AN ANALYSIS OF ELECTRICITY DEMAND IN NAMIBIA

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Abstract

This study analyzes the demand for electricity in Namibia as a function of income and the price of electricity, using quarterly data from 1993:Q1 to 2006:Q4. The study employs various econometric techniques such as unit root tests and the Engle-Granger approach to testing cointegration so as to establish the long-run relationship between the variables. It also applies an Error Correction Model (ECM) to cater for the short-run dynamics and to verify the long-run, or equilibrium relationship suggested by the cointegration test. The results show a significant impact of changes in income on the demand for electricity in both the long- and the short-run. Income elasticity is above unity (1.02) in the long-run and is 0.33 in the short-run. Price, on the other hand, has the correct sign, but is statistically insignificant.

Contents

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DEDICATION

Dedicated to my children, **Ngaitjitue** and **Karunduruka**, and to my nephews, **Vitjituaije, Ikuaterua** and **Okeri.**

DECLARATIONS

I, Kasnath Jazvirua Kavezeri, declare hereby that this study is a true reflection of my own research, and that this work, or part thereof has not been submitted for a degree in any other institution of higher education.

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.... Date 11/03/2009

Kasnath Jazuvirua Kavezeri

LIST OF ACRONYMS

ABOM	Agreement between Operating Members
ADF	Augmented Dickey-Fuller
AR	Autoregressive
CBS	Central Bureau of Statistics
CCGT	Combined Cycle Gas Turbine
CRDW	Cointegrating Regression Durbin-Watson
DF	Dickey-Fuller
DS	Difference Stationary
DSP	Difference Stationary Process
E-G	Engle-Granger
ECB	Electricity Control Board
ECM	Error Correction Model
ESI	Electricity Supply Industry
GDP	Gross Domestic Product
IGMOU	Inter-Governmental Memorandum of Understanding
IUMOU	Inter-Utility Memorandum of Understanding
MME	Ministry of Mines and Energy

MW	Megawatts
NDPs	National Development Plans
NPC	National Planning Commission
OG	Operating Guidelines
Okacom	Okavango Delta Commission
PDF	Probability Density Function
PJTC	Project Joint Technical Commission
REDs	Regional Electricity Distributors
REEE	Renewable Energy and Energy Efficiency
SADC	Southern African Development Community
SAPP	Southern African Power Pool
TS	Trend Stationary
TSP	Trend Stationary Process

CHAPTER 1: INTRODUCTION

1.1 Background

A sufficient stock of energy, especially electricity is crucial to the manufacturing process necessary for industrialization. Thus, developing countries wishing to become industrialized should put measures in place to ensure a long-term and reliable supply of electricity. According to De Vita, et al., (2005), developing economies may soon start consuming the majority of the world's energy given their faster income growth. Like other developing countries, Namibia also designed strategies to ensure economic development. It has a long-term development plan referred to as Vision 2030 and the medium-term National Development Plans (NDPs). One of the major economic objectives of Vision 2030 is to transform Namibia into an industrialized country. The target is to achieve a Gross Domestic Product (GDP) growth rate of 6.2% coupled with a GDP per capita growth rate of 4.4% (Republic of Namibia, 2004). As electricity is a vital input in the processes of economic development, it is essential that it is provided efficiently to all economic and social sectors. To cater for the nation's energy needs, Namibia should have a growing energy sector to meet the ever increasing demand.

Despite a relatively well-established energy sector, the current demand for electricity surpasses the country's total installed generation capacity of 393 megawatts (MW) and there is a projected shortfall of 157MW by 2012 (Bannon, 2006). The highest amount of electricity demand recorded was 449MW in the year 2007 (Sibeene, 2008). The country's power utility, NamPower needs to increase its generation capacity if it is to replace Eskom, the South African power supplier, in meeting the demand of the highly significant Scorpion mine and refinery near Rosh Pinah (Bannon, 2006). It is against this background that this paper seeks to do an analysis of demand for electricity in Namibia to serve as a guideline for policy makers in dealing with policies to equilibrate the power market. Electricity demand is analyzed as a function of Gross Domestic Product (GDP) and the price of electricity, using quarterly data over the period 1993:1 to 2006:4. Table 1 shows some statistics on the use and capacity of electricity in Namibia from 1996 to 2006.

Table 1.1: Electricity Demand and Capacity

Year	Unit sales (GWh)	Maximum hourly demand (MW)	Installed capacity (MW) from Namibian sources	Installed capacity (MW) from Interconnector	Total Installed capacity (MW)
1996	1731	294	384	200	584
1997	1700	321	384	200	584
1998	1904	326	384	200	584
1999	1863	298	393	600	993
2000	1978	317	393	600	993
2001	2050	332	393	600	993
2002	2136	348	393	600	993
2003	2246	371	393	600	993
2004	2795	461	393	600	993
2005	2976	491	393	600	993
2006	3199	490	393	600	993

Source: NamPower, Annual reports

The table shows the time period starting from 1996 to 2006. The second column displays the total annual amount of electricity units in millions of GWh, sold. This includes export sales, as well as sales to the Scorpion mine and Refinery. The table further shows that the maximum hourly demand remained well below NamPower's total installed generation capacity until the year 2004. Starting from this time onwards, the maximum hourly demand exceeds the total national capacity. As earlier noted, the maximum hourly demand for the year 2007 amounted to 449MW while the installed capacity remained unchanged at 393MW. This national installed capacity showed in the fourth column is the maximum amount of electricity units in megawatts available every hour, from Namibian Sources. These sources comprise the 120MW Van Eck coal-fired thermal power station in Windhoek, the 24MW

Paratus diesel-powered station at Walvis Bay, and the hydroelectric power station at Ruacana with a 249MW installed capacity (Bannon, 2006). In addition to the local installed capacity, Namibia also gets electricity through the Interconnector, a transmission line linking Eskom and NamPower systems. These figures are displayed in column five. The last column adds up columns four and five, giving the total installed capacity.

1.2 Statement of the problem

As earlier noted, Namibia is experiencing power shortages. Namibia had a 10-year contract with Eskom, a South African power utility, to supply cheap and reliable electricity. It supplies about 50% of Namibia's electricity. This contract expired on 1st July 2006 and had to be renegotiated (Bannon, 2006). The power shortage problem started in South Africa and is increasing. As a result, its export to Namibia not only reduced significantly, but also became more expensive (REEE Institute, 2008). In response, Namibia had to operate its costly coal-powered Van Eck power station at a loss to meet the ever increasing demand. On several occasions, the Windhoek municipality had to employ load-shedding to deal with the power crisis and Windhoek residents had to go without electricity for hours (Katswara, 2005).

Load-shedding means reducing the supply of electricity to selected areas, at given times. According to a local newspaper, there is a need to invest in power generation and transmission in order to meet current and future electricity demand (Sibeene, 2008). A recent study done by the Renewable Energy and Energy Efficiency (REEE) Institute revealed that a one hour black-out per month is likely to reduce Namibia's GDP by 3.7% and it predicts that excess supply of electricity in Southern Africa would not be available for at least the next five years (REEE Institute, 2008). These shortages are a joint result of increased demand and reduced supply. The increase in demand is partly due the increase in mining activities. For instance, the Scorpion Zinc mine is said to consume about 80MW per hour and more uranium mines are expected to open over the next two years, increasing electricity demand further

(Weidlich, 2008). Figure 1 below depicts the trend of annual electricity consumption over the period 1996 to 2006.

