DEMAND FOR LIQUEFIED PETROLEUM GAS (LPG) IN KENYA: 1971 – 2005

By

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DECLARATION

I hereby declare that this research paper is my original work and has not been presented in any other University.

Signed ....

Akinyi Elizabeth Joan

Date ...2nd September, 2008...

Approval

This research paper has been submitted for examination with my approval as University of Nairobi supervisor;

Signed ....

Prof. Peter Kimuyu

Date: Sept 4th, 2008

DEDICATION

This work is dedicated to the memory of my beloved husband Tobias, and to my wonderful children Jack, Mark and Sally.

ACKNOWLEDGMENTS

My foremost gratitude goes to the almighty God for his grace that has seen me through this course.

I am grateful to University of Nairobi, School of Economics for admitting me to the Master of Arts programme, and for their vehemence in upholding the academic discipline. My gratitude goes to my Supervisor; Prof. Kimuyu for his patience and guidance throughout this study and for the positive critique and suggestions which gave me the impetus to refine and produce quality work. I owe a lot to my friends at the University of Nairobi Dr. Joseph Onjala and Mr. Daniel Kamande for their invaluable advice throughout the study; and to the Petroleum Institute of East Africa for availing information that helped guide the research. My classmates too deserve special recognition for the time we spent together discussing and refining our academic work. To Eng. Joseph Gichuhi, Corporate Planning Manager, Kenya Pipeline Company, thanks for the comments and for challenging me to finish the course and move on. Lastly, I thank my family members and friends for their immense moral and spiritual support, in particular, my children who understood that their mother had to read.

Despite all this able assistance, I accept full responsibility for any flaws in the writing of this paper. The study was a worthy challenge and I hope it will add to existing literature in energy sector in Kenya.

ABSTRACT

This study provide evidence on the empirical determinant of LPG demand in Kenya using thirty five-year time series data over 1971-2006. The estimated model was a single regression equation with demand of Liquefied Petroleum Gas (measured as actual yearly LPG consumption) as the dependent variable and explanatory variables being price of crude oil, electricity tariff, urban population, per capita GDP, price of LPG, domestic revenue, price of kerosene and inflation are exogenous and explain demand of LPG. The model tests indicate that the estimated model was the "best" model on grounds of both theory and goodness of fit.

The results of the study showed that in the short and long run urban population, domestic revenue, per capita GDP, LPG previous demand and inflation are determinant of demand of LPG. However, crude oil, LPG price, kerosene price and electricity tariff coefficients have correct sign though insignificant. These variables' coefficients were inelastic except for LPG price coefficient. The estimated long-run fuel price elasticities of demand of LPG were smaller than the short run elasticities, indicating that economic units do not exercise their discretion in fuel and equipment choice in the long-run. The insignificance of these coefficients reflected the inefficiency in the energy sector and the oligopolistic structure of the sector. Policy approaches for higher LPG demand should be geared toward strengthening the LPG legal framework and development of LPG infrastructure to enhance competition within the LPG market; and ensuring macroeconomic stability and consistency in macroeconomic policies to favour investment in LPG infrastructure.

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Abbreviations and Acronyms

GOK	Government of Kenya
FEMA	Forum for Energy Ministers of Africa
KIPPRA	Kenya Institute for Public Policy Research and Analysis
Koe	Kilogramme of Oil Equivalent
KPRL	Kenya Petroleum Refineries Ltd.
KWh	Kilowatt per Hour
LPG	Liquefied Petroleum Gas
PDC	Petroleum Development Consultants
Toe	Tonnes of Oil Equivalent
UNDP	United Nations Development Programme
WDI	World Development Indicators

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CHAPTER ONE: INTRODUCTION

1.1 Introduction

It is estimated that about 2 billion people, one third of the world's population, continue to rely on traditional energy sources (firewood, wood for charcoal, industrial wood, wood wastes and farm residue) and are not able to take advantage of the opportunities made possible by modern forms of energy (electricity, wind/solar energy, and petroleum fuels) (UNDP, 2000). UNDP (2000) environmental report conferred that reliance on traditional sources of energy, especially wood fuel has adverse effects such as indoor pollution and health risk, environmental degradation and time wastage. Potential energy savings from the use of available efficient technologies is high and present significant case for switching from traditional to modern fuels.

Modern energy in its various forms is critical for achievement of economic, social and environmental development. In Africa, leaders have recognized that the current level of access to modern energy is very low compared to other countries and is a persistent impediment to survival and economic development (Forum for Energy Ministers of Africa, FEMA, 2005). There has been concerted effort to promote use of modern fuels, especially in the households in the developing countries. FEMA, 2005 suggested energy targets which included; 50% of inhabitants in rural areas should use modern energy for cooking and 75% of the poor in urban and peri-urban should have access to modern energy. The desired transition from traditional fuels to modern fuels may not be widely achieved unless policy makers understand the factors that determine demand for the various forms of energy and formulate appropriate policies.

This study examines the demand for Liquefied Petroleum Gas (LPG) in Kenya. LPG is a form of modern fuel used for cooking, heating and lighting in households. LPG is also used in industries particularly for manufacturing of ceramic and glass, chemical processes, soldering, welding, flare cutting, medical & laboratory use. The use of LPG is desirable due to its clean burning characteristics and environment friendliness.

The Government of Kenya strategy focus on promotion of LPG use include increase in investment in LPG facilities particularly storage and distribution facilities in order to enhance access to the fuel thereby promote its use. This study seeks to determine the factors that affect demand for LPG in Kenya, understand the existing technical relationship, and suggest LPG focused policy interventions.

Subsequent sections of this Chapter: 1-Introduction, present an overview of the world energy demand, followed by an assessment of energy demand situation in Kenya. The overview forms a background to the detailed review of the LPG situation in Kenya presented thereafter. The review of the LPG situation in Kenya provides an understanding of the LPG supply logistics, which to a large extent affect demand for the fuel. The last sections of chapter: 1 outlines the statement of the problem, study objectives and justification. Chapter: 2 give the literature review and provide both theoretical and empirical literature review. Chapter: 3 state the study methodology and detail the analytical framework, empirical model, the estimation techniques, and data type. Chapter: 4 present the data analysis and discussion results; and lastly Chapter: 5 present the study conclusions and policy implications.

1.2 Overview of World Energy Demand

The total world commercial energy use has increased over the years, rising from 6,930,291 thousand metric toe in 1980 to 8,615,951 thousand metric toe in 1990, and by the year 2003, energy use was 10,543,712 thousand metric toe. The average annual growth in energy consumption between 1990 and 2003 was estimated at 1.6% (World Development Indicators (WDI), 2006). Energy consumption has increased even with rising energy taxes, demand-side interventions and supply shortages (Anderson, 2000).

Despite Africa's abundant fossil and renewable energy resources, commercial energy consumption in the Sub-Saharan Africa remains very low. The per capita commercial energy consumption for Sub-Saharan Africa was estimated to be 681 koe/capita in 2003 (WDI, 2006), compared to per capita commercial energy consumption for Europe and Central Asia which was 2,794 koe/capita in the same year. The per capita energy for the year 1990 and 2003 for selected countries in the Sub-Saharan Africa is tabulated in Table 1.1 below:

Table 1.1: Energy Use Per Capita

Country/Region	Energy use per capita (Kg oil equivalent)		Average Annual % Growth
	1990	2003	
Kenya	533	494	-0.6
Angola	596	606	0.1
Ethiopia	296	299	0.1
Ghana	345	400	1.2
Tanzania	374	465	1.7
South Africa	2,592	2,587	0.0
Sudan	408	477	1.2
Sub-Saharan Africa	693	681	-0.1
World	1685	1734	0.2

Source: World development Indicators, 2006

The demand for energy in industrialized and transition economies is expected to grow, although the efficiency in conversion and end uses may result in levelling off or even reduction in the demand for primary energy. In the developing economies, primary energy demand is expected to grow as industrialization and motorization proceed and living standards improves (UNDP, 2000).

1.3 Energy Situation in Kenya

There are three major sources of energy in Kenya, wood fuel, petroleum and electricity which account for 70%, 21% and 9% of total energy consumption in the country respectively (KIPPRA, 2006). A survey on energy demand in households, small scale industries and service establishments, showed that traditional energy account for 87% of total energy consumed in the households, small scale industries and service establishments, while electricity and petroleum account for 2% and 12% respectively (Kamfor, 2002).

Rural and urban households often consume a mix of both traditional and conventional energy types depending on household income. The poor households use greater quantities of traditional fuels while higher income families tended to rely more on modern energy resources (Kamfor, 2002). Table 1.2 below depicts annual energy consumption share by type and sector. The table shows that biomass was the predominant fuel type in the rural households in year 2002, while the modern fuels (electricity and LPG) were the main fuel source for urban population.

Table 1.2: Annual Energy Consumption Share by Type and Sector (by Year 2002)

Fuels/Category	Firewood (43.8%)	Charcoal (46.0%)	Wood Wastes (0.6%)	Farm Residue (6.4%)	Electricity (0.7%)	LPG (0.2%)	Total Demand (100%)
Rural Household	89.4%	46.2%	61.9%	99.5%	8%	5.6%	80%
Urban household	2.3%	36.5%	38.1%	0.5%	61.8%	66.7%	13%
Cottages	8.3%	17.3%	0%	0%	30.2%	27.7%	7%
Subtotal	100%	100%	100%	100%	100%	100%	100%

Source: Kamfor 2002[1]

Although the per capita commercial energy consumption in Kenya has declined over the decades and remains below the per capita consumption of commercial energy for Sub-Saharan Africa (depicted in Table 1.1 above), the total demand for commercial energy has maintained an upward trend over the years as shown in Table 1.3. Demand for electricity rose from 2,014 million KWh in 1985 to 4,498.4 million KWh in 2005, while demand for petroleum products i.e. Liquefied Petroleum Gas (LPG), motor spirit (premium and regular), aviation spirit, jet/turbo fuel, illuminating kerosene, light diesel oil, heavy diesel oil and fuel oil, rose from 1,497,500 tonnes in 1985 to 2,797,200 tonnes in 2005.

[1] Kamfor, 2002, acknowledged that consumption data available may not present the actual demand for the various types of energy. Wood fuel, abundance may result in consumption patterns bordering on extravagance, while in the case of conventional energy, (electricity, LPG and Kerosene) shortages and high prices may constrain consumption.

