ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES

DETERMINANTS OF KEROSENE AND LPG DEMAND IN ETHIOPIA

BY
GETAMESAY BEKELE

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"Determinants of Kerosene and LPG Demand in Ethiopia"

By

Getamesay Bekele Meshesha

Approved by the Board of Examiners:

Dr. Syed Hasan Qayed	
Advisor	**Signature**
Shail Singh	
Examiner	**Signature**
Dr. Paramasivan	
Examiner	**Signature**

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ACRONYMS

ADF	Augmented Dickey Fuller
CSA	Central Statistical Agency
CH_4	Methane
CO_2	Carbon Dioxide
DF	Dickey Fuller
ECM	Error Correction Method
EEA	Ethiopian Economic Association
EELPA	Ethiopian Electric Light and Power Authority
EPC	Ethiopian Petroleum Corporation
EPE	Ethiopian Petroleum Enterprise
EPRDF	Ethiopian People Revolutionary Democratic Front
ERTA	Ethiopian Road and Transport Authority
ESMAP	Energy Sector Management Assistance Program
GHGs	Green House Gases
Gg	Giga gram
GDP	Gross Domestic Product
GNI	Gross National Income
GNP	Gross National Product
IRG	International Resources Group
LDCs	Least Developed Country

LM	Lagrangian Multiplier
LPG	Liquefied Petroleum Gas
LR	Likelihood Ratio
MC	Metric Cubic
MIT	Ministry of Industry and Trade
MOFED	Ministry of Finance and Economic Development
MT	Metric Tons
NBE	National Bank of Ethiopia
N2O	Nitrous Oxide
OCED	Organization for Economic Cooperation and Development
OLS	Ordinary Least Square
OPEC	Organization of Petroleum Exporting Countries
PECM	Parsimonious Error Correction Method
PPP	Purchasing Power Parity
UNDP	United Nation Development Program
VAR	Vector Auto Regression
VECM	Vector Error Correction Model
**	Denote rejection of the null at 1% level of significance
*	Denote rejection of the null at 5% level of significance

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ABSTRACT

In this paper attempts are made to identify determinants of Kerosene and LPG demand in Ethiopia. The study estimates Kerosene and LPG demand using time series data starting 1964/65 to 2004/05. To determine whether there exists long run relation between Kerosene and LPG demand and its determinants, the Johansen procedure of co-integration analysis is used. Accordingly, there exists one unique co-integration relation between Kerosene and LPG demand, and its result shows that the real price of Kerosene, real price of LPG, real per capita income and real foreign exchange earnings are found to be statistically significant while population growth and level of urbanization are statistically insignificant. Similarly in the case of LPG demand; real price of LPG (own price), real price of Kerosene (relative price), population growth, level of urbanization and real foreign exchange earnings are found to be statistically significant while only real per capita income is statistically insignificant. In the short-run, price of Kerosene, real per capita income and population growth are statistically significant in Kerosene demand and real price of LPG, real per capita income, population growth are statically significant in LPG demand. In terms of elasticities, Kerosene price and LPG price are elastic and inelastic, respectively while income is marginally elastic for both fuel demand model. In the long run, LPG is a substitute to Kerosene and electricity, other modern energy sources are a substitute to LPG..

Finally, in the short run, the government should use direct pricing policy on LPG product and regulated and pre determined kerosene pricing policy on Kerosene product to increase its revenue. This kerosene price should be set below LPG price. As the result, the government can earn more revenue from both products.

CHAPTER ONE

1.1 Introduction

Energy is important to economic development. It consists of traditional or bio mass energy and modern or commercial energy. At the level of the individuals, modern energy sources can transform peoples' lives for the better. It can improve peoples' productivity. It has the potential to many millions of women and children from the daily grind of water and fuel wood collection, and through the provision of modern energy can extend the working day, increase their income, invest more time in schooling, keep their health and do other activities to the community. In aggregate, they are a powerful engine of economic and social opportunity. No country has managed to develop much beyond a subsistence economy without ensuring at least minimum access to energy service for a broad sector of its population.

Energy demand, supply and pricing have enormous impact on social and economic development, the living standards and overall quality of the life of the population. On the other hand, the economic structure and the change in that structure as well as the macroeconomic condition are key determinants of energy demand and supply. Furthermore, energy affects environmental quality through deforestation associated with unsustainable biomass energy dependence and green house emission from fossils use resulting in global warming. [World Bank discussion paper (2000), Fuel for thought, USA]

Energy demand is a function of energy prices, income, population, degree of urbanization, and level of technological development and the overall structure of the economic. The energy sector is one indispensable sector for a country's socio-economic development, production, and better energy standards of living. Energy is an essential element and has a decisive role in our life, agriculture, Industry and social services. Plant, coal, petroleum, electricity, sun, geothermal steam and animals' wastes are the main energy sources. The effective demand for commercial energy is, therefore, related to economic conditions, which influences the availability and access to energy sources. Ethiopia's energy demand and end consumption patterns are similar with other developing countries.

The structure of energy supply and consumption in Ethiopia reviled that the traditional biomass energy sources (fuel-wood, charcoal, dung and agricultural residue) constitute 93%, an imported fuel oil and hydropower 5% and 2%. The major consumers of energy in Ethiopia are the households and constitute 89% of overall energy requirement of the country. Industry and transportation sectors are the second and third level of consumers of energy in a country about 4% and 2% respectively. Other sectors are services and agriculture constitutes 5% (Ministry of Mines and Energy of Ethiopia, 1999).

The consumption of petroleum product is mainly driven by demand within household and commercial and other sector which accounts around 50% of the total fuel consumption and the other remaining 50% demanded by transport sector. (Ministry of Water Resource). Electricity demand is mainly driven by three sectors the Industrial, Commercial and household sectors. Ethiopia's hydropower development potential is around 20,000 MW and 4,000 MW from geothermal generation. This enormous potential classifies Ethiopia as one of the world's leading countries in renewable energy potential. However, only around 2% of total potential is known to have been utilized so far. So most of the energy consumed in Ethiopia is non-commercial.

Ethiopia is endowed with a number of energy sources including biomass, hydropower, natural gas and coal, geothermal, solar and wind. Although currently dwarfed by traditional biomass consumption, hydropower and fossil fuels are the main potential of the country's development opportunities. Then, the resource availability and secondary use data are summarized below.

Table 1.1 Ethiopia Energy Resources

Source	Total resources		Current use	
	Toe X10^6	%	Toe X10^3	%
Hydropower (Annual gross)	55.5	23.2	110.0	0.7
Natural gas	71.8	30.0	0.0	0.0
Petroleum	0.0	0.0	918.0	5.9
Coal	10.2	4.2	0.0	0.0
Geo the mal	0.5	0.2	0.0	0.0
Fuel wood	93.5	39.1	11,976	77.2
Biogases	0.1	0.0	111.0	0.7
Other organic residues	7.7	3.2	2,397.0	15.4
Total	**239.10**	**100.0**	**15,509.0**	**100.0**

Source: CESEN, technical report 2, 1986 and Natural Energy Balance, EEA, 1992.

The country energy consumption pattern is detrimental to the environment and will not guarantee sustainable development in Ethiopia. For this reason, various measures such as the use of technologies that are energy efficient or the use of alternative sources should be encouraged.

All the energy consumed in developed countries is commercial. Of such energy, oil is the single most important fuel, supporting almost half of the total energy consumption (Dunkerly and Hock, 1987). By contrast, around 2.4 Billion people in developing countries like Ethiopia rely primary on traditional biomass fuel for their cooking and lighting needs. (IEA, 2002), which accounts more than 75% of the total energy used in these countries. However, commercial energy such as kerosene and liquid petroleum gas (LPG) are still an important input for economic development particularly in household and commercial or service sectors. (Ramus, Heltberg, 2003).

Despite a low consumption of commercial or modern energy and substantially dependence on non-commercial fuels, the demand for commercial energy has been rising very fast since 1960's due to modernization, rapid economic growth, raising income of the country, etc. So in many developing countries like Ethiopia that have relatively limited access to international financial market, due to the diversification of their exported products is also very limited. It causes trade balance to deteriorate with the resulting deficit being financed by borrowing or by running down foreign exchange resource (Lewis, 1980).

In Ethiopia, evolution of future commercial energy consumption revolves around development objectives. The structural change in the economy i.e. commercialization of the economy, and shifts in the relative importance of industrial and service sectors will be dependent on the pace of transition from traditional to commercial energy consumption. Most of these changes are associated with changes in economic sector such as household and services sectors which use commercial energy such as kerosene and LPG.

Therefore, the share of modern or commercial energy in the development process will increase because of a rapid growth of inherently modern fuel using sectors of the economy. (Dunkerly and Hock, 1987). In developing countries (hence Ethiopia) development is not only constrained by economic factors but also environmental consideration. Thus, in Ethiopia, like other developing countries commercial energy such as kerosene and LPG is an important factor for economic development, especially in the household and services sectors. Then the study has, therefore, a definite area to explore and give policy suggestion regarding energy consumption.

1.2 Statement of the Problem

Adequate and reliable supply of energy is crucial for social and economic development of any country. Easy access to affordable energy is often observed to be associated with the stage of development. Industrial countries that have already achieved high living standard and recorded high per capita energy consumption. While least developed countries (LDCs) are listed as low per capita energy consuming country. In Ethiopia, energy consumption per capita is 0.30toe, of which only about 0.02toe.(7%) was generated from modern energy sources. (Girma, 2000)

Energy is the basic element for economic development. Efficient utilization of available energy and improving the supply in quality are key elements in the developmental process. The relation ship between energy and economic growth in Ethiopia has become an emotive issue. If economic activity is to be a measure of welfare and continued growth, the implication of future energy development becomes central points of the debate about energy policy and planning.

Commercial energy planning is also an important in economic development. The developing countries have not mitigated much of the problems of energy, these countries encounter different problems, among others, shortage of finance and qualified manpower to study and develop the alternatives energy resources available. In addition, these countries use the energy inefficiently. In Ethiopia, as any other least developing country, modern energy resources are not well developed and utilized, due to lack of skilled manpower, financial, technical, policy, structural and institutional problems.

Despite the enormous interests shown in energy planning in Ethiopia, the general awareness among energy planners of available methodological tools is still in need of improvement. This is specially true where integrated approach to the energy sector and the rest of the economy are concerned. Moreover, the demand for petroleum product is relevant for the assessment of the effects of new policy initiatives that have direct or indirect on the consumption of petroleum products. It is also that knowledge of the form of the demand structure for kerosene and LPG become essential for rational policy decision.

In Ethiopia, energy is one of the most important factors for economic and social development like any other developing countries. Through commercial energy consumption in Ethiopia is important for a country development; there is a considerable uncertainty about effects of demand oriented policies in the utilization of kerosene and LPG. Such uncertainty can undermine formulation of effective energy polices due to inability to predict the likely impact of the change in important variable such as price, income and population. Also there is still an in formation gap that must filled to guide the policy makers on which area or demand variable to put their efforts in order to achieve a sustainable energy use.

Under development and lack of modern energy sources become of the limiting factors in the overall economic development in Ethiopia. Petroleum imports consume about large foreign exchange earning every year, that is, the country has to use valuable income from export to pay for imported petroleum products. For instance, the share of imported petroleum was about 23%, 24.2% and 16.4% of total import in 1979/80, 1997/98 and 2002/03 by respectively. This implies, the share of imported petroleum deteriorated country trade balance if there is an absence of equivalent increase in export earning.

The use of commercial energy in Ethiopia does not seem to be sustainable since the government spends large amounts of scarce resource to finance mainly the development of alternative energy sources like development of hydroelectric power generation, geothermal energy, Natural hydro carbons, wind, solar energy, etc. (MOFED, 1999).

Finally, in Ethiopia, few studies have attempted to identify household energy demand determinants at micro level. From these studies took place by Asmerom Kidane (1991) analyzed energy demand in rural and urban center of Ethiopia using a two stage least square model, and estimated the demand at micro level. Similarly, Berkete and Almaz (1999) studied the income and price elasticties of both traditional and modern fuel at urban levels. So, the above information's have limited studies on energy sector in Ethiopia then this study analyze at macro level. This study helps for an exploration of mechanisms for sustainable use of commercial energy in Ethiopia so that more investigation and clarification is crucial.

1.3 Objective of the Study

The general objective of this study is to investigate the major determinants of kerosene and LPG demand in Ethiopia. And identify both short and long run variables of the study.

Specific Objective

To identify other determinants like population growth, level of urbanization and foreign exchange earnings from the kerosene and LPG demand.

To suggest, based on finding the appropriate policy recommendations to improve commercial energy consumption, specially kerosene and LPG

1.4. Justification and significance of the study

Besides being an essential input in the production processes, energy is a direct requirement of people's daily lives. This explains why energy policy is a vital aspect of the overall development policy of the country and how energy policies are designed and implemented to influences the structure of the country economy.

The objectives to be pursued in this study postulate the demand for kerosene and LPG consumption. The identification of factors affecting energy consumption, specially the demand for kerosene and LPG, will indicate possible areas where action in energy development can exert significant influence on economic development. By providing such insight, this paper will also be useful in the formulation of commercial energy specific policies in Ethiopia.

In recent year, decision makers in various countries have realized that energy sector investment planning should be carried out on an integrated basis (Richard, 1985). In the past, supply and demand analyses were traditionally carried out for each energy source at disaggregate level in Ethiopia. Most existing studies on commercial energy particularly demand for kerosene and LPG have concentrated on developed countries. Hence, our study will give some insight in this area.

Unfortunately, Ethiopian imports petroleum products from oil producing countries. So the relationship between energy and economic long-term interaction on the imported petroleum depends on the internal energy action taken by the government and consumption of these products by consumer. I think the development of econometric tools which enhance understanding of the factors influencing the demand for kerosene and LPG will give more information about future energy flow. Moreover, the future commercial energy consumption and economic development are essentially interacting and therefore energy planning should be suggested. However, the suggestions must be flexible enough to accommodate developments as they occur.

One may ask why this study focuses on kerosene and LPG as a commercial energy in Ethiopia. The main reason is that the impact is largely influence kerosene and LPG the county's economy, especially in the household, commercial and other sector. These sectors use both fuel for cooking, lighting and other activities. Thus, the findings of this study will form a useful input into the literature on energy in Ethiopia; particularly on kerosene and LPG (household, commercial and other sector) and even provoke further studies in the kerosene and LPG sector.

1.5. Hypothesis of the study

The main hypothesis is to be tested is

Fuel price affects the consumption of kerosene and LPG negatively and significantly.

Income affects the consumption of kerosene or LPG positively

Population growth and level of urbanization affect positively the consumption of kerosene and LPG

1.6. Scope of the study

This study employed yearly data from 1964/65 to 2004/05 to estimate both kerosene and LPG demand function during the period. Specifically, the study will focus on kerosene and LPG demand in the household, commercial and other sector. The period is chosen on the basis of the availability of reliable data.

1.7. Organization of the study

The paper is structured as follows: The next chapter reviews the theoretical and empirical evidence of previous studies on determinants on kerosene and LPG demand. Chapter three discusses commercial energy and the Ethiopian economy, chapter four presents the data and methodology while chapter five discusses empirical results. Finally, conclusion remarks and policy implications presented in chapter six.

CHAPTER TWO

Literature Review

2.1 Theoretical Literature

In recent years, the energy sector of developing countries including Ethiopia has exhibited a dynamic character. In addition to important changes in the share of consuming sectors and fuels in aggregate demand patterns, the energy consumption trends in these countries have moved steadily upwards. This, together with the slow down in the growth of total energy consumption in the industrialized countries, has underlined the rapidly growing role of developing countries in the world energy market.

For instance, according to World Bank discussion paper (1999) and OPEC review (1994), the share of developing countries in the world energy consumption rose from 10% in 1970 to about 20% in 1992, the share of Africa rose 1% in 1970s, 8.9% in 1980, 17.8% in 1990 and 20.6% in 1994. While the share of OCED countries fell from 65% to 51% in the same period. The annual energy consumption growth rate for developing countries was about 5.5% in the period 1970-1992, in non-OCED countries was about 2.8% per annum during 1980s. In Asian developing countries was 5.3% per annum, compared with 1% per annum for the OCED countries in the same year. There are several economic, social and demographic factors behind these trends of the past three decades.

Theoretically, the demand for a good or service is determined by its own price, prices of other goods, income, geographical, demographical as well as environment factors. The relative energy costs and their supply stability are therefore expected to have an influence on kerosene and LPG consumption. If other factors remain constant, while the price of one energy form rises, it will be costly to continue consuming this particular source of energy. Therefore, to maximize utility, given the limited level of money income, a consumer will reduce consumption and increase the consumption of another form (substitute) whose price has decreased or remained constant (Pindyack Rotemberg, 1979).

From the consumer's point of view, the demand for kerosene and LPG is a derived demand from the service it provides within the household sector. For example, the household requires kerosene and LPG for there home cooking and lighting purposes. The demand for kerosene, in this respect, it is such as the demand for other goods and services. Assuming the above conditions for kerosene and LPG as a good and bearing in mind that Hicksian demand analysis does not provide us with observable parameters. Since, they are based on utility concept, we can postulate how the kerosene or LPG demand function responds in a Marshallian context.

Another consumption function from Cobb-Douglas (C-D) consumption function is the Cobb-Douglas utility function, the consumer's demand is obtained as the solution to the following maximization program.

Max $U = \Pi C_i^{\alpha}$ subject to $\sum P_i C = Y$ and $\sum ai = 1$

Where Y= total income, Π = constant, the consumption of each commodity i reads as,

$C_i = \frac{\alpha_i Y}{P_i}$, Values for the various elasticities presented above can be

Derived from this demand function and provide information in the restriction of the C-D function. Price and income elesticties, as well as the elasticity of substitution between each pair of goods, are all equal to one, where as the cross price elasticity is zero. Despite these assumption, which may be perceived as very strong and un realistic, many authors restart to the C.D function given that it can be easily calibrated and does not require outside a estimate of free parameters (Nabil Anabi et .al, 2006).

The simple static model for kerosene and LPG demand assumes that utility from Kerosene (K), LPG and other goods (O) depends on the price kerosene (P_k), the price of LPG (P_{LPG}) and the prices of other goods (Po), respectively. Assuming the consumer knows the price of kerosene (P_k), the price of LPG (P_{LPG}) and the other goods (Po), then choose kerosene, LPG and other to maximize utility U(K, LPG, O); subject to budget constraint

$P_kK + P_{LPG}LPG + P_oO \leq Y$; where Y = Income

Assuming a dynamic responses of kerosene consumption to price and income changes, several authors have used to other variable by consuming the former, as follows

$$K = f(P_k, Y, K_{t-1}, Pop, U, X, E)$$

Where K = Quantity of Kerosene	Kt-1 = Lagged kerosene consumption
PK = price of kerosene	U = Level of urbanization
Y = Income	Pop = Population
X = Export earning	E = Error term

The studies on kerosene and LPG demand have focused on the developed countries, few studies being undertaken for Asian developing countries, Africa and Latin America countries at macro and micro level.

Michael Kennedy (1974), mostly known by his studies on the kerosene and LPG demand. He began with a level of desired demand for a given energy demand (kerosene) which depend on income and prices K = f (P, Y) ....(1). In this case, price and income are explanatory variables. Like other commodities, we assume that the demand for kerosene and LPG increase with their income increase, ceters pairbus. Furthermore, assuming that if the kerosene or LPG are normal goods, their demand is inversely related with price.

Desired demand may depends on other factors as well, so he specialize this equation like

$$K = aP^{\beta}Y^{\alpha} \quad \text{------------------------------------} \quad (2)$$

Change equation (2) in log - linear form

$$\ln k = \ln a + B\ln p + \alpha \ln y \quad \text{------------------------------------} \quad (3)$$

The actual level of demand in one year; however, is not necessarily equal to the desired level. In particular, actual demand adjusts towards desired demand with a log. So, this year's consumption is a function of this year's economic variables and last year consumption. The adjustment process is represented.

$$\frac{K}{K_{t-1}} = \left[\frac{K^*}{K_{t-1}}\right]^{1-\lambda} \quad \text{Where K t-1 = last yeai consumption ----------} \quad (4)$$

This lagged adjustment of the actual demand to desired demand is the result of K = f (Y, P) and an existing stock of equipment which uses a specific form of energy at a specific efficiency, at which can not be replaced immediately and K = f (P, Y, K_{t-1}) is unwillingness by consumer to view price and income changes a permanent until they have continued for some time.