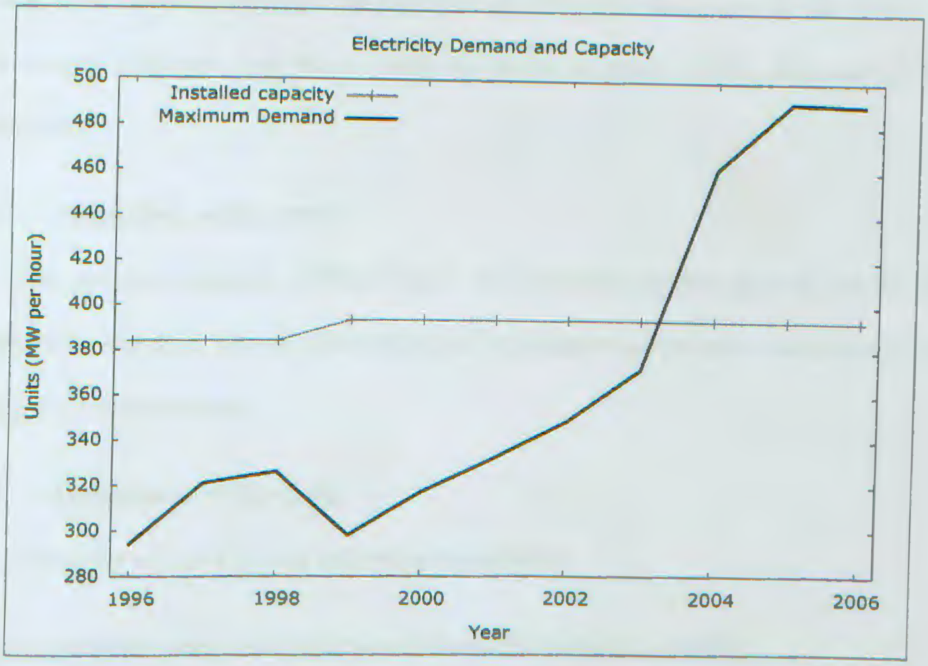

Figure 1. Electricity Demand and Capacity

Figure 1 is a graphical illustration of the information contained in Table 1. As already noted in Section 1, the current demand for electricity surpasses the current installed generation capacity. In the past, Namibia relied heavily on power imports from the South African power utility, Eskom to cater for its excess demand. However, given the current power crisis in South Africa, supplies from the aforementioned source are no longer secure.

In light of the current power crisis being experienced in the Southern African Development Community (SADC) region, accompanied by the volatile global oil price, it is essential for Namibia to promptly deal with the problem at hand as this might hinder the attainment of its development goals. In order to take proper economic decisions, policy makers need to be able to establish how current market behavior is likely to affect the future demand and supply of electricity. This would enable them to use appropriate policy measures to avoid or at least minimize the problem of electricity shortages in the future. Thus, given the current situation, this thesis seeks to do an analysis of the demand for electricity in Namibia.

1.3 Objectives of the study

The general objective of this study is to contribute to the general debate on electricity demand in Namibia. The specific objective is to determine the price and income elasticities of electricity consumption.

1.4 Hypothesis of the study

The study will test for the following hypotheses:

- A positive relationship exists between electricity demand and GDP
- An inverse relationship exists between electricity demand and electricity tariffs

1.5 Significance of the study

As already stated, the primary purpose of this analysis is to determine the income and price elasticity of electricity consumption. Such knowledge is important not only for policy implementation, but also to potential investors in the energy sector. For instance, a price inelastic electricity demand would mean that using price as a policy tool to influence power consumption may not be efficient. Moreover, potential investors can use such information, together with other factors and economic indicators, to determine their prices and make informed investment decisions. If the coefficients of both income and price are statistically significant, suppliers of this essential good can keep a keen eye on income and consumption expenditure.

1.6 Organization of the study

The rest of the study is organized as follows: Chapter 2 presents an overview of the power sector in Namibia and the SADC region. Chapter 3 reviews theoretical models and existing literature on the topic. Chapter 4 gives the methodology, while Chapter 5 shows the empirical analysis and interpretations. Chapter 6 presents the conclusions and recommendations.

CHAPTER 2: OVERVIEW OF THE POWER SECTOR IN NAMIBIA AND THE SADC REGION

2.1 Introduction

This chapter gives a brief background on the power sector in Namibia and the Southern African region. It looks at the sector's current generation capacity, the challenges it is facing as well as the measures taken to increase the generation capacity of Namibia and the region at large. It further outlines the role of the Southern African Power Pool (SAPP).

2.2 Namibia

The Electricity Supply Industry (ESI) in Namibia falls under the Ministry of Mines and Energy (MME), which is responsible for the overall national energy policy to ensure sustainable development and utilization of the country's energy resources. This industry has been governed by South African electricity acts from the colonial period until the year 2000 when the new Electricity Act of 2000 for Namibia came into existence. This Act made provision for the creation of an Electricity Control Board (ECB) to regulate the electricity industry and ensure customer protection (Ministry of Mines and Energy, 1998). The ECB is, thus, a statutory regulatory body mandated to restructure the ESI in collaboration with the MME and other stakeholders in the industry. The responsibilities of the ECB include, inter alia, the issuing of licenses for different types of activities in the industry. For instance, all generation operations with a capacity of 500kW and more, need to be licensed (MME, 2008).

To deal with the problem of power shortages the ECB did a study on how to manage electricity consumption from the demand side. This is called Demand Side Management (DSM). The study recommended several options to reduce electricity use from the consumer side of the electricity meter. These include reducing energy use on a permanent basis by using energy efficient technologies as well as using renewable energy sources. Load shedding and load shifting are also among the proposed measures of DSM (Electricity Control Board, 2006).

The other significant role players in the ESI that also came into existence as a result of government restructuring policy are the Regional Electricity Distributors (REDs). The purpose of the ESI restructuring was mainly to create a more efficient and competitive electricity sector. At that time, the distribution of electricity to end-users was the responsibility of about 46 different municipalities. This often led to inefficiency as many of the smaller distributors faced a lot of challenges, such as the lack of sufficiently skilled personnel, limited financial capacity, etc. As a result, the REDs were established to ensure efficient service delivery at cost-reflective prices. Three of the five proposed REDs were already in operation by 2006 and the remaining two were expected to join soon. The functional ones are NORED Electricity, which covers the North and North-eastern regions; CENORED Electricity, covering the central Northern region, while ERONGO RED distributes electricity in the Western part of Namibia (MME, 2008 and Bannon, 2006).

The Namibia Power Corporation, NamPower, is a state-owned power utility that generates and supplies power in bulk to the mines and industries, the Regional Electricity Distributors (REDs) as well as the local authorities, who in turn, distribute electricity to end-users. As earlier noted in this paper, the power utility has a total generation capacity of 393 MW from its three internal power sources and is currently facing a power deficit. NamPower was previously known as the South West Africa Water and Electricity Corporation (Pty) Ltd, better known by its Afrikaans acronym, SWAWEK. It came into existence on 19 December 1964 under the ownership of the Industrial Development of South Africa, during the colonial period. SWAWEK became NamPower in July 1996, six years after Namibia's independence (Bannon, 2006). NamPower has undergone a restructuring process and now concentrates on increasing the generation capacity of electricity in the country. In line with the objectives of Vision 2030, NamPower, in collaboration with the Ministry of Mines and Energy, implemented the Rural Electrification Program to make electricity accessible and available to the rural community. A N$3.5 million plan called the Namibian Rural Electrification Distribution Master Plan, was released in June 2000 whereby localities needing electrification were identified and ranked on a cost-benefit basis (Bannon, 2006). The aim is to complete the electrification of over 250 000 rural households by the year 2010. By the end of 2003, an amount of N$50 million was already spend to electrify about 80 more villages, sourced from the MBEndi website (http://www.mbendi.co.za/indy/powr/af/na/p0005.htm).

NamPower strives to meet 100 percent of the peak demand with locally produced power by 2010. In order to achieve this goal, NamPower has embarked on a number of projects. In addition to the Rural Electrification Program, other projects include the Kudu Gas-to- Power Project, the Kunene River Hydro Power Projects, the Popa Falls Hydro Project, the Orange River Small Hydro Schemes, to mention a few.

2.2.1 The Kudu Gas-to-Power Project

The Kudu Gas-to-Power Project is the most prominent one and consists of three distinct components namely, the development of a gas field near Oranjemund, the construction of a Combined Cycle Gas Turbine Power Station (CCGT) powered by gas field, and the erection of transmission lines to transmit the generated power to sub-stations connecting to Namibian and South African grids. The Kudu gas field is located some 130 kilometres offshore Southern Namibia and was discovered in 1974 by Chevron International in collaboration with the Namibia Petroleum Corporation (Namcor), previously known as Swakor. The gas field was not developed due to a lack of gas markets and other reasons pertaining to the oil and gas exploration and production at that time. In 1993, a new exploration license was awarded over the area and new partners including Shell and Energy Africa joined the business venture.

