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THE IMPACT OF ELECTRICITY PRICES ON ECONOMIC  
GROWTH: A CASE STUDY OF SOUTH AFRICA.

BY

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## ABSTRACT

This study examines the impact of electricity prices on economic growth in South Africa using Vector Error Correction Model (VECM) and the Johansen approach to co-integration. The results confirm that a stable, long-run relationship exists between electricity prices and economic growth. The empirical results show that there is a unique negative long-run relationship between electricity prices and economic growth. We find that higher electricity prices have a negative impact on economic growth. This indicates that as electricity prices increase, aggregate output in the economy will become constricted thereby reducing gross domestic product and thus reducing economic growth in South Africa.

This study recommended that the financing of Eskom's capacity expansion can be a composition of increased user charges, private sector investment and financing from the government. The negative impact of electricity prices on economic growth are indicative of the fact that higher user charges should not be the only source of financing Eskom's six year capital expenditure. Despite the economic advantages of increasing the price charged to customers to a cost reflective level, several sectors are vulnerable to sudden consistent increments in electricity prices. If the recommended policy mix contributes to the financing of Eskom's capitalisation then higher user charges will not be a requirement and in the short-run the economy will be able to function along its usual business cycle.



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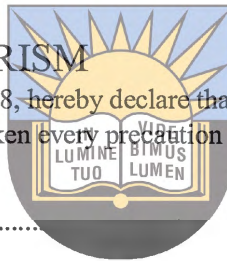
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Faith Rumbidzayi Mazambani.

Alice.

September 2015.

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## DEDICATION

To my loving and caring parents Maud and Edmore Mazambani; my supportive uncle Eddington Mazambani, my siblings Edias, Nelliah and Tawanda, my sister in law Tafadzwa and my niece Amarah , I gratefully and emotionally dedicate this Masters project to you for always being there when I was in need. I am because you are... Thank you.



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## LIST OF ACRONYMS AND ABBREVIATIONS

ADF	Augmented Dickey Fuller.
ARDL	Auto Regressive Distributive Lag.
DTI	Department of Trade and Industry.
ESKOM	Electricity Supply Commission.
GDP	Gross Domestic Product.
INT	Interest Rate.
LABPRO	Labour Productivity.
LM TEST	Langrange Multiplier Test.
NERSA	National Energy Regulator of South Africa.
NEP	National Electrification programme.
PPI	Producer Price Index.
STATS SA	Statistics South Africa.
OECD	Organisation for Economic Co-operation and Development.
OLS	Ordinary Least Squares.
SA	South Africa. <i>Together in Excellence</i>
SARB	South African Reserve Bank.
VAR	Vector Auto regression.
VEC	Vector Error Correction.
VECM	Vector Error Correction Model.



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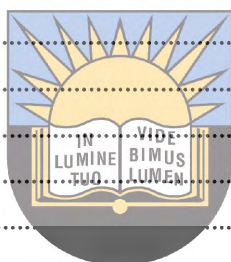
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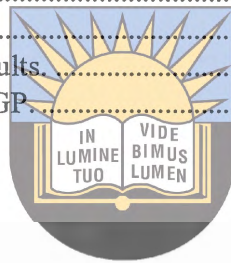
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## CHAPTER ONE

### 1.1 Introduction And Background Of Study

South Africa is one of the most sophisticated and promising emerging markets, offering a unique combination of highly-developed first world economic infrastructure, with a vibrant emerging market economy. It is one of the highest ranking developing economies in Africa, leading the continent by producing up to 40% of the continent's industrial output. The country also contributes 45% of Africa's total mineral production. In addition South Africa's state owned power utility Eskom generates 40% of the electricity consumed by the entire continent. Social and demographic changes since the abolishment of apartheid such as urbanisation, the burgeoning middle class and an expanding workforce are also creating new growth momentum in South Africa (KZN Department of Economic Development and Tourism, 2010).



Over the nineteen years of democratic freedom South Africa's intrepid macroeconomic developments have enhanced economic growth, job creation and have opened up South Africa to world markets. South Africa's success in creating a competitive economic policy is undoubtedly mirrored by its GDP figures, which reflected an unprecedented 62 quarters of uninterrupted economic growth between 1993 and 2007, when GDP rose by 5.1% (SARB, 2012). However due to South Africa's increased integration into the global market, its GDP contracted to 3.1% due to the 2008-09 global economic crisis. Nevertheless the economy continues to grow, driven largely by domestic consumption even though growth is at a slower rate than previously forecast. It is projected to grow at 2.7% in 2013, 3.5% in 2014 and 3.8% in 2015 (SARB, 2012).

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Under its inflation-targeting policy implemented by the South African Reserve Bank (SARB), prices have been fairly steady. In January 2013, the annual consumer inflation rate was 5.4%, plummeting from December 2012's 5.7% (SARB, 2012). Stable and low inflation protects living standards, especially of working families and low-income households. However it is important to note that developments in the energy sector pose a large constraint on the growth prospects of the country. The dominant energy supplying company, Eskom, has drawn up a six-year capital investment program to increase the energy capacity of the country. This has sparked a wave of anxiety across the economy since Eskom is a vital facilitator of growth for virtually all sectors of the economy (Seymour, Akanbi and Abedian, 2012).

Over the period 1994 to 2010 the South African economy nourished itself with the existing energy infrastructure built before 1994 without advancing in further capacity to meet the growing demands of the economy. For the past three decades, electricity prices in South Africa have been low and declining (Steyn, 2006). Conversely, in 2008 the trend in electricity prices took a dramatic turn when, in response to serious power supply shortages, Eskom undertook a large build program to increase its power generation capacity (Kohler, 2010).

The increment in aggregate demand for electricity rose as a result of higher economic growth and the developmental needs of a modern economy. The failure to invest adequately has created a real constraint on the growth prospects of the country as highly disruptive load-shedding episodes were experienced in the country in 2008. From 2008 to 2011 real electricity prices rose by 78%. It is argued that electricity prices will need to continue rising towards 'cost-reflective' levels so that a repeat of the costly over-investment in generation capacity in the late 1980s and the current supply shortages can be avoided (Cameron and Rosson, 2012).



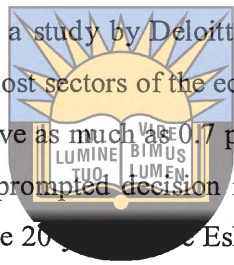
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Previously Eskom was able to charge low electricity prices because it did not bear the full economic cost of the capital it employed. This cost was borne in part by the state taxpayers. Because of the lenient financial requirements Eskom historically enjoyed under full state ownership it did not have to bear the full economic opportunity cost of the capital employed to finance its investments (Steyn, 2006). While tariffs were sufficiently high to allow Eskom to repay its debt they did not allow Eskom to recover full costs of its assets. As a result Eskom did not accumulate reserves to replace its assets in future. Consequently, consumers enjoyed a 17 year decline in real electricity prices that resulted in some of the most inexpensive electricity in the world. Although electricity prices rose by 78% in real terms between 2008 and 2011, they are still considered low by international standards and are yet to reflect the full economic cost of supplying power (Frost and Sullivan, 2011).

Electricity price adjustments in South Africa are currently determined by The National Energy Regulator of South Africa (Nersa) through the Multi-Year Price Determination (MYPD) methodology (2015). The MYPD is based on rate-of-return principles and was developed for the

regulation of Eskom's required revenues, which is the basis on which prices are effectively adjusted. The basic properties of an 'optimal' electricity tariff which in addition to cost-reflectivity include satisfying objectives such as revenue adequacy have been accepted by both Nersa and Government and are laid out in the Electricity Act of 1996 and Electricity Pricing Policy of 1998. Conceptually, a 'cost-reflective' tariff can be defined as a tariff equal to the long-run marginal cost (LRMC) of supply, since this is consistent with the efficient allocation of economic resources (Nersa,2012).

Following the establishment that power outages or 'unsaved energy' come at far greater cost to the economy than rising electricity prices, a study by Deloitte (2012) found that load-shedding had substantial economic impacts across most sectors of the economy and if continued at 10% of total power capacity over a year could shave as much as 0.7 percentage points off GDP growth. Thus the electricity supply crisis, finally prompted decision makers to respond to the capacity shortage that had emerged. However, in the 20 years since Eskom had last invested in base load capacity, electricity tariffs had declined to such an extent that it became apparent that Eskom would not be in a position to finance the new build program on the basis of its existing low tariffs and inadequate revenue stream (Deloitte, 2012).

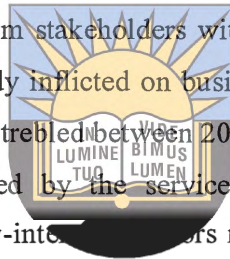


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It is asserting the inevitable that in order to provide a sustainable supply of energy more capital investment is needed. Therefore, the state-owned utility requested an allowable revenue allocation of nearly R1.1-trillion. This implied the request for permission from Nersa to increase its average selling price from 61candkWh currently (2015) to a nominal 128candkWh by 2017and18, or a real price of 96candkWh. In March 2013, Nersa announced that Eskom would be allowed to increase electricity tariffs at an average yearly rate of 8% between 2013 and 2018. This increase that was half the 16% initially required by the utility in its application for the third multiyear price determination (MYPD3) period. The approved tariff increases, which were premised on an allowable revenue of R906.6-billion, would result in the electricity price increasing to 89.13candkWh by the end of the MYPD3 (Nersa, 2012, Creamer Media Engineering News, 2013).

The severe increases in user charges of electricity since 2008 have unsurprisingly been welcomed with significant public resistance. Representatives of electricity-intensive industry and some members of the general public contend that the current electricity price path is 'unjustifiable'. This sentiment was unanimous despite Nersa chairperson C.Khuzwayo's indication that it considered about 200 written and 162 oral representations, covering issues such as Eskom's weighted average cost of capital, regulatory asset base, primary energy costs, integrated demand management, economic impacts and tariff restructuring (City Press, 17 March 2013).

There has been particular unhappiness from stakeholders with the fact that the latest round of increases would compound the pain already inflicted on business and residential consumers by the fact that the utility's prices had already trebled between 2007 and 2012 (City Press, 17 March 2013). The South African economy is led by the services sector but the contribution of manufacturing and other relatively energy-intensive sectors remains significant. This economy like most post-industrial, middle to high income economies, is subjugated by services-related activity which accounted for just over two thirds (67%) of GDP in 2010. However of important consideration in this matter is the fact that the highest electricity consumers, typically mines and industrial groups like Sasol, would be charged 9.6% increases. Rural businesses serviced directly by Eskom, typically farms, will pay 9.3% more. These energy-intensive sectors make a direct contribution of 28% of GDP (Frost and Sullivan, 2011)



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According to Eskom spokesperson Hillary Joffe, households typically located in townships, both in urban and rural areas will pay 7.6% more for consumption of more than 350kWh (Creamer Media Engineering News, 2013). This group represents about 3 million customers, according to Joffe. Meanwhile suburban consumers who receive their electricity directly from Eskom would pay 8% more. According to The Chamber of Mines, whose members would typically pay a 9.6%, the hike tend out to be slightly lower than expected but could still put more unnecessary pressure on parts of the sector that are already experiencing challenges (Creamer Media Engineering News, 2013). For its part, labour reported that additional above-inflation increases would not only threaten job security, but also sow the seeds of social discord as workers and the poor struggle to keep pace with rising costs across a range of essential products and services.

Meanwhile the South African Chamber of Commerce and Industry (SACCI) said that, in the current economic circumstances, the "right decision has been made as the capacity of businesses to absorb costs has diminished (Mail& Guardian, 4 February 2013).

## 1.2 Problem Statement

In March 2013, Nersa announced that Eskom would be allowed to increase electricity tariffs at an average yearly rate of 8% between 2013 and 2018 (Business Day, 18 March 2013). These higher user charges came into effect in April 2013 and have sent the economy in a frenzy of shuddering dread as there are predictions of negative impact on economic growth. It has been predicted that unemployment targets will not be met, job creation opportunities will be reduced, potential tax revenue losses will surge and there will be negative effects on the current accounts deficit and currency, a decline in foreign investment, possible job losses and the closure of many energy intensive companies (Van Heerden, Blignaut and Jordaan, 2008).

Electricity prices have abruptly changed over the period 2008 to 2012. South Africa has become vulnerable to rapidly rising electricity prices and electricity shortages (World Bank, 2011). Eskom has justified the electricity price increases as obligatory to fund its current build program and to ensure that user charges are cost reflective. Another reason that has been put across is that the increments can increase the financials of Eskom so that it can borrow funds on financial markets (Deloitte and Eskom, 2009). The price increases for users of electricity are further exacerbated by municipal mark-ups. At one fell swoop, the electricity sector is the largest emitter of CO<sub>2</sub> in the country and there is a plight from the international community for Eskom to shift from coal generation to cleaner types of generation. This is likely to come at a higher cost and put further pressure on electricity prices. This presents a challenge for government to improve the efficiency of the electricity market and smooth the price increases (Mail and Guardian, 3 February 2013).

All sectors of the South African economy use electricity, directly or indirectly, as an input. (Erero, 2010). Therefore, increased capital expenditure in the energy sector, leading to increased electricity hikes, will have an impact on all the sectors of the economy and subsequently economic growth. The relationship between electricity hikes and economic growth has significant policy implications as it expected that some structural changes will take place in the

economy (Human Sciences Research Council HSRC, 2008). At the same time current growth rates of inflation and GDP have been positive. It is thus imperative to assess the impact of these recent electricity hikes on economic growth.

South African history has revealed that electricity prices do not reflect the true economic cost of supplying power. This has resulted in poor investment decisions and a misallocation of resources. Many factors influenced the level and trend in electricity prices in South Africa but the outstanding stimuli were Eskom's investment history and its accounting and pricing policies (Seymore, Akanbi and Abedian, 2012). Several economic growth theorems suggest that the recently imposed electricity price increases are likely to result in a substantial decrease in output and employment across all of the major service sectors. This is because they are vulnerable to second-round effects of price increases on consumer spending.

Even though the direct contribution of electricity, gas and water to total South African GDP is minute at 2.1%, the sector plays a paramount role in that it serves as a critical input for all the other sectors of the economy. For instance, the electricity hikes have the potential to adversely affect mining, manufacturing and agricultural industries which contribute to exports and South Africa's foreign exchange earnings. The effects of these hikes may therefore also be transmitted in exports and the exchange rate (SARB, Deloitte, 2012). The experience of the South African electricity supply industry over the past thirty-odd years has demonstrated that poor price signals lead to poor decision-making and, given the nature of the industry (long lead-times required to install new capacity and large discontinuous investments) poor investment decisions take many years to recover from. Prices will inevitably need to continue to rise towards 'cost-reflective' levels so that a repeat of the costly over-investment in generation capacity in the late 1980s and the current supply shortages (and ever-increasing threat of a repeat of the highly disruptive load-shedding episodes of 2008) can be avoided.

It has been argued however, that further increases in electricity prices, especially if the adjustment to 'cost reflective' tariffs is a rapid one, will jeopardize the viability of firms and industries who invested in South Africa on the basis of cheap electricity and who have come to rely on this as a major source of comparative advantage. Local business and industry associations have argued that a more thorough understanding of the impact of rising electricity prices on the South African economy at an aggregate level is required.

### 1.3 Objectives

1. To analyse the pattern of electricity prices and economic growth in South Africa.
2. To econometrically analyse the impact of electricity prices on economic growth.
3. To make policy recommendations based on the findings.

### 1.4 Hypothesis

$H_0$  : Electricity prices significantly affect economic growth in South Africa.

$H_1$  : Electricity prices have no significant impact on economic growth in South Africa.

### 1.5 Significance of the Study

This study adds to the empirical work on the impact of electricity hikes by extending the literature to more recent years, a period characterised by a volatile global market, flexible exchange rate regime, an inflation targeting monetary policy framework and rising commodity prices. This is a current economic challenge which the government and the nation at large are facing and only a few related studies have been done (Amusa, Amusa and Mabugu, 2009). The few number of studies of the impact of electricity price increases on economic growth only focus solely on the short-run impact of rising prices on employment and output. These studies fail to note that in the absence of cost-reflective prices, costly mismatches between supply and demand are likely to continue to occur.

Consequently, examining the impact of electricity hikes on economic growth, which have increased significantly, should bear significant meaning for present and future considerations of Nersa and government policies. There have been a number of studies on the increase in electricity prices and Eskom's six year capitalisation program in South Africa. These include Frost and Sullivan (June 2011), Inglesi-Lotz and Blignaut (February, 2011), Balat (2006), (The Pan African Research and Investment Services, 2011), Cameron and Rossouw (2012), (Volkwyn and Kleynhans, 2014) and Mabugu (2012) to name a few. Most of the studies focused on the impact of electricity price increases in the Mining and Agricultural sector. This study focuses on the magnitude of the impact of electricity hikes on economic growth.

With respect to the outlook for energy consumption it seems unlikely that rising prices will be sufficient to reflect the economic cost of producing electricity in the economy over the next decade. It is however, not clear what impact structural effects will have on aggregate demand

and GDP (whether they will have a positive or negative impact) given the considerable differences in opinion around the trend in the electricity intensity of the South African economy.

### **1.6 Organisation of the Study**

The study is partitioned into six chapters, which will be sorted out as follows:

**Chapter 1:** this chapter gives the introductory statements of the study, the problem statement, the objectives, the hypothesis as well as the rationale of the study.

**Chapter 2:** this chapter intends to present an overview of the patterns and trends in the prices of electricity and economic growth in South Africa.

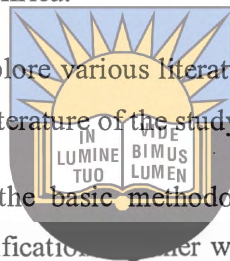
**Chapter 3:** this chapter will grant and explore various literatures that support the rationale of the study. Both the theoretical and empirical literature of the study will be reviewed in this chapter.

**Chapter 4:** this chapter furnishes with the basic methodological aspects of the study. The chapter will give the working model specification together with the econometric techniques that the study will implement in the estimation of the model.

**Chapter 5:** this chapter mainly looks at the representation of the empirical findings of the study. Various econometric techniques and results used are reported in this chapter.

**Chapter 6:** this is the final chapter of the study; this chapter looks at the summary and policy extrapolations obtained from the study. The chapter ends with some limitations and hindrances faced in this study, economic, statistical or otherwise.

The study ends with a concise and full list of acknowledgement of works adopted by the study, given as the bibliography of the study. An appendix is attached at the end of the study with supplemental information that would be helpful to the reader.



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## CHAPTER TWO

### LITERATURE REVIEW

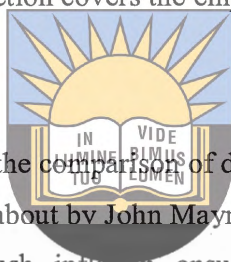
#### 2.1 Introduction

This chapter outlines the theoretical and empirical literature behind the impact of electricity prices on economic growth. The chapter is divided into three sections. The first section covers theoretical literature on the impact of electricity prices on economic growth. In this section the theory of Cost push inflation, the Neoclassical Growth Theory, Harrod-Damour economic growth model, the Endogenous Growth model and the Ecological Approach to economic growth are reviewed in this section. The second section covers the empirical findings on this subject. The last section concludes the chapter.

#### 2.2.1 The Theory of Cost Push Inflation

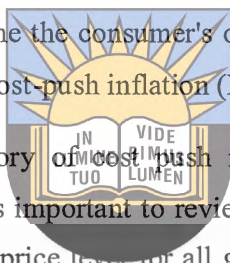
In essence the study of Economics entails the comparison of different schools of thought, and the theory of cost-push inflation was brought about by John Maynard Keynes, a British economist in 1936. His theory purports that cost-push inflation ensues when the cost of production unexpectedly rises whilst the demand for that particular good or service remains constant. In many instances the supplementary cost of production is passed on to the consumer in the form of a higher price in that good or service. Keynes (1936) supposed a country's economic welfare hinged on a balance of government and private controls. Other economists who support Keynes theory, popularly known as Keynesians extend this theory and put forward the notion that in a modern industrial economy, prices are rigid such that the prices of goods and services cannot change downwards. Furthermore, should a supply shock incur, a recession characterized by surging unemployment and decreasing gross domestic product will take place (Van der Merwe and Mollentze, 2010).

The cost-push view of inflation is premised on the assumption that prices are determined using the total cost of production and that these prices increase *only* when the total cost of production also increases. The condition of the quantity demanded in this case is absolutely not considered. Cost Push inflation is, as a consequence, the outcome of the productive inputs (capital, labour and land) importunately and unilaterally increasing in terms of their price for example interest, wages and rent respectively. Consequently, the total cost that a producer bears, arising from these inputs of the production process increase as well (Mohr and Fourie, 2007).



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Many elements can produce cost-push inflation, but when Keynes (1936) modeled his theory the two clearest causes are wage increments and the increase in the prices of material costs which would be part of the inputs used in the production process. This mostly occurred where imported goods formed part of the inputs. Since we have established that the selling price of a product that the consumer faces is often based on the current total cost of production that the producer is facing such as the wages of the workers who produce it (Mohr and Fourie, 2007). Accordingly so if the employees of the firm in question get wage increments, the total production costs increase as well. More often the firm is unable to absorb this marginal increase in production internally. It is much easier for the producer to pass on the increase in production costs in the form of higher prices to consumers. However, many a time the consumer's own wages will have remained the same making the price increase a form of cost-push inflation (Keynes, 1936).