Then using log-linear model of K = f (P, Y, K_{t-1}) the

$$\text{In K} = \text{Ina} + (1 - \lambda)\beta\ln P + (1 - \lambda)\delta\ln Y + \lambda \,\text{Ink}_{t-1} \text{ ---------------------------} \quad (5)$$

Substituting equation (5) in equation (4) generating the estimating variables in this equation β and δ are long-run elasticities of demand, and (1-λ)β and (1-λ)δ are short run elasticities. Masayasu Ishigure and T. Akyama, (1995), the main exogenous variable used in the model to project energy demand in 5 East Asian countries (Chain, India, Indonesia, Korea and Thailand) were GDP, population, energy price and structure of the economy (distributions of GDP among Industries, services and Agriculture). In this case, price affects inversely the demand for energy.

Similarly Masayasu, Ishigure and Akiyama (1995) observed that the income and price elasticities provide a quantitative measure of the impact of economic activity and energy prices on energy demand. Further they argued that total energy demand is the sum of demand in the various sectors of the economy. The sectors they considered include transportation, industry, household and agriculture sector.

Antoette D'Sc et. al (2004) analyzed factors contributing to use consumption of LPG. In this case, consumption of LPG are dependent variables, on the other hand, prices of LPG, prices of Kerosene, initial costs of appliance, restriction on the supply of computing fuels like kerosene, distributional factors like storage, bottling and refining, characteristics of stoves, stove efficiency, etc are explanatory variables on his analysis model.

Gately and Streifel (1997) analyzed the growth in oil demand. Both observed that GDP, population and price of oil affect much of the growth in the world oil demand. They also examined several alternative equation specifications of per-capital oil product demand as a function of per capita real in come and the real prices of crude oil.

L. Prise, L. Michielas et. al (1998) argued that there are different derivers of energy use and Green house emission on this condition key derivers of energy use and carbon emission includes actively derivers are total population, urbanization, building, commodity production etc), (the economic derivers are total population, income and price elasticities) and finally energy intensity like energy using equipment, appliance, etc. These factors are intern by change in consumer preferences, energy, technology with settlement and infrastructure patterns, technical change, and over all economic condition.

Hosier R. et. al (1993) argued that the demand for energy is determined by the price of fuel used, the price of other alternative or computing fuel, income and other characteristics of the resident and climate variable. In addition, Cesen (1986) analyzed the variation in the price of fuel overtime depends on a multitude factors such as variation in the production and distribution costs of the existing energy sources, supply status, competitiveness of prices in relation with other substitute fuels, social characteristics and income levels of the users.

Balabanoff (1994) argued that the two most widely important factors determining energy demand are income and its rate of change. Energy consumption and its related costs may affect the path of economic growth, while it is also a function of growth. He further stated that income elasticity of demand for energy in least developed counties is large than from industrialized countries, while price elasticity is small, due to structural effect of development on the demand for oil and the availability of energy source.

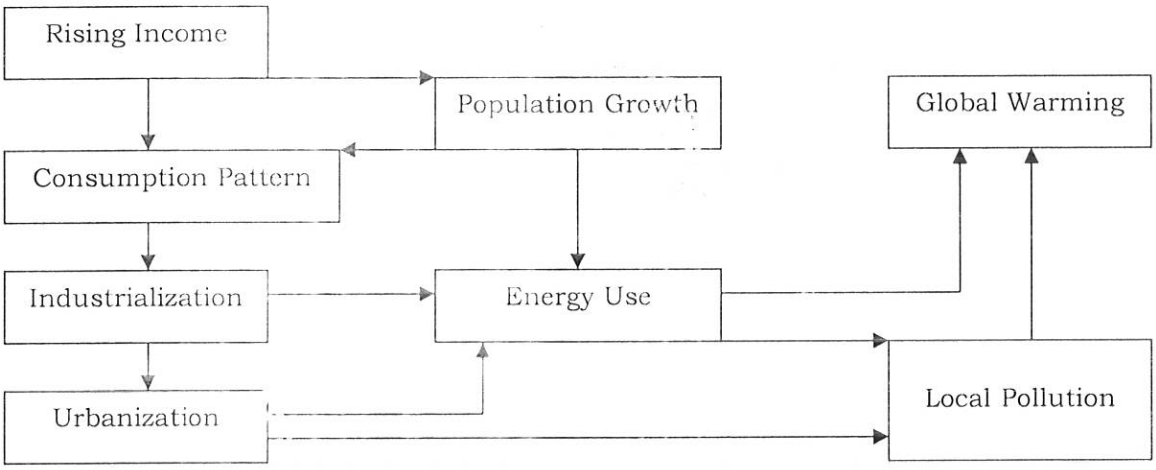
Therefore, with a fall in economic growth, price increase may have a depressing effect on economies and reduce energy use. With higher economic activity, the demand for energy increases. On the other hand, a greater availability of energy may raise the level of production and generate higher income and employment. Many factors affect this relationship. For example, demographic factors, such as population and urbanization, the price of energy, the state of technology, the level of activity in the different economic sector and environmental constraints.

International Energy Agency (2000) presented the consumption and forecasting household fuel consumption in sub-Saharan 45 countries. The per-capita consumption for modern fuel like kerosene or LPG is a ratio of a consumption of these fuels in period **t** over rural and urban population that uses these energy sources.

Arimah (1994) examined the relation between energy and economic growth. Energy and economic growth relationship within a given country is a reflection of that country's level of economic growth. Similarly, commercial energy consumption per-capita increases at a faster rate than per capital income, there by resulting in an increasing value of the income elasticity of energy consumption with high levels of economic growth. It is expected the commercial energy per-capita will rise at a much slower rate than per capital income, thereby displaying decline in their income elasticity of energy consumption.

Dr. Obas, Ebohon, et. al (2000) analyzed urbanization and energy consumption, the energy implication of rapid rates of urbanization is reflected in the specialized infrastructure inputs and services needed to sustain a large concentration of people in one spatial domain. One of the unique features of the influence of urbanization on energy consumption is in the fuel use pattern where clear shifts from traditional energy to modern or commercial fuel have occurred because of the suitability of such fuel for specialized urban facilities. As fig (2.1) shows, the combination of rising income level influences energy consumption patterns and the amount of energy consumed, especially relative to the size of the population, industrialization pattern and the level of urbanization. The environmental impact is initially felt logically as local pollution accentuates with higher levels of consumptions, where manifests in global warming.

Fig (2.1) Urbanization, Energy Use and Green House Linkages



Source Dr. Obas, Ebohon, et. al (2000)

Similarly, L. Price et al (1998), argued that increased urbanization in developing countries leads to increased use of commercial fuel, such as kerosene and LPG for cooking instead of traditional biomass fuel. In general, higher levels of urbanization are associated with higher income and increased house energy use.

According to Barnes, et al (1984), a country's demand for energy is linked with factors such as size of population, degree of urbanization and industrialization, patterns and levels of technological development.

Kevin B. Fitzgerald et al (1990) argued that at micro level, they estimated the household fuel consumption as a dependent variable. On the other hand, household income, family size, price of kerosene, price of LPG, and prices of other alternative energy sources are an explanatory or independent variables. As the results of these the prices of energy are negatively related with consumption. The household income increase, the individual shifts from other fuel to LPG and kerosene at different level, and the level of LPG increase with level of urbanization rise.

Tobies A. Person and C. Azar (2002), they presented use of energy in different rural and urban areas in developing countries, with modern energy carriers, LPG being more common on urban areas, which non-commercial biomass is still the most common energy carrier in rural areas, often, urbanization leads to shift in the use of energy carriers like to LPG and electrification.

Mark Resenezweig (1998), analyzed the macro economic models use historically data as well as estimates of future population, GDP, autonomous energy efficiency improvements rates, electricities and energy prices to determine energy demand level.

A. Senehadji et. al (1999), export play an important role in the growth process by generating the foreign exchange necessary to finance imports energy and investment goods, both of which are crucial to capital formation.

Despite the fact that kerosene and LPG demand is determined by the above mentioned major fundamentals of economic factors like price of kerosene and LPG and income. Kerosene and LPG demand is not free from the influence of government regulation. For example, in most developing countries oil is imported and marketed by the government. This makes the consumer to use the oil inefficiently which has a cross effect on the environment and resource allocation of the country.

Not only the marketing by government makes the oil market in developing countries inefficiently, but also the institutional framework and modern energy consumption are weak in these countries. The institutions responsibility for importing and price setting of oil are themselves inefficiently. The price of oil is usually set above the cost due to the rent seeking behavior of government (World Bank Discussion paper, 1999).

We can view the world oil market from two angles; based on the principles of markets these are classical and Keynesian. The classical view naturally proposes that, like any other commodity, oil should be left to the forces of demand and supply. However, the problem with oil market is that the oil reserve is owned by few and hence the supply is monopolized in most cases. For instance, OPEC has about 70% of crude oil reserve share and 40% average oil share. (Energy Information Administration, 1999). The classical view, therefore, could not be a solution, as the oil market is very small and hence not competitive due to the monopolistic nature of the market as seen from the supply side.

The Keynesian view states that when the market becomes uncompetitive and persists, government should intervene in the market with the objective of removing the obstacles of the market. Particularly, the Keynesian view implies that the oil market should be intervened to decartelize it.

It is recognized that the fuel price in many developing countries including Ethiopia are set and fixed by the government, and this price does not reflect the real opportunity cost of the resources(in this case kerosene and LPG). This suggests that the price level may not influence kerosene and LPG consumption in economic theory that suggests in the literature.

2.2 Empirical Literature

We critically review some empirical studies, which have been used in analyzing the demand for kerosene and LPG. Most econometric model of kerosene and LPG are formulated by static and dynamic model by the above mentioned framework, tend to be based on simple or multiple regression models where kerosene and LPG demand is a function of one or more independent variables.

The hypotheses that price of kerosene, price of LPG, and income are mainly determined kerosene and LPG demand. The research has been conducted by several researchers mainly in the context of developed countries. One such (simple static model) was developed by Michael Kennedy (1974) analyzed the demand for kerosene and LPG using yearly data for USA, Canada, Latin America, Europe, the Middle East, Africa, Japan and India.. He used in the kerosene and LPG demand dependent variables were expressed in per-capita consumption term. On the other hand, real price and real income per capita were used as explanatory variables.

Here, the long-run income elasticity was -2.5, indicating the kerosene is an inferior good, in agreement with common sense. The long-run price elasticity is rather high -2.0, indicating the existence of good substitute like LPG and coal for household sector services. These results are intuitively quite plausible when the role of kerosene as household sector services is considered, but increasing use of kerosene as jet fuel makes they suspect for projection purpose. As jet fuel, the income elasticity of kerosene demand would likely be over one, and the lack of good substitute should make the price elasticity low in absolute value (although clearly not zero).

In the case of LPG, the long-run income elasticity is +2.8, indicating the LPG is a superior good. Since it substitute kerosene and coal are much less convenient, this is very likely, a lower elasticity might be expected in the forecast period, however, as saturation of fuel oil begin to appear and an even more convenient fuel, natural gas, comes on the stream in some European countries, the long-run price elasticity of LPG is -0.76.

By the study of M. Ishiguru and T. Akiyama (1995), they divided few East Asia country with higher income countries (Korea and Thailand), and lower income countries (China, India and Indonesia), then the price elasticity of fossil fuel (kerosene and LPG) were statistically not significant in the higher income country of these group, and significant for the lower income country (China, India and Indonesia). This suggests that with increase in income, energy costs as a share of household income decline and household become less sensitive to price.

According to Ishiguru and Akiyame study, the price elasticities and income elasticities are as followed, the price elasticity of the two fuels are not significant in Korea and Thailand but in Indonesia could be -0.48. On the other hand, the income elasticity for Indonesia ranges from 0.83 to 1.62 and in the Korea and Thailand ranges from 0.57 to 1.15. But generally, the price elasticities are more inelastic for Korea and Thailand.

This analysis went to Africa like Ghana and Nigeria, the price elasticity of these fuels in Ghana around -0.2 and -0.3 in Nigeria. These results indicating, there is no substitute or access to use other modern energy like electricity to use the household sector.

Finally in this study, there is another consistency between two studies and earlier research is that income elasticities for residential or household and commercial sector are higher than the price elasticities especially in the long-run, with most reported greater than one.

There are also other studies in Asian countries by economists. Pitt (1985) found price and income elasticities for kerosene in Indonesia by dividing the country into rural and urban areas. In the urban and rural, price elasticity was -1.00 and -0.89 by respectively. In the case of income elasticity was +0.54 and +0.27 in rural and urban area respectively. These results were based on time series data from 1960-1970.

Rahman (1982), found to LPG price and income elasticities for India was -0.25 and +1.47, respectively, based on time series data covering the period 1960-1978.Moreover, in the other East Asian countries like Pakistan and Philippines, Ibrahim and Hurst (1990) found price and income elasticities for both fuel were -0.26 and +0.62, and Philippines -0.14 and +0.85, respectively. Both countries used pooled data for their analysis.

The econometric model discussed by Tzeng, et.al (1989), on yearly data from 1962-1984 employed the data for Taiwan. The price and income elasticity of LPG to be -0.12 and +0.67 for the short run, respectively, and -0.19 and +1.04 for long-run respectively. On the other hand, Fiebig et al (1987) used pooled data for Sirilanka, found price elasticity for commercial energy and income elasticity to be -0.80 and +1.51 respectively.

So in the analysis of price elasticity and income elasticity of LPG and kerosene for household sector purpose all price elasticities laid below one. It indicates that price elasticities are inelastic or more inelastic due to no substitution of other modern energy source like electricity for their cooking or lighting purposes. On the other hand, almost all income elasticities lied above one. This indicates that income elasticity is to be elastic; this result indicates that both modern fuels could act as a luxurious good in most countries or no fuel in an inferior goods.

Based on trans-log model studied by Griffin (1977), employed time series and cross sectional data for his analysis from 1955-1969, for USA. The short-run price elasticity for kerosene was -0.87 and LPG -0.68. On the other hand, these elasticities in the long-run were -4.32 and -0.98, respectively. Atikson and Holverson (197?) used time series data to analyze two fuel, then the price elasticity to be +0.01 and -2.55 for kerosene and LPG, by respectively. Finally, James Ko (2000) studies another long term time series data from 1949-1991, the price elasticity of kerosene and LPG was -0.29 and -0.13. From these result, the price elasticities for both fuels are inelastic, due to, the consumer are not willing to shift other modern energy sources like electricity due to more expensive electric service charges.

Another study was taken place in Latin America by different Economists, Such as Darby Jack (2004), he used cross sectional data for Peru, then the price elasticity of kerosene was 0.365 and income elasticity to be +0.430 respectively at 99% significant. Similarly in Guatemala, Ramus Heltberg, used cross section data analyzed and divided the country into two-part urban and rural section. They used Engle curve regression model and identified the price elasticity of LPG to be -4.59 and -0.105, in rural and urban area, respectively. On the other hand, the price elasticity of kerosene is to be -1.75 and 0.709, in urban and rural area, respectively. Finally, The income elasticity of LPG in urban was +1.11 and +2.70 in rural area. It indicates that the LPG in both areas or at country level becomes a luxurious good. .

Baltagi and Graffin (1983) conducted the research and grouped the country into low and medium income group; the income elasticities of the low income countries were larger than the middle income countries in the static model, but not in the dynamic model. However, price elasticity of the low income countries were smaller (in absolute value) then the middle income countries for both types of the models. This is because; energy is a necessary ingredient in development so the low income countries are less sensitive to price changes.

Mulenga (2000) studied, the income elasticity of household fuel energy are positive in East and South Africa. Indicating that no fuel is an inferior good i.e. an increase in the income of the household sectors at the country level, the demand for these fuel increase but. In Zambia, the result to be negative, due to most citizens uses other energy sources like charcoal.

Sathaye and Ketoff (1991) studied the consumption of petroleum products with the level of urbanization, the consumption of petroleum products increase when people tend to live in urban areas. In developing, countries fuel consumption pattern increases with expansion of urbanization. As the result, this increased consumption pattern similar with developed countries. (IEA, 1995).

Mureithi, Kimuyu, Ikira (1982), conducted to analyze the impact of increased energy costs on balance of payments, choice of production technology and real income in Kenya by using time series data for the period 1964-1976. These studies revealed that most of industry in Kenya used import energy sources in their production process. Which are affected by international fuel price. Under these studies, the energy cost was the major contributor of high raw material and product cost in Kenya. This high energy cost leads to high price of goods and services. As the result of high energy cost, the Kenya balance of payments highly affected.

Coming to Ethiopia, Asemerom Kidane (1991), proceeded by analyzing energy demand in rural and urban centers of Ethiopia using a two stage least square methodology. The model used to estimate demand for energy in rural and urban Ethiopia is based on the general household framework of micro economic theory. The model is closed by equating the demand for energy with the supply. He specified three demand functions for energy, namely, two demand functions for traditional energy sources and one for modern energy sources. The empirical results tend to support the theoretical prediction of the model. However, there is considerable variation in the direction and size of the elasticities depending on the type of energy source and on the urban or rural residence. Still the estimate suggested the economic variables, namely, price and wealth are important in explaining observed variation in demand for energy. Most importantly, the major finding of the study was that the price of traditional energy plays an important role in the consumption of fuel wood and other energy sources.

Similarly, another study was taken by Berket Kebede and Almaz Bekele (1999), the study indicated that the income elasticity vary for the different fuels. While the demand for charcoal, sawdust, dung cakes, electricity and LPG are income elastic, fuel wood and kerosene are income inelastic. In other words, the first group are luxurious, the latter are necessities according to study. The small income elasticity of kerosene is a clear indication of importance of this fuel for household energy sources. On the other hand, all own price elasticities are negative except for the LPG, and the latter is not statistically different from zero. The price elasticity for firewood, charcoal and kerosene are price elastic (own price elasticity greater than one) in urban i.e. the urban dwellers have an opportunity to substitute these goods by other energy sources.

This study, therefore, have identified a different factors that determine the demand for kerosene and LPG. And, the level of income and price of fuel are the main determinate factors for fuel consumption. It is also applied kerosene and LPG demand model synthesized from other models. The level of urbanization, population growth and foreign exchange earning are taken as an instrumental variable to the analysis of this study. Interestingly, the demand for kerosene and LPG needs a relevant policy initiative to the energy sector. On top of that, there is a lack of information regarding on empirical studies for the kerosene and LPG demand in Ethiopia.

CHAPTER THREE

HISTORICAL BACKGROUND OF ETHIOPIAN ECONOMY

3.1 The structure and characteristics of the Ethiopian economy.

The Ethiopian economy is fundamentally based on agricultural activities that are dominated by small farming practices and production is mostly for subsistence purposes. The agricultural sector is the major sources of production and employment for proportion of the population. (NBE Bulletin, 2005). From its economic contribution, the sector has the major share in terms of GDP. For instance From1964/65 to 2004/05 as a percentage of GDP, on average, the Sector constituted about 47.2% (Appendix - 1).

Under the imperial regime that lasted until 1974, the country was in land lord tenancy with capitalist system. During this period, the economy was in a period of relatively political stability. Then the economy (GDP) was growing 3.7% on average. In this period, agriculture was a dominant sector as compared with other sectors. AS a percentage of GDP, agriculture on average has constituted 68.1% while Industry, distributive services and other service were constituted 9.2%, 11.6% and 11.1%, respectively.

Similarly, in the same period agriculture, Industry, distributive sector and other services sector on average grew by 2.0%, 6.9%, 8.0%, and 7.2% respectively; this implies that the growth rate of distributive sector was higher than other sectors. Consistently the per capita income on average grew by 1.4% with only one year negative growths due to this period of political instability. (Appendix -1).

When the Derg military power came to power in 1974/75, Socialist System became the main ideology. As a result, the major productive industries including those edges in production, Export and agriculture sector were nationalized and replaced by government owned production and export promotion in socialist period, the economy (real GDP) was growing at 1.9% Per annum on average. The Sectoral bases of agricultural production grew by 1.6% Per-annun during the period while industry, distributive services and other services grew 1.4%, 1.0% and 4.1% per annum, on average, respectively. Of the five years negative growth rate in GDP, three of them were years of negative growth in agriculture, while all other sectors declined sharply leading to a negative growth rate in GDP and per capital income. As compared to the imperial era, the growth rates of all sectors were lower in the Derg reign. The share of Industry, distributive services and other service to GDP were higher in the Derg period while the share of agriculture was lower. It can also be observed that the average real GDP growth of the Derg regime was 1.9% per year compared with an average population growth of 3% leading to a net decline in per capital income of 0.7% per annum (Appendix I). The growth of both real GDP and per capital income in the Derg reign was lower as compared with the imperial era. The decline of the per capital income was mainly attributed by increase the in number and rate of population.