Some of the partners later withdrew from the joint venture after several unsuccessful attempts to develop the field on the basis of gas export and local power generation, leaving Namcor and Energy Africa in operation. After the takeover over of Energy Africa in 2004, the gas field is now operated by Tullow oil in partnership with Namcor. Tullow oil holds a controlling interest of 90% while Namcor holds the remaining 10%. These two partners were awarded a new production license in 2005 to replace the Petroleum Field status that governed the Kudu gas field from 1996. The Kudu gas power plant will be the first in Southern Africa to use the CCGT technology. This project is expected to have a capacity of 800MW with the potential to be doubled in size over time. Much of the generated electricity would probably be exported in the initial years of this plant's existence as its capacity exceeds the local demand. The estimated cost of this power plant amounts to US$ 530 million, while the total cost for the project is estimated at approximately US$ 1.5 billion. The power plant is expected to be in operation by 2010, if everything goes according to plan (MME, 2008; Bannon, 2006).

2.2.2 The lower Kunene River Hydro Power Project (Baynes)

The identification of the lower Kunene Hydro Power Project dates back to the early 1980's. This project was initially identified by the Angolan and Namibian governments to serve as additional generation capacity for the two countries, but it did not get off the ground due to the unstable political environment that prevailed in both countries at the time. However, Namibia decided to revive the project shortly after independence in 1990. The construction of this power scheme still required an agreement with neighboring Angola and once again, the two countries agreed for the project to be developed. According to a feasibility study that was commissioned in 1995 and completed in 1997, the project is viable. A Project Joint Technical Commission (PJTC), including heads of energy departments from both countries, was established to facilitate the project's implementation process. The PJTC has undertaken another study and the construction of the power plant is expected to take off in 2010 if all goes well. The project will probably be developed by private investors and both the Angolan and Namibian power utilities will have an option to become minority shareholders. Among the possible challenges facing the acceptability of the project are environmental issues (MME, 2008; Bannon, 2006).

2.2.3 The Popa Falls Hydro Project

The Popa Falls Hydro Project involves the construction of a small power plant with a capacity of 20 MW at Popa Falls in the Kavango River. The economic viability of the development of this project was indicated after a pre-feasibility study was commissioned in 1999 and completed in 2001. Namibia shares the precious water resources of the Kavango River with two of its neighbors, namely Angola and Botswana and thus, need their approval. All these three neighbors are members of the Okavanango Delta Commission (Okacom), whose responsibility is to ensure the protection and preservation of the environment and the ecosystem along the Kavango Delta. Okacom has not yet given its approval for the development of this project. It is also predicted that other stakeholders such as the communities living in the surrounding areas might object to development of the project. The project cost is estimated at around US$ 30 million (MME, 2008).

2.2.4 The Orange River Small Hydro Schemes

This project entails the development of various small power plants of 5 MW to 25 MW per plant, along the Orange River. Although the development of these small hydro plants is on the list of Namibia's potential power generation projects and despite the eagerness of potential investors, the actual implementation is likely to take some time. The major obstacle here is the unresolved issue pertaining to the boundaries between Namibia and South Africa as the Orange River separates the two countries. The total cost of this project is estimated at around US$ 5 million to US$ 25 million (MME, 2008).

2.3 The power sector in the SADC region

The power market in the SADC region is facilitated by the Southern African Power Pool (SAPP). The SAPP was established on 28 August 1995, through an Inter-Governmental Memorandum of Understanding (IGMOU) signed by 7 of the then 11 members of SADC (currently 15). In December the same year, another memorandum of understanding, the Inter-Utility Memorandum of Understanding (IUMOU) was signed by the national power utilities of the member countries to establish SAPP's basic management and operating principles. SAPP currently has nine operating and three non-operating members. The SAPP membership is summed up in Table 2.1 below.

SAPP is governed by four agreements, namely the IGMOU, the IUMOU, the Agreement between Operating Members (ABOM) and the Operating Guidelines (OG). The ABOM established the specific operation and pricing rules, and the OG provides standards and operating guidelines. SAPP was created to facilitate the development of a competitive electricity market and to ensure sustainable energy developments, among other responsibilities. It covers an area 9.09 square kilometers and serves a total population of about 150 million people. SAPP is the only international power pool of its kind established outside Europe or North America. By 2006, it had a total installed generating capacity 50,410 MW. Coal-fired thermal power stations account for about 74% of the total installed capacity. Among the challenges that SAPP has to deal with, are diminishing generation surplus capacity and cost non-reflective tariffs charged by its member utilities (Bannon, 2006; Southern African Power Pool, 2006).

Table 2.1: SAPP Membership

FULL NAME OF UTILITY	STATUS	ABBREVIATION	COUNTRY
Botswana Power Corporation	OP	BPC	Botswana
Electricidade de Mocambique	OP	EDM	Mozambique
Electricity Supply Corporation of Malawi	NP	ESCOM	Malawi
Empresa Nacional de Electricidade	NP	ENE	Angola
ESKOM	OP	Eskom	South Africa
Lesotho Electricity Corporation	OP	LEC	Lesotho
Namibia Power Corporation	OP	NamPower	NamPower
Societe Nationale d'Electricite	OP	SNEL	DRC
Swaziland Electricity Board	OP	SEB	Swaziland
Tanzania Electricity Supply Company Ltd	NP	TANESCO	Tanzania
ZESCO Limited	OP	ZESCO	Zambia
Zimbabwe Electricity Supply Authority	OP	ZESA	Zimbabwe

Source: SAPP Annual report, 2006.

OP = Operating Member

NP = Non-Operating Member

2.4 Summary

In a nutshell, this chapter described the Electricity Supply Industry (ESI) in Namibia. This industry is headed by the MME and the ECB is mandated to regulate it. Nampower is the national power utility that is responsible for power generation and transmission. Other significant role players in this industry are the REDs who supply power to different regions. NamPower has embarked on a number of projects that are still incomplete. These include the Kudu Gas-to- Power Project, the Kunene River Hydro Power Projects, the Popa Falls Hydro Project, and the Orange River Small Hydro Schemes. The power sector in the SADC region is facilitated by the SAPP. The SAPP comprises power utilities from thirteen member countries. The next chapter will review the existing literature on the concept of electricity demand.

CHAPTER 3: LITERATURE REVIEW

3.1 Introduction

This chapter looks at the theory of demand and the concept of elasticity in general. It further reviews some theoretical models commonly used in studies on electricity demand. Countless studies on the concept of energy consumption have been conducted globally. This chapter reviews some of this rich literature. The theoretical models looked at, are the two-stage model as well as the log-linear model commonly used to measure elasticity.

3.2 Theoretical framework

The law of demand states that there is an inverse relationship between the quantity purchased of a good or service and the price, all other things being equal (Mastrianna & Hailstones, 1998). It thus, suggests that a lower price for a product or service increases the quantity demanded of that product or service, while a higher price has the opposite result. However, the law of demand only suggests an inverse relationship, but does not state how much quantity demanded is affected by a change in price. To determine the degree of a change in quantity demanded resulting from a change in price, one needs to employ the concept of elasticity of demand.

Elasticity is defined as "a measure of the responsiveness of quantity demanded or quantity supplied to one of its determinants" (Mankiw, 2007). In particular, the price elasticity of demand measures the responsiveness of quantity demanded to a change in price, while the income elasticity measures the responsiveness of quantity demanded to a change in income. There are mainly three categories of the elasticity of demand: demand is said to be unitary elastic when it has an elasticity coefficient equal to 1.0; elastic when it has an elasticity coefficient greater than 1.0; and inelastic when it has an elasticity coefficient less than 1.0. Unit elasticity means that the percentage change in the explanatory variable, say price, is equal to the percentage change in demand. In the case of inelastic demand, the percentage change in the explanatory variable causes a smaller percentage in the dependent variable. Elastic demand exists were a percentage change in the explanatory variable causes a greater percentage change in the dependent variable (Mastrianna & Hailstones, 1998). In this study, the concept of elasticity is used to determine the degree to which electricity consumption responds to changes in income and the price of electricity. For instance, a price inelastic electricity demand means that changes in the price of electricity have little effect on the amount of electricity that consumers are willing and able to buy. Thus, using price as a policy tool to influence electricity consumption may not be very effective, as noted earlier.

3.2.1 The two-stage model of electricity demand

The general two-stage model was first suggested by Henri Theil and Robert Basmann, independently (Gujarati, 2003). Studenmund (2006), describes the two-stage model as one in which the dependent variable clearly affects at least one of the explanatory variables in addition to the effect that the explanatory variables have on the dependent variable. This model is broadly applied in economic research. It is employed in studies on GDP and money supply, studies on the joint determination of wages and prices as well as in research on electricity demand, among many others.