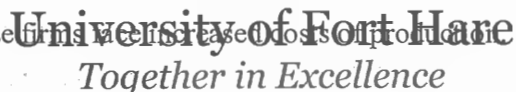
Before delving deeper into how the theory of cost-push inflation relates to the impact of electricity prices on economic growth, it is important to review the definition of inflation itself. Inflation is a persistent rise in the overall price level for all goods and services in the economy (Van der Merwe and Mollentze 2017). This is different to an increase in individual prices of goods and services, for example the increase in the price of electricity. According to Batten (1981) inflation is not the term used to describe the increase in the prices of individual goods or services. However an increase in the price of particular goods or services may affect the measurement of inflation. In addition specific price increases may accompany increases in the measure of inflation, although they cannot explain the cause of inflation. For instance, a single increase in the price of electricity in one moment in time which may have been caused by an unplanned shock such as labour unrest in coal mines is not considered inflation (Batten, 1981).

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Even though a moment in time increase in electricity may end up as a higher overall price level (inflation), the growth rate of the overall price level will be unaffected if the economy adjusts to this shock within the short-run. The main precept of the theory of cost push inflation assigns the fault of the cause of inflation to the activities of firms and labour unions. Proponents of the cost push theory are of the view that firms persistently increase the prices of their goods in order to retain large revenue. Ostensibly, firms of a monopolistic nature manage to effectively do such. Similarly labour unions may exercise monopoly influence in labour markets in order to bargain for higher wages for their members (Mohr and Fourie, 2007).

Such wage increments are usually above those determined by the market conditions of demand and supply. Some firms may have the decency and ability to absorb the additional wage bills so as to preserve a competitive price. Others however, will not. The firms which employ these union members will increase their prices in order to pay for the increased cost of labour. This is especially so for those with monopoly influences, such as a single supplier of electricity in an economy. The outcome of such a scenario is probably an increase in the price that the consumer pays for the good which demonstrates cost push inflation theory (Batten, 1981).

The cost push proponents view inflation as the result of incessantly surging costs of production without the influence of market forces (Van der Merwe and Mollentze, 2010). This relates to the scenario of the impact of electricity hikes on the economic growth of South Africa in the following way. Electricity is a key factor of production in the South African economy especially in the energy-intensive firms such as gold mining companies, the non-ferrous metals mines, as well as soap and pharmaceuticals firms. Such firms are more sensitive to the increase in the price of electricity (Human Sciences Research Council, 2006). Faced with higher prices of electricity, a key factor of production, these firms will raise the price of their products.



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Firms may transfer the higher production costs in the form of higher prices charged to consumers. When this occurs in the economy over a five year period, as is the South African scenario, the result will be a rise in the general price level (Ziramba, 2008). Moreover this theory compliments the study in that this type of inflation usually happens when the cost of a good or service goes up and nothing can easily be substituted for. Since there is no close substitute for electricity in South Africa, an increase in the general price level is highly probable (Akinboade, Niedermeier and Siebrits, 2004).

Akinboade *et al.*(2004) is also of the view that since firms are compelled to raise their prices, subsequently, employees and households alike will face higher prices of goods and services and will insist on matching wage and salary increments. This demand for higher wages arises from the fact that the same quantity of rand which could have bought a product last year can now only buy 90% of that product this year. This is what economists would call a lowering in spending power (Batten, 1981). This adds further to increasing costs and prices. Thus when this is the state of affairs in primary industries such as mining and manufacturing, the effects ripple throughout

the economy. Ultimately, households face higher costs of living. Workers demand further wage increases and the cycle starts over. This is cost push inflation (Akinboade *et al.*,2004).

However the limitation of the cost push theory of inflation is that it is often mistaken with an increase in the relative price. Another limitation is that the notion that continuously rising overall level of prices leads to inflation completely neglects the role that money supply plays in the determination of the overall price level. Thirdly the idea that gluttonous firms or labour unions can create an incessant episode of increasing prices cannot be supported by empirical evidence (Batten, 1981). In addition to these limitations the theory also disregards the relationship between aggregate demand and aggregate supply in the economy (Mohr and Fourie, 2007). Batten (1981) is of the opinion that supply shocks, such as the increases in the price energy, can be sources of cost push inflation if these lead to reduced supply and higher prices throughout the economy. Many of the causes of cost-push inflation come from external economic shocks (for example unexpected volatility in the prices of internationally traded commodities). A country can become vulnerable when a vital resource such as electricity becomes scarce due to substantially increased demand.

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### **2.2.2 The Neoclassical Growth Theory**

It is a delicate task to assess and describe exactly what the neoclassical growth theory is because the prevailing idea comes from the production function, the law of diminishing returns and then use technological advancement in a competitive industry. The standard neoclassical model, named after Nobel Prize-winning MIT economist Robert Solow, describes how the economy changes and grows over time as saving, investment, labour and advancing technology raise the economy's level of output per worker. According to Solow, any sustained level of growth is due solely to technology with saving and investment leading to a temporary increase in capital intensity (Solow, 1956).

Neoclassical economists such as Gilpin, North, Solow and Swan draw attention to the concept of diminishing returns and then use technological advancement as an explanatory variable (Cortright, 2007). In explaining the law of diminishing returns Samuelson (1975) in Salvatore (2004) stated that the successive increase of one factor of production on another fixed factor of production will result in an increase in the total product. However, after a certain level the additional total product resulting from the successive units of the variable factor of production

added to the fixed factor of production will start to decline. The decline in additional returns is a result of the fact that each addition of the varying resource has fewer amounts of the fixed resource to work on (Salvatore, 2004). This law holds only when one input is fixed, and the other input is increasing.

According to Ricardo, diminishing returns set in when one has a particular fixed area of land and successive units of labour will result in diminishing returns to each additional unit of labour. However if both land and labour are increased at the same rate there will be no diminishing returns. Instead there are constant returns to scale, a state whereby the firm realizes economies of large-scale production because both land and labour increase at the same rate (Salvatore, 2004). When economies of scale realize then an aggregate increase in the factors of production will result in increasing returns to investment and not decreasing returns.

The neoclassical model is built from an aggregate production function showing constant returns in labour and capital. The assumption put forward is that growth and labour supply are constant. It has the general form  $Y = F(K, L) = K^\alpha L^{1-\alpha}$ , where  $\alpha$  is the contribution of capital to output for the model and  $1 - \alpha$  is the contribution of labour.  $K$  measures the amount of capital, usually measured as the rand value of the plant and equipment and  $L$  is the amount of labour, usually counted as total man-hours used in the financial period under consideration.  $Y$  is the national output, usually defined as the gross domestic product (GDP) (Bade and Perkin, 2008).

The two properties of the aggregate production function,  $Y = K^\alpha L^{1-\alpha}$  are that when capital  $K$  and labour  $L$  are multiplied by the same amount for example if they are doubled then  $Y$  will be doubled. Thus there are constant returns to scale (Bade and Perkin, 2008). Secondly, the exponents  $\alpha$  and  $1-\alpha$  add up to one. In a condition of perfect competition factors of production reap exactly what they sow, therefore this the equation comprises aggregate income. Since when one factor of production is held constant, and another is increased, the latter factor will yield diminishing returns. The aggregate production function can be transformed into the equation:

$$Y \text{ and } L = (K \text{ and } L)^\alpha \text{ (Bade and Perkin, 2008).}$$

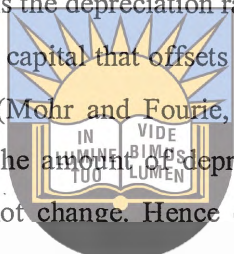
Whereby  $Y \text{ and } L$  = output per worker man and hour.

$K \text{ and } L$  = amount of plant and machinery per worker man-hour

$\alpha$  = percentage of aggregate income received by capital for example, interest.

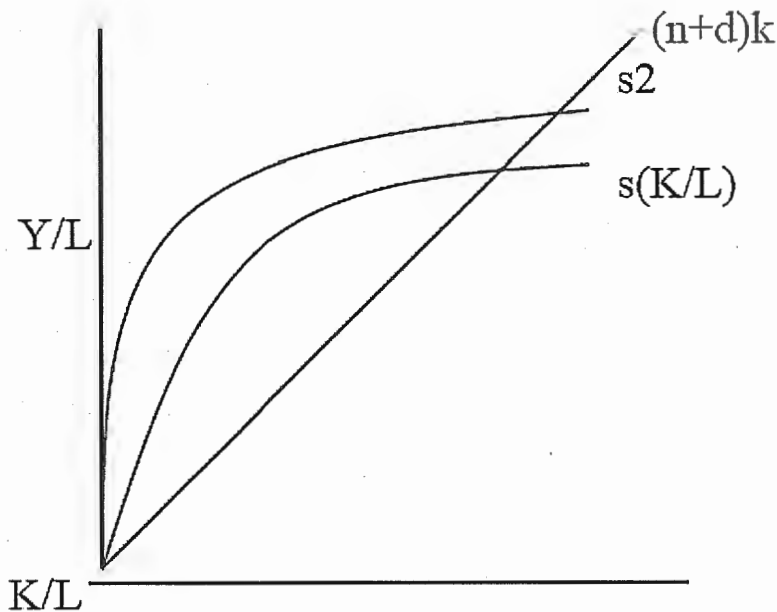
This transformed equation also shows that output per worker man-hour increases in proportion to the increase of capital per worker but at a diminishing rate. In the function of the form  $Y = (K\alpha L^{1-\alpha})$ , if capital per worker will decrease, when more workers are added without adding more capital because there is less capital to work with the additional units of labour (Bade and Perkin, 2008). This is what usually happens when capital equipment (plant and machinery) depreciate. If there is a decrease in the capital-to-labour ratio this means that there is less output per worker and a lower aggregate income.

Solow (1956) uses the term  $(n + d)k$  to model this decrease of capital per worker. Whereby  $n$  represents the rate of labour expansion,  $d$  is the depreciation rate, and  $k$  is capital per worker. As long as there will be additional increase in capital that offsets the value of  $(n + d)k$  there will be no decline in the output per worker (Mohr and Fourie, 2007). The amount of additional increase in capital will just compensate the amount of depreciation. The economy will be at equilibrium and aggregate income will not change. Hence economic growth will remain the same.



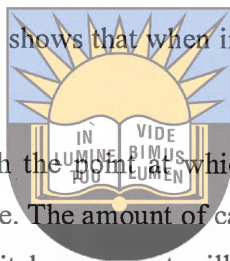
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Figure 2.1: An illustration of the theory of neoclassical growth.



Source: Rynn, 2001.

According to Mohr and Fourie (2007) curve  $s(KandL)$  represents the amount of investment in new capital per man-hour.  $s$  is the savings rate. Additions to capital stimulate more output and since there are diminishing returns, the curve subsequently flattens out. The point at which the  $s(KandL)$  curve crosses the line  $(n + d)k$  is the equilibrium point. Two non-equilibrium conditions are possible here; if the economy has a low amount of investment then the point at which the economy produces will be at  $s(KandL)$  curve to the left of the  $(n + d)k$  line. If the returns to investment are higher than depreciation then the outcome will be more capital per man-hour to the economy. The  $s(KandL)$  curve will move up and the production in the economy will move along the  $s(KandL)$  curve and eventually achieve equilibrium where it cuts the  $(n + d)k$  line. Solow's model shows that when in disequilibrium the economy self-corrects itself back to equilibrium.



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Alternatively when investment is too high the point at which the economy produces will be represented at the right of the  $(n + d)k$  line. The amount of capital invested will be much higher than the capital per man-hour output. Capital equipment will be much higher now even though the rate of depreciation remains the same and a lot of that capital equipment will be redundant. Consequently entrepreneurs will reduce the amount of capital equipment, capital will decrease because of depreciation, and the economy will move back to its equilibrium point (Mohr and Fourie, 2007).

According to this model an economy can experience a surge of growth and when investment is increased, that growth will stop. If savings are increased the economy will experience growth in the short-run but the increase in GDP will not be continuous. The sustenance of growth in this model is acquired through the introduction of technological progress. Uninterrupted increase in GDP at all points on the  $s(KandL)$  curve is achieved if  $YandL$  or output per worker-hour is increased (Mohr and Fourie, 2007).

When there is an improvement in technology the level of output per worker is increased using the same equipment resulting in higher productivity. This will occur due to a more efficient production process or improved equipment and that is technological progress. If investment level remains the same and there is technological progress, the amount of output per worker is increased and GDP will increase. Increasing GDP per capita incessantly is possible if technological progress is purposefully changed. Thus it is concluded that Savings and investment

is a necessary condition for accelerated economic growth but not a sufficient condition (Cortright, 2007).

This theory is a success because it is a simple model with clear implications and makes the use of a residual to estimate the impact of technology and capital accumulation on income growth. The model has also been critical to empirical work. However it is not without failure. For instance it is only able to explain income growth through technology which is often exogenous. In addition technological progress level is the outcome of the research and development of firms and individuals. Lastly the concept of aggregating capital is questionable because it bears more profit in a disaggregate state (Boianovsky and Hoover, 2009).

### 2.2.3 Harrod-Domar Theory

According to Bade and Perkin (2008) Harrod-Domar is the model upon which Soviet planned development and developmental planning in India was founded. Under this school of thought the main principal method for increasing GDP is utilization of savings and investment to bring about economic growth. The Harrod-Domar model shows how investment leads to growth and the key assumption here is that investment comes from savings. Rate of economic growth (GNP growth rate) is determined jointly by the ability of the economy to save (savings ratio) and the capital-output ratio (Domar and Harrod, 1957). A closed economy is also assumed and the theory states that at any date  $t$ , national income is divided between consumption and savings:

$$y(t) = c(t) + s(t) \text{ (Aghion and Howitt, 2009).}$$

It goes on to explain that the value of output produced ( $y$ ) must also be equal to consumption goods produced and goods needed by investors:

$$y(t) = c(t) + I(t).$$

Another assumption is that there exists unemployed labour, so there is no constraint on the supply of labour and that production is proportional to the stock of machinery (Domar and Evsey, 1957). To determine the growth rate of GDP, which is defined as:  $g(y) = (\text{change in } y) / y$  and  $y = \text{GDP}$ . Thus growth rate in the economy is:  $g = \frac{[y(t+1) - y(t)]}{y(t)}$

Since capital is assumed to be the only binding production constraint, investment ( $I$ ) in the Harrod-Domar model is defined as the growth in capital stock:  $I = (\text{change in } K)$  (Aghion and

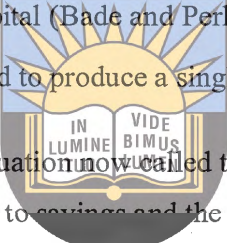
Howitt, 2009).  $K$  Denotes the national capital stock and if  $\delta$  is the fraction of capital stock which depreciates at a given time  $t$  then:

$K(t + 1) = (1 - \delta)K(t) + I(t)$  shows the rate at which capital stock changes over time. However investment is also equal to savings. Thus the savings rate is savings divided by income:  $s = s(t)$  and  $y(t)$ .

An estimate is made which is the Incremental Capital-Output Ratio (ICOR), which is a measure of capital efficiency.  $ICOR = (\text{change in } k) \text{ and } (\text{change in } y)$  where  $k$  = capital stock. A high ICOR implies a high increase in capital stock relative to the increase in GDP. Thus, the higher the ICOR, the lower the productivity of capital (Bade and Perkin, 2008). The incremental capital output ratio is the amount of capital required to produce a single unit of output:  $\theta = \frac{k(t)}{y(t)}$ .

From this Harrod and Domar derived an equation now called the Harrod-Domar growth equation which links the growth rate of the economy to savings and the capital output ratio:

$$\frac{s}{\theta} = g + \delta.$$

  
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In order to derive the population growth rate per capita we assume that the population  $P$  grows at the rate of  $n$ :  $P(t + 1) = P(t) (1 + n)$  for all  $t$ .

Substituting the Harrod-Domar equation into per capita magnitudes we get the following equation:

$\frac{s}{\theta} = (1 + g^*)(1 + n) - (1 - \delta)$ . Where  $g^*$  is now the rate of per capita growth (Bade and Perkin, 2008).

The model conceives growth by expanding the above equation to get:

$$\frac{s}{\theta} = g^* + n + \delta.$$

Whereby:  $s$  denotes the ability to save and invest,  $\theta$  shows the ability to convert capital into output and the rate of capital depreciation is shown by  $\delta$ . the letter  $n$  represents the rate of population growth. This means that a 1 per cent increase in population growth will lead to a growth rate of GDP per capita decreasing by 1 per cent (Weil, 2009). What causes growth in this

model is the increase in savings and lowering the capital output ratio. The limitation of Harrod-Domar is that GDP growth is assumed to be proportional to the share of investment expenditure in GDP and empirical studies have shown that low rate of savings in developing countries gives rise to a savings gap and capital constraint (Bade and Perkin, 2008).

#### **2.2.4 Endogenous growth Model**

The new Growth theory extended the neoclassical model by placing focus on a monopolistic model in which the rate of technological progress is endogenous. The internalization of technology into its model is the reason the New Growth Theory is termed “endogenous” growth theory. New Growth Theory assumes that knowledge and technology have increasing returns and that is what spurs continuous economic growth. The proponents of the New Growth Theory contested that the neoclassical does not describe how technology improves over time.

Romer (1994) is credited with introducing the endogenous growth theory. Its central notion is the increasing returns associated with new knowledge or technology. While traditional economic theory is formed on the basis of diminishing returns, the endogenous growth model revived the effects of increasing returns. Based on the foundation that knowledge plays a paramount role in making economic growth possible, this school of thought states that knowledge bears increasing returns because it is a non-rival good.

Two foremost features borne by ordinary goods and services are rivalry and excludability. This means that at any given time only one individual can consume that good or service and that individual has the ability to exclude others from use. On the other hand knowledge or ideas are intangible for example a software program. This makes it a non-rival good. Since they are of a non-rival nature the production of knowledge and ideas has a near zero marginal.

This non-rival quality makes it possible to use and divulge ideas to others at zero cost. As more and more ideas or knowledge is amassed about how an economy functions and the variety of ways in which to employ a scarce amount of resources, economic growth ensues. Therefore the New Growth Theory accentuates the importance of investing in new knowledge creation to sustain economic growth. Policy makers are urged to facilitate and encourage research and development, to enhance education methods, openness to trade in order to create and acquire new knowledge and ideas. This model ignores the perception of a one optimal equilibrium and is unable to predict prospective economic results.

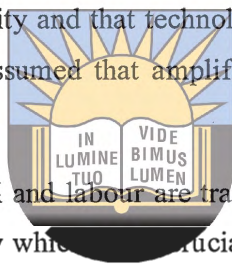
### 2.2.5 The Ecological Growth Theory

The role of electricity in economic growth stems from the economics of ecology and is also supported by geographers and economic historians. Economic history purports that energy; electricity in particular played a pivotal role in the industrial revolution. The theory of ecological economists states that varying combinations of capital, resources and technological progress put inadequate effort in alleviating the scarcity of resources. It is believed that electricity use is responsible for most increase in productivity and that technological progress only facilitates the use of additional electricity. Thus it is assumed that amplified electricity use is the basis for growth in GDP (Stern and Corden, 2011).

Ecological economics assumes that capital and labour are transitional factors of production that come from and are sustained by electricity which is a crucial factor of production. The crucial factor of production is considered to be the stock of fossil fuels and solar power. This view is formed on the basis of physical science models which consider that the rate of electricity extraction is based on geological barriers and the actual flow of electricity is the factor of production (Odum, 1994).

According to the ecological view, the level of electricity supply is calculated in terms of the associated electricity consumption. Thus market prices of goods and services should be based on the underlying electricity cost. Another assumption of this model is that there are constant returns to scale. The production function of the entire economy is a simulation of a Leontief model with energy as the single factor of production. Because information is also an important factor of production it is difficult to argue for a model where energy is the sole factor of production (Stern and Corden, 2011).

Biophysical economists put forth the idea that underlying energy in natural resource factors should also indicate total available energy. They developed the Energy return on investment (EROI) which is a proportion of valuable energy acquired from energy supply to the quantity of energy invested in obtaining that energy. A lower value of energy will yield a low EROI. If a high supply of electricity is employed to obtain electricity then there will be less electricity



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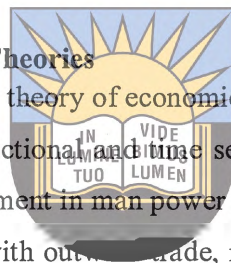
available for alternative use and such is the challenge of poor countries. Labourers in preindustrial civilizations would be employed in producing food and fuel but only a handful of those communities would use the additional energy for other uses (Odum, 1994). According to Stern (2010) it follows that a higher EROI through more use of fossil fuel facilitated the industrial revolution and the proceeding contemporary economic growth. A low EROI adversely affects the level of production in the economy and thus economic growth. However Murphy and Hall in several of their works have stated that a decline in EROI can be eradicated through the substitution of other production inputs for electricity or the advancement in the adeptness in electricity use (Stern and Corden, 2011).

### 2.2.6 Empirical validity of the Growth Theories

Knight *et al.* (1993) tested the neoclassical theory of economic growth by employing a panel data method to data for 98 countries. Cross sectional and time series analysis was used to examine factors focused with outward trade, investment in man power and civic investment. The observed outcome confirmed that factors focused with outward trade, investment in man power and civic investment significantly and positively affected GDP. Hence the positive and significant impact on economic growth. In addition, the estimated rate at which the margin between high income individuals and low income individuals can be diminished was provided.

Kaufmann and Azary-Lee (1991) also synthesized and tested growth theories in their research on unified models of energy and growth. Traditional growth models do not acknowledge energy or electricity. Neither do these models make an analysis to see whether scarce natural resources can be a barrier to economic growth. The economics of ecology postulates a significant role for energy in spurring on economic growth. However it is also included under that theory that limitations to the substitution or technical progress might hinder future economic growth.

Before the industrial revolution output per labourer was low and economies could not sustain continued economic growth. Ecological economists post that the introduction of use of fossil fuels is responsible for the industrial revolution and the growth of many economies. Traditional growth models which do not include energy or electricity in their theory attribute economic growth to technical change. The change in technical progress tested by Weil's (2009) models GDP as a function of the size of the population and education level. At first there is low technical



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progress and then as population grows there is a second round of technical progress and education and this births an equilibrium which is the only one in the model.