Table 1.3: Commercial Energy (Petroleum and Electricity) Demand

Fuel Type	1985	1990	1995	2000	2005
Electricity (million KWh)	2,014	2,665	3,289	3,320.7	4,498.4
Petroleum products demand ('000tonnes)	1,497.3	1,830.3	2,066.5	2,448.1	2,797.2

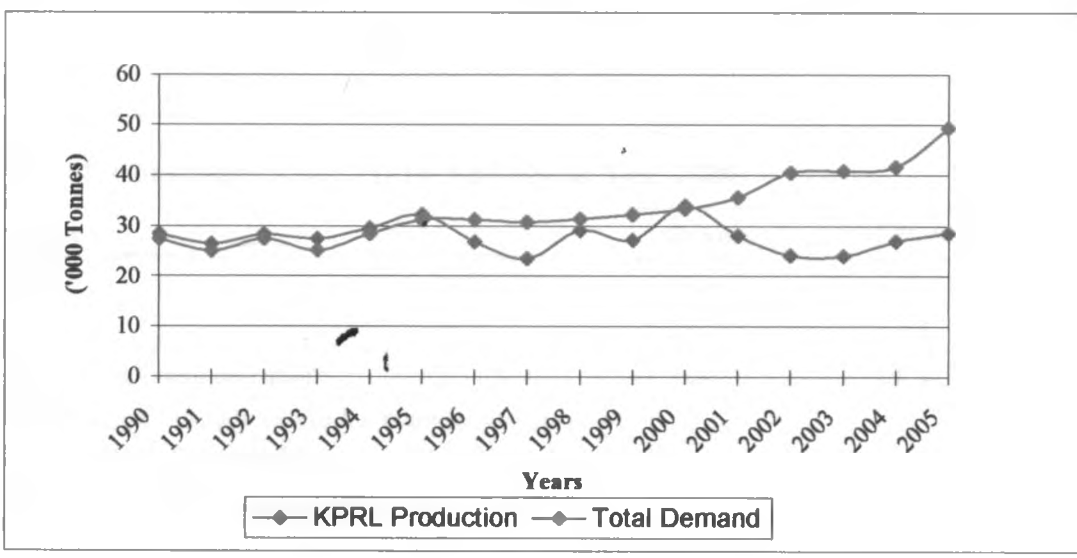
Source: Economic Survey (various issues)

1.4 LPG in Kenya: A Situation analysis

1.4.1 LPG Supply and Distribution Structure in Kenya

The main source of LPG in Kenya is the Kenya Petroleum Refineries Ltd. (KPRL) which produces about 70 % of total LPG consumed in the country. The production of LPG at the KPRL is however limited by the refinery throughput which is below the annual demand. This is depicted in Figure 1.1 below:

Figure 1.1: Comparison of KPRL LPG Production and Total Demand: 1990-2005



Source data: Kenya National Bureau of Statistics

LPG is imported into the country through the Shimanzi oil terminal in Mombasa. Typical cargoes size is 1,200 – 1,300 tonnes, while most suppliers prefer to ship large cargo sizes. The LPG cargo sizes are limited by the storage capacity at the Shimanzi terminal of about 1,300 tonnes. Currently, LPG imports come from Bahrain, one of the few LPG supply sources prepared to offer both large and small parcel size cargoes. Buying from a single source such as Bahrain allows the seller to charge a premium for the small cargo sizes (Petroleum Development Consultants (PDC, 2005). Increasing cargo sizes would result in economies of scale, however, the extent to which the cargo sizes can be increased is further limited by the market.

LPG use is preferred over traditional fuels due to its clean burning characteristics, high calorific value, easy transportation as it can be liquefied, ozone friendliness, and is therefore, a solution to environmental degradation which is a major concern. In Kenya, use of LPG is dominated by two primary end-use applications; cooking and lighting fuel in residential and commercial establishments and as process fuel in industrial manufacturing operations. Out of the total LPG consumed in the 2000, it was estimated that the domestic sector used 57.5%, while the commerce and industrial sector accounted for 38.3%, (Kamfor, 2000). The table 1.4 below shows the consumption of LPG in 2004 by sector.

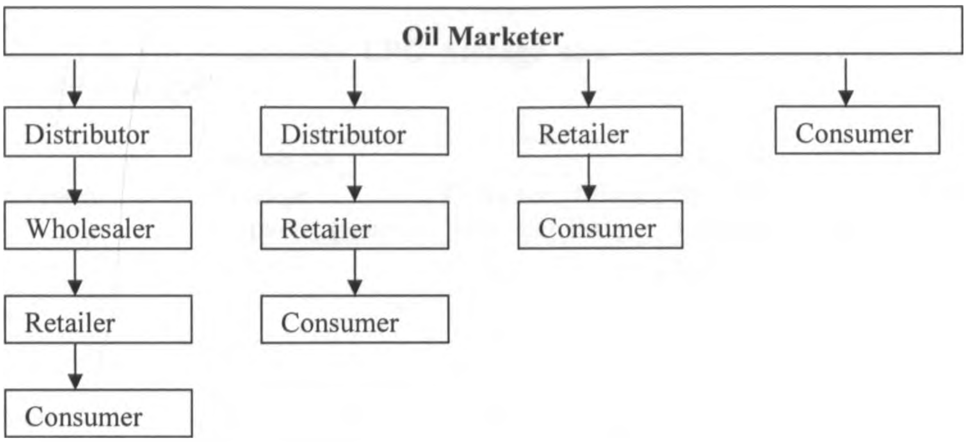
Table 1.4: Consumption of LPG by End-Use in Year 2000

Category	Tonnes	% Share
Domestic	19,161	57.5
Agriculture	251	0.8
Transport and Communications	324	1.1
Commerce and Industry (Includes manufacturing, power generation, tourism, mining etc.)	12,780	38.3
Government (includes government services and military	426	1.3

Source: Kamfor, 2000

LPG distribution structure is based on distribution costs of handling many small consumers versus profit margins given to the chain. There are four distribution chains, which are illustrated in Figure 1.2 below.

Figure 1.2: LPG Distribution Chain



Although there exists over twenty oil marketing companies, only six (6) of them are involved in LPG marketing i.e. Total, Caltex, Shell/BP, Kenol/Kobil, Triton and Mobil. Market access has been hindered by lack of 'common-user' LPG handling facilities, huge capital investment required for storage, bottling, distribution facilities and LPG equipment i.e. cylinders, valves and regulators. In the recent past, small scale LPG distributors operating within the estates in major towns have emerged.

LPG marketing by the Oil Companies involves high unit capital and operating expenditure due to the small volumes and high safety requirement, which makes LPG relatively expensive compared with other fuels (Kamfor, 2002). Safety implications and lack of consumer education on the use and handling of LPG have resulted in fear amongst potential LPG users, thus adversely influencing demand.

1.4.2 LPG Facilities, Equipment and Transportation Infrastructure in Kenya

1.4.2.1 LPG Storage and Distribution Facilities

The main hindrance to higher LPG demand in Kenya is lack of LPG handling facilities and supply infrastructure which affect availability and accessibility, and result in high prices. Of major concern has been the lack of adequate LPG import handling and storage facilities at the port of Mombasa, necessary for importation of larger quantities of LPG as the refinery production of LPG declines. Existing storage and bottling facilities are owned by major oil companies and are concentrated at Mombasa and Nairobi as presented in Table 1.5 below:

Table 1.5: Oil Companies LPG Storage and Filling Capacity in Mombasa and Nairobi as at 2005

Company	**Mombasa**		**Nairobi**	
	Storage Capacity (tones)	**Cylinder filling Rate (Per Day)**	**Storage Capacity (tones)**	**Cylinder filling Rate (Per Day)**
Caltex	100	1,000	90	500
Shell	450	300	250	1,500
Total	450	300	150	500
Mobil	410	1,100	143	650
BOC	-	-	98	800
Total	**1,410**	**1,800**	**731**	**3,950**

Source: Petroleum Development Consultants Report, 2005.

In addition to the above, the Refinery has 1,250 tonnes storage at Mombasa and Mobil has storage of 50 tonnes in Eldoret with a cylinder filling capacity of 850 per day. There has not been any investment in strategic importation and storage facilities for LPG by the Government of Kenya. Lack of adequate LPG import handling and storage facilities at Mombasa and a relatively small market size has contributed to the high LPG importation costs and subsequently high LPG retail prices.

1.4.2.2 LPG Appliances

The Kenyan LPG market is characterized by differentiated LPG equipment cylinders, valves and regulators, which are a constraint to competitiveness. The cylinder size differences do not allow the consumer to readily assess the relative unit prices of LPG among the companies for purposes of true price discovery and selection (Matthews and Thomson, 2003). Differentiated valves and regulators constrain the consumers from switching to another supplier, create barrier to entry by other firms in marketing of LPG and use of LPG by households in rural areas where unreliable supply necessitates owning second company equipment.

Matthews and Thomson (2003) reported that the distribution of LPG by mode in Kenya is estimated as 42% bulk and 58% cylinders, the cylinder sales being dominated by 12.5kg to 15kg range and the 6kg to 7kg range which when combined account for 92% of cylinder sales. Sizes of household cylinders vary by company and are as follows: -

Company	*Cylinder size*
Caltex	13 and 7
Kenol/Kobil	12 and 6
Mobil	13 and 6
Shell	15, 13 and 6
Total	12.5, 6 and 3

Source: Matthews and Thomson, 2003.

The majority of the households use the 12kg – 15kg range of cylinders, while low income new entrants use 3kg – 6kg range, which has lower initial costs but higher per kilograme filling costs (PDC, 2005). There are also 22.5kg, 25kg, 40kg, 45kg and 50kg cylinders sizes typically used in commercial/restaurant applications and occasionally by large, high income households. Commercial and institutional consumers are supplied in bulk.

The Ministry of Energy issued new regulations aimed at standardizing LPG cylinders, valves and regulators for households and small scale business industries. Through the Kenya Gazette Supplement No. 60 of 1st September 2006, Legal Notice No. 114, the Ministry of energy unified valves and provided for standard capacities of cylinders to be 1kg, 3kg, 6kg and 13kg and that the cylinders be fitted with unified valves. The regulations are aimed at making LPG more competitive and attractive to new consumers.

1.4.2.3 Prices of LPG and LPG Appliances

One of the factors constraining LPG market growth is the relatively high cost of both the fuel and the end use equipment, and a fully liberalized LPG supply/importation operations (Matthews and Thomson, 2003). A sample of LPG prices in January 2006 for the common 6kg cylinders shows significant LPG price differential by oil marketers.

Oil Marketer	6kg	LPG price/ Kshs./kg
Shell	985	164.2
Mobil	640	106.7
Kobil	720	120.0
Total	750	125.0

In Kenya prices of LPG equipment vary significantly as depicted in the Table 1.6 below:

Table 1.6: LPG Equipments Cost - Cylinders, Regulators and Cooking Appliances

Company	Size	Price (Kshs.)	VAT (Kshs.)	Total Ex VAT (Kshs.)
LPG Cylinders Cost				
Total	3.0	1,855	256	1,599
Kobil	6.0	2,095	289	1806
Mobil	6.0	2,295	317	1,978
Shell	6.0	1,725	238	1,487
Total	6.0	3,995	551	3,444
Caltex	7.0	2,695	372	2,323
Kobil	12.0	2,300	317	1,983
Total	12.5	3,395	468	2,927
Caltex	13.0	3,795	523	3,272
Mobil	13.0	3,600	497	3,103
Shell	13.0	3,400	469	2,931
Agip/Shell	15.0	3,400	469	2,931
Total	22.5	10,045	1,386	8,659
Caltex	25.0	5,495	758	4,737
Total	50.0	12,195	1,682	10,513
Caltex	50.0	8,795	1,213	7,582
LPG Regulator Costs				
Kobil		375	52	323
Mobil		895	123	772
Caltex		995	137	858
Total		1,015	140	875
Calgas		1,995	275	1,720
LPG Cooking Equipment costs – 2 Gas burners & grill				
Ramtons		4,595	634	3,961
Sanyo		6,695	923	5,772
Hitachi		6,975	962	6,013

Source; Petroleum Development Consultants (2005)

Affordability of LPG appliances is critical to influencing demand, given that demand for LPG is dependent upon stock of LPG appliances. According to Matthews and Thomson (2003) the major contributor to the high prices of LPG and LPG equipment was the onerous level of taxes, duties and levies on both the fuel and equipment. In 2003, taxation on fuel amounted to 20% of the final price while the taxation and duties on LPG utilization equipment was 35% import duty plus 18% VAT. Value Added Tax (VAT) on LPG was removed in July 2004. The effect of the VAT waiver was negated by the introduction of the East Africa customs union in January 2005, which led to harmonization of all import duties through the common external tariff, subsequently raising the import duty for LPG in Kenya from Kshs.3.04/Kg to 25%. The impact of the change was reflected in the increase in price for LPG. In June, 2006 the council of Ministers made a request for a waiver of the import duty, leading to East African Community zero rating of import duty for LPG.

