DEMAND FOR GASOLINE AND LIGHT DIESEL IN KENYA

By

SASIA JOSPHAT OGINDA

Research Paper Submitted to the Department of Economics, University of Nairobi in Partial fulfilment Of the requirements for Degree of Masters of Arts in Economics.

June 1987

This Research Paper is my original work and has not been presented for a degree in any other University.

SASIA, J. O.

This Research Paper has been submitted for examination with our approval as University Supervisors.

DR. P. Jumi

MR. P.K. Kimuyu

ACKNOWLEDGEMENT

My special gratitude go to my Supervisor Dr. P. Jumi for the guidance and assistance given to me throughout the writing of this thesis. I am also deeply indepted to Mr. P.K. Kimuyu for all the work he had to put into the preparation of this paper. I would also like to thank Mr. R.J. Richards and the entire Kenya/Canada Energy Advisory Project in the Ministry of Energy and Regional Development for their advice and assistance.

I am indebted to my sponsors, the Government of Kenya, whose financial support enabled me to undertake this study.

My sincere thanks go to the staff of Economics Department and to my classmates: Ongeri, Osundwa, Omukoko, Kirongo, Kiriti, Okore, Masya, Kiche and Obere for their comments and moral support given to me during the course of this study.

I wish to express my gratitude to my parents for the sacrifices they made to enable me undertake this study. I owe you my education and to you, I dedicate this thesis, to my brothers and sisters for their unfailing encouragement and to my friends especially Elusa to whom I am most grateful.

Finally, I pay tribute to Mrs. Rosemary Masbayi Aswani who typed the text.

A B S T R A C T

This study focuses on the analysis of the demand for gasoline and light diesel in Kenya. The main objective was to estimate demand functions of the two fuels. The specific objectives were: to identify the main factors influencing their demand; and to find their corresponding elasticities.

A log linear econometric model incorporating a geometric distributed lag was estimated using Kenya's time series data from 1964 to 1985.

The regression results show that in both cases, the positive income effect dominates the negative price effect. This in form suggests that policies that focus exclusively on prices would not be helpful in restraining growth in demand for these fuels. Additional measures should then be used along with the pricing policy if growth in demand for both the fuels is to be restrained.

It was also found that in both cases, the demand adjusts to changes in exogenous factors with a lag. However, the impact of the oil crisis on gasoline consumption turned out to be statistically insignificant. This tends to reinforce the low price elasticity which was obtained.

The results further show the existence of substitution between light diesel and gasoline. This suggests that the

pricing policy should be such that it does not allow the price differentials of these two fuels to be very large, otherwise excess demand for the cheaper fuel can ensue.

TABLE OF CONTENTS

PAGE

PAGE

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1. BACKGROUND INFORMATION

Kenya experienced relatively high economic growth immediately after independence. Gross domestic product (GDP) grew at an average rate of 6.2% per year in real terms between 1964 to 1972[1]. This rapid growth was mainly due to favourable conditions on the international markets where exports and imports prices were stable.

However, the emergence of instability on some of these markets, especially the supply disruptions and subsequent increased cost of energy, plus declining prices of agricultural products, affected the level of economic activity. This reduced the growth in GDP to an average rate of about 4.4% per year in real terms between 1972 and 1981.

1.1.1. Petroleum and the Economy

Kenya's modern sector is heavily dependent on petroleum which accounted for over 70% of total commercial energy consumed in the economy between 1968 to 1985 as shown in table 2.

Aggregate petroleum products consumption trends in Kenya is also shown in table 2.

Table 1: CONTRIBUTION TO GDP (AT FACTOR COST) BY MONETARY AND NON-MONETARY SECTORS FOR SELECTED YEARS

(1976 PRICES)

K£ Million

	1964	1966	1968	1970	1972	1974	1976	1978	1980	1982	1984
Non-Monetary	264.1	287.7	325.7	362.8	80.5	99.4	69.8	75.1	81.2	70.7	97.1
Monetary	437.7	511.5	586.9	694.6	1057.0	1122.5	1208.3	1401.4	1509.5	1662.4	1726.4
Manufacturing	60.3	67.4	78.6	92.7	111.2	134.8	144.2	188.2	312.0	224.9	245.1
Total GDP	701.8	801.2	912.6	1037.4	1137.5	1221.9	1278.1	1476.5	1590.7	1733.1	1823.5

In Percentages

	1964	1966	1968	1970	1972	1974	1976	1978	1980	1982	1984
Non-Monetary	37.6	36.2	35.7	35.0	7.1	8.1	5.5	5.1	5.1	4.1	5.3
Monetary	62.4	63.8	64.3	65.0	92.9	91.9	94.5	94.9	94.9	95.9	94.7
Manufacturing	8.6	8.4	8.6	8.9	9.8	11.0	11.3	12.7	13.4	13.0	13.4

Source: Statistical Abstracts and Economic Survey, Central Bureau of Statistics, Various Issues

Table 2: GDP and the Consumption of Petroleum Products

Year	GDP at factor cost (1976 Prices) K£ million	Real GDP growth rate %	Total Sale of Petroleum Products '000 mtoe*	Petroleum Products consumption growth rate %	GDP Elasticity of Demand for Petroleum Products	Real Domestic Price of crude oil K£/ton	Growth in crude oil Prices %
1968	912.65	-	905.1	-	-	9.4	-
1969	970.65	6.4	879.2	-2.9	-0.5	9.3	-1.1
1970	1037.40	6.9	964.1	9.6	1.4	9.2	-1.1
1971	1104.72	6.5	1082.6	12.3	1.9	8.7	-5.4
1972	1137.46	3.0	1203.0	11.1	3.7	9.8	12.6
1973	1192.63	4.8	1258.2	4.6	1.0	9.8	0.0
1974	1221.91	2.4	1231.5	-2.1	-0.9	31.5	221.4
1975	1247.95	2.1	1310.9	6.4	3.1	34.5	9.5
1976	1276.48	2.4	1356.3	3.5	1.5	37.5	8.7
1977	1390.26	8.8	1504.8	10.9	1.2	36.2	-3.5
1978	1476.48	6.2	1537.9	2.2	0.4	30.8	-14.9
1979	1539.54	4.3	1559.7	1.4	0.3	35.4	-14.9
1980	1590.66	3.3	1670.7	7.1	2.2	58.5	65.3
1981	1675.66	5.3	1584.5	-5.2	-1.0	70.1	19.8
1982	1733.09	3.4	1489.3	-6.0	-1.8	65.0	-7.3
1983	1800.76	3.9	1373.1	-7.8	-2.0	61.1	-6.0
1984	1823.53	1.3	1482.4	8.0	6.2	58.6	-4.6
1985	1913.40	4.9	1497.3	1.0	0.2	59.8	2.0
1968/72		4.6		6.0	1.4		1.0
1973/76		2.9		3.1	1.1		79.9
1973/78		4.5		4.1	0.9		44.2
1979/85		3.8		-0.6	0.2		9.9

Sources: Statistics of Energy and Power, 1968-1977, Economics Survey and Statistical Abstracts, Central Bureau of Statistics, Various Issues.

mtoe* metric tonnes of oil equivalent.

The table supports past energy-growth linkage studies which conclude that, commercial energy consumption increases rapidly in times of rapid economic growth while in times of slower growth, it increases more slowly.

For example, before the first oil crisis in the late 1973, when the price of crude oil was declining in real terms, consumption growth of petroleum products was quite high averaging 6% per year for the period 1968 to 1972. While GDP grew at an annual average rate of about 4.6% in real terms. This gave a GDP elasticity of 1.3.

The impact of the first oil crisis of late 1973, which was a 'shock to costs', can be observed from the table. In 1973, GDP grew at 4.8%. But the rise in oil price during the 1973-74 period of about 22%, GDP growth fell by half in 1974. The low growth in GDP continued until 1977 when it increased to 8.8% following the coffee 'boom', which was a 'shock to incomes'. In the same year, 1977, petroleum consumption grew at 10.9%.

The second oil price shock of late 1979 ended the effects of the coffee boom by reducing the growth in GDP to 3.3% in 1980. Meanwhile, petroleum consumption growth declined to 1.4%. In this connection the 1984-88 development plan[2] observed that:

> "... the rate of growth of GDP fell markedly for the period 1973-76 mainly due to the oil price show and its aftermath .... The coffee boom of 1976-77 explain the sharp recovery during 1976-78. The sluggish growth during 1978-80 was due to the petering out of the coffee boom ... and the sharp rise of oil prices towards the end of 1979"

Before 1973, when oil was available at affordable costs, rapid growth in petroleum products did not pose any balance of payments problems. The oil account was virtually in balance in exports and imports. This is shown in table 3. The table further shows that, immediately after the first oil price increase, Kenya's net oil import bill increased by almost 30 times of the previous year. As a result, the share of oil import bill in total export earnings increased tremendously. For example, the percentage share of oil import in total export earnings rose from 0.2% in 1970 to 38.9% in 1981 and stood at 33.6% in 1985. About the price hikes of oil, the 1979-83 development plan[3] asserted that:-

> "... one consequence of these trends will be that the pattern of further development will differ substantially from that preceeding 1973 ... This high dependence of foreign energy sources and the role energy plays in all economic activities necessitates high priority being accorded to comprehensive planning of the development in energy sector."

Table 3: Value of Imports and Exports of Petroleum Products

Year	(1) Crude Oil Imports K£ million	(2) Petroleum Products Re-exports K£ million	(3) Net Petroleum Imports K£ million	(4) Export Earnings K£ million	Percentage of (3/4)
1970	14.00	13.78	0.22	108.06	0.2
1971	15.91	17.50	(1.59)*	107.08	-
1972	19.74	19.09	0.65	123.38	0.5
1973	22.06	20.88	1.18	161.39	0.7
1974	80.29	54.18	35.11	211.28	16.6
1975	94.30	55.14	39.11	215.13	18.2
1976	102.54	68.56	33.98	318.66	10.7
1977	115.42	83.0	32.42	480.26	6.8
1978	115.95	69.92	47.03	369.91	12.7
1979	145.71	76.86	68.85	385.53	17.9
1980	277.28	160.88	116.40	487.64	23.9
1981	358.15	158.01	200.14	513.85	38.9
1982	327.77	148.99	178.78	545.74	32.8
1983	342.32	128.38	213.94	633.08	33.8
1984	326.17	141.50	184.67	754.81	24.5
1985	375.39	118.03	257.36	766.01	33.6

Source: Economic Survey, Central Bureau of Statistics, Various Issues

*Re-export value exceeded the import value of crude oil.

1.1.2. Demand for Individual Petroleum Fuels

The consumption of petroleum products by various consumer categories is shown in table 4.& 5. Transport sector comprising of consumer units: road, rail, marine and air transport, is the major consumer of these products. On average, this sector consumed 67% of all the petroleum products sold in the economy between 1968 and 1985. It was followed by the industrial and commercial sectors which consumed 20% and agriculture, power generation and government altogether consumed 13%.

Table 6 shows that in terms of quantity demanded, motor gasoline, jet fuel, light diesel, heavy diesel and fuel oil are the most important fuels.

Light diesel oil constituted about 17% of total fuel sales in 1969. However, this share increased to 27.8% by 1984, as indicated in table 7. On average, light diesel sales comprised about 21% per year of all fuel sales between 1969 and 1984.