Fisher and Keysen suggested a two-stage model of electricity demand (as cited by Holtedahl & Joutz, 2003). The model is specified as follows:

$$kWh_t = u_t \ast K_t = u_t(Y_t, PE_t) \ast K_t \qquad [I]$$

Where:

kWh_t = electricity consumption in kilowatts per hour

u_t = the utilization rate of the appliance stocks

K_t = the stock of electrical energy-using equipment

The first stage depicts the short-run where electricity consumption depends on two variables, namely: income, Y_t, and the price of electricity, PE_t. The second stage is the long-run and here, Fisher and Keysen tried to explain the factors that affect the stock of capital. Capital stock's dependence on economic factors only holds in the medium- to long-term, but not in the short-run. In Fisher and Keysen's model, the growth rate in appliance stocks is regressed on population, expected income, marriages, expected energy prices, and the number of wired households. The model presents a lot of problems and as a result, researchers developed an alternative approach that avoids the use of equipment stock. This alternative approach distinguishes between actual electricity consumption, kWh_t and the desired long-run, or equilibrium electricity consumption, kWh_t*. The long-run consumption depends on the level of income, relative prices, among other factors (Holtedahl & Joutz, 2003).

3.2.2 The log-linear model

A log-linear model is a model in which the regressand is logarithmic (Gujarati, 2003). An attractive feature of this model lies in the fact that the slope coefficients directly measure elasticity of the regressand with respect to the regressors. (Gujarati, 2003) employed a log-linear model in an illustrative example used to find the elasticity of expenditure on durable goods with respect to total personal income. The model is specified as follows:

$$\ln EXDUR_t = \propto + \beta_2 \ln PCEX_t + \mu_t \qquad [11]$$

Where:

α = the intercept

β = slope coefficient

EXDUR = expenditure on durable goods

PCEX = total personal consumption expenditure

t = time period

ln = natural log

Since this study attempts to determine the income and price elasticity of electricity demand, this model is considered to be more suitable as the regression directly gives the elasticities. Thus, a similar model is employed in this paper.

3.3 Empirical analysis

There are numerous studies done on electricity demand globally. One reason for researching on this topic is to keep a keen eye on the growth rate of electricity demand, because if left unchecked it will continuously grow at a rapid exponential rate until the next century (Kent, 1973). Such a rapid growth is not desirable because of the economic problem of scarcity. Natural resources are limited as opposed to unlimited human wants and needs. Thus, these limited resources must be used in a sustainable manner. To ensure this sustainable utilization of resources such as electricity, governments have to be well aware of the changes in the demand for such goods and/or services. One way of determining the demand for a particular good, is by looking at the factors that affect that demand and by analysing the extent of their influence. The concept of elasticity is a useful tool in trying to determine the degree to which a certain factor influences the demand for a given good and/or service.

For instance, De Vita, *et al.*, (2005) analyzed the demand for different types of energy in Namibia using annual data for the period 1980 to 2002, applying an Autoregressive

Distributed Lag (ARDL) bounds testing approach to cointegration. The study employed a linear econometrics model which is specified as follows:

$$ed_t = \alpha + \beta_1 y_t + \beta_2 p_t + \beta_3 x_t + \mu_t \qquad [III]$$

Where:

ed = the consumption of energy,

y = GDP,

p = the price of energy

x = additional regressors, namely the HIV/AIDS incidence rate[1], and the price of substitute energy and

t = time period

GDP is used as a proxy for private income. Their findings confirmed a positive relationship between energy demand and the Gross Domestic Product (GDP), and a negative one between energy demand and its price. This means that price and income are among the factors that affect the demand for energy, including electrical energy, in Namibia. According to these findings, and increase in income increases energy consumption, while and increase in energy price, reduces its consumption. The current study also intents to analyze the demand for electricity in Namibia, to see if there is any deviation from the findings of De Vita, *et al.*, (2005). Unlike the previous study that looked at the whole energy sector, the current study looks exclusively at the electricity sector.

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[1] The study by *De Vita, et al.*, (2005), briefly referred to the HIV/AIDS incidence rate as a variable that can influence energy consumption, but did not go into details about it.

Zachardis & Pashourtidou (2006) did an empirical analysis of electricity consumption in Cyprus, an island in the Eastern Mediterranean. The study used annual data over the period 1960 to 2004 and used tests of stationarity and cointergration as well as Error Correction models. It used similar variables to those employed in this paper. Electricity consumption was found to be income and price elastic in the long-run while affected only by weather conditions in the short-run. Cyprus is also a developing country like Namibia.

Holtedahl & Joutz (2003) examined residential electricity demand in Taiwan as a function of household disposable income, cooling degree day effects, the price of electricity and the degree of urbanization as a proxy for electricity-using equipment. The study made use of tests of stationarity and Error Correction Models (ECM) to both short- and long-term effects. It employed a two-stage model, specified as follows:

$$kWh_t = u_t * K_t = u_t(Y_t, PE_t, Urban_t, CDD_t) * Urban_t(Y_t, PE_t) \qquad [IV]$$

Where:

$Urban_t$ = the degree of urbanization as a proxy for electricity-using equipment

CDD_t = cooling degree day effects

The study found the demand for electricity to be price inelastic in both the short-run and the long-run. The income elasticity was found to be unit elastic in the long-run and less than unity in the short-run. The study further found the urbanization variable and the cooling degree-day effects to have significant explanatory power to the model in both the short-run and the long-run.

The findings of previous studies show that income affects the demand for electricity to a higher degree than price.

3.4 Summary

This chapter reviewed existing literature on the current topic in order to outline existing findings and theories surrounding the subject of electricity demand. One of the two econometric models reviewed in this chapter is the log-linear model, which is also employed in the current study. A similar study that looked at the whole energy sector in Namibia, unlike the current one which is researching only one sector, was also analyzed in this chapter. As per the findings of the reviewed papers, income shows dominance over price in affecting the demand for electricity.

CHAPTER 4: METHODOLOGY

4.1 Introduction

This chapter presents the model specification with a brief description of the model variables. These variables are summarized in tabular form for easy observation. The chapter further explains the methodology in terms of data collection and analysis. An elaborate description of each of the econometric techniques to be employed is provided.

4.2 Model Specification

The current study employs a log-linear model and the aggregated, long-run electricity demand function is specified as follows:

$$\ln ED_t = \propto + \beta_1 \ln GDP_t + \beta_2 \ln PE_t + \mu_t \qquad [1]$$

The Greek letters, $\propto$, μ, and the β_s represent a constant in the model, the classical error term, and the model parameters, respectively. The subscript t is the time period, or trend. The table below presents a summary of the main variables used in the model.

Table 4.1 Model variables

Variable	Description	Expected sign
ED	Electricity demand	
GDP	Real Gross Domestic Product	Positive
PE	Price of Electricity	Negative

The choice of the double log model is based on the fact that the slope coefficients directly measure elasticity of the regressand with respect to the regressors (Gujarati, 2003). As already defined in this paper, elasticity measures the responsiveness of quantity demanded or quantity supplied to one of its determinants (Mankiw, 2007). In this case, the slope coefficients will indicate the percentage change in electricity consumption due to a given percentage change in GDP as well as due to a percentage change in electricity tariff.

4.3 Methodology

4.3.1 Data sources

The study uses quarterly time series data for the period 1993:Q1 to 2006:Q4. Secondary data is used and is obtained from the Central Bureau of Statistics (CBS) at the National Planning Commission (NPC) secretariat and NamPower. The GDP time series is collected from the CBS in real terms at 1995 constant prices. Hourly electricity demand figures in megawatts are obtained from Nampower. These figures are then calculated to get the quarterly figures in gigawatts, which are used in the regression analysis of this paper. Information on electricity tariffs is also collected from NamPower. These tariffs remain fairly constant per financial year. As a result, there is just one price per quarter in most cases. Any changes in NamPower tariffs in a given financial year are considered in calculating the quarterly tariff figures. Maximum consideration is also given to the fact that NamPower's financial year runs from July to June, while the quarterly data in this paper are based on a calendar year. No extrapolation of data is used in this study.

