GASOLINE DEMAND ANALYSIS IN KENYA

BY

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DECLARATION

This research paper is my original work and has not been presented for a degree in any other university.

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DEDICATION

I wish to dedicate this work to my father, Mr. Joseph Maina and my mother, Mrs.Mary

Maina who sacrificed so much to facilitate my education.

ACKNOWLEDGEMENTS

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ABSTRACT

Kenya is an oil importing developing country with rapidly increasing commercial energy consumption whereas the oil industry is a very important sector in the economy. The oil prices revolution has profound impact on the Kenyan economy. Severe effects are felt in form of inflation, unemployment and direct income losses resulting in large current account deficit. Petroleum is the second largest source of primary energy and the largest source of commercial energy for the modern sector in Kenyan economy. Light diesel oil is the most consumed petroleum product. Motor spirit is third after fuel oil. Thus demand for gasoline (motor spirit and light diesel oil) is, therefore, central to economic development. On the other hand, gasoline consumption has negative effects to the environment in form of vehicular emissions. This calls for further investigation on the determinants of gasoline demand and its impact on the environment.

The objective of this study is to analyze the factors that determine gasoline consumption in Kenya. It incorporates a more detailed analysis of the relationship that constitutes the demand for gasoline and the environment in Kenya and uses the results to make policy suggestions. The exercise is deemed necessary to provide important information to policy makers on the energy sector.

Ordinary Least Square estimation method is applied on a dynamic double-log model for motor spirit (regular and premium) and light diesel oil using annual countrywide data The parameters in the model are estimated using time series data and the cointegration approach is applied. The data was extracted from secondary sources in yearly series for the period 1963 to 2000. The results show that gasoline is significantly driven by income. The income was found to be elastic. Other variables affect gasoline differently. The policy recommendation based on the results of estimated model emerged that pricing policies should be accompanied by other policies to achieve the desired objectives.

CHAPTER ONE

1.0 Introduction

This study investigates the factors that determine gasoline[1] consumption in Kenya. It incorporates an analysis of the relationship that constitutes the demand for gasoline and the environment in Kenya and will use the results to make policy suggestions.

Kenya is an oil importing developing country with rapidly increasing commercial energy consumption. The oil price revolution has profound impact on the Kenyan economy. Severe effects are felt in form of inflation, unemployment and direct income losses resulting in large current account deficit. Gasoline provides an important source of energy but at the same time emit billions of tonnes of green house gases[2] besides other pollutants. The conflict between economic development, energy consumption on one hand and environmental degradation on the other have not been given enough attention in Kenya. This study is therefore justified on a three-point basis. namely: - the importance of gasoline in total energy consumption in the economy, the dependence on foreign supplies and the environmental impact of this consumption

The study expects to compute the income and price elasticities of gasoline demand both in the short run and the long run. The impact on gasoline demand of other environmental variables like motor vehicle and population fleet will also be obtained. The outcome of

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[1] For the purposes of this study gasoline consists of motor spirit (regular and premium) and light diesel oil.

the study will add to available literature valuable knowledge on the energy-environmental interaction and aid policy makers in formulating energy policies that are environment friendly for sustainable development.

1.1 Background

Energy is an important input in the process of economic development. Thus its adequate and reliable supply is a necessary prerequisite to industrial, commercial and agricultural development as well as for domestic use. From the point of view of an energy economist, the volume of energy consumption per capita may be one of the best indexes of economic development. The development of civilization has depended upon energy. It provides the main services, which underpin human societies; heat, light, materials, transport and communication. Major energy sources in Kenya are petroleum fuels, electricity and wood fuel. Minor sources include solar energy, wind, ethanol, coal and biogas.

Modern societies have developed on the back of fossil fuels reserves, which provides energy in an accessible, concentrated form. For clear economic reasons, fossil fuels dominate energy supplies and their use globally is still growing rapidly. Petroleum products dominate the transportation industry's energy demand. This industry includes road transport, rail transport, marine transport and aviation mode of transport. This is why the price increase do not have an appreciable effect on quantity demanded. The industry plays a proportionately large role in the economic development process in Kenya: Freight

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[2] Green house gas is any gas that is thought to contribute to global warming

transport to develop an industrial base and passenger transportation to provide the mobility necessary for social development. Transportation facilitates linkages between rural, agricultural and urban centres, marketing and population centres, and integration of various production and population centres, mobility and enhancing human welfare. Lack of mobility hampers economic development (Afrepren, 1996).

Petroleum fuels constitute a major source of commercial energy in Kenya. It is the second largest source of energy in the Kenyan economy accounting for 22% of total primary energy consumed after woodfuel (Economic survey 2000). This is so because Kenya is a dualistic economy with a highly monetized, modern economy and a non-monetized, traditional economy. Commercial fuels include motor spirit (regular and premium varieties), liquidified petroleum gas (LPG), kerosene. aviation spirit, jet turbo fuel, heavy diesel oil, light diesel oil (gas oil) and residual fuel oil. This study focuses on motor spirit and light diesel oil. The domestic consumption of gasoline and the importance of petroleum products relative to total energy consumption in Kenya is presented in table 1.1 below.

From the table, it is evident that the demand for gasoline (both motor spirit and light diesel oil) has been on the rise since independence. However, the percentage proportion of petroleum products in total energy consumed in Kenya has been on the decline from 85.33% in 1973 to 69.42% in 1996 before turning around to a record of 90.67% in the year 2000.

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Table 1.1 Relative importance of petroleum in total energy consumed in Kenya

In'000 tonnes of oil equivalent

Year	Motor spirit	Light diesel oil	Total petroleum product	Total energy consumption	Percentage of petroleum products to total energy demand.
1973	232.7	254.0	1359.9	1580.3	86.05
1974	225.7	250.1	1352.7	1601.6	84.46
1975	234.8	255.0	1392.8	1643.3	84.76
1976	241.0	288.3	1563.5	1806.5	86.55
1977	270.5	311.8	1607.8	1884.2	85.33
1978	290.8	324.2	1659.9	2004.3	82.82
1979	302.0	349.2	1677.5	2041.2	82.18
1980	300.8	408.5	1768.2	2158.2	81.93
1981	298.5	375.6	1672.3	2123.5	78.75
1982	269.3	373.1	1573.3	2035.0	77.31
1983	256.4	388.9	1442.4	1966.7	73.34
1984	257.7	420.1	1553.5	2101.5	73.92
1985	267.8	447.7	1565.5	2160.9	72.45
1986	295.1	481.0	1654.1	2280.9	72.52
1987	321.8	572.7	1831.6	2489.3	73.58
1988	325.0	537.3	1809.1	2549.5	70.96
1989	376.7	543.6	1899.8	2688.2	70.67
1990	339.9	555.4	1830.3	2667.4	68.62
1991	339.3	559.9	1755.1	2619.7	67.00
1992	346.8	571.1	1839.3	2731.8	67.33
1993	352.0	554.2	1826.3	2763.1	66.10
1994	352.2	539.8	2008.8	2949.1	68.12
1995	378.7	603.1	2066.5	3028.8	68.23
1996	399.3	646.3	2230.5	3213.0	69.42
1997	390.6	615.9	2175.2	2588.6	84.03
1998	395.8	607.5	2199.1	2606.4	84.37
1999	384.6	601.7	2311.6	2676.4	86.37
2000	365.7	712.8	2448.1	2700.1	90.67

Source: Republic of Kenya: *Economic Surveys*, various issues
Author's own calculations.

Petroleum is the second largest source of primary energy in Kenya's economy and the largest source of commercial energy used in the modern sector. Total energy demand for industrial and commercial use in Kenya has been rising steadily from 2.6 million tons of

oil equivalent (TOE's) in 1991 to over 3.1 million TOE's in 1995. This is an average growth rate of 3.7% per annum (8th national development plan, 1997-2000).

Kenya depends on imported petroleum products. However oil exploration has been going on in Kenya since the 1950's (Senga et. al., 1980). Despite extensive geographical and seismic surveys no oil has been discovered in commercially feasible quantities. Until oil is discovered in commercially exploitable quantities, Kenya will have to continue to rely on imported crude oil and other petroleum fuels to satisfy a major portion of her commercial energy requirements.

There is a direct relationship between gasoline consumption and environmental degradation. Road transport is the most important mode of transportation for both freight and passengers and thus the biggest consumer of gasoline. Therefore, being the widely used mode it is a significant source pollutant in form of vehicular emissions. Motor vehicles emit carbon monoxide, sulfur dioxide, hydrocarbons, nitrogen oxides, particulate matter, lead (where leaded gasoline is used) and other toxic substances such as benzene 1,3, butadiene, formaldehyde (Faiz et. al., 1996). Exhaust emissions are caused by combustion process. Each pollutant has adverse effects on human health and welfare. Increased energy consumption as well as increased environment hazards accompanies economic growth thus energy is an important aspect of human life as well as a harmful part too.

Clearly a much greater progress is needed to bridge the gap between increasing transport demand hence increasing gasoline demand and the goal of environmental friendly sustainable economic development. This challenge can though be met and at acceptable costs through technical measures along with planning, policy and management options. For instance fixing a catalyst converter prior to discharge to the air can control gaseous emissions from automobiles. This reduces potential air pollution, unpleasant smell from these emissions and corrosion of building materials. The development of an energy policy is a key element in maintaining and improving the environment because the use of energy affects the environment in many ways.

1.1.1 Gasoline Pricing In Kenya

Kenya is a net importer of petroleum fuels either directly or as crude oil, which is refined in Mombasa. This importation, which is price insensitive, leads to large deficits in the balance of trade - especially after liberalization of Kenyan economy. The petroleum product prices in Kenya remained low and fairly stable before the oil crisis of 1973 74 after which the prices increased sharply. During the oil crisis, prices of crude oil went up by about 400 per cent from US$ 2.74 a barrel in 1973 to USS 9.33 a barrel in 1974. Consequently, the price of petroleum products rose with almost a similar margin. Consumption on the other hand reduced by 2.5% from 1.54 million litres in 1973 to 1.50 million litres in 1974 (Economic Survey, 1974). Since then oil prices have continued to rise persistently. Despite the increase in prices of petroleum products the domestic sales

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of these products have continued to rise. The instability of world oil prices has translated into erratic price movements of refined petroleum products in the domestic economy.

The price rise of petroleum products in 1974 and 1975 led to a reduction in consumption of motor spirit per vehicle from 2,103 litres in 1974 to 2,025 litres in 1975 (Economic Survey, 1976). In 1976 the price of crude oil rose to US$12.17 per barrel up from US$ 11.40 in 1975. This represents an increase of less than 7% compared to an increase of 11.2% in 1975. (Economic Survey, 1977).

The retail price of these products rose only once during 1978 by 5 per cent as compared to a total rise of 13 per cent in 1977. Consequently, the sales of petroleum products for domestic consumption rose by 2% with most of the rise occurring in motor spirit, light diesel oil and illuminating kerosene. The 1979 prices were 46 per cent higher than those of 1978. For refined products in Kenya, the total increase in oil prices, which also rose three times during the year, was above by 25%. However, there was a fairly substantial increase in sales of light diesel oil in 1979 (about 8%o rise in sales) but motor spirit showed only a moderate increase (Economic Survey, 1980). Table 1.2 shows how domestic prices responded to the oil crisis.