The main LPG transportation mode in Kenya is road. Petroleum Development Consultants (2005) estimated that 30,000 tonnes of LPG is transported by road per year while the rail system transports about 12,000 tonnes per year. The cost of transporting LPG from Mombasa to Nairobi by road ranges from US$ 0.110 – 0.135/tonne/km which is higher than the rail cost of US$0.095/tonne/km (PDC, 2005). Road transportation remains predominate despite its higher costs due to the inefficiencies in the rail system. Transporting LPG cylinders is even more expensive as transporters charge up to Kshs. 20/tonne/km (equivalent to US$0.29/tonne/km).

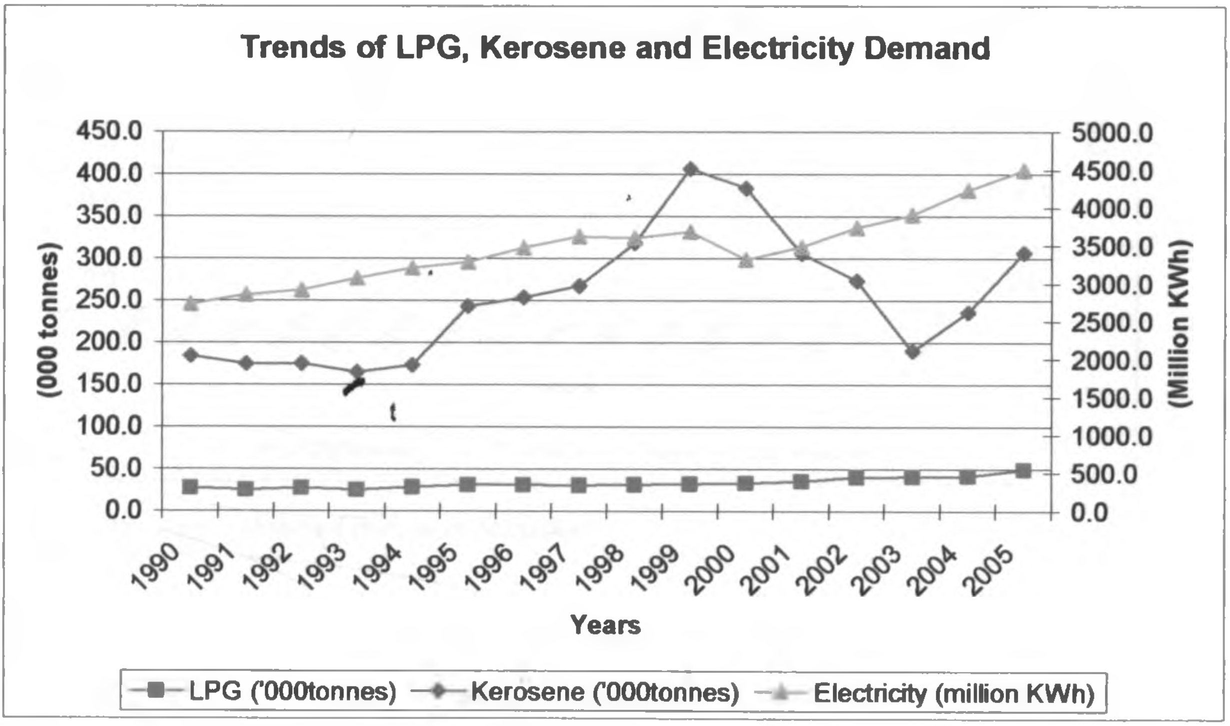
1.4.3 LPG Demand in Kenya

The international LPG industry has grown over the years as new markets have emerged and consumption increased in nearly all regions of the world (Purvin and Gertz, 2000). Utilization of LPG as fuel in residential and commercial sectors has more than doubled in many developing countries, creating investment opportunities in the downstream LPG industry which include LPG storage, handling, distribution and marketing.

In Kenya, LPG remains a 'lesser-used' but desired fuel source in most households. Although the total LPG consumption in Kenya has increased over the years, raising from 37.3 thousand tonnes in 2000 to about 50 thousand tonnes in 2005 the per capita consumption is still low, estimated to be 1.4kg per capita by year 2005, an improvement on the per capita consumption of 1.3kg per capita registered in 2003.

Main substitutes for LPG in households are kerosene, charcoal and electricity. Kerosene is regarded as a 'poor man's' fuel and is used by approximately 92% of all households mainly for lighting. LPG is not widely used with only 7.8% households using it due to various constraints (Kamfor, 2000), yet according to Dzioubinski and Chipman (1999), efficiency of a traditional fuelwood cooking stove is as low as 10-12 percent compared with Liquefied Petroleum Gas (LPG) stove efficiency of more than 40 percent. Figure 1.3 below trends demands of kerosene, LPG and electricity over the period 1990 – 2005.

Figure 1.3: Trends of LPG, Kerosene and Electricity Demand

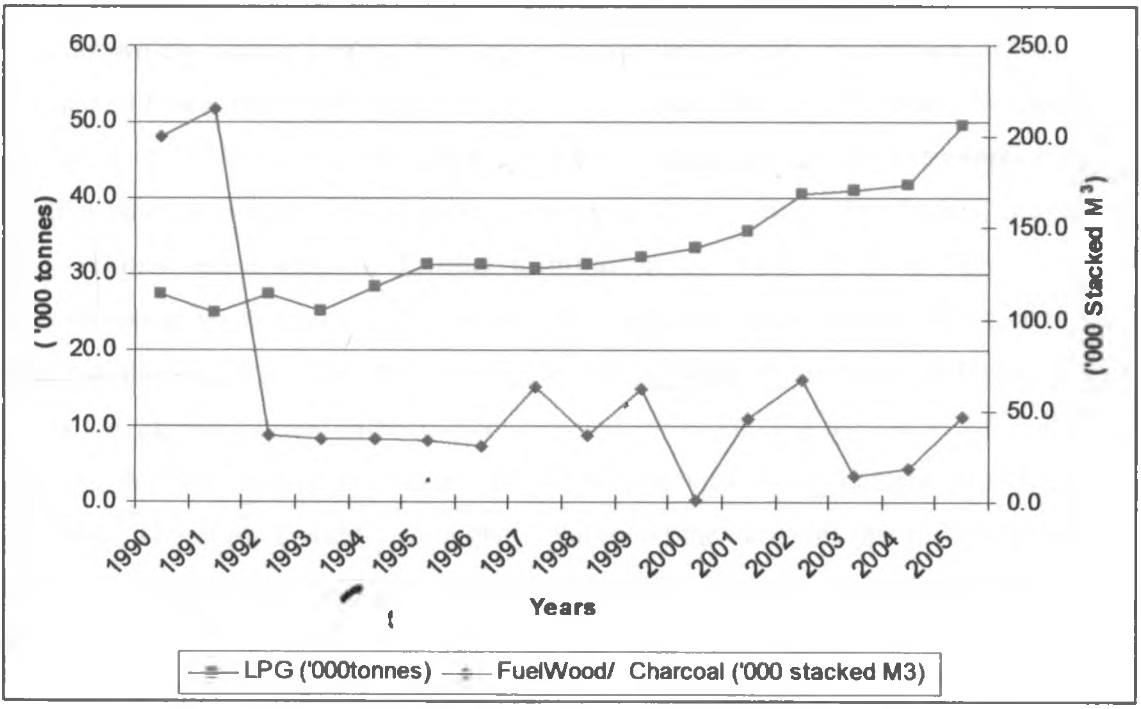


Source data: Kenya National Bureau of Statistics

While demand for electricity increased significantly over the years, demand for LPG has remained relatively low. Perhaps, this suggests existence of factors which have stifled demand for LPG.

It is recognized that fuel wood/charcoal is a major substitute for LPG especially in the rural households and among the urban low income households. Critical comparison of LPG and fuel wood/charcoal demand is however hampered by lack of reliable data. Existing statistics present the sales trend for fuel wood / charcoal as depicted in Figure 1.4 below, which is compared to the LPG demand for the period 1990 – 2005.

Figure 1.4: Trend in Sales of Fuel Wood / Charcoal and LPG Demand



Source data: Kenya National Bureau of Statistics

From the statistics, the sales trend for fuel wood / charcoal present significant yearly changes attributed to changes in government regulations on sale of charcoal. For example between 1991 and 1992 the sale of fuel wood / charcoal dropped by 178,000 stacked M^3 (215,000 stacked M^3 to 37,000 stacked M^3) as a result of a ban imposed on the sale of fuel wood and charcoal.

1.5 Statement of the Problem

Commercial energy is an economic good, capable of improving the living standards of billions of people. The critical problem for less developed economies characterized by high traditional energy consumption is to increase use of commercial energy for poverty reduction and economic growth. In Kenya, most households continue to rely heavily on traditional sources of fuel with its attendant socio-economic and environment problems which include massive deforestation and associated problems such as soil erosion, flooding, siltation of dams, loss of biodiversity.

Despite its clean-burning usefulness, versatility and tax waivers to bring down its price, LPG is not widely used in Kenya. The per capita consumption of LPG demand in Kenya has remained below the sub-Saharan average. In the National Energy Policy (Sessional Paper No. 4 of 2004) (GOK, 2004), the Government acknowledge that consumption of LPG, like other petroleum fuels, has been constrained by among other factors, limited supply facilities and inadequate distribution infrastructure which result in high prices. The Government has hence taken the initiative to encourage investment in LPG facilities throughout the country. For the development of appropriate policies and effective planning for investment and infrastructure required for promoting the use of LPG, it is imperative that the relative importance of the factors influencing demand are clearly understood. This study therefore attempts to determine the variables that influence LPG demand, give a quantitative insight on interaction of the variables, and suggest direction for future policy.

1.6 Research Questions of the study

This study is guided by the following research questions;

i. What economic variables affect LPG demand in Kenya?
ii. What is the impact of each variable on LPG demand in Kenya?
iii. What policy lessons can be derived from the relationship between LPG demand and variables that drive this demand?

