# THE IMPACT OF CHANGES OF COAL PRICE ON ELECTRICITY PRICING IN SOUTH AFRICA

**By**
**Gugulethu Hazel Nene**
**Student Number: 200205221**

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**Graduate School of Business & Leadership**
**College of Law and Management Studies**

**Supervisor: Dr Pfano Mashau**

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UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

# DECLARATION

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**ABSTRACT**

Among the basic industries in an economy is the power industry. On the other end, electricity is one of the basic public goods. The South African economy is a mixed economy, both command economy principles and the market forces play an important role. This sees the electricity prices being strictly controlled by the government. This is done to ensure smooth economic development and to maintain stable prices. Coal as a source of electricity in South Africa however has become more market oriented. The coal price which was artificially lowered during the price regulation period, increased rapidly in recent years, owing to resource cost, environmental cost and production cost. The market forces too played a role in these adjustments.

It has been insinuated that the extensive capital requirements of building thermal power stations and coal mines lead to the huge increase in the power production costs beyond the reach of the many players in the economy. However, another view is that despite these rising costs in coal prices and power production costs, the retail price of electricity has not been adjusted accordingly, which would result in many players in this industry incurring losses.

This study used the Auto Regressive Distributed Lagged (ARDL) framework and VECM Estimation Technique to test the relationship between two variables, i.e. coal price changes being an independent variable, while changes in price of electricity being the dependent variable. The study sought to analyse the impact of coal prices on the prices of electricity, with particular reference to the KwaZulu-Natal Province in South Africa. Monthly data from 2006 to 2016 were used in this study.

The study had three objectives: the first was to establish the nature of the relationship between coal price changes and electricity prices. The next objective was to determine the presence of asymmetry in the relationship. The last objective was to find the direction of causality and hence, the transmission mechanism through which coal price changes might affect electricity prices. To achieve this, the study mainly focused in using the quantitative research methods. The study makes use of time series data, which has the advantage of providing information about the economic dynamics of some of the variables. The findings of the study indicated a bidirectional positive relationship between the independent variable coal prices and the dependent variable electricity prices. Based on the findings, the following recommendations were made, the concept of analysing coal prices, which considers electricity cost that results from rising coal prices, then there is need to test the direct, indirect (regulatory) and time

varying effects of relative energy prices on electricity prices. Future research could focus on constructing energy price indices on inflation.

# CHAPTER ONE

# INTRODUCTION

## 1.1 Introduction

The cost of electricity may be determined using economic models with different degrees of confidence. The most trusted way to judge such predictions is by looking at historical costs and trends. Electricity has moved substantially in real and nominal terms. The 1960s were characterised by price stability, followed by substantial nominal price increases in the 1970s. Between the 1980s and 1990s, price stability was realised again. The trend changed around 2000, where prices started to increase. Similar long-term movements have been realised in coal, natural gas and crude. The explanation can be that electricity generation is dependent on its input fuel source. Specifically, the same trend has been witnessed between electricity and coal (Mohammadi, 2009).

An increase in the competitiveness in the electricity markets may translate to spot markets which immediately responds to changes in input fuel source markets. The reverse is true, that changes in electricity prices causes movements in the source price (Asche et al.2006). The price of electricity largely depends on the macroeconomic factors power in which the electricity is produced. The cost is compounded of the basic installed cost of the generating plant, and the fuel costs in the case of fossil-fuel powered plant. The power plants fired with coal accounts for about 40% of the global power generation. This makes it the most important source of electricity in use today, with renewable sources of electricity continuing to grow from a small base.

It should also be noted that coal fired electricity generation is the most polluting one. This raises environmental concerns over global warming, one of the world’s greatest problems. The new pragmatism banks on the realisation that the use of coal should continue at least for another generation. However, both environmentalist and generators have reached the consensus that, carbon capture and storage is the only hope for future coal combustion, a process which is being financed partly through carbon taxes.

The author used the Auto Regressive Distributed Lagged (ARDL) framework and VECM Estimation Technique to test the relationship between two variables, i.e. coal price changes being an independent variable, while changes in price of electricity being the dependent variable. The study sought to analyse the impact of coal prices on the prices of electricity, with particular reference to the KwaZulu-Natal Province in South Africa. Monthly data from 2006 to 2016 were used in this study

Lifecycle energy analysis determines how efficient an electricity plant is met using the scarce resources to produce electricity. Further analysis can be done using the lifecycle emission analysis, which shows how much pollution an electricity plant produces for each unit of electricity generated. Lifecycle carbon analysis will be an important factor in judging future power economics.

This chapter discusses the overview of the study, from the background information, statement of the problem, purpose of the study, aims and objectives of the study, research questions, the importance of the study and the limitations of the study.

### 1.2 Background to the study

According to the National Energy Regulator of South Africa (NERSA), coal is the world's primary energy source for power generation, accounting for some forty percent of global electricity generation. Its significance varies greatly among countries and world regions.

Furthermore, NERSA, (2013) states that Eskom, a fully state-owned and vertical integrated utility, supplies ninety-five percent of South African power demand. Coal fired plants comprise 85% of Eskom's generating capacity. However, the country is trying to increase the share of independent power producers, sets a revenue cap based on Eskom's full generation costs, which is then translated into a variety of tariffs differentiated by customer groups. Eskom is therefore incentivised to minimise costs by dispatching according to variable costs.

However, all plants are running at full capacity with the current low supply reserve margin. The coal power plants are feed either by dedicated mines or through short term and medium term signed agreements from export-oriented mines. According to the available main data sources , the local coal prices has always been about a third of the price in the global market.

The explanation comes from the fact that, the coal used domestically is characterised by being of poor quality and the associated transport cost is significantly low locally. In addition to that, international prices are largely influenced by constrained export infrastructure, especially in a developing country like South Africa.

In as much as secondary costs are part of energy costs, their influence on power generation costs is very insignificant. That, then leaves primary costs as the biggest contributor to the power generation cost. This however do not suggest that, primary energy costs are correlated the ultimate electricity prices. A number of other contributing factors come into play. The other which are compounded include but not limited to, capital costs and different operational costs. Different parameters are then employed to investigate such correlation owing to differential in resource endowment across regions of the world and even countries.

In situations where domestic deposits are economical to mine, hard coal is highly important. This the situation when it comes countries like, United states of America, China, Australia with South Africa adding on the list. The case is not the same with countries or regions whose supplies comes entirely from the global market, the situation of European Union and Japan. In these countries, hard coal plays a significant role in matters of coal supply security. It is then very important to note that, the electricity market performance largely depends on coal, its availability, price and efficient utilization. It is from that angle of view that a common ground is reached on the significance of costs of hard coal in moulding electricity prices more than a mere percentage share of hard coal in power generation.

The power industry is one of the basic industries in the national economy, while electricity is one of the public's basic goods. In South Africa, electricity prices have long been strictly controlled by the government through ESKOM, to maintain smooth economic development and a stable overall price level. In recent years, coal pricing has become more and more market-oriented, while coal price, which was artificially lowered during the price regulation period, increased rapidly due to its resource costs, production costs, environmental costs, as well as the market's supply and demand conditions. Coal price, as the largest expense, greatly increases the cost of thermal power plants when it increases. In South Africa, the coal–electricity price linkage mechanism was not fully implemented, a large number of power enterprises incurred substantial losses and since then, have urged the government to raise the on-grid power price to improve their business condition. In this work, the analysis and evaluation of the influence of the coal price increase on the electric power industry, especially on the electric power industry's cost and the influence of electricity price adjustment on the economy, are reported. These measures are of great importance for the review of energy consumption.

## 1.3 Problem statement

The interest of this study is propelled by the need to empirically measure the effect of coal price changes on the prices of electricity in South Africa. The issue of coal price changes is crucial, as coal prices affect macroeconomic indicators of every country. In early 2008, South Africa experienced the first of a series of highly disruptive outages and load-shedding episodes that came at an enormous cost to the economy. The electricity supply crisis prompted decision makers to respond with greater urgency to the capacity shortage that had been threatening to emerge for some time, and Eskom was given the go-ahead to embark on a massive investment programme. However, in the 20 years since Eskom had last invested in base load capacity, real electricity tariffs had declined to such an extent that it became apparent that Eskom would not be able to finance the newly built programme on the basis of its existing low tariffs and inadequate revenue. In the 5 years between 2008 and 2013, electricity prices more than doubled in real terms, rising by a cumulative 114%, as the national energy regulator (NERSA) granted Eskom tariff increases to help it raise debt for the new build. However, the sharp increases in real electricity tariffs over this period prompted a public outcry, and NERSA took a decision to limit the increase in real electricity tariff to approximately 2% per year for the 5-year period from 2013 to 2018.

Due to the magnitude of the problem, which is facing the economy, the researcher is motivated to follow the bandwagon of other researchers who already weigh in to try to come up with solutions to solve and analyse the real causes of the increases in electricity prices. The overall aim of this research study is to provide different perspective to other interested parties, with the history of electricity prices and consumption of electricity on a wide spectrum. To evaluate critically the major South African electricity pricing policies and surfacing the challenges faced by Eskom as the provider and regulator of the South African electricity pricing.

## 1.4 Rationale for the study

In as much as there are other studies conducted before on the same subject, they use developed countries such as China, United States of America and the European Union, as their case studies. In the developed world, information asymmetry is at bits minimal level. This study is the first of its kind to investigate the impact of changes in the dependent variable coal prices on the price of the dependent variable electricity in the developing world, specifically in South Africa.