Hansen and Prescott (2002) examined the validity of growth theories, postulating a model of an economy which transitioned from a Malthusian level to that of Solow. During the Malthusian era land is a primary factor while diminishing returns apply to labour and capital. The contemporary Solow era is characterized by constant returns to capital and labour and its transition begins when technological progress makes economic returns from use of new technology. However the conclusion from Hansen and Prescott is that although the Solow period might employ a technology which uses fossil fuels instead of land, they have not clearly included electricity or energy in their model.



### 2.3 Empirical literature

This section analyses studies on the impact of energy on economic growth and sheds some light on the relationship between electricity and economic growth. The relationship between energy consumption and economic growth has been debated quite extensively in literature, yet the direction of the causality relationship remains unresolved. The debate has focused on whether energy consumption causes economic growth or economic growth causes energy consumption, or whether a two-way relationship exists. From a policy viewpoint, the direction of causality between these variables has important implications. For instance, a finding in favor of a positive unidirectional causality running from GDP to electricity consumption finding implies that a country is not dependent on energy for growth and development. This is a strong justification for energy conservation policies, such as electricity rationing.

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However, if unidirectional causality runs from electricity consumption to GDP or labour force, then reducing electricity consumption could lead to a fall in income and/or employment. This is because a finding confirming evidence in favor of energy positively causing GDP implies that the country in question is energy dependent and negative shocks to energy, such as shocks leading to higher energy prices or energy conservation policies, will negatively impact on GDP (Narayan and Singh, 2007).

Empirical literature is categorized in a number of ways. These include categorization by country (developed and developing), variables used and also by type of analysis (survey and econometric studies). The empirical literature review in this section follows the first categorization. Empirical

literature to be considered are those from the developed countries in Europe, America and Asia, and those from least developed countries in Asia and Africa. The different results emanating from the literature across countries originate from the divergent assumptions, underlying estimation models, economic characteristics and sample era used.

### 2.3.1 Empirical literature from developing countries.

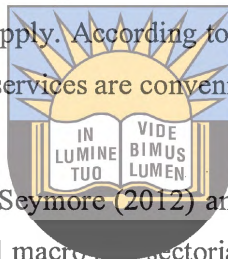
This section presents empirical literature from developing countries. Countries which are discussed in this section are Ghana, Fiji, Nigeria China, Korea, five South East Asian countries, 21 African countries and sub-Saharan African countries.

#### 2.3.1.1 African countries.

Using the rolling regression technique, a study by Adom, Bekoe and Akhoena (2011) investigated how the effects of income, economic structure and industry efficiency on aggregate electricity demand vary with time. Adom *et al.* (2011) used the Quandt– Andrews test to examine the presence or otherwise of structural breaks in the data set. Similar to South Africa's current electricity crisis, Ghana's electrical sector grapples from the prolonged challenge of frequent power outages with very high uncertainty levels in the timing, frequency and duration. Adom *et al.* (2011) employed the ARDL and Toda and Yomamoto Granger causality to investigate the long-run relationship and short-run causal relationship between electricity consumption and economic growth in Ghana. The author concluded that electricity consumption and economic growth are co-integrated and that in the short-run, economic growth causes electricity consumption. This is also in line with the result of Wolde-Rafael (2006), who also found evidence in support of a unidirectional causality from economic growth to electricity consumption for country groups that include Ghana. On the other hand a different conclusion came across from the study by Kwakwa (2012) which is a bidirectional causal relationship between economic growth and electricity consumption. Kwakwa (2011), in a disaggregate analysis of the relationship between economic growth and electricity consumption, found that economic growth causes an increase in electricity consumption in Ghana.

Dantama, Abdullahi and Inuwa (2012) studied the impact of energy consumption on economic growth in Nigeria over the period 1980-2010. In this study annual time series data were collected on real GDP proxied for economic growth and the energy consumption variables were electricity, coal and petroleum. The short-run and long-run relationship between energy

consumption variables and economic growth are estimated by using the developed autoregressive distributed lag (ARDL) approach to co-integration analysis. The results indicate a long-run relationship between economic growth and energy consumption variables. The coefficient of coal consumption is positive but statistically insignificant (Dantama *et al.*, 2012). These authors also found that petroleum consumption and electricity consumption have a positive, statistically significant relationship with GDP. In addition, the coefficient of error correction model put forward the notion that the speed of adjustment in the estimated model is comparatively high with an anticipated significant and negative sign. Dantama *et al.*, (2012) mentioned that the Nigerian régime must uphold its transformation agenda on electricity infrastructure to create sufficient power supply. According to their recommendation, one way to achieve this is by ensuring that electricity services are conveniently available and affordable.

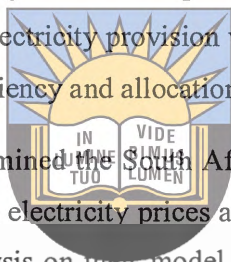


### 2.3.2 South Africa

A research done by Akanbi, Abedian and Seymore (2012) analysed the impact of an increase in Eskom's capital expenditure on the overall macro and sectorial economy. In this study two basic methods are used in the analysis namely the Short-Run Macroeconomic (TSME) model and a Computable General Equilibrium (CGE) model. The TSME model quantifies the impacts of the Eskom capital expenditure on the economy under a dynamic framework while the CGE model seeks to examine this in a static framework. The model results from the TSME model reveal that in the long-run, major macro variables such as household consumption, GDP, and employment are positively affected by the increased investment. A weak transmission mechanism of the shock on the macro and sectoral economy is detected both in the short-run and long-run due to the relatively small share of electricity investment in total investment in the economy. On the other hand, the simulation results from the CGE reveal similar but more robust positive impacts on the macro economy. Most of the short-run macroeconomic impacts are reinforced in the long-run.

Amusa *et al.* (2009) applied a bounds testing approach to co-integration within an autoregressive distributed lag framework to examine the aggregate demand for electricity in South Africa during the period 1960–2007. The results indicate that in the long-run, income is the main determinant of electricity demand. With electricity prices having an insignificant effect on aggregate electricity demand, future pricing policies will need to ensure that electricity prices are cost reflective and enhance efficiency of electricity supply and use.

According to Amusa *et al.* (2009) the empirical results indicate that in the long-run, income is the most important determinant of aggregate electricity demand in South Africa. In this study electricity price elasticity was in the range of minus 0.12 and 0.5. This is in line with other previous studies for example in a study of electricity demand Latin American countries, Balabanoff (1994) reports income elasticities of 1.73 and 1.88 for Brazil and Colombia, respectively. Similarly, Al-Faris (2002) reported that income elasticities for electricity in Gulf Cooperation Council countries range from 0.33 to 2.65. Amusa *et al.* (2009) concluded that in the South African environment where electricity demand is insensitive to price changes and lacks any close substitutes, there will be advantages from the apt costing of electricity. Implementing tariff reforms that reflect the true cost of electricity provision will assist in better management of electricity demand and boost resource efficiency and allocation.



Inglesi-Lotz and Blignaut (2011) also examined the South African economic sector's electricity consumption in response to fluctuations in electricity prices and economic output for the period 1993 to 2006. They used panel data analysis on their model and it exhibited that the industrial sector was the only one with statistically significant price elasticity over the study period. This is in contrast with the other three sectors, agriculture, transport and mining, whose electricity consumption was affected neither by price nor by their production. According to Inglesi-Lotz and Blignaut (2011) this anomaly is the result of both the relatively low and declining (in real terms) electricity prices over the study period, and the fact that the proportion of electricity cost to total cost is relatively small for the majority of sectors. There was therefore no major incentive to reduce electricity consumption and/or to be efficient.

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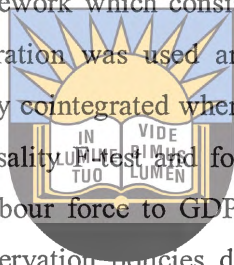
While these results explain, at least in part, the historical increases in electricity consumption, they may not hold for the period since 2008 (for which adequate data is not yet available), given the sharp increases in electricity prices recently experienced by the country.

### 2.3.3 Asian and Pacific Countries

Yuan, Kang, Zhao and Hu (2008) used a neo-classical aggregate production model of the Chinese economy whereby capital, labour and energy were treated as separate inputs. These authors set to test for the presence and direction of causality between output growth and energy use in China at both aggregated and disaggregated levels. Using the Johansen cointegration technique, their findings indicated that there exists long-run cointegration among output, labour,

capital and energy use in China at both aggregated and all three disaggregated levels of oil, coal and electricity. Then using a Vector Error Correction (VEC) specification, the short-run dynamics of the interested variables were tested. (VEC) demonstrated Granger causality running from electricity and oil consumption to GDP but there was no Granger causality running from coal and total energy consumption to GDP. On one hand, short-run Granger causality was present from GDP to total energy, coal and oil consumption while on the other hand it was absent from GDP to electricity consumption.

Narayan and Singh (2007) investigated the nexus between electricity consumption and economic growth for Fiji within a multivariate framework which consisted of labour force as a variable. The bounds testing approach to cointegration was used and the result was that electricity consumption, GDP and labour force is only cointegrated when GDP is the endogenous variable. Narayan and Singh used the Granger causality test and found that in the long-run causality runs from electricity consumption and labour force to GDP, implying that Fiji is an energy dependent country and thus energy conservation policies dependent and negative shocks to energy, such as shocks leading to higher energy prices or energy conservation policies, will negatively impact GDP and therefore adversely affect Fiji's economic growth (Narayan and Singh, 2007).



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#### **2.3.4 Empirical Literature from developed countries**

This section presents empirical literature from the developed countries. The countries which are discussed in this section are Italy, OECD countries, Japan and industrialized countries.

Stern (2011) used evidence from the economies of the United States of America (USA) and Sweden in order to investigate the mainstream resource economics and ecological economics models of growth. A fusion of energy-based and mainstream models is presented to show that when energy is scarce it imposes a strong constraint on the growth of the economy. However, it was also discovered that when energy is abundant, its effect on economic growth is much reduced. Stern (2011) also makes reference of how the industrial revolution decreased barriers to economic growth through the development of new methods of using coal and the discovery of new fossil fuel resources. Time-series analysis shows that energy and GDP cointegrated, and energy use Granger causes GDP when capital and other production inputs are included in the vector autoregression model. Stern (2011) also concluded that many mechanisms can weaken the

links between energy and growth. For instance, energy used per unit of economic output has declined in developed countries such as the United States Africa, owing to both technological change and a shift from poorer quality fuels, such as coal, to the use of higher quality fuels, especially electricity. Substitution of other inputs for energy and sectorial shifts in economic activity play smaller roles.

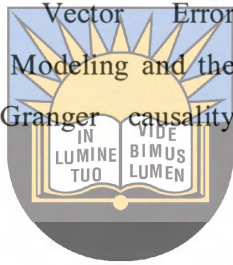
Bretschger (2007) developed a theoretical model with different channels through which energy prices affect economic growth. He envisaged an environment whereby intensive energy use results in the crowding out of capital accumulation. In his study Bretschger (2007) used a sample of 37 countries (which are Australia, Austria, Belgium, Canada, Cyprus, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland, Turkey, UK and USA) and employed panel data over the period 1975-2004 of negative annual averages.

Using a system with positive simultaneous equations on the panel data his estimation led to the conclusion that rising energy prices are not a general threat to long-term economic development. On the contrary, according to Bretschger (2007) lower energy use has a positive impact in the long-run in the sense that decreasing use of energy in production prompts investment in physical and human capital which raises the growth rate. However a cross sectional analysis of countries reveals a rather dissimilar illustration. For the OECD-countries, the simple correlation between energy use and growth is negative.

In economies where energy prices are relatively high, for example Japan, the growth rates are high as well. On the other hand those economies with relatively low energy prices, especially less developed oil producing economies have shown low growth rates. In this study Bretschger (2007) also concludes the idea that high energy prices can be good for growth is somewhat counterintuitive. Bretschger (2007) cautions that intuition may have been based on the business cycle in the 1970s and not on long-run growth experience. In his model Bretschger (2007) assumes that energy is an input in all sectors of the economy. However because the high interdependency of the variables in this model induces simultaneity.

Table 2.1: A review of Selected Studies from around the World.

Study	Methodology	Findings
Stern (2011) (Japan, USA and OECD and Industrialized countries)	Vector Autoregression Modeling, Johansen cointegration technique and the standard Granger causality test	Energy and GDP cointegrated, and energy use Granger causes GDP
Bretschger (2007) Australia, Austria, Belgium, Canada, Cyprus, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland, Turkey, UK and USA	Johansen cointegration technique, Vector Error Correction Modeling and the standard Granger causality test	In economies where energy prices are relatively high, for example Japan, the growth rates are high as well.
Narayan and Singh (2007) (Fiji)	Johansen cointegration technique and the standard Granger causality test	Electricity consumption, GDP and labour force are only cointegrated when GDP is the endogenous variable. In the long-run causality runs from electricity consumption and labour force to GDP.
Akanbi <i>et al.</i> (2012) (South Africa).	Time-Series Macro-Econometric (TSME) model and a Computable General Equilibrium (CGE) model.	In the long-run, major macro variables such as household consumption, GDP, and employment are positively affected by the increased investment.



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### 2.3.5 An overall analysis of empirical literature

Empirical literature investigated by the study showed that there is a relationship between the two variables. Studies conducted in developing countries were analysed and it was observed that found that economic growth causes electricity consumption in Ghana. In Nigeria the results indicate a long-run relationship between economic growth and energy consumption variables. Moreover, the coefficient of coal consumption is positive but statistically insignificant (Dantama *et al.*, 2010). These authors also found that petroleum consumption and electricity consumption have a positive, statistically significant relationship with GDP. An analysis of the methodologies applied in these studies was examined and it was seen that the Vector Error Correction Model, Johansen Cointegration Tests and the Granger Causality tests were the most widely used tools in examining the link between the electricity prices and economic growth.

An analysis of studies conducted in emerging economies was also examined and it can be noted that in Amusa *et al.* (2009) the South African environment is characterized by electricity demand which is insensitive to price changes and lacks good substitutes. Thus it is concluded that there will be advantages from the upriving of electricity. Implementing tariff reforms that reflect the true cost of electricity provision will assist in better management of electricity demand and boost resource efficiency and allocation. In China electricity and oil prices were found to have a long-run cointegrating relationship with GDP and electricity consumption granger causes GDP. In developed countries, Energy and GDP cointegrated, and energy use Granger causes GDP. Furthermore, in economies where energy prices are relatively high, for example Japan, the growth rates are high as well.

### 2.4 Conclusion

This chapter reviewed literature relating to the impact of electricity prices on economic growth in South Africa. Consideration was given to the theory of cost push inflation, the neo classical growth model, the Harrod-Domar growth theory, the endogenous growth model and the ecological economics approach. All these theories explain the relationship that exists between energy prices and economic growth. Empirical studies that examined the link between electricity prices and economic growth were also assessed. Results from various studies examine the relationship or the impact of electricity consumption or demand on economic growth and hence do not expose the impact that electricity prices have on economic growth. There exists theoretical consensus on the existence of a relationship between electricity prices and economic

growth. However, the direction of the relationship is not clear (that is, whether causality flows from electricity prices to economic growth or vice versa). This study overlaps with and draws on relevant aspects of the foregoing studies but defines its scope somewhat differently.



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## CHAPTER THREE

### An overview of the electricity prices and economic growth developments in South Africa

#### 3.0 Introduction

The aim of this chapter is to present an overview of the trend in electricity prices and economic growth over the period 1986 to 2013. The knowledge of the electricity pricing policies and changes in economic growth helps to shed light on understanding the reason why electricity prices have an effect on economic growth. This chapter is divided into four sections. The first section of this chapter gives an overview of the history of electricity prices and developments in the policies pertaining to electricity prices in South Africa. An understanding of the South African electricity policy and the behaviour of electricity prices is crucial to policy makers.

The second section provides an analysis of the developments of the economic growth of South Africa. An overview of economic growth trends is necessary as it is not only central to this study but it is imperative in order to understand the role which electricity play in the growth of the economy. The chapter ends with some concluding remarks to serve as a summary of the whole chapter.

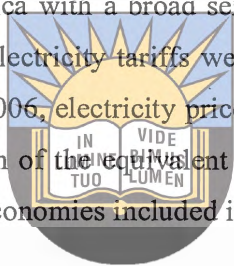
#### 3.1.1 International comparisons of electricity prices

Second only to New Zealand, electricity prices in South Africa are viewed as the lowest in the world (Van Heerden, Blignaut and Jordaan, 2008). The cost of electricity as a fraction of the whole production cost to the supplier has been small. This fraction is usually below 5% even though the contribution of electricity towards GDP is 3.5%. According to Inge-Lotsi (2011) that is part of the reason why the quantity demanded for electricity has remained the same and electricity demand was observed to be price insensitive even when price changes.

Industries in South Africa are charged US\$0.01andkWh while households are charged US\$0.03andkWh. The only country that has ever come close to that household price is India which charges US\$0.04andkWh (Van Heerden *et al*, 2008). There are large margins in the differences in prices charged to different consumers in South Africa for instance in 2004 Households and the Agricultural sector paid the highest prices of 38.7 candkWh and 30.8

candkWh respectively. On the other hand Manufacturers paid 13.97 candkWh while mining industries paid 15.36 candkWh which was approximately half the price of household consumption. This may be caused by the fact that household consumption has numerous customers unlike the manufacturing and mines sector and thus the latter who consume nearly 60% of total electricity supplied receive wholesale discounts. Real electricity prices have decreased since 1995. At this time Eskom believed that lower electricity prices would ignite economic growth. Using the price compact approach electricity prices declined by 43% for all sectors and by 53% for the manufacturers alone.

An international comparison of South Africa with a broad selection of countries reveals that in 2006, Eskom's industrial and household electricity tariffs were among the lowest in the world (International Energy Agency, 2010). In 2006, electricity prices charged to manufacturing firms in South Africa were approximately a fifth of the equivalent OECD Europe average electricity price. This was at the bottom of the total economies included in the International Energy Agency Report.



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Despite the sharp 78% increase in real electricity prices between 2008 and 2011, a more recent survey of international electricity prices by NUS Consulting (June 2011) shows that South Africa still had one of the lowest average electricity prices compared to a smaller sample of 15 developed countries. Moreover, when this survey was undertaken the exchange rate was comparatively resilient with the rand trading at 6.80 to the United States dollar.

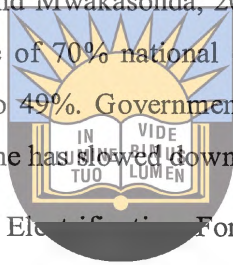
While the margin between the price of electricity in South Africa and other developed countries has thinned out, the assessment made suggests that in 2011 electricity prices in South Africa were still low by international standards and beneath 'cost-reflective' levels. South Africa's electricity prices are still low when equated to a country like Australia which also primarily produces electricity largely from coal.

### **3.1.2 The post-1994 restructuring of the South African electricity sector.**

During apartheid the structural progress of the economy was based on race margins and this array extended to the electricity sector. Emphasis of energy supply was on manufacturing and mining firms and white residential property (Davidson and Mwakasonda, 2004). Under the new independent regime in 1994 energy policy took on a different path. The new regime placed

importance on the supply of electricity to the marginalized in its intonation: “access to electricity for all” (Davidson and Mwakasonda, 2004).

In its effort to ensure electricity provision to the poor, the National Electrification Program was introduced by the government. This was spurred on by the fact that only 36 % of the South African residents had access to electricity in 1993 (Davidson and Mwakasonda, 2004). Firstly the National Electrification Program provided access to grid electricity and then brought up off-grid electrification at a later stage. This government funded enterprise targeted the formerly marginalized areas, schools and clinics. NEP set out to enlarge national electrification levels to nearly 70% by the year 2001 (Davidson and Mwakasonda, 2004). The task was to electrify 2.5 million households. The set out objective of 70% national electrification was attained. Rural homes with electricity access increased to 49%. Government continues to increase electricity access although the rate at which this is done has slowed down.

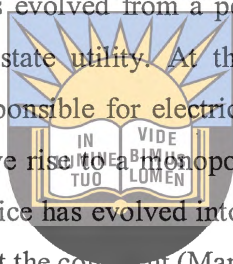


Under policy restructuring the National Electricity Forum was created in 1994 and it reflected the modification of the electricity sector to the national cabinet. The Reconstruction and Development Program (RDP) proponents endorsed this as a key program setting electrification goals for residents, health facilities and schools. The new regime also set up the National Electricity Regulator (NER) in 1995 to replace the 1987 Electricity Control Board (Davidson and Mwakasonda, 2004). In 1998 government changed the South African electricity sector created the White Paper on the Energy Policy of the Republic of South Africa (hereon, the White Paper). The White Paper’s key objective is to establish an energy industry capable to stimulate incessant economic growth and a successful nation (DME, 1998).

The reformation of the electricity sector included the improvement of the generation, transmission and distribution of power. Like many public service divisions in South Africa, restructuring consisted of fractional privatisation which would advance competitiveness and therefore the efficiency of the industry. Another reason for the reformation was to rectify past inequalities in management and operations of the energy industry. To date Eskom is the prevalent state owned supplier of electricity generation. This state owned utility is responsible for the operation, maintenance and nationwide transmission of energy and is in effect monopolist partly due to the nature of the industry (ISES, 2001).

Legislative changes in the year 2000 effected the conversion of Eskom into a tax and dividend-paying firm through the Eskom Amendment Act 126 of 1998 (FFC, 2002). This preceded the declaration of the Eskom Conversion Act 13 of 2001, which results in unbundling Eskom's generation and transmission operations, licensing each unit separately. Under this Act 30 % of Eskom's generating equipment were sold by the year 2006 in an effort to gain independent power producers (Davidson and Mwakasonda, 2004). Concurrently the state owned utility took the initiative to serve 39 nations across the continent in a bid to make its products a commercial establishment.