1.7 Objectives of the Study

The main objective of this study is to determine the economic variables that influenced demand for LPG in Kenya during the period 1971- 2006. In specific terms, the study will;

1. Specify and estimate LPG demand model in order to determine:
    a) price and income elasticities on LPG demand; and
    b) impact of other economic variables on LPG demand.
2. From findings, suggest policy interventions for enhancing demand for LPG in Kenya.

1.8 Importance of the Study

The low consumption LPG particularly in households has been of concern to the Government. In an endeavour to promote LPG use, the Government has zero rated LPG and instituted regulation framework for LPG cylinders and valves. This action is driven by the assumption that use of LPG is adversely influenced by the price of LPG and LPG equipment. Modelling of LPG demand, and particularly, estimating reliable price and income elasticities of LPG demand will provide further input for appropriate policy and investment decisions making regarding the energy markets.

The need for sustainable energy i.e. production and use of energy in ways that support human development in all social, economic and environmental dimensions, (UNDP 2000) further support the significance of this study. The current energy use in Kenya dominated by use of traditional fuels has resulted in massive deforestation and environmental degradation and is not sustainable. The Government recognizes the socio-economic and environmental problems associated with use of traditional energy and is establishing legal framework and encouraging capital investments geared towards a shift from use of traditional fuels to modern fuels. An in-depth understanding of the behavioural relationship between LPG demand and the macro-economic variables, will ensure institution of appropriate policies that would result in the shift from use of traditional fuels to LPG or other available modern fuels.

Ultimately, the study will add to the existing literature on LPG demand. It is hoped that it will provide further quantitative insights on the LPG demand trends and present additional information for formulation of appropriate policy framework that would guide LPG sub-sector. Appropriate policy framework and investment planning in the LPG sub-sector will eventually encourage consumption in Kenyan households thereby enhance the peoples standards of living.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This Chapter reviews the theoretical and empirical literature on LPG demand. Due to limited literature specific to LPG demand, it is assumed that factors that generally affect energy demand also affect LPG demand.

The Chapter is divided into two parts; the first section discusses the theoretical literature relevant to the study, highlighting the factors suggested by scholars as influencing demand for energy. Only factors considered relevant to LPG demand are considered. The second part reviews empirical literature and presents the general energy demand models developed to explain the behavioural relationship between energy use and the quantifiable determinants of energy demand.

2.2 Theoretical Literature Review

2.2.1 Theoretical Framework

The theoretical framework for demand for energy, like any other good or service is generally determined by its own price, prices of other goods, income, geographical location, demographic and environmental factors. Optimization of demand for energy differs for household consumers and firms. While the objective of the household consumer is to maximize satisfaction at minimum costs, the firm's objective is to maximize output at minimum costs.

Energy demand has been traditionally modelled as a function of economic activity, energy price and temperature. Hunt and Ninomiya (2003) recognized that in addition to the traditional energy demand drivers i.e. prices and incomes, energy demand is determined by technical efficiency and 'tastes' which are non-observable factors. They considered the influence of non-economic factors, i.e. 'tastes' to significantly affect the demand for oil. These non-economic factors include socio-demographic and geographic factors i.e. family size and structure, gender, work status, population age structure, population density, urban and rural changes, physical and telecommuting pattern. Hunt and Nimomiya 2003 argued that changes in 'tastes', holding technical progress and the economic influences such as prices and incomes constant will result in a shift in the demand curve.

2.2.2 *Factors that Determine Energy and LPG Demand*

Prices

Recent studies on LPG in Kenya found that one of the major constraints to market growth is the relatively high cost of both LPG and the end-using equipment i.e. cylinders, valves, regulators and cookers (Matthews and Thomson, 2003). Contributors to these high prices were the onerous level of taxes, duties and levies on both the fuel and the equipment. PDC (2005) explain LPG supply demand constraints as arising due to lack of adequate import and storage facilities leading to importation of uneconomical LPG batches, rail transport bottleneck leading to use of more costly road transport and LPG shortages which force consumers to buy more than one cylinder and regulator as they cannot be assured of supply from any single source. These constraints have led to high LPG prices, high cost of using LPG for users and subsequently constrained LPG demand.

In a competitive market without market regulation, supply constraints cause prices to rise. LPG prices in Kenya have been deregulated since 1994, the supply constraints hence reflect in the higher prices. High prices of energy depress the economy which in turn reduces demand. High price also encourage conservation and shift to alternatives. The impact of high prices on energy consumption is documented by Onjala (1992) where it is explained that increase in price constrain energy consumption, and even in cases where prices of energy do not rise, a fall in real incomes will constrain commercial energy consumption in Kenya.

Income

Anderson (2000) considers income, price, population and energy efficiency as influencing energy demand. He argues that modern energy are not affordable until income rise above a certain threshold. The link between income growth and energy consumption is provided by the estimate of income elasticities. There is a rising trend as per capita income grows from very low levels and then a declining trend at high income levels (Anderson, 2000).

Economic Growth

Energy demand has been linked to economic growth, but the strength of the link varies among regions. The strength of this link is influenced by level of economic development of a country and the standard of living of its people (Onjala, 1992). Advanced economies with high living standards have a relatively high level of energy use per capita which tends to change very slowly. Advanced modern market economies also have a high penetration rate of modern appliances and motorized personal transportation equipment. Consequently, there is more spending on energy-consuming goods that involve replacement of more efficient equipment, resulting in a weaker link between income and energy demand. In the emerging economies, energy demand and economic growth are more closely correlated. While examining the energy-economy interactions, Onjala (1992) documents that there is a concave relationship between GDP and energy consumption in Kenya.

Matthews and Thomson (2003) state that the general drivers of LPG growth in developing countries will be the economic and population growth, but the rate of growth in energy demand in different countries and regions will depend on specific factors influencing the availability and demand for LPG. Such factors include stability of political and legal system, control of prices and margins, initial 'start-up' costs to household consumers, cost of LPG and reliability of supply compared to other fuels.

Capital Investment

Economic literature presents the demand for energy as derived demand. It is argued that demand for energy is derived from the demand for the services provided by that energy source in conjunction with the capital used with that energy source. Hartman and Werth (1981) state that to the residential user, this demand behaviour involves decision to buy or replace fuel-burning equipment capable of providing a particular service, decision on technical and economic characteristics of the equipment purchased i.e. its requisite fuel and whether the equipment embodies new technology and decision on frequency and intensity of use. Purvin and Gertz (2005) links rising LPG use to the development of infrastructure required to effectively distribute and market the products. They state that utilization of LPG as fuel in residential and commercial sectors is rising in developing countries as a result of expansion of access and liberalization.

Population and Urbanization

Sasia (1987) correlates commercial energy demand to population and urbanization and states that commercial energy consumption can rise due to high population and urbanization growth which entail need for more energy for lighting, cooking, and public transport especially in the urban areas. Dzioiubinski and Chipman (1999) present urbanization as an important determinant of both the quantity and type of fuel used in developing countries. They postulate that urbanization leads to higher levels of household energy consumption and a shift from traditional to commercial fuels. They nonetheless recognize that use of traditional fuels in many cities of the developing economies remain high among the low income groups.

Government Policies

Government environmental and fiscal policies are known to influence consumption of various forms of energy. Matthews and Thomson (2003) contributing to LPG demand theories postulates that Government policies and measures influence LPG market development. They argue that active government support in terms of making favourable regulatory and business environment, making LPG more affordable and competitive and liberalization of LPG importation and supply networks can catalyse LPG market take-off and establish a virtuous circle of growing market potential, increased investment and expanded availability.

Summary

Factors that affect energy demand are aptly summarized in UNDP (2000) as; economic structures and activities, income levels and distribution, access to capital, relative prices, market conditions, demographics, geographical, including climatic conditions and distances between major metropolitan centres, technology base including age of existing infrastructure, level of innovation, access to research and development, technical skills, and technology diffusion, natural resource endowment and access to energy resources, lifestyles, settlement patterns, mobility, individual and social preferences and cultural mores.

2.3 Empirical Literature Review

Hunt and Ninomiya (2003) emphasized the importance of accurately specifying the demand functions to ensure that more accurate price and income elasticities of energy demand area obtained, while capturing the underlying changes in energy efficiency and other non-measurable factors. They suggested adoption of a flexible approach so that the Underlying Energy Demand Trend (UEDT) captures the important influences on energy demand (technology and tastes) in addition to conventional variables such as income and price. They further argued that unless energy demand models are formulated to allow for stochastic trends and seasonals, estimates of price and income elasticities could be seriously biased.

Hunt and Ninomiya (2003) used structural time series approach model combined with an Autoregressive Distributed Lag (ARDL) incorporating stochastic trend and seasonals, to estimate energy demand functions, thus allowing for both stochastic trend and stochastic seasonality when estimating the price and income elasticities of aggregate energy demand. The rationale for using Structural time series approach was that cointegration technique used in the past either ignored 'technical progress' or approximated it by a deterministic time trend.

The energy demand function took the form:

$$A(L)e_t = \mu_t + \gamma_t + B(L)y_t + C(L)p_t + \varepsilon_t \quad \text{.......(1)}$$

where *A(L)* was the polynomial lag operator $1 - \o_1 L - \o_2 L^2 - \o_3 L^3 - \o_4 L^4$; *B(L)* the polynomial lag operator $\pi_0 + \pi_1 L + \pi_2 L^2 + \pi_3 L^3 + \pi_4 L^4$; and C(L) the polynomial lag operator $\varphi_0 + \varphi_1 L + \varphi_2 L^2 + \varphi_3 L^3 + \varphi_4 L^4$. e_t was the natural logarithm of energy for the appropriate sector; y_t the natural logarithm of the activity variable of the appropriate sector; and p_t the natural logarithm of the real price of energy for the appropriate sector. *B(L)/A(L)* and *C(L)/A(L)* represented the long run activity and price elasticities respectively and θ represented the effect of a change in temperature on aggregate energy demand. μ_t was the stochastic trend, γ_t was the stochastic seasonal variation and, εt was a random white noise disturbance term.

The trend component μ_t was assumed to take the following stochastic process:

$$\mu_t = \mu_{t-1} + \beta_{t-1} + \eta_t \quad \text{.......(2)}$$

$$\beta_t = \beta_{t-1} + \xi_t \quad \text{.......(3)}$$

where $\eta_t = NID(0, \sigma_\eta^2)$ and $\xi t = NID(0, \sigma_\xi^2)$. Equations (2) and (3) represented the level and the slope of the trend respectively, and depended upon the variances σ_η^2 and σ_ξ^2, known as the *hyperparameters* that governed the shape of the estimated trend model.

The trend component y_t in equation (1) had the following stochastic process:

$$S(L)y_t = \omega_t \quad \text{.......(4)}$$

where $\omega_t = NID(0, \sigma_\omega^2)$ and $S(L) = 1 + L + L^2 + L^3$.

Hunt and Ninomiya (2003) assumed the disturbance terms to be independent and mutually uncorrelated with each other. In the model, the hypeparameters σ_η^2, σ_ξ^2 and σ_ω^2 governed the basic properties of the model and were, together with other parameters of the model, estimated using maximum likelihood. The optimal estimates of β_t, μ_t y_t were estimated by the Kalman filter which represented the estimates of the level and slope of the trend and seasonal components.