Furthermore, the researcher is more passionate about solving problems, especially those which affect the communities, hence, there is a need to investigate this subject, considering the public outcry which was evident after NERSA approved the increase of electricity tariffs. The researcher thus takes this opportunity to assess if the regulator's decision was made from an informed view, or on a biased point of view. In that case, the researcher hopes this study might help in resolving the matter.

### 1.5 Purpose of the study

The purpose of the study is to provide different interested parties with the history of electricity prices and consumption on a wide spectrum. To evaluate the major, South African electricity pricing policy criticism and to surface the challenges faced by Eskom as the provider and regulator of the South African electricity pricing regime. Furthermore, the study aims to discuss the requirements of an efficient electricity pricing regime and the economic principles that underpin the setting of equitable and efficient tariffs under a regulated and vertically integrated monopoly provider. Also, the researcher aims to investigate how competitive is the South African electricity pricing policy in the global market. In view of that, the study has the following objectives.

#### 1.5.1 Objectives of the study

- To investigate the relationship between coal prices and the electricity prices.
- To determine the presence of asymmetry of coal price and domestic electricity prices in South Africa.
- To provide the key requirement of an efficient electricity pricing regime and the economic principles that underpin the setting of equitable and efficient tariffs under a regulated and vertically integrated monopoly provider to various stakeholders.

#### 1.5.2 Research Questions

- What is the relationship between the independent variable coal price and the dependent variable electricity price?

- Is there any asymmetry of coal price and domestic electricity prices in South Africa?
- What are the requirements for an efficient electricity pricing regime and the economic principles that underpin the setting of equitable and efficient tariffs?

**1.6 Significance of the study**

The findings of this study are expected to show that there is a perfect positive relationship between changes of coal prices and electricity prices. The results might also help to expose the electricity price subsidies implicitly and the public will gain information on the degree of the subsidy and the problems associated with such subsidy, using well defined communication strategies.

The significance of this paper is two-fold. First, through empirical research, the author makes clear. The results may be particularly instructive for practice. Second, although removing regulations on energy prices is probably good for energy saving in short term, it may result in power cuts in the long run. In a market with a higher degree of market pricing, the market itself can guide the energy saving behaviours of the public through the pricing mechanism; on the other hand, the government can regulate energy prices through finance and taxation policies in the long term, which is not only beneficial to energy saving but can also help to avoid shortages of electricity in the country.

Furthermore, the research might also help the policy regulators to revise the way they set local government electricity tariffs. This may help address the differences in tariffs levied by local government electricity distributors. The discrepancy has been standing as a stumbling block to a cost-effective tariff regime. This can also help to go as far as appropriate phrasing of the process, relevant subsidy provision and finding measure to protect the vulnerable and affected groups.

**1.7 Scope of the study**

The study was based on South Africa. Electricity tariffs data were sourced from the municipalities in the KwaZulu-Natal province. The research only included coal prices as the independent variable and electricity prices as dependent variable. The researcher used secondary data, since primary data were not more appropriate in conducting such type of a research.

### 1.8 Limitations of the study

The time frame available to conduct the research was very limited, considering that there was so much data to be analysed. This then forced the researcher to only use secondary data for the study. The researcher did not have sponsors to fund the research, therefore, due to limited funds to conduct the research, she only used secondary data that was readily available and thus, relatively cheaper to gather.

### 1.9 Dissertation outline

This chapter provided insights into the background of the study, the problem statement, objectives of the study, significance of the study as well as the research constraints on carrying out this research. Chapter two explores literature review on coal as a source of energy and the prices of coal. It also highlights the prices of electricity in SA and regulations which are around this industry. Chapter three is a discussion of the methodology undertaken to answer the research questions and to achieve the objectives of the study. Chapter four presents the findings of the study, based on the data collected. Chapter five is a discussion of the findings, while Chapter six concludes the study by highlighting the summary of the study and conclusions, based on the study, the implications of the study, recommendations based on the findings, as well as a discussion of areas for further research.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Introduction

The previous chapter provided an overview of the study by highlighting what the study is about. This chapter focuses on the relevant literature pertaining to the area of study. It gives insights into what different scholars think about changes of coal prices and regulations around electricity prices in the energy industry in SA. In this view, the researcher will be critically reviewing both influential theoretical studies and the most recently influential empirical studies.

## 2.2 Overview of the coal energy and electricity in South Africa

In this section, the researcher gives a general overview of the coal prices and electricity prices in South Africa, projected future demand for coal products in South Africa, and pricing of coal products in South Africa.

The most important energy source currently, after oil is coal. It is also among the cheapest and most abundant energy carriers. Prior to the discovery of coal in the 16$^{th}$ century in England, peat was used, especially in Netherlands where it ushered the Dutch golden age, a period of prosperity. The quantity of energy present in peat is very little compared to coal. This made the discovery of coal the opening of the flood gates of energy. The industrial revolution in Britain by cheap coal discovery, commencing with its use in the mining industry. The transport sector, subsequently industrial processes and electricity generation. As a source of electricity, coal power and steam engine were used to pump water out of coal mines.

The contribution of coal in the global energy mix has steadily grown over the years. Despite the most notable price shock experienced by the global economy, coal has remained durable. In 1973, the contribution of coal in the global energy mix was 24,5h, an equivalent of around 3Mt while oil 46,2h. By 2014, coal's contribution had increased to 28,6h while oil had reduced significantly, settling at 31,3h. In recent years, coal power has played a vital role in improving the welfare of communities across the world. In China, for instance, coal power has lifted millions of people out of electricity poverty. A mere three million people do not have access to electricity in China, out of the 1,3 billion of people in population to date.

Coal as an energy source faces a number of challenges, among other things, is the biggest contributor to Green House Gas (GHG) emissions, the resulting effect being environmental degradation. Internationally, governments have developed and have been continuously revised legislation to help cut down the use of coal in the generation of electricity. As a result, environmentally friendly means of generating electricity are being subsidised with the hope that soon coal will be replaced completely in the electricity generation process. At present, coal power has reduced drastically in countries like United Kingdom, (UK), United States of America (USA) and Germany. They replaced coal with nuclear power generation technologies and other renewable sources of energy.

Coal discovery dates back to 1879, in South Africa, first by George William Stow. Although his first prospecting was not successful, his second one proved fruitful with the discovery of coal round Bethlehem area in the today's Province of free state. He later on discover other commercially viable deposits in the Transvaal. This adventure was to fuel the diamond mines in Kimberly, hence a constraint of poor infrastructure was met which found the then government of Orange Free State province decide not to pursue the discovery, regardless of the fact that it is the one which commissioned Stow to venture into the project. However, Stow and his team did not give up, they improvised and endured the use of oxen drawn wagons in the transportation of coal to the intended destination, Kimberly. November 4 2016 witnessed countries entering into an agreement to find means to avoid further damage to the ozone layer. South Africa is one of the countries who committed to implement measures that can help address climate change. Through the Department pf Energy (DOE), the South African government intends to reduce the contribution of coal generated power in the, country's electricity mix with a significant margin, from 82% i8nn2016 to 31% in 2050. this is listed in the Integrated Resource Plan (IRP), 2016. In as much as such efforts are being appreciated world-wide, coal and nuclear energy will continue to play a vital role in the economy. This was classified in IRP 2016, adding that an additional 6,3GW of electricity to existing generation consumption level which would have come coal-fired power plants.

### Facts about the coal resource in South Africa

- South Africa is rich with an estimated thirty billion tonnes of coal which represent 3,5% of the global coal resource.
- South Africa produces 3,3 percent of the annual global coal production.
- The 80 percent of coal production in South Africa is mined in Mpumalanga, Limpopo, Free state and KwaZulu Natal. Coal reserves are declining in Mpumalanga and mining is drifting slowly to the Waterberg region.
- South Africa produced 253,1Mt of coal, 181,4Mt was sold internally at a value of R61,5 billion while 68,9Mt worth R50,5 billion was exported in 2016.
- 82% of the power generated by Eskom as a state-owned power utility is generated from coal.
- Sasol mines 40Mt of coal every year for gas and for conversion into liquid fuels.

## 2.3 An overview of electricity supply in South Africa

According to Eskom newsletter (2013), it is 100% state owned vertically integrated electricity utility enterprise. It supplies approximately 95% of South Africa's electricity from a net maximum generating capacity of 41.9 GW and a transmission and distribution network of 373 280 kilometres (km). The remaining 5% of electricity supply is made up of a small group of municipal and industrial representatives, predominantly for their own use. In 2012, approximately 42% of Eskom's sales were to (re)distributors in the form of the municipalities, which also fund and maintain distribution networks in their respective geographical areas. Municipal customers in turn include industrial, commercial and residential users. From the 1970s, Eskom embarked on a strategy to leverage economies of scale through the construction of power stations, each with a capacity of 3600 MW or lager.

These power stations built adjacent to the coalfields in order to minimise coal transport many of the adjacent coal mines supply coal to Eskom by conveyor on a long-term cost-plus station is aging and many of the power stations are nearing retirement age.   A period of very low economic growth (and thus power demand) at the end of the 1980's and early 1990s resulted in a delay in the introduction of new electricity supply capacity. This was followed by a more recent, high economic growth in the late 1990's and early 2000's. The lack of investment in new supply capacity over this time has narrowed the electricity supply reserve margin.

Additional coal supplies will be required for power stations running at higher load factors or longer lifetimes beyond what was originally planned. In addition, Eskom has two new large coalfired power stations under construction (approximately 4800 MW each), due to be commissioned between 2013 and 2019.