The Iran/Iraq war of 1980 was a major cause of an increment in price of crude oil, which ended in December 1981 when the price stood at US$ 34.52 (Economic Survey, 1982). The government to defray both transport and refining costs, which had increased, raised

the wholesale prices of all petroleum products at Mombasa. However, consumption of gasoline continued on an upward trend (Economic Survey, 1985).

The gulf conflict affected the oil industry resulting to overproduction of crude oil above the OPEC quotas. Daily production increased by 8% from the official 16.6 million to 18 million barrels. This led to fluctuation of crude oil prices at around US$ 18 per barrel compared to US$ 9 per barrel in 1986 when overproduction coupled with lower crude oil prices charged by some countries resulted in build-up of stocks. The retail prices of motor spirit remained relatively low in 1986 but shot up in April 1987 after government announced the increase in response to the increase in prices of oil from US$9 to US$18 in 1986 and 1987 respectively. However, the domestic sales of petroleum products increased by 10% in 1987, from 1.583 million litres in 1986 to 1.748 million litres in 1986 (Economic Survey, 1988)

Nominal prices of gasoline at some selected dates are presented in table 1.2 below. It is clear that these prices have been on an upward trend. The effect of oil crisis of 1974 and 1979 on local gasoline prices is evident. For instant the price of premium variety of motor spirit rose from Ksh. 1.62 in February, 1974 to Ksh. 2.03 in February, 1975 and then from Ksh. 3.36 in June, 1979 to Ksh.5.35 in June, 1980.

Table 1.2: Nominal prices of gasoline at selected dates

In Kenya Shillings

Date	Motor spirit		Gas oil
	Premium	Regular	
22/3/1971	1.19	1.09	0.82
02/01/73	1.24	1.14	0.84
12/02/74	1.62	1.50	1.16
20/02/75	2.03	1.91	1.36
10/3/76	2.57	2.42	1.77
14/4/77	2.64	2.52	1.84
16/6/78	3.03	2.91	2.11
8/6/79	3.36	3.36	2.31
20/6/80	5.35	4.70	3.23
21/2/81	6.15	5.71	3.93
3/12/82	8.00	7.52	5.48
27/4/84	8.61	8.13	5.94
13/6/86	8.02	7.64	5.30
1/7/87	9.01	8.43	5.62
17/6/88	9.31	8.63	5.72
08/09/90	14.41	14.11	10.90
29/11/91	15.79	15.49	11.96
1/2/92	17.88	17.58	13.46
10/6/93	27.64	27.12	22.81
17/6/94	29.14	28.82	23.81
06/1995	29.83	29.16	25.33
06/1996	32.83	31.93	25.42
06/1997	36.76	35.69	29.45
06/1998	39.51	38.44	31.80
06/1999	43.84	42.72	35.85
06/2000	52.44	51.42	43.46

Source: Republic of Kenya; *Economic Surveys*, various issues

Prior to liberalization of the energy sector in October 1994, the government used to control the prices of petroleum products. Local petroleum product prices have continued to be unstable since the liberalization. Rapid changes in prices were due to change in government taxes on these products, changes in global prices, fluctuation of domestic currency relative to international convertible currencies. The government has licensed

independent filling stations to operate in several parts of the country with the aim of stabilizing and lowering the retail prices of petroleum products.

On the international market, OPEC[3] and Non-OPEC members agree to cut output to boost prices. An example is in March 1999, where this led to 27.8% increase in prices between January and October 2000 i.e. from US$25.2 to US$32.2 per barrel. This is the highest price level since the 1990 gulf war (Economic Survey, 2001).

1.2 Statement Of The Problem

Kenya depends heavily on imported oil. This import dependency teamed up with the vulnerability of domestic oil prices to international oil market prices and weakening of the Kenya Shilling against high-powered currency makes oil prices to have profound impacts on the Kenyan economy. Severe effects are felt in form of inflation, unemployment and direct income losses resulting in large current account deficit. This position is likely to persist since there are no economically feasible substitutes. This means that Kenya will continue being susceptible to external destabilizing forces and it will be difficult to plan effectively for the country's future development. The decline in economic growth in the mid-70's was triggered by the first international oil price crisis of 1973. The onset of oil crisis revealed serious structural constraints within the economy. Thus any factor that affects petroleum products has far reaching effects on economic growth and development of this country.

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[3] OPEC means Organization of Petroleum Exporting Countries

Kenya, as well as other African countries, is pressed to meet the national demand for economic and social progress and challenges of the world competition in international trade. The transportation of both people and goods is an essential human activity and has a crucial input to social development and national economy. Gasoline provides an important source of energy for the transportation sector. However, the sustainability of the use of gasoline in Kenya is questionable as it draws heavily on scarce resources to finance petroleum product sources. Furthermore, the environmental cost of this energy-intensive sector is also critical and far-reaching.

In the light of the above, demand management and conservation appear as necessary policies in order to optimize on the use of gasoline in Kenya and at the same time maintain environmental quality. The study focuses on the gasoline demand in the context of environmental quality management and makes recommendations that can be used to make environmental friendly energy policies for sustainable development.

1.3 Objectives Of The Study

This study has a general objective of analyzing demand for gasoline in accordance to the standard theory of demand and to suggest policies aimed at improving gasoline demand management and environmental quality in Kenya

Specific attention will be paid to the following key areas: -

I. To analyse the factors that influence demand for gasoline in Kenya

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II. To draw policy recommendations for energy sector in the contexts of environmental friendly sustainable economic development.

1.4 Justification Of The Study

Kenya aims at being industrialised by the year 2020 (Sessional Paper no. 1, 1996). This process teamed up with population growth will lead to rise in economic activities which, in turn, will need an expansion in transport facilities and road network. On the other hand, increased industrial activities and agricultural output will all lead to gasoline demand increment and at the same time emission of more pollutants. Therefore economic management is needed to optimise energy consumed.

The identification by this study of linkages between gasoline consumption and the environment will indicate possible areas of action in the energy sector development. The research findings will provide policy-makers with some valuable knowledge and suggestions for long-term energy policy formulation as a way towards environmental friendly sustainable economic development

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Theoretical Literature

Gasoline demand has been analyzed extensively especially in developed countries. A wide range of studies attempts to do this analysis over the years mainly in price and income elasticities. There are three models used in studies: -

      (1) Static model

      (2) Dynamic model

      (3) Motor vehicle model

2.1.1 The Static Model

The model analyses price and income elasticities of demand for gasoline and provides information for forecasting and policy formulation. It assumes that the dynamic features of demand like habit formation and capital stock adjustment takes place rapidly with changes in demand determinants.

The model is of the form: -

$G = g(P_g, Y)$

      Where; G is the quantity of gasoline demanded

          P_g is the price of gasoline

          Y is the real income

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2.1.2 The Dynamic Model

This model represents a dynamic behaviour in partial adjustment model. It is based on the recognition that demand does not adjust instantaneously/rapidly to the changes in its determinants i.e. the argument that today's consumption is not only a function of today's real income and prices but also, previous prices and income. It takes time for existing fuel utilising stocks of vehicles to be modified and/or replaced. The simplest version of the model is given by: -

$G = f(P, Y, G_{t-1})$

Where; G is gasoline demand

Y is real income

P is the price of gasoline

G_{t-1} is the quantity demanded in the previous period.

2.1.3 The Motor Vehicle Model

This model includes stocks of automobile and motor vehicle characteristics in the analysis. It is based on the technical relationship between gasoline demand and stock of automobile. In the short run the total gasoline demand is determined by the rate of utilisation of stock of automobiles and in the longer run by the level of stock of automobiles which grows in time as economy (Senga et. al., 1980).

Thus, $G_t = k(P, Y, V)$

Where; V is the stock of automobiles. Other variables are as defined above.

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Part of stocks of automobiles is under-utilised or idle at a particular point in time therefore the rate of utilisation depends on the general state of the economic activity

Thus, $D = \alpha S$

Where; D is gasoline demand in certain units;

S is stock of automobiles;

α is the rate of utilisation of S.

Due to their versatility, flexibility and low initial cost, motorized road vehicles overwhelmingly dominate the markets for passengers and freight transport throughout the developing countries (Faiz et. al., 1996). Owing to the rapidly increasing number and very limited use of emission control technologies, motor vehicle emerge as one of the largest source of urban air pollution in these countries. Faiz et. al. identified other adverse impacts of motor vehicle use to include accidents, noise, congestion, increased energy consumption and green house gas emissions. They argued that without timely and effective measures to mitigate the adverse impacts of motor vehicle use, the living environment in these countries will continue to deteriorate and become increasingly unbearable. They pointed out that stopping the growth of motor vehicle use was neither feasible nor desirable given the economic and other benefits of increased mobility The challenge, then, is to manage the growth of motorized transport so as to maximize its benefits while minimizing its adverse impacts on the environment and on society. Such measures include; one, technical measures involving vehicles and fuels, two, transport

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demand management and marketing incentives and, three, infrastructure and public transport improvement. They focussed on technical measures for controlling and reducing emissions from motor vehicles and argued that changes in technology can achieve very large reduction in pollutant emissions at modest cost. They identified factors effecting vehicle emissions as driving patterns, traffic speed & congestion, altitude, temperature and other ambient conditions; by the type, size, age and condition of vehicle engine and above all the emission control equipment and its maintenance. They advocated for establishment of motor vehicle standards.

Gonzalez (1971) stressed the need for increased effort to provide cleaner air and water as an expanding population creates more waste products. He disapproved the argument that better environment can only be achieved by reducing population growth or by prohibiting the use of internal combustion engines. He argued that, when aspirations to reduce poverty are analyzed, it becomes clear that we cannot and need not reduce consumption. A high energy society improves productivity so much that it can afford to spend part of the additional output to improve the environment to enjoyable standards, provided the costs are kept in relation to the results achieved.

Omursal and Gautam (1997) analyzed the pollutant emitted by motor vehicles, their effects and measures targeted to vehicles, fuels and transport management to control them. He presented case studies for seven urban areas, namely Mexico City, Rio de Janeiro. Sao Paulo. Belo Horizonte, Buenos Aires, Santiago and Bogota. They illustrated

how these measures have been used in the region and how they can be strengthened. They pointed out that formulation and implementation of a comprehensive and effective urban air quality management strategy require a coordinated effort among national, regional and local institutions representing the various jurisdictions in urban areas. This is being hampered by unclear or overlapping institutional responsibilities, inadequate equipments, technical expertise and human & financial resources; weak financial management; lack of political will and limited public support or participation. They recommended the participation of scientific, business communities, labour unions and NGO[4].

Gordon (1971) argued that the development of an energy policy is a key element in maintaining and improving the environment because the use of energy affects the environment in an almost infinite number of ways. He said that beyond the obvious question of pollutants lie the tremendously complex sociological and economic problems associated with the ever-increasing energy demand of our society

To put environmental issues in perspective, it is first worth considering levels, trends and geographical changes in energy consumption (Anderson, 1990). He discussed the issues of environmental concerns faced by the oil and gas industry both in the industrial and developing countries. Among other issues the assessment included gaseous emissions from end-use. He identified end-use types of emissions that give cause for environmental

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[4] Non-Governmental Organization

concerns as sulfur dioxide, nitrogen oxides, carbon monoxide, unburned hydrocarbons or particulate and the green house gases. He argued that environmental benefits can be achieved by regulatory and tax approaches.