Using the above model, Hunt and Ninomiya (2003) estimated the income and price elasticities of demand for transportation oil demand in the UK and Japan. The results of the study indicated that the models fitted the data well for both countries and specifications passed all diagnostic tests with no indication of mis-specification. In addition, the results were little affected by changes in the hypeparameter values suggesting the estimated elasticities to be robust, while the trends and seasonal dummies exhibited stochastic patterns. In their conclusion, Hunt and Ninomiya (2003) noted that the evidence presented showed that, even when the data for energy efficiency, tastes and other variables are unavailable or inappropriate, the structural time series model would still be able to accommodate the effect of these factors on oil demand with the estimated UEDT acting as an approximation.

Ninomiya (2002) further used structural time series model while presenting an analysis of past trend in energy demand in Japan for the period 1887 – 1999. He was particularly concerned with the effect of autonomous improvement of energy efficiency whose effect had been ignored or at best approximated by a liner time trend. Ninomiya (2002) econometric energy demand model was of the form:

$$e = \alpha y + \beta p + \delta Temp + \mu + u \quad \text{...(5)}$$

where e was the energy demand in log; y was the real GDP in log; p was the real energy price in log and *Temp* was the air temperature. α was the income effect (+) income elasticity; β was the price effect (-) price elasticity; δ was the temperature effect (-); μ was the technical progress (+ or - unknown) and u was the residuals.

Ninomiya (2002) argued that the estimation of μ as well as income and price elasticities would provide valuable information on how to reduce energy demand under environmental constraints. The autonomous improvement of energy efficiency was important since it was the only one parameter to determine whether energy demand can be reduced autonomously when GDP growth was necessary and energy price could not be increased via tax due to social constraints. The estimated results indicated that during the late 1970 and the 1980s energy demand in Japan was autonomously reduced through the effect of autonomous improvement of energy efficiency by 1.4% per annum. Implying that had the autonomous improvement of energy efficiency not existed energy demand would have increased.

Benard, Denis, Khalaf and Yelou (2005) attempted to develop a dynamic demand model that encompasses the choice of the energy using equipment and the associated energy use over time. They argued that such a model should provide information on the utilization of the set of energy using equipment and their rate of turnover over time. The variables that were assumed to influence the behaviour of utility maximizing agents were the prices of energy source and their expected evolution, the prices of energy using equipment, the level of economic activity, weather and a set of socio-economic variables pertaining to users.

Benard, Denis, Khalaf and Yelou (2005) used a total energy model derived from partial adjustment framework :

$$\ln X_t = \mu_t + a_1 \ln X_{t-1} + a_2 \ln P_t + a_3 \ln Y_t + a_4 \ln HDD_t - a_1 a_4 \ln HDD_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots \quad (6)$$

where X_t = total energy demand, P_t = real price of energy, Y_t = real income, HDD_t = heating degree days, μ_t = random trend, ε_t = random error term and $a_1,\ldots,a_4$ were structural parameters of interest. They used Hunt, Judge and Ninomiya (2003) random trend (equations 2 and 3).

The log linear model with a lag dependent variable was used to take into account the fact that the stock of energy using equipment adjust slowly over time in response to various factors including energy prices. Applying the model on annual data on the residential, commercial and industrial sectors of the province of Quebec from 1962 to 2002, Benard, Denis, Khalaf and Yelou (2005) concluded that in aggregate energy demand studies at the national and sectoral level, the dependence of energy use on the available stock of energy using equipment would be taken into account implicitly through lag effects that are assumed constant over time.

A number of econometric analyses of energy demand have been undertaken for the Kenyan economy. Senga, House and Manundu (1980) estimated the demand for energy in Kenya with particular interest in measurement of response of energy demand to change in GDP (or incomes of households and firms) and prices of energy in its various components. There model was as follows:

$$D_t = AY_t aP_t be_t \ldots\ldots(7)$$

where D_t = the consumption of energy measured in appropriate units, depending on the energy component under consideration ,in year t; Y_t = the GDP in year t measured in 1964 prices; P_t = prices of energy product under consideration in year t measured at 1964 prices; e_t was the error term which captured all other influences on Dt which were not included in the equation ; a was the short run elasticity of demand for energy with respect to GNP; and b was the short run elasticity of demand for energy with respect to the price of energy.

Using data spanning the period 1950 to 1977, Senga et al (1980) found that motor spirit and diesel fuel, the GDP and price elasticities were highly significant. The results of the estimation by Sasia (1987) however showed that the price factor was negative but not significant in the demand for gasoline and light diesel, while income was a significant factor, hence growth in consumption of the two fuels was largely influenced by growth in income. Sasia (1987) estimating equations allowed for short-run and long-run adjustment and incorporated lagged consumption, based on the hypothesis that consumers adjust actual consumption towards some desired level. The estimating equation for gasoline used price and income variables, which were considered to capture most of the aspects of gasoline demand. The gasoline estimation equation took the form:

$$\ln G_t = \theta \ln \beta_0 + \theta\beta_1 \ln P_{gt} + \theta\beta_2 \ln Y_t + (1-\theta)\ln G_{t-1} + X_{it} \ldots\ldots(8)$$

where G_t was the demand for gasoline, P_{gt} was the price of gasoline, Y_t the income and $\theta\beta_1$ and $\theta\beta_2$ were the short run price and income elasticities respectively.

While the demand function for light diesel was the same as that for gasoline and was expressed as:

$$\ln LD_t = \lambda \ln \alpha_0 + \lambda\alpha_1 \ln P_{dt} + \lambda\alpha_2 \ln(Pd/P_g)_t + \lambda\alpha_3 \ln Y_t + (1-\lambda)\ln LD_{t-1} \ldots\ldots(9)$$

where LD was the consumption levels of light diesel, P_{dt} was the price of light diesel, Y_t was GDP, Pd/P_g was relative price of light diesel to gasoline and $\lambda\alpha_1$ and $\lambda\alpha_2$ were the short run price and income elasticities respectively.

Based on time series data for the period 1964 – 1986, Sasia (1987) regression results for gasoline showed that income, lagged consumption and dummy variable which captured the impact of oil crisis on gasoline affected the demand for gasoline positively, while its own price affected the consumption negatively. While income and lagged consumption were found to be statistically significant at 0.05 level of significance, price and dummy variable (impact of oil crisis on gasoline consumption) were statistically insignificant at 0.05 level of significance. Oil price shocks experienced in the 1973 and 1979 which resulted in drastic hike in oil price appeared to have had no significant impact on the consumption of gasoline. In the case of light diesel, the results showed that all variables expect for price were statistically significant determinants of light diesel at 0.05% level of significance. The relative price of light diesel to gasoline was also statistically significant, suggesting substitution between the two fuels.

Recognizing that the structure of energy demand varies across sectors and across fuels, Kimuyu (1988) used fuel-wise demand models on the assumption that in the cases where fuels are sector specific, the analysis at the fuel level leads to estimates that approximate sectoral fuel demand responses as well. Kimuyu (1988) developed individual fuel demand models at two levels. The first level involved construction of basic fuel demand models for eliciting behavioural responses in terms of basic variables other than those representing either the structure of the economy, efficiency and conservations. Assuming the desired demand for fuel i was given by:

$$E_{it}^* = f(X_{it}, Y_t, Z_{jt}) \quad \text{...(10)}$$

where E_{it}^* was pear unit desired demand for fuel i at time t; X_{it} was the price of fuel i; Y_t was per unit income; and Z_{jt} was the price of a related fuel.

The multiplicative form of the general fuel demand function represented in equation 10 was outlined as:

$$E_{it}^* = b_0 * X_{it}^{b1} * Y_t^{b2} * Z_{jt}^{b3} * e^{\alpha} it \quad \text{...(11)}$$

where b_0 * was the usual constant, bi^*, i = 1, 2, 3 were long-run price, income and cross elasticities of demand for fuel i, and $e^{\alpha} it$ was the error term with the usual stochastic assumptions.

The process of adjustment towards the desired level of demand for fuel i following a change in the conditions of demand was summarized by:

$$E_{it} / E_{it-1} = (E_{it} * / E_{it-1})^k \text{..}(12)$$

where k was the coefficient of adjustment and $1\text{-}k$ was the proportion of adjustment derived in the first period. Combining equations 11 and 12 taking natural logarithms, the following equation 13 was derived which could be estimated since all its variables were observable:

$$LnE_{it} = b_0 + b_1 LnX_{it} + b_2 LnY_t + b_3 LnZ_{it} + b_4 LnE_{it-1} + U_{it} \text{..}(13)$$

In the second level of the model, Kimuyu (1988) used two secondary models, one for capturing the impact of changes in the structure of the economy on demand for fuels and the other for tracing any changes in efficiency of and conservation in energy use. The impact of economic-structure variables was separated from the other structural variables in order to assess the impact of alternative sectoral growth strategies as well as relate energy demand to planned structural changes. The secondary log-linear demand functions in economic-structure variables for each fuel took the form:

$$LnE_{it}' = h_0 = h_1 LnUP_t + h_2 LnA_t + h_3 LnM_t + h_4 LnT_t + h_5 LnS_t + u_t' \text{..........................}(14)$$

where E_{it}' was demand for fuel i; A_t, M_t, T_t and S_t were shares of GDP accruing from agriculture, manufacturing and repair, transport, storage, refrigeration and communication and the service sector; UP_t was urban population represented by the proportion of people living in Nairobi; h_0 was the usual constant; h_i, $i = 1,, 2, \ldots 5$ were elasticities; and u_t' was an error term with the usual stochastic assumptions.

The secondary log-linear fuel demand models in fuel prices, incomes and lagged consumption of the fuel in question to the form:

$$E_{it}'' = a_0 + a_1 LnX_{it} + a_2 LnY_t + a_3 LnE_{it-1}'' + u_{it} \text{..}(15)$$

where a_0 was constant; a_i, $i = 1, 2, 3$ were structural coefficients; u_{it}'' was the error term; and all the other variables were as defined earlier.

Kimuyu (1988) OLS estimation results revealed that demand for fuels in Kenya was price inelastic in the short run, which implied that either fuel use in the country was a matter of necessity or that inter-fuel substitution possibilities was limited in the short run or both. The estimated long-run price elasticities of demand were larger than the short run elasticities since economic units were better able to exercise their discretion in fuel and equipment choice in the long-run. The results also showed positive short-run income elasticities of demand for all fuels except jet fuel and illuminating kerosene. Kerosene hence appeared as an inferior fuel.

The long-run demand for fuels was found to be income-elastic, with elasticities larger than the short-run elasticities.

CHAPTER THREE: METHODOLOGY

3.1 Introduction

This chapter presents the methodological approach employed to analyze the demand of LPG in Kenya. Analytical framework for the study is first outlined followed by the specification of the empirical model. The variables used in the study are explained, including sources of data and diagnostic tests to be employed on the data.

3.2 Analytical Framework

This study adopted a simple static analytical model. An individual is assumed to use a given level of LPG expenditure (L) and other non LPG expenditure (K) to maximize his utility (U). In his maximization problem the individual has scarce resources available to him. This can be formalized in equation below;

Maximize utility $U = f(L, K)$ ....(16)

Subject to budget constrain $Y = lL + kK$ ....(17)

where l is the price LPG (L), k is the price of other commodities (K) and Y is total individual income. Combining and solving equations 16 and 17 through langrage multiplier method we get the demand for LPG.