EPRDF took the power in 1990/91, in this period, initiated the recent economic reform. The state objective of the economic policy for transitional period issued on November 1991 by TGE include establishing peace and security, encourage growth and reduce poverty. To his effect, the government aimed at replacing the previous centrally co manned Derg economy with a market based economy through rationalizing the role of the state in the economy by encouraging private Investment, mobilize external resource, and creating macro economic and Sectoral polices. To achieve the state objective, agriculture was taken as the engine and driving forces of growth and development under strategy of agricultural development led industrialization (ADLI) in tandem with structural adjustment programme Polices (SAPP).

Agriculture has remained the dominant sector and takes the highest share in terms of contribution to GDP. The average growth rate of agriculture in the EPRDF period was 2.9%, while in the imperial and Derg period it was 2% and 1.6%, respectively. Therefore, this indicates that agriculture has performed better during the EPRDF period. In contrast, Industry and Distributive sector were growing by about 7.6%& 7.3% in each. While other Services sector (banking, Insurance, Public administration and social services) were growing by 8.1%. This shows that industry, distributive sector and other services sector during the EPRDF period have performed better than the Derg period. (Appendix -1). In terms of real GDP and per capital income growth, the present government is well performed as compared with the last two governments.

Ethiopia is one of the poorest countries in the world. Nevertheless, recent assessment indicated that, the economy have recorded some promising result with respect to the growth rate of the economy. Between 1990/91 to 2004/05, the real GDP of Ethiopia grew at an average rate of 5.5%. Excluding year 1991/92, which was the year of highest political instability in the country, the average growth rate registered 3.5% with a per capital GDP growth rate on average. In 1992/93 and 2003/04, the highest GDP growth rate was 12% and 12.3%, respectively (Appendix 1).

3.2 Energy and Economic Development

The need to determine the relationship between energy and economic growth derives from the increasing realization of importance of energy to the economic development. "Energy is vital to economic development" the share of modern or commercial energy in development process will increase because of rapid growth of inherently modern fuel using sectors of the economy. (Dunkely and Hock; 1987) in the developing countries (like Ethiopia), poverty can not be reduced with out the greater use of modern form of energy. For instance, even now, around 2.4 billion people have no access to modern fuel and electricity relying on traditional fuel such as dung and fuel wood. (World Bank, 2000).

Hence, several studies undertaken to show the relationship between energy and economic growth in the world. (Leach, etal 1990, Dunkerly 1987, Arima 1994, Balabanof 1994). Common of these studies in finding the income elasticity of energy demand generally tends to be highly elastic and greater than unity, where as estimated price elasticities have been different from zero and very inelastic. The implication being that the fuel are necessary good in their economic activities.. Analogously price elasticity of energy demand is far less responsive to price change. (Dr Obas Johe. et.al, 2000).

Petroleum is one of the valuable commodities in the world, it has many advantage to man kind. Its economic value is to use for transportation activity, Industry, agriculture, service sector and communication etc .it is also touching every aspect of our daily life (World Bank, 1999).

The level of petroleum consumption is directly related with economic development and the number of population. Table 3.1 shows that from, 1964/65 to 2004/05 the Ethiopia Economy (GDP) went up from 6,121.3 Billion Birr 20,732.7 Billion Birr, and the number of population went up from 26.0 Million to 73.0 Million people in given years. Similarly, the refined and imported petroleum increased from 262,310 metric ton in 1964/05 to 1,248,092 metric tones in year 2004/05. (Appendix -5) Therefore, increases in the level of economy or GDP and population have an impact on petroleum consumption.

Table 3.1 Economic Sector, Total Population refined and imported petroleum.

GDP by economic sector, population refined and Imported petroleum	**1964/65**	**1974/75**	**1984/85**	**1994/95**	**2004/05**
Agriculture (In million Birr)	4,320.4	5,083.6	4,679.0	6,284.0	9154.8
Industry(In million Birr)	508.5	833.2	1,284.8	2,412.5	2228.6
Distributive (Transport communication) (In million Birr)	667.3	1,166.7	1,404.6	1,757.3	3160.3
Other Services (HH, Bank, Insurance) (In million Birr)	625.1	1,203.8	1,908.5	3,190.5	6189.0
GDP (In million Birr)	6,121.3	8,287.3	8,676.9	12,644.4	20,732.7
No of population (In million)	26.0	32.7	40.73	54.65	73.0
Per capital GDP (in hundreds birr)	235.4	253.4	213.0	231.4	284.0
Total Refined and Imported petroleum (In metric tone)	262,310	551,110	853,332	890,104	1,248,092

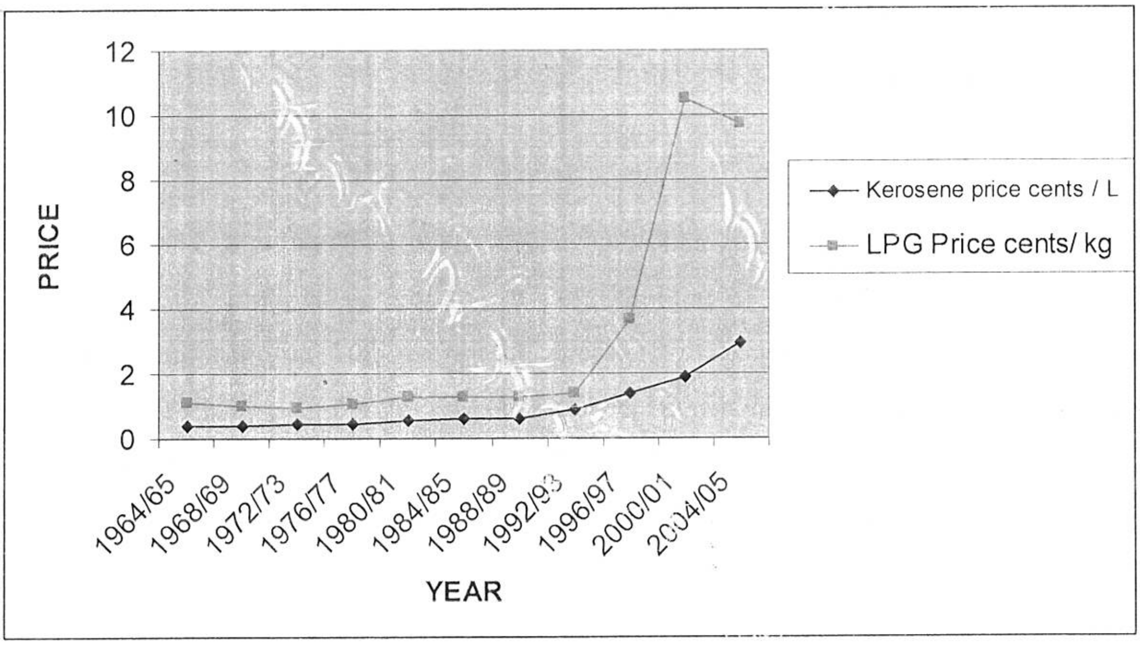
Source NBE and own computation

3.3 increase Effects of petroleum price on Economic growth and Balance of payment.

Energy pricing in Ethiopia, as in any other countries, is an effective instrument for implementing policy. In the energy pricing policy, an important consideration is that energy must be delivered to the point of end use and made to the consumers. However, it is recognized that a prohibitive price may lead to inefficient utilization of resources or may make future investment in the resource un-economic. Energy pricing is used as a tool to affect energy conservation, environmental protection, and as means of encouraging exploitation and use on natural resources. For instance, biomass energy prices depend on supply and demand conditions. Charcoal and fuel wood prices in urban areas fluctuate with availability of these resources. But the general observation is that the prices of these sources are generally rising overtime.

Before 1991, supply of petroleum products was characterized by inconsistent due to intensive civil war of Ethiopia, no imports of large amount of petroleum products. These leads the government rationing the petroleum products to consumer in year between 1984/85 to 1988/89 to relief supply falls. The rationing petroleum product creates black market for petroleum products in a country. As the result, the EPRDF government takes measure to stable the price of petroleum through cross subsidization. (MOFED, 1999.268).

Fig 3.1 Kerosene and LPG price (cents/ liter)



Source EPE, own computation, Appendix 2

Fig. 3.1, shows on average, the price of both fuel types was increasing from year to year. Domestic price change is mainly depends on the prices of world oil market. In all years the price of kerosene was lower than LPG. The kerosene retail prices are tightly controlled by the Ministry of Trade and Industry.

Prior to October 1992, petroleum prices have been fixed in Ethiopia by Ministry of Trade and Industry. The prices were fixed in 1991/92. The price structure in 1991/92 was affected following the devaluation of Birr. In October 1992, price revision enabled product prices reflect actual costs for the first time. This is shown in **table 3.2,** Price revision were made to reflect economic value of the petroleum products.

Table 3.2 Kerosene and LPG retail price structure (Birr /Litter)

Product type	1980 to 1992	Oct. 1992	1993/94	1994/95	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	% change
Kerosene	0.60	0.90	0.90	1.0	1.25	1.40	1.40	1.40	1.45	1.90	1.95	2.00	2.00	2.92	160.38
LPG	1.30	1.30	1.40	2.0	2.50	3.69	3.69	3.69	3.69	10.48	10.10	9.38	9.57	9.74	321.48

Source: EPE, Addis Ababa retail price.

In line with, the government of Ethiopia shifts toward a market economy; there have been two prices adjustment in 1992 alone. These adjustments reflect first, an increase in the transportation allowance to distributors, to reflect the 70% increase in road tariff rates affected in April 1992 and second, the currency devaluation from Birr 2.07/US dollar to Birr 5.60/US dollars on October 1992, the first devaluation in over 20 years. (Ministry of Mines and Energy, 1997: 12). The government has already started to revise petroleum price every three months. The revised prices are based on import parity price, transportation and distributive costs.

The revised Petroleum prices was took many times from 1992/93 to 1997/98, the main objective of the pricing system during these periods was to set prices properly and to reflects economic values of the fuel products ,to facilities the supply and distribution of petroleum products. (MOFED, 1999).

In September 1998, the government opened an account called "Petroleum Stabilization fund" account. The main objective was to put excess money in this account when the world oil market price became lower, and to be paid from it when the price goes up. It is believed that this account helps to stabilize the rise of domestic price and make stable for some period.

In short, starting October 1992 to 2004/05, the government changed the domestic price for ten times. Accordingly the percentages of Kerosene price and LPG were160.38% and 321.48% respectively (table 3.2). This implies that the world market price of commercial energy is increasing form time to time and its demand is also increasing. In addition higher petroleum price also produce higher price on domestic product and service sectors.

Increasing of petroleum price negatively affect the economy of developing countries like Ethiopia. To import petroleum products, we need large amount of foreign exchange and this brings a problem in trade balance. For instance, the country's balance of payment deficit was increasing from 1980/81 to 2002/2003. (Appendix 5). This deficit was financed by foreign borrowing and donation.

Table 3.3. The impact of petroleum import on Ethiopia foreign trade balance. (In million birr)

Description	1980/81	1985/86	1990/91	1995/96	1997/98	2000/01	2002/03
Value of good imported	1,384,234	2,201,265	2130305	7708246	9338459	16193600	15930000
Imported petroleum	325,322	252,534	210426	931865	2265515	2151326	2465000
Share of imported product	24.9%	11.5%	10.0%	21.1%	24.2%	13.1%	15.4%
Values of exported goods	851,509	923,816	542485	2539056	4141582	7981500	9777900
Trade balance	-532,725	-1,277,449	-1587820	-5169190	-5,196,877	-8,212,100	-6,152,100

Source- own computation

As shown in table 3.3 during the period 1980/81 to 2002/03, the payment for imported petroleum was 24.9%, 11.5%,10.0%, 12.1%, 24.2%, 13.1%, and 15.4%. respectively. This implies that imported petroleum share (like kerosene) has an impact on the country imported goods. Therefore, high petroleum price implies high foreign exchange requirement to import it. In addition, it has negative impact on the trade balance and depletes the foreign exchange reserves of the country. (Appendix -5)

3.4 ENERGY AND ENVIRONMENTAL INTERACTION

The relationships between human being and environment have strong interdependence. Man survives when the wider environment is conducive to his Survival. It is true also that the atmosphere plays key role in the exchange of radiation energy between the earth and the Sun. However, this important function of the atmosphere is being threatened by the rapidly increasing concentration of Green House Gases **(GHGs)** in the atmosphere as a result of human interference.

Emissions from commercial energy use are the single largest contributor to global warming, Energy related activities, Such as transportation, Contribute both directly and indirectly to generation of Carbon dioxide **(CO_2)** and other GHGs. Emission from agriculture and end use, Methane emissions from natural gas leaks and coal mines are significant and harmful as well. It is known that most of historical and current emissions of green house gases originate from developed countries. Ethiopia's green house gas emission is very small as compared as other developing countries.(Leach .G 1990)

According to United Nation for Developing Countries report indicators (2004), the GDP per unit of energy use from imported petroleum product (which measures energy efficiency) of Ethiopia in 1980 and 2000 was 3.4% and 3.9%, respectively. The carbon oxide per capital metric tone was 0 and 0.1 in 1980 and 2000, respectively. as compared with all developing countries, 1.3 and 1.9 metric tone in 1980 and 2000, respectively. The **CO_2** emission per capital in Ethiopia was very low. In addition, it was very low in Ethiopia as compared with world wide emission level of 3.5 and 4.1 for the same period, respectively.

Table 3.4 The residential and other service sector wise Ethiopia's GHGS emission in the Periods between 1990/1991-2004/05. (IN MT)

Year	**Kerosene GHG emission gm/litter**					**LPG GHG emission gm/kg**				
	Co	**CH4**	**TNMC**	**N2o**	**Total**	**Co**	**CH4**	**TMNC**	**N20**	**Total**
1990/91	34.6	15.4	7.7	1.15	58.85	14.0	1.5	1.5	0.04	17.04
1992/93	92.7	41.2	20.6	3.1	157.6	16.3	1.6	1.6	0.04	19.54
1994/95	148.7	66.1	33.1	4.9	252.8	18.3	1.8	1.8	0.05	22.15
1996/97	192.0	85.4	42.7	6.4	326.5	15.9	1.6	1.6	0.04	19.14
1998/99	177.1	78.7	39.3	5.9	301.0	4.1	0.4	0.4	0.01	4.91
2000/01	202.1	89.8	44.9	7.8	344.6	25.5	2.6	2.6	0.06	30.76
2002/03	242.3	107.7	53.8	8.1	411.9	27.9	2.8	2.8	0.07	33.57
2004/05	299.7	133.2	66.6	9.9	509.4	42.2	4.2	4.2	0.10	50.7
Total	1,389.2	617.5	308.7	47.3	2362.7	164.2	16.5	16.5	0.41	197.6

And

Year	Wood GHG emission gm/kg					Charcoal GHG gm/Kg				
2000/01	6998	437.7	787.2	5.2	82,224,800	581	17.5	8.7	0.09	6,073,000

Source IPCC and own computation.

There was a general increasing trend of GHG emission in Ethiopia in period 1990/91 to 2004/05. The relative composition of GHG emission for year 1990/91 to 1996/97 and 1996/97 to 2004/05 show that total (gross) GHGs emission increased by 454% and 56%, respectively for kerosene. Similarly, Increased by amount of 12.3% and 164.9%. respectively for LPG.

In Ethiopia, the total amounts of GHGs emission from period 1990/91 to 2004/05 was 0.002MT for kerosene and LPG with 0.00019MT .on the other hand, the GHGs emission from wood and charcoal that used in 2000/01was (82 MT and6 MT) respectively. This result shows the emission of GHGs from kerosene and LPG that are used by household and service sectors is very small than the GHGs emission from wood fuel and Charcoal. (EPE (2000), FAO (2000), IEI (2004)).

3.5 Commercial Energy in Ethiopia.

During pre-reform period, import and processing of crude oil and the task of whole sale distribution was the responsibility of the Ethiopia petroleum corporation. Its operation was under the supervision of the ministry of Mines and Energy. In the post-reform period, it was given a status of public enterprise to be managed and supervised by a Board Management and Ethiopia Petroleum Corporation has been renamed as the Ethiopia Petroleum Enterprise (EPE).

EPE played a very important and prominent role in the national economy, within its capacity it has done everything possible to ensure adequate and reliable supply of petroleum to satisfy consumers need. Until 1978, all the oil need of the country was covered by Assab refinery at an average production rate of 45,000 metric tones of products per year. However, from 1978 to 1991 the country's demand for oil became beyond the capacity of the refinery and the balance was imported as refined products. During this period, the balance was 700.000 metric tons per annum on average (EPE, 2000).

Assab refinery was governed by the Ethiopian government before 1991, but in 1991 the Ethiopian government gave the Assab refinery to Eritrea when Eritrean decided to independent from Ethiopia. As the results of Eritrean independent, the Ethiopia government tends shifts to import different petroleum products from abroad through EPE. The products were liquid petroleum gas (LPG), Motor gasoline, Jet fuel, Kerosene, Automotive diesel oil (Gas oil), in land fuel oil, export fuel oil, marine fuel oil and asphalt used for road and construction activities within the country. (EPE,,2000).

Since July 1997 Ethiopia's petroleum product imports have been solely confined to imports of refined petroleum products the suspension of petroleum refining at Assab is exclusively made for economic reasons and it benefited both Ethiopia and Eritrea. According to one opportunity cost calculation, the net saving by direct import of refined products is around 10 millions USD (MOFED, 1999). By so doing, EPE has kept the country from heavy expenditure of foreign currency which would have been spent on importing crude petroleum. Most importantly, to avoid shortage and in convenience, EPE has built fuel depots in Bahirdar, Gondar, Shashemene, Kombolcha, Agaro, Gambella, Adigrat, Welayta and Nekemete.

Ethiopia lacks domestic petroleum sources and all its oil need is fulfilled through importation. This importation uses a significant part of its foreign exchange although Ethiopian's petroleum consumption is among the lowest in Africa. For instance, 1980/81, the imported petroleum product used up 40.5%, in 1990/91, 38.8%, in 2000/01, 26.9%, and in 2004/05 with 19.3% of total export earning, respectively. These figures indicates that the improved export earning caused by exporting different items and expand export opportunities, but, still, using large amounts of foreign exchange for importing the petroleum product to Ethiopia (Appendix -5).

As presented Table 3.5, we compared the average consumption of petroleum products from 1980/81 to 2004/05. During 1980/81 to 1992/93 and 1993/94 to 2004/05, Kerosene consumption increased from 5.5% to 18.8% and LPG went up from 1.0% to 2.0%. Contrary, the consumption of jet fuel, gasoline and inland fuel oil went down from 15.3 % to 5.2%, 18.5 to 15.2% and 12.0% to 9.2%, respectively. In 1980/81to 1992/93and 1993/94 to2004/05, the consumption kerosene and LPG went up by 241% to 100%, respectively between the two categorized periods.

The consumption pattern of kerosene and LPG is directly related with the development of economic activities i.e. when the countries tends to move more urbanize,the economic activity of individuals changes from traditional to modern life, due to the increase the prices of biomass fuel in urban areas, etc. as the result, kerosene and LPG become the most preferable energy source to urban dwellers. Similarly kerosene used for lighting purpose where no electricity in rural and remote areas of Ethiopia. On the other hand, the decline in consumption share of other petroleum products such as Jet fuel is mainly attributed that fuel used by jet for defense activity is decreased due to stopping of civil war between Ethiopia and Eritrea. On the other hand, the consumption of inland fuel oil become decline where the industries that using electricity for their energy sources.

Table 3-5 consumption of petroleum product by product type.

Petroleum products	In 1980/81-1992/93 Average annual product in %	1993-94-2004/-05 Average annual product in %
Kerosene	5.5	18.8
LPG	1.0	2.0
Diesel	46.5	49.5
Gasoline	18.5	15.2
Jet fuel	15.3	5.2
Inland fuel oil	12.0	9.1
Other	1.2	--

Source – EPE, Own computation.