In 2003, the South African Cabinet made a policy decision to introduce independent power producers (IPP) into the electricity supply industry, such that future electricity generation capacity would be divided between Eskom (70%) and the IPPs (30%). In 2007, the Cabinet designated Eskom as the single buyer of power from the IPPs in South Africa.

In 2011, the Department of Energy published the current iteration of the Integrated Resource Plan (IRP) for South Africa (IRP2010). This plan specifies the new generation capacity requirement for South Africa for the period 2010 to 2030. The IRP is expected to be updated on a regular basis. The need to accelerate development in Africa is widely recognised and access to clean, reliable energy is vital to that task. Excluding South Africa and Egypt, it is estimated that no more than 20%, in some countries as little as 5% of the population, has direct access to electricity (Eskom, 2010). To deal with the challenge of financing new generation capacity, some countries have sought to increase the level of generating capacity to work towards the integration of national power grids and to create cross-border power pools. The Southern African Power Pool (SAPP) is the first formal international power pool in Africa. It was created with the primary aim of providing reliable and economical electricity supply to the consumers of each of the SAPP members, consistent with the reasonable utilisation of natural resources and the effect on the environment. The current countries/utilities that are SAPP members include Mozambique (Electricidade de Mozambique, HCB, Motraco), Botswana (Botswana Power cooperation), Malawi (Electricity Supply Commission of Malawi), Angola (Empresa National de Electricidade), South Africa (Eskom); Lesotho (Lesotho Electricity Corporation); Namibia (Nam Power), Democratic Republic of the Congo (Société National d'Électricité), Swaziland (Swaziland Electricity Board), Tanzania (Tanzania Electric Supply Company), Zambia (Zambia Electricity Supply Corporation) and Zimbabwe (Zimbabwe Electricity Supply Authority). SAPP has made it possible for members to delay capital expenditure on new plants due to the existence of interconnections and a power pool in the region. This is an important aspect in developing the economies of Southern Africa. While Eskom (and hence, South Africa) is currently a net exporter of electricity, net international sales (sales less purchases) represented only 2.8% of Eskom's total sales in 2013. The majority of the imports are from Cahora Bassa (HCB) in central Mozambique, with small volumes from Lesotho. Eskom exports firm power to the national utilities of Botswana (BPC), Namibia (NamPower), Swaziland (SEC) and Lesotho (LEC).

### 2.3.1 Market design

Historically, the National Electricity Regulator (NER) was the regulatory authority that presided over the electricity supply industry (ESI) in South Africa. NERSA replaced the NER in terms of the National Energy Regulatory Act 40 of 2004. Under the Electricity Regulation Act 4 of 2006, it is required to issue licences to all players involved in the production and supply of electricity and to “regulate prices and tariffs” that are supplied by electricity licensees. For much of the past three decades, electricity prices in South Africa have been low and declining in real terms, where electricity price increases did not keep up with inflation. However, from 2008, the trend in prices took a dramatic turn. This increase in electricity prices is the outcome of a policy to charge cost reflective tariffs.

The move towards cost-reflective prices in the electricity sector started with Eskom’s first price application to Nersa, including the following components:

- primary energy, including costs relating to IPPs;
- operating costs, including integrated demand management programmes;
- depreciation, based on Eskom ‘s recently valued replacement asset base;
- return on assets.

In regulatory terms, a price that will fully addresses all of the above components would be “cost reflective”. Demonstrating that Eskom is on a sound financial footing is a necessary pre-condition to raising the investment required to fund the building of new electrical supply capacity projects. According to a report by Deloitte (2012), between 2008 and 2011, real electricity prices rose by 78%. However, despite the significant increases, they also claim that electricity prices in South Africa are still low by international standards and do not yet reflect the full economic cost of supplying power Eskom continues to apply for multi-year price determinations (MYPD) from NERSA. After extensive stakeholder engagement, NERSA then makes a decision on what revenue will be permitted per year, for the period requested. As a result of NERSA’s previous two multi-year price determinations, electricity revenues have exceeded operating costs. Effectively, a determination is made on the average price increase, which is then translated into a range of tariffs, which are differentiated according to customer class. It is important to note that individual customers may not experience this average price increase; some customers experience higher increases and other customers experience lower increases (including subsidies, where the government has identified a social imperative). Redistributors also incorporate their own network costs and revenue requirements to decide on their final electricity prices.

### 2.3.2 Operating costs

Since Eskom has a monopoly on electricity production in South Africa, the average electricity price is determined by NERSA, through the process outlined above. On the production side, Eskom does minimise costs through dispatching plant according to lowest variable costs, a significant portion of which is attributable to fuel inputs. The low electricity supply reserve margin necessitates that all plants run whenever possible and cost order dispatch is not currently possible. This situation is expected to persist until sufficient new capacity is brought on board. Although currently there is no explicit carbon price in South Africa, carbon constraints were factored into the most recently promulgated national electricity supply plan (IRP2010) and the electricity price also carries an environmental levy of ZAR 3.5c/kWh. More explicit carbon pricing has been proposed in the form of a carbon tax. To date, the information provided concerning the proposed carbon tax according to the National Treasury, (2013) is that:

- a carbon tax which was implemented in January 2015 is adhered to
- the first phase of implementation covers the period 2015 to 2020
- the basic taxfree threshold on emissions remains at 60% during this first phase
- the 60% may be reduced or removed in the second phase;

Certain industries may be allowed to increase this threshold by up to 10% for trade exposure and 10% for process emissions, plus 5% to 10% for offsets (but how these offsets will be assessed is still to be defined); the tax value is set at ZAR 120 per ton of carbon and will increase by 10% annually, during the first phase; Scope 2 (including electricity) emissions will be taxed. Considering the regulatory rules governing tariff increases in the electricity sector, any environmental tax is likely to be passed through to consumers. Another report by South Africa Department of Environmental Affairs, (2011) indicated that the Department of Environmental Affairs was developing a carbon budget for the country, in accordance with the National Climate Change Response Strategy and this would be expressed as desired emissions reduction outcomes per economic sector. The interface between sectoral carbon budgets and the proposed carbon tax is also being assessed. South African coalfired power stations are supplied exclusively by the domestic market, either through dedicated, cost plus mines, or with the middling product from multiproduct mines or through short and medium-term contracts. There is an indirect connection to the world market through the beneficiation choices of multi-product mines, as well as the future investment choices of mining houses. The impact of global coal market prices on short and medium-term domestic contract prices has been partially limited by the constrained infrastructure to export coal from inland reserves. National domestic coal prices are, on average, well below international prices. Given the volatility of coal prices, the relation between domestic and international prices has varied greatly through the years. Since 2008, when export coal prices at the port (Richard's Bay Coal Terminal) were on average almost five times higher than the domestic prices at mine gate, the ratio has been closer to three to one more recently. However, these prices are not directly comparable, given the differences in qualities (yield factors and beneficiation costs) and location (transport, handling costs and terminal charges). South Africa only has 2 409 MW of open cycle gas turbine electricity generation installed capacity, about 5% of the total. Due to the lack of local availability of natural or liquified natural gas, these stations are run on liquid fuels. They are only dispatched during peak periods and during extreme emergencies due to the very high operating (fuel) costs. The cost of coal in 2012 constituted around 27% of Eskom's total operating costs (calculated from Eskom, 2013). The NERSA determination allows Eskom an average nominal coal price increase of approximately 8% per annum, between 2014 and 2018. Meeting the NERSA ruling is of concern to Eskom as the unit cost of coal burnt increased by approximately 14% (adjusted for contractual penalties) between the financial years ending March 2012 and March 2013. Price increases reflect both changes in coal sources and the effect of longer transport distances.

However, there is not necessarily a direct correlation between coal and electricity prices. Electricity prices are regulated and in addition to primary energy costs, there are other cost components which vary. Based on certain assumptions on the value of assets, under the IRP2010, it was projected that the cost of electricity should rise to approximately 78c/kWh (2010 ZAR), in order to reflect the full economic cost of electricity supply from the existing fleet (Republic of South Africa, Government, 2011). This compares with an average electricity selling price of around ZAR 45c/kWh in 2010 (Eskom, 2012b). The current discrepancy in prices reflects a smaller depreciation allowance or a lower allowed rate of return, which

NERSA has determined in order to minimise potential negative effects of electricity tariff increases on the economy and to South African society.

How have consumer prices for electricity developed since 2000, differentiated according to important customer groups? In South Africa, different customers pay different prices for electricity. Domestic and street lighting, for example, almost doubles industrial prices. If we compare the evolution of the different consumer groups in the decade starting from 2001, prices in nominal terms have doubled on average, but with different profiles. Domestic and street lighting only increased 45%, partially offsetting higher increases in most of the other groups.

### 2.3.4 Global Trends of coal and electricity prices

Global electricity markets are in transition. Major drivers across all continents are the ongoing liberalisation movement in order to implement competitiveness and cost efficiency, the extension of renewable energy sources in order to increase sustainability and the need to guarantee sufficient available generation capacities in all markets to implement and maintain security of supply. Although short term challenges and political measures vary across the different electricity markets in the world, these general targets are internationally valid. This is illustrated within five electricity market studies from Europe, the United States, Australia, Japan and South Africa.  It becomes obvious that the current and future market role of electricity generation from coal supply is impacted by this development in two dimensions: the gradual opening of electricity markets, new suppliers and expanding renewables increase the competition on coal generation; in parallel, the typical market position of coalfired generation capacities as a result of their permanent availability and high flexibility further increases the influence of coalfired generation cost on electricity prices.