Adopting Kimuyu (1988) model we assume demand for LPG (L) is given by:

$L_{it} = f(X_{it}, Y_t, Z_{jt})$ ....(18)

where L_{it} is per unit desired demand for LPG i at time t; X_{it} is the price of LPG i; Y_t is per unit income; and Z_{jt} is the price of a related fuel. The multiplicative form of the general LPG demand function is presented as:

$L_{it} = b_0 * X_{it}^{b1} * Y_t^{b2} * Z_{jt}^{b3} * e_{it}$ ....(19)

where b_0 is the usual constant, b_i (i = 1, 2, 3) are long-run price, income and cross elasticities of demand for LPG and eit is the error term with the usual stochastic assumptions. The process of adjustment towards the desired level of demand for LPG following a change in the conditions of demand is summarized by:

$L_{it} / L_{it-1} = (L_{it} * / L_{it-1})^k$ ....(20)

Where k is the coefficient of adjustment and $1\text{-}k$ is the proportion of adjustment derived in the first period. Combining equations 19 and 20 taking natural logarithms, the following equation 21 is derived which lends itself to estimation since all its variables are observable:

$$LnL_{it} = b_0 + b_1 LnX_{it} + b_2 LnY_t + b_3 LnZ_{it} + b_4 LnE_{it-1} + U_{it} \ldots\ldots(21)$$

3.3 Empirical Model

This study adopted a reduced-form specification (21) as derived by Kimuyu (1988). However since the aim was to analysis factors that influence the demand for LPG in Kenya more variables are introduced into it. Therefore, to achieve the desired objectives the study estimated the model specified below (equation 22);

$$LnL = b_0 + b_1 LnPL + b_2 LnPK + b_3 LnPE + b_4 LnPC + b_5 UB + b_6 DR + b_7 INF + b_8 PKY + b_9 L_{t-1} + \eta \ldots\ldots(22)$$

where;

L	=LPG demand measured in tonnes
PL	=Price of LPG measure in Kshs
PK	=Price of Kerosene measured in Kshs
PE	=Average tariff of electricity measured in Kshs/KWh
PC	=Crude oil price measured in Kshs/MT
UB	=Urban population
DR	=Domestic revenue (Kshs)
INF	=Inflation as percentage
PKY	= Income per Capita
η	=error term

3.4 Definition and measurement of variables

LPG demand measured in tonnes

This is the dependent variable. It is the annual demand for LPG measured in kilograms.

Price of LPG measure in Kshs

This is the retail price of LPG. It is preferred because it reflects the sacrifice, in monetary terms, the consumers are willingly to forgo in order to acquire a unit of LPG. This variable is expected to be negatively related with LPG demand.

Price of Kerosene measured in Kshs

This is the retail price of a litre of Kerosene measured in Kshs. LPG and kerosene are substitutes. Therefore, the price of kerosene is most likely to influence the demand of LPG. This variable is expected to be positively related with LPG demand.

Average tariff of electricity measured in Kshs/KWh

This is the average tariff of electricity measured in Kshs/Kwh. Average tariff between the commercial and domestic electricity use is calculated. Electricity is a close substitute of LPG and its price is likely to influence the demand of LPG. This variable is expected to be positively related with LPG demand.

Crude oil price measured in Kshs/MT

LPG is extracted from crude oil hence the international price of crude oil price is likely to be a major component of LPG production cost affecting its supply. Indirectly, this is likely to influence the demand of LPG. Crude oil price measured in Kshs/MT. This variable is expected to be negatively related with LPG demand.

Urban population

Population drives the demand for LPG. LPG is mostly consumed in urban areas than in rural areas hence the preference of urban population. Urban population is also a measure of urbanization, increase of which is likely to increase the demand of LPG. This variable is expected to be positively related with LPG demand.

Per capita GDP

Per capital GDP measures the purchasing power of the population/LPG consumers. This variable is used as a measure of economic growth and development. It is an appropriate measure since figures on remittances from abroad and depreciation which enables the derivation of Net National Product (NNP) are not easily available and when they exists, they are broad estimates which affect the accuracy of results. This study therefore will use the GDP at factor cost. The GDP figures at the factor cost are better measures of growth than those at market price since they do not contain distortions caused by changes in prices. A positive relationship is expected between this variable and LPG demand. As an income variable, higher per capita GDP should raise LPG demand.

Domestic revenue

This is total revenue collected within the domestic economy. The total amount collected determines the budget allocations to various sectors especially the infrastructure which will determine LPG availability. The higher the collection of the domestic revenues the higher the infrastructure allocation will be hence LPG availability implying its high demand. This variable is measured in total amount of shillings collected by revenue authorities in a given year.

Inflation as percentage

This is a sustained increase in general price level. This variable is included to measure the macroeconomic instability in the economy. If the economy experience macroeconomic instability, then the country revenue and per capita income might reduce, affecting negatively the demand of LPG. Inflation is captured using the consumer price index.

3.5 Estimation techniques

The model in equation (22) was estimated using Ordinary Least Squares (OLS) estimation method. A specification associated with Error Correction Modeling (ECM) was be applied to capture long-run equilibrium after the variables were differenced to make them stationary. By using cointegration and error correction model, the study established both the short run and long run equilibrium. The appropriate tests for stationarity of all the variables were be performed to avoid spurious regression results. Where the variables were not stationary at levels, they were differenced to achieve their stationarity. Cointegration test for series with higher order of integration was performed using Augmented Dickey Fuller (ADF) test to the residuals of the statistic cointegration (long-run) regression. The following are tests performed on the model in equation 22;

3.5.1 Unit root tests

Unit root tests are used to test whether data is stationary. Economic time series data may exhibit a trend or unit root(s) over time. A stationary stochastic process implies that the underlying stochastic process that generated the series is invariant with time. The results that come from an econometric analysis when using non-stationary series are ambiguous. Granger and Newbold (1974) ascertained that non-stationary time series produce "spurious regression" results where results may suggest statistically significant relationships when in reality there are no meaningful relationships between the variables.

In the presence of unit roots, one may de-trend the series or difference the data to remove the non-stationary trend in it. However, this may lead to a loss of some vital long-run information contained in the data or it may only partially solve the problem. This shortfall is addressed through differencing which was proposed by Dickey and Fuller (1979). This is known as the Augmented Dickey-Fuller (ADF) test. It tests for the existence of systematic and linear relationships between past and present values of variables. The ADF is applied to regressions run in the following form:

$$\Delta Y_t = \beta_1 + \beta_2 T + \delta Y_{t-1} + \sum_{i=1}^{m} \Delta Y_{t-i} + \varepsilon_t \qquad \text{(ADF regression)}$$

Where T is the time trend variable and ε_t is the error term which is independently and identically distributed. In each equation, the null hypothesis is that $\delta = 0$, that is, there exists a unit root in Y_t. The acceptance of the null hypothesis confirms the presence of unit root. This study adopted the last equation above considering that it takes into account both the stochastic trend and constant rather than just assuming that stationary trend existed. Furthermore, since the data generating process for the model was unknown, the use of this equation ensured that the deterministic components present were taken care of as much as possible.

3.5.2 Cointegration analysis and error correction modeling

According to Engle and Granger (1987), a linear combination of two or more non-stationary series may yield a stationary series. If such a linear combination exists, then the non-stationary series are said to be cointegrated. This means that the non-stationary series move closely together over time, and the difference between them is stable. The resultant linear combination is called a cointegrating equation, and it may be interpreted as a long-run relationship between the variables. It is likely that there exists a long run relationship between LPG used and other variables that influence this consumption in Kenya.

Following the work of Engle and Granger (1987) the cointegrating regression was specified as follows;

$$x_t = \alpha_0 + \alpha_1 z_t + \varepsilon_t$$

Where x was the dependent variable, z were all independent variables, all having the same order of integration and the residual of the equation $\varepsilon_t = (x_t - \alpha_0 - \alpha_1 z_t)$ was simply the 1(1) series. If the residuals from the linear combination of nonstationary series were themselves stationary, then it was accepted that the 1(1) series was cointegrated and the residuals taken from the cointegrating regression as valid and were then built into an Error Correction Model (ECM). An ECM was the restricted autoregression that had cointegration restrictions built into the specification, so that it could be used for cointegrating non-stationary time series at levels. It restricted the long-run behaviour of the endogenous variables to converge to their cointegrating relationships, at the same time allowing for short-run dynamics. The cointegrating term showed the speed with which short-term deviations were corrected gradually towards the long-run equilibrium. This study applied the Augmented Dickey Fuller (ADF) test to the residuals of the statistic cointegration (long-run) regression rather than the levels of the series since it was believed that variables differenced to achieve their stationarity loose their long-run relationship.

3.5.3 Diagnostic tests

Diagnostic tests are typically used as a means of indicating model inadequacy or failure. For example, in the case of a linear regression model which is estimated by OLS, a series of diagnostic tests could be used to indicate whether any of the assumptions required for OLS to be the best linear unbiased estimator (BLUE) appear to be violated. These assumptions include a serially uncorrelated and homoscedastic error term, absence of correlation between the error term and the regressors and correct specification of the model. Diagnostic testing played an important role in the model evaluation stage of this study. This study carried out various diagnostic tests including serial correlation test for autocorrelation residuals, the White test for Heteroscedastic errors, normality test for the distribution of the residuals and the Ramsey Reset test for the regression specification.

3.6 Data type and source

Time series data used in the analysis for the period 1980-2005 was secondary data sourced from the Central Bureau of Statistics, Ministry of Energy and any other organization or study where such data was generated. The data the form is outlined in Annex I.

3.7 Data analysis

The raw data was collected, cleaned, refined and converted into the required form as discussed in part 3.4 of this Chapter. Before embarking on data analysis, descriptive statistics (such as maximum, minimum, mean, standard deviations, kurtosis, skewness and Jarque-bera statistics) of all the variables were obtained. This was followed by a linear regression in order to establish the relationship between the dependent variable and independent variables. The data was analyzed using the E-Views econometric software.

CHAPTER FOUR: DATA ANALYSIS AND DISCUSSION OF RESULTS

4.0 Introduction

This Chapter presents analysis of the empirical results of the study. The Chapter commences with the descriptive statistics, which gives the normality tests of the series among other statistics. Regression results which include unit root tests, model estimations and diagnostic tests respectively are presented at the end of the Chapter.

4.1 Descriptive statistics

Before embarking on the details of empirical issues, data was examined to determine whether it exhibits normality. Most economic data are usually skewed (non-normal), possibly due to the fact that economic data has a clear floor but no definite ceiling or due to the presence of outliers. The Jarque-bera statistics test is used to test normality of the series. It utilizes the mean based coefficients of skewness and kurtosis to check normality of variables used. Skewness is the tilt in the distribution and should be within the -2 and +2 range for normally distributed series. Kurtosis put simply is the peakedness of a distribution and should be within -3 and +3 range when data is normally distributed. Normality test uses the null hypothesis of normality against the alternative hypothesis of non-normality. If the probability value is less than Jarque-Bera chi-square at the 5% level of significance, the null hypothesis is not rejected. Table 4.1 gives the summary of the descriptive statistics of the data used in this study. The normality test showed that Liquefied Petroleum Gas (LPG), price of crude oil, electricity tariff and urban population were normally distributed while per capita GDP, price of LPG, domestic revenue, price of kerosene and inflation were not normally distributed. The descriptive statistics among others guided on which of the equations was able to yield better results and highlight on possible problems that would be encountered. However, there was need to supplement the statistics with more incisive quantitative analysis such as the correlation matrix.