The rapid growth in light diesel consumption is mainly because of its use in the rapidly growing transportation sector whose services are required in the movement of freight and persons and also in boilers in the industrial sector.

TABLE 4: DOMESTIC SALES OF PETROLEUM PRODUCTS BY CONSUMER CATEGORY FOR SELECTED YEARS

'000 tonnes

	1968	1970	1972	1974	1976	1978	1980	1982	1984	1985
Road Transport	128.8	192.9	283.5	336.5	374.3	433.8	520.8	507.4	568.7	616.6
Rail Transport	351.9	219.3	195.0	91.4	79.9	90.3	70.7	41.9	42.5	35.0
Marine (excl. Naval forces) ...	157.5	157.3	181.4	196.3	82.8	111.4	248.5	144.1	158.9	147.1
Aviation (excl. Government) ...	50.7	76.1	111.0	275.4	319.1	339.4	372.1	283.2	258.8	260.4
Total Transport Sector	688.9	645.6	770.9	899.6	856.1	974.9	1106.0	976.6	1028.9	1059.1
Agriculture	35.1	57.6	62.0	57.6	56.6	75.8	69.1	48.5	44.0	48.9
Power Generation	57.5	76.3	114.4	94.4	169.3	106.9	150.7	95.6	54.5	27.4
Tourism	-	-	-	-	-	-	-	-8.5	9.3	9.4
Industrial, Commercial, etc ...	87.2	123.6	184.3	295.8	369.5	363.2	497.3	445.2	452.6	452.7
Government	30.2	48.3	92.1	40.9	47.3	63.3	92.5	51.2	52.8	46.7
Balancing Item	+9.0	+2.7	-29.2	-149.7	-42.3	-46.2	-244.6	-133.6	-158.7	-146.9
TOTAL SALES	908.0	964.1	1194.5	1238.6	1456.3	1537.9	1671.0	1489.3	1482.4	1497.3

Sources: Statistics of Energy and Power, 1968-77, 1978 and Economic Survey, Central Bureau of Statistics , Various Issues

TABLE 5: DISTRIBUTION OF PETROLEUM PRODUCTS BY CONSUMER CATEGORY

Percentage

	1968	1970	1972	1974	1976	1978	1980	1982	1984	1985	1968-85
Road Transport	14.2	20.0	23.7	27.2	25.7	28.2	31.2	34.1	38.4	41.2	28.0
Rail Transport	38.6	22.7	16.3	7.4	5.5	5.9	4.2	2.8	2.9	2.3	10.5
Marine	17.3	16.3	15.2	15.8	5.7	7.2	8.5	9.7	10.7	9.8	12.0
Aviation	5.6	7.9	9.3	22.2	21.9	22.1	22.3	19.0	17.5	17.4	17.0
Total Transport Sector	75.7	66.9	64.5	72.6	58.8	63.4	66.2	65.6	69.5	70.7	67.0
Agriculture	3.9	6.0	5.2	4.7	3.9	4.9	4.1	3.3	3.0	3.3	4.5
Power Generation	6.4	7.9	9.6	7.6	11.6	7.0	9.0	6.4	3.7	1.8	7.0
Industrial and Commercial .	9.6	12.8	15.4	23.9	25.4	23.6	29.8	29.9	30.5	30.2	22.0
Government	3.5	5.0	7.7	3.3	3.2	4.1	5.5	3.4	3.6	3.1	4.3
Tourism*..................	-	-	-	-	-	-	-	0.6	0.6	0.6	0.6

Source: Derived from Table 3

*Tourism comprises of Sales to four operators

TABLE 6: DOMESTIC FUEL SALES FOR SELECTED YEARS

million litres

	1969	1971	1973	1974	1976	1978	1979	1980	1982	1984
L.P.G.*	10.8	15.2	12.0	12.4	14.7	16.9	20.0	20.9	20.9	21.6
Motor Gasoline	272.8	271.5	321.0	311.5	33.6	393.3	412.2	422.5	372.8	356.7
Aviation Spirit	7.8	6.1	7.7	7.6	8.3	9.1	7.5	7.8	8.4	7.8
Jet/Turbo fuel	203.0	242.4	341.8	318.9	407.5	402.9	375.1	467.6	356.1	346.3
Illuminating Kerosene	53.7	58.2	87.0	68.3	68.1	95.8	110.7	107.9	104.8	103.1
Light diesel oil	183.9	248.5	302.6	297.9	340.8	365.0	413.2	487.3	436.9	500.3
Heavy diesel oil	36.8	47.1	54.8	47.6	52.6	33.0	36.0	37.9	30.4	29.7
Fuel Oil	352.6	419.9	432.9	437.1	534.0	493.6	440.5	519.3	431.9	436.5
Total Sales	1061.4	1308.9	1559.8	1501.5	1759.6	1809.6	1815.2	2031.2	1762.2	1802.0

*Liquified Petroleum Gas

Sources: Statistical Abstracts and Economic Survey, Central Bureau of Statistics, Various Issues

TABLE 7: PROPORTION OF FUELS IN TOTAL FUEL SALES

Percentage

	1969	1971	1973	1974	1976	1978	1979	1980	1982	1984	1969-84
Motor Gasoline	20.0	20.7	20.6	20.8	19.0	21.7	22.7	20.3	21.2	19.8	21.0
Light diesel oil	17.3	19.0	19.4	19.8	19.4	20.2	22.8	23.4	24.8	27.8	21.0
Sub-Total	37.3	39.7	40.0	40.6	38.4	41.9	45.5	43.7	46.0	27.6	42.0
L.P.G.	1.0	1.2	0.8	0.8	0.8	0.9	1.1	1.0	1.2	1.2	0.8
Aviation Spiriti	0.7	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.5	0.4	0.5
Jet/Turbo fuel	19.1	18.5	21.9	21.2	23.2	22.3	20.7	22.5	20.2	23.1	21.0
Illumination Kerosene	5.1	4.5	5.6	4.5	3.9	5.3	6.1	5.2	5.9	5.7	5.0
Heavy diesel oil	3.5	3.6	3.5	3.2	3.0	1.8	2.0	2.3	1.7	1.7	3.0
Fuel Oil	33.2	32.0	27.7	29.1	30.4	27.3	24.2	24.9	24.5	24.2	29.0

Source: Derived from Table 6.

The price of light diesel is kept at relatively low levels than that of gasoline, its close substitute, in the transport sector. This differential fuel pricing together with discrimination in the pricing of vehicles which tended to favour diesel-propelled vehicles, led to a growth of diesel propelled appliances and a rise in the use of light diesel. On these pricing systems, the 1984-85 budget[4] observed that:

> "Passenger motor cars are subjected to varying rates of tax depending both on their engine capacity and whether they are diesel or petrol propelled. Diesel propelled vehicles are taxed at a lower rate. As a result of this favourable treatment of diesel propelled vehicles, the number of diesel propelled vehicles has increased considerably that the government has been forced to allow imports of refined diesel to meet domestic demand."

Graph 1 shows the pattern of consumption of individual fuels. Apparently, the first oil crisis did not have a considerable effect on the consumption of this fuel as its sales declined only by 1.6% in 1973-74. For the period 1976-80, the growth in the consumption recorded the highest rates of about 9.6% per year.

The second oil crisis of 1979-80 did not have an immediate effect on its consumption. It can be observed that (table 8), in the period 1979-80, Graph 1: PETROLEUM PRODUCTS CONSUMPTION (MILLION LITRES)