2.2 Empirical Literature

Balestra and Nerlove (1966) developed a dynamic model of the demand for natural gas in the residential and commercial sectors of the United States. They considered two basic aspects of the demand analysis:- the fundamental one was the formulation of demand function for commodities whose consumption is technologically related to the stocks of appliances - in such markets the consumers' behavior can be best described in a dynamic mechanism. Secondly, was the specific problem of estimating the parameters of demand function when the demand model is cast in dynamic terms and when observations are drawn from a time series of cross-section. They made point estimates of the 36 states over six years which suggested an implausible, negative rate of depreciation of gas appliances. The results obtained suggested that time regional effect accounts for about three-quarters of the residual variance in the gas demand equation. The estimated net long-run price and income elasticities of gas demand were 0.63 and 0.62 respectively in the unconstrained case and 0.63 & 0.44 when the depreciation rate is assumed to be 11% for all fuel consuming appliances.

Mehta et. al. (1978) studied demand for gasoline by private individuals in the United States. They formulated a demand function for gasoline whose consumption is

technologically related to stock of automobiles owned by individuals. They employed a dynamic model and quarterly observation from 1963 to 1973. The paper explored consumer demand for gasoline within the framework of the house production function model. They worked with time series of regional cross-sections and found that parameters in gasoline demand model varied across states.

Senga, House and Manundu (1980) assessed trends of energy consumption in Kenya using time series data. The study showed a positive relationship between consumption and GDP with a significant coefficient of elasticities and R-squares. They obtained -0.26 and 1.39 for short run price and income elasticities respectively. They made projections for 1985 and 2000.

Mureithi, Kimuyu and Ikiara (1982) analyzed the impact of increased energy cost on balance of payments, choice of production technology and real income in Kenya using a time series data for the period between 1964 to 1976. They posited the possibility of substitution between different fuels and energy & capital. They argued that cost of raw material not energy was the major contributor to economic problems in Kenya during the period under review.

Berndt and Botero (1983) did a study on demand for energy in Mexican transport sector focusing on rail board, air and motor vehicle modes. For motor vehicle mode. they considered gasoline demand as the product of gasoline consumption per vehicle times the

total number of vehicles and related these components to economic and structural variables. Their structural framework involved two-stage approach where first stage modeled demand for transport services and secondly modeled demand for gasoline as a derived demand from the demand for transport services. Further they developed three identity models based on the identity that gasoline consumption is equal to the utilization rate per vehicle times total number of vehicles. These models are postulated for motor vehicle energy use, the difference among them being various structural restrictions imposed based on the said identity. The data used in the study varied from national time series to cross-sectional data pooled over time. They found gasoline demand as price-responsive even in the short run based on the two-stage approach. Specifically the estimated price elasticities were -0.17 in the short run and -0.33 in the long run. The corresponding income elasticities were larger in absolute values; 0.70 in the short run and 1.35 in the long run. Based on the other models the price elasticity in the short run ranged from -0.24 to -0.15 and in the long run raged from-1.21 to −0.492. The income elasticties from these models varied from 0.15 to 0.39 in the short run and 0.478 to 2.76 in the long run. They argued that structural approach provides for greater opportunities for better understanding and thus planning for future energy demand growth. They found both income and price as important determinants of gasoline consumption and argued that lifting of price controls in Mexico could have great impacts on gasoline and diesel demand especially in the long run.

Iqbal (1984) developed a model for demand for energy in Pakistan on the basis of fuel-consuming appliances and the rate of utilization. He formulated energy demand model on the basis postulates of neo-classical economics i.e. (a) the supply of that commodity is fairly inelastic and (b) the government do not interfere in fixing prices and determining quantity of the commodity. Demand for fuel was expressed as a function of utilization rate of appliances (assumed to be constant and same for all appliances) and the stock of appliances. The equation was expressed in log-linear and assumed a continuous partial adjustment by consumers towards desired level of appliance holding. He estimated income and price elasticities of fuel in the short & long run using OLS and GLS methods and annual data from 1960 to 1981. He found out that these elasticities were statistically significant and consistent with the a priori knowledge of economic theory. He noted that the elasticities should be applied with reservation because they are general indicators not exact estimates having been derived from a simple demand model.

Iqbal (1985) used a dynamic flow adjustment model to analyze demand for gasoline in Pakistan. He observed that in developed countries, models are based on standard neoclassical assumptions of elastic supply and absence of government interference in quantity and price determination. In Pakistan the Government determines the price of gasoline. He formulated desired gasoline demand, as a function of income and price and previous quantity demanded. He employed OLS and GLS[5] estimation techniques and found out that income is an important determinant of gasoline demand in Pakistan. The price elasticity was found to be small and not very significant statistically. His results

were -0.11 as short run price elasticity, 0.28 as income elasticity in the short run. Long run price and income elasticities were -0.77 and 2.1 respectively. He observed that stocks of automobiles are insensitive to prices of automobiles, prices of gasoline or income in the short run.

Adegbulugbe and Dayo (1986) used the static model to analyse gasoline demand in Nigeria. They used annual data from 1965 to 1980. They formulated gasoline consumption as a function of disposable income and a dummy variable, which qualitatively take into consideration government policy affecting the stock of automobiles. The model was then expressed in log-linear forms. OLS[6] estimation method was used and the estimated income elasticity was found to be 1.165. They observed that availability of reliable and consistent data constraints studies in the energy sector in developing countries.

Adegbulugbe and Dayo (1986) also employed the dynamic model in the aforementioned study. They introduced a lagged dependent variable as an independent variable. This implies that gasoline demand at any given time is a dynamic adjustment on the quantity demanded in previous periods influenced by income.

Sasia (1988) analyzed demand for gasoline and light diesel oil in Kenya. He used a dynamic stock adjustment model. OLS estimation method was used for a time series data from 1964 to 1985. He found income as the most important and statistically significant

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[5] Generalised Least Square
[6] Ordinary Least Square

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factor influencing demand for both gasoline and light diesel oil. Price was negatively related to demand but statistically insignificant. He argued that pricing policy alone couldn't reduce consumption of these products. The results obtained for gasoline was income elasticity in the short run of 0.762 and 1.482 in the long run. Price elasticities were -0.05 and -0.10 in the short run and long run respectively. For light diesel oil income elasticity in the short run was 1.066 and in the long run was 1.774. Price elasticities were -0.043 and -0.072 in the short & long run respectively.

Kimuyu (1988) did a structural investigation on the demand for commercial energy in Kenya from 1963 to 1985. He pointed out that oil price revolution adversely affects the BOP[7], employment, capital formation, capacity utilization and overall economic performance. He observed a heavy drain on foreign resources as three-quarters of commercial energy requirements was imported. He identified factors that determine energy demand as aggregate production in the economy, price of energy using equipment, price of energy and the structure of the economy (whether energy intensive or not).

Imran et. al. (1990) did a study on energy demand in developing countries and found out that increased levels of motor vehicle use and urbanization are the main factors contributing to increase in energy consumption in these countries. The study covered China, India, Indonesia, Malaysia, Pakistan, Philippines, Brazil and Thailand. They posited that increased income and shift away from traditional fuels would continue to

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support increases in commercial energy use over the long term. They predicted a doubling of oil consumption by the year 2010 in these countries under optimistic assumptions on conservation and substitution largely due to motorization and switching out of traditional fuels. These countries account for 53% of total energy and 35% of oil consumption in developing countries. They observed a high level of state control in energy supply and demand in these countries. They employed a technico-econometric energy demand model that combines economic determinants of energy demand (i.e. price & income) with technical and engineering information (like fuel efficiency). It assumed that efficiency is price induced and is tied to the stock of capital. By means of pass-through factor, the model established the link between domestic prices and the world prices. They also found that energy demand reacts to price changes with a lag which can stretch over several periods, however, little is known about the exact structure of such lags.

Krupnick (1992) reviewed the existing models of urban transport and evaluated their ability to simulate the effects of different policies on emissions and other variables relevant to welfare. He found out two things; that little modeling work was done on developing countries and that models varied greatly in complexity. He proposed eclectic use of several models since a model with long-term responses, shorter-term responses and emission consequences is not easily tractable. He acknowledged the many complex links between policies (on one hand) and welfare and air pollution (on the other), but said that research can often be narrowed according to policy instruments, data availability and

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[7] BOP is the Balance of Payment   24

the implications considered relevant. Often, simple models can improve the basis for policy evaluation, particularly when there are limited data and resources for research.

A study done by Akiyama and Ishiguro (1995) identified the salient features of energy use in five major Asian developing countries. They developed an econometric model to project energy demand for each of the five countries and estimated the income and price elasticities of demand. The models differed from one country to another mainly depending on availability of data and information. The projection showed a 2.5 to 3 times rise in demand in the year 2005 relative to the 1990 demand. They found energy prices as one of the key variables affecting the progress of energy conservation. They recommended that developing countries should give more attention to energy conservation.

Deogratias (1997) did a study on gasoline demand and the environment in Tanzania. He applied the dynamic log-linear model and used time series data from 1966 to 1996. OLS estimation technique was used and he did stationarity and cointegration tests incorporating them in an Error Correction Method (ECM). He found out that demand for gasoline is generally price inelastic and responds more rapidly to income changes both in long run and short- run. He extended his model to include vehicle stock, exports, and population besides price and income. He concluded that all these are important variables in determining gasoline demand.

Gately and Streifel (1997) analyzed the growth of oil product demand. This study covered 37 largest oil-consuming developing countries, which represented 90% of oil demand for developing countries and nearly 70% of the world's population. For each country the relationship and changes over time of income, population, energy and oil demand was analyzed. Their model had GDP, population and price of oil as the exogenous variables. They calculated the income and price elasticities and made projections of oil demand to the year 2010. They noted extreme heterogeneity in many aspects of these countries, not only among themselves but also compared with the relative homogenous developed countries. They found a great variance oil/income ratios, change in demand and share of transportation products among countries. They found a much greater demand response to income growth than to changes in oil prices. For many oil-exporting countries, oil consumption responded asymmetrically to changes in income, increasing rapidly when income is growing and continuing to increase - albeit more slowly - even when income is declining. The econometric results and analysis suggested that the medium term future were to be like the past; with continued growth in real income in the developing countries, oil demand was to grow about as fast as income. They predicted a doubling of oil demand by the year 2010 relative to the 1993 levels.

Khaoya (1998) found own price, real price of gas oil, real income per capita and the stock of motor vehicle as the determinants of motor spirit demand in Kenya after analyzing the demand for motor spirit. Using a dynamic model he found inelastic long run real price and income. The effect of liberalization of petroleum sector in October 1994 on demand

of motor spirit was found to be insignificant same with the oil crisis of 1973, however, the oil crisis of 1979 had significant effect.

2.3 Overview Of The Literature

Literature based on dynamic model distinguishes between short run and long run income and price elasticities. While these studies are useful especially in providing information on gasoline demand, they assume that each energy source is homogenous and is used for only one purpose.

While most past studies have concentrated on demand for energy at aggregate level, others have tried to access the scope and magnitude of demand for each product but little have been done to obtain information of the environment as a result of gasoline consumption in developing countries. Without such analysis, undesirable assumptions might be made about petroleum use and the environment in Kenya, which may distort any major policy initiative.

Most studies done in Kenya on gasoline assumes that the data is stationary and thus do not employ the relatively new time series econometrics techniques to deal with stationary problems.