The South African electricity industry has evolved from a period of minute systems set up by municipalities up to the founding of a state utility. At the end of the 19th century local municipalities and mining firms were responsible for electricity supply. In Witwatersrand the setting up of electricity to gold mines gave rise to a monopoly in the period 1900-1930. From here on till present day a government service has evolved into a system that generates transmits and distributes to the nation and throughout the continent (Marquard, 2006).



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However the volume of present electricity generation has a limit and cannot be extended. Thus it has become impossible to escalate quantity supplied in the short-run. An upsurge in economic growth, automation, and electrification program itself has led to higher electricity demand. Such an upsurge coupled with inadequate electricity supply brought about national black outs that threatened continued economic growth. Eskom has responded to the situation by embarking on a capital expansion program that will reduce the imbalance between quantity demanded and quantity supplied.

The capital expansion entails a four power plant construction in Kusile, Medupi, Ingula, and Sere wind farm which will increase electricity supply by a total of an estimated 11000MW. In addition the development of a coal generation plant has ensued in Botswana which will supply 4,800 MW. Moreover, the existing plants will be renovated so as to efficiently extract energy across the country. These transitional strategies are called Simunye projects. These projected supply increments are to be in effect in 2015. Thus in the short-run electricity supply remains the same.

### 3.1.3 Distribution of Electricity

In 1990 Eskom branched out into urban councils and minute municipalities, making nearly 430 separated distributors (ISES, 2001). In 2003 190 licensed energy electricity suppliers still existed in South Africa, characterized by a relatively high price for local consumers due to the small number of consumers and sales. Currently (2015) the distribution of electricity continues to be disaggregated.

There are large electricity price margins among the varying industries in the country. Local customers also face noteworthy price differences according to the region they live in. Often low income households in rural regions of South Africa are charged higher per unit prices than those in metropolitan regions. More over there is a large price differentiation in those metropolitan or urban areas. For instance in 2001 residents in the township of Soweto paid 30% higher unit prices than the residents in affluent areas in Johannesburg (Fiil-Flynn and SECC, 2001).

Presently, a large quantity of electricity is distributed to municipalities which in turn feed demand by the Household, Residential, Industrial and Commercial sector. This group is the leading electricity consumer and producer in the country. It is often questioned if the price of electricity affected these consumption levels. Over the years the level of inflation has been higher than that of the increase in electricity prices. Many economists are of the view that Eskom hoped that electricity price increments would keep up with the inflation rate.

The White Paper held the conviction that the industry could finance the supply of electricity and electrification despite the fact that many distributors were financially unsustainable (DME 1998). This was implemented through the Electricity Distribution Industry Holdings (EDI Holdings) set up in 2003. EDI Holdings, a wholly government controlled entity, was tasked to apply and supervise the foundation of Regional Electricity Distributors (REDs) (Thale, 2004). These REDs are located in Johannesburg, Tshwane (Pretoria), Ekurhuleni (East Rand), eThekweni (Durban), Nelson Mandela Metro (Port Elizabeth) and Cape Town. Under the REDs system Eskom Distribution and the electricity distributing municipalities would shift their assets, liabilities, staff and rights to the six REDs (Thale 2004). Once established EDI Holdings would supervise and sustain the REDs until its disbandment in 2008 (Thale, 2004).

### 3.1.4 The era of formal electricity price regulation in South Africa

It was only in 2001 that the NER really began to engage in effective electricity price regulation and the development of a uniform regulatory methodology for price setting was initiated (Deutsche Securities Pty Ltd, March 2010). In the same year, The Eskom Conversion Bill of 2001 replaced the old Eskom Act of 1987 and Eskom was converted into a public company (Eskom Holdings Ltd), which with its share capital owned by the state was now subject to taxes and dividends. The stated aim of the bill was to bring about more efficiency and competitiveness in the running of Eskom, to expose the utility to global trends and to ensure that it was run in terms of a protocol on cooperative governance.

Although a framework for the economic regulation of electricity prices based on the Rate of Return (ROR) Methodology was approved in 2003 for implementation in 2004 it is clear that between 2001 and 2007, the price of electricity was simply increased in line with or somewhat below consumer price inflation. In 2005 the National Energy Regulator (Nersa) was established (replacing the NER in July 2006). In 2005 Nersa moved to multi-year price determination (MYPD) process for Eskom covering the period April 2006 to March 2009. The intention was that the MYPD would allow price stability under long-term planning horizon as Eskom had to start providing for large capital investments in new generation capacity. (Nersa, 2009).

For the first MYPD period, Eskom was initially granted a price increase of CPI plus 1%. The approved price increases however proved completely inadequate as the projected capital costs associated with the construction of Medupi and Kusile power stations (and associated infrastructure) rose from initial estimates of R97 billion to R345 billion. Eskom was also subject to large increases in primary energy costs as it increasingly had to source coal on the open market. In December 2007, Nersa granted Eskom a revised increase of 14.2% for 2008 and 9 (up from 6.2% previously).

In early 2008 demand for electricity outstripped supply and Eskom was forced to engage in extensive load shedding. In March 2008 Eskom applied for a further revision of the 14.2% increase (for 2008 and 2009) to 60%, the Regulator approved a further price increase of 13.3% bringing the overall increase for 2008 and 9 to 27.5%. Eskom was unable to submit a second MYPD application within the stipulated timelines because of uncertainty regarding its funding model and applied instead for an interim price increase of 34% for 2009 and 10. In September

Nersa approved a 31.3% increase but this included a government environmental levy of 2candkWh (so Eskom's effective increase was considerably lower). (Nersa, 2010).

Nersa received Eskom's MYPD2 application in September 2009. The application generated considerable public interest and so after a process of extensive stakeholder engagement Nersa granted Eskom price increases of 24.8%, 25.8% and 25.9% for 2010and11 through to 2012and13. In an attempt to appear to be softening the blow Nersa also decided to implement an inclining block tariff for domestic customers in the MYPD2 period. Over the period 2008 to 2011 Nersa's pricing decisions gave rise to a 78% increase in real electricity prices.

As a consequence of resource endowment and advantageous agricultural conditions, South Africa's economy has conventionally been imbedded in the primary sectors. On the other hand, the country has gradually experienced a structural shift in production over the last thirty years. As of 1990 economic growth has been propelled largely by the tertiary sector. This sector comprises wholesale and retail trade, tourism, and communications. In 2015 South Africa is shifting to being a knowledge-based economy, with a more focus on technology, e-commerce and financial and other services (Stats SA, 2013). The main sectors that contribute to GDP (gross domestic) are manufacturing, retail, financial services, communications, mining, agriculture and tourism.



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### 3.2 Electricity prices in South Africa

Cumulatively electricity prices increased by 11.96% since 1995 until 2000, an additional 34.58% from 2000 to 2006 and by 78% from 2007 until 2013. To say this is in contrast with sizeable demand surge and restricted supply is an understatement. Economic sectors have doubled their consumption since 1995 indicating increased growth in these sectors, for example the non-metallic mining companies, construction and the household sector.

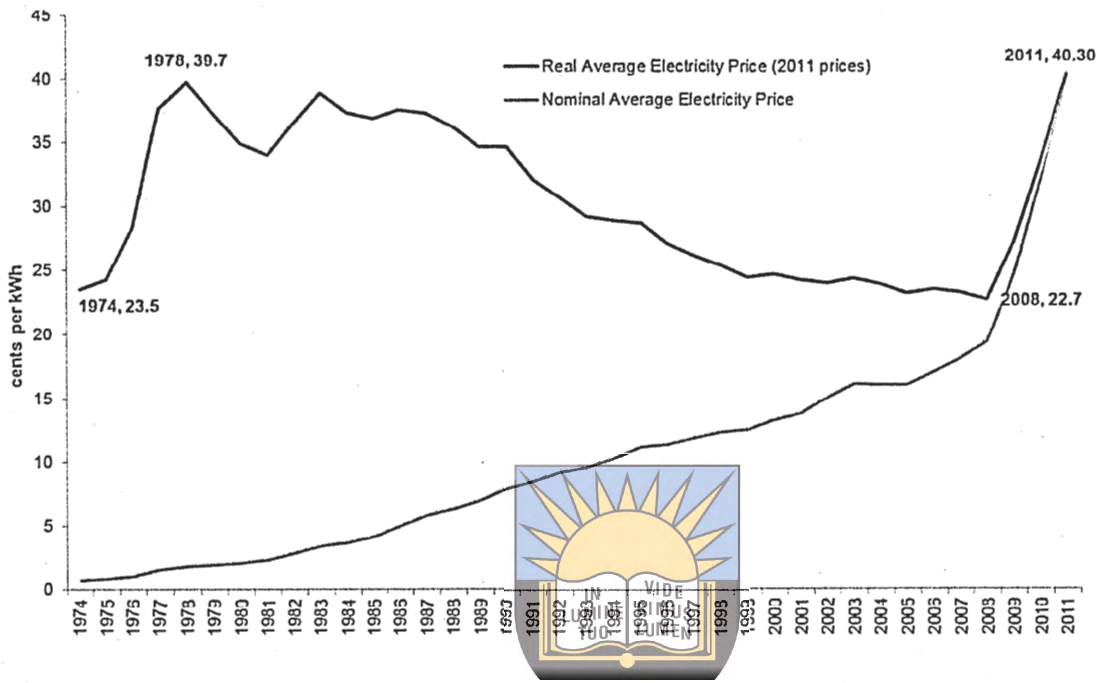
Although electricity prices had surged upwards from 1970 to 1983 it suddenly declined from the 1980s to 2000s. The surge in electricity prices in 1970 to 1983 was partly due to the global oil crisis and the sanctions placed on the country in the 1980s. The mining sector faced declining electricity prices until the early 2000s. In the transport sector consumption escalated from 1995 and then sharply decreased in the final years of the study period. The GDP of this sector persistently increased over the sample period even though electricity prices declined at first between 1993 and 2002 and then began to increase again afterward.

In agriculture it is believed that structural changes from 1994 until 2000 caused an upward turn in electricity usage. A decline in electricity usage of 31% is believed to have been caused by structural changes. However the GDP of this sector gradually improved over the years. Apart from 1997, the commercial sector's electricity usage also increased gradually over the years 1995 till 2012. Urban customers are charged 24cents per kWandh while rural customers are charged 48cents per kWandh (Fiil-Flynn and SECC, 2001). Such a distribution structure makes it challenging to meet financial liabilities since electrification to municipalities is financed through electricity tariffs (FFC 2002). This may be one of the reasons tariff increases became mandatory. This extra pecuniary affliction on consumers has a great impact on the poor.



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Figure 3.1: Real Average Electricity Prices in South Africa



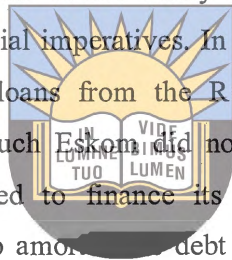
Several aspects of the South African electricity industry explain why there were low electricity prices. Eskom incurred comparatively low production costs in comparison with the cost of coal which is a main input in electricity production. The low production costs valued at 4candkWh to 5candkWh enabled Eskom to incur a small marginal cost of production and obtain substantial revenue. One reason for this is that the number of clients serviced in the Residential sector has been much larger than the number of clients serviced in the Manufacturing and Mining sectors, who consume about 65 per cent of total electricity. This indicates that Manufacturing and Mining receive bulk sales at lower prices.

Another reason why electricity prices have been considered low is the fact that energy costs were a fraction of 3 % to the total cost of production, an example that shows that in the past the proportion of electricity to total production costs was financially insignificant (Ziramba, 2009).

### 3.2.1 The major criticisms of South Africa's historical pricing policies

One of the major criticisms of Eskom's historical pricing policies is the fact that electricity prices in South Africa, while low by international standards, have remained well below 'cost-reflective' levels for a prolonged period of time. Electricity prices have not reflected the true economic cost of supplying power, which has led to poor investment decisions and a gross-misallocation of the country's economic resources.

It is argued that lenient financial requirements under full state ownership, state guarantees and Eskom's flawed historic cost-accounting practices contributed directly to the underpricing of electricity (Steyn, 2004). Eskom was a state-owned utility until 2001 and was not subject to taxes, dividends or other typical commercial imperatives. In the late 1980s it also received free forward cover on its foreign currency loans from the Reserve Bank and benefited from government guarantees on its debt. As such Eskom did not have to bear the full economic opportunity cost of the capital employed to finance its investments (including risk and uncertainty) and it was effectively able to amass debt while maintaining artificially low electricity prices.



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The traditional historical cost accounting approach is concerned with the recovery of sunk costs (for example recovering the actual cost of an investment in a newly constructed power station). Under this approach, electricity tariffs were designed to recover (in addition to variable costs) the depreciated historic cost of Eskom's assets multiplied by a nominal return on assets (ROA) (Deutsche Securities Pty Ltd, March 2010). But the historical cost asset valuation approach suffers from a number of drawbacks - Firstly it is a backward looking approach implies that future generation capacity will be as cheap or as expensive as it was in the past (Vedavelli, 1989). For example, if the cost of building a coal-fired power station has doubled since the last coal-fired power station was built and tariffs are based on the depreciated historic value of the existing station, there would be no incentive to expand capacity unless tariffs rose sharply since the power station investor would not be able to recover the cost of their capital investment at the existing low tariff.

Secondly tariffs based on historical cost accounting cannot incorporate the impact of evolving technologies and a potential change in plant mix. Tariffs based on historical cost approaches will not reflect the costs of a utility employing new technologies (be they nuclear, renewable or

simply more efficient) (Telecommunication Development Bureau, March 2009). Thirdly, the depreciation charge is determined somewhat arbitrarily and if assets exceed their estimated 'useful lives', the depreciated value of the asset will be zero and tariffs will reflect only the operating costs associated with the power plant and not its true economic value.

In the capital intensive electricity supply industry, where investments are lumpy and assets may last for 20 to 40 years, the historic cost approach will typically result in a declining tariff over the life of the asset and a large increase in tariffs when the old asset is replaced. In Eskom's case the decline in prices was particularly severe because after the over-investment in base load generating capacity in the late 1970s and early 1980s no new capacity was built for almost 20 years. Once the build program resumed, the existing asset base was so heavily depreciated that significant price hikes were required to fund investment in new capacity. Steyn (2006) notes that in 2006, Eskom's 39810 MW generation capacity had a balance sheet depreciated value of R24.7 billion. In the same year, the construction of a new 4000MW plant which would have added 10% to installed capacity would have cost around R26 billion – more than the balance sheet value of the entire existing asset base.



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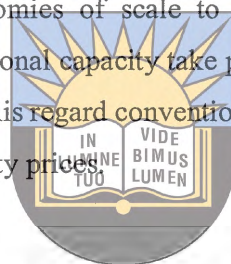
Electricity price adjustments in South Africa are currently determined by Nersa through the Multi-Year Price Determination (MYPD) methodology (2015). The MYPD is based on rate-of-return principles and was developed for the regulation of Eskom's required revenues, which is the basis on which prices are effectively adjusted. As discussed above, the first implementation period for the MYPD was from 01 April 2006 to 31 March (the duration of each MYPD period is three years) while the second and current period MYPD2 runs from 1 April 2010 to 31 March 2013 (Nersa, 14 October 2011).

### **3.2.2 Defining 'cost-reflective' tariffs**

There are many vast views about how cost-reflectivity should be defined (Danilyuk, 2009). The definition of cost-reflective tariffs is complicated by differences in the economic and accounting definitions of costs. Accounting costs are the costs that appear on a firm's financial statements. These are explicit financial costs that have been incurred in the past and tend to be backward looking. Economic costs by contrast are the sum of explicit costs and the implicit opportunity cost incurred and are forward-looking. According to Turvey (2000) economists define costs in terms of static, timeless models with continuous cost functions. However the reality is that costs

are based on businesses and systems which already exist and have accumulated a collection of assets of various vintages whose accounting cost reflects past prices, past circumstances and arbitrary conventions about depreciation.

According to economic theory a cost-reflective tariff is one that is equal to the long-run marginal cost (LRMC) of supply. This concept is consistent with the efficient allocation of economic resources. Resources are found to be most efficiently allocated when their prices are set according to marginal costs (London Economics, 1997). In the case of an electricity utility, the marginal cost is the cost of supplying one additional unit of electricity. However in the case of electricity industry there are large economies of scale to be realized in the generation of electricity. Moreover, investments in additional capacity take place in large discrete amounts and at intervals of several years. Therefore in this regard conventional short-run marginal cost pricing would lead to large fluctuations in electricity prices.



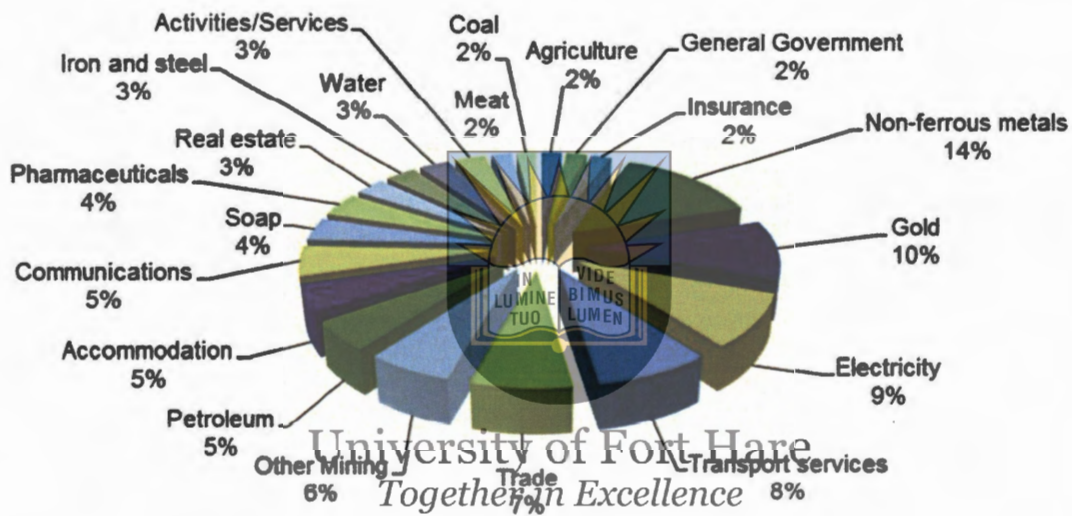
### **3.2.3 Electricity consumption**

The following section discusses the trend in South African electricity consumption. Usage of electricity comes in a twofold manner. Firstly, electricity usage may be considered from the supply side whereby electricity is a factor of production in the production process. Secondly electricity usage may be regarded from the demand side as the outcome of GDP and prices (Inglesi-Lotz and Blignaut, 2011). In Inglesi-Lotz and Blignaut (2011) a model was specified to examine the demand for electricity in South Africa. The results showed that the amount of electricity demanded in South Africa is a function of the price of electricity and the GDP of the many sectors in the economy. One such sector was manufacturing which uses up to 58% of total electricity usage (Inglesi-Lotz and Blignaut, 2011). Excessive coal supply is the cradle of South African energy.

The transformation of coal to man-made energy results in electricity supply. Other sources of energy are crude oil and nuclear energy. These sources supply 22%, 3%, 1% and 5%. Historically coal was the predominant electricity source providing 93 % of electricity in the economy in 2001 and nuclear and hydropower contributed the remaining 7 % (Inglesi-Lotz, 2011). Manufacturing sector consumed 40 % of overall electricity consumption in South Africa in 2012. The second largest consumers were mines at 27 % of overall consumption. Households in total used up to 17 %. Despite the upsurge in household electricity consumption and the fact

that it is the single largest consumer, its proportion to total supply has remained constant at 17%. Commerce and public services sector consumed between 10% and 13%. These partial sectorial electricity intake summaries reflect the change in economic structures and social divergence that have taken place since 1994.

Figure 1.2: Electricity Consumption by Sector.



Source: Stats SA, 2013

Non-ferrous metals and gold mining firms are the largest consumers of energy yet they add 14% to GDP (Statistics South Africa, 2013). On the other hand wholesale and retail industry consumes a relatively high amount of electricity and still contributes a large portion to GDP. Energy intensive sectors such as non-ferrous metals, soap and pharmaceuticals augment diminutive value to GDP in relation to the amount of energy they use up. However their overall contribution is more as they are connected to other economies.

### 3.2.4 Trend in electricity consumption by sector and customer segment

Two factors which influence electricity consumption at the sectorial and microeconomic level are the structural effect and the efficiency effect. The structural effect relates to the changes in the structure of the economy and differences in the energy intensity of different sectors. The efficiency effect is the influence of new technologies on electricity consumption. The structural

effect takes place when the total electricity usage of a country grows as its economy industrializes. This energy-intensity can reduce when that economy passes from the post-industrial phase to a services dominated economy (Inglesi-Lotz & Blignaut, 2011).

In 1970 the mining sector was responsible for 21% of South Africa's total GDP but by 2010 its direct contribution to GDP was only 6%. In divergence finance and business services was responsible for 24% of GDP in 2010 which had only been 15% in 1970. Even though less electricity intensive services increased their activity in South Africa the South African economy more than doubled its electricity consumption in the period from 1990 to 2007 (Inglesi-Lotz & Blignaut, 2011). The increase in electricity concentrated manufacturing activities in the 1990s may be accountable for this. The electricity consumption of the South African economy rose between 2001 and 2007. The reduction in consumption which follows could be as a result of the effects of the global recession on the mining decline in the electricity intensity of the economy since 2007 is probably due in part to the impact of the global economic recession in 2008 on the demand for mining and manufacturing exports from South Africa.