1969 - 1984

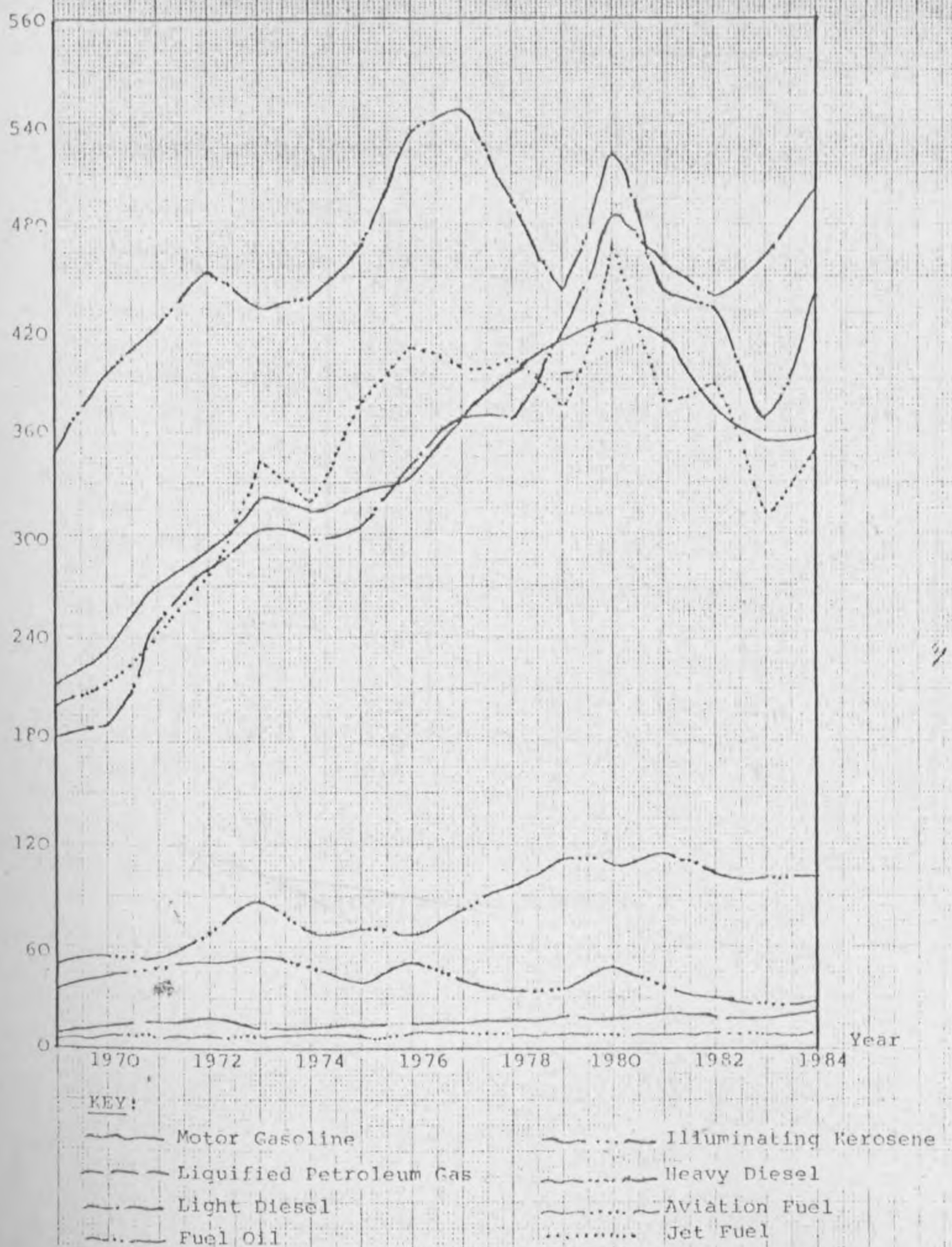

Table 8: Percentage Growth Rates for Domestic Fuel Sales

Year	Motor Gasoline	L.P.G.	Aviation Spirit	Jet/ Turbo Fuel	Illuminating Kerosene	Light Diesel Oil	Heavy Diesel Oil	Fuel Oil
1969-70	10.5	18.5	7.7	10.6	8.9	3.3	14.9	11.2
1970-71	15.4	18.8	-27.4	8.0	-0.5	30.8	11.3	7.1
1971-72	7.7	19.7	14.8	14.8	17.5	11.8	6.6	7.8
1972-73	9.7	34.1	10.0	22.8	27.6	8.9	9.2	-4.4
1973-74	-3.0	3.3	1.3	-6.7	-21.5	-1.6	-13.1	1.0
1974-75	4.3	10.4	9.0	18.2	3.8	1.9	-18.9	6.2
1975-76	2.6	7.3	-2.4	8.1	-3.9	12.2	36.3	15.0
1976-77	10.8	9.5	4.8	-2.8	20.7	8.2	27.0	2.2
1977-78	6.4	5.0	4.6	1.7	16.5	-1.0	-13.5	-9.5
1978-79	4.8	18.3	-17.6	-6.9	15.6	13.2	8.4	-10.8
1979-80	2.5	4.5	3.8	24.7	-2.5	17.9	33.1	17.9
1980-81	-2.3	0.5	-1.3	-18.8	4.6	-6.5	-26.5	-14.5
1981-82	-9.6	-0.5	9.1	-6.2	-7.2	-4.1	-13.6	-2.7
1982-83	-4.9	4.8	0.4	-12.4	-1.0	-6.0	-10.9	-15.4
1983-84	0.6	8.5	-7.5	11.0	-0.7	8.1	9.6	19.5
1969-73	10.8	22.8	1.3	14.1	13.3	13.7	10.5	5.4
1973-76	4.5	7.0	2.6	6.5	-7.2	4.2	1.4	7.4
1976-80	6.1	9.3	-1.1	4.2	12.6	9.6	13.8	-0.1
1980-84	-4.1	3.5	0.2	-6.6	-1.1	2.1	-10.4	-3.3
1969-84	4.3	10.9	0.6	4.4	5.2	6.5	4.0	2.4

Source: Derived from Table 7

consumption grew at the highest level of about 18% eccept for that experienced in 1970-71 when consumption grew at 30.8% . The effect of this oil crisis, however, was felt in the period 1981-83, although, it is also during this period that the level of economic activities declined drastically. as the international community experienced a devastating recession.

The recovery from the recession led to increased growth in GDP which had declined to 3.3% in 1982 and a rise in light diesel consumption.

The consumption of motor gasoline has generally been rising. Unlike light diesel, the first oil crisis seems to have had an immediate marginal downwards effect on the level of consumption. During the period 1973-74, the consumption declined by 3%. Thereafter, the growth in consumption was quite high averaging 6.1% between 1976-80.

The second oil shock of late 1979 seems to have had a considerable downwards effect on its consumption growth. However, the impact was felt with some lag. For example, in 1980, the highest amounts (in quantity) ever consumed were recorded reaching 422.5 million litres.

The decline in motor gasoline consumption after the second oil crisis may have been a result of allowing domestic prices to increase to international levels. This decline reversed in 1983 when consumption started to pick up and in 1984, almost 2 times more motor gasoline was consumed compared to 1969.

Jet fuel is one of the major fuel sold in the economy. Its share in total fuel sales rose from 19.1% in 1969 to 23.1% in 1984. The increase may reflect the expanding needs of the tourist industry and increased international airlines refueling. However, the growth in consumption show wide disparities since the demand of this fuel is internationally determined. The peak periods in its consumption were recorded in 1973 when 341.8 million litres were sold, 407.5 million litres in 1976 and 467.6 million litres in 1980. The corresponding shares in total fuel consumed of these amounts were 21.9%, 23.2% and 22.5% respectively. On average, this fuel constituted 21% of the total fuel sales between 1969 and 1984.

However, since the consumption of this fuel is mainly by international airlines (hence not domestic demand) who pay in foreign exchange, its sale in the domestic economy is not a cost to the economy but an earner of foreign exchange.

Another heavily used fuel is fuel oil. Its share constituted approximately 29% of the total fuel sales in the economy over the period 1969 and 1984.

This product is mainly used for industrial and transportation purposes. However, its importance in the economy has been declining as indicated by the fall in its share in total fuel sales from 33.2% in 1969 to 24.2% in 1984. Its consumption growth registered a decline of about 10.4% per year between 1980 and 1984 but showed high consumption levels in 1972, 1977 and 1980 when industrial production increased rapidly.

The declining consumption of this fuel may be a result of: a switch by rail (a major user) from fuel oil propelled locomotives to diesel propelled locomotives which are more fuel efficient; increased importance of road transport over rail transport in the movement of freight; increasing importance of electricity use in the industrial sector; and the break-up of the East African Community.

Most noteworthy is the declining position of heavy diesel. Its shared declined from 3.5% in 1969 to 1.7% in 1984. On average, however, this fuel accounted for only 2.6% of all fuel sales over this period.

Liquified Petroleum Gas (LPG) and illuminating Kerosene showed a marginal increase in their shares in total fuel sales. The former constituted

1% in 1969 and the share increased marginally to 1.2% in 1984. While, the latter showed a slight increase from 5.1% in 1969 to 5.7% in 1984.

However, these fuels registered the highest growth between 1969 and 1984. LPG grew at an average rate of 22.8% per year over this period. While illuminating kerosene grew at an annual average growth rate of 13.3%. This rapid growth in consumption of these fuels is primarily from increased household demand for cooking and lighting and also because growth is from a narrow base.

The growth in aviation fuel consumption has been the lowest averaging 1.3% per year for the period 1969-84. This is mainly because the propeller type air crafts using this fuel have been phased out. As a result, its share in fuel sales has been almost constant at a lower level averaging only 0.5% over this period.

Domestic consumption of petroleum fuels indicate that those used in the transport sector - motor gasoline, diesel and jet turbo, constitute the largest share of the total fuel sales in the country. These fuels comprise 63% of total fuel sales. Next of importance is fuel oil which is mostly used in industry, and also in transport which constituted about 29% of total fuel sales over the period 1969 to 1984.

Further observation about domestic demand of the largely used fuels - light diesel and motor gasoline is their slow adjustment to price increases as was seen for the 1973-74 and 1979-80 oil crises. This depicts the importance of time lags in their domestic demand analysis.

The above discussion of petroleum products consumption over the years, indicate that petroleum will continue to play a very important role in the transport and industrial sectors.

However, unlike in industry which provides possibility of substituting for petroleum products, no substitution possibilities exist in the transport sector at present. The short supply of alcohol fuels to replace motor gasoline in addition to the absence of coal-fueled or electrified trains, implies that, the economy and notably the transport sector will be heavily depended on petroleum for some time. About the possibility of substitution, the World Bank[8] notes that:-

> "In order to effect a 100% substitution of 1,000 barrels per day of gasoline by ethanol it would require between 23,000 - 100,000 hectares of land under sugar cane production. The true cost of producing ethanol as a fuel is not simply the cost of sugar... but also depends upon the value of alternative crops which could be grown on good agricultural land."

Therefore in sectors where substitution of petroleum fuels is negligible, other measures can be undertaken to reduce the rate at which petroleum fuels are consumed. However, such measures can only be instituted after understanding the nature of the demand for such energy fuels.

Accordingly, more information regarding the present use and probable future requirements of major energy fuels in the economy becomes very important for any comprehensive energy policy formulation. Hence, our study is focused on demand for motor gasoline and light diesel in the economy.

1.2 STATEMENT OF THE PROBLEM

The present pattern of petroleum consumption has been largely shaped during a period when petroleum prices were stable or declining in real terms. Adjustments to this pattern of petroleum demand resulting from price changes can only develop slowly because of the time lags involved in developing new sources of energy and changing the technology of energy use.

Since petroleum is no longer cheap, several issues need to be considered in relation with energy planning. One of these issues in incorporating the high cost of oil in the overall planning process.

However, in order to assess the proper scope and magnitude of petroleum demand, it is necessary to obtain more information on the demand for each petroleum product. This disaggregated approach provide valuable information since it unravels the determinants of demand for each petroleum fuel and also uncovers the responsiveness of their demand to changes in these determinants.

The preceeding section indicated that, motor gasoline and light diesel constituted approximately 42% of total fuel sales between 1969 and 1984. These products are mainly used in road transport a mode of transport which has exhibited a dramatic rise in the consumption of petroleum despite the rising cost of oil. Furthermore, these fuels show a general rise in their consumption as shown in graph 1. It can also be observed (from graph 1) that, consumption of these fuels largely influence the consumption trend in petroleum.

This implies that, as the economy increases in its economic and social activities, such as, rising incomes, rapid population growth and urbanisation expansion of road transport facilities in the remote rural areas, increased industrial and agricultural output, and many others, gasoline and light diesel are likely to continue to be used extensively in the economy.

Accordingly, if savings are to be made both in total energy consumed and in oil imports, there will be need to obtain information about the magnitudes and patterns of consumption of these petroleum products. This will be more useful in outlining.policy options including specific conservation targets than overall energy demand analysis.

Past studies have tended to concentrate on demand for energy at a higher aggregate level. But little has been done to access the scope and magnitude of demand for each petroleum fuel. It is equally important to obtain more information on demand for individual petroleum fuel. Without such analysis, undesirable assumptions might be made about petroleum use in Kenya which may distort any major policy initiatives.

1.3. THE OBJECTIVES OF THE STUDY

The broad objective of the study is to estimate demand functions for motor gasoline and light diesel in Kenya. Motor gasoline includes premium and regular motor spirit and gasohol. The specific objectives are:-

(1) to identify the determinants of demand for motor gasoline and light diesel; and

(2) to determine their elasticities of demand to changes in factors in (1) above

This will help in making suggestions about implications of the present consumption pattern in the long run and hence provide room for possible policy recommendations.

1.4. SIGNIFICANCE OF THE STUDY

As noted earlier, motor gasoline and light diesel are the major petroleum products consumed in the economy. The information generated from this study about their demand is vital for it can be used by policymakers in assessing the impact on the economy of changes in factors identified to be determining their demand.

Furthermore, knowledge about short run demand functions and their corresponding elasticities can help in understanding the future demand requirements in the economy. This will give a picture to possible policy measures which is essential ingredient for sound overall national energy policy.

1.5. ORGANISATION OF THE REST OF THE PAPER

This chapter covered the general background of the consumption of petroleum products and how it relates to the level of economic activity indicated by the growth in GDP. The consumption of commercial energy is discussed in Chapter 2. In Chapter 3, we review existing literature on demand for transportation fuel with emphasis on gasoline and light diesel products. Model specification and estimation methodology is the subject of Chapter 4. In Chapter 5 we discuss the sources and nature of data, presentation, analysis and interpretation of results. Conclusion and policy implications of the study are described in Chapter 6.

FOOTNOTES

1. Republic of Kenya; Development Plan 1984-88, The Government Printer, Nairobi, 1983, pp.2

2. ibid, pp. 2-4

3. ________; Development Plan 1979-83, The Government Printer, Nairobi, 1983, pp. 9

4. ________; The Budget 1984-85, The Governemnt Printer, Nairobi, 1984, pp. 17-18.