4.3.2 Data analysis

The ordinary least square method is used to estimate the regression, using Eviews econometric software. The analysis of electricity consumption is carried out with the aid of time series econometric techniques such as unit root tests and Error Correction Model (ECM). The first step is to test for nonstationarity of variables by means of graphical analysis and the Dickey Fuller (DF) and Augmented Dickey-Fuller (ADF) tests. These tests can determine whether a time series is trend-stationary (TS) or difference-stationary (DS). In the case of TS time series, it is common practice to detrend the data by including the trend variable in the regression model. Variables that are found to be nonstationary are also differenced to different orders of integration until they become stationary. The Engle-Granger (EG) test is used to test for cointegration[2]. Finally, the paper employs the Error Correction Mechanism (ECM) to obtain the short run effects of the variables.

4.4 Stationary vs Nonstationary time series

A time series whose basic properties such as its mean, variance, and covariance, are time invariant, is said to be stationary. On the other hand, a nonstationary time series has one or more basic properties that change over time. For instance, nonstationarity exists if there is no long-run mean to which the time series returns; if the variance goes to infinity with time approaching infinity, etc. (Enders, 1995). Nonstationarity is a problem in regression analysis as it tends to inflate regression results such as the R^2 and t-statistics, giving misleading results. In this case, the change in the dependent variable is attributed to the nonstationary explanatory variabe while such causal relationship between the two variables is non-existent in reality. Such regression results are said to be *spurious*.

Nonstationarity could occur due to a deterministic trend or a random walk[3]. This can be best illustrated by means of the following autoregressive (AR) equation:

$$Y_t = \gamma Y_{t-1} + v_t \qquad [2]$$

Where v_t is the white noise error term that follows the classical assumptions of zero mean, constant variance δ^2, and no autocorrelation. If γ, the coefficient of Y_{t-1} is less than one in absolute terms ($|\gamma| < 1$), then Y_t is stationary as its expected value will eventually approach zero with an increase in the sample size. In the case where $|\gamma| > 1$, then the expected value of

---

[2] Cointegration generally refers to the existence of a long-term, or equilibrium, relationship between variables

[3] A random walk is a time series variable where the value in the next period is a sum of the current period's value and a stochastic error term (Studenmund, 2006).

Y_t will continue to increase, causing Y_t to be nonstationary. This nonstationarity is caused by trend and can be eliminated by adding a time trend to the equation as an independent variable. In this case, the trend variable is said to be deterministic and the time series is generated by a trend stationary process (TSP).

In the case where $|\gamma| = 1$, the expected value of Y_t does not converge on any value. Y_t has a unit root and follows a random walk and is thus, nonstationary. Alternatively, equation 2 can be expressed as

$$\Delta Y_t = (\gamma - 1)Y_{t-1} + v_t$$

$$= \delta Y_{t-1} + v_t \qquad [3]$$

Where $\delta = (\gamma - 1)$ and where Δ is the first difference operator. By definition,

$$\Delta Y_t = Y_t - Y_{t-1} \qquad [4]$$

is the same as equation [3] with the exception that the null hypothesis now is that $\delta=0$. Thus,

$$\Delta Y_t = Y_t - Y_{t-1} = v_t \qquad [5]$$

Equation [5] tells us that the first differences of a random walk time series are stationary time series because of the assumption that v_t is purely random. Here, the time series shows a stochastic trend and stationarity can only be achieved by differencing the time series, unlike in the previous case where the inclusion of a trend variable in the equation was enough to get rid of nonstationarity. This is a difference stationary process (DSP).

A time series that has to be differenced once to obtain stationarity is said to be integrated of order 1, i.e I(1). In general terms, if a nonstationary time series is differenced *d* times to get stationary series, it is said to be integrated of order *d,* I(d). A stationary time series is I(0).

It is of vital importance to determine whether a time series is nonstationary due to a deterministic or stochastic trend variable. A time series that has a unit root exhibits a stochastic trend, while the one with no unit root exhibits a deterministic trend. Many economic time series variables are nonstatiory even after removing the time trend. Thus, it is necessary to use the right method to generate a stationary time series. The unit root test can be used to avoid spurious regressions (Studenmund, 2006; Gujarati, 2003).

4.4.1 The Unit Root Test

Graphical analysis as way of testing for nonstationarity enables us to de-trend the time series by including the trend variable in the model as an independent variable. These include the use of line graphs and sample correlograms. Although the latter is a useful tool for unit root testing, it is not necessarily precise as observers may see the result differently. This is due to the fact that a near unit root process will have a similar shape as a unit root process. Thus, to detect the presence of a unit root in a time series, one needs to employ more formal tests. One such test that is employed in this paper is the set of the Dickey-Fuller (DF) and the augmented Dickey-Fuller (ADF) tests. The DF test usually comes in the following three versions:

$$\Delta Y_t = \delta Y_{t-1} + v_t \qquad [6]$$

$$\Delta Y_t = \beta_1 + \delta Y_{t-1} + v_t \qquad [7]$$

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + v_t \qquad [8]$$

Where t is the trend variable and in each case the null hypothesis is that $\delta = 0$, meaning that there is a unit root. Equation [6] is the simplest version of the DF test. Equation [7] includes a constant term, while equation [8] includes both a constant term and a trend variable. All three equations are estimated in the same way, but use different critical values of the t-statics. The parameter of interest is δ in all three cases. $\delta = 0$ implies the presence of a unit root in the time series sequence. These DF tests assume independent error terms and a constant variance, but this is not always the case. In the case where the error term v_t is autocorrelated, the rule is to use lagged difference terms to generate a serially independent error term, using the augmented Dickey-Fuller (Studenmund, 2006; Gujarati, 2003). Thus, equation [8] is modified as follows:

$$\Delta \mathbf{Y}_t = \beta_1 + \beta_2 t + \delta \mathbf{Y}_{t-1} + \mathbf{v}_t + \alpha_i \sum_{i=1}^{m} \Delta \mathbf{Y}_{t-i} + \varepsilon_t \qquad [9]$$

4.5 Cointegration

Generally, regressing a nonstationary time series on another nonstationary time series may produce dubious results. If two variables, X_t and Y_t, are both I(1) series, than their linear combination $_{\alpha 1}X_t + _{\alpha 2}Y_t$ is also I(1). That is, the disturbance term, u_t, of the regression below, is I(1):

$$u_t = Y_t - \beta_1 - \beta_2 X_t \qquad [10]$$

In this case the best way to transform the nonstationary time series to make them stationary is by taking their first differences. However, when there is a causal relationship between the two aforementioned variables, then the error term, u_t may well be stationary or I(0). The unit root in the variables X_t and Y_t cancel out and they are said to be cointegrated. This means that even though the variables are increasing over time, they may drift apart in the long run. Thus, the concept of cointegration implies a long term or equilibrium relationship among variables.

4.6 The Error Correction Model (ECM)

According to the Granger representation theorem, the relationship between two variables that are cointegrated can be expressed as the ECM. Suppose two variables, Y_t and Z_t are cointegrated, then equation (11) below illustrates the simple ECM:

$$\Delta Y_t = \alpha_1 + \alpha_2 \Delta Z_t + \alpha_3(Y_{t-1} - \gamma_2 Z_{t-1}) + \varepsilon_t \qquad [11]$$

Where α_2 and γ_2 are the short and long run elasticities of Y_t, respectively. The term $(Y_{t-1} - \gamma_2 Z_{t-1})$ measures the deviation of Y_t from the equilibrium $\gamma_2 Z$, in period t-1. Thus, α_3 is the speed of adjustment of Y_t to last period's error. If $Y_t > Z_t$ then $(Y_{t-1} - \gamma_2 Z_{t-1}) > 0$ and $\alpha_3(Y_{t-1} - \gamma_2 Z_{t-1}) < 0$ and next period's Y_t decreases towards its long run equilibrium. The reverse is also true. The conclusion is that Y_t fluctuates around its long run equilibrium value. Thus, the point estimates imply that ΔY_t and ΔZ_t converge to the long run equilibrium relationship.

4.7 Summary

This chapter outlined the econometric model employed in this paper. It also described the various econometric methods that are used to test the data. The data are collected from the CBS and NamPower. The mean, variance, and covariance, of a stationary time series are time invariant. Nonstationarity occurs when one or more of the aforementioned properties of time series, are time-variant. Unit root exists when a time series is nonstationary due to a stochastic trend. Regressing a unit root time series on another unit root time series generates spurious results. Cointegration refers to a possible long-term, or equilibrium relationship among variables. The ECM captures the short-run relationship among variables and also verifies the existence of cointegration. The next chapter will give the actual results of the regression model.