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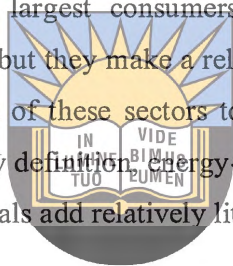
In terms of the current structure of the economy and contribution of the various sectors we found that the South African economy, like most post-industrial, middle to high income economies, is dominated by services related activity which accounted for just over two thirds (67%) of GDP in 2010. However, manufacturing remained the second-largest individual sector contributor at 17.2% of GDP and the, the direct contribution of the relatively energy-intensive primary and secondary activities which include manufacturing, mining, electricity and other utilities, and agriculture remains significant at 28% of GDP (Statistics South Africa, 2013).

The importance of an individual sector to a national economy however should be assessed both in terms of its contribution to output and employment. The sectors that make the largest contribution to employment in South Africa are wholesale and retail trade, government services and manufacturing. Industries such as construction and personal services make a relatively small contribution to GDP but are nevertheless critically important to the South African economy because they are very labour intensive and employ 9% and 12% respectively of the total labour force (Statistics South Africa, 2013).

In South Africa, the extent to which an industry generates or can generate employment for relatively low skilled workers is also of interest to policymakers because a large proportion of

the potential workforce and unemployed have attained only a basic level of education. It has been argued that the economy would become more energy intensive if it is reoriented towards creating employment for semi-skilled and unskilled workers but it is not clear that this would be the case since the industries that demand the largest proportion of low and semi-skilled labour are agriculture (85%), private households (89%) and construction (70%) and wholesale\retail trade (53%) and these labour intensive industries are generally among the least energy intensive (Statistics South Africa, 2013).

In terms of the contribution of sectors to total electricity consumption we found that non-ferrous metals and gold mining are the single largest consumers of electricity in South Africa, responsible for 25% of total consumption, but they make a relatively small direct contribution to GDP (about 4%). The overall contribution of these sectors to GDP however, also depends on their linkages to sectors in the economy. By definition, energy-intensive sectors like gold mining, non-ferrous metals, soap and pharmaceuticals add relatively little value to the economy (in terms of GDP) per unit of energy consumed.



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At the macroeconomic level, the key drivers of electricity consumption are income and the price of electricity. Over the past two decades, economic growth (income) has proven to have been the main driver of electricity consumption in South Africa while electricity prices used to have insignificant bearing on electricity consumption. The responsiveness of electricity consumption to electricity prices increased as electricity prices rose beyond certain 'threshold' levels and started to influence consumption.

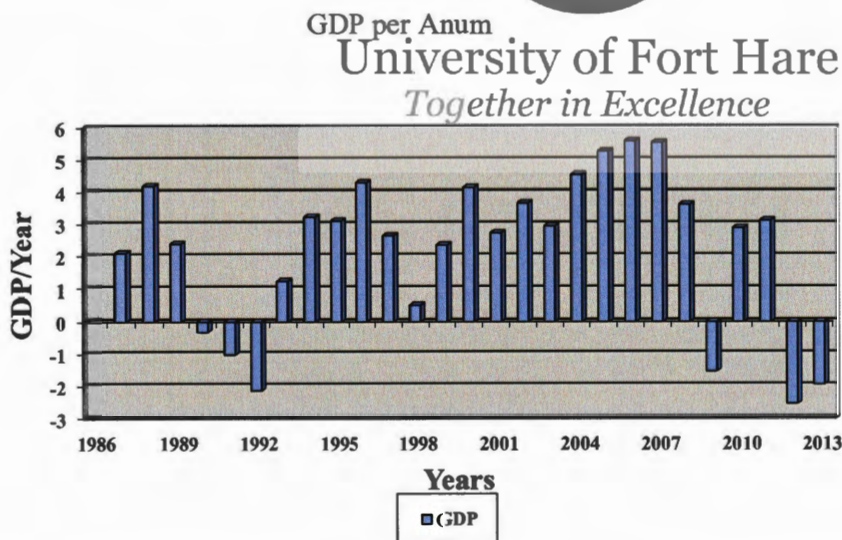
Despite the increasing contribution of less energy-intensive services to the economy, the electricity intensity of the South African economy more than doubled in the period from 1990 to 2007. This was probably due to the increase in energy-intensive manufacturing activities in the 1990s, particularly investment in the non-ferrous metals sector. In early 2008 South Africa experienced a series of highly disruptive outages and load-shedding episodes that came at an enormous cost to the economy. The electricity supply crisis, finally prompted decision makers to respond to the capacity shortage that had been threatening to emerge for some time, and Eskom ensued a large investment program.

### 3.3 Trends in Economic Growth in South Africa

South Africa has the second largest economy in Africa. The country has an abundance of natural resources and is a leading producer of platinum, gold, chromium and iron. GDP at the beginning of the study period is much lower due to the sanctions placed against the ruling apartheid regime. The new democratic government introduced policies that resulted in lower inflation, stable public finances and foreign capital. In the year 2000 then President Thabo Mbeki promoted economic growth and foreign investment by reducing strict labour laws, accelerating privatisation, increasing government expenditure and decreasing interest rates. From 2004 economic growth rose substantially. South Africa grew at an average rate of 4.5 per cent per annum between 2002 and 2008. This was its fastest growth since independence in 1994. The aftershocks of the 2008 global recession began to affect South Africa in 2009 and economic growth took a downward trend.



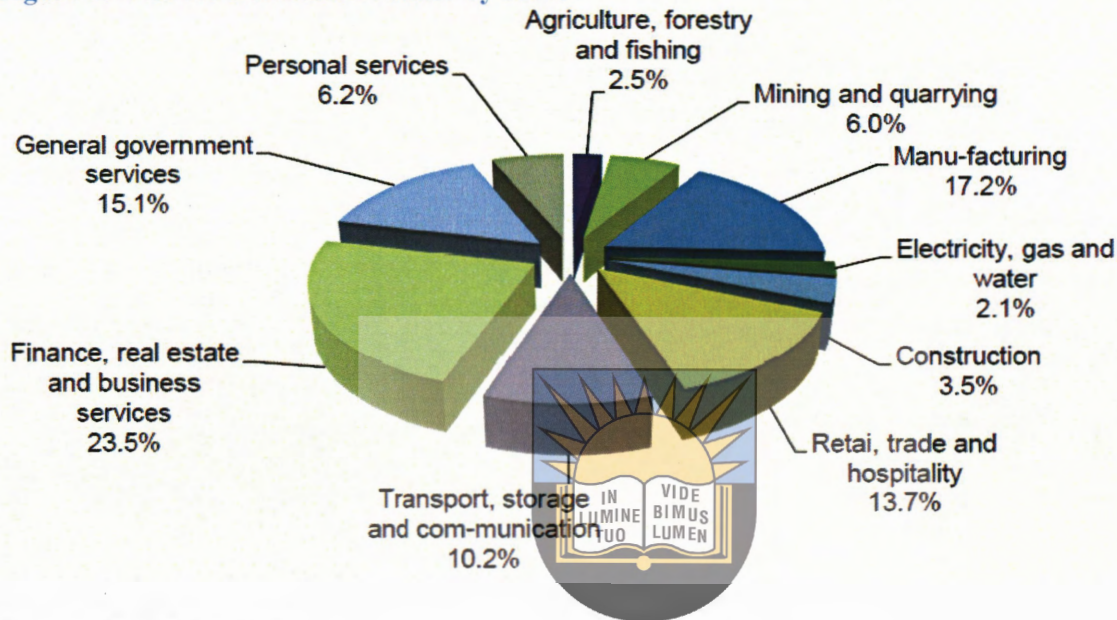
Figure 3.3: Trends in Economic Growth



Source: Own graph made from figures from SARB (2013).

The mining sector has played a leading role in the history and progress of South Africa’s economic growth. Although mining’s impact to economic growth has decreased from 21% in 1970 to 6% in 2012, it still contributes nearly 60% of exports. On the other hand South Africa as a post-industrial middle to high income economy is steered by services-related activity.

Figure 3.4: Gross Domestic Product by Sector



Source: Stats SA (2012)

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Service related economic activity single handedly contributed over two thirds (67%) of GDP in 2013. In 2013, finance and business shared the largest proportion of GDP at 23.5%. Second to that was Government services (15.1%), in third place was the trade and accommodation sector at 13.7% and transport contributed the least proportion of 10.2%.

However the manufacturing sector was the second-largest individual sector contributor at 17.2% of GDP in 2013. Frost and Sullivan (2011) argue that while South Africa has become a largely services dominated country, the direct contribution of the energy intensive sectors is still significant. Sectors regarded as energy intensive are manufacturing, mining, electricity and other utilities as well as agriculture.

The direct proportion of output from the electricity, gas and water industry is only 2.1%. Nonetheless this industry has the enabling role of a dire input for all the other sectors of the country. Even though it only adds 12% towards GDP directly, it ominously supports jobs and gives output within the tertiary and secondary sectors.

The prominence of a single sector to a country ought to be weighed in relation to its contribution to GDP and employment. In a country like South Africa which bears an unemployment rate of 25% (Frost and Sullivan, 2011), a sector that escalates employment is more favorable to social and economic stability, than that which increases GDP. The National Planning Committee (NPC) report and the New Growth Path (NGP) ascertain employment creation as being of utmost importance. On that note it is important to consider the fact that finance and business services, contributed 23.5% of GDP in 2013 but only has a 14% proportion to total employment. Conversely wholesale and retail trade contributed 13.7% of GDP but employed 25% of the South African labour force in the same year. Therefore some sectors have higher employment to GDP ratio than others which makes them relatively more labour intensive (Statistics South Africa, 2013).



### 3.4 Conclusion

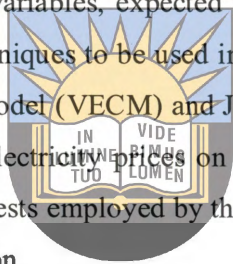
The purpose of this chapter was to give context to the broader analysis of the impact of rising electricity prices on different sectors of the economy, by providing a brief overview of the current structure of the South African economy and the trends in the drivers of electricity consumption. This chapter provided a background to the study by analysing developments in electricity price increases and by providing an overview of economic growth. An overview of the developments of the increase in electricity prices was necessary as it is through examining these developments that we can understand the impact of electricity price increases on economic growth. The electricity prices in South Africa have increased considerably. Since the economic activity increased substantially the electricity supply industry has been characterized by excessive price increments. A general analysis of the performance of the electricity consumption and economic growth was also conducted. An analysis of both the electricity consumption and the economic growth was also necessary to see the relationship that exists between the two. Clearly, prices of electricity charged to South African consumers affect the economic growth of the country. Changes in electricity prices have considerable effects on the way in which economic growth develops. The next chapter shall provide the methodology and estimation techniques used to determine the impact of electricity price increases on economic growth.

## CHAPTER FOUR

### Methodology.

#### 1. Introduction

Chapter four examines the methodology employed in finding the impact of electricity prices on economic growth in South Africa and also sets the analytical framework that is used in this study. The chapter is divided into five sections, with the first section examining and constructing the model specification to allow the construction of variables to be estimated in the study. The second section looks at the definition of variables, expected priori and data sources. The third section looks at different econometric techniques to be used in performing the model estimation of the study. A Vector Error Correction Model (VECM) and Johansen approach to cointegration will be used to measure the impact of electricity prices on economic growth. Following this section is a presentation of the diagnostic tests employed by the study. This chapter closes with a summative conclusion in the fifth subsection.



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#### 4.1 Model Specification

In order to measure the impact of electricity prices on economic growth in South Africa, this study follows the framework used in (Ghali and El Sakka, 2004) and also used in Yuan, *et al.*(2008). Ghali and El Sakka (2004) used the orthodox neo classical aggregate production model whereby capital, labour and energy are treated as separate units. The study employed the following model:

$$Y_t = F(K_t, L_t, E_t) \dots\dots\dots(4.1)$$

Where Y is the aggregate output or real GDP, K is the capital stock; L is the employment level; E is the total energy consumption in aggregated level or coal or oil consumption and the subscript t denotes the time period. The differential of equation 1 and dividing through  $Y_t$  will yield;

$$Y_t = aK_t + bL_t + cE_t \dots\dots\dots(4.2)$$

The constant parameters  $a$ ,  $b$ ,  $c$  are the elasticities of output with respect to capital, labour and energy respectively. The relationship between output labour, and capital and energy described by the production function in equation 1 suggests that their long-run movements maybe related.

Thus, in formulating the model for economic growth for South Africa the work of Ghali and El Sakka, 2004 and Yuan *et al.* (2008) is followed closely and the following specification from equation 2 is adopted and modified:

$$Y_t = aK_t + bL_t + cE_t \dots \dots \dots (4.2)$$

Whereby the relationship between output labour, and capital and energy are described by the production function.

The model to be estimated in this study will be written in linear form as follows:

$$Y_t = aElec_t + bLABPRO_t + cINT_t + \beta PPI_t + U_t \dots \dots \dots (4.3)$$

- Where  $Y_t$  = Real GDP as an endogenous variable
- $aElec_t$  = Electricity prices for the period 1995Q1 to 2012Q4
- $bLABPRO_t$  = Labour productivity in the economy.
- $cINT_t$  = Represents the interest rate in South Africa.
- $\beta PPI_t$  = Producer Price Index.
- $U_t$  = error term



Also,  $a$ ,  $b$ ,  $c$ , and  $\beta$  are the coefficients to be estimated and  $U_t$  is a white noise error term. The error term represents the influence of the other variables in the construction of the data. To obtain elasticity coefficients and remove the effect of outliers, some of the variables have to be transformed to logarithms.

#### 4.2 Definition of variables

This section provides a description of variables and their validation effect on the model used to measure the impact of electricity prices on economic growth.

**GDP** – GDP in this study is used as a measurement of economic growth of a country. Specific to this study, GDP represents Gross domestic product growth rates in the South African economy. This is the annual rate at which a country’s income or production level increases. This rate is adjusted for inflation and given as a percentage increase or decrease from the previous economic period (Menyah and Wolde-Rufael, 2010).

$aElec_t$  = Average annual aggregated electricity price increases charged to various consumers in South Africa (Inglesi, 2010).  $aElec_t$  Is the Eskom average electricity price annual percentage

increases measured over the period of our study. Electricity price is expected to have a negative sign although the relationship between electricity prices and GDP might move in opposite directions. The sign is expected to be negative because as electricity prices increase, the cost of production is expected to rise on an aggregate level in the economy. This subsequently increases the general price level stemming from cost push inflation or it may discourage the operations of electricity intensive industries. These two factors bear the expected outcome of reducing gross domestic product thereby reducing economic growth.

**Interest rate** – Interest rate is the discount rate at which a central bank repurchases government securities from the commercial banks, depending on the level of money supply it decides to maintain in the monetary system. The interest rate in our model is represented by the Prime overdraft rate in South Africa. The sign of the interest rates is expected to be negative. According to money demand theory as interest rates decrease, real GDP is expected to increase, ceteris paribus. When the interest rate falls aggregate investment expenditure will increase as businesses tend to invest more since their cost of borrowing would have decreased. Businesses tend to invest more and their profitability will increase when interest rates are lower. This will lead to a higher aggregate demand coupled with higher investment expenditure which subsequently increases real GDP. This shows that a negative relationship might exist between interest rates and GDP (Kadir, Selamat, Masuga, and Taudi, 2011).

**LABPRO** – This represents labour productivity. Labour productivity measures the amount of goods and services produced by an hour of labour. It basically measures the amount of real GDP produced by an hour of labour (Barker, 2003). Labour productivity hinges on human capital, physical capital and new technology. Growth in this labour productivity number can usually be interpreted as improvements or rising standards of living in the country as it plays a prominent role in the competitiveness of an economy (Nell, 2007).

**PPI** represents the Producer Price Index (PPI) and is a weighted index of prices measured at producer level. This index measures the degree of inflation in the eyes of producers. The PPI shows trends within the wholesale markets (the PPI was once called the Wholesale Price Index), manufacturing industries and commodities markets (Mohr and Fourie, 2007). It is also an early inflationary warning since an increase in prices of raw materials being fed to producers to create

their final product greatly affects their wholesale pricing to retailers. All of the industries that produce physical goods which make up the economy are included. Imports are usually excluded from this category.

Table 4.1: Expected Priors

Variable	Expected Sign	Explanation
$aElec_t$	-	A sudden increase in electricity prices may have a negative effect on economic growth as it raises insecurity for businesses and consumers and may even curtail investment spending (Bignaut and Inglesi-Lotz, 2011).
$bLABPRO_t$	+	Labour productivity is expected to be positively related to GDP. Thus a unit increase in the amount of goods and services produced by an hour of labour is expected to increase GDP or economic growth, other things constant.
$cINT_t$	-	A unit increase in interest rates is expected to reduce GDP or economic growth. As interest rates increase, fewer businesses are willing to invest as the cost of borrowing capital increases. This results in a decrease in aggregate demand and investment which reduces GDP.
$\beta PPI_t$	-	Since this is an index which measures the degree of inflation in the eyes of producers, it is expected to negatively affect GDP. As early inflationary warning, an increase in prices of raw materials may be transmitted to the prices of final goods and services. Such an increase in the general price level (inflation) is detrimental to the economy.

#### 4.2.1 Data Sources and Analysis

The data for the variables, in level form were obtained from secondary sources such as the Quantec Online Data base, ESKOM and the South African Reserve Bank. Nominal figures shall be used for the study. To empirically test the model specification the study adopts annual South African data for the period 1986 – 2013. The study makes use of time series data which has the

advantage of providing information about the economic dynamics of some the variables. This may prove useful in our case since electricity prices have substantially surged. The annual data frequency selected of 27 years ensures an adequate number of observations. An observation lower than 25 will not provide enough observations from which consistent conclusion can be drawn. The data shall first test for stationarity or the order of integration of the data series in order to eliminate spurious regression results. This shall be done using the Augmented Dickey Fuller method and the Phillips Peron test.

### 4.3 Estimation Techniques

The model specified previously will be transformed into an econometric model by using the above mentioned data to construct variables of the model. To estimate the equation:

$$Y_t = aElec_t + bLABPRO_t + cINT_t + \beta PPI_t + U_t \dots \dots \dots (4.3)$$

Thee study uses an Auto Regressive Distributed Lagged (ARDL) framework using the postulation that GDP is a function of electricity prices, investment, labour productivity and producer price index. Therefore the behaviour of this model is estimated using a standard ARDL to determine the response of GDP to the increase in electricity prices.

#### 4.3.1 Stationarity and Cointegration

There are several techniques available for parameter estimation, ranging from classical regression methods to cointegration based techniques. The former is based on the assumption that all the variables to be included in a regression are stationary. However, most economic series are not stationary in their levels such that estimations based on this technique will be spurious. Differencing the variables to mechanically turn them stationary has been the preferred approach to deal with this problem. To avoid spurious regressions the study will implement various initial tests which entail the Augmented Dickey Fuller and the Phillips Peron unit root tests for stationarity as well as an ARDL approach to cointegration. Unit root tests are carried out on individual variables in isolation. Unit root tests are carried out because any relationship that may exist between the variables being tested and any other variables selected in the model are not recognized (Cameron, 2005).

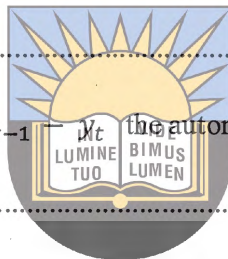
### 4.3.2 Stationarity

A stationary time series can be defined as one with constant mean, constant variance and constant auto-covariance for each given lag (Hylleberg, Engle, Granger, and Yoo, 1990). Since the study will implement the VECM, it is important that the data should be stationary because stationarity in VECM allows the model coefficient to be efficient and it will exhibit error terms that will not have a declining effect on the current value of the dependent variable (Brooks, 2008). As prearranged that the study will adopt the VECM econometric technique which requires stationary variables rather than their levels. For simplicity assuming the following autoregressive structure;

$$y_t = \beta_0 + \beta_1 \Delta x_t + p \varepsilon_t + \mu_t \dots \dots \dots (4.4)$$

The study defines stationarity as,  $\Delta y_t = y_t - y_{t-1}$  the autoregressive structure becomes:

$$\Delta y_t = \beta_0 + \beta_1 x_t + \mu_t \dots \dots \dots (4.5)$$



Therefore if a regression model is estimated using a non-stationary time series the ARDL model would give rise to a meaningless conclusion. In addition incorrect inferences will be made and the R-squared would be artificially high (that is, close to 1). Non-stationary variables can be made stationary by differencing the variables. As an example, if variable X is differenced d-times to make it stationary, it implies that X is integrated of order d, denoted by X (1). The study will use both the Augmented Dickey- Fuller (ADF) and the Phillip- Peron (PP) unit root tests.

### 4.3.3 The ADF Test

Brooks (2008) held that the Dickey Fuller (DF) tests calculate an autoregressive model and test whether the coefficient  $\phi_1$  is statistically different from one. If it is not, it will be necessary to difference the series to achieve stationarity. The Dickey Fuller test is of the model:

$$\Delta Y_t = \alpha + \gamma Y_{t-1} + \varepsilon_t \dots \dots \dots (4.6)$$

Where  $\gamma = \rho - 1$  and the null alternative hypotheses are:

$$H_0 : \gamma = 0$$

$$H_1 : \gamma > 1$$

A major problem with ordinary DF test is that their critical values are biased if there is autocorrelation in the residuals of the DF regression. To correct this, Dickey and Fuller (1981) came up with an augmented version of the Dickey Fuller Test (ADF). They included as many

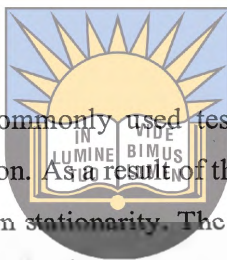
lagged variables as necessary to remove any autocorrelation in the residuals. The ADF approach controls for higher-order correlation by adding lagged differences terms of the dependent variables to the right hand side of the regression (Sarkar, 2012). Mishra and Sethi (2008) held that the Augmented Dickey Fuller will, then, take the form:

$$\Delta Y_t = \alpha + \gamma Y_{t-1} + \delta_1 \Delta Y_{t-1} + \delta_2 \Delta Y_{t-2} + \dots + \delta_p \Delta Y_{t-p} + \varepsilon_t \dots \dots \dots (4.7)$$

This augmented specification is then tested for:

$$H_{0:\gamma} = 0 \qquad H_{1:\gamma} > 1$$

For the purposes of making sure that the data in this study is stationary the Augmented Dickey Fuller test is used.