CHAPTER THREE

3.0 THEORETICAL FRAMEWORK AND METHODOLOGY

3.1 Theoretical Framework

Gasoline demand is a derived demand since its use is dependent on its utilisation in automobiles hence dependent on stocks of automobiles and some economic measures of its utilisation. These economic measures include price of gasoline, price of competing fuels, disposable income level, utilisation rate and fuel efficiency. Stocks of automobiles are determined by vehicle's price, credit terms and interest rate (Senga et. al., 1980)

Gasoline demand model can be formulated as below: -

$$G_t = f(P_t, C_t, Y_t, A, U, F)\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(1)$$

Where: G_t is the demand for gasoline at time t;

P_t is the price of gasoline at time t;

C_t is price of alternative/competing fuels;

Y_t is income level of individuals;

A is the stocks of automobiles;

U is utilisation rate;

F is fuel efficiency.

The parameters governing fuel use for transportation include: -

- The use of automobile which, is in turn determined by the size of the motor vehicle fleet and the average number of miles driven per vehicle.

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- The technical features of motor vehicle i.e. the average fuel efficiency. Fuel efficiency of the average vehicle depends on the characteristics of the vehicles such as: -

(a) Cars and trucks mix in the fleet. Trucks have low fuel efficiency than cars. In general light vehicles uses less fuel than heavier ones.

(b) The circumstances in which it has to operate including average speed and road conditions.

(c) Traffic density - Greater traffic density tends to reduce the fuel efficiency of vehicles. Congestion problems in Kenya's urban areas affect the car usage and lower the average vehicle-miles per year.

3.2 Model Specification

Since our main interest is both the short run and long run effect. we are going to use a dynamic model that captures adaptation process. The reason for this is that consumers react with a lag to changes in demand determinants. As a result, therefore, gasoline demand is not only a function of current income and prices but also previous income and prices. We try to develop a model that will be capable of satisfying our goals of energy-environment interaction. Thus we incorporate environmental policy variables like population growth and motor vehicle fleet in the model.

Assume that gasoline demand is a function of income level, gasoline price, price of alternative fuel and stock of motor vehicles. Letting Gt* be the desired gasoline demand at time t, we then write the gasoline demand model as: -

$$G_t^* = \alpha_0 Y_t^{\alpha_1} P_t^{\alpha_2} C_t^{\alpha_3} M_t^{\alpha_4} e^{(\alpha_5 ID_{73} + \alpha_6 ID_{79} + \alpha_7 SD_{94} + \varepsilon_t)} \quad \text{.........................(3)}$$

Where; Y_t is income level at time t;

P_t is price of gasoline at time t;

C_t is the price of alternative fuel;

M_t, is the motor vehicle stock at time t;

$\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6, \alpha_7$ are partial demand effects with respect to Y_t, P_t, C_t, M_t, ID_{73}, ID_{79} and SD_{94}

ID_{73} and ID_{79} are impulse dummies for the 1973 and 1974 oil crises.

SD_{94} is a dummy variable capturing oil liberalisation in Kenya in 1994.

ε_t is the white noise.

We assume this is a double-log function.

Log G_t^* = log α_0 + $\alpha_1$log Y_t + $\alpha_2$log P_t + $\alpha_3$log C_t + $\alpha_4$log M_t + $\alpha_5 ID_{73}$ + $\alpha_6 ID_{79}$ + $\alpha_7 SD_{94}$ − U_t...(4)

Where U_t is error term in logarithmic form

Equation (4) cannot be estimated because of the unobservability of desired demand. We therefore replace 'desired' with 'actual' by assuming 'actual' change in gasoline demand is a fraction of the 'desired' change in time t.

$$\text{Log } G_t - \text{Log } G_{t-1} = \lambda \ (\log G_t{}^* - \log G_{t-1}) + e_t \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (5)$$

Where; G_t is actual gasoline demand at time t;

e_t is error term in logarithmic form;

λ is adjustment factor and with $0 < \lambda \leq 1$

Consequently;

$$\text{Log } G_t = \lambda \log G_t{}^* + (1-\lambda) \log G_{t-1} + e_t \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (6)$$

Substituting equation (4) in (6)

$$\text{Log } G_t = \lambda \log \alpha_0 + \lambda\alpha_1 \log Y_t + \lambda\alpha_2 \log P_t + \lambda\alpha_3 \log C_t + \lambda\alpha_4 \log M_t + (1-\lambda) \log G_{t-1} +$$

$$\lambda\alpha_5 ID_{73} + \lambda\alpha_6 ID_{79} + \lambda\alpha_7 SD_{94} + V_t \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (7)$$

$$\text{Where; } V_t = U_t + e_t$$

Modification has been made on Iqbal (1985) model, which we adapted by introducing environmental policy variable like motor vehicle stock and the dummy variables. Estimating equation (7) yields the short run elasticities as respective coefficients. Removing the adjustment lag from the equation can derive the long run elasticities. To do this, we first solve for the coefficient of the lagged consumption term $(1-\lambda)$. Then, we remove the adjustment rate from short run elasticities as $\lambda\alpha_i/(1-\lambda)$ for respective long-run elasticities.

We shall also take note of the influence of population growth to gasoline consumption by taking per capita figures. We thus divide the variables by the population to get the per capita values as follows: -

$$\text{Log}(G/N)_t = \lambda \log \alpha_0 + \lambda \alpha_1 \log(Y/N)_t + \lambda \alpha_2 \log P_t + \lambda \alpha_3 \log C_t + \lambda \alpha_4 \log(M/N)_t + (1-\lambda)$$

$$\log (G/N)_{t-1} + \alpha_5 ID_{73} + \alpha_6 ID_{79} + \alpha_7 SD_{94} + V_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(8)$$

Where; $(G/N)_t$ is per capita gasoline consumption at time t,

$(Y/N)_t$ is per capita income,

$(M/N)_t$ is the motor vehicle stock at time t,

N_t is the population at time t,

Other variables are as specified before.

3.3 Hypotheses

Variable	Explanatory variable	Expected sign
Log of motor spirit	Own price	Negative
	Price of gas oil	Positive
	Real income	Positive
	Stock of automobiles	Positive
	Lag of log of motor spirit.	Uncertain
Log of gas oil	Own price	Negative
	Price of gas oil	Positive
	Real income	Positive
	Stock of automobiles	Positive
	Lag of log of motor spirit.	Uncertain

- We expect the own price to be negatively related to demand for gasoline. Increase in price is hypothesised to lead to a fall in demand, *ceteris paribus*.

- Price of alternative fuel is hypothesised to be positively related to demand since these are hypothesised as substitutes.

- Gasoline is a normal good and thus income is expected to be positively related to gasoline demand. Increase in income leads to increase in stocks of vehicles and miles travelled and thus increase in gasoline demanded.

- Stock of automobiles is expected to have a positive relationship with gasoline demanded as well as vehicular emissions. This stock is determined by investment in new vehicles and the rate of depreciation.

- The sign of the coefficient of the lagged endogenous cannot be determined apriori.

3.4 Estimation Technique

The study estimates demand elasticities by regressing equation (8) on time series data using PC-give version 8.0 econometric package. The estimation is based on Ordinary Least Square (OLS) estimation method. Before applying OLS the data is subjected to diagnostic econometric tests to deal with the problem of stationarity and spurious correlation. The following steps are followed in data analysis.

3.4.1 Univariate Analysis

Univariate data analysis is essential in this study because the features we come across during the analysis have implications on the multivariate analysis. Good results in a regression analysis can only be properly understood if we know the distribution of each of the variable. Failure to do this can lead to spurious regression. Basically, univariate data analysis are done with a view of identifying data points that are potentially problematic (Hamilton, 1992). The tests for normality are done to check whether the series follow normality distribution.

3.4.2 Stationarity And Unit Roots

The standard classical method of estimation that we shall use in this study is based on the assumption that the mean and variance of the variables are well-defined constants and independent of time. However past experiences have shown that these assumptions are not satisfied by a number of economic time series variables. A time series is stationary if its mean, variance and autocovariance are independent of time (Bhaskara, 1994). Variables whose mean and variance change over time are known as non-stationary or unit-root variables. Stationarity is a very important property in time series econometric analysis. This is because regressing non stationary variables increases the possibility of spurious correlations (Granger and Newbold, 1974) and unless there is cointegration among these variables, the estimated parameters will not posses standard distribution

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properties (Sjoo, 1996). The reason behind this preposition is that if the variables used in the regression have unit roots the sample moments do not converge to constant matrices as required by the asymptotic characteristics of the OLS, which assume stationarity.

Here, we are concerned with the idea of weak stationarity. Weak stationarity requires a series to have a constant mean and constant finite variance. There are several tests for unit roots. In this study we shall use Dickey-Fuller (DF) and the Augmented Dickey-Fuller (ADF) tests. The first step is to test whether the variables are stationary, or to test for the level of integration through the unit root test. The simplest case of this test comes from a random walk variable, that is a variable that assumes the same value as in the last period, modified by current shocks:

$$Y_t = \delta Y_{t-1} + \varepsilon_t \quad ....(1)$$

Where εt is assumed to be independently and identically distributed (IID) random variable. It has expected value zero, constant variance (σ^2) and is non-autocorrelated. When equation (1) is estimated, we look for δ i.e. the value of the coefficient of (Y_{t-1}) and test the hypothesis of null against alternative as follows

Ho: $\delta = 1$ i.e. the variable has a unit root or is a random walk variable meaning that the
   variable is non-stationary.

Ha: $\delta < 1$ i.e. the process generating the variable is integrated of order zero and hence
   stationary. We refer to δ being less than one in absolute value as the stationarity

condition.

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The Dickey - Fuller (DF) Tests.

The test for unit root as formulated using the Dickey - Fuller (DF) test is based on the estimation of the following three models:

$$\Delta Y_t = \rho Y_{t-1} + \varepsilon_t \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (2a)$$

$$\Delta Y_t = \alpha + \rho Y_{t-1} + \varepsilon_t \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (2b)$$

$$\Delta Y_t = \alpha + \beta t + \rho Y_{t-1} + \varepsilon_t \dots\dots\dots\dots\dots\dots\dots\dots\dots (2c)$$

Where, in each equation we assume ε_t is an IID process.

Null hypothesis is the same for the three equations; which is: -

Ho: $\rho = 0$ (non-stationarity or unit root)

Ha: $\rho < 0$ (stationarity)

The conventional statistics for $\rho = 0$ in equation (2) is identical to the t-statistic for $\delta = 1$ in equation (1)

The Augmented Dickey - Fuller (ADF) Test

So far we have assumed that ε_t is an IID process. If this is not true then the limiting distributions and critical values obtained by Dickey and Fuller cannot hold. However Dickey and Fuller (1981) themselves demonstrated that the limiting distributions and critical values that they obtain under the said assumption are in fact valid if the

Augmented Dickey - Fuller (ADF) regression is run. The ADF test as suggested by Granger and Engle (1987) follows the same procedure as the DF test.

$$\Delta Y_t = \rho Y_{t-1} + \Sigma \gamma \Delta Y_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3a)$$

$$\Delta Y_t = \alpha + \rho Y_{t-1} + \Sigma \gamma \Delta Y_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3b)$$

$$\Delta Y_t = \alpha + \beta t + \rho Y_{t-1} + \Sigma \gamma \Delta Y_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3c)$$

The null hypothesis is the same for ADF as for the DF test.