5. World Bank., "Energy Options and Policy Issues in Developing Countries". World Bank staff Working Papers, No. 350, August, 1979, pp. 9

CHAPTER 2

THE ENERGY SECTOR

2.1. Energy and the Economy

Energy plays an important role in the process of economic development of any economy. Its use can be analysed in the context of economic and social changes in the country. Among these changes are: level of economic activity, demographic changes, changing sectoral contributions in GDP, rural-urban set-up, and many others.

In Kenya, commercial energy sources comprise only 25%[1] of total energy consumed in the economy. The rest, 75% is from non-commercial energy sources mainly wood resources. Commercial energy is mainly linked to the modern economy and the sizeable portion of the economy - the traditional economy heavily depends on non-commercial energy sources.

Many studies have been conducted elsewhere on the linkage between economic growth and commercial energy consumption. Shur and Netshert (1960)[2] traced the energy consumption in the United States over the period 1850-1975. One of their major findings was that energy consumption increased rapidly in times of faster economic growth while of slower growth, it increased more slowly. These findings were compatible with those of Darmstadler (1977)[3] who also demonstrated that countries with high GNP per capita had a higher per capita consumption of commercial energy.

However, these patterns of commercial energy consumption were exhibited before the 1973 price oil shock. Ching Yaun Lin (1984)[4] noted that the developments before 1973 showed an increase in the elasticity of energy consumption with respect to the growth of real world output. This was attributed to the increase in global per capita income, increased share of industrial production and decline in the real price of oil and energy generally.

However, since 1974, increased price of oil has called for a decline in the consumption of energy. Consumption of oil in some sectors, such as industry, has declined since substitution of other cheaper energy sources is possible. But for others such as road and air transport, petroleum consumption decrease cannot be achieved largely from substitution.

The possibility of substitution for oil in some sectors implies that as the cost of oil increases, more of other viable sources of energy are to be used for fueling these sectors. However, decline in total commercial energy can also arise from increased efficiency in the use of fuels.

Table 11 shows that before 1973, the growth in total commercial energy was quite high averaging 6.2% per year between 1968-72. But since that time, the growth has been dumpened by the high cost of oil. As a result between 1973 - 79, total commercial energy grew at 4.4% per year between 1980-85 reflecting the effect of the two major oil crises of 1973-74 and 1979-80 respectively.

Consequently, given the decline in the growth of total commercial energy resulting from the oil crises, and increased growth in the tempo of economic activity which entails more use of energy, it follows that either increased demand is met through substitution from other energy sources or there has been increased efficiency in the use of fuels. If the former is the case, then it implies that other sources of energy such as wind power, solar energy, biogas, woodfuel, and many others, are increasingly becoming important in the economy thereby reducing the share of commercial energy in total energy consumed. But, if the latter is the case, then increased demand can be met not necessarily consuming more energy,in obsolute terms, but reducing energy per unit of output produced.

2.1.1. Distribution of Commercial Energy in the Economy

Kenya's known commercial energy sources are electricity, coal, petroleum and power alcohol. Table 9 shows that consumption trends for commercial energy resources in Kenya from 1969 to 1985.

The table illustrates that petroleum products constituted, on average, approximately 80% of the total commercial energy demand over the period 1969 to 1985. The proportionate share of petroleum declined from 83.3% during the period 1969-72, to 82.5% over the period 1973-76. This was because of the rise in price of oil and increased importance of electricity in the economy. For the same reasons, the share of petroleum declined further during the period 1980-85 to an average of 75.5%.

Meanwhile, the relative share of electricity in total commercial energy increased over this period. Between 1969-72, the average annual growth rate was 13.3% . The growth increased to 15.6% for 1973-79 and 21.7% for 1980-85 periods.

Coal and coke are consumed in comparatively smaller amounts. They comprised less than 3% of the total commercial energy demand during the period 1969-85.

The consumption patterns of commercial energy are shown in graph 2. It shows that the general trend in the consumption of petroleum products takes the same shape as that exhibited by total commercial energy. For example, when total petroleum consumption

Table 9: Commercial Energy Consumption 1969 - 85

Year	Petroleum ('000 toe*)	Coke and Coal ('000 toe*)	Electricity ('000 toe*)	Total ('000 toe*)	Petroleum (Percentage)	Coke and Coal (Percentage)	Electricity (Percentage)
1969	879.3	22.8	138.2	1040.3	84.5	2.2	13.3
1970	964.1	58.1	155.0	1177.2	81.9	4.9	13.2
1971	1082.6	57.9	171.6	1312.1	82.5	4.4	13.1
1972	1203.0	28.4	190.8	1422.2	84.6	2.0	13.4
1973	1258.2	50.0	206.3	1514.5	83.1	3.3	13.6
1974	1231.5	47.0	220.0	1498.5	82.2	3.1	14.7
1975	1310.9	32.2	240.4	1583.5	82.8	2.0	15.2
1976	1356.3	44.9	259.8	1837.5	81.7	2.7	15.6
1977	1504.8	48.8	288.9	1837.5	81.9	2.4	15.7
1978	1537.9	34.8	312.2	1884.9	81.6	1.8	16.6
1979	1559.7	11.3	338.3	1909.3	81.7	0.6	17.7
1980	1670.7	16.9	352.4	2040.0	81.9	0.8	17.3
1981	1584.5	63.8	387.4	2035.7	77.9	3.1	19.0
1982	1489.3	52.5	409.2	1951.0	76.3	2.7	21.0
1983	1373.1	63.7	460.6	1897.4	72.4	3.4	24.3
1984	1482.4	82.7	465.3	2030.4	73.0	4.1	22.9
1985	1497.3	59.9	535.4	2092.2	71.6	2.9	25.6
1969-72					83.3	3.4	13.3
1973-76					82.5	2.8	14.8
1973-79					82.1	2.3	15.6
1980-85					75.5	2.8	21.7
1969-85					80.1	2.7	17.2

Source: Economic, Survey,
Central Bureau of Statistics, Various Issues

*toe- tonnes of oil equivalent.

Graph 2: TOTAL DOMESTIC COMMERCIAL ENERGY CONSUMPTION ('000 TONNES) 1969 - 1985

fell in 1973-74 period by 2%, total commercial energy consumption likewise fell, but by only 1.1% in the same period. Similarly, for the entire period 1980-83, there occured a marked decline in the consumption of petroleum and this was also reflected in total commercial enrgy consumed during that period. Also illustrated is that peak, commercial energy consumption levels coincide with peak petroleum consumption levels.

Electricity consumption has been growing very fast averaging 8.9% per year over the period 1969-83. However, its growth has been from a small base relative to that of petroleum. The growth in demand for electricity is because of increased supply as the existing resources are being exploited especially geothermal resources and also because of increased industrial electricity demand.

Coal consumption growth has been rather erratic showing no particular pattern. This is because its demand is based largely on one consumer - Bamburi Portland Cenment Factory and also infrastructural difficulties and technological constraints that are involved in switching to coal.

Additionally, table 10 shows that when the total commercial consumption growth rates and petroleum consumption growth are compared, it is observed that,

Table 10 : Growth Rates in Commercial Energy Sources

Year	Petroleum	Coke and Coal	Electricity	Total
1969-1970	9.6	154.8	12.2	13.2
1970-1971	12.3	-0.3	10.7	11.5
1971-1972	11.1	-50.9	11.2	8.4
1972-1973	4.6	76.1	8.1	6.5
1973-1974	-2.1	-6.0	6.6	-1.1
1974-1975	6.4	-31.5	9.3	5.7
1975-1976	3.5	39.4	8.1	4.9
1976-1977	10.9	-2.4	11.2	10.6
1977-1978	2.2	20.5	8.1	2.6
1978-1979	1.4	-67.5	8.4	1.3
1979-1980	7.1	49.5	4.2	6.9
1980-1981	-5.2	277.5	9.9	-0.2
1981-1982	-6.0	-17.7	5.6	-4.2
1982-1983	-7.8	21.3	12.6	-2.7
1983-1984	8.0	29.8	1.0	7.0
1984-1985	1.0	-27.6	15.1	3.0
1969-72	11.0	34.5	11.4	9.9
1973-76	2.8	19.5	8.0	4.0
1973-79	3.6	4.1	8.5	4.4
1980-85	-0.5	55.5	8.1	1.6
1969-85	3.6	27.9	8.9	4.6

Source: Derived from table 9

as long as there occur a decline in the growth rate of petroleum consumption, there is a corresponding fall in the consumption of total commercial energy. However, the proportionate fall in the growth rate of total petroleum is lower. For example, in 1973-74, total petroleum consumption growth declined by 2.1% while total commercial energy growth fell by 1.1% . The same trend was observed for the period 1981-83. This can be attributed to the impact of oil crises on the economy.

This relationship indicates the importance of petroleum as a source of commercial energy in the economy. Despite the decline of its share in total commercial energy, its position is not likely to change very soon.

The linkage between total commercial energy and economic growth is shown in table 11. It illustrates that, for the period 1968-72, commercial energy consumption grew at an average rate of 6.2% per year while GDP grew at an average rate of 4.6% per year over the same period. However, the high cost of energy in 1973/74 period reduced both the consumption of commercial energy and also economic growth. Commercial energy consumption growth fell from 6.2% over 1969-72 period to 4.4% during the period 1973-79 and to 1.6% between 1980-85. While GDP grew at an annual rate of 4.6% between 1969-72, 4.3% over 1973-79 and 3.7% over 1980-85 period.

Table 11: GDP and Commercial Energy Growth Rates

Year	GDP	Commercial Energy
1968 - 1969	6.4	-2.0
1969 - 1970	6.9	13.2
1970 - 1971	6.5	11.5
1971 - 1972	3.0	8.4
1972 - 1973	4.8	6.5
1973 - 1974	2.4	-1.1
1974-- 1975	2.1	5.7
1975 - 1976	2.4	4.9
1976 - 1977	8.8	10.6
1977 - 1978	6.2	2.6
1978 - 1979	4.3	1.3
1979 - 1980	3.3	6.9
1980 - 1981	5.3	-0.2
1981 - 1982	3.4	-4.2
1982 - 1983	3.9	-2.7
1983 - 1984	1.3	7.0
1984 - 1985	4.9	3.0
1968 - 72	4.6	6.2
1973 - 76	2.9	4.0
1973 - 78	4.3	4.4
1979 - 85	3.7	1.6
1968 - 85	4.2	4.0

Source: Compiled from Tables 2 and 10

It can also be observed from the table that, during sound economic performance such as 1976-77 period, commercial energy consumption grows much faster. During this period, for example, commercial energy consumption growth was 10.6% while GDP growth was 8.8%. This supports the earlier energy-growth linkage studies. It is then not a surprise that the 1979-83[5] development plan remarked that:

> "The demand for energy will continue to rise with the growth of the economy"

2.1.2. Future Demand for Commercial Energy:

Total commercial energy consumption in Kenya is expected to increase with the growing commercial and industrial developments. As a consequence, the 1979-83 development[6] plan specified the following objectives for the Kenyan energy sector:

(1) increasing the supply of energy to meet the requirements of the economy;

(2) rationalising the use of imported petroleum;

(3) developing indigeneous energy resources;

(4) and lessening dependence on imported fuels.