**4.3.4 Phillips- Peron test**

Although the ADF is one of the most commonly used tests, it sometimes behaves poorly, especially in the presence of serial correlation. As a result of this, Phillips and Peron developed a more comprehensive theory of unit root non stationarity. The tests are similar to the ADF tests, but they incorporated automatic correction to the DF procedure to allow for auto correlated residuals. The Phillips Peron test performs better than (or at least as well as) the ADF test in terms of comparative power and yields tighter confidence intervals (Cashins and McDermott, 2003). In addition to this, the Phillips and Peron tests are non-parametric tests of the null of the unit root and are considered more powerful, as they use consistent estimators of the variance.

Another great quality of the Phillip- Peron test is that it allows the additive outlier type shift as the test simply adds a dummy to the equation. The Phillips Peron test is based on the model:

$$X_t = \eta + \beta_t + \pi X_{t-1} + \psi_t \dots \dots \dots (4.8)$$

With the unit root null hypothesis expressed by  $H_0 : \pi = 1$ ; the stationary process  $\psi_t$  is not assumed to be white noise and serial correlation and heteroscedasticity in the  $\psi_t$  term are handled in the test statistic (Donner and Barbosa, 2008).

**4.3.5 Cointegration Testing Techniques.**

The autoregressive distributed lag (ARDL) model deals with single cointegration and is introduced originally by Pesaran and Shin (1997) and further extended by (Pesaran, Shin and Smith, 2001). The ARDL approach has the advantage that it does not require all variables to be

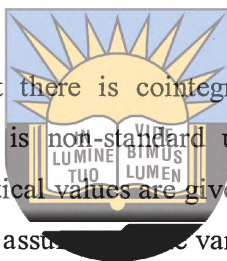
I(1) as the Johansen framework and it is still applicable if we have I(0) and I(1) variables in our set. The bounds test method of testing for cointegration has certain econometric advantages: for example all variables of the model are assumed to be endogenous. To investigate the presence of long-run relationships between GDP and ELEC, bound testing under Pesaran, *et al.* (2001) procedure is used. The bound testing procedure is based on the F-test under the hypothesis of no cointegration among the variables against the existence or presence of cointegration among the variables. This is denoted as:

$$H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$$

Whereby the null hypothesis is that there is no cointegration among the variables.

$$H_a: \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq 0$$

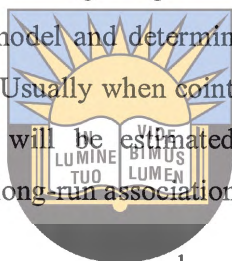
Whereby the alternate hypothesis is that there is cointegration among the variables. The asymptotic distribution of the Wald-test is non-standard under the null hypothesis of no cointegration among the variables. Two critical values are given by Pesaran *et al.* (2001) for the cointegration test. The lower critical bound assumes that the variables are I (0) meaning that there is no cointegration relationship between the examined variables. The upper bound assumes that all the variables are I (1) meaning that there is cointegration among the variables. When the computed F-statistic is greater than the upper bound critical value, then the H<sub>0</sub> is rejected (the variables are cointegrated). If the F-statistic is below the lower bound critical value, then the H<sub>0</sub> cannot be rejected (there is no cointegration among the variables). When the computed F statistic falls between the lower and upper bound, then the results are inconclusive.



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Another cointegration test which will be carried out in this study is the Johansen cointegration test. This is for the sole purpose of validating our ARDL approach to cointegration. The Johansen (1991, 1995) technique has become an essential tool in the estimation of models that involve time series data. This approach is preferred as it captures the underlying time series properties of the data and is a systems equation test that provides estimates of all cointegrating relationships that may exist within a vector of non-stationary variables or a mixture of stationary and non-stationary variables (Harris, 1999). The Johansen technique has several advantages over other cointegration based techniques in the sense that this technique allows us to estimate a dynamic error correction specification and provides estimates of both the short and the long-run dynamics in our production function model.

Several detailed and highly interrelated steps will be followed in implementing the Johansen methodology in this study. Testing for the order of integration of the variables under examination is the first step. All the variables should be integrated of the same order before going on with the cointegration test. Secondly, setting the appropriate lag length of the model is required. Normally the lag which has the lowest Akaike information criterion value is the recommended lag to choose before proceeding with the cointegration test. The third step is to make an analysis of the normalized co-integrating vector(s) and speed of adjustment coefficients is made. The final step is the determination of the number of co-integrating vectors. Causality tests on the error correction model to identify a structural model and determine whether the estimated model is reasonable is. This is done in the last step. Usually when cointegration exists in the model then a short-run vector error correction model will be estimated. The cointegration econometric property allows the study to check for any long-run association of the variables of interest.



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It is also necessary to mention that impulse response and variance decomposition analyses will also be employed if our estimated models pass the residual diagnostic tests. These analyses are therefore discussed in this chapter, as they may be used in the following chapters to provide more information on our model.

#### 4.3.6 VECM Estimation Technique

To square up if data series is stationary or co-integrated series data need to be checked for spurious regression analysis (Gujarati, 2010). If two series appear to move together over time, it indicates that there exists an equilibrium relationship even though the variables are non-stationary in the short-run, but if they are co-integrated, they will run closer together over time and their difference will be stationary.

The vector autoregressive (VAR) model is a general framework used to depict the dynamic interrelationship among stationary variables. Dolado *et al.* (1999) posited that if the time series are not stationary, then the VAR framework needs to be amended to allow consistent estimation of the relationships among the serial publication. The vector error correction (VEC) model is merely a particular instance of the VAR for variables that are stationary in their differences (for instance,  $I(1)$ ). The VEC can also take into account any cointegration relationships among the variables.

In parliamentary law to rationalize the role of vector error correction model (VECM) there is a need to test for cointegration. A VECM is intended to be practiced with non-stationary series that are known to be cointegrated. Brooks (2008) argues that the VECM has cointegration relations built into the spec so that it restricts the long-run behaviour of the endogenous variables to converge to their co-integrating relationships while allowing for short-run adjustment dynamics. Brooks (2008) also says that the cointegration term is known as the correction term since the divergence from long-run equilibrium is corrected gradually through a serial publication of partial short-run adjustments estimated. Thus, the presence of a cointegration relation(s) forms the basis of the vector error correction model (VECM) specification.

The two major ways of testing co-integration are;

The Engle-Granger approach which is residual based and the Johansen and Julius (1990) technique which is based on maximum likelihood estimation on a VAR system.

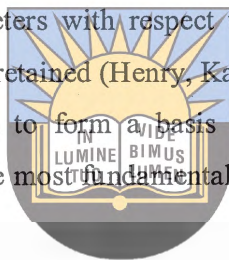
The Brooks (2008) contends that the problems of the Engle-Granger approach include a deficiency of power in unit root tests, simultaneous estimation bias and the impossibility of performing hypothesis tests about the relationships.

Referable to the shortfall of Engle-Granger approach, the vector error correction model (VECM) by Johansen (1991; 1995) shall be embraced in this field because this approach determines the long-run and short-run of the dependent variable in a model. This approach also offers the speed of adjustment coefficient.

The incorporation of the distributed lag model in the study is the increased importance of lags in econometric models. These lags may arise from both technological and institutional factors for instance the decision by Nersa to increase the price of electricity. The production costs of electricity intensive firms, particularly mines and manufacturing companies may increase but the effects of a general increase in production costs such as higher prices or lower output may manifest in the following financial period. If an increase in these production costs is expected to be temporary a drop in price of capital is expected to be temporary and firms may not rush to increase the prices of their goods and services (Gujarati, 2004). The study then performs most of its analysis making use of VECM techniques.

#### 4.3.7 Advantages of using ARDL

The autoregressive distributed lag (ARDL) model employs the bounds test method and holds the advantage that bounds test method for cointegration is applied irrespective of the order of integration of the variable. There may be either integrated first order  $I(1)$  or  $I(0)$ . Another advantage is that both the short-run and long-run coefficients of the model are estimated simultaneously. In order to test both the theoretical as well as the empirical underpinnings of the study; the study uses an Autoregressive distributed lag model. The ARDL model enables the study to test the dynamic econometric analysis of the long-run relations of the variables in the model. Aggregation under ARDL ensures that no information is lost since the model specification has marginalized the parameters with respect to disaggregates from the model. Statistical information for the error term is retained (Henry, Karanassou and Snower, 2000). Data partition in ARDL allows the simulation to form a basis on which decisions about which variables to omit or to include, which is the most fundamental aspect of the success or failure of any empirical modeling.



#### 4.3.8 Disadvantages of the ARDL model

The main problem with ARDL model just like any other structural multivariate estimation, is the problem of the goal of fitting a parsimonious model. In many cases a model can be over-parameterized model and there is also the possibility of including large coefficients which in turn add variability to the model forecast (Enders, 1995). The other problem with this methodology is that sometimes there is no feedback effect. To combat these estimation issues the study will implement other estimation techniques to help in the minimizing of the limitations above.

#### 4.4 Diagnostic Tests

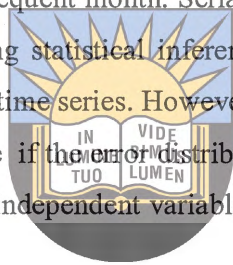
Residual diagnostic Tests form the last step of the estimation techniques. This forms a significant role for hypothesis testing in econometrics (King, Zhang and Akran, 2007). Even though the main objective of this study is to test the impact of electricity prices on economic growth, it is also important to assess the properties of the equation simulated above and its oscillating behaviour.

The study adopts a typical test procedure which involves the use of a test statistic and critical values in order to control the probability of wrongly rejecting the null hypothesis (King, *et al.*, 2007). The proposed testing procedure of applied econometric tests is to test for serial correlation

in an observed time series, for normality, and the significance of coefficient in a dynamic regression model (King, *et al.*, 2007).

**4.4.1 Serial Correlation Test**

Serial correlation occurs when there is dependence between error terms. Error terms of the equation estimate must be distributed independently of each other and hence the covariance between any pair of error or residual terms must be zero (Lhabitant, 2004). Serial correlation occurs when the covariance is not zero. The use of time series data often leads to the problem of autocorrelation, which means, in this study that after a positive stock return for one month there follows a positive stock return for the subsequent month. Serial correlation is a problem because standard errors are not consistent, affecting statistical inferences (hypothesis testing). Durbin-Watson is the most commonly used test in time series. However, it is important to know that it is not relevant in many instances, for instance if the error distribution is not normal, or if there is a dependent variable in a lagged form as an independent variable this is not an appropriate test for autocorrelation.



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A test that is suggested that does not have these limitations is the Lagrange Multiplier test (LM test) which will be used in this study. Song, Witt and Li (2009) held that the calculation of the LM test is based on an auxiliary equation of the form:

$$\hat{\epsilon}_t = \alpha + \beta_1 X_{1t} + \beta_2 X_{2t} + \dots + \beta_k X_{kt} + \rho_1 \hat{\epsilon}_{t-1} + \rho_2 \hat{\epsilon}_{t-2} \dots + \rho_p \hat{\epsilon}_{t-p} + \mu_t \dots \dots \dots (4.9).$$

Where  $X_{it}$ s are explanatory variables, the  $\beta_i$ s and  $p_j$ s re parameters and the  $\hat{\epsilon}_t - j$ s are the lagged residuals from the regression model. Under the null hypothesis of no auto-correlation:

$$H_o : p_1 = p_2 = \dots \dots \dots p_p = 0$$

Where  $X_{it}$ s are explanatory variables, the  $\beta_i$ s and  $p_j$ s re parameters and the  $\hat{\epsilon}_t - j$ s are the lagged residuals from the regression model. Under the null hypothesis of no auto-correlation:

$$H_o : p_1 = p_2 = \dots \dots \dots p_p = 0.$$

Song *et al.* (2009) further maintain that the test statistic is  $n R^2$ , where n is the sample size. In large samples, the test statistic has a  $\chi^2$  distribution with p degrees of freedom. If the value of  $n R^2$  exceeds the critical value of  $\chi^2$ , this suggests the presence of auto-correlation.

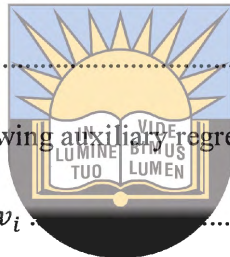
**4.4.2 Testing for Heteroscedasticity**

In order to get consistent standard errors, the study will need to get a model that is dynamically complete. Essentially, this means that the model has to have white noise error. It is imperative that the study conducts tests for the presence of heteroscedasticity in the tested variables. To dictate heteroscedasticity the study adopts various techniques of dictating as well as for correcting this heteroscedasticity. The following tests are considered in this study.

**4.4.3 White’s General Heteroscedasticity Test**

The main advantage of the white’s test does not rely on the normality assumption and is easy to use. Assuming that the following standard regression model is estimated (Gujarati, 2004: 413):

$$Y_i = \beta_1 + \beta_2 X_2 + \beta_3 X_3 + u_i \dots\dots\dots (4.10)$$



The White’s test suggests running the following auxiliary regression (Brooks, 2008: 135):

$$\hat{\mu}_i^2 = \alpha_1 + \alpha_2 x_{2i} + \alpha_3 x_{3i}^2 + \alpha_4 x_{4i}^2 + v_i \dots\dots\dots (4.11)$$

The test is one of the joint null hypothesis that  $\alpha_1 = 0$  and  $\alpha_2 = 0$  and  $\alpha_3 = 0$  and  $\alpha_4 = 0$ . For the LM test, if the  $\chi^2$ - test is greater than the corresponding value in the statistical tables then reject the null hypothesis that the errors are homoscedastic (Brooks, 2008: 135).

**4.4.4 Testing for Normality**

Jarque-Bera is a test statistic for testing whether the series is normally distributed. The test statistic measures the difference of the skewness and kurtosis of the series with those from the normal distribution. The Jarque-Bera test is based on the fact that skewness and kurtosis of normal distribution equal zero. Therefore, the absolute value of these parameters could be a measure of deviation of the distribution from normal. Jarque and Bera proposed a normality test using classical skewness and kurtosis coefficients. The Jarque Bera test is a goodness of fit measure to departure from normality, based on the sample kurtosis and skewness. Machiwal and Jha (2012) states that the test statistic *JB* is defined as

$$JB = \frac{n}{6} \left( S^2 + \frac{(k-3)^2}{4} \right) \dots\dots\dots (4.12)$$

Where *n* = number of observations, *S* = sample skeness and *k* = sample kurtosis.

The *JB* test is based on the result that a normally distributed random variable has skewness equal to zero and kurtosis equal to 3. In other words, the test of normality compares skewness and

kurtosis to 0 and 3, their values under normality. The test statistic is *JB*. The statistic *JB* has an asymptotic chi-square distribution with two degrees of freedom and can be used to test the null hypothesis that the data are from a normal distribution. Machiwal and Jha (2012) further maintain that 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 this study, the Jarque-Bera (*JB*) test is used to test whether stock returns and exchange rates individually follow the normal probability distribution.

**4.4.5 Testing for significance of regression coefficients**

It is imperative that the study explores the statistical properties of the model. It is a common practice that the study conducts various test statistics of the coefficients. Since the study uses the ARDL model to test the parameters. One of the conventional tests for the significance of the regression coefficient in an AR (*d*) model is the conducted through the F- static (King *et al.*, 2007). The F statistic is given by:



$$F = \frac{SRR/d}{SSE/(n-d-1)} \dots\dots\dots \text{University of Fort Hare} \dots\dots\dots (4.13)$$

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Where SSR is the sum of squares due to the regression and SSE is the sum of squared residuals.

**4.4.6 Pairwise Granger Causality Tests**

When two or more unrelated variables are trending over time they will appear to be correlated simply because of the shared directionality. Therefore, traditional linear regression or correlation methods cannot be used to establish casual relations among a group of variables. Two methods for testing for causality among time series variables are Granger causality tests and cointegration analysis (Hylleberg *et al.*, 1990).

According to Hylleberg *et al.* (1990), a time series *X* is said to Granger-cause *Y* if it can be shown that lagged values of *X* values provide statistically significant information about future values of *Y*. If  $X_t$  is the series one wishes to forecast and  $Y_t$  and  $Z_t$  are possible explanatory series, then a further example of an explanatory model is

$$x_t = a + by_t + cz_{t-1} + dy_{t-1} + e_t \tag{3}$$

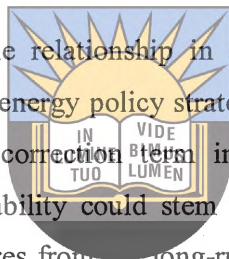
To forecast one step ahead, write (3) as:

$$x_{n+1} = a + by_{n+1} + cz_n + dy_n + e_{n+1} \dots \dots \dots (4.14)$$

Another model is therefore required to provide a forecast for  $y_{n+1}$  so that a forecast for  $x_{n+1}$  can be constructed. To forecast two or more steps ahead, a further equation is required to provide forecasts for  $z_{n+j}, j \geq 1$ . Once the necessary models are obtained, it becomes quite easy to construct forecasts; the problem is to achieve the correct explanatory or forecasting model in the first place (Hylleberg *et al.*, 1990).

#### 4.4.7 Stability Tests

The existence of a stable and predictable relationship in our GDP model is considered a necessary condition for the formulation of energy policy strategies. The stability of the long-run coefficients are used to form the error-correction term in conjunction with the short-run dynamics. Some of the problems of instability could stem from inadequate modeling of the short-run dynamics characterizing departures from the long-run relationship. In view of this we apply the CUSUM. The CUSUM test is based on the cumulative sum of recursive residuals based on the first set of  $n$  observations. This is updated recursively and is plotted against the break points (Zeileis, 2004). If the plot of CUSUM statistic stays within 5% significance level, then estimated coefficients are said to be stable.



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If the plots of CUSUM statistic for GDP marginally cross the critical value lines, we are safe to conclude that our model is stable. However if the plot of CUSUMS statistic for GDP crosses the critical value line it indicates some degree of instability.

#### 4.4.8 Impulse Response and Variance decomposition

Brooks (2008) stress that impulse response analysis traces out the responsiveness of the dependent variable in the VAR to shocks to each of the other variables. In this study, therefore, it depicts the sign, magnitude and persistence of real and nominal shocks to the manufacturing sector. Brooks (2008) further states that impulse response analysis is utilized on the VECM and, provided that the organization is unchanging, the shock should gradually go out. This study applies the generalized impulse response analysis and this approach fully takes into account historical patterns of correlations amongst the different shocks.

After performing the impulse response analysis further information on the link between GDP and electricity prices is found using the variance decomposition analysis. Brooks (2008) explains that variance decomposition analysis provides the proportion of movements in the dependent variables that are due to its own shocks, against shocks to other variables.

#### 4.5 Conclusion

This chapter laid down the model which determines the impact of electricity prices on economic growth. Included in this model are variables that are likely to affect economic growth. These variables are the electricity prices, labour productivity, interest rates, and the producer price index. For stationarity or unit roots purposes, the model employed the Dickey-Fuller and the Phillips Perron tests. Diagnostic tests such as the Normality test, white test for heteroscedasticity and the LM test were discussed. The ARDL technique has been chosen as the estimation technique for the impact of electricity prices on economic growth in South Africa. The succeeding chapter will discuss the preliminary examination of the data and the final ARDL model using the econometric package EVIEWS-8. Diagnostic tests shall also be performed on the residuals.

## CHAPTER FIVE

### Presentation of empirical data analysis of results.

#### 5.1 INTRODUCTION

The previous chapter presented the analytical framework on research methods used to analyse the data in this dissertation. The purpose of this chapter is to present the empirical findings which emanate from the methods described in chapter four. The data was analysed using the VECM and Johansen approach to cointegration on annual data covering a period, 1986 to 2013.

This chapter is divided into seven sub-sections. The first section presents the results of stationarity and unit root tests followed by a presentation and discussion of the cointegration test results. The third section presents the long-run relationships and short-run dynamic adjustments from a vector error correction model. The fourth section of the chapter presents diagnostic test results in order to establish the adequacy and robustness of the model. The fifth sub-section presents impulse response analysis and variance decomposition results. Concluding remarks are provided towards the end of the chapter.

#### 5.2.1 Stationarity and unit root test results

One of the most popular informal tests for stationarity is the graphical analysis of the series. A visual plot of the series is usually the first step in the analysis of any time series before pursuing any formal tests. This preliminary examination of the data is important as it allows the detection of any data capturing errors, structural breaks and gives an idea of the trends and stationarity of the data set. Figure 5.1 plots the five variables of the model used in this study against time.