3.4.3 Cointegration Analysis

Cointegration can be viewed as a technique that provides a framework for estimating the equilibrium or long-run parameters in a relationship with unit root variables. It enables the utilization of the estimated long-run parameters into the estimation of the short run disequilibrium relationship. Variables are said to be cointegrated if there exist a long run relationship between them. The basic concept behind cointegration is that though short run deviations from the equilibrium are most likely, due to random shocks, these deviations are bounded since stabilizing mechanism tends to bring the system back to equilibrium (Granger and Engle, 1987). In this analysis, the long run relationship among the levels of the variable is restored through the error correction mechanism. The cointegration technique examines whether some linear combination of the non-stationary series in the regression produces a white noise process or not. The tests normally fall into

two categories; the Residual Based tests and the Johansen Approach. This study uses the

Granger and Engle-two step procedure (Residual-Based Test). The steps taken under this

procedure are;

i. Perform OLS to the series in levels and generate the residuals.

ii. Perform a unit root test and save the residuals.

The test is based on the following hypotheses;

Ho: the estimated error term has a unit root.

Ha: the variables are cointegrated

The test of stationarity is done on the residuals. If the residuals are stationary then the two

series are cointegrated

We now perform the above tests on the variables. If the variables are cointegrated, an

error correction mechanism (ECM) is introduced to ensure a systematic disequilibrium

adjustment process through which the dependent and explanatory variables are prevented

from drifting too far apart from their mean values.

3.4.4 Error Correction Mechanism (ECM)

If we are to view a time-series variable or data in isolation and it happens to have a single

unit root, then we need to difference it once to obtain a stationary process. However,

since our aim is the relationship between economic variables, we will more usefully

consider differencing within the context of a regression model Running the regression on the differences of non-stationary variables corrects spurious regression problems but loses information on the equilibrium or long-run relationship between the variables at their levels. As a result we employ an error correction mechanism to capture both long- and short-run relationship between the variables. However, a problem encountered in this process is that of choice of appropriate lag structure of the variables in the model. We shall make use the Swartz Criteria

3.5 Data Type And Source

This study will employ secondary data, which will be gleaned from Government publications like *Economic Surveys, Statistical Abstracts* and the IMF's *International Financial Statistics.* Annual data will be collected on the following variables:

♦ *Quantity of gasoline;* variables for some periods are recorded in tonnes and will be converted into litres using the Central Bureau of Statistics conversion factor.

♦ *Real price of petrol and diesel;* retail price for each type of gasoline is recorded in each year for Nairobi. An average will be taken as several prices are taken for each product and it is assumed to represent the whole country. This data will be obtained from the Economic Surveys.

♦ *The number of motor vehicles with current licences* will be obtained directly from the Statistical Abstracts.

♦ *The real income* is proxied by the GDP, which will be directly obtained from the IMF's international financial statistics.

CHAPTER FOUR

4.0 DATA ANALYSIS AND EMPIRICAL RESULTS

This chapter presents the estimation results, which have been obtained using econometric tools. It also presents interpretations and explanations of the findings. As a prelude to results following areas are first covered:

Univariate data analysis i.e., test of normality; stationarity tests results and cointegration analysis; and lastly the OLS estimation test results are reported. In presentation, the underlying econometric theory is first discussed prior to its application on data.

4.1 Normality Tests Results

In empirical analysis of data, the major problem faced is that of finding an appropriate model (model specification). model estimation and testing methodologies. Typically, estimation is done on the assumption that the univariate sample is drawn from a normal distribution. This assumption is made because of two reasons. First, most data encountered in practice are approximately normal. Therefore, if normality is the rule, then it is prudent to start with this assumption. Secondly, normal distribution is ideal for obtaining meaningful averages and, hence, serves as useful starting point.

Figures 4.1 to 4.4 below shows the graphical analysis using PC-give 8.0 to check for normality of the variables.

Figure 4.1: Data normality of variables in logs
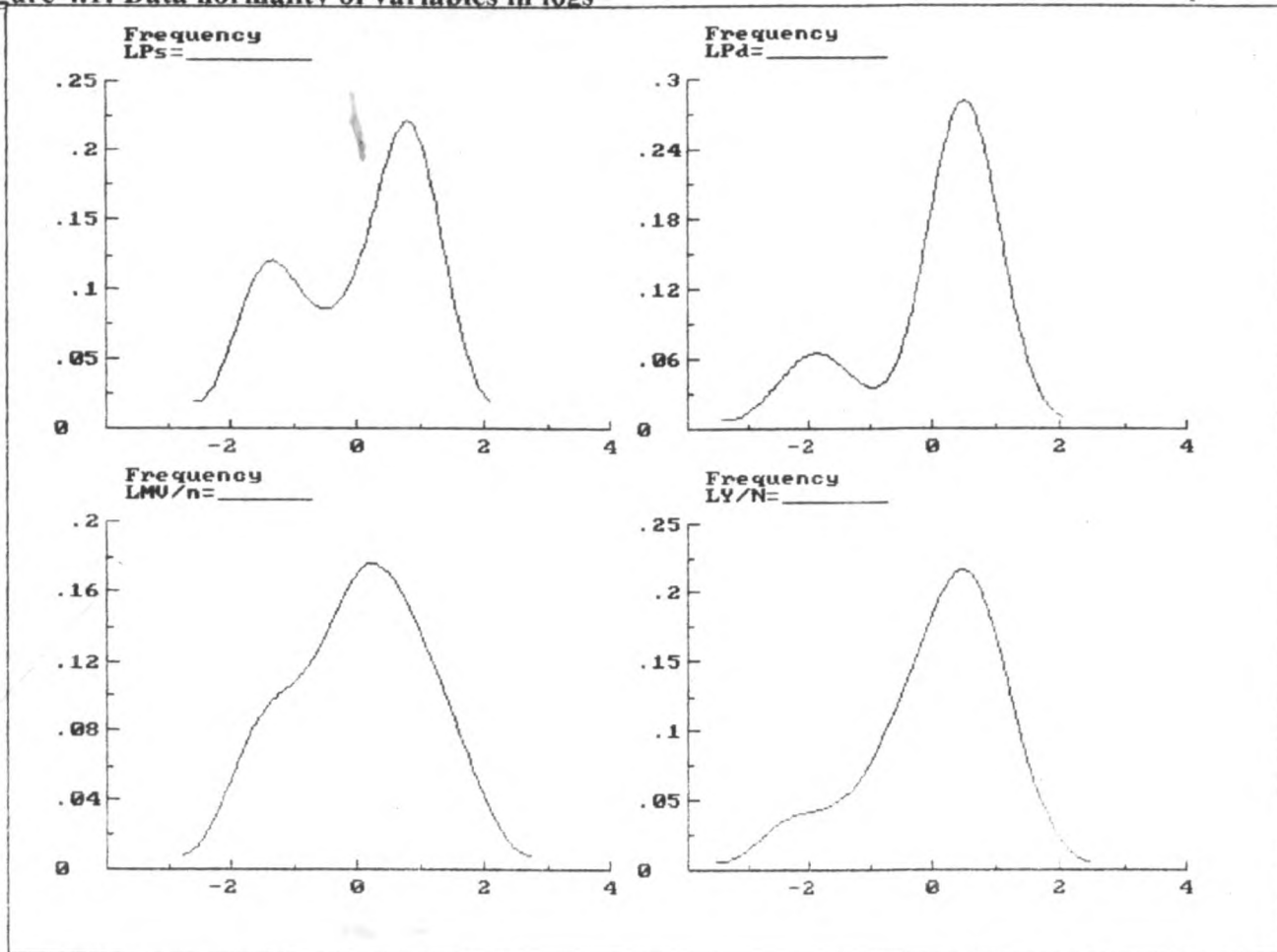
Where, LPs is the log of the real price of motor spirit

       LPd is the log of the real price of light diesel oil

       LMV/n is the log of the number of motor vehicles with current licenses

       per 1000 people

       LY N is the log of per capita income.

Figure 4.2: Data normality of variables in logs
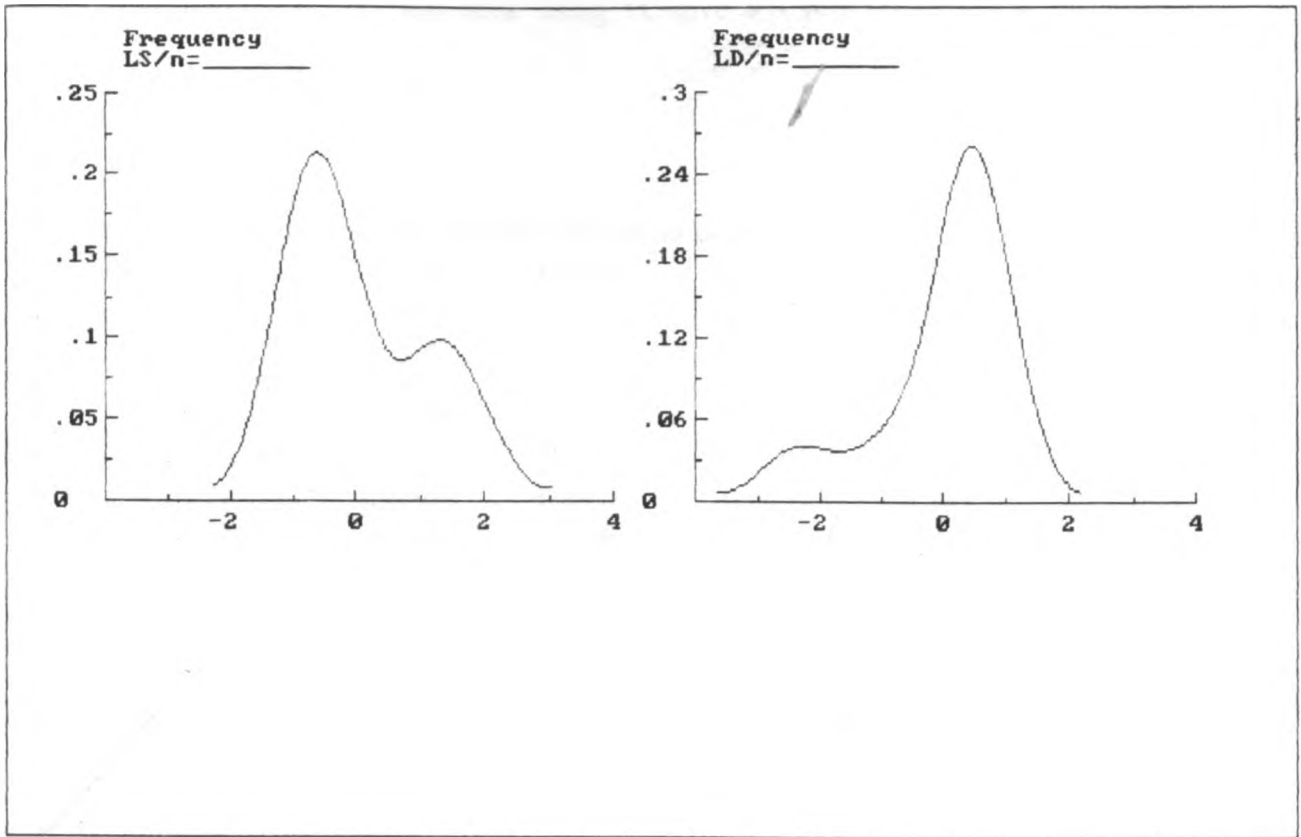
Where: LS n is the log of per capita demand of motor spirit

LD n is the per capita demand for light diesel oil.