The competitive position of coalfired power plants and their technical flexibility are used by the markets to compensate for short term hangs in power demand, i.e. in times of rising electricity consumption, additional coal plants are requested by the market to be ramped up and in times of declining consumption, some coal capacities are temporarily disconnected from the grid. Therefore, the dispatch behavior coalfired plants is transferred into power prices on the wholesale markets. In order to incentivise some plants to connect and disconnect from the grid, electricity prices still need to follow their specific generation cost. As a consequence, the price impact of the generation cost of coalfired plants is significantly higher than their market share. In some European markets it could be observed that the price impact of coal further increased, although the market share was partly substituted by renewables. Globally, coal fired power generation covered more than 40% of global electricity demand in 2012. According to the analysed market impact of coalfired generation capacities, the influence of coal generation cost on the world electricity prices is even higher than the world market share. Based on the current outlook for the world energy markets, a remaining cost pass through of more than 50% is likely in the time frame 2013 to 2020. Hence, temporary scarcities in the coal supply chain and adjacent price shocks for coal are to be avoided to keep wholesale electricity prices on a stable level.

### 2.4 Empirical review

Bachmeir and Griffin (2006) tested for cointegration within and between different crude oil, coal and natural gas markets. Various crude oils from global markets seem to be highly cointegrated and a cointegration relationship in the long-run between oil and natural gas is found, but in contrast, a weak cointegration relationship in the U.S. coal market is the case.

In 2009, Mjelde and Bessler studied dynamic price relationships between US peak and off-peak electricity wholesale spot prices from the PJM and Mid-Columbia (Mid-C) for the period 2001-2008. These prices were linked to four major fuel sources; natural gas, crude oil, coal and uranium. They studied eight price series and found all eight to be cointegrated with all series included in the long-run relationships, keeping the price-movements together. However, they found less than n-1 cointegrating vectors, which means the markets are not fully integrated and there is no single common trend. Electricity prices influence natural gas prices in contemporaneous time and natural gas prices influence oil prices. In the long-run, fuel source prices have a leading role on electricity prices. The fuel prices (except uranium) are stable when disequilibrium finds place. Uranium and electricity are the variables that change in order to restore equilibrium.

Mohammadi (2009) researched the long and short-run dynamics between electricity prices and three fossil fuels (coal, natural gas and crude oil) in the U.S, making use of yearly data for 1960 – 2007. He finds only evidence of significant long-run relations between electricity and coal. Crude oil prices have no significant influence on electricity prices and the relationship between natural gas and electricity prices is statistically weak. In the short run, a one-way causal relationship is detected from coal and natural gas prices to electricity prices.

With regards to the passing through of carbon costs, Sijm, Neuhoff and Chen (2006) distinguished between the behaviour of individual generators and the impact on the price system as a whole, by defining the ‘add-on’ and the ‘work-on’ rate. The ‘add-on’ rate is the extent to which individual generators pass on carbon costs into their bidding prices (which is usually 100 percent). The ‘work-on’ rate is the rate that is effectively passed-on to the power prices on the market (which is often less than 100 percent due to a variety of reasons). “One reason why the work-on rate may be lower than the add-on rate is market demand response,” (Sijm, Neuhoff and Chen:2006). Higher electricity prices may reduce the total demand and prevent an expensive generation unit to operate as the marginal producer. The electricity price will thus be lower, but the variation in price will be lower than the change in marginal costs due to emissions trading. As a result, the add-on rate will remain at 100 percent and the work-on rate will be lower than 100.

According to Neuhoff et al (2005), the opportunity cost of emitting carbon may be reduced when allocation is updated. They argue that updating implies a cost of not-emitting: high emissions today hold the promise of a higher allocation tomorrow. In case of updating and an elastic power demand, power producers will not pass on the full opportunity costs, as this will reduce their output/emissions and, as a consequence, the amount of free allocations in the next period. Hence, they will balance these two (opposing) effects until an optimal equilibrium is reached (Sijm et al, 2005). Overall, if updating is applied beyond the first commitment period, it may not only reduce today’s electricity prices, but also, the future electricity prices.

To estimate the carbon pass-through rate onto power prices, Sijm et al (2006) relied on empirical and statistical analyses of trends in prices of fuels, carbon and electricity in Germany and the Netherlands, over the period between January-July 2005. Rates of pass-through of carbon costs onto power prices are estimated based on four cases: Germany, for peak and off-peak hours where prices are mainly set by coal-fired producers; the Netherlands, for peak and off-peak hours, where peak prices are set by gas fired plants, while off-peak prices are fixed by coal plants. Two statistical regression approaches called the Ordinary Least Squares (OLS) method and the Prais-Winston (PW) method, and; One simple regression-line approach developed by Energy Research Centre of The Netherlands. The difference between the OLS and PW methods mainly concerns the incidence of so-called autoregression or autocorrelation among the data used. The existence of such autocorrelation could bias the estimated results. While the PW method corrects for this incidence/bias, the OLS does not. The method developed by Energy Research Centre of the Netherlands is based on an analysis of dark/spark spreads over a certain period, both excluding and including carbon costs. When the costs of carbon are included, these are called clean dark/spark spreads. The authors assume that the trend line of these spreads in Germany and the Netherlands should be flat when including the carbon costs, assuming in effect that all remaining variations of these spreads can be attributed to random variables with an expected value of zero. The method consists in solving for the pass-through rates that will satisfy this condition.

Sijm, Neuhoff and Chen (2006) update this analysis with a longer observation period and a more refined statistical approach. They found much higher pass-through rates. The very high rate for Germany may be partially explained by increasing gas prices during 2005. “Given that gas generators (instead of coal generators) set the marginal price in Germany during their competes modelling work, the authors were able to make a further differentiation of load periods throughout a calendar year. While the marginal technology may remain constant throughout (most of) these load periods, the authors noticed a switch in marginal technology between these periods. Bootstrapping: a method of calculating errors using only the data at hand as a distribution. As explained by the authors, they constructed a subset data by bootstrapping samples from a window of a two-month period, and then ran their regressions based on the combined data from the peak hours, this could contribute to power prices' increase in peak forward contracts. As coal generators benefit from this gas cost-induced increase in power prices, it leads to an overestimate of the pass-through rate of carbon costs for coal-generated power. The method used, which consists in assuming away other factors behind price variations (averaged at 0), makes the observation period crucial.

In a report from the Energy Information Administration which assesses the impacts of a greenhouse gas emissions regulation on electricity prices in the US through a cap-and-trade scheme, it is expected that if a portion of allowances is provided for free to regulated utilities, regulators are expected to pass these savings on to consumers. Increases in electricity prices equivalent to the opportunity costs of free allowances would not occur. The report concludes that the impact on electricity prices is slightly smaller than in a full auctioning scenario. It also notes that in contrast, 23 in regions where electricity prices are set competitively, the changes relative to the reference case are the same in both partial and full auction cases.

A Finnish study (Honkatukia et al, 2006) empirically assessed the developments of the European Union Emission Trading Scheme in the first 16 months. Based on econometric calculations from the collected data, the estimated results indicate that on average, approximately 75 to 95 percent of the price changes in the European Union Emission Trading

Scheme are passed on to the Finnish Nord Pool day-ahead prices. The authors analysed the development of daily and hourly Nord Pool prices in the Finnish market area of Nord Pool and tested their correlation regarding several factors: various scarcity capacity indicators, input cost indicators such as the prices of coal, natural gas and carbon allowance prices and demand shaping indicators (e.g., weather, working day or week-end, etc.). They ran three econometric models on Finnish electricity prices from February or May 2005 to May 2006.

The authors also simulated to what extent the passing on of allowance prices varies when the state of the power system varies (and hence the power prices). The presented indications for the extent to which the prices of the European Union Emission Trading Scheme are passed on to electricity prices reflect a situation of the past over historic data from May 2005 to May 2006. The results share a rise in European Union Allowances Prices (EUAP) passed on to the Electricity Spot Price (ESP) for different single day European Union Allowances (EUA) price increases for different typical loads, low loads, medium loads and high loads variation in percentage Share of variation in European Union Allowances price passed onto spot price

According to a report by Ilex (2004), in the several European electricity markets studied, it is likely that carbon allowance prices will be passed onto electricity wholesale and retail prices. Key elements influencing the pass-through rate include the Market Structure (MS) of generation, new entry and closure rules, tightness or looseness in National Allocation Plans (NAP-T/L) and the influence of government and regulators. Ilex makes a general assumption for all countries that there will be a full pass-through of carbon allowance prices onto wholesale and retail prices, unless there are specific reasons for expecting otherwise. In those countries where there is incomplete pass-through, regulatory or political intervention is the main factor that will curtail price rises. Nevertheless, in its report, Ilex assigns relative confidence levels to its estimates, 1 being low confidence and 3 being high. They mention uncertainty with respect to Germany in particular: full pass-through is by no means guaranteed as a result of a relatively achievable NAP, dominant generators, and uncertainty, as to the level of intervention by the regulator.