CHAPTER 5: EMPIRICAL ESTIMATION OF NAMIBIA'S DEMAND FOR ELECTRICITY MODEL

5.1 Introduction

Neoclassical theory suggests the price of goods and services as well as the level of available income as important variables that influence the demand for those goods and services, among other factors. Generally, households and communities perceive electricity as a normal good, as opposed to other energy sources such as oil, biomass, coal, etc., that are regarded as inferior goods (Louw, et al., 2008). Economic theory suggests that the demand for a normal good vary positively with changes in income, while the relationship between a normal good and its price is expected to be negative. The hypothesis tested in this paper is based on this notion. However, electricity may be viewed as having no close substitutes and its demand may be expected to be slightly inelastic to changes in its own price. This chapter gives empirical results on this concept in the context of Namibia through the use of econometric techniques.

5.2 Unit root test

The graphical plots of the variables show a trend, thus suggesting the possible presence of nonstationarity. Therefore, all variables are tested for stationarity using the ADF unit root test. The tests include both intercept and trend. Tables 5.1 below displays the test results performed in levels and in levels.

Table 5.1 Unit root test results

Variable	Test statistics	Probability	Longest lag	Order of integration
LED	-2.266184	-0.4444	4	I(1)
LGDP	-1.076050	0.9231	4	I(1)
LPE	-2.158502	0.5025	4	I(1)

The primary interest here is in the t-statics. For all three variables, the computed t values of -2.266184, -1.076050 and -2.158502 are less negative than the given ADF test critical values at the 1, 5, and 10% levels (see appendix A.2). The conclusion is that all variables are nonstationary or they are I(1). In this case, the time series are difference stationary. The common practice to transform nonstationary time series into stationary time series is by taking the first differences of the variables. However, valuable information that economic theory can provide in the form of equilibrium relationships between the original variables might be lost in the process of differencing (Studenmund, 2006). Thus, differencing the time series as way to achieve stationarity should be used after testing the residuals for cointegration. That is the procedure followed in this paper.

5.3 Cointegration test

After testing the variables for unit root, the cointegration test is performed to establish a possible long term relationship among the variables so as to avoid taking the first differences of the time series. The empirical cointegrating regression model is given by equation 12 below. The t-statistics and probabilities are given in parenthesis.

$$\ln ED = 4.742 + 1.018 \ln GDP - 0.007 \ln PE \qquad [12]$$

$$t = \quad (14.741735) \quad (23.08533) \quad (-0.288001)$$

(0.0000) (0.0000) (0.7745)

$R^2 = 0.9408$ $d = 1.5540$

The residuals from Equation (12) are then tested for unit root and it is verified that there exist an equilibrium relationship (see appendix A.3). The testing methods applied here are the Engle-Granger (EG) test and cointegrating regression Durbin-Wtson (CRDW) test. The computed EG t-statistic of -5.971718 is more negative than the critical t-value at all three levels of 1, 5, and 10% (See Table 5.2 below). Therefore the null hypothesis that the residuals have unit root, is rejected. Residuals are stationary, that is, they are I(0). Hence, the regression in Equation (12) is not spurious.

Table 5.2 Residual test

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.971718	0.0000
Test critical values:	1% level	-2.607686	
	5% level	-1.946878	
	10% level	-1.612999	

*MacKinnon (1996) one-sided p-values.

The (CRDW) test results also confirm that there is cointegration among variables. The variable of interest here is the Durbin-Watson d obtained from the cointegrating regression. Unlike the standard null hypothesis of $d = 2$, in this case the null hypothesis is that $d = 0$. This is due to the fact that $d \approx 2(1 - \rho)$, thus in the case of a possible unit root, the estimated ρ will be about 1. The given critical value for the hypothesis $d = 0$, are 0.511, 0.386 and 0.322 for the 1, 5 and percent levels, respectively. Since the computed t-statistic of 1.554 is greater than all the given critical values, we do not reject the null hypothesis of cointegration and thus, conclude that the variables are cointegrated.

Having confirmed that the variables are cointegrated, it is now appropriate to interpret equation [12], which is the empirical counterpart of equation [1]. Both explanatory variables have the correct signs, however, only GDP as a proxy for income is statistically significant. It implies that an increase in income leads to an increase in electricity consumption. Assuming electricity to be a normal good, this positive relationship between income and electricity demand conforms to the neoclassical theory of demand. It suggests that income is one of the factors that influence the demand for a normal good. The coefficient of the price of electricity has a negative sign as per a priori, but it is not statistically significant, hence its exclusion from subsequent analysis. However, despite it not being statistically significant, price as a determinant of the demand for electricity is theoretically relevant. It's insignificance in the Namibian context could perhaps be ascribed to the lack of close substitutes for electricity. Therefore, it remains an empirical puzzle, which could perhaps be uncovered by further research.

5.4 The Error Correction Model

Since a long run equilibrium relationship between the variables is confirmed, it allows for the specification of the Error Correction Model (ECM) to cater for the short-run dynamics of the system. Equation [13] below outlines the empirical results of the ECM with t values and probabilities in parenthesis:

$$\Delta \ln ED_t = 0.008 + 0.333DlnGDP + 0.272DlnED(-1) - 0.349DlnED(-2) - 0.462UHAT(-1)$$

t = (1.849) (2.858) (2.545) (-2.619) (-3.220)

(0.071) (0.006) (0.014) (0.011) (0.002)

R-squared 0.568064

Where UHAT(-1) is the lagged residual.

The variable of interest here is UHAT(-1), the lagged residual, as it is the error correction factor. The coefficient of UHAT(-1) is negative and statistically significant, thus implying that the dynamics adjust into the long-run equilibrium. It indicates that 46% of disequilibrium is corrected every quarter.

5.5 Diagnostic tests

A number of tests are performed in order to determine whether the model is reasonably fitted for the data. For instance the R^2 is a summary measure that indicates how well the sample regression line fits the data (Gujarati, 2003). The R^2 of about 57% obtained in this model, means that the given explanatory variables, including GDP as a proxy for income, are responsible for the variation in the demand for electricity in Namibia. This is a fairly satisfactory value, taking into account that the value of R^2 cannot exceed 1.

Another test applied in this paper is the Histogram of residuals, which is a simple graphic tool that gives us an idea about the shape of the probability density function (PDF). In this case, the residuals from the regression of the demand for electricity in Namibia, seem to symmetrically distributed (see appendix A.5 (I)). The JB statistic of the Jarque-Berra test is about 2.2676 and the probability of obtaining that statistic is about 87%. Thus, the hypothesis that the error terms are normally distributed, is not rejected. However, it should be noted that this test is more accurate if the sample size is large.

5.6 Structural Break

The structural break was tested using the Chow test. The critical value at the five percent level is 4.08 versus a computed value of 1.17. Therefore, the null hypothesis of no structural break is not rejected. The change in the tariff figures could be ascribed to the various changes that took place in the industry in the early 2000s. For instance, the ectricity industry has been governed by South African electricity acts from the colonial period until the year 2000 when the new Electricity Act of 2000 for Namibia came into existence. This Act made provision for the creation of an Electricity Control Board (ECB) to regulate the electricity industry and ensure customer protection (MME, 1998). The aim of the restructuring process was to obtain efficiency in the industry. This could perhaps, resulted in a drop in the tariffs in mid 2003. However, the SADC power crisis might have caused the upward trend in tariffs after 2003.

5.7 Summary

This chapter presented the empirical results. All model variables are found to be I(1). There exists a long-run, or equilibrium relationship among the given variables. The demand for electricity in Namibia is income elastic in both the short- and the long-run. Price is statistically insignificant. The ECM verifies the cointergration relationship. Diagnostic tests justify the validity and reliability of the model. The next chapter gives the conclusions and policy implications.

CHAPTER 6: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

This study analyzes the demand for electricity in Namibia, using quarterly data from 1993:Q1 to 2006:Q4. The study employs various econometric techniques such as unit root tests and the Engle-Granger approach to testing cointegration so as to establish the long-run relationship between the variables. It also applies an Error Correction Model (ECM) to cater for the short-run dynamics as well as to verify the long-run, or equilibrium relationship suggested by the cointegration test.

The basic objective of the study is to determine the price and income elasticities of electricity consumption in Namibia. Economic theory predicts that the relationship between income and demand for electricity is positive, while price is expected to be inversely related to the demand for electricity.