The Regional distribution of petroleum consumption in. retail sale of petroleum is categorized under 6 business regions of the country as used by EPE and the companies. These regions are Addis Ababa, North, South, East, West and central regions.

From table 3.6 we observe that the consumption of petroleum in Addis Ababa on average decreased from 40.2 to 38.1%, followed by the central region whose share declined from 19.0% to 17.0% in the given two periods, similarly the Easter region also went down form 17.1% to 16%. On the other hand, Northern, Western and Southern region consumption, on average increased by 0.5%, 0.7%, and 3.7%, respectively. (Appendix -3). This was because of the size of Addis Ababa decline, the central and eastern region shifts to Southern Parts when the country implements Federalism. In line with, Northern, Western and Southern region have Shown increasing consumption due to urbanization, investment growth, population growth etc.

In terms of petroleum station different companies(Shell, Mobil, Agip, Total, NOC, Y.B.P) has installed their stations in different parts of the country to whole and retail purposes of petroleum products, and their distribution depends on economic and infrastructural developments of the regions.

Table 3.6 Regional consumption of Petroleum (in percent)

Region	1985/86-1994/95	1995/96-2004/05
Addis Ababa	40.2	38.1
Central	19.0	17.0
Eastern	17.1	16.0
Northern	10.7	11.0
Western	8.2	8.9
Southern	5.1	8.8

Source- EPE, Own Computation.

The consumption of Kerosene and LPG for residential and other services sectors are increasing form time to time, from Table 3.7, we look at kerosene and LPG Consumption growth by regions indicate that Kerosene consumption of north region registered the largest growth about 384.6%, followed by Eastern region and Southern region, 266.4% and 188.2 %, respectively between the two given years. Similarly, the consumption growth of the given region like Eastern, Northern, and Western region have shown 358.1%, 349.0% and 326.1%, respectively on the same period. As the result, the consumption of Kerosene and LPG increased larger proportion in Northern, Southern and Eastern than the region of Addis Ababa and Central region. In line with, the annual growth consumption of the given six regions as a whole, on average, the consumption of kerosene went up by 50.1% in 2003/04 from year 1993/94. In addition, the consumption of LPG in year 2003/04 has grown by 95.0% from year 1993/94.

Table 3.7 kerosene and LPG consumption growth by region

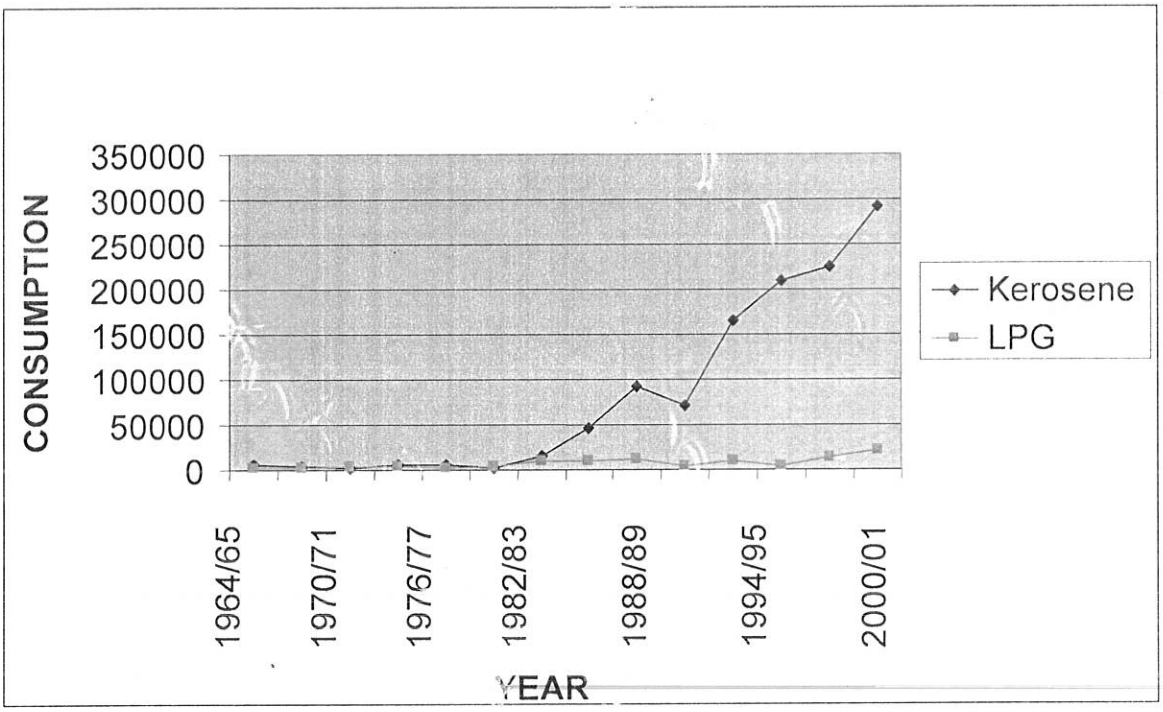
Region	Kerosene(MC)			LPG(MT)		
	1993/94	2003/04	Average annual growth In %	1993/94	2003/04	Average annual growth in %
Addis Ababa	61,866	84278	36.0	7804	8312	6.5
Central	37932	46182	21.7	930	3948	324.5
Eastern	21,489	49307	129.5	771	3532	358.1
Northern	5625	27261	384.6	508	2283	349.4
Western	6,527	23916	266.4	390	1662	326.1
Southern	9902	28533	188.2	250	1038	319.2
Total	143,341	251,100	50.1	10,653	20,775	95.0

Source own computation

Fig 3.2.shows, the consumption of kerosene and LPG have grown almost similar from year 1964/65 to 1986/87, but from year 1987/88 to2004/05 increasing from time to time except the year 1989/90. This increasing consumption brings from high level of urbanization, population growth, investment growing etc. (Appendix -6)

From year1989 /90 to year1991/92, the consumption of Kerosene and LPG were decreased due to an intensive civil war between Ethiopian and Eritrean, after the civil war stopped, the EPRDF government took the power and liberalize the market, set economic reform, and make new energy policy. As the result, the consumption of Kerosene and LPG has been growing from year 1991/92 to year 2004/05.

Fig 3.2 Consumption kerosene (in MC) and LPG (in MT) in Ethiopia.



Source EPE, own computation

CHAPTER FOUR

THE DATA AND METHODOLOGY

4.1 The Data – Sources and Types

The study employed a time series data from different sources that covered the period from 1964/65 to 2004/05. The major sources of data for the analysis are statistical abstracts and journals, different annual Bulletins, reports, etc. These materials collected from Ministry of Mines and Energy, Ethiopian Petroleum Enterprise (EPE), Ministry of Trade and Industry, the Ministry of Finance and Economic Development (MOFED), Ethiopian Rural Energy Development and Promotion Center, Central Statistic Agency (CSA), National Bank of Ethiopia (NBE), Ethiopian Custom Authority and Addis Ababa University library

4.2. Methodology

4.2.1. Model Specification

4.2.1.1. Kerosene and LPG Demand function

The theoretical foundation of Kerosene and LPG demand (Specially Kerosene demand) model used in this study is based on different research by Michael Kennedy (1974), Masayasu, Ishigure and Akiyama (1995), Antonete D's etal (2004)' Gately and Streifel (1997) and Hosier.R.etal (1993). All of them agreed that kerosene demand (K) is a function of the price of Kerosene (P_K) and Income(Y).

Accordingly, the static models are used by Michael Kennedy (1974) and Masa Yasu, Ishigure and Akiyama (1995) attempt to analyze the price and Income elasticity of demand for Kerosene and LPG. The model considers Kerosene demand (K) is a function of the real price of Kerosene (P_K) and real income. (Y):

$$K=f(P, Y) \text{ --(4.1)}$$

In this case, the Authors agreed that the two variables are the major determinants of Kerosene demand.

Similarly, Michael Kennedy also considered a dynamic model specification like Kerosene demand is a function of its lag variable as K_{t-1}, then it shows below

$$K = f(P, Y, K_{t-1}) \text{------------------------------------} (4.2)$$

Considering equation (4.2) above, the implication is that, prices and income have similar lag structures, If this assumption is relaxed, the result is a distributed lags dynamic of the general form.

$$K = f(\Sigma P_{t-1}, \Sigma Y_{t-1}) \text{------------------------------------} (4.3)$$

Then, Michael Kenedy (1974) modeled demand for both fuel. He began by a simplistic model which assuming that demand is homogenous of degree zero in price and Income and deflected price and Income into real value which yielding a log-linear simple static model as

$$\ln K = C + \beta \ln P + \alpha \ln Y + \varepsilon. \text{------------------------------} (4.4)$$

Where, **K** is kerosene consumed, C is constant, P is real price of kerosene, Y is real income and ε is random error term.. To distinguish between the effects of a rise in GNP due to an increase in population, He took the Number of people into consideration and come up with the equation (4.5).

$$\ln(K/POP) = C + \beta \ln P + \alpha \ln(Y/POP) + \varepsilon. \text{--------------------} (5.5)$$

Dr. Obso and Ebohom (2000), L. price, etal (1998), Barnes, etal (1994), Tobies, etal (2002), Mark Rusenezeweig (1998), in their study analysed Kerosene demand is a function of Population growth and Urbanization level. Like

$$K = f(POP, U) + \varepsilon \text{--} (4.6)$$

Where K is Kerosene consumed, POP is Population growth; U is level of urbanization and ε is error term.

A. Senehadji .etal (1991), in his study employed Kerosene demand is a function of foreign exchange earning through export like

$$K = f(FEE) + \varepsilon \text{--} (4.7)$$

Where , FEE is foreign exchange earning.

Accordingly, different studied by different Authors analyzed that demand for Kerosene and LPG as a function of Price of the fuel, Income, Population growth, level of Urbanization, foreign exchange earnings and others, then the model is as follow

$$K = f(P_k, P_{LPG}, Y, POP, U, FEE, \varepsilon) \text{----------------------------} (4.8)$$

And the above given equation (4.8) and format that also help to use the model for LPG, as follow,

$$LPG = f(P_{LPG}, P_K, Y, POP, U, FEE, \varepsilon) \text{------------------------} (4.9)$$

Where, LPG: - Liquid Petroleum Gas Consumed

P_{LPG}: - Price of Liquid Petroleum gas

In general, Smith and Person (1995), acknowledge the fact that, in principle the demand for any particular commodity is determined simultaneously by all other variable of the economy. The implication is that inclusion of additional explanatory variable, will improve that realism of the model and its performance at least for forecasting. Using equation (4.8) and (4.9) and expressing the variable in a natural logarithmic form, we attempt to look at the relative contribution (Elasticity) for each variable, to the consumption of both fuels; the model to be estimated is specified as

$$LKCPC_t = \beta_0 + \beta_1(LRP_k)_t + \beta_2(LRP_{LPG})_t\text{[1]} + \beta_3(LRIPC)_t + \beta_4(LPOPG)_t + \beta_5(LU)_t + \beta_6(LRFEE)_t + \varepsilon_t \text{ ------------- } (4.10)\text{[3]}$$

In equation (4.10) , KCPC is Kerosene Consumption Per Capital, RPK and RPLPG are real price of Kerosene and LPG, respectively, RIPC is real income per capital, POPG is population Growth, U is Level of Urbanization, RFEF is Real foreign Exchange earning and ε is the error term.

Similarly, the LPG demand log-linear equation can be given as

$$LLPGCPC_t = \alpha_0 + \alpha_1(LR_{LPG})_t + \alpha_2(LRP_K)_t\text{[2]} + \alpha_3(LRIPC)_t + \alpha_4(LPOPG)_t + \alpha_5(LU)_t + \alpha_6(LRFEE)_t + \varepsilon_t \text{ ---------------------------- } (4.11)\text{[4]}$$

Where, LPGCPC is Liquid Petroleum Gas Consumption Per Capita and the other variables are defined as before.

1, 2 the LPG Price (P_{LPG}) is included in the kerosene equation to capture the substitution effect between Kerosene and LPG. The same case applies to the kerosene Price (P_k) in the LPG equation.

3, 4 the variable are in logarithms since this has to be the most appropriate functional form and further more has to convenience of giving constant elasticities (the elasticites of demand are assumed to remain constant.)

In the literature review attempt was made to give the variable which influence the demand for energy (Kerosene and LPG) in the economy. A fall in consumption of both fuels is likely to follow higher prices. It would also be expected that kerosene / LPG consumption can increase due to growth in income (GDP), Population growth, Urbanization, Foreign exchange earning. There fore, the set of relation ship described in the literature review and model specification constitute the basis for the hypothesis to be tested in the study.

Finally, the anticipated signs of the coefficients will be $\beta_1<0$, while β_2, β_3, β_4, β_5 and β_6 are >0 for kerosene demand. Similarly $\alpha_1<0$, while α_2, α_3, α_4, α_5 and α_6 are >0 for LPG demand.

4.2.2. Econometric Methodology.

Stationary and Non-Stationary series

Time series data have become so frequently and intensively used in empirical research. In dealing with time series data is common practice to test the hypothesis that the process generating a series has a unit root versus stationary. If the variables are stationary, we can apply the ordinary Least Square method. if the variable entering a regression are not stationary. These result that are not obtained using Ordinary Least Square technique would be ''spurious'' (Leybourn and Newbold, 1999)

A series is said to be covariance (weakly) stationary if it exhibits the following three criteria

i) Exhibits mean reversion in that it fluctuates around a constant long run mean.

ii) Has finite variance that is time invariant, and

iii) Has a theoretical correlogram that diminishes as lag length increases. Moreover, the impact of stationary series is temporary while for unit root is permanent.

On the other hand, a series is non-stationary (Unit root) if it has no long run mean to which the series reverts, has a variance that is time dependent and a slowly dying out sample correlograms (Enders, 1995). Thus, the first thing that one has to do for this estimation of time series data is ensuring whether the series is stationary or not. Because, estimation techniques applied to estimate the relationships between variables in the presence of unit roots result in regression that are spurious.

Spurious regression is a situation in which results obtained from the regression model that there are statiscally significant relationship between the variables, has a higher $\mathbf{R}^2$, But without meaningful causal relation or contemporaneous correlations (Harris, 1995).

One possible Solution of avoiding unit-root problem is through a transformation of variables in the form of differencing to remove the non-stationary (Stochastic trend). Accordingly , if the series is differenced once to induce stationary,[5] it is often referred to as integrated of order one I(1);on the other hand, if they are differenced, they become stationary.[6] most economic variables are however, in the category difference stationary process(maddala, 1992). Such a procedure gives the short run dynamics while ones interest may be in determining the long run parameters. But, if the series is stationary at levels, it is often described as integrated of order zero I (0). Generally if the series is differenced d time to attains its stationary, it is referred as integrated of order d; I (d).

Test for Unit Roots.

There are several mechanisms that aid to identification of unit root in time series date. The most commonly used test for order of integration is the DF (Dickey Fuller) test and ADF (Augmented Dickey fuller) test. The Dickey fuller approach tests the null hypothesis that the series is non-stationary against the alternative of stationary. Based on DF test, the series Y_t becomes stationary if the absolute value of δ in the equation (4.12) is less than 1. It will not be stationary when the absolute value of is δ greater than or equal to 1.

$$Y_t = \delta Yt\text{-}1 + \varepsilon_t \quad \text{------------------------------------} (4.12)$$

The DF test is based on the following regression equation.

$$\Delta Y_t = \gamma Y_{t-1} + \varepsilon_t \quad \text{------------------------------------}(4.13)$$

$$\Delta Y_t = a_0 + \gamma Y_{t-1} + \varepsilon_t \quad \text{------------------------------------}(4.14)$$

$$\Delta Y_t = a_0 + \gamma Y_{t-1} + a_2 t + \varepsilon_t \quad \text{------------------------------------}(4.15)$$

---

5. A stochastic trend can be removed by the first differencing, since x_t is then trend less as $x_t = a+U_t$. X_t is then referred to as a difference stationary process(Tomas, 1997).
6. A deterministic trend can not be removed by first differencing, Since this does not remove t-from the process. If $xt = \alpha + B_t + U_t$, and x_t Subject to such a trend then it is said to be a trend Stationary process. (Thomas, 1997).

Equation (4.13) is a pure random walk model, Equation (4.14) adds drift or Intercept term and equation (4.15) includes both drifts and a linear time trend.

The above equation (4.12) can be transformed to equation (4.13) to make it more sensible for economic hypothesis testing. Hence equation (4.12) is subtracted by Y_{t-1} to generate equation indicated in (4.13). In this case, $\gamma=1-\delta$. The Dickey fuller test then states the will hypothesis as γ is statistically equal to zero against the alternative of $\gamma<0$. Rejection of $\gamma=0$ in favor of the alternative $\gamma<0$ indicates that Y_t is integrated of order zero. But, if the null $\gamma=0$ not rejected, then the process is not stationary and one needs to test for higher order of integration. However, if the error term in the above equation is not white noise i.e. doesn't have a zero mean and constant variance; however, the DF test will not be valid. This is the major weakness of DF test, in other words, the disturbance term E_t is assumed to be independently and identically distributed (IID). If this assumption is incorrect then the limiting distributions and critical values obtained by DF test cannot hold. The Augmented Dickey Fuller (ADF) test, however, take care of this problem by including the lagged left hand side variable as an additional explanatory variable to approximate the auto correlation. The ADF test procedure is identical to the standard DF test procedure. Then the ADF has the following form. (Harris 1995)

$$\Delta Y_t = a_0 + \gamma Y_{t-1} + a_2 t + \Sigma^{P}_{i-1}\beta_i \Delta Y_{t-1} + \varepsilon_t \text{-------------------(4.16).}$$

Therefore, if $\delta_1=0$, the Y_t sequence contains a unit root. So, after estimating the equation by OLS, the resulting t-statistics are compared with the critical values given by the ADF table, if the t-statistics computed is less than the critical value, then the series can be said non-stationary (Enders 1995).

Although DF and ADF unit root tests are widely known and used in the literature; however, there are other unit root tests which can use those widely to stationary tests i.e. Phillips-Peron (pp) tests, Sargen-Bhargaua, Variance ratio test can be representative example other than ADF and DF tests (Maddala et al 1999).

Philips-Peron test has serious "size distortion" problem in finite sample size when the data generating process has a predominance of negative auto correlation in the first difference (De. Jong et al 1992) as quoted in Maddala et al (1999). This has often been taken to suggest that the Philips - Peron may be less reliable than the ADF tests where there is pre-dominance of negative correlation in first difference (Maddala et al 1999).

Moreover, Philips-person has been suffering from the problem of "size distribution and lack of power of unit root tests" (Maddala et al 1999). They argued that the Philips-person test displays size distortion the presence of negatively correlated moving average error with having a low power of 0.10 against the trend stationary alternatives. In contrast, the ADF test has the power of approaching 0.33 and thus likely to be more useful in practice. (Maddala et al 1999).

In this paper, stationary test is undertaken by ADF because, as discussed previously, it is better then DF and Philips person test and it is widely practiced in most literature, moreover, ADF test can be easily accessible in various Econometric software, such as PCGIVE and PCFIML than the others. Therefore, the ADF test for unit root is selected in this paper.

Co-integration and the Error-correction Model (ECM)

In order to obtain both short run and the long-run relationships, one can use to what is known as co integration. The concept of co-integration implies that even if many economic variables are non-stationary, their linear combination may be stationary (Cutumbersone , et al ,1992). If this holds, we say there is long run relationship (Co- integration) between the variables involved.

According to Engle and granger (1987), Co integration is defined as situation where two or more time series are linked to form an equilibrium relationship over span of time. In other words, even if the individual time series data are non-stationary, their linear combination could be stationary and they will move closely together overtime to make their differences stable (stationary)

Lack of co integration on the other hand suggests the absence of long-run link[7] between the two variable and this leads to the problem " Spurious correlation." , more formally, If two variables say X_t and Y_t are I(d) and error term E_t is I(0), then the two series are said to be co-integrated of order(1,1) .

There are two common methods of testing for co-integration. These are the Engle and Granger (1987), {hence forth called EG two step procedure} and Johansen (1988) maximum likelihood method.

In EG two-step methodology, [8] the residual from a long-run model OLS regression is tested for unit roots based on ADF statistics. Next, order of integration is tested whether the error term $\varepsilon_t \sim$ I (0) against its alternative $\varepsilon_t \sim$ I (1) from the first OLS regression.