From the graph only the log of income and the number of motor vehicles with current

licenses per 1000 people appear to be normally distributed since their graphs are

approximately bell-shaped. All the other variables are not normal. These results suggest

that the double-log model may not be appropriate. Apart from these graphical

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descriptions, a formal test for normality is essential. The test that is commonly used is the Jarque-Bera test, which uses the mean-based coefficients of skewness and kurtosis to check for normality. The test done using PC-give 8.0 progamme yields the results summarized in the table below.

Table 4.1 Normality test results of the variables in levels

Variable	Mean	Std. Dev.	Skewness	Excess Kurtosis	Normality Chi sq.	Normality Probability
S/n	14.6949	2.3268	0.7688	-0.7899	17.109	0.0002
D/n	20.2983	3.3904	-1.1532	0.3888	19.358	0.0001
Ps	4.3245	2.5636	-0.1932	-1.6499	16.138	0.0003
Pd	4.0168	1.7718	-0.7365	-0.4892	9.3497	0.0093
MV/n	271.0377	136.919	0.6970	-0.2901	5.9493	0.0511
Y/n	160.3484	16.0050	-0.7795	-0.0702	6.605	0.0368

The normal probability value is the probability of committing a type 1 error by rejecting the null hypothesis of normality when it is indeed true. The results from table 4.1 show that only the number of motor vehicles per 1000 people and income that are normal in the levels.

Table 4.2: Normality results of the variables in logs

Variable	Mean	Std. Dev.	Skewness	Excess kurtosis	Normality Chi sq.	Normality Probability
LS/n	2.6757	0.15151	0.6273	-0.9738	13.051	0.0015
LD/n	2.9939	0.1911	-1.441	1.0564	33.219	0.0000
LPs	1.1943	0.8154	-0.5242	-1.4536	24.457	0.0000
LPd	1.2099	0.7097	-1.3619	0.3230	50.723	0.0000
LMV/n	5.4691	0.5291	-0.1742	-0.9067	1.5941	0.4507
LY/n	5.0720	0.1050	-0.9871	0.2940	10.841	0.0044

The variables are not normally distributed even in the logs as shown in table 4.2. This implies that the double log functional form of the model is not appropriate. However. we shall use it since our aim is to get elasticities.

4.2 Data Stationarity

Before actual estimation of equation (8) specified in chapter three, the variables are subjected to unit root tests in order to determine the time series characteristics of the data. These tests are relevant to check the order of integration of variables with a view of avoiding the problem of spurious regression. Stationarity analysis classifies variables into two broad categories;

♦ The first category consists of variables that are stationary i.e. integrated of order zero denoted I(0).

♦ The variables that are non-stationary i.e. integrated of order one or higher denoted I(i) for $i>0$.

If a variable is I(n) it is differenced n-times to achieve stationarity

Stationarity graphical analysis using PC-give on variables in their levels is presented in figure 4.5 below The graphical analysis shows whether the data has unit roots. One of the most important characteristics of a stationary series is that it has to be mean reverting.

Figure 4.3: Graphical analysis for unit roots of variables in levels
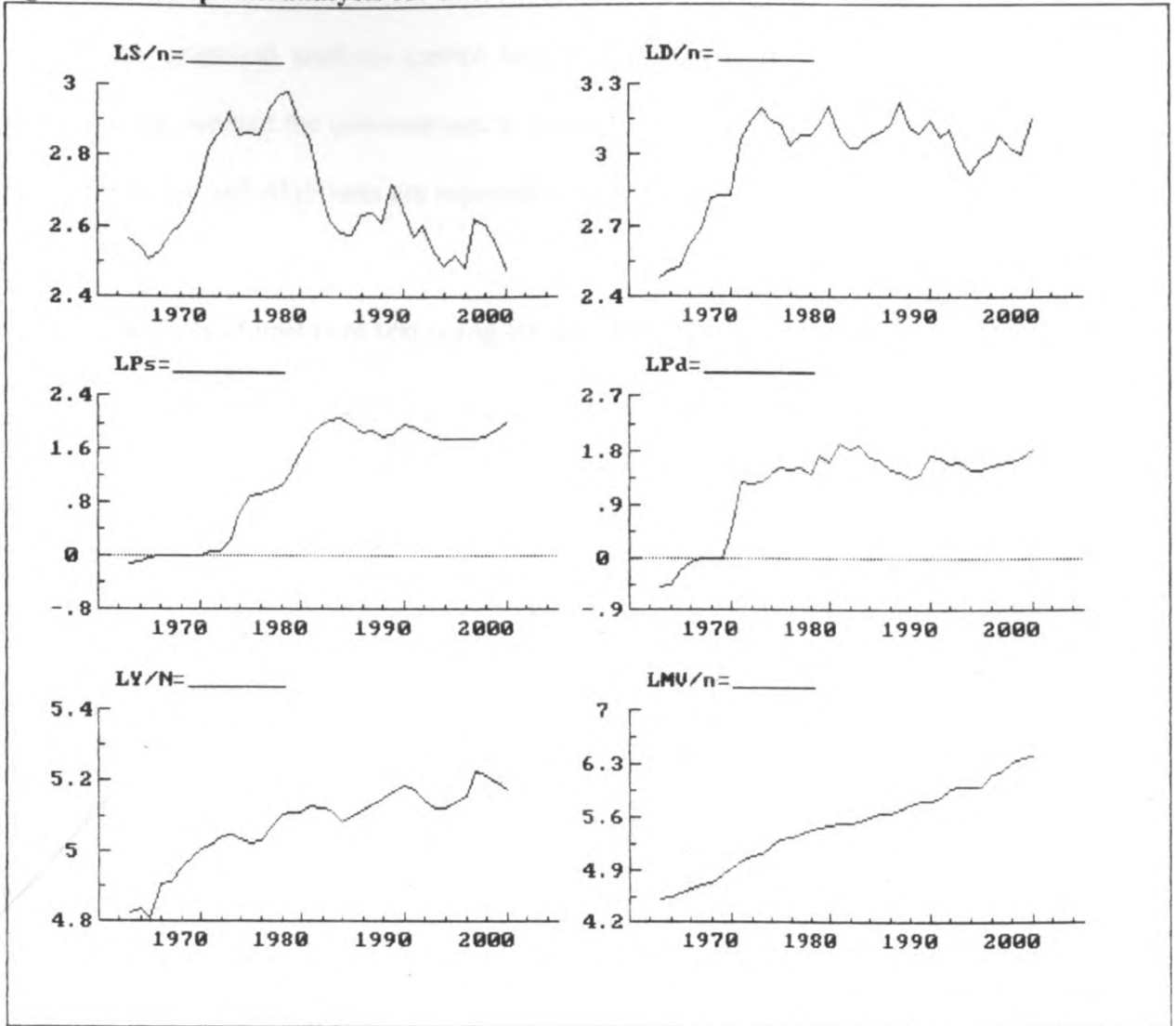
Where: LS/n is the log of per capita demand for motor spirit;

LD/n is the log of per capita demand for light diesel oil;

LPs is the log of the real price of motor spirit;

LPd is the log of the real price of light diesel oil;

LY/N is the log of the per capita income;

LMV/n is the log of the number of motor vehicle with current licenses.

From the graphs, all the variables are not mean reverting and thus non-stationary. However, the graphical analysis cannot fully identify the order of integration of the variables so we conduct the unit-root test to confirm or reject the graphical findings. The results of both DF and ADF tests are reported in table 4.3 below

Table 4.3: Results of unit root test using DF and ADF test procedures

Variable	DF	ADF	Order Of Integration
LS/n	-1.0017	-1.752	$I(i)$ $i>0$
LD/n	-2.7477	-1.248	$I(i)$ $i>0$
LPs	-3.3609	-2.509	$I(i)$ $i>0$
LPd	-2.5766	-0.8135	$I(i)$ $i>0$
LMV/n	-0.4923	-3.911	$I(i)$ $i>0$
LY/N	-2.4560	-3.457	$I(i)$ $i>0$

From the above observations, the variables are not stationary, hence we accept the null hypothesis that these variables are integrated of order higher than zero. As a result of non-stationarity, the variables were differenced to remove the time trend and to prevent their variances from exploding. To ascertain the order of integration, unit root tests were conducted on the differenced variables. The graphical analysis of the differenced variables is presented in figure 4.6 below:

Figure 4.4: Graphical analysis for unit roots of variables after differencing.
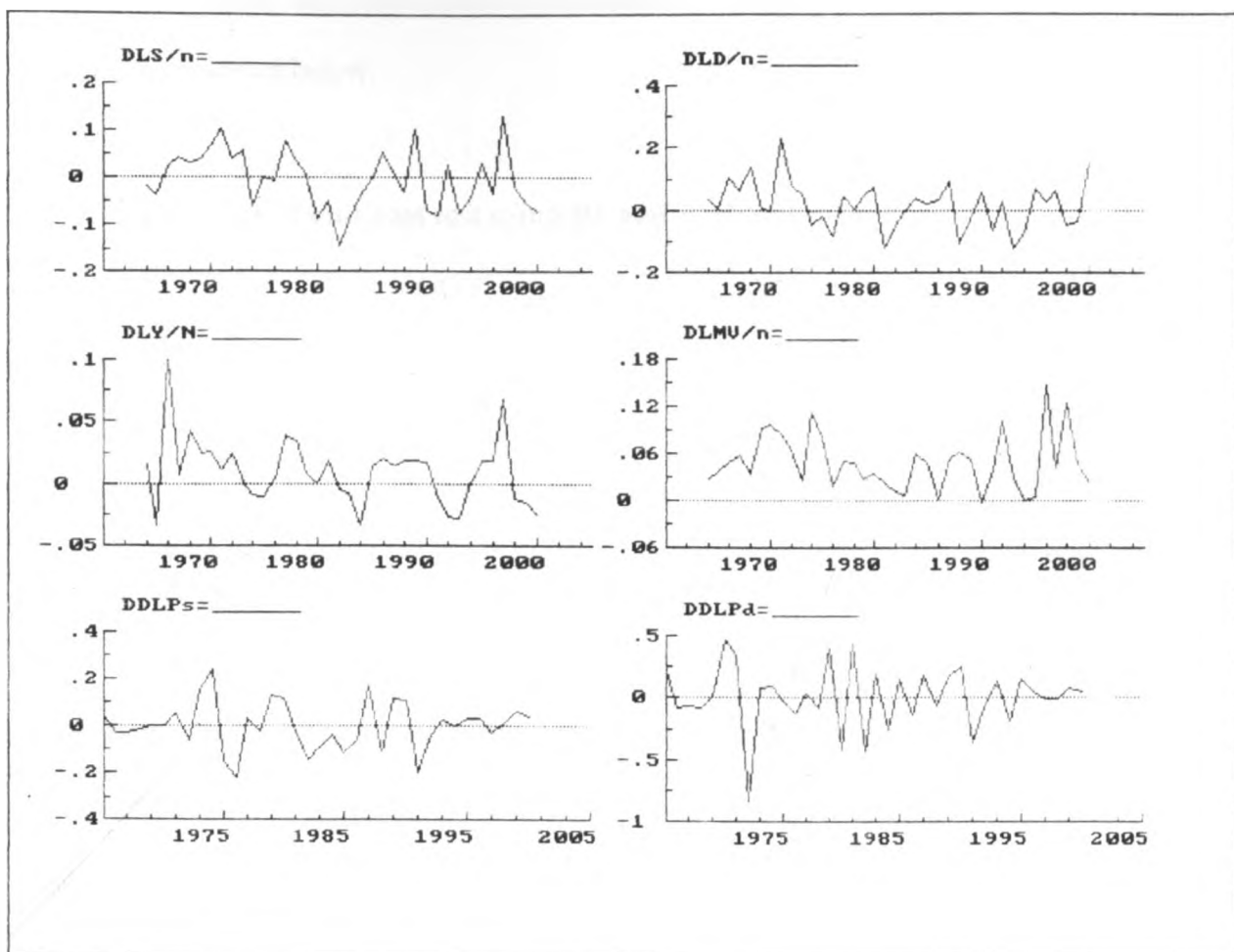
Where; DLS n is the 1st difference of log of per capita demand for motor spirit.