These objectives recognise the fact that commercial energy requirements are increasing with the growth of the economy. To meet the growing demand, emphasis is given to developing existing domestic energy resources in order to reduce the vulnerability of the economy to changes in prices of foreign energy sources.

Reorientation of the economy away from primary production means a shift which is commercial energy intensive. For example, as the level of economic activities expand and the amount of freight to be handled from both the agricultural and industrial sectors increase, relatively higher energy will be consumed.

Increased commercial energy consumption can also arise from the current high population and urbanisation growth which entail need for more energy for lighting, cooking and public transport especially in the urban areas. Furthermore, rural-urban dichotomy, which is a characteristic of most developing countries, and the localisation of many industries in a few urban areas, necessitates rural-urban movements of especially urban workers who are constantly in touch with their rural relatives since they are heavily dependent on.

In Kenya, just as many other countries, commercial energy is mainly used by transport and industrial sectors. These sectors have been growing very fast and as a consequence, their demand for commercial energy has been rising.

However, their energy needs are primarily met by petroleum. This implies the position of petroleum products as a source of energy is not likely to change because at present and presumably the near future, there exist no viable close substitutes for these fuels to be used by their major consumers.

2.2. Commercial Energy Supply

The main known commercial energy sources in Kenya are electricity, coal, petroleum and power alcohol. However, the country's indigenous sources are hydro and geothermal for electricity generation and power alcohol but at present no coal or deposits are known to exist.

The potential for power alcohol production is limited because producing energy crops require the diversion of large high potential areas from the production of food and other crops to the production of these crops (especially for sugar cane production). But, given the high population growth, which already has led to the diminishing of high potential areas, coupled with rapid urbanisation and need for more food, the future production of energy crops on large-scale in Kenya looks gloomy.

Kenya's indigenous resources of hydro and geothermal for electricity generation are also limited. The country's total potential for hydro generation is estimated to be only 30150 million kilowatt hours per annum, however not all of it can be economically exploited. In addition, geothermal potential is estimated at 7000 million kilowatt hours per year[7]. Electricity demand is supplemented by imports from Uganda.

Therefore, the overall demand balance is met through importation of fossil fuels predominantly petroleum. Consequently, the limited potential of domestic commercial energy sources indicate further that, the country will continue to depend inevitably heavily on foreign sources of commercial energy to meet the unprecendented growth in its demand. However, the growth in demand can be restrained through the encouragement of using energy more efficiently, reducing wastage and development of new energy technologies such as modification of inefficient existing fuel utlising appliances.

2.3. Commercial Energy Market

Commercial energy demand and supply levels are shown in table 12. This shows that, liquid fuels continue to be the main energy sources in the economy. Further revelations include the substantial deficits in Kenya's energy supply which has to be

Table 12 : Domestic Commercial Energy Supply and Demand for Slected Years

'000 mtoe*

	1968	1970	1972	1974	1976	1978	1980	1982	1984	1985
Demand:-										
Petroleum	905.1	964.1	1203.0	1231.5	1356.3	1537.9	1670.7	1484.3	1482.4	1497.3
Electricity	127.2	155.0	190.8	220.0	259.8	312.2	352.4	409.2	465.3	535.4
Coal and Coke	29.2	58.1	28.4	47.0	44.8	34.8	16.9	52.5	82.7	59.9
Total Demand	1061.5	1177.2	1422.2	1498.5	1660.9	1884.9	2035.7	1951.0	2030.4	2092.2
Supply:-										
Electricity	73.4	95.7	121.9	146.3	201.7	260.1	276.8	358.3	413.7	483.8
Total Supply	73.4	95.7	121.9	146.3	201.7	260.1	276.8	358.3	413.7	483.8
Imports:-										
Deficit	988.1	1081.5	1300.3	1352.1	1459.2	1624.6	1763.5	1592.7	1616.7	1608.4
Percentage:-										
Imports	93.1	91.9	91.4	90.2	87.9	86.2	86.4	81.6	76.6	76.9
Domestic Supply	6.9	8.1	8.6	9.8	12.1	13.8	13.6	18.4	23.4	23.1

Source: Economic Survey, Central Bureau of Statistics. Various Issues

mtoe* - Metric tonnes of oil equivalent

met by imports.

Efforts to reduce this dependence on liquid fuels, which are primarly imported, continue and this is reflected in the gradual reduction in the share of imported fuels in the total commercial energy consumed.

In 1968, imports to meet the demand, constituted 93.3% of total commercial energy consumed, compared to 76.9% in 1985. This is because total demestic primary energy generated has been increasing. For example, in 1968, total electricity produced was almost 6 times that produced in 1985.

The relatively small share of domestic commercial energy supply means that any unprecedented growth in economic performance will inevitably entail increased imports. Therefore, it is expected that energy shortfalls will continue but the high cost of energy is likely to lead to the development of potentially viable energy resources.

The commercial energy market is characterised by many consumers and a few sellers of the fuels. In the petroleum market, all the crude oil is imported and the refined products are marketed by the domestic economy by a few oil multinational corporations. While electricity is solely supplied by Kenya power and Lighting company.

This suggests an oligopolistic market structure for the petroleum market while Kenya power and Lighting company is a monopolist. However, the government in consultation with these institutions determine the price of electricity and petroleum products.

Petroleum products prices are set on the basis of C.i.f. (cost insurance and freight) curde oil price, transportation costs within the country retailers' and wholesellers' margins and refining fee. On some products the government collects some tax. While electricity prices are set according to the category of use and the consumer uses in a given period of time.

Hence, the prices of commercial energy sources are not left to be determined by market forces but rather administered by the government. This implies that, the exogenoursly determined price is given to consumers who can consume as much as they can at the given price.

FOOTNOTES:

1. Mureithi, L.P., Kimuyu, P.K., and Ikiara, G.K., "The Effects of Higher Energy Costs on Balance of Payments, Employment, Technology choice and Real Incomes in Kenya," World Programme Research Working Papers, ILO, Geneva, 1982.

2. Shur, J.S. and Netshert, B.C., Energy in the American Economy 1850-1975, Baltimore, John Hopkins University Press.

3. Darmstadler, J., Dunkerley, J., and Alterman, J., How Industrial Societies Use Energy: A comparative Analysis Baltimore, John Hopkins University Press

4. Ching Yaun Lin., "Global Patterns of Energy Consumption Before and After 1974 oil crisis", Economic Development and Cultural change, Vol. 34, No. 4, July 1984.

5. Republic of Kenya; Development Plan 1979-83, The Government Printer, Nairobi, 1979, pp. 442

6. ibid pp442

7. ____., Development Plan 1983-88, The Government Printer, Nairobi, 1983, pp.133

CHAPTER 3

LITERATURE REVIEW

3.1. Demand for Transportation Fuels

The demand for transportation fuels is a derived demand based on the demand for transport services in conjuction with transport equipment and rate of utlisation of the stock of capital.

Several studies have been conducted on demand for these fuels with various variables such as fuel prices, income, population, stock of vehicles, price of vehicles, and many others entering the demand formulations.

However, the extent and nature of the responsiveness of fuel demand to changes in these variables varied with the theoretical framework underlying the adopted models. We now consider studies conducted on gasoline and light diesel demand.

3.2. Studies on Demand for Gasoline

The demand for gasoline has been analysed extensively. The main issues of analyses have been estimating the magnitudes of price and income elasticities.

Among the several studies carried out, the main difference has been primarily the modeling approach. These approaches are:

(a) static demand models; and

(b) dynamic demand models

Our literatue review will be organised according to these categories and conclude the results of these studies.

3.2.1. The Static demand models for Gasoline

Static gasoline demand specifications have been used in estimating long run and also short run elasticities depending on the nature of the data used. This specification is based on the assumption that dynamic features of demand such as habit formation and capital stock adjustiment occur rapidly with changes in demand determinants. For example, if fuel demand increases, the requisite stock of capital mysteriously increases. In such a case all short run and long run responses are equivalent.

Some of the studies which adapted this specification include Senga, House and Manundu (1980)[1] who assessed commercial energy demand and supply in Kenya. Using time series data they obtained short run price elasticity of -0.26 and short run income elasticity of 1.39.

Adams, Graham and Griffin (1974)[2] using pooled data from OECD countries also analysed demand for gasoline in a static framework. Gasoline consumption per car per country, gross domestic product per capita and number of cars per capita were the variables used. The price elasticity was obtained to be -0.4 while the income elasticity was 0.72. Their results indicated that, additional cars reduces average gasoline consumption.

Green (1978)[3] estimated a static demand function for average annual highway gasoline sales per household using pooled state data in United States. He obtained short run elasticities of -0.19 and 0.24 for price and income respectively. The dependent variable was gasoline consumption per household while the independent variables were: disposable income per household, vehicles per household, population density, urban population and trucks as a percentage of vehicles. Urban population appeared unimportant with gross population density showing an inverse relationship with gasoline consumption per household.

Ramsey, Rasche and Allen (1975)[4] analysed private and commercial demand for gasoline in United States. He used cross section time series data and the exogenous variables were retail prices of gasoline, disposable income, the proportion of population between 16-24 years and diesel prices. While the endogenous. variables were quantities demanded and supplied. The results were that long run own price elasticity of private demand for gasoline was -0.77 and 1.34 as the income elasticity.

3.2.2. Dynamic Demand models for Gasoline

These models are based on the recognition that demand for transportation fuels does not adjust in- rapidly to changes in its determinants. This is because it takes time for consumers to adjust their consumption habits and also for the existing fuel utilising stock of transportation capital to be modified and ultimately replaced. Even changes in the rate of utilisation of existing capital takes time as consumers must adjust their habits in response to say, changes in the price of gasoline.

Dynamic demand formulations follow Nerlove (1956)[5] postulation of stock adjustment principle which was adopted by Houthakker and Taylor (1966)[6] in analysing consumer demand. This formulation helps in tracking short run and long run adjustments in demand.

Three basic approaches have been used in the literature to differentiate between short and long run elasticities. These are:-

(a) using different sample data;

(b) using both static and stock adjustment formulations; and

(c) introducing lagged endogenous and or exogenous variables.

(a) Using Different Sample Data

In this approach, time series data is used to measure short run elasticities while cross section data used to measure long run elasticities. As we saw in Section 3.2.1., for example, Senga, House and Manundu (1980) and Greene (1978) by using time series data, obtained short run elasticities, while Adams, Graham, Griffin (1974) and Ramsey, Rasche and Allen (1975), by using annual pooled cross section data, obtained long run elasticities.

This distinction arises because time series data is assumed to exhibit dynamic adjustment to exogenous influences while cross sectional data reflect steady state variation.

(b) Using both Static and Stock adjustment Formulations

This approach uses static demand specification to estimate short run elasticities and a stock adjustment model to estimate long run elasticities.