The EG method is applicable only for single co-integration vectors; moreover, it pre-assumes that the variable in the right side is weakly exogenously (determined outside the model) while the left side (dependent variable) being endogenous. But in many instances, there exists endogenity character among variables and, inferences made based on such pre-supposition, may become some time misleading (Harris, 1995).

The EG procedure; However, is critized on grounds (Harris, 1995).

i) Tests for co-integration is likely to have lower power against alternative
ii) Infinite Samples, estimates of long run relationship are potential biased
iii) Inferences cannot be drawn using standard t-statistics about the significance of the parameters of the long run model. Because, since the procedure involves two steps, errors commuted in the 1st step are carried over to the next steps (Enders, 1995).

7, a failure to find co-integration does not necessarily mean that there is no long run relationship but only suggests the absence of long-run linear relationships (Harris 1995).

8, in testing for co-integration in EG approach, the 1st step is to estimate the Long run model and obtain the resulting residuals and the second step involves testing for the stationary of the residuals. If the residual is stationary, the series is co-integrated (Enders, 1995). ($\Pi = \alpha \beta$; rank of matrix Π)

By, using the Johansen's (1988) maximum likelihood estimators, the above pitfalls of the EG test can be avoided. In Johansen's procedure

i) It does not make a prior assumption about the existence of at most a single co-integrated vector; rather, it explicitly tests for the existence of multiple co-integrating vectors.

ii) It is set up on a unified frame work for estimating and testing co-integration relationships on the basis of the Vector Error Correction Mechanisms (VECM) approach. The VECM contains information on both the short and long run adjustment to changes in the variables in the model.

iii) It rests upon appropriate statistics for hypothesis testing for the number of co-integrating vectors and tests for restriction upon the coefficients of the vectors.

Therefore, my study applies the Johansen Maximum likelihood procedure to test for the existence of a co-integration Vectors(s). In the Johansen procedure, there is no a priori Categorization of variables as exogenous and endogenous. Hence, given equation are (4.10) and (4.11). It is possible to represent our variable by a vector X_t and our model as an unrestricted vector Auto regression (VAR) with K-lags (Johansen, 1995, 45).

$$X_t = \prod_1 X_{t-1} + \prod_2 X_{t-2} + \text{--------------} + \prod_k K_{t-k} + \Phi D t + U_t \quad \text{------}(4.17)$$

Where, X_t is an (nx1) vector of endogenous variable. II_i is an (nxn) matrix of parameter, and U_t is independent and normally distributed with mean of null vector O and Variance of Ω, i.e. $U_t \sim IN(O,\Omega)$. The deterministic terms D_t represents vectors of dummies and constants that are fixed and non-stochastic Equation (4.16) can be specified in VECM form as

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \Gamma_2 \Delta X_{t-2} + \text{-----} \Gamma_{k-1} \Delta X_{t-k+1} + \Phi D + \prod X_{t-k} + U_t \quad \text{-----}(4.18)$$

Where, estimate of **Γi** define the short run speed of adjustment, while $\prod$ contains the LR information, D_t represents Vectors of dummies, intercepts and pre-determined exogenous variables. If the rank (r) of $\prod$ is zero, no stationary linear combination can be identified and hence the variables in X_t are not co integrated. If $\prod$ has full rank, that is if $r = n$ where n is the number of variables entering the co-integrating space, it implies that each variable is "Co-integrated" to itself, and hence each variable is I (0), which is in contradiction with the fact that the variables are I(1).The interesting case is, however, where $\prod$ has a reduced rank, that is, there are $r \leq (n-1)$ co-integration vectors presents in β

$\prod$ may be decomposed into two matrices α and β, such that $\prod = \alpha\, \beta^1$, where α and β represents the speed adjustment to disequilibrium both can be reduced in dimension to (nxr)[9] . In this regard, β represents (nxr) vector of long run parameters that makes $\beta^1 X_t$ stationary and the (nxr) α -matrix constitutes the speed of adjustment to disequilibrium. Hence, $\prod X_{t-k}$ in equation (4.17)[10], is equivalent to $\alpha\, \beta^1\, X_{t-k}$ represents up to (n-1) linear combinations(co-integrating vectors) that ensure the convergence of the vector X_t to their long-run steady state path. (Harris, 1995, Cheremeza and Deadmen, 1997).

9, Once we know how many r linearly independent columns there are in $\prod$ (i.e. one we know its rank), we then known that the last (n-r) columns of ;are zero and thus that the 0.38Last (n-r) columns of B are non-stationary and do not enter equation (4.17 . Thus, it is in this sense that we can then reduce the dimensions of $\alpha$and β to (nxr).

10- for more analysis, equation (4.17) can be written out in full as

Table

$$\begin{pmatrix}\Delta X_{1t}\\ \Delta X_2\\ \cdot\\ \cdot\\ \Delta X_{nt}\end{pmatrix} = \Gamma_1 \begin{pmatrix}\Delta X_{1t-i}\\ \Delta X_{2t-i}\\ \cdot\\ \cdot\\ \cdot\\ \Delta X_{nt-i}\end{pmatrix} + \begin{pmatrix}\alpha_{11} & \alpha_{12}---- & \alpha_{1n}\\ \alpha_{11} & \alpha_{12}----- & \alpha_{1n}\\ \cdot & \cdot & \cdot\\ \cdot & \cdot & \cdot\\ \cdot & \cdot & \cdot\\ \alpha_{n1} & \alpha_{n2}--- & \alpha_{nn}\end{pmatrix} \begin{pmatrix}\beta_{11} & \beta_{21}------- & \beta_{n1}\\ \beta_{12} & \beta_{22}------- & \beta_{n2}\\ \cdot & \cdot & \cdot\\ \cdot & \cdot & \cdot\\ \cdot & \cdot & \cdot\\ \beta_{1n} & \beta_{2n}----- & -\beta_{nn}\end{pmatrix} \begin{pmatrix}\Delta X_{1t-i}\\ \Delta X_{2t-i}\\ \cdot\\ \cdot\\ \Delta X_{nt-i}\end{pmatrix}$$

a_{11} represents the speed at which ΔX_{1t}, the dependent variables of the VECM, adjusts towards the single long-run co-integration relationship ($\beta_{11}\, \Delta X_{1t-1} + \beta_{21}\, \Delta X_{2t-1}$ ----$+\beta_{n1}\, \Delta X_{nt-1}$). While α_{21} represents the speed at which ΔX_{2t} adjusts. and ΔX_{nt} shows how fast ΔX_{nt} responds to the disequilibrium changes represented by the co integration vector. Each of the r non-zero columns of α contains information on which co integration vector enters which short-run equation, and on the speed of the short-run response to disequilibrium on. (Harris, 1995, 98).

Finally, In the Johansen procedures there are two tests that help to identify the number of co integrating vectors, called. The trace (λ_{trace}) and the maximal (λ_{max}) statistics, These test are given as follows (Harris 1995).

$$\lambda\ trace\ (r) = -T \sum_{i=r+1}^{n} \ln(1 - \lambda i)$$

$$\lambda\ max\ (r,\ r+1) = -T \ln(1 - \lambda_{r+1}), \qquad r=0,1,2,\ldots,n-2,\ n-1$$

Where, λ_I = Eigen vectors,

T = number of observations.

n = the number of variables.

The trace statistics is used to determine whether there are at most r co integrating relationships while the maximal statistics tests the null-hypothesis of r co integrating vector against the alternative of r+1. The magnitude of λ_i is a measure of the strength of the co integration relations (denoted as $\beta_i^1 X_i$) are correlated with the stationary part of the model.

Other Diagnostic Tests

R-squared

The R-squared (R^2) statistic measures the success of the regression in predicting the values of the dependent variable within the sample. It is the fraction of the variance of the dependent variable explained by the independent variables. The statistic will equal one if the regression fits perfectly, and zero if it fits no better than the simple mean of the dependent variable. It can be negative if the regression does not have an intercept or constant, or if the estimation method is two-stage least squares.

Adjusted R-squared

One problem with using R^2 as a measure of goodness of fit is that the R^2 will never decrease as you add more regressors. In the extreme case, you can always obtain an R^2 of one if you include as many independent regressors as there are sample observations.

The adjusted R^2 penalizes the R^2 for the addition of regressors, which do not contribute to the explanatory power of the model.

Durbin-Watson Statistic

The Durbin-Watson statistic measures the serial correlation in the residuals. As a rule of thumb, if the DW is les than 2, there is evidence of positive series correlation. In contrast if the DW is greater than 2, there is evidence of negative serial correlation

F-Statistic and Probability

The F-statistic tests the hypothesis that all of the slope coefficients (excluding the constant, or intercept), in a regression are zero. The p-value given just below the F-statistic, denoted Prob (F-statistic), is the marginal significance level of the F-test. If the p-value is less than the significance level you are testing, say, you reject the null hypothesis that all slope coefficients are equal to zero.

A Breusch-Godfey or Lagrangeian multiplier (LM) test

This is test for serial correlation up to nth lags obtained be regressing the residuals from the original model on all regressors of that model and the lagged residuals.

An ARCH test

It is a test for autoregressive conditional hetroskedasticity. It has obtained by regressing the squared residuals from the model on their lags and the constant. ARCH in itself does not invalidate standard LS inference. However, ignoring ARCH effects may result in loss of efficiency.

Ramsey test for general misspecification. (RESET)

It is obtained by adding power if the fitted values from the model to the original regression equation. RESET is a general test for the following types of specification errors:

- Omitted variables: X does not include all relevant variables
- Incorrect functional form: some or all of the variables in Y and X should be transformed to logs, powers, reciprocals, or in some other way.
- Correlation between X and ε_t , which may be caused be measurement error in X, simultaneous equation considerations, combination of lagged Y values and serially correlated disturbances. Under such specification errors, LS estimators will be biased and inconsistent, and conventionally inference producers will be invalidated.

CHAPTER FIVE

Analysis of empirical results

5.1. Empirical analysis and results

5.1.1. Test for unit roots

Before any meaningful regression is performed with time series variables, it is essential to test the existence of unit roots in the variables and to establish their order of integration. The variables used in the analysis need to be stationary and/or should be co- integrated in order to infer meaningful relationship from the regression.

Several tests can be used to test for unit root, but widely acceptable and reliable are the Dickey-Fuller (DF) and the Augmented Dickey Fuller (ADF) tests. These tests help to detect whether a variable is stationary[11] or not. If a variable is stationary in level i.e. without running any differencing, then that variable is said to be integrated of order zero or I (0). Similarly, if it becomes stationary by differencing once, then the variable is said to be I (1) variables.

The Augmented Dickey Fuller tests for unit root indicate Table 5.1 Shows that, the null hypothesis of a unit root can not be rejected at level for all variables at 1% significance level. Where as, the null hypothesis of a unit root is rejected at first differences for the same significance level. This leads us to the conclusion that all the variables in the kerosene demand function are [I (1)] [12]. Similarly, Table 5.2 Shows that, the null hypothesis of a unit root can not be rejected at level for all variables at 1% significance level. Where as, the null hypothesis of a unit root is rejected at first differences for the same significance level. This leads us to the conclusion that all the variables in the LPG demand function are [I (1)] [12](See table 5.1 and 5.2)

Table 5.1 Results of unit root test for kerosene			
Variables	**Augmented Dickey Fuller**		
	with out drift and trend	**with drift only**	**with drift and trend**
lnKCPC	0.8094	-0.6294	-2.6068
lnRPK	0.0378	-2.3717	-2.0907
lnRPLPG	0.0888	-1.3679	-1.4501
lnRPCI	0.5648	-2.1634	-2.0980
lnPOPG	0.1186	-0.2334	-0.8529
lnLU	0.9904	-1.9572	-0.9797
lnRFEE	1.4119	-0.4446	-2.0970
ΔlnKCPC	-5.3862**	-5.4659**	-5.3991**
ΔlnRPK	-9.1065**	-8.9776**	-9.3840**
ΔlnRPLPG	-5.8891**	-5.8130**	-6.1537**
ΔlnRPCI	-5.6165**	-5.5782**	-5.5763**
ΔlnPOPG	-6.4775**	-6.3976**	-6.3115**
ΔlnLU	-3.1182**	-6.4935**	-7.5952**
ΔlnRFEE	-8.6340**	-9.2610**	-9.3554**
critical value			
1%	-2.624	-2.940	-3.531
5%	-1.950	-3.612	-4.216

**Denote rejection of the null at 1% level of significance

*Denote rejection of the null at 5% level of significance

---

[11] A process is said to be integrated of order d, denoted as I(d), if it has to be differenced d, times before it becomes stationary (Thomas, 1997)

[12] If two I (1) variables are co integrated, then their dynamic specification can be written as an Error Correction Model. (ECM), and vice versa, if the dynamic relationship between two I(1) variable can be written as an ECM, they are co integrated (Hendry, 1995).

Table 5.2 Results of unit root test for LPG			
Variables	**Augmented Dickey Fuller**		
	with out drift and trend	**with drift only**	**with drift and trend**
lnLPGCPC	0.3157	-2.4424	-3.1931
$lnRP_{LPG}$	0.0888	-1.3679	-1.4501
$lnRP_{K}$	0.0374	-2.3717	-2.0907
lnRPCI	0.5648	-2.1634	-2.0986
lnPOPG	0.1168	-2.2334	-2.8527
lnLU	0.9904	-1.9572	-0.9797
lnRFEE	1.4119	-0.4446	-2.0970
ΔlnLPGCPC	-3.1147**	-8.2449**	-8.1613**
ΔlnRPLPG	-5.8891**	-5.8130**	-6.1537**
ΔlnRPK	-9.1065**	-8.9776**	-9.3840**
ΔlnRPCI	-5.6165**	-5.5782**	-5.5763**
ΔlnPOPG	-6.4775**	-6.3976**	-6.3115**
ΔlnLU	-3.1182**	-6.4935**	-7.5952**
ΔlnRFEE	-8.6340**	-9.2610**	-9.3554**
critical value			
1%	-2.624	-2.940	-3.531
5%	-1.950	-3.612	-4.216

**Denote rejection of the null at 1% level of significance

*Denote rejection of the null at 5% level of significance

5.1.2. Co integration and Estimation of the long run model.

It is worth examining the data testing of the VAR before determining the co integration rank. One problem can be encountered in estimating the model is the choice of the appropriate lag structure of the variable in the model .if different lag structures produces white noise then the test for rival model will be used to select the appropriate lag, choose the minimum absolute value of AIC . Thus, the Shawart Bayesian Criteria (SBC), Hannan Quinn(HQ) Statistics and Akaike Information Criteria(AIC) are used and according to these tests, , the second lag selected as an appropriate lag in this analysis (see appendix 11)

The fact that the times series variables under consideration are not stationary at levels imply that the variables taken alone do not have the tendency to revert to their long run levels. Since the variables are ensured to be non-stationary at levels, or, are I(1) in table 5.1. The next step is to check whether any linear combination of the variables is stationary or not i.e. determine how many co integrating vectors exists. To do so we adopt the Johansen's frame work in which the variable lnKCPC, lnLPGCPC, lnRPK, lnPRLPG, lnRPCI, lnPOPG lnLU, lnRFEE can be represented as a vector auto Regression as

$$\begin{pmatrix} \Delta lnKCPC_{1t} \\ \Delta lnRPK_{2t} \\ \Delta lnRPLPG_{3t} \\ \Delta lnRPCI_{4t} \\ \Delta lnPOPG_{5t} \\ \Delta lnLU_{6t} \\ \Delta lnRFEE_{7t} \end{pmatrix} = \Gamma_i \begin{pmatrix} \Delta lnKCPC_{1t-i} \\ \Delta lnRPK_{2t-i} \\ \Delta lnRPLPG_{3t-i} \\ \Delta lnRPCI_{4t-i} \\ \Delta lnPOPG_{5t-i} \\ \Delta lnLU_{6t-i} \\ \Delta lnRFEE_{7t-i} \end{pmatrix} + \alpha\beta' \begin{pmatrix} lnKCPC_{1t-i} \\ lnRPK_{2t-i} \\ lnRPLPG_{3t-i} \\ lnRPCI_{4t-i} \\ lnPOPG_{5t-i} \\ lnLU_{6t-i} \\ lnRFEE_{7t-i} \end{pmatrix}$$

N.B The VAR model for LPG demand equation by substituting $\Delta lnLPGCPC_t$, into $\Delta lnkCPC_t$. the other Variables are the same as the kerosene demand equation.

Under the above formulation, the rank of the matrix r determines the number of co integrating vectors between the variables. The method used to determine the number of co integrating is the Johansen's (1988) technique based on maximum likelihood approach. The approach is only a variable in PC film version 9 and pcGIVE soft ware packages.

In estimating the model, the Johansen maximum likelihood procedure is used to test for co integrating and existence of a long run relationship between the variables in lnKCPC and in lnLPGCPC equation, the λmax test formulate the null hypothesis by verifying the existence of r co integrating vector against alternatives r+1, the other one is the λ trace test formulate, the null hypothesis i.e. there are number of distinct co integrating vector less than or equal to r against the alternative that there are r or more co integrating vectors.

With this test, the decision to reject or not to reject the null hypothesis is made by comparing the computed maximum value (λ max) and (λ trace) with a given critical values. If the computed value of the test statistics is greater than the critical value the null hypothesis (no co integrating vector) is rejected. Hence, there is no cointergration among the variables under consideration at 5% level of significance.

Table 5.3 Results of co integration analysis for kerosene and LPG demand						
		From PCfilm output				
Ho=rank=r	n-r	λι	λmax	λmax (95%)	λtrace	λtrace (95%)
r=0	7	0.64961	48.9479*	45.28	158.5316*	136.61
r≤1	6	0.57392	34.1254	39.41	107.5837	104.94
r≤2	5	0.47498	26.0817	33.178	73.4583	77.74
r≤3	4	0.41452	21.413	27.169	47.4566	54.64
r≤4	3	0.34076	16.6668	20.778	26.0436	34.55
r≤5	2	0.20063	8.9572	14.036	9.3768	18.17
r≤6	1	0.01044	0.4194	3.74	0.4196	3.74
LPG demand						
r=0	7	0.69874	47.9914*	45.28	147.814*	136.61
r≤1	6	0.59533	36.1871	39410	99.8226	104.94
r≤2	5	0.47675	25.9126	33.178	63.6355	77.74
r≤3	4	0.37437	18.7547	27.169	37.7229	54.64
r≤4	3	0.22826	10.3272	20.778	18.9682	34.55
r≤5	2	0.19033	8.4747	14.036	8.6041	18.17
r≤6	1	0.00323	0.1294	3.74	0.1294	3.74
*Denote rejection of the null at 5% level of significance						

It is clear from the results of co integration test that both the trace and maximum eigen value statistic identify only one co integrating vector, the null of r=0 against the general alternative r ≤ n-1 is rejected at the 5% level of significance, which assures us the existence of at least one co integrating vector; and, the maximum eigen value statistic test rejects the null of r=0 against r=1 which again assures us the existence of one co integrating vector.

After establishing the existence of one co integrating vector, the next step is to test for the long-run weak exogeneity. The test for zero restriction on α's matrix is referred as the test for weak exogeneity, the result of the test of, no co integration showed the existence of at least one co integrating vector. However, it does not show which vector is the co integrating vector. Since in lnKCPC is assumed as endogenous variable in our model, this assumption is also for in lnLPGCPC model. But we should confirm our assumption by performing weak exogeneity tests for the rest of the variables i.e. the significance of α coefficient. If the speed of adjustment coefficient (α's) in the co integration analysis approaches zero, then the corresponding variable can be consider week exogenous.

Hence, in order to know the validity of these results there is theoretically determined restriction that has to be tested on the co integrating vectors. This is done by imposing a zero restriction on α coefficient (indicated in each first row of table 5.4) to determine whether the explanatory variable in the model are weakly exogenous or endogenous, by using the likelihood ratio test (LR) statistics that has X^2 distribution with one degree of freedom. In this case the null hypothesis states that the variables taken as explanatory variable are weak exogenous against the alterative endogenous. The guideline to determine the endogenity or exogenity of the explanatory variable can be known by p. value (in each last row of table 5.4), which indicate the probability of not rejecting the null hypothesis. If the P. value is greater than 0.05, the null hypothesis of weak exogeneity can not be rejected at 5% significance level.