DLD.n is the 1st difference of log of per capita demand for light diesel oil.

DDLPs is the 2nd difference of log of real price of motor spirit,

DDLPd is the 2nd difference of the log of real price of light diesel oil.

DLY N is the 1st difference of the log of per capita income.

DLMV n is the 1st difference of the log of the number of motor vehicle

with current licenses per 1000 people.

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It is evident from the graphs that the variables are mean-reverting thus stationary. Nonetheless, the DF and ADF tests were conducted on the differenced variables and the results are presented below.

Table 4.4: Results of unit root test using DF and ADF test procedures.

Variable	DF	ADF	Order Of Integration
DLS/n	-4.4351	-3.123	I(0)
DLD/n	-5.1852	-2.886	I(0)
DLMV/n	-5.1646	-2.097	I(0)
DLY/N	-5.5731	-3.4	I(0)
DDLPs	-5.5634	-4.828	I(0)
DDLPd	-9.6382	-4.346	I(0)

The test shows the first differences of the series of motor spirit, light diesel oil, motor vehicle stock and per capita income at five per cent significance level. Thus since differencing once produces stationarity, we can conclude that they are integrated of order one or I(1). The prices were differenced twice to produce stationarity and thus are integrated of order two or I(2).

As a result a model will be specified in first differences of motor spirit, light diesel oil, motor vehicle stock, per capita income and second differences of the prices. Although differencing a non-stationary series to obtain a stationary series, it leads to loss of long run properties. To solve this problem, we specify an error correction model. This can only be done if the variables are cointegrated and to ascertain this we carry out cointegration analysis

4.3 Cointegration Analysis

Cointegration provides a formal, rigorous framework for testing whether long-run equilibrium relationships between variables exist or not. Variables are said to be cointegrated if a linear combination of the variables assume a lower order of integration. The variables must be of the same order of integration individually. The intuition behind this is that for two variables to form a long-run relationship, they must share a common stochastic trend in the long run; otherwise they would be drifting away from each other over time. This study makes use of Granger and Engle two step procedure or the Residual - Based test. As the name suggests, this test involves two steps: - first we get the static equation of the variables in levels and then we generate the residuals. Stationarity test is done on the residuals. If the residuals are stationary then the series are cointegrated.

Table 4.5: Cointegration test results on residuals on level regression of motor spirit

Residuals	t-adf	σ	Lag	t-lag	t-prob.
Res	-2.7867	0.046920	2	-0.31434	0.7554
Res	-3.6464	0.046255	1	-0.073351	0.9420
Res	-5.1385	0.045552	0		

Critical values: $5\% = -1.951$ $1\% = -2.632$

Table 4.6: Cointegration test results on residuals of level regression of light diesel oil.

Residuals	t-adf	σ	Lag	t-lag	t-prob
Ecm	-3.3074	1.3214	2	-0.15907	0.8746
Ecm	-4.3009	1.3011	1	0.57097	0.5720
Ecm	-5.4990	1.2877	0		

Critical values: $5\% = -1.951$ $1\% = -2.632$

The ADF tests shows that the residuals of the two equations are stationary both at 5% and 1% significance levels. This indicates that there is a cointegrating relationship between the variables.

4.4 The Error Correction Model (ECM)

Having established a stable long-run relationship between gasoline (motor spirit and light diesel oil) on per capita income, prices and motor vehicle stock, we proceed to specify an error correction model (ECM) which includes the residuals from the cointegrating regression as a regressor. In the error correction model all the variables are stationary or integrated of the same order unlike the cointegration analysis and therefore the student 't' statistic can be used to test the hypothesis.

4.5: Regression Results

Table 4.7: Modeling DLS/n by OLS – Dependent Variable is S/n.

Variable	Short- Run Coefficient	t-value	t-probability	Long-run Coefficient
Constant	-0.018	-0.918	0.3672	
DLS/n_1	0.554	1.981	0.0583	
DLMV/n	0.067	0.212	0.8335	0.120
DLY/N	1.340	4.128	0.0003	2.454
DDLPs	-0.069	-0.633	0.5320	-0.125
DDLPd	0.067	1.671	0.1068	0.121
ld73	0.026	0.419	0.6787	
ld79	0.031	0.556	0.5831	
Sd94	-0.0003	-0.006	0.9954	
Res_1	-0.809	-2.236	0.0341	

The present sample is: 1965 to 2000

$R^2 = 0.522$ $F_{(9, 26)} = 3.1592 [0.0104]$ $DW = 2.07$

The results of motor spirit demand equation are presented in table 4.7. The R^2 is 0.522 meaning that the model captures 52.2% of the variations in motor spirit demand. The DW statistic is 2.07 this is close to two implying that there is no existence of serial autocorrelation in the error. The F-statistic of $F(8.17) = 3.159 (0.0104)$ is lower than the critical statistic of 3.22 thus accepting the significance of the coefficient of the equation.

Table 4.8: Modeling DLD/N by OLS - Dependent Variable is D/n.

Variable	Short - Run Coefficient	t-value	t-probability	Long - Run Coefficient.
Constant	0.016	0.678	0.5041	
DLD/n_1	0.419	1.499	0.1458	
DLY/N	0.886	1.988	0.0575	2.116
DDLPd	-0.028	-0.508	0.6157	-0.067
DDLPs	0.209	1.596	0.1226	0.50
DLMV/n	-0.260	-0.694	0.4938	-0.620
Id73	0.037	0.475	0.6386	
Id79	-0.009	-0.125	0.9019	
Sd94	-0.118	-1.548	0.1336	
Ecm_1	-0.042	-2.576	0.0160	

The present sample is: 1965 to 2000

$R^2 = 0.402$ $F(9, 26) = 1.9402 [0.0903]$ $DW = 1.84$

Light diesel oil results are reported in table 4.8 above. The R^2 is 0.402 and shows that the explanatory power of the equation is 40.2%. This is because there are factors that explain light diesel oil demand but which have not been addressed by this equation. The DW is 1.84 and shows the presence of minimal serial autocorrelation in the error term but is still acceptable as it is close to two. Most of the coefficients in the equation have taken their

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theoretical signs as postulated in the hypothesis. The F-statistic of F (9, 26) = 2.09 is lower than the critical statistic of 3.22 thus we accept the significance of the coefficients of the equation.

4.6 Diagnostic Test

Before making interpretation to the results above it is necessary to subject the model to rigorous diagnostic tests. The tests are necessary since they indicate whether the model is consistent with the data or not. If the model does not track the data well over the sample period then it will be pointless interpreting the results. The tests were carried out as follows: -

4.6.1 Jarque-Bera (JB) Test

The first test was done to determine the distribution of the error term. The normality of the error term is necessary for the efficient and consistency of the OLS estimation to hold. The Jarque-Bera test is utilized for this purpose and focuses on the first four moments of distribution i.e. the mean, standard deviation, skewness and excess kurtosis along with the minimum and maximum values of the series to construct a distribution. This is then compared against the equivalent value produced by the standard normal distribution (Adam, 1992). If the calculated chi squared statistic for the error distribution

fall below the critical chi squared value at some confidence level, then normal distribution of the errors is not rejected

Table 4.9: Normality test for Residual

Statistic	Motor spirit	Light diesel oil
	Value	value
Mean	0.000000	0.000000
Std. Deviation	0.043218	0.058434
Skewness	0.235867	0.689769
Excess kurtosis	-0.717787	0.727200
Minimum	-0.068976	-0.098309
Maximum	0.098958	0.172278
Normality chi sq. (2)	0.99379	3.6529
Normality probability	0.6084	0.1610

From the test statistics reported in table 4.9 above, it was established that the error term for the model is normally distributed. This is so because the computed $\chi^2(2) = 0.994$ for motor spirit and $\chi^2(2) = 3.653$ for light diesel oil are less than the critical $\chi^2(2) = 18.5$ at 5% level of significance.

4.6.2 Regression Specification (RESET) Test

The test is conducted in order to detect any mis-specification of the model due to non-linearity in the model. This test pre-supposes that there are two models - a null model without non-linearity and an alternative with non-linearity. The results obtained using PC-give for motor spirit is $F_{(1, 25)} = 0.80827$ which is less than the critical $F_{(1, 25)} = 4.24$. In the case of light diesel oil the computed $(1, 25) = 0.0001$ is also less than the

critical value. We therefore accept the null hypothesis that the models are correctly specified as linear. The tests were conducted at 5% per cent significance level.

4.6.3 Autocorrelation (AR)Test

This is a test for autocorrelation to supplement the Durban Watson (DW) test. This is deemed necessary since the DW test is inefficient when higher lagged order of the dependent variable are included as explanatory variables. The test takes a chi squares distribution for samples over 50 variables. For sample size of less than 50 observation the F-statistics are used. The test statistics obtained reject any serious error autocorrelation, as their values are less than the critical values. In the case of motor spirit the computed F-statistic $F(2, 24) = 0.152$ and in the light diesel oil model the calculated $F(2, 24) = 0.631$, which are less than the critical value of $F(2, 24) = 3.40$ at 5 per cent level of significance.

4.6.4 Autoregressive Conditional Heteroscedasticity (ARCH)Test

The ARCH test was used to test for the existence of heteroscedasticity. If the calculated values of F-statistic are higher than the critical values, the presence of ARCH is not rejected. The computed results are $F(1, 24) = 0.0057$ for motor spirit and $F(1, 24) = 0.1884$ for light diesel oil. The two are less than the critical value of $F(1, 24) = 4.26$. The test statistic obtained from this test indicates absence of heteroscedasticity i.e. we do not

reject the null hypothesis that the conditional variance of our estimated model is not related to the size of its past errors.

4.7 Discussion Of The Results

The objectives of the study was, one, analyzing demand for gasoline in accordance with the standard theory of demand and, two, to draw policy recommendations for energy sector in the contexts of environmental friendly sustainable economic development. The over fitness shows that 52.2 percent of the variations of motor spirit demand and 40.2 percent of the variation of light diesel oil demand is explained by per capita income, own price, price of alternative fuel and motor vehicle stock. From a statistical point of view the regression results are generally satisfactory, and conform to the study hypothesis and the theoretical expectations; they confirm certain relationships that are consistent with theory. Based on the expectations as presented in the hypothesis all the key coefficients have the expected signs except the stock of automobile on light diesel oil demand, which has a negative sign. According to the study findings, the variable that appear to have the strongest effect on gasoline demand is per capita income. The econometric analysis focuses on the roles played by income, motor vehicle stock, own price and price of alternative fuel in determining the demand for gasoline. We have used a double logarithmic specification to estimate the various demand effects of these variables. The double logarithmic specification has the well-known advantage that the coefficients are elasticities. Analogously, if a one percent rise in the price of gasoline results in 1 per cent

fall in gasoline consumption, assuming all other factors remaining unchanged, then the price elasticity would be –1 (unitary).