The results of the study show a significant impact of changes in income on the demand for electricity in both the long- and the short-run. Income elasticity is above unity (1.02) in the long-run and is 0.33 in the short-run.

This finding is in accordance with other studies. For instance, Zachardis & Pashourtidou (2006) did an empirical analysis of residential electricity consumption in Cyprus. Income elasticity was also above unity in the long-run, while electricity demand was found to be inelastic to both income and price in the short-run. In the current study, price, on the other hand, has the correct sign, but is statistically insignificant. Thus, it is excluded from subsequent analysis. However, despite it not being statistically significant, price as a determinant of the demand for electricity is theoretically relevant. Economic theory suggests that the demand for a normal good is inversely affected by changes in the price of that good. That is why the statistical insignificance the electricity price in the Namibian context remains an empirical puzzle, which could perhaps be uncovered by further research. However, one possible explanation for this outcome could be a lack of close substitutes for electricity in Namibia. As Namibia is still a developing country, it could be that both households and commercial customers find it difficult to resort to alternative sources of energy.

6.2 Policy implications

Given the volatile electricity market in the SADC region, member countries, including Namibia, should have good measures in place to deal with the problem of electricity shortages. Policy makers need to use the correct mixture of policy tools to stabilize aggregate electricity demand in Namibia. This is a very complex task as using one policy measure to achieve a certain macroeconomic objective may have undesirable results in terms of another macroeconomic objective. Therefore, the choice of which combination of policy measures to select is a big challenge facing policy makers.

According to the findings of this thesis, electricity demand in Namibia is very responsive to changes in private income. Thus, given a statistically insignificant price, an increase in electricity demand should be an indication that the average level of income is increasing, which is a good thing for any economy. However, it should be borne in mind that electricity is extracted from natural resources, which must be utilized sustainably. Thus, for instance, if electricity consumption increases to an undesirable level, where it far exceeds the current generation capacity, there will be mainly two options for policy makers. One option is to apply measures that will curb the electricity demand, while the other option is to tackle this excess electricity demand problem from the supply side.

The first option entails using Demand Side Management (DSM) measures. These include launching public awareness campaigns on how to use energy efficiently as well as using regulations on energy use. Furthermore, it is also advisable to use renewable energy such as solar energy as suggested by the ECB. The use of solar energy is still a new technology in Namibia. Thus, the country is not yet reaping the benefits of using renewable energy and still has a long way to go. Although raising public awareness to use electricity efficiently is a good way to reduce electricity consumption, it is not enough to deal with a serious excess demand problem. As per the findings of this study, the price of electricity has no explanatory power on electricity demand. Thus, using price as a policy measure to influence electricity consumption would be inappropriate. Therefore, one possible way is to use a contractionary fiscal policy such as a tax increase to affect disposable income. For Namibia, given its current economic growth of a mere 4.7% as opposed to the Vision 2030 target of 7%, contracting the economy to reduce electricity consumption would be a bad choice. Hence a mixture of supply and demand side management could be more effective. However, increasing electricity supply will be at the cost of the environment, in addition to possible socio-political consequences.

The conclusion here is that there is no one perfect policy measure that can be used to achieve the desired goal. Therefore, it is necessary that the costs and benefits of all policy measures, economic and/or political decisions, are weighed before they are implemented.

6.3 Areas for further research

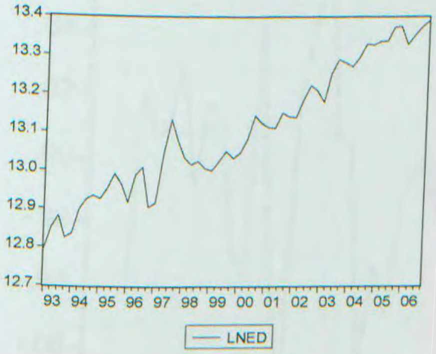
Life is dynamic and factors that affect human life are constantly changing. Human needs and wants are unlimited, while the resources needed to satisfy those needs and wants are limited. Thus, sustainable and efficient use of the natural resources is a matter of crucial importance. This calls for continuous research in different subjects in order to find ways to best deal with the problem of scarcity. Many economic researchers have come up with new theories and recommendations on different topics of economic importance, but there is still room for new research.

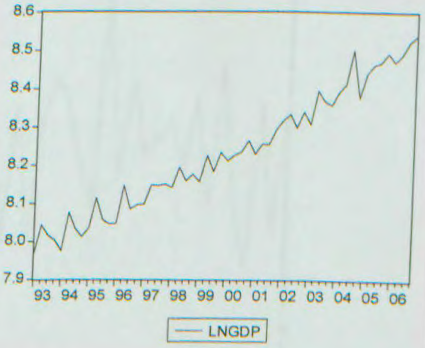
Areas for further research on this topic include a sectoral analysis of the electricity demand in Namibia as well as an analysis of the SADC electricity market.

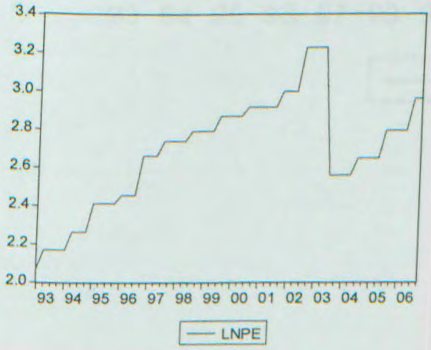
APPENDICES

Appendix A.1: Graphical Analysis of Stationarity

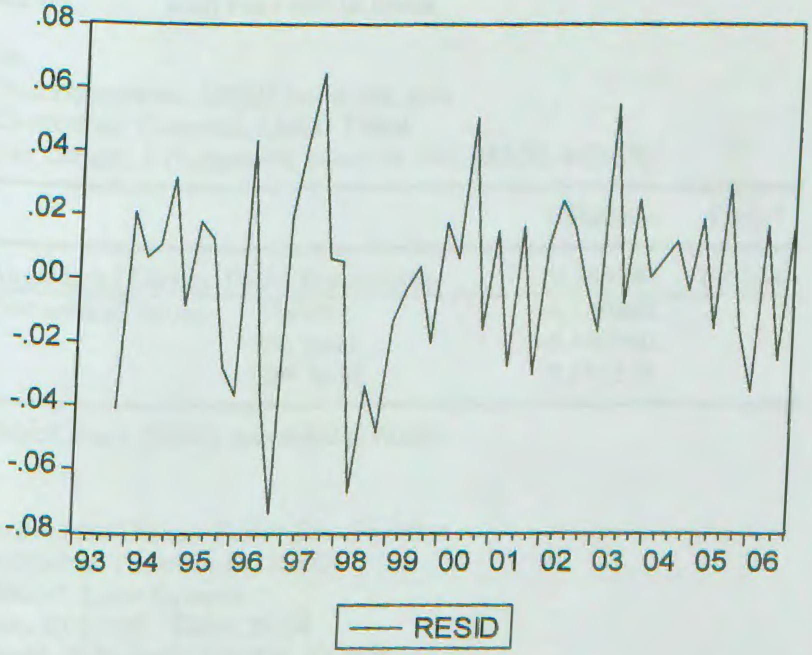
A.1 (I) Variables in levels







A.1 (II) Plot of residual



APPENDIX A.2: ADF UNIT ROOT TEST RESULTS

A.2 (I) Unit root test in levels

(a)

```
Null Hypothesis: LNED has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 2 (Automatic based on SIC, MAXLAG=10)
==========================================================================
                                               t-Statistic      Prob.*
==========================================================================
Augmented Dickey-Fuller test statistic         -2.266184       0.4444
--------------------------------------------------------------------------
Test critical values:        1% level          -4.140858
                             5% level          -3.496960
                             10% level         -3.177579
==========================================================================
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNED)
Method: Least Squares
Date: 01/21/09   Time: 20:58
Sample (adjusted): 1993Q4 2006Q4
Included observations: 53 after adjustments
==========================================================================
                        Coefficie
       Variable               nt     Std. Error    t-Statistic     Prob.
==========================================================================

                                -
       LNED(-1)         0.302416     0.133447     -2.266184       0.0280
     D(LNED(-1))        0.245241     0.117852      2.080912       0.0428
                                -
     D(LNED(-2))        0.509971     0.121933     -4.182383       0.0001
           C            3.888300     1.709396      2.274664       0.0274
   @TREND(1993Q1)       0.003049     0.001355      2.250778       0.0290
==========================================================================
R-squared              0.515806    Mean dependent var       0.009573
Adjusted R-squared     0.475456    S.D. dependent var       0.039876
                                                                   -
S.E. of regression     0.028880    Akaike info criterion    4.161731
                                                                   -
Sum squared resid      0.040035    Schwarz criterion        3.975855
Log likelihood         115.2859    F-statistic              12.78344
Durbin-Watson stat     1.811821    Prob(F-statistic)        0.000000
==========================================================================
```