Table 5.4 Tests for zero-restriction on α-coefficients(weak exogeniety of variables)

	Kerosene demand						
	lnKCPC	lnRPK	lnRPLPG	lnRPCI	lnPOPG	lnLU	lnRFEE
α-coefficient	-0.7811	0.24240	0.09957	-0.37479	-0.74615	4.1730	-0.05790
LR-test; $X^2(\approx 1)$	6.7192	4.2148	0.17568	10.033	2.7961	0.12558	0.18696
p-value	0.0001**	0.0501	0.6751	0.015*	0.945	0.7231	0.6654
	LPG demand						
	lnLPGCPC	lnRPLPG	lnRPK	lnRPCI	lnPOPG	lnLU	lnRFEE
α-coefficient	-0.15293	0.018759	-0.15173	0.09518	-0.12424	0.02577	-0.14427
LR-test; $X^2(\approx 1)$	5.9348	0.14989	11.354	0.24061	0.00289	3.2303	3.3487
p-value	0.0148*	0.6896	0.0008**	0.6238	0.9571	0.0723	0.0673

*denote rejection at 5% level of significance

**denote rejection at 1% level of significance

As can be seen from table 5.4, the zero restriction on α-coefficient is rejected for lnKCPC alone while the restriction cannot be rejected for the rest of the variable except lnRPCI at 5% level of significance. It is implying the fact that lnKCPC is endogenous while the rest variables being exogenous. On the other hand, the zero restriction on α-coefficient is rejected for lnLPGCPC alone while the restriction can not be rejected for the rest of the variable except lnRPK at 5% level of significance. Indicating the fact that lnLPGCPC is endogenous while the rest variables being exogenous

The issue of weak exogenity the explanatory variables are important in estimating the Error Correction model. If all the dependent variables are exogenous, we can directly estimate with the single equation otherwise, if one of the independent variable is endogenous, Engle-Granger causality test must be undertaken in order to cheek whether the independent variable really granger causes the dependent variable.

Granger causality test involves using F-statistic to determine whether the lagged information on one variable x has any statistically significant role in explaining y with its lag. If the lagged value of X's makes no statistically significant contribution to explain y with its lag, then it is said that "x doesn't granger cause y". Similarly if lagged value of y makes no statistical contribution to the explanation of x with its lags then it is said that y doesn't granger cause x.

According to the result reported in table 5.4 the assumption of weak exogenity is rejected for real per capita income (lnRPCI) in the kerosene demand function and real price of kerosene (lnRPk) in the LPG demand function .Thus ,It is necessary to test whether there is a causality between the variables that are not weakly exogenous . Following Engle and Granger (1987) ,a variable Y is said to be Granger caused by another variable X if current values of Y can be predicted with better accuracy by using past value of X. To this effect, a Grange causality relationship lnKCPC and lnRPCI, and lnLPGCPC and lnRPK are examined and the test result suggested that there is no causality between them (see Appendix 12). This implies that we do not have a series problem of endogeniety and it has possibility to normalize with lnKCPC and lnLPG by conditioning on the remaining variables.

Therefore, the structural long run relationship derived from the co integrating vector normalized with respect to lnKCPC can be represented as

$$lnKCPC= -1.1451(lnRPK)_t+0.4088\ (lnRPLPG)_t\ -1.5386(\ lnRPCI)_t\ -3.0632(lnPOPG)_t\ +$$

$$17.132(lnLU)_t\ +0.2377(lnRFEE)_t \text{ ---}(5.1)$$

Similarly the long-run LPGCPC equation can be represented as follow

$\ln LPGCPC = -0.2514(\ln RPLPG)_t + 1.7404(\ln RPK)_t + 5.1145(\ln RPCI)_t + 0.8015$

$(\ln POPG)_t + 2.6017\ (\ln LU)_t - 0.1613\ (\ln RFEE)_t$.--(5.2)

Given the above co integrating vectors, there is also a need to test for the significance of the long run coefficients (β) in order to identify the unique co integrating vector. Here again a zero restriction is imposed on each coefficient and the results for the LR statistics are given in table 5.5

5.5

Table 5.5 Tests for zero restriction on long run coefficients for kerosene and LPG demand.

Table 5.5 Tests for zero-restriction on β -coefficients(long run variables)

	Kerosene demand						
	lnKCPC	lnRPK	lnRPLPG	lnRPCI	lnPOPG	lnLU	lnRFEE
β-coefficient	1.0000	1.1451	-0.40880	1.5386	3.0632	-17.132	-0.23772
LR-test; $X^2(\approx1)$	15.498	8.3226	5.6129	17.782	0.58369	0.50258	10.307
p-value	0.0001**	0.004**	0.0178*	0.0001**	0.4994	0.4784	0.0013**
	LPG demand						
	lnLPGCPC	lnRPLPG	lnRPK	lnRPCI	lnPOPG	lnLU	lnRFEE
β -coefficient	1.0000	0.25140	-1.7404	-5.1145	-0.8015	-2.6017	0.1612
LR-test; $X^2(\approx1)$	4.9645	6.5009	12.677	0.022186	5.833	5.9225	4.3461
p-value	0.0213 *	0.005 **	0.004 **	0.8824	0.0157 *	0.0149 *	0.0371 *

*denote rejection at 5% level of significance

**denote rejection at 1% level of significance

The test results in table 5. 5 shows that the real price of kerosene (lnRPK), the Real price of LPG (lnRPLPG), the real per capita in come (lnRPCI), the real foreign exchange earnings (lnRFEE) are statistically significant at 5% in explaining kerosene consumption per capita (lnkcpc) in the

Long run and the signs are as expected except real per capita in come (lnRPCI). The other variable, namely, the population growth (lnPOPG) and the level of urbanization (luLU) are not statistically significant in explaining kerosene consumption per capita in the long run. More importantly, as shown from Table 5-4 kerosene price is negatively related while LPG price (cross price) is positive as expected. Similarly, in table 5 .5, LPG price is negative while kerosene price (relative price) is positive and the signs are expected. This implies that kerosene and LPG substitute each other in the long run.

In the case of LPG demand, real price LPG ($lnRP_{LPG}$), real price of kerosene ($lnRP_K$), the population growth (lnPOPG), the level of urbanization (lnLU), real foreign exchange earnings (lnRFEE) are statistically significant at 5% in explaining LPG consumption per capita (lnLPGCPC) in the long run the signs are as expected except the real foreign exchange earnings (lnRFEE). The real income per capita (lnRPCI) is statistically insignificant and the sign is as expected.

5.2. Estimation of the short run and Error-correction model.

So far we have determined the long-run relationship between the variables of kerosene and LPG having already obtained the long-run model and estimated the coefficient, the next step is the estimation of coefficient of the short run dynamic test to have important policy implication. Hence, an error correction model (ECM) will be estimated that incorporates the short-term interaction and the speed of adjustment towards long run equilibrium. In the Error Correction Model, the short run disequilibria are approximated by the first lag of the Error Correction Model.

The procedure adopted for estimation is the Hendry's approach of general to specific vector error correction modeling. In this approach, a large model is estimated first which includes as many explanatory variables and their lags as possible (Appendices 9and 10). Then all insignificant explanatory variables are continuously dropped until remain a parsimonious model with few explanatory variables but acceptable in terms of significance, economic interpretation and diagnostic validity is obtained. After step-by-step dropping of the insignificant variable from the estimate one will have a specific parsimonious vector Error Correction Model.

Table 5.6 Results of the specific parsimonious vector Error Correction model (PECM)

Modeling of kerosene demand (ΔlnKCPC)				
Variables	**Coefficient**	**Std. Err**	**t-value**	**t-probability**
constant	0.018715	0.11613	0.161	0.8733
$\Delta lnRPK_{t-1}$	1.7086	0.75879	2.252	0.0338
$\Delta lnRPLPG_{t-2}$	-0.55594	0.35173	-1.581	0.1271
ΔlnRPCI	2.9144	1.4420	2.021	0.0546
ΔlnPOPG	0.66601	0.38720	1.720	0.0983
$\Delta lnPOPG_{t-1}$	1.1091	0.46087	2.407	0.0242
ΔlnRFEE	0.31689	0.25187	1.258	0.2204
*Dummy	-0.04525	0.20494	-0.221	0.8271
ECM_1	-0.54307	0.31697	-1.713	0.0500

*Dummy -represent for structural break

R^2 =0.79922 F (12, 23) = 4.580[0.0009] **

DW = 2.12 RSS=5.8025

AR1-1F (1, 22) = 0.59114[0.4502]

ARCH1 F (1, 21) = 1.5535[0.2263]

Normality chi^2(2) = 1.3926[0.4984]

RESET F (1, 22) = 0.0345[0.8543]

The result of the various diagnostic tests are reported and the tests did not detect and problems of hetroscedasticing (ARCH- Auto Regressive Conditional Hetroskedasticity test), there is no problem of higher order serial correlation (Breusch –Golfrey or LM tests) up to second lag. Normality chi 2(2) test shows that the residuals are normally distributed. None of these tests reported were to suggest that the model was mis specified. Then, the tests covered, respectively Auto regressive test, an ARCH test for conditional hetroscedasticity, Normality test and the RESET general tests for misspecification are done for diagnostic tests, respectively.

Short run kerosene demand Results from equation (5.3) the 1st lag of Real price of Kerosene, the real per capita income($\Delta lnRPCI)_t$, the first lag of population growth (ΔlnPOPG) are significant at 5% level. The signs are as expected except real price of kerosene. From result we can look at price is elastic , it implies that, if other factors remain constant while the price of kerosene rises, the consumption of kerosene become decline, this indicates that, the consumer may have other opportunity to consume, such as traditional fuel and modern energy source. But practically in our country this economic law does not work because of government monopolized fuel imports and regulated retail price, expensive LPG price and electricity tariff, no other competitive fuel importer and distributor etc. In cases of elasticity, their short run price and income elasticities are (1.7086 and 2.9144), respectively, these results (price and income elasticity in the short run) are consistent with empirical results of Micheal Kennedy(1974) , Ishiguru and Akiyama(1995) ,Pitt(1985),Giffin(1977), Ramus Heltberg(2003) etc . And the demand for kerosene is price elastic and elastic for income.

$$\Delta lnKCPC = \underset{(0.0187)}{0.01874} + \underset{(0.77879)}{1.7086}(\Delta lnRP_K)_{t-1} + \underset{(1.44200)}{2.9144}(\Delta lnRPCI)_t + \underset{(0.46087)}{1.1091}(\Delta lnPOPG)_{t-1} - \underset{(0.31697)}{0.5430}(ECM)_{t-1} \quad \text{------------} (5.3)$$

The population growth variable, the first lag of population growth that affects the current kerosene consumption positively, indicates that while the number of population increases, the consumption of kerosene also increases. This result is similar with the literature of Gately and Streifel(1997), L. Prise, L. Michielas et. al (1998).

In the case of LPG demand result of equation (5.4) the real price of LPG $(\Delta RPLPG)_t$,the first lag of real price of kerosene(ΔRPK), the first lag of population growth (ΔlnPOPG) are statistically significant at 5% level with the expected sign, real per capita income$(\Delta RPCI)_t$ is significant at 1% level with expected sign. The short run price and income elasticity of LPG are -0.2986 and 3.8632, respectively. The demand for LPG is price inelastic and elastic for income. These results (price and Income elasticities) are consistent with empirical results of Micheal Kennedy(1974) , Rahaman(1982) ,Tzeng(1989) ,Fiebig et al(1987) , Griffin(1977), Ko(1993) , Ramus Heltberg(2003) etc

$$\Delta lnLPGCPC= -0.06014- 0.29861(\Delta lnRP_{LPG})_t+ 1.3062(\Delta lnRP_K)_{t-1} +3.8632(\Delta lnRPCI)_t$$
$$(-0.14309) \quad (-0.19526) \quad (0.43864) \quad (0.88843)$$

$$+ 0.6705(\Delta lnPOPG)_{t-1} - 0.6307(ECM)_{t-1} \text{-------------------------------------}(5.4)$$
$$(2.50760) \quad (0.225)$$

The population growth variable, the first lag of population growth that affects the current LPG consumption per capita, indicates that while the number of population increases, the consumption of LPG also increases. As the result, in the short run, population growth and LPG demand are positively related. .

In the above model, the coefficient of the Error Correction Model is significant at 5% level with expected sign in both models. Their magnitude indicate that the speed of adjustment of kerosene and LPG demand to its dis-equilibrium level is (are) about 54% and 63% per annum, respectively. The sign of ECM are negative and implying that any shock in the system in the SR will return back to its long run path.

R^2(goodness of fit) shows that about 79% and 77% of the variation in the dependent variable (lnKCPC and lnLPGCPC) is (are) explained by the explanatory variable, respectively.

Table 5. 7 Results of the specific parsimonious Error Correction Model (VECM)

Modeling of LPG demand (ΔlnLPGCPC)				
Variables	**Coefficient**	**Std. Err**	**t-value**	**t-probability**
constant	-0.06041	0.14309	-0.422	0.6764
Δlnrplpg	-0.29861	0.15526	-1.923	0.0463
$\Delta lnrpk_{t-1}$	1.3062	0.43864	2.978	0.0062
Δlnrpci	3.8632	0.88843	4.348	0.0002
$\Delta lnrpci_{t-1}$	-2.7085	1.1899	-2.276	0.0313
$\Delta lnpopg_{t-1}$	0.67049	0.26760	2.506	0.0188
$\Delta lnlu_{t-1}$	1.5026	1.9005	0.791	0.4363
$\Delta lnrfee_{t-2}$	0.28815	0.15437	1.867	0.0733
*Dummy	-0.16594	0.14258	-1.164	0.2551
ECM_1	-0.6307	0.2555	-2.468	0.0450

*Dummy -represent for structural break

R^2 =0.768 F (10, 26) = 2.0661[0.0045] **

DW = 1.98 RSS=2.922

AR1-2F (2, 24) = 0.3876 [0.5423]

ARCH1 F (1, 24) = 0.0036[0.8214]

Normality chi^2(2) = 0.1.8531[0.3958]

RESET F (1, 25) = 0.04493[0.833

CHAPTER SIX

Conclusion and Policy Implication

Ethiopia's energy consumption is predominately based on biomass energy sources. An overall proportion (93%) of the country energy demand is met by traditional energy sources such as fuel wood, charcoal, dung, and agricultural residues. The balance is met by commercial energy source such as petroleum and electricity. The major consumer of energy in Ethiopia is the household followed by industry and transport sector. With an exception of hydro-electric power, the country petroleum product' requirement is mainly depends on imports. The consumption of petroleum is mainly derived by demand within household, commercial and other sectors which accounts around 50% of the total fuel consumption. Therefore, both Kerosene and LPG fuel are important inputs for household, commercial and other sector.

The study used Kerosene and LPG demand model synthesized from other model, such as Mickeal Kennedy (1974), Massayossu Ishigure and T. Akayame, (1995), Gately and Streifel (1997), Hosier R *et al* (1994) ,Balabanoff (1994). Therefore, Kerosene consumption is a function of real price of Kerosene (Own price), real price of LPG, real per capita income, population growth, level of urbanization and real foreign exchange earning. Similar definition has been adopted for LPG consumption per capita.

The estimation procedure was accomplished by resorting time series econometric techniques and appropriate yearly data from different sources that cover the period from 1964/65 to 2004/05. The ADF test has been employing in the analysis to test the unit root tests in the variables. In most cases, the variables entering the regression are found to be integrated of order one [I (1)]. In determing the long run behaviors of the variables, the Johansen Multivariate co-integration test was employed as it has possessed a unique advantage over the residual-based two step Engle-Granger approach.

Applying the Johansen procedure to Kerosene and LPG function, to test the co integration that both the trace and maximum eigen value statistic identify only one co integrating vector. More importantly, using both λ max and λ trace statistics, we could not reject the null of no co-integration. Besides, the parsimonious Error correction model (PECM) is formulated from long run model using the general to specific modeling approach of David Hendry.

The result showed from long run equation that, real price of Kerosene (own price), real price of LPG (cross price), real per capital income and real foreign exchange earning determine Kerosene consumption per capita demand function in the long run with expected sign except real per capita income. On contrary, the population growth and levels of urbanization do not determine the kerosene demand in the long run. Similarly, in the short run, real price of Kerosene, real per capita income and population growth are significant and they explained kerosene consumption per capita in the short run. Indicating that, these variables are useful to analysis of pricing policy in kerosene demand.

For LPG demand, real price of LPG (own price), real price of Kerosene (cross price), population growth, level of urbanization and real foreign exchange earnings are significant and they explained LPG consumption per capita demand function in the long run while real per capita income are insignificant and does not explained the LPG demand in the long run. The short run coefficient of real price of LPG, real per capital income, real price of Kerosene and population growth are marginally significant. Hence, the signs are as expected and this result consistent with Micheal Kennedy (1974), Rahaman (1982), and Tzeng (1989). Etc, which stated that income elasticity of LPG demand, tends to be elastic whereas price elasticity is in significantly different from zero and inelastic.

6.2 Policy Implication

Proper evaluation of Kerosene and LPG fuel policy requires good estimates of demand elacticties. Here, the long run income electricity is (-1.5386), indicating that the kerosene is an inferior good. On the other hand, the long run income elasticity of LPG is (+5.114), indicating that the LPG is a superior good. Since it substitute kerosene and traditional fuels are less convenient. In case of Price elasticity, the long run price elasticity is (-1.145), indicating the existence of good substitute like LPG, Electricity, other energy sources for household, commercial and other sector. Similarly, the long run price elasticity of LPG is (-0.2514), indicating that the price is inelastic.

Therefore, from the results of the study, the following policy implications can be derived. In the short run, the coefficient from Kerosene and LPG equation shows that the price elsticities are elastic and inelastic, respectively while real per capital income is marginally elastic for both fuels. The short run policy implication of this is that the government can increase its revenue by increasing the real price of LPG through directly. Since LPG user do not have opportunity to shift other energy sources.

On the other hand, the price elasticity of Kerosene is(+1.7086)i.e. it is an elastic this means ,1% increase real price of Kerosene causes about 1.7 % increases the consumption of kerosene on average in the short run. since the consumer do not needs to shift to other energy sources due to expensive of other energy sources like LPG ,electricity ,traditional fuel. etc .similarly, the government monopolized fuel imports and regulated retail price, no other competitive fuel importer and distributor, opening of new oil station, population growth etc are the major contributor to price elastic.

The result indicates that, the government pricing policy to increase its revenue become successful in the LPG demand, in other words, the policy implication that price elasticity of LPG is inelastic since the quantity of LPG is far less responsive to price changes. . In case of Kerosene demand, the government pricing policy becomes successful in kerosene demand through regulated and at pre determined level. It means that, if the government increases the price of kerosene through increasing price, it can earn much revenue with out reduction of kerosene demand. These conditions that occur the consumer do not have opportunity to use other energy sources. Then, Kerosene pricing policy does work at regulated and pre determined retail price by the government.

As the result of different fuel pricing policy, the government can earn revenue through different pricing policy. So the government should the following policy implication to increase its revenue in the short run;

- The government should increase the price of LPG through directly, the consumer still can use this product due to demand of LPG is price inelastic since the consumer have no opportunity to substitute LPG with other products in the short run.
- The government should use regulated and pre determined kerosene pricing policy .i.e. an increases the price of Kerosene at pre determined level and this price is set below the price of other energy sources. The government can earn more revenue with out reduction of kerosene consumption in the short run. Otherwise, if the government set the price of kerosene above the other energy sources, the consumer will shift to other cheap energy sources.

Hence, in the short run, the government increases its revenue through direct pricing policy in LPG product, and Regulated and pre determined pricing policy in Kerosene product.

In the long run, LPG is a substitute to kerosene, electricity and other modern energy sources like solar energy are a substitute to LPG. Hence the government may not earn revenue from kerosene product since kerosene becomes an inferior good to consumer in the long run. As the results, the user of kerosene will shift to other energy sources like LPG, electricity, biogas etc. Similarly LPG consumer will shift to use electricity, biogas etc. then, the government may not earn revenue from LPG products.

The population growth directly affects the consumption of Kerosene and LPG product. Hence, the government should address the population growth at determined level. Otherwise, large population needs high kerosene and LPG products to its energy sources. This high needs affect the country foreign exchange earning, moreover high population growth affects environment through using traditional energy sources like forest by the population As the results, It needs high investment on the other energy sources like electricity biogas, solar energy etc.

In addition to these, government energy policy should address the price of the fuels (taxes and subsidies), information and training program for energy expertise, regulate Kerosene and LPG distribution on proper and fair way, environmental policy, other energy sources, etc are related energy policy to household, commercial, and other sectors.