**Figure 5.1: Graphs Before Differencing.**

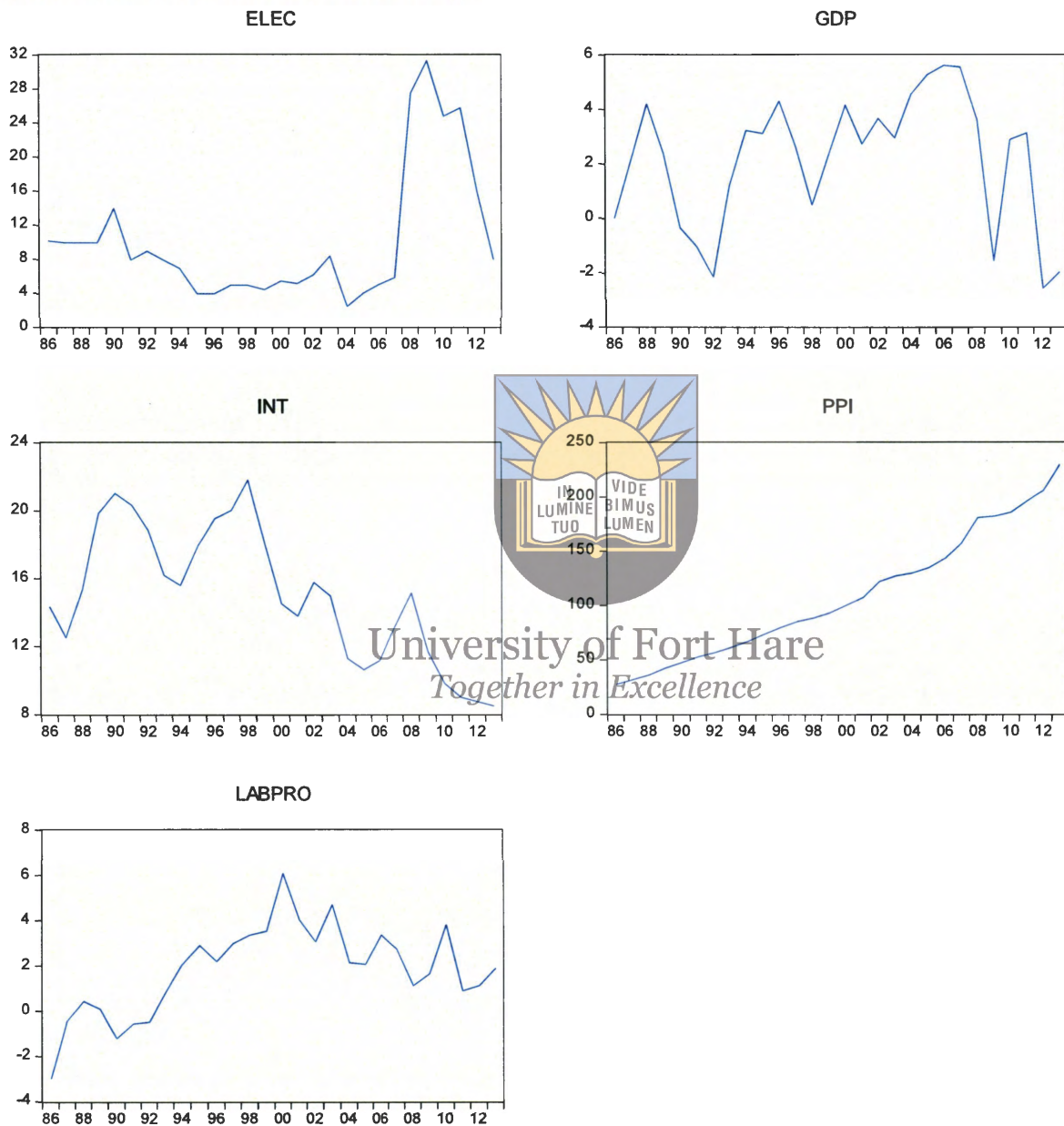


Figure 5.1 shows that all variables, namely, PPI, LABPRO, INT, ELEC and GDP (Producer Price index, labour productivity, interest rate, electricity prices and gross domestic product respectively) are trending. In other words the residuals are not distributed around the mean zero. The variables have a time variant mean and variance suggesting that they are not stationary in

their levels. Their variances are not constant over time. Given this scenario formal tests were applied, namely, Augmented Dickey Fuller and the Phillips Peron Test. A discussion on both these tests is presented in chapter four. These tests were applied under different models, namely, constant, trend and constant, no constant and no trend. The results of formal tests for stationarity are presented in tables 5.1 and 5.2.



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### 5.2.2 Augmented Dickey Fuller (ADF) Results

The results from the ADF tests are given in Table 5.5. The results are tabulated according to level data series and for first differences in the data series.

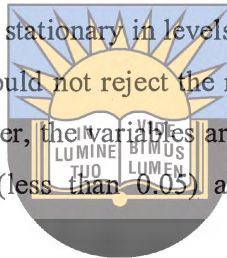
Table 5.1: Augmented Dickey Fuller Results.

Augmented Dickey- Fuller Test						
Variables	Level			First Difference		
	Constant	Trend and Constant	None	Constant	Trend and Constant	None
LELEC	-1.968774*	-2.047525*	-0.648025*	-4.959702***	-9.696666***	-5.067949***
LINT	-0.017898*	-4.834073*	-1.148803**	-5.205523***	4.834073***	-5.059883***
LPPI	0.195881*	-6.149342*	4.141218**	-5.074007***	-6.149342***	-3.461223*
LABPRO	-3.037134**	-0.734000**	-1.557969*	-6.116082***	-6.580885***	-3.192905***
GDP	-2.574963*	-2.376916*	-1.858957**	-5.511678***	-5.464690***	-5.601960***
CV (5%)	-2.919952	-3.500495	-1.947381	-2.919952	-3.500495	-1.947381
CV (1%)	-3.565430	-4.148465	-2.611094	-3.565430	-4.148465	-2.611094

## Notes

- (1) The null hypothesis,  $H_0$  = Variables have a unit root.
- (2) The critical values are obtained from MacKinnon (1996) one-sided p-value.
- (3) The appropriate lag lengths are selected by Akaike information Criteria and E-views program automatically selected the appropriate lag length.
- (4) CV stands for Critical Values.
- (5) \*, \*\* and \*\*\* represent a stationary variable at 1%, 5% and 10% level respectively.

Table 5.1 shows that all variables were not stationary in levels. The p- values of the variables all being greater than 0.05 indicate that we could not reject the null hypothesis of the existence of unit root in levels for all variables. However, the variables are stationary after first differencing them. The magnitude of the p –values (less than 0.05) are significant, indicating that the variables are stationary at first difference.



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### 5.2.3 Phillips Peron test results

The results from the Phillip Perron test are given in Table 5.2 below.

Table 5.2: Phillips Peron Unit Root Test Results.

Phillip- Peron Test Results						
Variables	Level			First Difference		
	Constant	Trend and Constant	None	Constant	Trend and Constant	None
LELEC	-2.020618*	-2.092213*	-0.648025**	-4.959702**	-4.837582**	-5.067949**
LINT	-0.946061*	-1.990361*	-0.718306*	-3.473502**	-3.743496**	3.547467**
LPPI	-3.306604*	-7.105493**	5.721846**	-3.195718**	-3.206815**	-1.173682
LABPRO	-3.034534	-2.692295	-1.569573	-8.663121	-13.78960	-7.855751**
GDP	-2.615528*	-2.406264**	-1.763879**	-6.107333**	-6.803255**	-6.248422**
CV (5%)	-2.976263	-3.587527	-1.953858	-2.981038	-3.595026	-1.954414
CV (1%)	-3.699871	-4.339330	-2.653401	-3.711457	-4.356068	-2.656915

Notes

- (1) The null hypothesis,  $H_0$  = Variables have a unit root.
- (2) The critical values are obtained from MacKinnon (1996) one-sided p-value. CV stands for Critical Value.
- (3) The appropriate lag lengths are selected by Akaike information Criteria and Eviews program automatically selected the appropriate lag length.
- (4) \*, \*\* and \*\*\* represent a stationary variable at 1%, 5% and 10% level respectively.

Applying the Phillips Peron test the results show that the variables were not stationary at levels and had to be differenced. All variables were stationary after differencing. The Philips Perron results are more or less similar to ADF tests. After the stationary tests, graphical plots were done to observe the nature of the mean and variance of the stationary data. The graphical plots of the differenced variables are shown in Figure 5.2 below.

Figure 5.2: Graphs of variables after differencing.

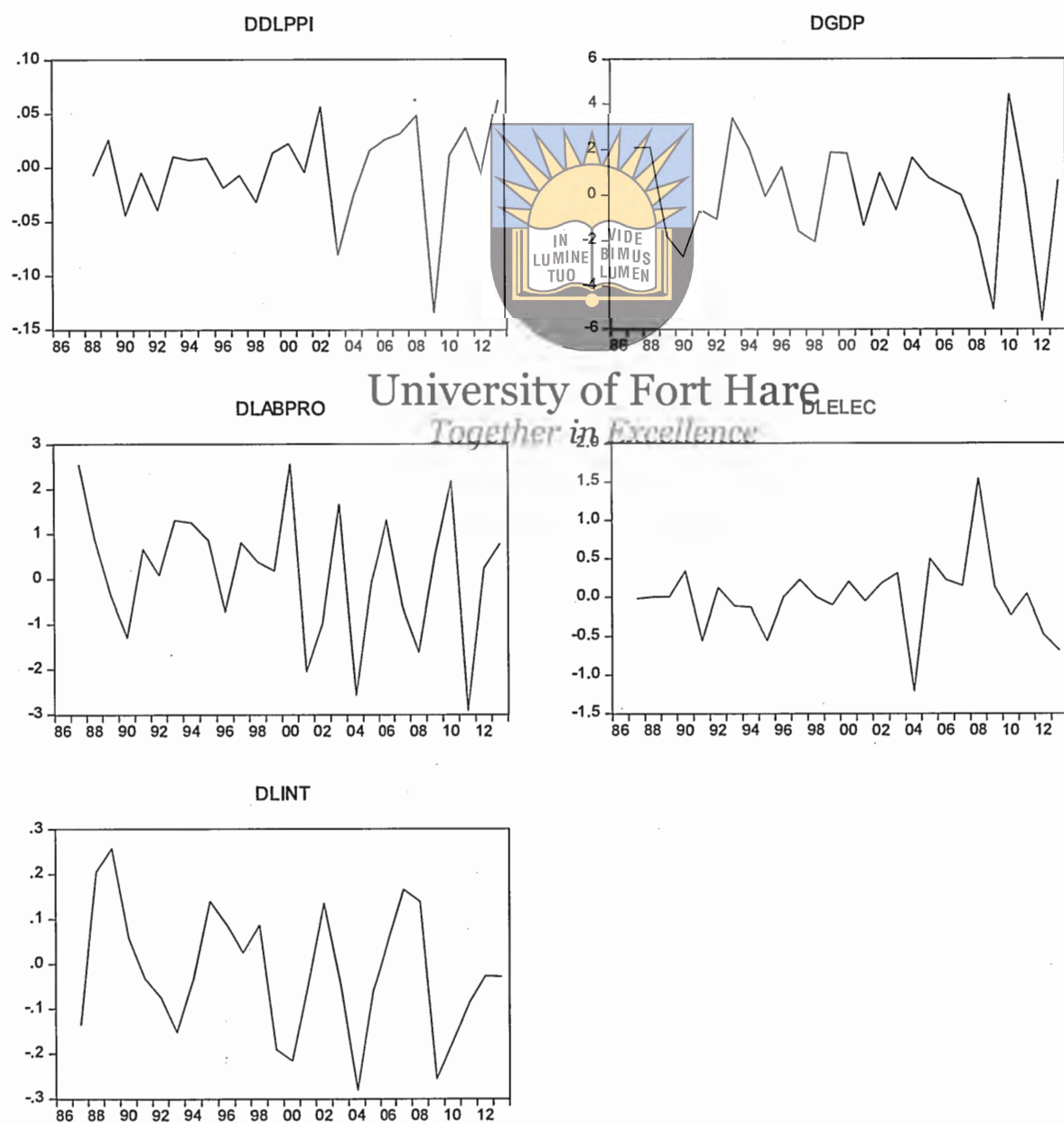
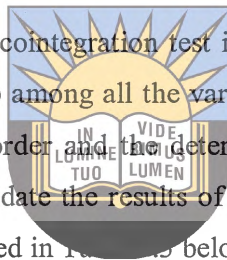


Figure 5.2 shows that the first differenced variables show sign of returning to their mean suggesting that the series are stationary. After differencing, the sequence plot indicates that the data have a constant location and variance, although the pattern of the residuals shows that the data depart from the model in an orderly way.

Having established stationarity tests on the variables the next step is to test for cointegration. The next section presents ARDL approach to cointegration.

### 5.3 Johansen Approach to Cointegration

Before performing the VECM analysis, a cointegration test is conducted to determine whether there is a long-run equilibrium relationship among all the variables. The Johansen cointegration technique requires us to specify the lag order and the deterministic trend assumption for the VAR. This complementary route is to validate the results of the VECM (Dritsakis, 2011). The results of the lag order criterion are displayed in Table 2.3 below:



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Table 2.3: Lag Order Specification.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-45.10462	NA	4.48e-05	4.175385	4.420812*	4.240497*
1	-18.60235	39.75339*	4.17e-05*	4.050196*	5.522763	4.440869
2	5.791880	26.42709	6.01e-05	4.100677	6.800383	4.816910

#### Notes

\* 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

HQ: Hannan-Quinn information criterion

SC: Schwarz information criterion

The appropriate lag structure is determined using Akaike Information Criterion (AIC) (Wolde-Rufael, 2005). The lag length with the lowest AIC value is always encouraged as it reflects a

better model. Therefore in this regard lag length 1 is selected as it has the lowest AIC value. Other information criteria which have selected lag 1 are the Final prediction error and sequential modified LR test statistic at 5 per cent level. After viewing the appropriate lag length criteria, the Johansen Cointegration is carried out and the results of the cointegration tests are displayed in Table 5.4 and Table 5.5 below:

**Table 5.4: Cointegration Rank Test (Trace) Results.**

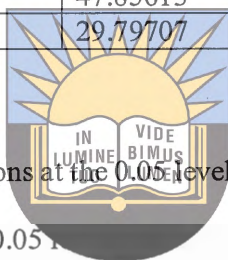
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob**
None*	0.773768	95.48986	69.81889	0.0001
At most 1	0.734042	59.82120	47.85613	0.0026
At most 2	0.570278	28.03515	29.79707	0.0787

Notes

\*Trace test indicates 2 cointegrating equations at the 0.05 level

\*denotes rejection of the hypothesis at the 0.05 level

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



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**Table 3: Cointegration Rank Test (Maximum Eigen Value) Results.**

Hypothesized No. of CE(s)	Eigenvalue	Max- Eigen Statistic	0.05 Critical Value	Probability
None*	0.773768	35.66866	33.87687	0.0303
At most 1	0.734042	31.78605	27.58434	0.0136
At most 2	0.570278	20.27078	21.13162	0.0656

Notes

Max-eigenvalue test indicates 2 cointegrating equations at the 0.05 level

\* denotes rejection of the hypothesis at the 0.05 level

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

Results from the Johansen cointegration trace test in Appendix Table 4 reflected that at least two cointegrating equation exist at 5% significance level. The null hypothesis of no cointegrating vectors is rejected since the trace (test) statistic of 95.48 is greater than the critical value of approximately 69.81 at 5% significance level. Using the Maximum-Eigenvalue test in Table 4 there are two cointegrating equations at 5% significance level. Therefore, it can be concluded

that there are two cointegrating equations in our model and this implies that there are significant long-run associations among the variables.

#### 5.4 The Vector Error Correction Model Empirical Results

After testing for co integration as well as depicting a suitable lag length of the variables, the study implemented a standard VECM econometric modeling technique to the annual data using the following function form:

$$Y_t = aElec_{t-1} + bLABPRO_{t-1} + cINT_{t-1} + \beta PPI_{t-1} + U_{t-1}$$

The VECM estimates the short and long-run dynamic relationships in the impact of electricity prices on economic growth with all exogenous variables lagged once. The results of the above VECM are presented in table 5.6 below:

Table 5.6: VECM Results (Annual Data 1986-2015).

Variable	coefficient	Standard error	t- statistic
Constant	1.020848		
DGDP(-1)	1.000000		
DLELEC (-1)	0.059918	1.61314	0.03714
DLINT(-1)	20.00349	3.82509	5.22955
DDLPI(-1)	55.10528	26.8307	2.05382
DLABPRO(-1)	-2.852619	0.53260	-5.35603

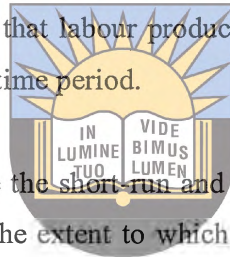
The long-run dynamics in the model are represented in the following equation:

$$GDP = -1.0208 - 0.05992ELEC_{t-1} - 20.0035INT_{t-1} - 55.1053PPI_{t-1} + 2.8526LABPRO_{t-1}$$

The above equation suggests that labour productivity (LABPRO) has a positive long-run relationship with GDP, while ELEC (average electricity price increases), INT and PPI have a negative long-run relationship with economic growth. All the variables which have absolute t-values greater than 2 are statistically significant in explaining GDP. This means that INT

(interest rate), PPI (producer price index) and LABPRO (labour productivity) are significant in explaining GDP in the long-run. However, ELEC (average electricity price increase) are not statistically significant in explaining GDP. The results show that a percentage increase in ELEC (average electricity price increases) lagged once decreases GDP by approximately 0.05 per cent.

Furthermore, the VECM results suggest that a percentage increase in INT lagged once decreases GDP by approximately 20 per cent in the long-run. A percentage increase in PPI lagged once decreases GDP by approximately 55 per cent and a percentage increase in LABPRO increases GDP by 2.85 percent. This positive impact of labour productivity (LABPRO) on economic growth is in line with economic theory in that labour productivity measures the amount of real GDP produced by labour within a specific time period.



VECM has been useful in this study since the short-run and long-run coefficients of the model are estimated simultaneously to estimate the extent to which electricity prices (ELEC) have an impact on economic growth (GDP).

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The short-run impacts in the model are illustrated in the table below.

**Table 5.7: VECM Short-run Results.**

Variable	Coefficient	Standard error	t-statistic
D(DGDP)	-0.129392	0.15711	-0.82359
D(DLELEC)	0.022779	0.03497	0.65133
D(DDLPPPI)	-0.010020	0.00269	-3.72969
D(DLINT)	-0.025369	0.00948	-2.67627
D(DLABPRO)	0.224324	0.13176	1.70246

The above table 5.7 shows the short-run speed of adjustment. Since the coefficient of electricity variable is negative and also not statistically significant, it is concluded that there is no short-run adjustment in this model.

### 5.5.1 Diagnostic Tests

In order to test for the adequacy and robustness of the model, diagnostic Tests were performed (Gujarati, 2004). The model was tested for fitness using three main tests, these are, the langrage multiplier (LM) test for serial correlation, the White test for heteroskedasticity and the Jarque-Bera test for normality. Results presented in Table 5.8 suggest that there is no serial correlation, there is no conditional heteroskedasticity, and there is a normal distribution in the GDP model

Table 5.8: Diagnostic Check Results.

Test	Null hypothesis	t-statistic	Probability
Langrage Multiplier	No serial correlation	18.85930	0.8038
White (CH-sq)	There is no conditional heteroskedasticity	186.2657	0.3589
Jarque-Bera(JB)	There is a normal distribution	5.733807	0.8371

The White's test of heteroscedasticity and the study found that the t-statistic was 186.2657 with a corresponding probability of 0.3589. The White heteroscedasticity test suggests that the disturbance term in the equation is homoscedastic. The Lagrange Multiplier (LM) test of autocorrelation suggests that the residuals from the South African data 1986- 2013 are not serially correlated. According to the Jarque-Bera (JB) test, the null hypothesis of normally distributed residuals cannot be rejected. The Jarque- Bera (BJ) statistic was 5.733807 and this suggests that the residuals in the data were clearly normally distributed.

### 5.5.2 Pairwise Granger Causality Tests

Table 5.9: Pairwise Granger Causality Results.

Sample: 1986 2013			
Null Hypothesis:	Obs	F-Statistic	Prob.
ELEC does not Granger Cause GDP	27	4.50886	0.0442
GDP does not Granger Cause ELEC		4.85617	0.0374

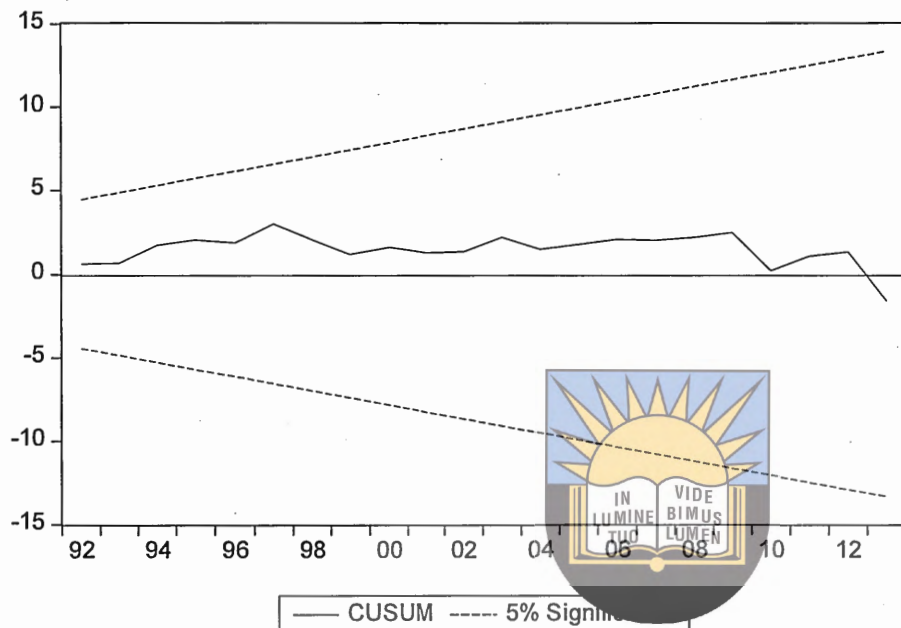
Our null hypothesis is that ELEC does not granger cause GDP. In order to tests this hypothesis we use F statistics. If our p-value is less than five per cent we reject the null hypothesis and accept the alternative hypothesis. Our p-value of 0.04 is less than 5 per cent meaning that we reject the null hypothesis and conclude that there is causality running from electricity prices (ELEC) to economic growth (GDP). Our second null hypothesis is that GDP does not granger cause ELEC. Our probability value is 0.03 and is lower than the 5 per cent critical value. Therefore we reject the second null hypothesis and conclude that GDP does granger cause ELEC. These results are in line with our expectations stated in chapter four of the study and they also validate the inclusion of ELEC in our GDP model.