4.7.1 Motor Spirit Results

The results of motor spirit demand regression are reported in table 4.7. The income elasticity was found to be a statistically significant factor in determining demand for motor spirit with the expected positive effect on motor spirit demand. On the bases of these results gasoline is a normal good. The impact of an increase in income on demand for gasoline was greater in the long run than in the short run. The results show the short run income elasticity of 1.36 and 2.45 in the long run. This implies that a 1 per cent growth rate changes in per capita income translates into an increase of motor spirit demand of 1.36 per cent in the short run and 2.45 per cent in the long run

The price of motor spirit as expected has a negative effect on its demand. However, it is not statistically significant suggesting that own price of motor spirit has no effect on its demand in the short run. Not surprisingly then, the own price elasticity of motor spirit is quite small. The short run price elasticity is -0.0693 and a long run price elasticity of -0.125 was obtained. This may be explained by the fact that there tend to exist a relatively inelastic demand for mobility and subsequent inelastic demand for gasoline. This implies that, if the price of gasoline increases, in the short run, the utilization rate will not change as was earlier expected. Consequently, there will be no change in the travel pattern and therefore, in the long run, there will be no shift to the fuel-efficient motor vehicles, no

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change in business location or shift to alternative modes of transport

The price of alternative fuel has the hypothesized positive sign. The price of light diesel oil has an elasticity of 0.067, implying that a 1% increase in the price of light diesel oil lead to rise of 0.067% in motor spirit oil demanded. This corresponds to economic theory where the two products are substitutes. However, in general there is limited substitution of motor spirit to light diesel oil and vice versa as this (substitution) takes time and resources. People willing to buy motor vehicle consider. among other factors, the price of the fuel it consumes and that of the alternative fuel. Besides vehicles require minor engine modification to enable them use the alternative fuel type.

The motor vehicle stock variable has a positive sign with an elasticity of 0.067 motor spirit. which is consistent with our hypothesis. The results suggests that a 1 per cent rise in the number of motor vehicle with current licenses would bring forth an increase of 0.067 per cent in consumption of motor spirit.

There is a large and statistically significant impact from the lagged exogenous variables in the model on current demand for gasoline. The coefficient of this variable is 0.554. The fact that the lagged exogenous variable is shown to be important suggests that previous consumption practices may not change overnight

The oil crisis of 1974, 1979 and the liberalization of petroleum sector in October. 1994

appear to have no significant effect on the demand for motor spirit. The coefficients of the dummy variables capturing the oil crisis and the liberalization of petroleum sector are quite small. This is a reinforcement of the insignificance of the price factor. This suggests that gasoline price may be consisting a smaller proportion of motorist operation cost

4.7.2 Light Diesel Oil Results

These results are presented on the table 4.8 The results obtained lead to the conclusion that income is positively related to light diesel oil demand and statistically significant In the estimates, the per capita income elasticity of demand for light diesel oil is 0.89 in the short run and 2.12 in the long run. This implies that as in the case of motor spirit the income effect is greater in the long run than in the short run.

In the light diesel oil regression the own price elasticity of demand was found to be – 0.028 in the short run statistically insignificant, in the long run the own price elasticity was –0.067. We conclude that own price of gasoline is not significantly linked to the demand for gasoline both motor spirit and light diesel oil. However, this could be explained by the fact that demand for gasoline is somehow sticky. This so because most motorists are either. one. businessmen who pass the burden to the passengers they carry in their vehicles or, two, are people who are able to adjust and absorb the increment.

The price of motor spirit has a positive sign corresponding to expectations The cross-price elasticity of demand for light diesel oil is 0.209 and 0.50 in the short- and long-run

respectively. This implies that one per cent increase in the price of motor spirit leads to an increase of 0.209 per cent and 0.5 percent increase in the short- and long-run respectively. This confirms that the fuels are substitutes.

In the case of stock of automobile the elasticity of demand is -0.26 and −0.62 in the short run and the long run respectively. This is against the expectation However, these are not statistically significant. These results suggests that a 1 per cent rise in the number of motor vehicle with current licenses would bring forth a decline of 0.26 percent and 0.62 percent in consumption of light diesel oil in the short run and long run respectively. The explanation to these results is that as more people are acquiring automobiles, majority of them are opting for motor spirit consuming vehicles rather than light diesel oil ones. From an environmental quality point of view, this preference is good, as light diesel oil is a more polluter than motor spirit as it (diesel) contains sulfur. This is especially so in the case where unleaded motor spirit is consumed. From our discussion in chapter one, it is conclusive that consumption of gasoline especially light diesel oil leads to environmental hazards through pollution resulting from vehicular emissions. Therefore increased consumption of gasoline resulting from increase in per capita income and stock of motor vehicles will cause more pollution.

The oil crisis did not have any significant effect on light diesel oil demand. However the liberalization of petroleum sector had a marginally significant negative effect on the demand.

CHAPTER FIVE

5.0 CONCLUSION AND POLICY RECOMMENDATIONS

5.1 Summary And Conclusion Of The Study

The demand for gasoline has been rising steadily in Kenya since independence. However, this has to be met from the external sources as none is produced locally. To finance the importation of these products the balance of payment is affected negatively. Equally, the increased gasoline consumption impacts negatively on the environment, which calls for regulations to protect the environment.

The study results indicate that gasoline demand at any given time is determined by the real per capita income, own price, price of substitute fuel, automobile stock and the amount demanded in the previous periods. Most of the variables in the model had the expected signs, which is consistent with theory and the study hypothesis. The results analysis indicates that gasoline is driven significantly by income and insignificantly by stock of automobiles and prices. The results suggest that as income rises motor spirit consumption increases in more than proportionate percentage (elastic), while light diesel oil demand increases significantly too. The study also found out that motor spirit is a substitute for light diesel oil in the medium to long term. The study established that the oil crisis of 1973/74 and that of 1979 had no significant effect of gasoline demand in Kenya. However, liberalization of the oil market in 1994 had negative and marginally

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significant effect on light diesel oil demand but insignificant negative effect on motor spirit demanded.

5.2 Policy Implications

The study found income to be a statistically significant factor in determining demand for gasoline. This suggests that increase in income will increase consumption of gasoline through increased mobility i.e. increased stocks of automobile and increased miles traveled per vehicle. The income effect on gasoline consumption is a manifestation of the need for mobility by Kenyans. This has resulted in an increase in stocks of automobiles despite the slow growth in per capita income resulting in growth in the demand for gasoline. Thus, any policies directed at reducing gasoline consumption in the face of increasing incomes should also aim at reducing the stock of automobiles. However, given the economic and other benefits of increased mobility, stopping the growth of motor vehicle stock is neither feasible nor desirable policy measure. The policies therefore should aim at managing the growth of automobile stocks so as to maximize the benefits and at the same time minimize the adverse impacts on the environment. As income rises the pricing policies on automobiles should be such that it helps in the choice of fuel-efficient vehicles and replacing the existing old motor vehicle stock with new, more fuel-efficient stock. Establishment of motor vehicle standards and technical measures aimed at controlling and reducing vehicular emissions should be employed.

The price elasticities of demand for gasoline are low and statistically insignificant. This suggests that price policies alone cannot reduce gasoline consumption. It therefore means that if consumption of gasoline is to be restrained or if wasteful & environmental hazardous consumption practices are to be reduced, then additional measures are required alongside the pricing policies. These may include; tax policies and public transport services policies. Increased taxes on gasoline increases the total motorist cost of operation and consequently people can switch to public transport. The government should oversee comprehensive public awareness campaign on fuel conservation and environmental management. Other measures to go together with pricing policies include adjustment of import duties to favour importation of fuel efficient and environmental friendly automobiles. This means placing high import duties on vehicles that are too old and with inefficient engines.

The estimated elasticities of demand for gasoline with respect to automobile stock shows that it is also an important control variable available to the government for managing demand as well as protecting the environment. It is evidence that the stock of automobiles has increased due to importation of second hand motor vehicles. However, there is growing concern on the role played by some of these imported automobiles on environmental degradation. These importations are dependent on government policy on imports, which should regulate the age of fleet being imported. It must be pointed out, however, that energy management or environmental considerations did not motivate the government measures to allow importation of used motor vehicles. While reliable

transport modes for the populace is crucial, this should be balanced with a consideration on policy instruments for managing demand and environmental quality. Furthermore, an improved communication system can go a long way towards reducing unnecessary intra- and inter-city journeys. For example, the chronic traffic congestion in major cities especially Nairobi and the great deal of black markets can be greatly relieved with better and increased telephone services. The negative light diesel oil elasticity with respect to motor stock suggest that as the motor vehicle stock increases people are shifting from light diesel oil consuming vehicles to motor spirit consuming automobiles.

The own price of gasoline appears inelastic even in the long run. Therefore a substantial increase in price is necessary to have a marked effect on demand. Such a policy may, however, lead to a redistribution of income without decreasing the consumption of gasoline. In view of cross price elasticities the two fuels are substitutes, but there is limit to which these fuels can be substituted for each other. However, large price differentials between different fuels may lead to substitution in fuel use by making minor modifications in motor vehicle engines. With slight modification, motor spirit can be substituted for light diesel oil and vise versa. LPG can be substituted for gasoline in spark ignition engines and kerosene can be used to adulterate gasoline - the later cases have been reported in Kenya. The government indirectly regulates the prices of gasoline by imposing various taxes. Such measures may, however, lead to adulteration of gasoline and black markets. It is therefore advisable that the taxes on all the petroleum products be

balanced. Surveillance on black markets for petroleum products is necessary if the policies formulated are to attain their objectives.

Another important option available to the government lies in the area of fuel substitution from gasoline to natural gas in the transportation sector. In the medium to long term, Liquidified Petroleum Gas (LPG) may be used. In Tokyo, for example, it has been estimated that almost all taxis are LPG-powered (Schamm, 1983). The feasibility of this option will, however, depend on the price of LPG relative to gasoline, the competing use of gas, the LPG supply infrastructure and technical change which may affect the conversion costs for automobiles currently using gasoline.

5.3 Limitations And Suggested Areas Of Further Research

The elasticities estimated in this study are general indicators rather than exact estimates, as they are based on a relatively simple model of demand. The model, however, captures with a fair degree of precision, the underlying factors driving gasoline consumption, and hence the model can be used for the forecasting of gasoline demand.

The study did not capture the gasoline that go through the black market after the bonded facilities in Mombasa. This is because data on black markets are not documented. In addition the study focuses on gasoline alone leaving out other petroleum products hence the findings may not be readily applied to the whole range of petroleum products.

Another limitation is that the data has been published for general purposes but not meant for this specific study.

Some of the areas that were found merit for further research during the course of this study include analysis of other types of petroleum products apart from gasoline. Equally, the current rate of gasoline consumption shows environmental degradation resulting from gasoline consumption which calls for rigorous tests based on other functional forms. Measurement data are urgently needed to determine the characteristics of vehicle fleets in Kenya and to determine emission factors[1] and incorporate it in such studies.

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[1] Emission factor is defined as the estimated average emission rate for a given pollutant for a given class of vehicle. Estimate is obtained by multiplying an estimate of the distance traveled by a given class of vehicle by an appropriate emission factor

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