Table 4.1: Summary of Descriptive Statistics

	L	PC	PE	PL	UB	PKY	INF	DR	PK
Mean	26.031	2,680.568	6.162	19,691.640	3.938	3,168.917	12.614	77,763.7	12.570
Median	25.050	2,235.897	5.555	6,400.000	3.834	3,346.000	11.000	37,539.5	4.320
Maximum	49.400	4,726.215	13.020	57,018.000	6.860	3,812.000	46.000	304,826	51.180
Minimum	14.800	468.377	0.640	2,413.000	1.350	1,930.000	1.600	2,601.00	1.670
Std. Dev.	8.307	1,300.002	2.548	20,156.170	1.716	586.478	8.310	80,724.0	13.506
Skewness	0.883	0.015	0.486	0.909	-0.014	-1.194	2.078	0.888	1.233
Kurtosis	3.294	1.679	3.267	2.140	1.896	3.043	8.714	2.746	3.433
Jarque-Bera	4.811	2.545	1.526	6.063	1.778	8.561	74.883	4.828	9.402
Probability	0.090	0.280	0.466	0.048**	0.411	0.014**	0.000*	0.089**	0.009*
Observations	36	35	36	36	35	36	36	36	36

*Note: **Reject hypothesis of normality at 5% level*
**Reject hypothesis of normality at 1% level*

The correlation matrix is an important indicator that tests the linear relationship, between the explanatory variables. The matrix also helps to determine the strength of the variables in the model, that is, which variable best explains the relationship between the demand of Liquefied Petroleum Gas (LPG), and its determinants. This is important and helps in deciding which variable(s) to drop from the equation. Table 4.2 presents the correlation matrix of the variables in levels.

Table 4.2: Correlation Matrix at Levels

	L	PC	PE	PL	UB	PKY	INF	DR	PK
L	1.0000								
PC	0.0765	1.0000							
PE	0.7937	-0.1445	1.0000						
PL	0.9035	-0.2183	0.8602	1.0000					
UB	0.9457	0.1291	0.8235	0.8873	1.0000				
PKY	0.4718	0.4784	0.4137	0.4018	0.7129	1.0000			
INF	-0.472	0.2947	-0.0335	-0.1876	-0.0004	0.1204	1.0000		
DR	0.9445	-0.1611	0.8302	0.9544	0.9102	0.4716	-0.1349	1.0000	
PK	0.9447	-0.1410	0.8515	0.9661	0.8829	0.3657	-0.1843	0.9658	1.0000

The table above shows that there was positive correlation between Liquefied Petroleum Gas (LPG) and its determinants: price of crude oil, electricity tariff, urban population, per capita GDP, price of LPG, domestic revenue and price of kerosene. Only inflation had negative correlation with Liquefied Petroleum Gas. While the correlation between Liquefied Petroleum Gas (LPG) and price of crude oil, per capita GDP and inflation was low (below 0.5), all the other variables were highly correlated with Liquefied Petroleum Gas (LPG).

4.2 Time series properties

Non-stationarity of time series data has often been regarded as a problem in empirical analysis. Working with non-stationary variables leads to spurious regression results from which further inference is meaningless. The first step was therefore to test for stationarity of the variables. Augmented Dickey-Fuller (ADF) tests were used to test for stationary of the series. The results of the test for all the series are presented in the Table 4.3.

Table 4.3 Unit Root Tests

VARIABLE	ADF (2)	CRITICAL VALUE 1%	CRITICAL VALUE 5%	ORDER OF INTEGRATION
LPG	-6.430	-3.653	-2.957	1(1)
Price of LPG	-6.616	-3.653	-2.957	1(1)
Price of kerosene	-4.973	-3.657	-2.959	1(2)
Price of crude oil	-4.413	-3.642	-2.952	1(1)
Domestic revenue	-4.128	-3.642	-2.952	1(2)
Inflation	-3.674	-3.635	-2.949	1(1)
Per capita income	-5.900	-3.642	-2.952	1(1)
urban population	-4.357	-3.649	-2.955	1(1)
Electricity tariff	-4.424	-3.649	-2.955	1(1)

The tests showed that all variables were stationary after first differencing except price of kerosene and domestic revenue which were differenced twice to attain stationarity. The next step after finding out the order of integration was to establish whether the non-stationary variables at levels were cointegrated.

Differencing of variables to achieve stationarity leads to loss of long-run properties. The concept of cointegration implies that if there is a long-run relationship between two or more non-stationary variables, deviations from this long run path are stationary. To establish this, the Engel-Granger two step procedure was used. This was done by generating residuals from the long-run equation of the non-stationary variables, which were then tested using the ADF test. The results of cointegrating regression are given below in Table in 4.4.

Table 4.4: Cointegrating Regression, Reporting the Long Run Relationship

Dependent Variable: Demand of LPG
Method: Least Squares

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	7.738*	2.157	3.587	0.0014
Price of LPG	-0.698	0.121	-0.698	0.4913
Price of kerosene	-0.116	0.149	-0.781	0.4419
Electricity tariff	0.091	0.191	0.476	0.6378
Price of crude oil	0.0001	0.00026	0.547	0.5891
Per capita GDP	0.002**	0.00074	2.7001	0.0123
Urban population	2.242*	0.697	3.213	0.0036
Inflation	-0.133*	0.031	-4.325	0.0002
Demand of LPG_{t-1}	0.680*	0.126	5.361	0.0000
Domestic revenue	0.619*	0.164	3.776	0.0009
R-squared	0.8665	Mean dependent var		26.1600
Adjstd R-squared	0.8408	S.D. dependent var		8.39163
Log likelihood	-50.629	F-statistic		177.031*
D-Watson stat	2.092	Prob(F-statistic)		0.0000

*Note: * significance at 1%*
*** significance at 5%*

The long-run relationship for demand for LPG was thus:

L = 7.738 + 0.0001*PC + 0.091*PE – 0.0698*PL + 2.242*UB - 0.002*PKY - 0.133*INF + 0.680LT + 0.619DR - 0.116*PK

The error term was ECT and was derived from the above cointegrating regression and expressed as:

ECT= L - 7.738 - 0.0001*PC - 0.091*PE + 0.0698*PL - 2.242*UB + 0.002*PKY + 0.133*INF - 0.680LT - 0.619DR + 0.116*PK

The Table 4.5 below reports the stationarity test for the residuals of the co-integrating regression.

Table 4.5: Unit Root Test of the Error Correction Term

ADF Test Statistic	-7.8956	1% Critical Value	-2.632
		5% Critical Value	-1.951

The residuals were found to be stationary at 1% and 5% levels of significance for both tests. The residuals became the error correction term and consequently, an error correction formulation was adopted.

4.3 Error Correction Modeling

After accepting cointegration, the next step was to re-specify equation (22) to include the error correction term (ECM), which captures the long-run relationship. It reflects attempts to correct deviations from the long run equilibrium and its coefficient can be interpreted as the speed of adjustment or the amount of disequilibrium transmitted each period to LPG demand. The results of the error correction model are presented in Table 4.6 below:

Table 4.6: Error Correction Model Reporting the Short Run Relationship

Dependent Variable: Demand of LPG
Method: Least Squares

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	5.586**	2.474	2.257	0.033
Price of crude oil	0.041	0.125	0.329	0.744
Electricity tariff	0.1569	0.188	0.831	0.414
Price of LPG	-0.982	0.502	-1.957	0.348
Urban population	1.635**	0.751	2.176	0.040
Per capita GDP	0.0017**	0.0007	2.422	0.023
Inflation	-0.1183*	0.0312	-3.791	0.000
Demand of LPG_{t-1}	0.823*	0.143	5.749	0.000
Error correction term(-1)	-0.832*	0.224	-1.929	0.006
Domestic revenue	0.606*	0.158	3.837880	0.000
Price of kerosene	-0.103	0.144735	-0.715789	0.481
R-squared	0.7860	Mean dependent var		26.494
Adjstd R-squared	0.7699	S.D. dependent var		8.2781
Log likelihood	-47.003	F-statistic		162.255*
Durb-Watson stat	1.9278	Prob(F-statistic)		0.000000

Note: * significance at 1%
** significance at 5%

Model tests

ARCH F = 0.020 [0.8880]
RESET F = 1.36568 [0.25315]
Normality χ^2 = 1.008 [0.6038]

AR-2 F = 0.176 [0.8397]
WHITE TEST F = 1.282 [0.3279]
CUSUM 5% LEVEL Stable

Before embarking on the discussion of the regression results, the error correction model was subjected to a number of diagnostic tests in order to evaluate its validity. The diagnostic test outcomes were satisfactory. These were: the LM-autocorrelation, which supplement the DW-statistics, the ARCH (Autoregressive conditional heteroscedasticity) which detects the problem of heteroscedasticity, the Jaque-bera test for normality of the residuals and the RESET test for specification of the regression. In addition to the above tests, CUSUM test was done. The results obtained revealed that the parameters were stable and the model could be used for forecasting at the 5% level. Apart from Jaque-Berra normality test, which was distributed as chi-square statistics, the rest of the diagnostic tests utilized the F-statistics distribution. A summary of these tests are included below Table 4.6 above.

4.4 Discussion of the results

All the variables considered in the determination of demand of LPG in Kenya were as hypothesized. Table 4.4 and 4.6 summarizes the results of the impacts of the main regression variables based on equation 22 which was specified as the "best" model on the grounds of both theory and goodness of fit. In particular, they reported the partial elasticities for the variables, as well as the partial effects. It is apparent that all these variables exhibit inelastic elasticity except urban population, domestic revenue, previous LPG demand and price of LPG. The results further confirm the above observation based on the partial effects that urban population, domestic revenue, previous LPG demand and price of LPG exhibit considerable impacts on the current demand of LPG.

In addition, on the basis of R_2 and SEE, the estimated equation displayed better fit. Thus, on both theoretical and econometric grounds, the equation was well specified. These results are attributable to the rationale that most of the variables: price of crude oil, electricity tariff, urban population, per capita GDP, price of LPG, domestic revenue, price of kerosene and inflation are exogenous and explain demand of LPG.

Both in the short and long run the coefficients of urban population, domestic revenue, per capita GDP, LPD previous demand and inflation had the correct sign and were significant while crude oil, LPG price, kerosene price and electricity tariff coefficients had correct sign though insignificant (see Tables 4.4 and 4.6). Of interest was the coefficient of the error correction term which was observed to be negative and statistically significant.