The Granger causality tests results show a bilateral direction between electricity prices and economic growth in South Africa. This reiterates the conclusions that electricity is a mainstay of economic growth in previous studies on electricity consumption and the price elasticity of electricity in South Africa (Inglesi-Lotz and Blignaut, 2011). Empirical evidence from several studies has also illustrated that energy consumption and economic growth are correlated (Wolde-Rufael, 2004; Cameron and Rossouw, 2012; Inglesi-Lotz and Blignaut, 2011). Inglesi-Lotz and Blignaut (2011) examined the South African economic sector's electricity consumption in response to fluctuations in electricity prices and economic output for the period 1993 to 2006. The results of their panel data analysis show that economic output was a positive contributing factor to the electricity consumption of industrial and commercial sectors (having high and significant coefficients). This suggests that there is bilateral Granger causality between total energy consumption and real GDP.

### 5.5.3 Stability Tests

In order to view the constancy of long-run parameters and stability of the model we apply the CUSUM CUSUMSQ tests, which (Brown, Durbin and Evans, 1975) developed. The CUSUM test is based on the cumulative sum of recursive residuals based on the first set of observations. It is updated recursively and is plotted against the break points. If the plot of CUSUM statistic stays within 5% significance level, then the estimated coefficients in our model are said to be stable. The recursive stability test is given by Figure 5.5 below:

Figure 5.3: CUSUM Test Results.

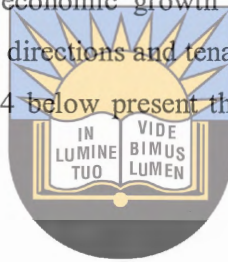


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The blue line within the two red lines represents or model. When the model trends in the area between the 5 per cent significance red lines then it means that our model is stable. Since the plots of CUSUM statistic for GDP marginally cross the critical value lines, we are safe to conclude that our GDP model is stable. This means that in the long-run, the VECM model is stable and the coefficients are relatively statistically significant.

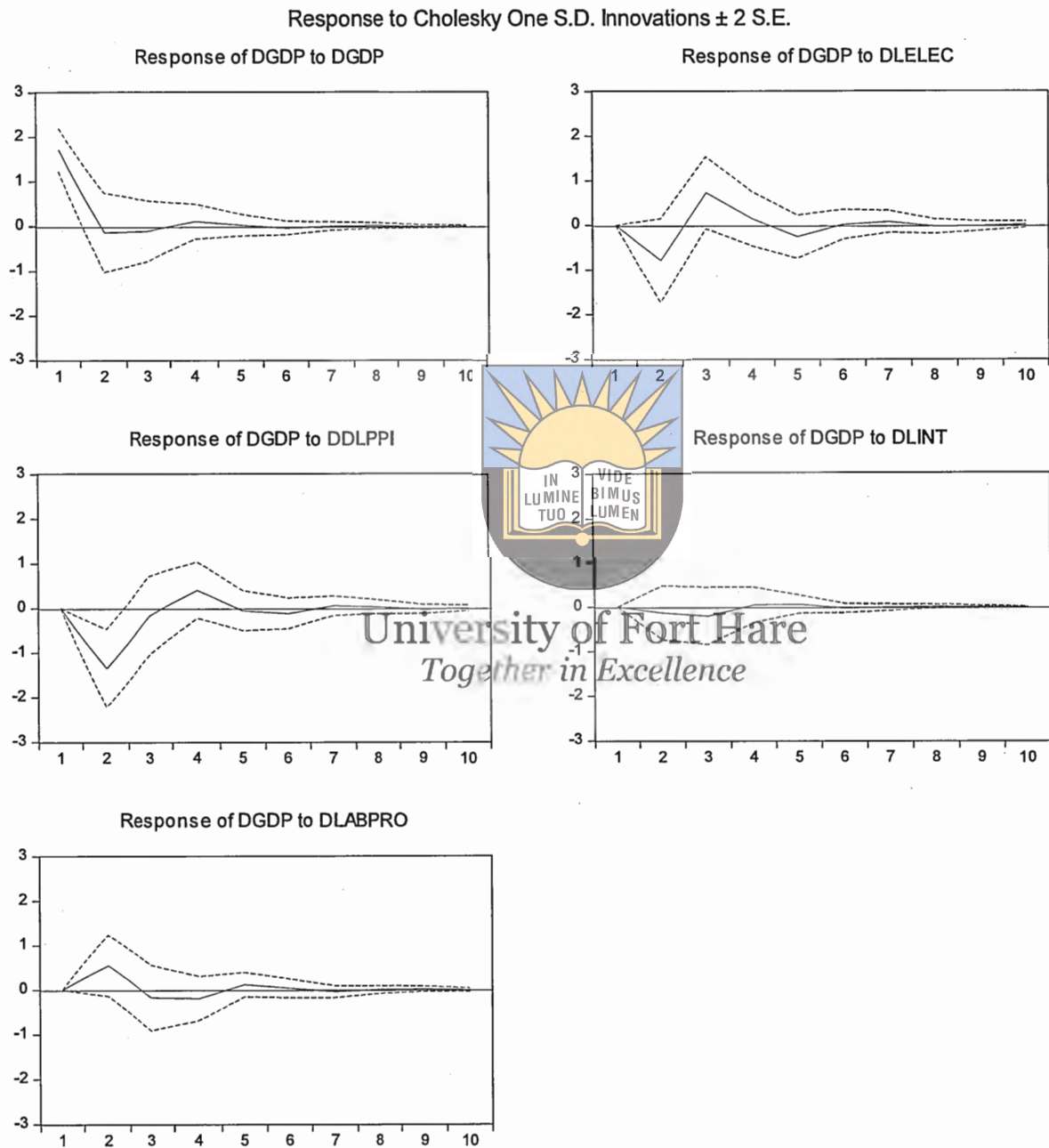
## 5.6 Impulse Response and variance decomposition

The Impulse response analysis whereby the responsiveness of the dependent variables in a VAR to shocks from each of the variables are traced out (Brooks, 2008). To determine the impact of electricity prices on economic growth, only the responses of GDP are illustrated in Figure 5.4. Impulse response functions show the effects of shocks on the adjustment path of the variables while forecast error variance decompositions measure the contribution of each type of shock to the forecast error variance. These computations are useful in assessing how shocks to the variables in our model will reverberate through a system. Accordingly impulse response functions aid us to see the response of economic growth (GDP) to a one-period standard deviation shock to the system and show the directions and tenacity of the response to each of the shocks for a period of 10 years. Figure 5.4 below present the results of the impulse response analysis:



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Figure 5.4: Response to Cholesky One S.D. Innovations.



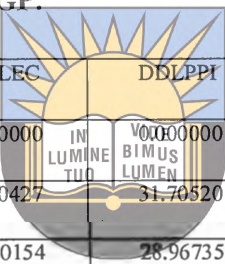
The impulse response function endorses results from our long-run analysis using an expected pattern. A one standard deviation shock to the electricity prices (ELEC) decreases economic growth (GDP). However the effect is not statistically significant and dies out of the system. A

one standard deviation in PPI is statistically insignificant and the shocks to PPI decrease GDP. A one standard deviation to LABPRO shocks the system for about 4 years. Generally the shocks in this model last four years and die out of the system thereafter.

### 5.7 Variance Decomposition of GDP

Since this study focuses on the impact of electricity prices on economic growth in South Africa, the study reports only the variance decomposition in economic growth (GDP) and it analyses the relative importance of electricity prices in influencing GDP.

Table 5.10: Variance Decomposition of DGP.



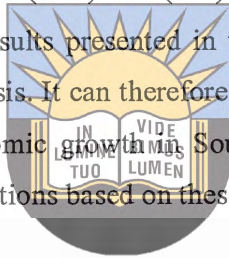
Period	S.E.	DGDP	DLELEC	DDLPPPI	DLINT	DLABPRO
1	1.716341	100.0000	0.000000	0.000000	0.000000	0.000000
2	2.390304	51.90261	10.90427	31.70520	0.313339	5.174570
3	2.520695	46.84881	18.10154	28.96735	0.927893	5.154406
4	2.566710	45.35313	18.56451	30.33330	0.92195	5.555846
5	2.583917	44.76102	18.56451	30.03330	0.962705	5.678465
6	2.587390	44.66654	18.51894	30.16276	0.971886	5.679868
7	2.589535	44.59269	18.58672	30.14792	0.972156	5.700511
8	2.589866	44.58371	18.59206	30.15102	0.974155	5.699051
9	2.590089	44.57628	18.59496	30.15343	0.973996	5.701329
10	2.590135	44.57487	18.59704	30.15252	0.974223	5.701336

The study allows the variance decompositions for a 10 year period. During the first year all of the variance in GDP is explained by its own shocks (Brooks, 2008). For most of the time GDP explains most of the variation in GDP. PPI explains almost 30% of the variation in GDP and ELEC explains 18 % of the variation in GDP. The rest of the variables have a marginal impact on variations to GDP. This is not surprising as electricity plays a role in explaining PPI and producer costs.

GDP explains most of its variations, followed by PPI and ELEC and then LABPRO. INT does not explain much of the variations in GDP in this model. From the variance decomposition analysis it can be seen that electricity prices (ELEC) and producer price index PPI are important variables in explaining economic growth (GDP) in South Africa over the study period.

### **5.8 Concluding Remarks**

The results reveal that economic growth (GDP) has a long-run association with electricity prices and this relationship is negative. Economic growth (GDP) is positively related to labour productivity (LABPRO) while interest rates (INT) and (PPI) have a negative relationship with economic growth (GDP). Based on the results presented in this chapter the null hypothesis is rejected in favor of the alternative hypothesis. It can therefore be concluded that electricity price changes have a negative impact on economic growth in South Africa. The following chapter gives the policy inference and recommendations based on these results reported in this chapter.



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## CHAPTER SIX

### SUMMARY, CONCLUSIONS, RECOMMENDATIONS AND LIMITATIONS

#### 6.1 Introduction

The main objective of this study was to examine the impact of electricity prices on economic growth in South Africa. The aim of this chapter is to present the highlights of the main findings of the study. The chapter begins by providing a brief summary of the finding. This is followed by a presentation of recommendations and conclusions. Limitations as well as recommendations for future research are presented towards the end of the chapter.

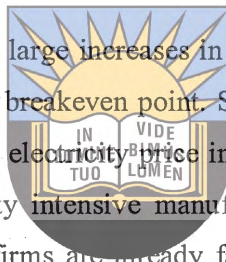
#### 6.2 Summary

Chapter one presented the introduction, problem statement and the objectives set out for the study. The objectives were to econometrically analyse the impact of electricity prices on economic growth and to make policy recommendations based on the findings. Chapter two reviewed the theoretical and empirical literature. The theories reviewed in this chapter were the theory of Cost push inflation, the Neoclassical Growth Theory, Harrod-Damour economic growth model, the Endogenous Growth model and the Ecological Approach to economic growth. The role of electricity in economic growth stems from the economics of ecology and the crucial factor of production is considered to be the stock of fossil fuels and solar power. Empirical literature which was carried out by a number of authors was also reviewed in chapter two. Their findings were inconclusive in the sense that some findings revealed that electricity prices have a positive impact on economic growth while others revealed a negative impact on economic growth.

Chapter three presented an overview of the trend in electricity prices and developments in GDP which reflects economic growth over the period 1986 to 2013. Chapter four examined the methodology employed in finding the impact of electricity prices on economic growth in South Africa. Chapter four also sets out the analytical framework that is used in this study and presents a detailed discussion of the econometric techniques used. Chapter five presented the empirical findings of the study. The results from Chapter five show that there is a negative long-run relationship between electricity prices and economic growth. The important insights of the results can be summarized as follows:

Firstly, the analysis reported a negative long-run relationship between electricity prices and economic growth. This result is supportive of the presumption that higher electricity prices have a negative impact on economic growth. A continuous increase in electricity prices may have a negative effect on economic growth as it raises insecurity for businesses and consumers and may even curtail investment spending (Bignaut and Inglesi-Lotz, 2011). Results from this study provided the evidence that supports the above assertion. The negative effect of electricity prices on economic growth supports our priori expectations that as electricity prices increase, aggregate output in the economy will become constricted thereby reducing gross domestic product and thus reducing economic growth in South Africa.

This is a result of the fact that unexpected large increases in the price of electricity are fatal to business operations that are slightly above breakeven point. Such businesses will not be able to bear extensive operational costs caused by electricity price increments. Other examples include the marginal gold mining firms, electricity intensive manufacturing firms such as those that manufacture transport equipment. These firms are already facing volatile currency challenges coupled with unfavourable global economic conditions. An increase in electricity prices itself is not of substance to these firms, it is the percentage change in the short-run which gives them the ability to engross the production cost increases. At this point firms have to reduce their level of production, retrench employees and in some extreme cases even close down (Deloitte, 2012).



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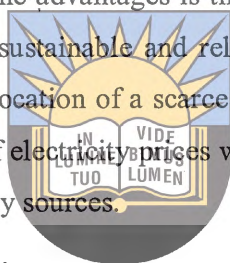
After a comparison of results across various models and studies, it became apparent that the relatively electricity-intensive mining and manufacturing firms suffer substantial declines in output and employment as electricity prices increase in South Africa. Thus as a matter of subsequence economic growth decreased due the reduced output suffered by the different sectors of the economy (Deloitte, 2012).

According to Pan African (2011) TSME Model and Pan African (2011) CGE Model the extent to which a firm can bear the electricity price increases depends on the proportion of electricity costs to total production costs as well as its current level of profitability. South African sectors that showed susceptibility to losses due to electricity price increases are Mining, Agriculture, Transport and Communication and the Electricity Industry itself (Conningarth, 2011). The Pan African (2011) study showed that employment output investment real wages exports imports

would be reduced due to electricity price increments. Subsequently this would reduce gross domestic product and economic growth in the long-run (Deloitte, 2012).

### 6.3 Implications and Recommendations

The findings from this study have a number of policy implications. Firstly, the negative impact of electricity prices on economic growth are indicative of the fact that higher user charges should not be the only source of financing Eskom's six year capital expenditure. Whilst the results of this study suggest that there is negative relationship between economic growth and electricity prices in South Africa, it should also be borne in mind that increasing the price charged to customers has economic advantages as well. One of the advantages is that increasing electricity price to a cost reflective level forms a platform for sustainable and reliable electricity generation in the country. This will allow for an efficient allocation of a scarce resource such as electricity in the long-run. In addition the cost-reflectivity of electricity prices will create prospects for alternative energy options and lead to diversified energy sources.



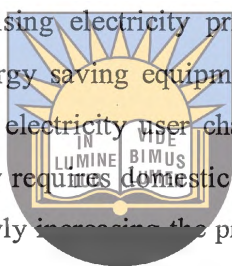
The financing of Eskom's capacity expansion can be a composition of increased user charges, private sector investment and financing from the government. If the state contributes to the financing of Eskom's capitalisation then higher user charges will not be a requirement. In the short-run the economy will be able to function along its usual business cycle. The drawback in this case would be that the government will have to finance Eskom's capitalisation by increasing tax or government debt or both. Thus substantial financing of Eskom's capitalisation can distract the economy's stability and hinder the government from financing other urgent social and economic needs.

Eskom's capitalisation should also include the participation of the private sector in the medium to long-run. Although this does not mitigate increases in user charges, private-sector investment should be encouraged in order to diversify the sources of national electricity supply. Policy makers need to facilitate a regulatory framework for private-sector participation in the provision of electricity. These options for capitalisation should be implemented whilst policy makers ensure that the cost reflectivity is not diminished and market competition thrives in the electricity supply industry.

Secondly there are policy options that are available to government to lessen the impact of rising electricity prices. Policy options such as subsidies, gradual price increments, enhanced energy

efficiency and demand side management, promoting competition in the electricity supply industry and providing targeted support to vulnerable sectors. Subsidising electricity has the effect of preserving jobs in vulnerable sectors while maintaining broad social objectives such as electricity provision to low income communities. This will also enhance rural economic development and lessen the inflationary effects of rising prices.

Gradual price increases over time will give reasonable certainty to firms as they get time to acclimatize and introduce energy efficient methods in production processes. This reduces costs and diminishes the negative impact of rising electricity prices on employment and output. Minimum adjustment time to acquire energy saving equipment and technology is 18 months (HSRC, 2008). Therefore abrupt hikes in electricity user charges have the probable effect of withering output. However cost reflectivity requires domestic prices to increase at a faster pace than global energy prices. In addition, slowly increasing the price lengthens the investment time taken to expand electricity capacity. Moreover, given that energy shortages in South Africa are an urgent matter, slowly increasing the user charges will only hinder efficiency progress and could result in more power cuts.



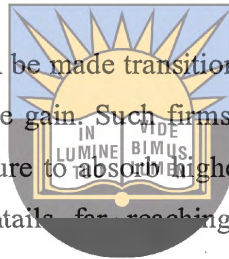
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Enhanced energy-efficiency and demand side management is a cost effective manner of reducing electricity demand and costs. Encouraging the energy efficient methods of production and demand side management resourcefulness reduces the need for an expansion in generating capacity. This also lessens the need to continually increase user charges. Increased energy prices are the key motivation for energy efficiency and demand side control (DNA Economics, 2011). Eskom has successfully implemented this model in the past by buying electricity savings or demand cutbacks from its customers. Paying the fixed amounts per kWh to electricity saving customers reduced demand effectively. The augmentation of this program can continue to significantly control the demand for power and improve energy efficiency at an aggregated level.

Commercializing state-owned utilities exposes them to heightened competition and private sector involvement. This improves efficiency in electricity supply (Goldstein, 2009). Government

utilities that undergo such changes have reported efficiency gains in a newly competitive market (Goldstein, 2009). For instance the Kenyan case whereby, in the face of electricity deficiencies, electricity prices first rose threefold after the privatisation of the power utility. Subsequently these prices became more competitive and this is viewed as a success (Eberhard and Gratwick, 2005). South African policy makers should make regulatory and legislative developments to encourage competition in the power supply sector and involve independent electricity suppliers into the power supply grid. Such private investment participation can be lured by placing regulative and legislative measures and higher cost reflective prices.

Lastly, support to vulnerable industries can be made transitional to those firms that historically relied on low energy prices as comparative gain. Such firms are vulnerable to electricity price increments and as stated before, their failure to absorb higher user charges could lead to their closure. The closure of these firms entails far-reaching implications such as increased unemployment.



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### 6.4 Recommendations for future research *Together in Excellence*

Most of the studies that sought to examine the relationship between electricity demand or electricity prices and economic growth including this one, established that the two are closely correlated and they have a bi-directional causality. These studies concentrated on the impact of aggregate electricity on aggregate economic growth. However, it must be noted that the vulnerability of each sector to this challenge differs simply because of the different energy intensities of the varying sectors of South Africa. Therefore a sectorial analysis of the impact of increasing electricity prices on economic growth could provide a more useful insight.

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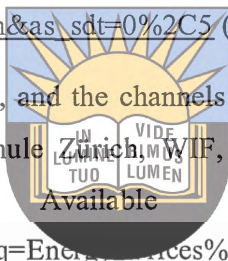
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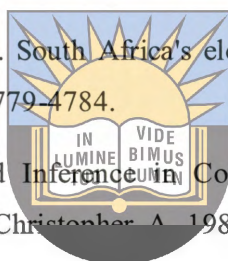
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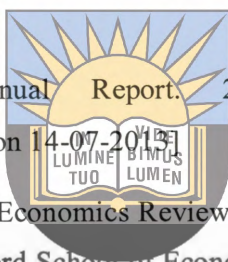
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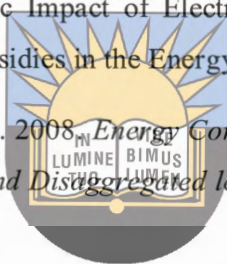
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## APPENDICES

### Appendix 1 Data used in the regressions

YEAR	ELEC	INT	LABPRO	PPI	GDP
1986	10.2	14.3333	-3	27.55833	0.017787
1987	10	12.5	-0.45	31.66667	2.100778
1988	10	15.3333	0.425	36.11667	4.200043
1989	10	19.8333	0.075	42.26667	2.39486
1990	14	21	-1.225	47.33333	-0.31778
1991	8	20.3125	-0.575	52.75833	-1.01831
1992	9	18.8333	-0.5	56.54167	-2.13704
1993	8	16.1667	0.8	61.21667	1.233613
1994	7	15.5833	2.05	66.74167	2.34099
1995	4	17.8958	2.9	73.40833	3.115696
1996	4	19.5208	2.175	79.25833	4.306696
1997	5	20	2.975	84.975	2.646764
1998	5	21.7917	3.35	88.24167	0.517383
1999	4.5	18	3.525	92.88333	2.358129
2000	5.5	14.5	6.075	99.96667	4.154589
2001	5.2	13.7708	4.025	107.1	2.735423
2002	6.2	15.75	3.05	121.3833	3.667838
2003	8.43	14.9583	4.7	126.9083	2.949074
2004	2.5	11.2917	2.125	129.4917	4.554543
2005	4.1	10.625	2.05	134.25	5.277117
2006	5.1	11.1667	3.35	142.8167	5.603718
2007	5.9	13.1667	2.725	156.7667	5.547757
2008	27.5	15.125	1.1	180.6083	3.618562
2009	31.3	11.7083	1.625	181.925	-1.53731
2010	24.8	9.83333	3.8	185.3333	2.889619
2011	25.8	9	0.875	195.875	3.122729
2012	16	8.75	1.1	205.3917	-2.55

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2013	8	8.5	1.875	229.2123	-1.95
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