.195585	-0.001293	-0.184313	-0.000695
	(0.00197)	(0.18837)	(0.00194)	(0.06461)	(0.00199)
	[-4.27872]	[-1.03829]	[-0.66622]	[-2.85275]	[-0.34930]

Diagnostic Tests Results

Normality Test

Component	Jarque-Bera	df	Prob.
1	0.549856	2	0.7596
2	1.163656	2	0.5589
3	0.807527	2	0.6678
4	0.649258	2	0.7228
5	0.778396	2	0.6776
Joint	3.948692	10	0.9496

Serial Correlation Test

VEC Residual Serial Correlation LM Tests
Null Hypothesis: no serial correlation at lag order h
Date: 08/19/15 Time: 21:35
Sample: 1985 2014
Included observations: 28

Lags	LM-Stat	Prob
1	20.07534	0.7429

Probs from chi-square with 25 df.

Heteroskedasticity Test

VEC Residual Heteroskedasticity Tests: No Cross Terms (only levels and squares)
Date: 08/19/15 Time: 21:36
Sample: 1985 2014
Included observations: 28

Joint test:

Chi-sq	df	Prob.
194.8778	210	0.7654