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Appendix 1- Growth Rates of GDP and Value Added in the various Sectors (1960/61-2004/05)

Year	growth rate real GDP	Agriculture		Industry		Distributive Service		Other Service		Growth rate of per capita Income
		As % of GDP	Growth rate	As%of GDP	Growth rate	As %of GDP	Growth rate	As %of GDP	Growth rate	
1960/61		75.8		7		8.4		8.8		
1961/62	3.7	74.3	1.8	7.4	9.6	8.9	9.8	9.4	10.4	1
1962/63	3.8	73.7	2.9	7.6	6.4	9.2	7.3	9.5	5.3	1
1963/64	4.3	72.3	2.3	8	10.6	10	13.9	9.6	5.8	2
1964/65	6.3	70.6	3.7	8.3	10.3	10.9	15.3	102	12.7	4
1965/66	3.3	68.9	0.8	9.1	12.8	11.4	8.4	10.6	7.5	1
1966/67	4.1	68.4	3.4	9.7	11.1	11.1	0.7	10.8	6	1
1967/68	3.3	66.9	1.1	9.9	5.5	12	11.9	11.2	7.1	1
1968/69	3.7	66	2.2	10.1	5.7	12.4	7.4	11.6	6.7	1
1969/70	3.4	65.3	2.4	9.9	1.9	13	8.3	11.8	5.2	1
1970/71	3.7	64.2	2	10.4	9.1	13.4	6.3	12	5.8	1
1971/72	3.1	63.3	1.6	10.6	4.4	13.7	5.5	12.5	7.7	0
1972/73	2.7	62.5	1.4	10.6	3.1	13.9	4.1	13.1	7.3	0
1973/74	2.2	61.7	1	10.3	-0.3	14.3	5.4	13.6	6.7	0
Average	3.7	68.1	2	9.2	6.9	11.6	8	11.1	7.2	1
1974/75	1.1	61.3	0.5	10.1	-1.6	14.1	-0.4	14.5	7.6	-1
1975/76	0.7	61.4	0.8	9.4	-6.2	14	0.3	15.2	5.3	-1
1976/77	1	61	0.4	9.5	2.9	13.8	-0.6	15.6	3.9	-1
1977/78	-0.6	61.6	0.3	9.3	-3.1	12.5	-9.8	16.6	5.6	-3
1978/79	4.8	59.3	0.9	10.2	14.5	13.5	13.2	17	7.5	2
1979/80	4.8	59.2	4.6	10.6	9.7	13.6	5.4	16.6	2.3	2
1980/81	0.6	58.1	-1.2	10.9	3.4	14	3.3	17	3.2	0
1981/82	0.5	55.7	-3.6	11.8	8.5	14.5	4.4	18	6.3	0
1982/83	10.1	57.5	13.6	11.3	5.9	13.5	2.8	17.6	7.8	6
1983/84	-6.3	53.7	-12.5	12.8	6	14.5	0.3	19	1.1	-9
1984/85	-9.7	47	-20.9	14.8	4.3	16.2	0.9	22	4.4	-12
1985/86	9.9	49.6	16	14.4	6.6	15.2	3.5	20.8	3.8	6
1986/87	14	51.7	18.8	13.6	8	15.4	15.1	19.3	6.2	10
1987/88	-0.1	50.3	-2.8	13.1	-3.8	15.9	3.4	20.7	7.1	-3
1988/89	0.3	50.6	1	12.2	-6.7	15	-5.5	22.2	7.5	-2
1989/90	4.1	51.2	5.3	11.2	-4.7	15	4.4	22.6	5.8	0
1990/91	-3.6	56	5.2	9.4	-19.1	12	-23.5	22.8	-2.7	-6
Average	1.9	55.6	1.6	11.4	1.4	14.3	1	18.7	4.9	0
1991/92	-3.7	56.5	-2.7	9	-7.1	12.1	-2.5	22.4	-5.2	-6
1992/93	12	5305	6.1	10.4	28.1	13.2	22.2	23	14.8	8
1993/94	1.7	50.7	-3.7	10.9	7	13.8	6.2	24.7	9.2	0
1994/95	5.4	49.7	3.4	11.2	8.1	13.9	6.4	25.2	7.7	3
1995/96	10.6	51.5	14.7	10.6	5.4	13.7	9	24.1	5.9	7
1996/97	5.2	50.7	3.4	10.8	7	14	7.7	24.5	6.7	2
1997/98	-1.2	45.7	-10.8	11.2	2.3	15	5.6	28.1	13.3	-4
1998/99	6.3	44.7	3.8	11.7	11.4	14.6	3.5	29	9.8	3
1999/00	5.3	43.2	1.9	11.5	3	14.9	7.5	30.4	10.4	2
Average	4.6	49.6	1.8	10.8	7.3	13.9	7.3	25.7	8.1	1
2000/01	7.9	45.1	11.5	10.5	5.2	14.7	4.9	29.7	4.5	-2.3
2001/02	0	43.5	-2.3	10.6	2.3	15.1	4.4	30.7	4.6	-9.6
2002/03	-3.1	39.6	-12.6	11.5	4.3	16.3	3.2	32.6	7	5.2
2003/04	12.3	42.2	18.9	11	7.1	15.7	7.1	31	6	19.1
2004/05	8.7	44.1	15.1	10.7	7.1	15.2	7.2	29.8	6	11.7
Average	5.5	47.2	2.9		7.6		7.3		8.1	3.5

Source ; NBE Bulletin and own computation

Appendix 2 Consumption of Petroleum Products by Product type (IN MC)

year	kerosene	erosene pri	%of share	LPG	LPG price	%of share	Gasoline	%of share	Diesel	%of share	Inland fuel	%of share	Jet fuel	%of share	Others	%of share	Total
1964/65	6000	0.39	0.01	2600	1.12	0.006	76700	0.17	195900	0.45	94500	0.22	62600	0.14	0	0	438300
1965/66	6800	0.39	0.01	2900	1.12	0.006	83300	0.18	212800	0.45	100800	0.21	67700	0.14	0	0	474300
1966/67	4500	0.39	0.01	2900	1.12	0.006	77000	0.17	205800	0.46	99100	0.22	58400	0.13	0	0	447700
1967/68	4800	0.39	0.01	2800	1.12	0.007	70000	0.18	176100	0.46	73000	0.19	48200	0.12	11617	0.03	386517
1968/69	6100	0.39	0.02	2700	1	0.007	70700	0.18	178800	0.45	78700	0.2	49800	0.12	13114	0.03	399914
1969/70	7800	0.39	0.02	3000	0.92	0.007	74700	0.19	186600	0.46	64600	0.16	54800	0.14	12072	0.03	403572
1970/71	2200	0.39	0	3400	0.92	0.007	93500	0.2	212700	0.46	56900	0.12	77500	0.17	15449	0.03	461649
1971/72	1900	0.42	0	4200	0.92	0.008	99100	0.19	248500	0.48	70900	0.14	71300	0.14	21613	0.04	517513
1972/73	1800	0.42	0	4200	0.92	0.008	106700	0.19	270600	0.49	80500	0.15	65800	0.12	24273	0.04	553873
1973/74	5400	0.42	0.01	4500	0.92	0.008	105700	0.19	268400	0.48	96500	0.17	59300	0.11	19350	0.03	559150
1974/75	4464	0.44	0.01	2875	0.92	0.006	63948	0.14	205820	0.45	99078	0.22	58393	0.13	24527	0.05	459150
1975/76	4836	0.44	0.01	2875	0.92	0.008	60466	0.16	176057	0.46	73020	0.19	48232	0.13	17520	0.04	383006
1976/77	6102	0.44	0.02	2747	1.03	0.007	62695	0.16	178807	0.45	78748	0.2	49792	0.13	16328	0.04	395219
1977/78	7789	0.45	0.02	2975	1.08	0.008	60386	0.15	186628	0.47	64579	0.16	54814	0.14	19039	0.05	396210
1978/79	2183	0.45	0	3357	1.08	0.007	90189	0.2	212691	0.46	56855	0.12	77485	0.17	18843	0.04	4461603
1979/80	1916	0.53	0	4214	1.08	0.008	98313	0.19	248505	0.48	70928	0.14	71267	0.14	27700	0.05	522843
1980/81	1849	0.53	0	4191	1.26	0.007	105344	0.19	270592	0.48	80472	0.14	65839	0.12	32851	0.06	561138
1981/82	5589	0.6	0.01	4500	1.3	0.008	105626	0.19	268420	0.48	96455	0.17	59302	0.11	24113	0.04	564005
1982/83	16000	0.6	0.02	9000	1.3	0.012	158000	0.21	352400	0.48	97500	0.13	82400	0.11	25461	0.03	740761
1983/84	21000	0.6	0.03	10000	1.3	0.013	169200	0.21	374000	0.47	95200	0.12	99300	0.13	24854	0.03	793554
1984/85	35800	0.6	0.04	9000	1.3	0.01	174000	0.19	392400	0.42	110400	0.12	183300	0.2	28861	0.03	933761
1985/86	47092	0.6	0.05	9462	1.3	0.01	174640	0.19	394039	0.43	112900	0.12	145969	0.16	30307	0.03	914416
1986/87	62980	0.6	0.07	11164	1.3	0.012	172491	0.18	436242	0.45	122149	0.13	126354	0.13	31700	0.03	963008
1987/88	80440	0.6	0.08	10457	1.3	0.011	174164	0.18	449998	0.45	119084	0.12	154219	0.16	4392	0	992754
1988/89	93266	0.6	0.09	11883	1.3	0.011	170408	0.16	472600	0.46	132111	0.13	154341	0.15	3094	0	1037703
1989/90	98097	0.6	0.1	10563	1.3	0.011	162412	0.16	454834	0.46	113328	0.11	144606	0.15	1754	0	985594
1990/91	38398	0.6	0.05	7324	1.3	0.01	124671	0.17	349175	0.47	70194	0.09	151424	0.2	5331	0	746517
1991/92	71634	0.74	0.11	4562	1.3	0.007	130687	0.19	349647	0.52	56246	0.08	61065	0.09	100	0	673941
1992/93	102979	0.9	0.13	8163	1.4	0.01	145930	0.18	396731	0.48	80138	0.1	83910	0.1	459	0	818310
1993/94	136207	1	0.17	8831	1.4	0.011	152322	0.18	374391	0.45	91961	0.11	59727	0.07	307	0	823746
1994/95	165263	1	0.18	9132	2	0.01	166812	0.18	414184	0.45	106609	0.12	63504	0.07	186	0	925690
1995/96	199716	1.25	0.2	8227	2.5	0.008	184378	0.18	460584	0.46	97739	0.1	53887	0.05	196	0	1004727
1996/97	213382	1.4	0.2	7950	3.69	0.007	182757	0.17	495141	0.47	105746	0.1	54938	0.05	247	0	1060161
1997/98	209101	1.4	0.19	4558	3.69	0.004	180355	0.16	539998	0.49	109204	0.1	62415	0.06	297	0	1105928
1998/99	196794	1.4	0.18	2054	3.69	0.002	181724	0.16	561309	0.5	109148	0.1	71421	0.06	0	0	1122450
1999/00	199671	1.45	0.16	2060	3.69	0.002	185368	0.15	631133	0.52	117541	0.1	68252	0.06	0	0	1204025
2000/01	222587	1.9	0.16	12758	10.48	0.01	181889	0.13	710506	0.64	127712	0.09	74903	0.06	15526	0.01	1345881
2001/02	259751	1.95	0.19	10134	10.1	0.01	171338	0.13	682747	0.51	127399	0.09	81504	0.06	17257	0.01	1350130
2002/03	269210	2	0.18	11395	9.38	0.008	187666	0.13	754259	0.51	141942	0.1	94887	0.06	15712	0.01	1475071
2003/04	292766	2	0.21	20780	9.57	0.017	193969	0.13	769044	0.54	82648	0.06	68029	0.05	15985	0.01	1443221
2004/05	333079	2.92	0.22	21118	9.74	0.019	200450	0.13	746316	0.53	90700	0.06	60100	0.04	18450	0.01	1470213

Source ; EPE , 2004/05 and own computation

Others includes Asphalt ,AV gazoline and Lubricants

Appendix-3 consumption of petroleum products by Region(IN MT)

	Addis Ababa						North						South					
year	kerosene	LPG	Gasoline	Diseal	total	%share	kerosene	LPG	Gasoline	Diseal	total	%share	kerosene	LPG	Gasoline	Diseal	total	%share
1985/86	15813	4034	58953	47103	125903	0.35	11097	287	10086	27225	48695	0.14	2603		4623	6837	14063	0.04
1986/87	22895	4789	58102	50815	136601	0.35	12826	285	11043	23589	47741	0.12	3247		4885	8044	16146	0.04
1987/88	27936	6304	58623	49778	142838	0.36	15199	196	10957	22596	48948	0.12	4697	76	5106	9118	18997	0.05
1988/89	35878	9336	58113	53828	157155	0.36	17831	119	10704	21741	50395	0.12	6099	368	4842	9561	20870	0.05
1989/90	40677	8501	62805	50439	162422	0.39	11794	198	7049	14333	33374	0.08	5869	19	4742	12185	22817	0.05
1990/91	28303	6071	64339	52477	151250	0.5	339	32	722	3294	4387	0.01	852	212	3191	9698	13953	0.05
1991/92	41573	3844	77455	65973	189844	0.49	7247	83	4973	33895	46198	0.12	3715	2	4042	11540	19299	0.05
1992/93	53855	6687	84048	64477	209067	0.46	7820	264	5444	42684	56212	0.12	6363	28	4018	12141	22550	0.05
1993/94	61866	7804	89498	62652	221820	0.44	5625		3680	20942	30247	0.06	9902	25	5210	14542	29679	0.06
1994/95	64387	7915	99427	71010	242719	0.42	7901	4	4113	24638	36556	0.06	12915	30	7401	2117	41463	0.07
1995/96	78716	6604	110321	81366	277027	0.41	11258		4945	32115	48318	0.07	19550	37	8881	27822	58290	0.08
1996/97	84045	6185	112339	92010	294579	0.41	15853		5389	43389	64631	0.09	19329	17	8819	29634	57799	0.08
1997/98	100057	6934	110733	74789	292513	0.39	48793		5118	16679	70590	0.09	32902	22	9531	21028	63583	0.09
1998/99	79473	1085	113082	123913	317552	0.44	12728	9	5258	44228	63223	0.09	16626	4	8803	31723	57146	0.08
1999/00	75795	946	114687	111217	302645	0.38	15962		6852	64791	87605	0.11	20656	10	12990	42778	74724	0.09
2000/01	82480	5100	114682	119882	322144	0.36	22585	1403	6443	78092	108523	0.12	22866	638	10521	43539	77564	0.08
2001/02	76991	4136	112943	129542	323612	0.38	22147	1115	6862	73506	103630	0.12	22733	506	9436	43235	75910	0.09
2002/03	76913	5581	122240	123406	328140	0.35	24135	1535	7208	88916	121794	0.13	25015	698	10964	52343	89020	0.09
2003/04	84278	8312	124828	135606	353024	0.34	27261	2283	8011	93307	130862	0.13	28533	1038	12100	63440	105111	0.1
2004/05	142663	8447	130325	150500	431935	0.35	28269	2323	9100	108400	148092	0.12	30988	1056	20726	70640	123410	0.1

	East						West						Central						Total Petroleum Product				
year	kerosene	LPG	Gasoline	Diseal	total	%share	kerosene	LPG	Gasoline	Diseal	total	%share	kerosene	LPG	Gasoline	Diseal	total	%share	kerosene	LPG	Gasoline	Diseal	total
1985/86	5723	421	10828	54745	71717	0.2	1215		6774	19774	27763	0.08	6808		15855	46492	69155	0.19	43259	4742	107119	202176	357296
1986/87	7679	347	10633	52847	71506	0.19	1928		7079	24984	33991	0.09	9682		16267	54315	80264	0.21	58257	5421	107979	214592	386249
1987/88	9182	251	11277	53363	74073	0.19	2117	53	7616	26129	35969	0.09	9832	306	15361	52809	78308	0.2	69017	7184	108940	213793	398934
1988/89	14789	26	13178	57149	885142	0.2	2513	53	7067	28524	38157	0.09	12642	731	14626	52282	80279	0.19	89752	10633	108528	223085	431998
1989/90	17503	377	11688	60190	89759	0.21	2790	14	6132	26230	35166	0.08	15095	768	12795	46506	75164	0.18	93728	9878	105213	209884	418703
1990/91	3829	11	10997	53691	68528	0.22	675	7	3717	16949	21348	0.07	3298	377	7945	34317	45937	0.15	37296	6710	90971	170425	305402
1991/92	3992	25	7305	33800	45122	0.12	2000		4426	16993	23419	0.06	10135	104	11213	41664	63116	0.16	68661	4058	109414	204865	386998
1992/93	10841	57	10313	29845	51056	0.11	3387	7	5487	24038	32919	0.07	18422	349	14538	54038	87346	0.19	100688	7391	123848	227222	459149
1993/94	21489	71	13375	33897	68832	0.14	6527	7	6585	29608	42727	0.09	28352	230	14855	61990	105428	0.21	133762	8136	133203	223631	498732
1994/95	27042	57	14357	34683	76139	0.13	10501	5	7652	36816	54974	0.1	37932	251	15905	70747	124835	0.22	160658	8262	148855	259011	576786
1995/96	28597	48	17507	40052	86204	0.13	12175		8996	40137	61008	0.09	45891	110	17810	76200	140011	0.21	196167	6798	168160	297721	668846
1996/97	30351	31	14401	34994	79777	0.11	15761		9098	43139	67988	0.1	54540	82	17571	82551	145774	0.21	210879	6315	167617	355747	740558
1997/98	54996	36	14576	30596	100204	0.13	44799		8745	17277	70821	0.09	84340	68	17962	47080	149450	0.2	365887	7060	166765	207449	747161
1998/99	24468	5	13768	65604	103846	0.14	11652		7635	37588	56875	0.08	31824		17142	81409	130375	0.18	176772	1103	165688	364454	708017
1999/00	27393	500	13435	81862	122690	0.15	15820	612	8611	49163	73594	0.09	36731	1224	17438	83709	137878	0.17	192357	946	172313	433520	799136
2000/01	43859	2167	15770	113170	174966	0.19	17669	1020	7731	49995	76415	0.08	33192	2424	13884	76845	126345	0.14	222651	12752	169031	481523	885957
2001/02	41373	1723	13168	88054	144318	0.17	19280	810	6125	48928	75143	0.08	25084	1925	11541	67845	106395	0.13	207608	10215	160075	451110	829008
2002/03	44135	2373	14678	108165	169351	0.18	20200	1116	8240	56209	85765	0.09	36925	2650	13035	82051	134661	0.15	227323	13953	176365	511090	928731
2003/04	49307	3532	15906	119121	187866	0.18	23916	1662	8713	66158	100449	0.09	46182	3948	14556	88507	153193	0.15	259477	20775	184114	566139	1030505
2004/05	61897	3590	17110	127200	209797	0.17	40564	1689	9998	71158	123409	0.1	80704	4012	16440	96300	197456	0.16	385085	21117	203699	624198	1234099

Appendix 4 Consumption of Kerosene and LPG by Region (IN MC)