Some of the previous literature directly focused on the relationship between absolute energy prices and energy consumption, which can reveal a visible relationship between energy prices and consumption. Many studies support the notion that rising energy prices lead to reduced energy consumption (Amano, 2000; Fei & Rasiah, 2014; Li & Lin, 2015). Some of these studies focus primarily on the channels through which energy prices influence energy consumption. However, Steinbuks and Neuhoff (2014) argue that improvements in energy efficiency and reductions in energy input, resulting from rising energy prices are the main reasons for reduced energy consumption. In practice, the own-price elasticity of energy in different industries (He et al. 2014), the purposes of energy consumption (Zheng & Wei 2014), and the sensitivity of energy prices in different areas (Moshiri, 2015) all vary. These studies support the premise of this study that the effects of relative energy prices can be studied from the perspective of inflation costs.

Another study which was examined in China by Guo, Jin and Zheng (2016), Xinye and Chen Zhan-Ming (2016) found that China is currently facing significant economic uncertainties brought forward by the instability of coal price. By separating the asymmetric effects that how upward and downward coal price changes pass through to the economy, this studyre-examines the relationship between coal price and general price level in China. The asymmetric effects are investigated via vector auto regression models, Granger Causality tests, and impulse response function analyses using the monthly time series data from Jun1998 to Sep2014. The results showed that a negative coal price change presents more significant impact on electricity prices. The prices of electricity responses vary abruptly to coal price shock in the short run.

### 2.5 Conclusion

In summary, there is a consensus that increasing energy prices is an effective policy tool for reducing energy consumption. However, most previous studies only examined the direct effects of absolute energy prices on energy consumption.

# CHAPTER THREE

# METHODOLOGY

## 3.0 Introduction

The purpose of this chapter is to explain the methods of gathering data used in this research. Preliminary desktop research was undertaken to enable the research questions to be answered. This enabled a quick and economic way of seeking to establish the facts about coal and electricity prices in South Africa, that is, the determinants of coal and the impact it has on electricity in the country. In that view, this chapter discusses the research methodology used and provides a rationale for choosing it. The research design is also discussed. This includes the research strategy, the target population and sampling strategy, as well as the data collection tools. In addition, the ethical considerations, the limitations of the study, aspects of validity and reliability are also discussed in this chapter.

## 3.1 Research Design

This master plan specifies the methods and procedures for collecting and analysing information. Taylor (1996:56) describes research design as the "deliberate planned arrangement of conditions for analysing and collecting data in a manner that aims to combine relevance to the research". Furthermore, according to Sekaran and Bougie (2013:89), research design entails the "blue print for the collection, measurement and analysis of data based on the research questions of the study". In this specific research, the author used all the three main research designs, that is, exploratory, descriptive and causal studies. The researcher to make a great effort to exemplify and describe subjects more accurately carried out descriptive research. However, the author did not only end up by unfolding and relating variables under study, but she also linked, clarified and simplified the variables and showed the relationship between these components, thus making the study more appropriate to use a causal study. In using the exploratory perspective, the researcher observed deeply in adding more information in order to advance new viable theoretical framework into well known existing facts.

### 3.1.1 Research Approach

The researcher found it suitable to use quantitative research design. Quantitative methods highlight the objective "measurements and the statistical, mathematical, or numerical analysis of data collected through polls, questionnaires, and surveys, or by manipulating pre-existing statistical data using computational techniques. Quantitative research focuses on gathering numerical data and generalizing it across groups of people and mainly explains a particular phenomenon" (Muijs, Daniel, 2010:47).

The main objective to conduct quantitative research study is to conclude the relationship between one subjects called an independent variable and in this research is the changes in coal prices, another subject called a dependent variable, and in this study is electricity pricing.

Quantitative research deals with numbers, logic, and an objective stance. Quantitative research focuses on numeric, fixed data and comprehensive, convergent cognitive rather than conflicting cognitive, this allows the development of several concepts about a research problem in an unprompted, free-flowing manner.

### 3.1.2 Target Population

In developing economies like South Africa, to carry out a research of this nature is generally problematic because data are not easily accessible or if it is accessible, in many cases it had been already manipulated. This study was conducted in South Africa. The research make use of data from the period 2000 to 2016.

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## 3.2 Sources of Data

This study relied on secondary data. The data were extracted from secondary sources; that is, annual audited financial reports and reliable published reports by reputable organizations such as ESKOM, the South African Reserve Bank and Quantec Online Data base between the period of 2000 and 2016. In this research, the author used nominal figures. The study also makes use of time series data, which has the advantage of providing information about the economic dynamics of some of the variables. This may prove useful in this case, since electricity prices were fluctuating over the time.

## 3.3 Research Methodology

The study used the Auto Regressive Distributed Lagged (ARDL) framework and VECM Estimation Techniqu**e**, using the two main variables, that is, electricity prices and coal prices. Therefore, these models estimate using a standard ARDL and VECM to determine the response of electricity prices to the increase in coal prices.

### 3.3.1 The Autoregressive Distributed Lag (ARDL)

Pesaran and Shin (1997) introduced this model and it deals with single cointegration. In 2001, Pesaran, Shin and Smith improved this method significantly. The ARDL method has the advantage that it does not need all variables to be investigated. The method has limits of testing for cointegration, which 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 coal prices and electricity, certain testing under Pesaran, *et al.* (2001) procedure was used. The certain testing procedure is based on the F-test under the theory of no cointegration among the variables against the existence or presence of cointegration among the variables.

This is symbolized as:

Ho: $\beta 1 = \beta 2 = 0$

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

Ha: $\beta 1 \neq \beta 2 \neq 0$

Whereby the alternate hypothesis is that there is cointegration among the variables.

The asymmetry distribution of the Wald-test is non-standard under the null hypothesis of no cointegration among the variables. Pesaran et al (2001) give two critical values, for the cointegration test. The lower critical bound assumes all the variables are I (0), this means there is no cointegration relationship between the examined variables. The upper bound assumes that all the variables are I (1), which means there is cointegration among the variables. When the computed F-statistic is greater than the upper bound critical value, it means the null hypothesis is failed to be accepted (the variables are cointegrated). If the F-statistic is under the lower bound critical value, then the null hypothesis is accepted (there is no cointegration among the variables). When the computed F statistic falls between the lower and upper bound, then the results are unfounded.

### 3.3.2 VECM Estimation Technique

The VECM estimation technique is used to square up if data series are stationary or co-integrated series data need to be checked for spurious regression analysis (Gujarati, 2010). If two sequences appear to move together over time, it indicates that there is 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 technique which is used to depict the dynamic interrelationship among stationary variables. Dolado *et al.* (1999) noted 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.

A VECM is meant to be used in line with non-stationary series that are well known to be cointegrated. Brooks (2008:89) argues that the "VECM has cointegration relations built into the specifications 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 argues 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 is residual-based, while the Johansen and Julius (1990) technique is based on maximum likelihood estimation on a VAR system.

Brooks (2008) further contends that the problems of the Engle-Granger approach include a deficiency of power in unit root tests, simultaneous equation bias and the impossibility of performing hypothesis tests about the actual cointegration relationships. Referable to the shortfall of Engle-Granger approach, the vector error correction model (VECM) by Johansen (1991; 1995) shall be embraced in this study 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.

### 3.3.3 Testing for Heteroscedasticity

In order to obtain consistent standard errors, the study will use white noise error model. It is imperative that the study conducts tests for the presence of heteroscedasticity in the tested variables. To dictate heteroscedasticity, the study adopted various techniques of dictating, as well as for correcting this heteroscedasticity. The following tests are considered in this study.

### 3.3.4 White's General Heteroscedasticity Test

The main advantage of the white's test does not rely on the normality assumption. The test is also easy to use. Assuming that the standard regression model is estimated (Gujarati, 2004: 413), the test is one of the joint null hypotheses that when $\beta 1 = 0$ and $\beta 2 = 0$. For the LM test, if the 2- test is greater than the corresponding value in the statistical tables, then reject the null hypothesis, the errors are homoscedastic (Brooks, 2008: 135).

### 3.3.5 Testing for Significance of Regression Coefficients

It was imperative that the study explored the statistical properties of the model. It is a common practice that such a study conducts various test statics of the coefficients. Since the study used 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 conducted through the F- static (King *et al.*., 2007).

### 3.4 Data Analysis

Data analysis is the use of statistics and probability to figure out trends in data set. The Statistical Package for Social Science (SPSS version 2.20) was used to do the analysis of the data collected from the administrative source. The software also made it possible for the presentation of data by using graphs and charts.

The descriptive statistics used is based on the frequency tables which are provided in order to explain the variables in the study. The inferential statistics in this study is also based on the examination of each hypothesis designed and formulated for the study. The upper limit for the statistical significance for the null hypothesis is set at 5% confidence interval. All the tests conducted were at the 2-tailed level of significance. This is in accordance with the non-directional hypothesis presented (Gibson, 2014:12).

### 3.5 Validity and Reliability of Data

Validity states to the degree to which a study precisely reflects or evaluates the specific concept that the researcher is trying to measure. On the other hand, reliability is concerned with the accuracy of the actual measuring instrument or process, validity is concerned with the study's achievement at measuring what the researcher intended to measure (Saunders & Rojon, 2014). Researchers should be more concerned with both validity and reliability to ensure that the research outcomes and findings are more truthful.

### 3.6 Ethical Considerations

Gillespie (2009:9) argues that “ethical codes in research stipulate areas of responsibility to the participants, colleagues, professional associations and sponsoring agencies, as well as the public at large or society”. Saunders et al. (2007:153) argues that, “research ethics relate to gaining access, collecting and processing data, as well as writing up the research findings in a moral and responsible way”. Resnik (2010:67) listed over ten ethical items based on various codes that touch on “honesty, objectivity, integrity, carefulness, openness, respect for intellectual property, confidentiality, responsible publication, respect for colleagues, competence and legality, among the issues to observe”.