From Table 4.6, a partial effect of 1.635 was obtained for urban population. Hence, a one percentage-point increase in the urban population would, on average, translate to a 1.635 percentage point increase in the demand of LPG, ceteris paribus. The results showed that there was positive relationship between demand of LPG and urban population. This agrees with earlier results of Dzioiubinski and Chipman (1999) that present urbanization as an important determinant of both the quantity and type of fuel used in developing countries. The results also support Sasia (1987) work that correlated commercial energy demand to population and urbanization and stated that commercial energy consumption can rise due to high population and urbanization growth which entail need for more energy for lighting, cooking, and public transport especially in the urban areas.

There was a positive effect of per capita GDP on demand of LPG. A 1% rise in per capita income leads to 0.0017% rise in the LPG demand (see Table 4.6). This was expected. An increase in real per capita income/GDP increases the purchasing power and hence aggregate demand in the economy, including LPG demand. The results agree with postulation by Anderson (2000) that income, price, population and energy efficiency as influencing energy demand.

In the both models proxy for the macroeconomic instability: inflation had the correct sign and was statistically significant at the 1% level (see Table 4.4 and 4.6). A 1% rise in inflation leads to 0.1183% fall in demand of LPG (see Table 4.6). With inflation, there is capital flight, reduced direct foreign investment and overall reduced investment. This implies less domestic revenue and income per capita which erode the purchasing power and consequently demand of LPG will reduce.

There was a positive effect of domestic revenue on LPG demand. From Table 4.6, a partial effect of 0.606 was obtained for domestic revenue. Hence, a one percentage-point increase in the domestic revenue would, on average, translate to a 0.606 percentage point decrease in the LPG demand, ceteris paribus. The result was expected. Increase in domestic revenue collection by the Government directly contributes resources into the vital energy sector of Kenya economy.

Both in the short and long run demand of LPG lagged one period coefficient had the correct sign (see Tables 4.4 and 4.6). It exhibited a positive coefficient that was significant and elastic. The result implies that previous LPG demand influences the current LPG demand.

Both in the short and long run the crude oil, LPG price, kerosene price and electricity tariff coefficients had correct sign though insignificant (see Tables 4.4 and 4.6). These coefficients exhibited inelastic except LPG price coefficient. The estimated long-run fuel price elasticities of demand of LPG were smaller than the short run elasticities, perhaps this reflects that economic units are not able to exercise their discretion in fuel and equipment choice in the long-run. The insignificance of these coefficients reflects the inefficiency in the energy sector and the oligopolistic structure of this sector. It implies the demand of LPG is not determined through market fundaments (law of demand). The result partially reflect Kimuyu (1988) OLS estimation results that revealed that demand for fuels in Kenya was price inelastic in the short run, which implied that either fuel use in the country was a matter of necessity or that inter-fuel substitution possibilities are limited.

The lagged error correction term (ECT) included in the estimated LPG demand model to capture the long-run dynamics between the cointegrating series was correctly signed (negative) and statistically significant. It indicated a rapid response of LPG demand to deviations from long run relationship with each of the variables. In particular, negative deviations from the stationary relationship are "corrected" by increases in LPG. The coefficient 0.832 was stable and statistically significant. This indicated a speed of adjustment of 83% from actual LPG demand in the previous year to equilibrium in current demand of LPG. This is high and implies that the deviations from the long run equilibrium path are almost corrected in one period.

CHAPTER FIVE: CONCLUSIONS AND POLICY IMPLICATIONS

5.1 Conclusions

The main objective of this study was to determine the economic variables that influenced demand for LPG in Kenya during the period 1971-2006. Specifically the study sought to specify and estimate LPG demand model to determine the price and income elasticities of LPG demand and impact of other economic variables on LPG demand. The study objectives were accomplished by first identifying the LPG demand determinants, specifying the LPG demand model and determining the corresponding elasticities.

This study provide evidence on the empirical determinant of LPG demand in Kenya using thirty five-year time series data over 1971-2006. The estimated model was a single regression equation with yearly demand of Liquefied Petroleum Gas (measured as actual yearly LPG consumption) as the dependent variable. The explanatory variables were price of crude oil, electricity tariff, urban population, per capita GDP, price of LPG, domestic revenue, price of kerosene and inflation, which were exogenous and explained demand of LPG.

Using equation 22 as the "best" model on the basis of theory and goodness of fit, the study shows that both in the short and long run urban population, domestic revenue, per capita GDP, LPG previous demand and inflation are determinant of the current demand of LPG.

However, crude oil price, LPG price, kerosene price and electricity tariff coefficients have correct signs though insignificant. These coefficients exhibits inelastic except for LPG price coefficient. The estimated long-run fuel price elasticities of demand of LPG are smaller than the short run elasticities, perhaps this reflects that economic units are not able to exercise their discretion in fuel and equipment choice in the long-run. The insignificance of these coefficients reflects the inefficiency in the petroleum sub-sector and the oligopolistic structure of this sub-sector. It implies the demand of LPG is not determined through market fundaments (law of demand). Despite the usual caveat associated with econometric studies such as the present one, the finding in the this study suggests that removing the inefficiency constraint associated with cartels and oligopolistic structure in the sector would be good for growth of petroleum sub- sector, as other studies have uncovered.

5.2 Policy implications

It is evident that urban population, domestic revenue, per capita GDP, LPD previous demand and inflation influence the demand of LPG. Fuel prices i.e. crude oil price, LPG price, kerosene price and electricity tariff were found not to influence the LPG demand reflecting inefficiency in the energy sector. The study results indicates that removal of these inefficiencies and constraints would positively impact on the growth of the petroleum sub-sector and result in the desired switch in the fuel use from the traditional fuels to LPG. There is need therefore for the government to address the inefficiencies in the energy sector and facilitate competition within the sector.

There is further need for macroeconomic stability and the establishment of conditions which would favour investment in the LPG infrastructure. This would include allocation of more domestic revenue to the LPG infrastructure development. The study supports the current Government policy to enhance LPG infrastructure through development of LPG handling facilities (sessional paper No. 4, 2004).

Policy approaches should thus be geared toward strengthening the LPG legal framework, development of LPG infrastructure enhanced competition within the LPG market and ensuring macroeconomic stability and consistency in macroeconomic policies.

5.3 Limitations of the study

A major limitation of the study was the problem concerning the data in the Kenyan economy. Important variables which should have been included in the model were left out due to lack of data. These include time series data of price of charcoal and price of LPG equipments. Time series data on LPG demand for each sector was also not available. To maintain consistency, the study relied on data published by the government press.

This study estimated a single LPG demand while incorporating price of crude oil, electricity tariff, and urban population, per capita GDP, price of LPG, domestic revenue, price of kerosene and inflation as explanatory variables on assumption that they are exogenous. However, some of these variables may have been endogenous and using a VAR could have shown the effect on both in direction.

5.4 Areas for further research

This paper finds that several fuel prices i.e., crude oil, LPG price, kerosene price and electricity tariff do not influencing the LPG demand. Perhaps this reflects inefficiency in the energy sector. There is need therefore to carry out a research on the efficiency in the energy sector in Kenya. This will go a long way establishing the nature and structure of this sector.

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ANNEX I: DATA USED IN THE ANALYSIS

Description of Data Used in the Analysis

	Dependent Variable	Independent Variable							
Year	LPG Demand in Tonnes (L)	Price of LPG in Kshs./tonne (PL)	Price of Kerosene in Kshs./litre (PK)	Average Electricity Tariff in Kshs./KWh (PE)	Domestic Revenue in Kshs. (DR)	Inflation as a percentage (INF)	Urban Population in numbers (UB)	Income Per Capita in Kshs. (PKY)	Crude Oil Price in Kshs./MT (PC)
1971	14.8	2,413	1.67	3.59	2601	3.70	1.35	1930	491.08
1972	15.9	3,167	1.89	2.68	2927	5.40	1.39	1950	468.38
1973	16.4	3,345	2.04	3.82	3539	8.90	1.44	2178	623.20
1974	16.9	3,675	2.21	3.88	4506	16.30	1.55	2030	1910.32
1975	17.2	3,789	2.27	4.44	5138	17.80	1.59	1990	2235.90
1976	17.6	4,109	2.34	4.81	6117	10.00	1.64	2050	2201.91
1977	17.8	4,298	2.41	5.81	9167	12.70	1.76	3090	2233.75
1978	18.9	4,321	2.45	5.63	9792	12.60	1.83	2266	2311.49
1979	19	4,432	2.75	4.92	11794	8.40	2.32	3380	2112.06
1980	21	4,456	2.78	4.90	13899	12.80	2.86	3216	3337.03
1981	21.1	4,546	2.92	4.44	15845	12.60	3.12	3314	4476.06
1982	20.9	6,050	3.80	4.68	17280	22.30	3.25	3280	4726.21
1983	19.9	6,050	3.90	5.08	19033	14.60	3.38	3248	3897.98
1984	21.6	6,399	4.26	5.51	21152	9.10	3.52	3152	3960.48
1985	22.4	5,893	4.38	5.60	24298	10.80	3.64	3280	3680.70
1986	24.1	6,400	7.74	5.05	28140	10.50	3.78	3346	3845.91
1987	25.3	6,400	3.78	4.64	34268	8.70	3.83	3662	3749.50
1988	26.9	6,400	3.78	5.03	40811	12.30	3.83	3698	3963.99
1989	26.4	7,820	4.06	4.63	44557	13.50	3.88	3774	4236.71

	Dependent Variable	Independent Variable							
Year	LPG Demand in Tonnes (L)	Price of LPG in Kshs./tonne (PL)	Price of Kerosene in Kshs./litre (PK)	Average Electricity Tariff in Kshs./KWh (PE)	Domestic Revenue in Kshs. (DR)	Inflation as a percentage (INF)	Urban Population in numbers (UB)	Income Per Capita in Kshs. (PKY)	Crude Oil Price in Kshs./MT (PC)
1990	27.4	11,629	6.38	2.57	51105	15.80	4.22	3812	4267.45
1991	25	14,843	8.29	6.91	65698	19.60	4.35	3774	4334.77
1992	27.4	16,643	9.38	7.68	76362	27.30	4.75	3662	4576.21
1993	25.1	23,855	15.16	8.30	108108	46.00	4.94	3346	2378.04
1994	28.4	24,454	17.13	7.91	132308	28.80	5.09	3346	1291.82
1995	31.2	25,200	17.04	8.35	144430	1.60	4.79	3414	1466.88
1996	31.3	25,956	19.28	7.09	148227	9.00	5.00	3736	1588.27
1997	30.7	45,000	21.76	7.08	182778	11.20	5.34	3698	1551.64
1998	31.3	42,000	22.03	7.39	171394	6.60	5.35	3554	1166.93
1999	32.2	51,000	24.82	7.39	168014	5.80	5.36	3518	1639.92
2000	33.4	55,813	31.82	10.00	172123	10.00	6.04	3414	1690.50
2001	35.6	54,490	34.74	13.02	179089	5.80	6.18	3414	1741.60
2002	40.5	53,320	34.19	11.03	183678	2.00	6.36	3380	1985.90
2003	40.9	54,230	35.41	9.11	186356	9.80	6.54	3284	2097.90
2004	41.7	55,140	40.18	8.77	196234	11.60	6.72	3328	3744.50
2005	49.4	57,018	51.18	9.45	304827	7.41	6.8600	3351	3834.9

Source: Kenya National Bureau of Statistics