	Addis Ababa				North				South				East			
year	kerosene	Growth	LPG	Growth	kerosene	Growth	LPG	Growth	kerosene	Growth	LPG	Growth	kerosene	Growth	LPG	Growth
1985/86	15813		4034		11097		287		2603				5723		421	
1986/87	22895	0.4478594	4789	0.187159	12826	0.155808	285	-0.00697	3247	0.247407			7679	0.341779	347	-0.17577
1987/88	27936	0.2201791	6304	0.31635	15199	0.185015	196	-0.31228	4697	0.446566	76		9182	0.195729	251	-0.27666
1988/89	35878	0.2842927	9336	0.480964	17831	0.173169	119	-0.39286	6099	0.298488	368	3.842105	14789	0.610651	26	-0.89641
1989/90	40677	0.1337588	8501	-0.08944	11794	-0.33857	198	0.663866	5869	-0.03771	19	-0.94837	17503	0.183515	377	13.5
1990/91	28303	-0.3042014	6071	-0.28585	339	-0.97126	32	-0.83838	852	-0.85483	212	10.15789	3829	-0.78124	11	-0.97082
1991/92	41573	0.4688549	3844	-0.36683	7247	20.37758	83	1.59375	3715	3.360329	2	-0.99057	3992	0.04257	25	1.272727
1992/93	53855	0.2954321	6687	0.739594	7820	0.079067	264	2.180723	6363	0.712786	28	13	10841	1.715681	57	1.28
1993/94	61866	0.1487513	7804	0.167041	5625	-0.28069	0	-1	9902	0.556184	25	-0.10714	21489	0.982197	71	0.245614
1994/95	64387	0.0407494	7915	0.014223	7901	0.404622	4	0	12915	0.304282	30	0.2	27042	0.258411	57	-0.19718
1995/96	78716	0.2225449	6604	-0.16563	11258	0.424883	0	-1	19550	0.513744	37	0.233333	28597	0.057503	48	-0.15789
1996/97	84045	0.0676991	6185	-0.06345	15853	0.408154	0	0	19329	-0.0113	17	-0.54054	30351	0.061335	31	-0.35417
1997/98	100057	0.190517	6934	0.121099	48793	2.07784	0	0	32902	0.702209	22	0.294118	54996	0.812	36	0.16129
1998/99	79473	-0.2057227	1085	-0.84352	12728	-0.73914	0	0	16626	-0.49468	4	-0.81818	24468	-0.55509	5	-0.86111
1999/00	75795	-0.0462799	946	-0.12811	15962	0.254085	0	0	20656	0.242391	10	1.5	27393	0.119544	500	99
2000/01	82480	0.0881984	5100	4.391121	22585	0.414923	1403	0	22866	0.106991	638	62.8	43859	0.601102	2167	3.334
2001/02	76991	-0.0665495	4136	-0.18902	22147	-0.01939	1115	-0.20527	22733	-0.00582	506	-0.2069	41373	-0.05668	1723	-0.20489
2002/03	76913	-0.0010131	5581	0.349371	24135	0.089764	1535	0.376682	25015	0.100383	698	0.379447	44135	0.066759	2373	0.377249
2003/04	84278	0.0957575	8312	0.489339	27261	0.129521	2283	0.487296	28533	0.140636	1038	0.487106	49307	0.117186	3532	0.488411
2004/05	142663	0.6927668	8447	0.016242	28269	0.036976	2323	0.017521	30988	0.086041	1056	0.017341	61897	0.255339	3590	0.016421

	West				Central				Total			
year	kerosene	Growth	LPG	Growth	kerosene	Growth	LPG	Growth	kerosene	Growth	LPG	Growth
1985/86	1215				6808				43259		4742	
1986/87	1928	0.5868313			9682	0.42215			58257	0.346702	5421	0.143189
1987/88	2117	0.098029	53		9832	0.015493	306		69017	0.184699	7184	0.325217
1988/89	2513	0.1870572	53	0	12642	0.285801	731	1.388889	89752	0.300433	10633	0.480095
1989/90	2790	0.1102268	14	-0.73585	15095	0.194036	768	0.050616	93728	0.0443	9878	-0.07101
1990/91	675	-0.7580645	7	-0.5	3298	-0.78152	377	-0.50911	37296	-0.60208	6710	-0.32071
1991/92	2000	1.962963	0	-1	10135	2.073075	104	-0.72414	68661	0.840975	4058	-0.39523
1992/93	3387	0.6935	7	0	18422	0.817662	349	2.355769	100688	0.466451	7391	0.821341
1993/94	6527	0.9270741	7	0	28352	0.539029	230	-0.34097	133762	0.32848	8136	0.100798
1994/95	10501	0.6088555	5	0	37932	0.337895	251	0.091304	160658	0.201074	8262	0.015487
1995/96	12175	0.1594134	0	0	45891	0.209823	110	-0.56175	196167	0.221022	6798	-0.1772
1996/97	15761	0.294538	0	0	54540	0.188468	82	-0.25455	210879	0.074997	6315	-0.07105
1997/98	44799	1.8423958	0	0	84340	0.546388	68	-0.17073	365887	0.735057	7060	0.117973
1998/99	11652	-0.7399049	0	0	31824	-0.62267	0	-1	176772	-0.51687	1103	-0.84377
1999/00	15820	0.3577068	612	0	36731	0.154192	1224	0	192357	0.088164	946	-0.14234
2000/01	17669	0.1168774	1020	0.666667	33192	-0.09635	2424	0.980392	222651	0.157488	12752	12.47992
2001/02	19280	0.0911766	810	-0.20588	25084	-0.24428	1925	-0.20586	207608	-0.06756	10215	-0.19895
2002/03	20200	0.0477178	1116	0.377778	36925	0.472054	2650	0.376623	227323	0.094963	13953	0.365932
2003/04	23916	0.1839604	1662	0.489247	46182	0.250697	3948	0.489811	259477	0.141446	20775	0.488927
2004/05	40564	0.696103	1689	0.016245	80704	0.747521	4012	0.016211	385085	0.484081	21117	0.016462

Appendix 5- Value of Import ,Export ,Crude and Refined Petroleum

year	value of import	value of export	value of crude and refined petroleum	growth of import	growth of export	%of crude &refined petroleum as import	Trade balance
979/80	1432858	950667	339384	0	0	23.7	-482191
980/81	1384234	851509	345322	-0.0339	-0.1043	24.9	-532725
981/82	1641661	778083	361453	0.186	-0.0862	22	-863578
982/83	1752945	809625	396992	0.0678	0.0405	22.6	-943320
983/84	2067005	929625	378388	0.1792	0.1482	18.3	-1137380
984/85	1770433	744572	317925	-0.1435	-0.1991	18	-1025861
985/86	2201265	923816	252534	0.2433	0.2407	11.5	-1277449
986/87	2236946	795284	225824	0.0162	-0.1391	10.1	-1441662
987/88	2274651	773672	216770	0.0169	-0.0272	9.5	-1501009
988/89	1824119	902753	212851	-0.0722	0.1869	10.1	-1207600
989/90	2130305	736806	225081	-0.1356	-0.1838	12.3	-1087313
990/91	1810897	542485	210426	0.1679	-0.2637	9.9	-1587820
991/92	3618718	279026	193153	-0.1499	-0.4857	10.7	-1531871
992/93	4739967	800814	821090	0.9983	1.87	22.7	-2817904
993/94	6546274	1238729	737567	0.3098	0.5468	15.6	-3501238
994/95	7708246	2732046	993914	0.3811	1.2055	15.2	-3814228
995/96	8505200	2539056	931865	0.1775	-0.0706	12.1	-5169190
996/97	9338459	3485626	1504100	0.1034	0.3728	17.7	-5019514
997/98	11702004	4141582	2265515	0.098	0.1882	24.3	-5196877
998/99	11438681	3637260	1308988	0.2531	-0.1218	11.2	-8064744
999/00	16193600	3957802	2012220	-0.0225	0.0881	17.6	-7480879
000/01	16193600	7981500	2151326	0.4157	1.0164	13.3	-8212100
001/02	17709500	8027400	2202554	0.0931	0.006	12.5	-9682100
002/03	20138700	9777900	2463917	0.1372	0.2181	12.4	-10358900
003/04	27333900	12916600	2608208	0.3573	0.321	9.5	-14417300
004/05	33728700	15578800	3008400	0.234	0.21	9.1	-18149900

Appendix 6   Data of kerosene price LPG price and consumption

year	Kerosene price	LPG Price
1964/65	0.39 cents / L	1.12 cents/ kg
1968/69	0.39	1.00
1972/73	0.42	0.92
1976/77	0.42	1.03
1980/81	0.53	1.26
1984/85	0.60	1.30
1988/89	0.60	1.30
1992/93	0.90	1.40
1996/97	1.40	3.68
2000/01	1.90	10.48
2004/05	2.92	9.74

YEAR	**Kerosene**	**LPG**
1964/65	6000	2600
1967/68	4800	2800
1970/71	2200	3400
1973/74	5400	4500
1976/77	6102	2875
1979/80	1916	4214
1982/83	16000	9000
1985/86	47092	9462
1988/89	93266	11883
1991/92	71634	4562
1994/95	165263	9132
1997/98	209101	4558
2000/01	224537	12758
2003/04	292766	20780

Appendix 7 - interpretation of the Estimated Variables

- KCPC and LPGCPC: Kerosene and LPG consumption per capita income, respectively. Data on these variables are recorded in metric cubic. These were however converted to litters by use of the conversion factors (multiplying the metric cubic by 1000). The data obtained from Ethiopian petroleum enterprises. The per capita consumption is obtained by dividing the litters by the population for the respective year.

- $RP_{K\ and}$ $RP_{LPG:\ Real}$ price of Kerosene and LPG, respectively. Since there was no common unit price for Kerosene and LPG l in the country. We have taken Addis Ababa retail price for Kerosene and LPG. This price is taken to represent the retail price for the whole country in this study. This is then divided by GDP deflator (Nominal GDP divided by Real GDP) to obtain the real price. Kerosene and LPG price data also obtained from EPE and Ministry of trade and Industry.

- RIPC: Real income per capita: The income is proxied by the real GDP. We shall also taken note of the influence of population growth to real GDP by using per capita income instead of aggregate figures (dividing real GDP by total population). The data of GDP is obtained from the National Bank of Ethiopia.

- POPG (population growth): Higher population densities (usually high population growth rate) exert pressure on Kerosene and LPG use due to increase in demand for cooking lighting and other activities. So that we took population growth as one determinant factor for of Kerosene and LPG demand. The data is obtained from central statistics office and the Ministry of Finance and Economic Development.

- LU (level of urbanization): when people tends to live in urban, they use more commercial energy for their cooking, and other purposes,. The rate of urbanization may affect Kerosene and LPG use in both the short and long-run. LU obtained by dividing urban population by total population.

- RFEE: real foreign exchange earnings (this includes export of goods and service, net capital inflow, net transfer government and private (net income) and errors and omissions). The real value is obtained by dividing the nominal exports by export unit value index.

Appendix 8 Calculation of GHGs emission for residential fuel combustion (gm/kg)or (gm/litter)

	Co	**Ch4**	**TNMOC**	**N20**
Gas	2.0	0.2	0.2	0.005
Oil	0.9	0.4	0.2	0.030
Wood	80.9	5.0	9.0	0.060
Charcoal	200.0	6.0	3.0	0.030
Dung(Agricultural state)	68.0	4.0	8.0	0.050

1. Determining using IPPC emission factor given for "Natural gas" and the net calorific value given for LPG.
2. Determining using the IPCC emission factor given for "Oil" and the net Calorific value given for "Kerosene".
3. Determined using the IPCC emission factor for "other biomass and wastes" and the average of the net calorific values for "dung" and "agricultural wastes".

TNMOC* - Total non-methane organic compound.

Source- International Energy Initiative (IEI)

Bang lore, 2000.

Appendix -9 estimated coefficient of the general parsimonious model
(Including all insignificant variables; lnkcpc pc-give out put)

Equation 1 for D2lnkcpc

Variable	Coefficient	Std.Error	t-value	t-prob
D2lnkcpc_1	1.3645	0.49853	2.737	0.0339
D2lnkcpc_2	-1.6807	0.62151	-2.704	0.0354
D2lnkcpc_3	0.97545	0.40573	2.404	0.0530
Constant	0.23116	0.88589	0.261	0.8029
D2lnrpk	2.9991	2.9566	1.014	0.3495
D2lnrpk_1	4.4442	1.6572	2.682	0.0365
D2lnrpk_2	0.44310	1.5246	0.291	0.7811
D2lnrpk_3	5.7855	1.7897	3.233	0.0179
D2lnrplpg	-0.20410	0.95518	-0.214	0.8379
D2lnrplpg_1	-1.4573	1.1605	-1.256	0.2559
D2lnrplpg_2	1.7086	0.75879	2.252	0.0338
D2lnrplpg_3	1.6242	1.0054	1.616	0.1573
D2lnrpci	-10.870	4.7830	-2.273	0.0634
D2lnrpci_1	-3.1053	10.485	-0.296	0.7771
D2lnrpci_2	2.9059	7.3124	0.397	0.7048
D2lnrpci_3	-9.2596	9.8112	-0.944	0.3817
D2lnpopg	3.0493	1.0799	2.824	0.0302
D2lnpopg_1	-1.1041	0.3769	-2.931	0.0110
D2lnpopg_2	0.63073	1.6775	0.376	0.7199
D2lnpopg_3	0.47344	1.4863	0.319	0.7609
D2lnlu	17.658	11.671	1.513	0.1810
D2lnlu_1	-7.8014	10.623	-0.734	0.4904
D2lnlu_2	-6.7481	8.0292	-0.840	0.4329
D2lnlu_3	-3.1858	8.8500	-0.360	0.7312
D2lnrfee	1.3385	0.65152	2.054	0.0857
D2lnrfee_1	0.079857	0.92263	0.087	0.9338
D2lnrfee_2	0.044603	0.57884	0.077	0.9411
D2lnrfee_3	-0.43063	0.48575	-0.887	0.4095
ECM_1	-0.81670	0.48541	-1.683	0.1435
Dummy	-0.49350	0.81170	-0.608	0.5655

R^2 = 0.935838   F(29,6) = 3.0177 [0.0852]   DW = 2.42
RSS = 1.261952529 for 30 variables and 36 observations

R^2 relative to difference+seasonals = 0.93228
AR 1- 1 F(1, 5) = 55.791 [0.0007] **
ARCH 1 F(1, 4) = 0.037115 [0.8566]
Normality Chi^2(2)= 3.7087 [0.1566]
RESET F(1, 5) = 0.19834 [0.6747]

Appendix -10 estimated coefficient of the general parsimonious model

(Including all insignificant variables; lnLPGcpc pc-give out put)

Equation 1 for D3lnlpgcpc

Variable	Coefficient	Std.Error	t-value	t-prob
D3lnlpgcpc_1	1.1416	0.24204	4.716	0.0053
D3lnlpgcpc_2	-0.63404	0.30936	-2.049	0.0957
D3lnlpgcpc_3	-1.2940	0.22270	-5.811	0.0021
Constant	0.79803	0.26044	3.064	0.0280
D3lnrplpg	-0.45212	0.19004	-2.379	0.0321
D3lnrplpg_1	-1.2651	0.45910	-2.756	0.0400
D3lnrplpg_2	1.2869	0.89359	1.440	0.2094
D3lnrplpg_3	-0.67558	0.75882	-0.890	0.4141
D3lnrpk	0.93659	1.1413	0.821	0.4492
D3lnrpk_1	2.7149	0.59777	4.542	0.0062
D3lnrpk_2	-0.40387	0.54692	-0.738	0.4934
D3lnrpk_3	-0.55914	0.99088	-0.564	0.5969
D3lnrpci	3.9840	1.6011	2.313	0.0365
D3lnrpci_1	-6.4558	2.5502	-2.531	0.0240
D3lnrpci_2	-1.5561	4.0965	-0.380	0.7196
D3lnrpci_3	8.9200	4.3245	2.063	0.0941
D3lnpopg	1.3389	0.79179	1.691	0.1516
D3lnpopg_1	0.94314	0.51651	1.826	0.0893
D3lnpopg_2	0.48694	0.57367	0.849	0.4347
D3lnpopg_3	2.4421	1.0849	2.251	0.0742
D3lnlu	-11.913	7.3232	-1.627	0.1647
D3lnlu_1	8.1866	4.0940	2.000	0.0820
D3lnlu_2	-6.4683	4.1583	-1.556	0.1805
D3lnlu_3	5.6746	3.1213	1.818	0.1287
D3lnrfee	0.12797	0.24058	0.532	0.6176
D3lnrfee_1	-0.89361	0.36005	-2.482	0.0557
D3lnrfee_2	-0.87445	0.38662	-2.262	0.0732
D3lnrfee_3	-0.61923	0.28980	-2.137	0.0857
ECM_1	-0.42346	0.38282	-1.106	0.3190
Dummy	0.11817	0.39936	0.296	0.7792

R^2 = 0.978387   F(29,5) = 7.8048 [0.0152]   DW = 2.63
RSS = 0.1456304798 for 30 variables and 35 observations
R^2 relative to difference+seasonals = 0.98300

AR 1- 1 F(1, 4) = 1.0223 [0.3692]
ARCH 1 F(1, 3) = 0.036445 [0.8608]
Normality Chi^2(2)= 0.23295 [0.8901]
RESET F(1, 4) = 1.87 [0.2433]

Appendix - 11 Determination of lag length on kcpc and LPG demand models.

EROSENE DEMAND							
rogress to date; LAG 1,2,3,4 compare with system 4,3,2,1 respectively							
ystem	T	p		log-likelihood	SC	HQ	AIC
4	37	14	COINT	34.082833	-0.47602	-0.87067	-1.8423
3	37	21	COINT	39.507863	-0.086120	-0.67809	-1.1356**
2	37	28	COINT	49.749926	0.043401	-0.74589	-1.6892
1	37	35	COINT	107.32331	-2.3855	-3.3721	-4.8013

```
Tests of system reduction
System  3 --> System  4: F( 7,   16) =   0.77891 [0.6198]
System  2 --> System  4: F(14,    9) =   0.85650 [0.6165]
System  1 --> System  4: F(21,    2) =    4.8954 [0.1832]

System  2 --> System  3: F( 7,    9) =   0.95085 [0.5153]
System  1 --> System  3: F(14,    2) =    5.4405 [0.1659]

System  1 --> System  2: F( 7,    2) =    6.1336 [0.1473]
```

PG DEMAND							
rogress to date; LAG 1,2,3,4 compare with system 4,3,2,1 respectively							
ystem	T	p		log-likelihood	SC	HQ	AIC
4	37	14	COINT	56.105910	-1.6665	-2.0611	-3.0328
3	37	21	COINT	59.659526	-1.1754	-1.7674	-2.2248**
2	37	28	COINT	72.533446	-1.1881	-1.9774	-2.9207
1	37	35	COINT	126.78032	-3.4373	-4.4239	-5.8530

```
Tests of system reduction
System  3 --> System  4: F( 7,   16) =   0.48406 [0.8324]
System  2 --> System  4: F(14,    9) =   0.91942 [0.5717]
System  1 --> System  4: F(21,    2) =    4.2491 [0.2076]

System  2 --> System  3: F( 7,    9) =    1.2928 [0.3517]
System  1 --> System  3: F(14,    2) =    5.2347 [0.1718]

System  1 --> System  2: F( 7,    2) =    5.0772 [0.1744]
```

WHERE;

AIC Akaike Information Criteria
SC Shawartz Bayessian Criteria
HQ Hannan-quinn Statistics 89

Appendix 12 Result of Granger-causality test for KCPC and LPGCPC.

```
Autoregressive-distributed lag model of lnkcpc on lnrpci
Auto regression part has lags 1 to 2
Distributed Lag part has lags 0 to 2
The present sample is:  3 to 41
Auto regression
             Lag  1     Lag  2
Coeff.        1.089    -0.1321
Std.Err       0.173     0.1759

Distributed Lag
          Constant      Lag  0      Lag  1      Lag  2
Coeff.       3.658    0.08882     -0.6217       0.314
Std.Err      27.58      1.861       2.499       2.039

RSS = 8.886265312                         R^2 = 0.904379
F(5,33) = 62.4228 [0.0000] **

Granger-Causality test for adding lnrpci to lnkcpc:
F(3,33) = 0.028286 [0.9935]


Autoregressive-distributed lag model of lnlpgcpc on lnrpk
Auto regression part has lags 1 to 2
Distributed Lag part has lags 0 to 2
The present sample is:  3 to 41
Auto regression
             Lag  1     Lag  2
Coeff.       0.5967     0.1914
Std.Err      0.1709     0.1801

Distributed Lag
          Constant      Lag  0      Lag  1      Lag  2
Coeff.      0.3429     0.0154      0.4092     -0.2373
Std.Err      1.546     0.3719      0.4169      0.3924

RSS = 3.074184816                    R^2 = 0.689318
F(5,33) = 6.32388 [0.0003] **

Granger-Causality test for adding lnrpk to lnlpgcpc:
F(3,33) = 0.41132 [0.7459
```

DECLARATION

I, the undersigned declared that this thesis is my original work and it has not been presented in any other university. All sources of materials used for this thesis have been duly acknowledged.

Declared by

Name GETAMESAY BEKELE

Signature

Date 05 APRIL 2007

Place Addis Ababa University

Addis Ababa

Confirmed by

Name Syed Hasan Sayed

Signature

Date 05-04-07