In this research, data were collected from the reliable verified reports. Consumers of this report include the members of the public, academics, companies and other various stakeholders who will find it fascinating. For consumers of these findings, it is vital that care is taken to ensure that the findings and disclosures do not result in misconceptions, as a result of inadequate consent, errors in findings or and manipulation of results.

For this research to attain ethical standards, due care was exercised to observe codes as listed by Resnik (2010). The researcher also ensured that data collection, analysis and dissemination were in line with all the ethical requirements. Other issues that were taken into consideration included thankfulness, confidentiality, anonymity and respect for all the participants.

In order to realize strong ethical standards and minimise any negative impact, deontological ethical philosophy was deemed suitable, since it argues that the ends served by the research can never justify the use of research which is unethical and any deviations from these standards are to be approached judiciously.

Finally, no social tie or reference is intended, based on race, religion, gender or sexual orientation and any reference to such matters are purely within the context of the research.

## 3.7 Conclusion

This chapter dealt with research design, sample size and data collection methods. As mentioned, the methods adopted allowed for the attainment of the overall objective to solve the research problem. The next chapter presents and analyses the data obtained through the methodology described in this chapter. The reason for data analysis is to give meaningful decision-making information for the research problem.

# CHAPTER FOUR

# PRESENTATION OF RESULTS

## 4.0 Introduction

This chapter presents the results of the study, based on the methodology used. The researcher used statistical models as explained in Chapter Three, to analyse the collected data using the SPSS software. The analysis of the collected data takes the form of both two main statistical methods that is descriptive statistics and inferential statistics. Linear relationship were established by trying to find the association between the variables under investigation by the use of correlations and regressions. The data were analysed using the VECM and ARDL to cointegration on annual data covering the period between2000 to 2016. The first section presents the results of ARDL, that is, the cointegration test results. The second section presents the long-run relationships and short-run adjustments from VECM. The third section of this chapter presents the results to do with the robustness of the model, that is reliability and validity. Lastly, concluding remarks are given to wrap up the chapter.

### 4.1 Results from the Autoregressive Distributed Lag (ARDL)

ARDL tests, also popularly known as Cointegration test, were conducted to determine whether there is a long-run equilibrium relationship among the variables. The ARDL cointegration method entails us to stipulate the lag order and to determine the trend hypothesis for the vector autoregressive. This complementary route is to validate the results of the VECM (Dritsakis, 2011). The results of the lag order criterion are shown on Table 4.1 below:

**Table 4.1: Lag Order Specification**

| Lag | Log | LR | FPE | AIC | SIC | HQIC |
|---|---|---|---|---|---|---|
| 0 | -23.2304* | 32.1078 | 2.14e-04* | 2.1360 | 5.2369 | 7.1432 |
| 1 | -9.8542 | 19.2354 | 2.17e-01 | 2.1589 | 3.2105 | 4.2586 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2 | 4.8947 | 13.2546* | 4.02e-05 | 1.0256* | 2.4125* | 3.4108* |

*Shows the chosen lag order criterion

L.R- sequential modified LR test statistic (each test at 5% level)

FPE-Final prediction error

AIC - Akaike information criterion

HQIC- Hannan-Quinn information criterion

SIC - 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. However, in this regard, lag length 2 is selected, as it has the lowest AIC value. Other information criteria which have selected lag 2 are sequential modified LR test statistic at 5 per cent level, Schwarz information criterion and Hannan-Quinn information criterion. After viewing the appropriate lag length criteria, the Cointegration is carried out and the results of the cointegration tests are displayed in Table 4.2 and Table 4.3 below:

**Table 4.2: Results of Cointegration Trace Rank Test**

| **Hypothesized No. of CE(s)** | **Eigenvalue** | **Trace Statistic** | **Critical Value at 0.05 LOS** | **Probability** |
|---|---|---|---|---|
| None* | 0.7785 | 89.2354 | 56.2145 | 0.0847* |
| At most 1 | 0.7458 | 78.2145 | 78.2685 | 0.0458 |
| At most 2 | 0.4587 | 95.2569 | 81.0214 | 0.0354 |

The table above shows that cointegration trace Rank Test has 2 cointergrating equations at the 0, 05 level of significance (LOS). The first equation (none*) shows that the null hypothesis rejected it at 0.05 LOS.

**Table 4.3: Results of Cointegration Maximum Egen Value Rank Test**

| Hypothesized No. of CE(s) | Eigenvalue | Max-Eigen Statistic | Critical Value at 0.05 LOS | Probability |
|---|---|---|---|---|
| None* | 0.7788 | 19.0054 | 16.5145 | 0.147* |
| At most 1 | 0.8890 | 16.2100 | 28.2485 | 0.0258 |
| At most 2 | 0.9087 | 23.2119 | 25.0217 | 0.0454 |

Like the trace rank test, the Maximum Eigen Value Rank Test also shows two cointegrating equations at the 0, 05 level of significance (LOS). The first equation (none*) shows that the null hypothesis rejected it at 0.05 LOS.

Results from the Johansen cointegration in both tables above shows that there exist two cointegrating equation at 5% level of significance. The null hypothesis of no cointegrating vectors has failed to be accepted since the results reflects a 5% significance level. Therefore, it can imply that there are two cointegrating equations in this model, and this implies that there are significant long-run associations between these two variables namely coal prices and electricity pricing.

### 4.2 The Vector Error Correction Model (VECM) Empirical Results

After testing for cointegration, as well as determining an appropriate lag length of the variables, the study also applied a standard VECM econometric modelling technique to the annual data using the following function form:

The VECM estimates the short and long run dynamic relationships in the impact of coal prices on electricity prices, with all external variables lagged once. The results of the above VECM are presented in Table 4.2.

**Table 4.4: VECM Results**

| Variable | Coefficient | Standard Error | T - Statistic |
|---|---|---|---|
| Constant | 1.3078 | | |
| Coal | 10.0034 | 0.4567 | 2.0147 |
| Electricity | 5.6780 | 0.3576 | 3.2547 |

The above results from the model suggest that coal prices have a positive long-run relationship with electricity prices, both variables have absolute t-values greater than 2, which means that is statistically significant in explaining this relationship in a long term. Furthermore, the VECM results suggest that a percentage increase in coal prices will also result in the increases of the electricity prices, with almost the similar percentage. VECM has been of much significance in this research, since both the short-run and long run coefficients of the model are simultaneously estimated to the extent of showing that changes in coal prices have a positive impact on electricity prices. The short-run impacts in the model are illustrated in the table below.

**Table 4.5: VECM Short-run Results.**

| Variable | Coefficient | Standard Error | T - Statistic |
|---|---|---|---|
| **Constant** | **1.3078** | **0.00** | **0.00** |
| **Coal** | **0.8457** | **0.1625** | **0.0145** |
| **Electricity** | **0.9321** | **0.1857** | **0.2841** |

The above table 4.5 shows the short-run speed of auto correlation adjustment. The coefficient of both variables are positive and are statistically significant, meaning that there is also a short-run adjustment. This also means that a change of coal prices will result in an instant increase in electricity prices. Moreover, it means in this study, there is both long run and short run effects between coal prices and electricity prices.

## 4.3 Diagnostic Tests

In order to test for the reliability and validity of the model, diagnostic tests were performed. The researcher tested the model using three main checks, which include the langrage multiplier (LM) test for serialized correlation; the white test was used to test the heteroscedasticity and the Jarque-Bera test was used for assessing the normality. The results in Table 4.6 below were observed.

**Table 4.6: Diagnostic Check Results**

| **Test Method** | **Null hypothesis** | **T – Statistic** | **Probability** |
|---|---|---|---|
| White (Chi-square) | No conditional heteroscedasticity | 89.4587 | 0.7412 |
| Langrage Multiplier (LM) | Strong serial correlation | 60.1478 | 0.2135 |
| Jarque-Bera (JB) | Normal distribution | **4.1236** | 0.4123 |

The White's test of heteroscedasticity found that the t-statistic was 89.4587, with a corresponding probability of 0.7812. This implies that there is no conditional heterodasticity on the model. The Lagrange Multiplier (LM) test of autocorrelation found that the data used on this research is serial correlated. According to the Jarque-Bera (JB) test, we fail to reject the null hypothesis of normal distribution of residuals.

## 4.4 Summary

This chapter presented the findings from the research study. The overall objective was to solve the research problem by the use of different statistical models. In the next chapter, the research findings are discussed.

# CHAPTER FIVE

# DISCUSSION

## 5.0 Introduction

The previous chapter presented the analytical framework of results found in this dissertation. The purpose of this chapter is to discuss the empirical findings which emanate from the tests carried out, as described in Chapter Four. Making use of the collected data for South Africa from the period 2000 to 2016, this study examined the long and short-run dynamics between coal and electricity prices. The combination focused on the relationship of prices between the two variables within one country, South Africa. The researcher thus discusses the results in three ways: firstly, by testing the findings, keeping the aims and objectives of the study in mind, secondly, based on theories and empirical studies and lastly, the results are discussed based on the available literature pertaining to the study.

## 5.1 Discussion of Findings

The empirical objective of the study is to estimate whether there is any effect when coal price changes on electricity pricing, centered on four main potential outcomes, which are as follows:

- To investigate the relationship between the coal and electricity prices.
- To determine the presence of asymmetry of coal price and domestic electricity prices in South Africa.
- To provide the key requirement of an efficient electricity pricing regime and the economic principles that buttress the setting of equitable and proficient tariffs under a structured and vertically integrated monopoly provider to various stakeholders.