The approach was postulated by Fisher and Kaysen (1962)[7] in analysing demand for electricity. His formulation begins with defining the rate of stock utilisation (R) which is equal to the amount of fuel used (G) divided by the stock of capital (K):

$$R = G/K \quad ......(1)$$

But since K is fixed in the short run, then K varies directly with G's determinants:

$$K = \alpha_0 + \alpha_1 P + \alpha_2 Y + \alpha_3 C \quad .....(2)$$

where P - price of fuel;

Y - income level;

Z - a vector of other relevant exogenous variable; and

α_1 and α_2 - are the short run price and income elasticities if we assume a log-linear formulation.

In the long run K varies, but R is assumed constant for simplicity and difficulties involved in obtaining relevant data on R. Hence, K becomes a function of G and expressed as;

$$K = \beta_0 + \beta_1 P + \beta_2 Y + \beta_3 C$$

If measured in logarithms, β_1 and β_2 are the long run price and income elasticities respectively.

This approach has not been used extensively in the estimation of gasoline demand. But Mehta, Narasimhan and Swamy (1978)[8] adopted it in their analysis of gasoline demand within the framework of household production function. Using time series of regional cross section data in the United States, they incorporated the technological adjustment of the stock of automobiles to changes in price of gasoline and level of income. They obtained long run income elasticities ranging from 0.39 to 1.40 and price elasticities ranging from 0.44 to -0.48 indicating that some price elasticities had wrong sign.

However, this approach does not allow changes in the utilisation rate in the long run despite changes in the capital stock and factors determining demand for the fuel.

(c) Introducing Lagged Endogenous and or exogenous variables

This approach has been extensively used in demand analysis. The introduction of lagged explanatory variables or lagged endogenous variables in the specification can be done in several variations:

(i) polynomial lag model;
(ii) Koyck's specification; and
(iii) Houthakker and Taylor (1966) model

(i) Polynomial lag models

This specification is based on Almon's (1965)[9] formulation in which present consumption is determined by past price levels and by a vector of other exogenous variables over past periods.

The polynomial lag scheme is given by

$$Q_t = a + \sum_{i=o}^{k} b_i P_{t-1} + \sum_{i=o}^{m} C_i N_{t-1}$$

where Q_t - current consumption

P_{t-1} - prices over the past K periods

N_{t-1} - vector of other exogenous variables over the past in periods.

In this formulation, the short run demand response to price is given by the coefficient of the first lag term b_1 and the long run price response is the sum of all coefficients $b_o + b_1 + b_2 + \ldots\ldots + b_k$. Price elasticities are then calculated by multiplying the price response by (P/Q).

The formulation has been adopted by several authors. Sweeney (1978)[10] employed this approach in estimating gasoline demand in United States. The analysis was based on time series and engineering data. Sweeney expressed the demand for gasoline in two equations. One explained the demand for cars which he incorporated in the second that explained gasoline consumption per car. He obtained short run price elasticity of -0.2 and long run elasticity of -0.8. The long run income elasticity was 0.86.

Pindyck (1979)[11] also utilised a polynomial distributed lag model to estimate demand for gasoline. Using time series pooled data from 5 developing countries, he obtained short run elasticity to be

-0.05. The long run price elasticity fell between -0.3 and -0.5 while long run income elasticity was between 1.2 and 1.7.

Griffin (1979)[12] also adopted this approach using pooled OECD data. The results were that, long run price and income elasticities were between -1.3 to -1.5 and 0.77 to 1.75 respectively. While the short run price elasticites were comparatively small ranging between -0.05 to -0.1.

However, this procedure, although does not place any prior restrictions on the nature of the adjustment path, it is not based on any theoritical hypotheses that can be tested. Rather, it depends on choosing the result that best fits the data. Consequently, the test statistics may be significant but may not have sound economic meaning.

Furthermore, this procedure by including lagged exogenous variables in the formulation suffers from multicollinearity and reduced degrees of freedom especially when time series data is used.

(ii) Koyck's Specification

The second lag specification is that postulated by Koyck (1954)[13]. He specified energy demand as a function of lagged prices, where the weights attached to each lagged price sum to unity and decline geometrically as they move back in time. That is,

$$Q_t = b_o + b_1 \; b_1 \sum_{i=o}^{\infty} \lambda^i P_{t-1} + U_t \cdot, \quad 0 < \lambda < 1 \qquad \ldots(1)$$

where Q_t is the quantity of fuel demand

P_t is the price of the fuel, and

U_t is an error term

This specification is known to reduce to

$$Q_t = b_o \; (1-\lambda) + b_1 \; (1 - \lambda) P_t + \lambda Q_{t-1} + (U_t - \lambda U_{t-1}) \qquad \ldots(2)$$

Assuming a log linear specification, the short run price elasticity is given by $b_1(1-\lambda)$ and the long run elasticity is given by $b_1(1-\lambda)/\,(1-\lambda)$ and the mean lag period is measured by $\lambda/(1-\lambda)$.

This formulation has not been largely used in estimating demand for gasoline but has been quite useful in electricity demand estimation. For example, the works of Taylor, Blathenberger and Verleger (1977)[14].

The main problems of this procedure is that there is no theory to justify the geometric decline in the adjustment pattern. In addition, the error term is complex which introduces serial correlation in the formulation.

(iii) Houthakker and Taylor Flow Adjustment model

This was introduced by Houthakker and Taylor (1956)[15] as an adoption from Nerlove (1956)[16]. They argued that, quantity demanded in any one period depends on the quantity demand in the previous periods because of what they referred to "habit formation principle'.

The adjustment is expressed by assuming a level of desired demand for a given fuel (F_t^*) which depends on its own price (P_t) and income. This is given by,

$$F_t^* = a_o + a_1P_t + a_2Y_t + C_t + E_t \quad .... (1)$$

where C_t is the vector of other variables, and

E_t is the error term.

However, the actual level of demand in one year is not necessarily equal to desired level. The actual demand (F_t) adjusts towards desired demand (F_t^*) with a lag, so that, current consumption is a function of current economic variables and previous level of consumtpion (F_{t-1}). The adjustment process can be represented by,

$$(F_t/F_{t-1}) = (F^*/F_{t-1})^{\theta} \qquad 0 < \theta \leq 1 \quad ...(2)$$

assuming a log linear form. Where θ is the adjustment coefficient.

Since long run equilibrium quantity consumed cannot be observed equation (1) cannot be estimated. Combining (1) and (2) gives,

$$F_t = a_o + a_1P_t + a_2Y_t + a_3C_t + (1-)F_{t-1} + E_t \quad ...(3$$

which is the estimating function and similar to Koyck's formulation but with a simpler error term. The short run price elasticity is θa_1, and long run is $(a_1\theta)/1-(1-\theta)$.

This formulation has been largely utilised in gasoline demand studies. Houthakker, Verleger and Sheehan (1974)[17] studied demand for gasoline using this formulation and United States quarterly time series data. They obtained short run price elasticity of -0.075 and short run income elasticity of 0.30. The long run price and income elasticities were -0.24 and 0.98 respectively. The relatively small long run price elasticity resulted from the geometrically adjustment pattern which was assumed.

They concluded that rising gasoline prices reduced its demand and therefore price mechanism itself appeared capable of bringing necessary adjustment in demand.

Alt, Bopp and Lady (1976)[18] estimated demand for gasoline by including a lagged endogenous variable in their formulation. The exogenous variable were: price of gasoline, aggregate personal income and dummy variable for oil price hikes. They used United States pooled time series data and obtained short run price and income elasticities of -0.2 and 0.38 respectively. The long run elasticities were -0.5 for price and 1.03 for income.

McGillivray (1976)[19] using United States time series data estimated demand for gasoline. The exogenous variable in the formulation were: new car registrations per capita, and price of gasoline.

While, average gasoline consumption per car was the dependent variable. He deleted income as an explanatory variable. The calculated short run price elasticity was -0.23 and long run value was -0.78.

Kennedy (1974)[20] also estimated gasoline demand using this formulation. He worked with pooled time series data from 12 European countries and United States. The results showed short run price and income elasticities to be -0.47 and 0.74 respectively while the long run price and income elasticities were -0.82 and 1.3 respectively.

Houthakker and Taylor (1966) for adoption has been very useful in gasoline demand estimation because: it has a simple error term and reduces estimation difficulties unless is serially correlated a priori; it economises on degrees of freedom by including a single lagged dependent variable in the formulation and lastly, like any other dynamic model, helps to truck both long run and short run variation in demand.

3.3. Studies on Demand for Light Diesel

Studies on demand for light diesel have been very few. This may be explained partly by the variety of uses of this fuel.

However, the few existing studies use the same formulations as that for gasoline. Griffin (1979)[21] estimated diesel fuel demand utilising a polynomial distributed lag model. He worked with pooled data for industrial countries and obtained price coefficient and its dynamic path to have the wrong sign.

Pindyck (1979)[22] using pooled data for industrial countries found the long run income elasticity to be 1.0, but the long run price elasticity was quite high in the range of -0.16 to -1.0. But for a group of developing countries, long run income elasticity was approximately 1.5 but the price elasticity had a wrong sign. In both the estimations, he employed a polynomial distributed lag model.

Senga, House and Manundu (1980)[23], using Kenya's time series data estimated a static demand function for light diesel. They obtained short run price elasticity to be -0.2 and short run income elasticity to be 1.6. Both the estimates were highly significant.

3.4. Summary

The literature reviews gasoline and light diesel demand under both static and dynamic considerations. Static conditions based on rapid changes in demand behaviour while dynamic conditions cover principles of stock adjustment and habit formation.

The literature distinguishes between short run and long run adjustment with the use of various dynamic models. Among the dynamic models, the stock adjustment formulation by Fisher and Kaysen (1962) was reviewed. This specification assumes constant utilisation rate in the long run.

Other dynamic models reviewed included Almon (1965) polynomial distributed lag model, Koyck(1954) geometric distributed lag model.

Almon (1965) model introduces lagged exogenous variables in the specification but there exist no theoritical under pinning to justify their inclusion. It also reduces the degrees of freedom since the adjustment path is not determined a priori and may cover several years and, in addition, there exist multicollineority among the explanatory variables.

Koyck (1954) formulation has not been used widely for the estimation of gasoline and light diesel demand.

Houthakker and Taylor (1966) formulation is widely used in gasoline demand estimation especially when time series data is used. It economises on degrees of freedom and has a simpler error term which reduces estimation difficulties.

A summary of the estimates reviewed is given in table 13. Estimates of short run price elasticity of gasoline demand range from -0.05 to -0.47 but tend to cluster around -0.2. While long run price elasticity range from -0.24 to -0.82.

Estimates of the long run income elasticity of demand for gasoline range from 0.24 to 1.39 but tend to cluster around 1.0.

Light diesel demand tend to show unusual trends. Price elasticity estimates of the few studies reviewed are positive.

The literature review shows that few studies have been conducted in Kenya on the demand for gasoline and light diesel. Other studies (not reviewed) such as Mureithi, Kimuyu and Ikiara (1982)[24], are addressed to either finding possibilities of substitution among various energy sources or generally assessing demand at a more aggregate level and not focused on individual fuels.

While these studies are useful especially in providing information about commercial energy requirements in the economy, they assume each energy source (for example, petroleum) is homogenous and is used for only one purpose. Such studies do not narrow down to explicitly finding the determinants for an individual fuel which is important in revealing its sources of demand.

Furthermore, most of the few studies in Kenya adopted static demand formulations which helped to generate short run price and income elasticities for gasoline and light diesel.