(b)

Null Hypothesis: LNGDP has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 4 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.076050	0.9231
Test critical values:	1% level	-4.148465	
	5% level	-3.500495	
	10% level	-3.179617	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNGDP)
Method: Least Squares
Date: 01/22/09 Time: 21:20
Sample (adjusted): 1994Q2 2006Q4
Included observations: 51 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNGDP(-1)	-0.270531	0.251411	-1.076050	0.2878
D(LNGDP(-1))	-1.023371	0.248305	-4.121427	0.0002
D(LNGDP(-2))	-1.008193	0.216233	-4.662523	0.0000
D(LNGDP(-3))	-0.940389	0.179851	-5.228704	0.0000
D(LNGDP(-4))	-0.365469	0.133713	-2.733233	0.0090
C	2.179417	1.995349	1.092248	0.2807
@TREND(1993Q1)	0.003125	0.002448	1.276793	0.2084

R-squared	0.737583	Mean dependent var	0.011085
Adjusted R-squared	0.701799	S.D. dependent var	0.044098
S.E. of regression	0.024081	Akaike info criterion	-4.487919
Sum squared resid	0.025515	Schwarz criterion	-4.222766
Log likelihood	121.4419	F-statistic	20.61198
Durbin-Watson stat	1.975512	Prob(F-statistic)	0.000000

(c)

```
Null Hypothesis: LNPE has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic based on SIC, MAXLAG=10)
==========================================================================
                                                  t-Statistic     Prob.*
==========================================================================
Augmented Dickey-Fuller test statistic            -2.158502      0.5025
--------------------------------------------------------------------------
Test critical values:      1% level               -4.133838
                           5% level               -3.493692
                           10% level              -3.175693
==========================================================================
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNPE)
Method: Least Squares
Date: 01/22/09   Time: 21:25
Sample (adjusted): 1993Q2 2006Q4
Included observations: 55 after adjustments
==========================================================================
                          Coefficie
      Variable                   nt    Std. Error    t-Statistic    Prob.
==========================================================================
                                 -
      LNPE(-1)            0.145670     0.067487     -2.158502     0.0355
          C               0.376855     0.160813      2.343442     0.0230
  @TREND(1993Q1)          0.001062     0.001218      0.872195     0.3871
==========================================================================
R-squared                 0.091669    Mean dependent var        0.016032
Adjusted R-squared        0.056734    S.D. dependent var        0.109810
                                                                 -
S.E. of regression        0.106650    Akaike info criterion     1.585533
                                                                 -
Sum squared resid         0.591456    Schwarz criterion         1.476042
Log likelihood            46.60216    F-statistic               2.623940
Durbin-Watson stat        1.930246    Prob(F-statistic)         0.082100
==========================================================================
```

APPENDIX A.3: COINTEGRATION TEST RESULTS

A.3 (I)

Dependent Variable: LNED
Method: Least Squares
Date: 01/20/09 Time: 16:29
Sample: 1993Q1 2006Q4
Included observations: 56

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNGDP	1.017867	0.044092	23.08533	0.0000
LNPE	- 0.007107	0.024677	-0.288001	0.7745
C	4.741735	0.326573	14.51970	0.0000

R-squared	0.940845	Mean dependent var	13.10325
Adjusted R-squared	0.938612	S.D. dependent var	0.168341
S.E. of regression	0.041709	Akaike info criterion	- 3.464111
Sum squared resid	0.092201	Schwarz criterion	- 3.355610
Log likelihood	99.99511	F-statistic	421.4734
Durbin-Watson stat	1.554064	Prob(F-statistic)	0.000000

A.3 (II)

```
Null Hypothesis: RESID01 has a unit root
Exogenous: None
Lag Length: 0 (Automatic based on SIC, MAXLAG=10)
================================================================
                                        t-Statistic    Prob.*
================================================================
Augmented Dickey-Fuller test statistic  -5.971718     0.0000
----------------------------------------------------------------
Test critical values:      1% level     -2.607686
                           5% level     -1.946878
                          10% level     -1.612999
================================================================
*MacKinnon (1996) one-sided p-values.


Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RESID01)
Method: Least Squares
Date: 01/22/09   Time: 21:58
Sample (adjusted): 1993Q2 2006Q4
Included observations: 55 after adjustments
================================================================
                     Coefficie
     Variable               nt   Std. Error  t-Statistic   Prob.
================================================================
                             -
   RESID01(-1)        0.788861    0.132099   -5.971718    0.0000
================================================================
R-squared             0.397710   Mean dependent var     0.000323
Adjusted R-squared    0.397710   S.D. dependent var     0.051511
                                                               -
S.E. of regression    0.039976   Akaike info criterion  3.583055
                                                               -
Sum squared resid     0.086297   Schwarz criterion      3.546558
Log likelihood        99.53402   Durbin-Watson stat     2.001396
================================================================
```

APPENDIX A.4: THE ERROR CORRECTION MODEL (ECM)

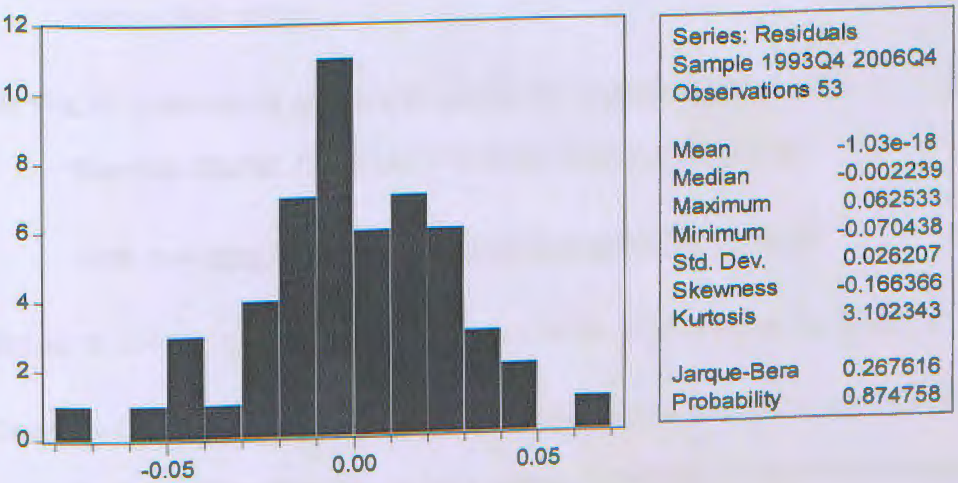
Dependent Variable: D(LNED)
Method: Least Squares
Date: 01/20/09 Time: 18:10
Sample (adjusted): 1993Q4 2006Q4
Included observations: 53 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNGDP)	0.332660	0.116395	2.858025	0.0063
D(LNED(-2))	-0.349103	0.133319	-2.618551	0.0118
D(LNED(-1))	0.271520	0.106706	2.544570	0.0142
UHAT(-1)	-0.461788	0.143411	-3.220024	0.0023
C	0.008414	0.004551	1.848702	0.0707

R-squared	0.568064	Mean dependent var	0.009573
Adjusted R-squared	0.532069	S.D. dependent var	0.039876
S.E. of regression	0.027277	Akaike info criterion	-4.275940
Sum squared resid	0.035714	Schwarz criterion	-4.090064
Log likelihood	118.3124	F-statistic	15.78190
Durbin-Watson stat	1.789956	Prob(F-statistic)	0.000000

APPENDIX A.5: NORMALITY AND VALIDITY TEST

A.5: Jarque-Bera test



```
Series: Residuals
Sample 1993Q4 2006Q4
Observations 53

Mean        -1.03e-18
Median      -0.002239
Maximum      0.062533
Minimum     -0.070438
Std. Dev.    0.026207
Skewness    -0.166366
Kurtosis     3.102343

Jarque-Bera  0.267616
Probability  0.874758
```

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