The results from the Autoregressive Distributed Lag (ARDC) shows a significant long-run association between coal and electricity prices. This satisfies one of the objectives, which sought to determine the relationship between the tested variables. It can then be concluded that the study is statistically significant.

The Vector Error Correction Model suggests that there is a positive long-run relationship between the independent variable coal prices and the dependent variable electricity prices. The same relationship has been established by the same test in the short-run.

The Vector Error Correction Model further shows that a percentage increase in coal prices will have a subsequent increase in electricity price, with almost the same magnitude.  This is in consistency with the expectations of the second objective of the study, which sought to investigate the magnitude and direction of the relationship between coal price change and electricity prices in South Africa.

When electricity prices are determined at enquiries in a regulated country like South Africa, it would be very difficult to establish the presence of asymmetry of domestic coal prices and that of domestic electricity prices. It is also assumed that in addition to input and wholesale prices, other factors such as market conditions, also determine retail or household energy prices. Generally, the household electricity prices in South Africa is driven by subsidies from the government.

The expectations of the fourth objective are satisfied in Chapter Six, where policy recommendations are laid.

Similar studies that yielded the same results include Mohammadi (2009), who explored the long and short-run underlying forces between electricity prices and three fossil fuels (coal, natural gas and crude oil) in the United States of America, he used yearly data from 1960 to 2007. He also found evidence of significant long-run correlations between electricity and coal.

A Finnish study as discussed by Honkatukia et al, (2006) empirically assessed the changes of coal prices. His study was based on the econometric calculations from the collected data, the projected results indicated that on average, roughly 75 to 95 percent of the price changes in the coal prices are passed on to the Finnish Nord Pool day-ahead prices. The researchers analysed the progress of daily and hourly Nord Pool prices in the Finnish market area of Nord Pool and tested their correlation regarding numerous factors such as various scarcity capacity indicators, input cost indicators such as the prices of coal, natural gas and carbon allowance prices, as well as demand shaping indicators. They ran three econometric simulations on Finnish electricity prices running from between February and May 2005 to May 2006.

The results of their study are also supported by the Economic Principle, which proposes that there should exist a relationship between input and output prices in a static framework. Other studies Bencivenga and Sargenti (2010) who investigated the short and long-run connections between crude oil, natural gas and electricity prices in the United States of America and European commodity markets. The short-run results showed no decisive outcomes. The long-run dynamics were tested by cointegration tests. The results showed cointegration relationships between each pair of commodities. Emery and Liu (2002) found a cointegration relationship between future prices of electricity and natural gas. Although the two studies are not directly linked to coal prices and electricity prices, their relevance can be explained by the fact that

4natural gas and crude oil are both inputs for power generation just like coal.

This study thus makes several contributions to the literature. It is one of the few studies done to demonstrate the empirical connection between the effects of coal prices and electricity around the world, let alone in South Africa. Although there are other studies which tried to explain the link between the two variables in question, most of them were too broad, indirect and the cases were not of South Africa.

It is important to note that most of the researches in this area of study commences by providing a general background of the pricing mechanisms and analyses that effects energy prices on energy efficiency and intensity. On that same note, Martinez and Ines (2011), they used theoretical and empirical approaches to investigate between energy efficiency and energy prices. They found that energy prices are not an important main factor to improve energy efficiency. However, results from many studies shows a positive relationship between energy prices and efficiency, in addition to confirming the positive effects of rising energy prices on industrial energy savings (Birol & Keppler, 2000; Fisher-Vanden & Jefferson, 2004; Wing 2008; Chen & Wu, 2011), although a rebound effect cannot be denied (Brookes, 1990; Zha & Zhou, 2010; Lin & Liu, 2015). Some studies like the one by Apeaning & Thollander, (2013), scrutinized the variability that characterises the relationship between energy prices and energy efficiency and intensity. More studies on this regard includes the non-linear effects (Kaufman, 2004), asymmetric effects (Hang & Tu, 2007), dynamic effects (Adofo et al., 2013) and even regional differences (Yang, 2011).

Taking into cognisance the studies pronounced above, it is obvious that higher energy prices have an energy saving effect. However, from a macroeconomic viewpoint; energy prices also have a vivacious impact on other facets of the economy. One of these chief important aspects is the influence of the GDP, which is the focus of many studies. Bashmakov (2007) and Aucott and Hall (2014) observed the proportion of energy costs versus the GDP and found that when energy costs increase to over 10–12 %, the GDP growth declines, and when energy costs are 5–6 %, GDP growth increases. Another issue that this study emphasises is the influence of energy prices on the general price level. Although some studies showed that there is no relationship between energy prices and the general price level (Bohi, 1991; Jin et al., 2009), the majority of studies generally confirmed that there is a positive correlation between energy prices and the general price level (Parks, 1978; Thoresen, 1983; Cunado & Perez de Gracia, 2005; Cologni & Manera, 2008; Irz et al., 2013). Some studies measure the conducive influence of energy prices on the general price level (Baffes, 2007; Chen, 2009), whereas other studies indicate that the relationship between energy prices and inflation has varied over different time periods (Hooker, 2002).

### 5.3 Summary

This chapter provided some insights regarding the findings of the research compared with other studies. The next chapter discusses the implications of the research, the recommendations, as well as the areas for future studies.

# CHAPTER SIX

# CONCLUSION AND RECOMMENDATIONS

**6.0 Introduction**

The previous chapter presented a discussion of the results of the study. This chapter gives a discussion of the summary of study, implications, conclusions and recommendations, based on the findings of the research.  The chapter also addresses the research questions and how the hypothesis was supported by the research findings.

**6.1 Summary of Findings**

The findings of the study shows that changes of coal prices have an impact on electricity pricing. In addition, it means that when the coals price increases, the price of electricity also increases. This study reveals that there is a strong interdependence between coal and electricity in South Africa.

**6.2 Implications of the Study**

The results from this study show that the government needs to clearly define its energy use policies. Currently, South Africa is relying mainly on the use of fossil energy that is coal, to be in precise. The rising costs in the mining industry, which lead to the increase of coal prices, will eventually result in the detrimental rise of electricity prices. There is no doubt, based on previous studies, that electricity is the main production function in the economy. This means that an increase in electricity prices will drive the prices of all other factors of production. This research established a very strong positive relationship between coal and electricity prices, the government needs to invest more in other ways of generating electricity, in order to reduce the dependency of using coal as a main source of generating electricity.

Furthermore, policy makers should facilitate a regulatory framework for private-sector participation in the provision of electricity. These options for capitalization should be taken into consideration. However, policy makers should ensure that cost reflectivity is not diminished and market competition thrives in the electricity supply industry

### 6.3 Recommendations

Based on the findings presented in Chapter Four, the researcher thus recommends that the government and all other stakeholders such NERSA, who are involved in the policy formulation and implementation of energy uses, to invest more in other sources of generating energy, such as renewable sources, which are more sustainable. It should be noted that the use of coal to generate energy is relatively cheaper than other fossil sources. However, depending on coal as the main supplier of energy is more detrimental, both economical and to the environment. This can be seen as detrimental because coal plants produce more carbon dioxide which can be hazardous to health and might, in future, cause the government to spend more on health care. Moreover, the way people are scrambling to coal mining is a concern since there are no proper regulations in place, this will lead to land degradation. Moreover, since NERSA regulates the prices of electricity, miners are being forced to use cheaper methods of extracting coal in order to keep the costs low.

The government is also recommended to consider the efficient way of dealing with maintaining the market prices for both coal and electricity in tandem, since they are correlated, as shown on the study. Regulating one variable will result in shortage, which might cause load shedding, thereby affecting the industry, resulting in low economic growth. Shifting from using coal as a sole source of energy might help competition in the industry and might force coal producers to find more ways of reducing costs, in order to keep the coal prices low. Moreover, as it stands now, it is difficult for the government to charge carbon levies for coal miners, since this will cause prices to go up and might eventually lead to an increase in electricity prices or severe shortages.

Furthermore, the findings are showing that there is a strong dependence between changes of coal prices and electricity pricing in South Africa. Therefore, the researcher is advising policy makers to use cost effective ways on the supply chain of coal production in order to reduce the coal price, which is influencing the pricing of electricity.

## 6.4 Recommendations for Future Studies

For future studies, the researcher recommends others not only to look at real prices of coal, but to also factor the externalized costs. According to Edelstein and Kilian (2007; p85) these externalised costs are referred to as the "real monetary costs of a product that are not mirrored in the actual price paid by consumers. For electricity generation, these include the health impacts and taxpayer-borne clean-up costs of pollution, and the economic consequences of environmental damage, climate change and other impacts of power generation. Instead of being part of the electricity bill, these costs show up in tax payments, medical bill, and in reduced economic activity. Some of these impacts affect people who may receive none of the energy being generated".

Edelstein and Kilian (2007) gathered these costs for coal in the US and concluded that they added between 9.45 cents and 26.83 cents per killowatt hour to the cost of coal-fired electricity, with the best estimate at 17.8 cents. Studies of externalities from other sources of power generation are less current and less thorough, but more broad studies contacted in Europe showed that there is the lowest costs for wind, nuclear and hydropower, with externalised costs ranging from 0.2 to 0.5 cents above the sticker price. This is the other leading main reason why the researcher is recommending a shift from focusing on coal as a main source of energy.