Consequently, because of the limited studies which have been conducted in Kenya at various levels of aggregation for these major fuels in the economy, it is equally important to explore their demand using formulations which can help in tracking both the short run and long run variations in their demand. The results will then be compared with those of previous studies.

Table 13: Summary of Price and Income elasticities of Demand for Gasoline and Light diesel

Study and Model Characteristics	Sample Characteristics	Price Elasticity		Income Elasticity	
		Short run	Long run	Short run	Long run
GASOLINE Flow adjustment (Geometric distributed lag)					
Alt, Bopp & Lady (1976)	Annual time series US data	-0.19	-0.5	0.38	1.02
McGillivray (1976)	Annual time series US data	-0.23	-0.77		
Houthakker, Verleger and Sheehan (1974)	US quarterly time series Cross Section data	-0.075	-0.24	0.30	0.98
Kennedy (1974)	Pooled European & USA data	-0.47	-0.82	0.74	1.3
Polynomial distributed lag					
Sweeney (1978)	Time series & Engineering US data	-0.22	-0.8		0.86
Griffin (1979)	Pooled OECD data	-0.05 to -0.1	-1.3 to -1.5		0.77-1.75
Pindyck (1979)	Pooled time series data	-0.05	-0.3 to -0.5		1.2-1.7
Static Models					
Senga, House & Manundu (1980)	Kenya time series data	-0.26		1.39	
Greene (1978)	US time series data	-0.19		0.24	
Adams, Graham & Griffin (1974)	Pooled OECD data		-0.4		0.72
Ramsey, Rasche & Allen (1975)	Pooled US data		0.75		1.15

.../2

Table 13:

Study and Model Characteristics	Sample Characteristics	Price Elasticity		Income Elasticity	
		Short run	Long run	Short run	Long run
DIESEL FUEL					
<u>Static Model</u>					
Senga, House and Manundu (1980)	Kenya time series data	-0.20		1.6	
<u>Flow adjustment (Polynomial)</u>					
Pindyck (1979)	Pooled OECD data		-0.16 -1.8		1.0

FOOTNOTES

1. Senga,W.M., House, W.J. and Manundu, M., "Assessment of Commercial Energy Supply and Demand in Kenya," IDS Consultancy Report, 1980.

2. Adams, F.G., Graham, G.H. and Griffin, J.M., Demand Elasticities: Another view; Discussion Paper No. 279, Philadephia, University of Pennsylvania, Economic Research Unit, 1974.

3. Greene, D.L., Econometric Analysis of the Demand for Gasoline at the State level, Report ORNL/TM - 7326, Oak Ridge, Tenn. Oak Ridge National Laboratory, 1978.

4. Ramsey, J., Rasche, R. and Allen, B., "An analysis of the private and commercial Demand for Gasoline," Review of Economics and Statistics, Vol. 57, 1975, pp. 501 - 507.

5. Nerlove, M., "Estimates of the Elasticities of Supply of Selected agricultural commodities" Journal of Farm Economics, Vol. 38, 1956

6. Houthakker, H.S. and Taylor, L.D., Consumer Demand in in United States 1929-1970: Analysis and Projections, Haward University Press, Massachusetts, 1966.

7. Fisher, F.M. and Kaysen, C., A study in Econometrics: The Demand for Electricity in the United States, Amsterdam, North Holland Publishing Co., 1962.

8. Mehta, J.S., Narasimham, C.V.L. and Swamy, P.A.V.R., "Estimation of a Dynamic Demand function for Gasoline with different schemes of Parameter variation," Journal of Econometrics, Vol.7, 1978, pp 263 - 279

9. Almon, S., "The Distributed lag-Between Capital Appropriations and Expenditures," Econometrica, Vol. 33, No. 1, 1965, pp 178 - 196

10. Sweeny, J.L., "The Demand for Gasoline in the United States: A vintage capital model," in Workshops of Energy supply and Demand, Paris IEA/OECD, 1978, pp 240 - 277

11. Pindyck, R.S., The structure of World Energy Demand, Cambridge Massachusetts, The MIT Press, 1979.

12. Griffin, J.M., Energy conservation in the OECD 1986-2000, Cambridge Massechusetts, Ballinger Publishing Company, 1979.

13. Koyck, L.M., "Distributed Lags and Investment Analysis, Amsterdam, North Holland Publishing Co., 1964.

14. Taylor, L.D., Blattenberger, G.R. and Verleger, P.K., The Residential Demand for Energy, Vol. 1, Report A-235 Palo Alto, California, Electric Power Reseach Institute 1977.

15. Houthakker, H.S. and Taylor, L.D., Consumer Demand in United States 1929-1970, Analysis and Projections, Holland University Press, Massachusetts, 1966.

16. Nerlove, M., "Estimates of the Elasticities of Supply of selected Agricultural Commodities," Journal of Farm Economics, Vol. 38, 1956.

17. Houthakker, H.S., Verleger, P.K. and Sheehan, D.P., "Dynamic Demand Analyses for Gasoline and Residential Electricity," American Journal of Agricultural Economics, Vol. 56, 1974, pp 412-418.

18. Alt, C., Bopp,A. and Lady, G., "Short run Forecasts of Energy Supply and Demand," in Bradley Askin and John Kraft, eds., Econometric Dimensions of Energy Demand and supply, Lexington, Mass. D.C., Heath and Co., 1976.

19. McGillivray, R.G., "Gasoline use by Automobiles", in Transportation Energy Conservation and Demand, Washington D.C, National Research Council, 1976, pp. 45-56.

20. Kennedy, M., "An Economic Model of the world oil market," The Journal of Econmics and Management Science, Vol.5, No. 2, 1974, pp: 540-577

21. op cit, Ref. 12

22. op cit, Ref. 11

23. op cit, Ref. 1

24. Mureithi, L.P., Kimuyu, P.K. and Ikiara, G.K., The Effects of Higher Energy costs on balance of payments, Employment, Technology, choice and Real Incomes in Kenya, World Programme Research, Working Papers, ILO, Geneva, 1982.

CHAPTER 4

MODEL SPECIFICATION AND ESTIMATION METHODOLOGY

4.1. Demand and Model Specification for Gasoline

4.1.1. Demand for Gasoline

We are interested in finding out the main determinants of demand for gasoline and their corresponding elasticities.

In Kenya, gasoline is mainly consumed by private users. In this respect, the main relevant determinants include:

(a) level of real income;

(b) price of gasoline and of competing fuels;

(c) the utilisation rate of automobiles;

(d) stock and average fuel consumption of automobiles; and

(e) availability of public transport

With rising incomes, gasoline consumption is expected to rise through increased demand for cars and increased utilisation rate arising from an increase in demand for travel. Additionally, at relatively higher incomes, consumers tend to choose the luxury and comfort of large, fuel-inefficient cars thereby have a negative impact on fuel efficiency[1].

Gasoline prices constitute a significant part of total vehicle operating costs and even much larger proportion of variable operating costs[2]. The nature and extent of the responsiveness of gasoline demand to price change will vary with time. The short run response will be limited to changes in other factors apart from stock of cars, residential and business locational patterns. Therefore, if the price of gasoline goes up, it is expected that gasoline consumption declines through reduced utilisation rate as certain travel patterns (for example, fewer local trips) change.

In the long run, adjustment may be made in the stock of automobiles and geographical patterns. It is expected that, as price of gasoline increases: there will be a change in the composition of automobiles to more fuel efficient models; change business or residential locations that either reduce the distance or improve access to alternative modes.

The utilisation rate of automobiles is determined by the price of gasoline and the level of incomes of consumers through the demand for travel. Therefore, as the price of gasoline goes up, it is expected that, in the short run, utilisation rate decreases if income remains constant. But rising incomes will increase utilisation rate through increased local travelling.

The average efficiency of cars depends on the characteristics of the existing stock of automobiles, such as: car weight, engine capacity, and body design and also on the style of driving. In our analysis, we assume that the composition of stock of automobiles is largely determined by the price of gasoline and the average price of a car. Consequently, as the price of gasoline goes up, it is expected that, in the long run, the composition of automobile stock will change to fuel efficient vehicles. While the size of the stock of automobiles is expected to decline as the price per car rises as people may switch to public transport.

The high population growth and urbanisation requires the provision of reliable transport services to all residential areas if private ownership of cars, is to be reduced. Otherwise, with increasing distances between residential areas and places of work, there will be heavy demand for transport services. Hence, without adequate public transport services, it is inevitable that, as income increases, residents in those areas not adequately served by public transport and who do not own cars, will increase the utilisation of their vehicles. This results in traffic congestion at rush hours and high gasoline consumption.

To capture the possibilities of substitution between private ownership and the use of cars, and the use of public transport, we include the relative price of gasoline to light diesel. It is expected that as the price of gasoline goes up, car owners will shift to alternative transportation modes.

This discussion suggests that utilisation rate of a car is a function of price of gasoline and income and so is the composition and average efficiency of the stock of automobiles. Furthermore, switching to other modes of transport is a function of the operating costs of a car (price of gasoline) compared with those of alternative modes which can be captured by including in the formulation, the relative price of gasoline to light diesel.

Therefore, the estimating demand equation for gasoline only needs, price and income variables which captures most of the aspects of gasoline demand.

4.1.2. The Model for Gasoline Demand

The most common model of gasoline demand that allows for distinguishing between short-run and long-run adjustments incorporates lagged consumption with prices, income and other explanatory variables in the formulation.

The basis for this approach as discussed in the literature review, is either the flow adjustment hypothesis where consumers are assumed to adjust actual consumption toward some desired level, or the stock adjustment hypothesis where demand is distinguished by that associated with the existing capital stock and that associated with new additions and replacements.

In both cases, changes in gasoline demand is viewed as adjustments between actual and desired demand overtime, and both yield identical estimating equations.

Our estimating equations are based on Houthakker and Taylor (1920)[3] adoption of Nerlove (1956)[4] postulation. In this formulation, we assume that there is a level of desired demand for gasoline (G_t^*) which depends on its own price (P_{gt}) and a vector of other relevant factors (C_t) which can be expressed generally as:

$$G_t^* = f(P_t, Y_t, \ldots . C_t) \quad \ldots\ldots(1)$$

After exploring several functional forms, a log linear form was adopted since it produced the most reasonable results. Therefore, in log linear form, equation (1) can be expressed as

$$G_t^* = \beta_o P_t^{\beta_1} Y_t^{\beta_2} \prod_{i=1}^{n} C_{it}^{\beta i} e^{\Sigma t + X_t} \ldots\ldots\ldots(2)$$

where Σ_t is the error term and β_o, β_2, β_i are parameters, and X_t is a dummy variable which is to capture the

the effect on gasoline consumption as a result of the oil crisis. But since the actual level of demand in one year (G_t) is not necessarily equal to the desired level (G_t^*), the adjustment process is assumed to be

$$\left(\frac{G_t}{G_{t-1}}\right) = \left(\frac{G_t^*}{G_{t-1}}\right)^{\theta} \qquad 0<\theta<1 \qquad \ldots\ldots(3)$$

Where G_{t-1} is the previous levels of gasoline consumption and θ is the adjustment coefficient. However, G_t^* cannot be observed, therefore, to estimate equation (2), we substitute (3) into (2) and the estimating equation becomes

$$\ln G_t = \theta \ln \beta_o + \theta\beta_1 \ln P_{gt} + \theta\beta_2 \ln Y_t + (1-\theta)\ln G_{t-1} + X_t \ldots(4)$$

where $\theta\beta_1$ and $\theta\beta_3$ are short run price and income elasticities respectivley.