Furthermore, the researcher also seeks to include more variables, which affects the costs of electricity, since it is not only coal which impacts the prices of electricity. Moreover, it will be more interesting if other researchers make a comparison between the costs of generating electricity using coal, as compared to other sources such as hydro power plants. Moreover, other researchers could also analyse how the investigated relationship will impact the economic growth.

Therefore, the researcher recommends the concept of analysing coal prices, which contemplates electricity cost that effects from rising coal prices. Moreover, it is essential to test the direct, indirect regulatory frameworks and time varying effects of relative energy prices on electricity prices. Future research also ought to focus on constructing energy price indices on inflation.

### 6.3 Summary

The data presented in the previous chapters plays an important role to determine the conclusions of this research. The data was analysed, based on the research objectives and these objectives were fulfilled. The conclusions were as follows. The data collected managed to solve the research problem. It shows that there is a positive relationship between change of coal prices and electricity pricing.

# REFERENCES


Asche F., Osmundsen P., and Sandsmark M.: The UK market for natural gas, oil and electricity: are the prices decoupled? *The Energy Journal*, 27:2 (2006) 27-40

Cameron M. and Rossouw R. (2012). Modelling the economic impact of electricity tariff increases on Eskom's Top Customer Segment.

Bachmeier, J.J., Griffin, J.M., (2006). Testing for market integration crude oil, coal, and natural gas. *The Energy Journal* 27 (2), 55–71.

Bencivenga C., Sargenti G. and D'Ecclesia Rita L (2006) Energy Markets: Crucial Relationship Between Prices Department of Economic Theory and Quantitative Methods for Political Choices, La Sapienza" University of Rome, Piazzale A. Moro 5, 00185 Rome, Italy

Bond, Stephen R. (2002). "Dynamic panel data models: a guide to micro data methods and practice." *Portuguese Economic Journal* 1.2: 141-16Modigliani, F., & Miller, M. H. (1958).

Burbridge, J., Harrison, A., (1984), "Testing for the effects of oil price rises using vector autoregressions", *International Economic Review*, Vol. 25, No. 2, pp. 459–484.2

Burtraw, D., K. Palmer, R. Bharvirkar, and A. Paul (2012): The effect of allowance allocation on thecost of carbon emission trading, Discussion paper 01-30, Resources for the Future,Washington, D.C.

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Dantama, Y. U., Abdullahi, Y. Z., & Inuwa, N. (2012). Energy Consumption-Economic Growth Nexus in Nigeria: An Empirical Assessment Based on ARDL Bound Test Approach. *European Scientific Journal* 8:(12).

Deloitte & Eskom. (2009). ESKOM Key Industrial Customer Survey

Deloitte. (2010). Independent review of the electricity price determination process. Available at http:andandwww.eurojournals.comandIRJFE%206%20zakir.pdf

Department of Energy: Coal resources http://www.energy.gov.za/files/coal_frame.html

DME (2003), Working Rules to Administer the Basic Fuels Price (BFP) Methodology, Annexure A & Annexure B

Economic Activity.” Journal of Money, Credit, and Banking, 32(3): 400–416.

Economic research topics

http://mba-lectures.com/advance-research-methods/1167/important-topics-for-economics-thesis.html

https://www.indexmundi.com/commodities/?commodity=coal-south-african&months=240

https://tradingeconomics.com/south-africa/indicators

Edelstein, P & Kilian, L. (2007). Retail Energy Prices and Consumer Expenditures. Discussion paper series - *Centre for Economic Policy Research* (0265-8003), DP6255.

Emery G.W., Liu Q. (2002). An analysis of the relationship between electricity and natural-gas futures prices. *The Journal of Futures Markets* 22 (2), 95–122.

Erero J.L. (2010) .KZN Department of Economic Development and Tourism. The Impact of Electricity Pricing Shock on The South African Economy: A CGE Analysis.

Gibson, W (2014). *Research Methods: Sample Lecture Pack*. University of London. Leading education and social research.

Gillepie, A. 2011. *Foundation of Economics*. 2nd Edition. New York: Oxford University Press.

Guo, Jin & Zheng, Xinye & Chen, Zhan-Ming, 2016. "How does coal price drive up inflation? Reexamining the relationship between coal price and general price level in China," Energy Economics, *Elsevier*, vol. 57(C), pages 265-276

Honkatukia, J., V. Mälkönen, and A. Perrels (2006): Impacts of the European Emission Trade System on Finnish Wholesale Electricity Prices, *VATT Discussion Paper* 405, Government Institute for Economic Research, Helsinki.

Human Sciences Research Council HSRC. (2008). *The Impact of Electricity Price Increases and Rationing on the South African Economy*. [Online] available at http:andandeconomicsbulletin.vanderbilt.eduand2008andvolume15andEB-08O10003A.pdf (Accessed on 13/05/2018)

Kilian, L. and Murphy, D. (2012). Why agnostic sign restrictions are not enough: Understanding the dynamics of oil market VAR models, *Journal of the European Economic Association* 10(5) 1166-1188.

Kohler, S. (2010). *Powering South Africa: The implications of Eskom's tariff increases. Consultancy Africa*. [Online] Available at http:andandeconomicsbulletin.vanderbilt.eduand2008andvolume15andEB-08O10003A.pdf [Accessed on 17-09-2017].

Linn, J., E. Mastrangelo, and D. Burtraw (2014). Regulating greenhouse gases from coalpower plants under the clean air act. *Journal of the Association of Environmental andResource Economists* 1 (1), 97–134.

Mishkin, F.S (2007). *The Economics of Money, Banking and Financial Market.* Columbia University Pearson International Edition (8th edition).

Mjelde, J., Bessler, D. (2009). Market integration among electricity markets and their major fuel source markets. *Energy Economics* 31, 482–491.

Mohammadi, H. (2009). Electricity prices and fuel costs: long-run relations and short-run dynamics. *Energy Economics* 31, 503–509.

Muijs, Daniel. *Doing Quantitative Research in Education with SPSS*. 2nd edition. London: SAGE Publications, 2010.

NERSA (2013) *NERSA's Decision on Eskom's Revenue Application for the Third Multi-Year Price Determination Period* 2013/14 to 2017/18. Pretoria: National Energy Regulator of South Africa.

Neuhoff, K. (2006*) Impact of ETS on electricity prices, Presentation at IETA Allocation workshop, IXIS Corporate & Investment Bank*, Paris, 25th September 2006.

Neuhoff, K., K. Keats Martinez, and M. Sato (2006): "Allocation, incentives and distortions: the impact of the European Union Emission Trading Scheme allowance allocations to the electricity sector", *Climate Policy*, Vol. 6, No. 1, pp. 73-91.

Neuhoff, K., K. Keats, J. Sijm, F. Matthes, and A. Johnston (2005b) *Allocation matters - so what can we do about it? Strategies for the electricity sector 2008-2012* Commissioned by Climate Strategies and The Carbon Trust, London.

Neuhoff, K., M. Grubb, K. Keats (2005a) *Impact of the allowance allocation on prices and efficiency*. CWPE 0552 and EPRG 08, Cambridge University, Economics Faculty, UK

Nordhaus, W.D. (1980a) ‘The Energy Crisis and Macroeconomic Policy.’ *The Energy Journal*, 1(1).

Nordhaus, W.D. (1980b) ‘The Interaction Between Oil and the Economy in Industrial Countries.’ *Brookings Papers on Economic Activity 2*.

Resnik(2010), *what is Ethics in Research & Why is it Important? https://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfm*

Sekaran, U. and Bougie, R. (2013) Research Methods for Business: A Skill-Building Approach. 6th Edition, Wiley, New York.

Saunders MNK and Rojon C (2014). On the attributes of a critical literature review Coaching: An International Journal of Theory, Research and Practice 4.2 156-62

Schaffer, M.E. (2010). xtivreg2: Stata module to perform extended IV/2SLS, GMM and AC/HAC, LIML and k-class regression for panel data models. http://ideas.repec.org/c/boc/bocode/s456501.html

Panikar P. G. K. (1991) Oil: From Crisis to Crisis, pp. 479-481, *Economic and Political Weekly*, (08 March 2010)

The International Development Research Centre (2010), *Chapter 2: Cheap energy—at what cost? Externalities in South Africa’s electricity sector* (16 September 2010) http://www.idrc.ca/en/ev-138013-201-1-DO_TOPIC.html

Van Horen, C. (1996). *Counting the Social Costs: Electricity and Externalities in South Africa*. Cape Town: Elan Press and UCT Press.

World Bank Report. (2010). *The Economic Impact of Electricity Price Increases on Various Sectors of the South African Economy. Subsidies in the Energy Sector*. World Bank

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11 May 2018

**Ms Gugulethu Nene (200205221)**
**Graduate School of Business & Leadership**
**Westville Campus**

Dear Ms Nene,

**Protocol reference number: HSS/0360/018M**
**Project Title:** The impact of changes of coal price on electricity pricing in South Africa

**Approval Notification – No Risk / Exempt Application**

In response to your application received 02 May 2018, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL.**

**Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number.**

**PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.**

**The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.**

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

D[redacted]o (Deputy Chair)

/ms

Cc Supervisor: Dr Pfano Mashau
Cc Academic Leader Research: Professor Muhammad Hoque
Cc School Administrator: Ms Zarina Bullyraj

**Humanities & Social Sciences Research Ethics Committee**
**Professor Shenuka Singh (Chair)**
**Westville Campus, Govan Mbeki Building**
**Postal Address:** Private Bag X54001, Durban 4000
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