4.2. Demand and Model Specification for Light Diesel

4.2.1. Demand for Light Diesel

We are also interested in finding out the main determinants of demand for light diesel and their corresponding elasticities.

In Kenya, light diesel is largely used by commercial users (especially in transport and industry). For example, most of it is consumed by freight trucks and public passenger transport vehicles, trains and in boilers. Consequently, the main demand determinants include:

(a) Price of light diesel and competing fuels;

(b) and GDP or its components

In many developing countries, such as Kenya, light diesel price has been kept at relatively low levels compared to gasoline as a result, the stock of light diesel appliances have been growing very fast. However, in our analysis, we expect that, as the price of light diesel goes up its consumption will decrease, and consequently in the long run, the stock of light diesel appliance is expected to reduce.

As the level of economic activities increases and agricultural and manufacturing output increase, light diesel consumption is expected to increase to either fuel freight trucks or used in industry.

Both gasoline and light diesel are used in the transportation sector, therefore to capture the possibility of substitution (or switching to other modes of transport), the relative price of light diesel to gasoline will be included in the estimating function.

4.2.2. Model Specification for Light Diesel

The demand function for light diesel is the same as that for gasoline. The estimating function of light diesel is expressed as:

$$\ln LD_t = \lambda \ln\alpha_o + \lambda\alpha_1 \ln P_{dt} + \lambda\alpha_2 \ln(Pd/P_g)_t + \lambda\alpha_3 \ln Y_t$$

$$+ (1-\lambda)\ln LD_{t-1} \quad \ldots\ldots(5)$$

where $\theta\alpha_1$ and $\theta\alpha_3$ are the short run price and income elasticities respectively, P_{dt} is the price of light diesel, LD_t is the consumption levels of light diesel, Y_t is GDP, (Pd/Pg) is relative price of light diesel to gasoline and θ is the adjustment coefficient.

4.3. Estimation Methodology

The estimating procedure is an adoption of Houthakker and Taylor (1970)[5]. The log linear models (4) and (5) are estimated by ordinary least squares using Kenya's time series data from 1964 to 1985.

The estimated coefficients of the short run price and income elasticities are used together with the coefficient of adjustment to obtain the long run elasticities. For example, the long run price and income elasticities of demand for gasoline (from equation 4) are obtained by computing

$\alpha_1 = (\theta\beta_1/(1-\theta))$ and $\alpha_2 = (\theta\beta_2 /(1-\theta))$

respectively.

The students' 't' statistic is used to test the statistical significant of the coefficient. In all cases, one tail 't' test are used. The Durbin Watson 'd' test is used for testing autocorrelation.

FOOTNOTES

1. However, it should be noted that as income rises, consumers will be able to buy new vehicles which incorporate the latest fuel efficient technology.

2. Verleger and Sheehan (1976) calculated that gasoline comprises about 25% of total automobile operating costs and about 50% of variable operating costs.

3. Houthakker, H.S. and Taylor, L.D., Consumer Demand in the United States: Analyses and Projections, Harward University Press, Cambridge, 1970, pp. 6-30.

4. Nerlove, M., "Estimates of the Elasticities of Supply of selected Agricultural Commodities," Journal of Farm Economics, Vol. 38, 1956, pp. 496-509

5. Op cit, Ref. 3.

CHAPTER 5

DATA AND EMPIRICAL RESULTS

5.1. Data Sources

In order to be able to estimate equations (4) and (5) in Chapter 4, we require information on: total sales of gasoline and light diesel; their annual average price which includes taxes; annual total earnings; GDP and consumer price index.

The study relies on secondary data obtained from several sources primarily statistics of Energy and Power 1968 - 1977, and various issues of economic survey, Statistical Abstracts and Development plan.

5.1.1. Nature of Data

The data on gasoline and light diesel consumption is based on the assumption that their total sales are indicative of their levels of demand. This information is obtained in the official government publications named in Section 5.1.

Data on total earnings is also obtained by adopting definitions laid in the statistical Abstracts[1] and deflated by the consumer price index.

Prices for both the fuels are treated as exogenous. Data on price of light diesel for the period 1964 and 1966 was missing so we assumed that light diesel prices assumed the same growth rate as those exhibited by gasoline over this period. All the annual prices were expressed in 1976 prices.

GDP at factor cost data is obtained by adopting definitions laid down in the United Nations System of National Accounts. This data is extracted from the earlier named government publications GDP data was deflated using the GDP deflator.

5.1.2. Limitations of Data

Price data for motor gasoline is highly aggregative since the product is not homogeneous. In addition, annual average prices, for both the fuels, may lack adequate variations within the year or even regionally.

5.2. ANALYSIS OF RESULTS

The estimating functions are those which were formulated in Chapter 4 using Houthakker and Taylor (1970) adoption of Nerlove (1956) postulation. These functions are:

$$\ln G_t = \theta \ln \beta_o + \theta\beta_1 \ln P_{gt} + \theta\beta_2 \ln Y_t + (1-\theta)\ln G_{t-1} + X_t \quad ....(4)$$

and

$$\ln LD_t = \lambda \ln \alpha_o + \lambda\alpha_1 \ln P_{dt} + \lambda\alpha_x \ln(Pd/pg)_t + \lambda\alpha_3 \ln Y_t + (1-\lambda)\ln LD_{t-1} \quad ....(5)$$

for gasoline and light diesel respectively.

The estimated coefficients for gasoline demand are given in table 14 and for light diesel in table 15 respectively.

5.2.1. Analysis and Results of Gasoline Demand

The regression results show that income, lagged consumption and dummy variable (capturing the impact of oil crisis on gasoline consumption) affect the demand for gasoline positively. While, its own price affect the consumption negatively.

The yearly consumption of gasoline has a short run price elasticity of -0.05 and long run elasticity of -0.10. The short run and long run income elasticities are 0.762 and 1.482 respectively.

The coefficient for lagged gasoline consumption is 0.486 while that for the dummy variable is 0.057. On the basis of the coefficient of multiple determination, R^2, we note that the four variables

Table 14: Estimated Coefficients of Demand for Gasoline

(t-statistic in Parentheses)

Variable	Coefficient	ELASTICITY Short run	Long run	Standard Error
Constant	1.966			
Price		-0.05	-0.10	
		(-0.177)		0.0286
Income		0.762	1.482	
		(3.311)		0.2303
Lagged variable	0.486			
	(3.301)			0.1472
Dummy Variable	0.057			
	(1.225)			0.0468

Standar error of regression = 0.045

R^2 = 0.98

d.f. = 17

Durbin Watson d test = 1.509

F(4,17) =208.3

jointly explain about 98% of the variation in demand for gasoline.

The 4-variable model is highly statistically significant as indicated by the high F-ratio and the standard error of regression of about 5%. From the d test, autocorrelation is not a problem.

Though all the identified variables affect the demand for gasoline, not all of them are found to be statistically significant. For example, price and the dummy variable (indicating the impact of oil crisis on gasoline consumption) are found to be statistically insignificant at 0.05 level of significance. While income and lagged consumption are found to be statistically significant at 0.005 level of significance.

While some of these regression results are similar to those of studies conducted outside the Kenyan context, there are some fundamental differences with those of studies conducted in Kenya.

First, price of gasoline though affecting demand for gasoline inversely, is not a statistically significant factor. This is contrary to the results of Senga, House and Manundu (1980). This may be explained by the fact that there tend to exist a relatively inelastic demand for travel and a consequent inelastic demand for gasoline. This suggests that, if the price of gasoline goes up, in the short run, the utilisation rate will not change as was earlier expected. Consequently, there will be no change in the travel patterns and therefore, in the long run, there will be no shift to fuel-efficient automobiles, no change in business location or shift to alternative modes of transport. This implies that, gasoline price may be constituting a smaller proportion of motorist operating costs. Furthermore, the insignificance of price factor, is reinforced by the positive impact of the oil crisis on gasoline consumption, although, this factor is also statistically insignificant.

Second, the fact that the weighted sum of past values of income, price and dummy variable have shown to be important, suggests that previous consumption practices may not change over night.

Finally, our results show that income is the most important and statistically significant factor influencing demand for gasoline. The large income elasticity suggests that in the short run, rising incomes will increase the demand for travel and increase the utilisation rate of automobiles. However, unlike our study, Senga, House and Manundu (1980) defined the variable income as real GDP at factor cost and obtained short run income elasticity to be statistically significant but greater than 1.

5.2.2. Analysis and Results of Light Diesel Demand

The regression co-efficients estimated have the correct signs for own price, income and for the relative price of light diesel to gasoline. The short run price and income elasticities are -0.043 and 1.066 respectively. While the long run price and income elasticities are -0.072 and 1.774 respectively. The coefficient for relative price of light diesel to gasoline is -0.270 and for the lagged variable is 0.399.

The coefficient of multiple determination, R^2, of 0.98 indicates that the four variables identified jointly explain about 98% of the variations in the demand for gasoline.

The model is statistically significant as it shows high F-ratio value and relatively low standard error of the regression. Furthermore, the d test value shows the absence of autocorrelation.

The results show that all expect for price variable are statistically significant determinants at 0.05 level of significance. The price of light diesel, though, affecting light diesel demand inversely, has turned out to be an insignificant factor.

Table 15: Estimated Coefficients of Demand for Light Diesel

(t - statistic in Parentheses)

Variable	Coefficient	ELASTICITY Short run	ELASTICITY Long run	Standard Error
Constant	-0.064			
Price		-0.043	-0.072	
		(-0.772)		0.0563
Income		1.066	1.774	
		(2.386)		0.4468
Relative Price of light diesel to gasoline	-0.270			
	(-1.793)			0.15055
Lagged Variable	0.399			
	(1.785)			0.2231

Standard error of regression = 0.068

R^2 = 0.98

d.f. = 17

Durbin Watson d test = 1.511

F(4,17) =208.39

Our results also show that the coefficient of adjustments is statistically significant. This reflects the importance of past levels of exogenous variables on current consumption levels.

The relative price of light diesel to gasoline is also a statistically significant factor. It shows that as the price of light diesel increase relative to the price of gasoline, the demand for light diesel declines. This suggests existence of substitution between the two fuels. This implies that as the price of light diesel goes up, which may be reflected in increased transport costs or fare, people will tend to switch to other forms of transport, in this case, it may be private transport or private ownership of vehicles.

Among the significant factors, income is the most important. The results show a large impact of a rise in income both in the short run and long run. This may be explained by the close link between light diesel consumption and the level of economic activity (indicated by growth in GDP) such that increased level of economic activity entails immediate rise in light diesel consumption. These results are similar to those of Senga, House and Manundu (1980) who obtained short run elasticity to be greater than 1.

FOOTNOTES

1. Total earnings covers all cash payments including basic salary, cost of living allowances, profit bonus, together with the value of rations and free board, and an estimate of employer's contribution towards housing. Excluded in total earnings, are pensions, employer's contribution to National Security Fund or private provident funds, personal emolments for the armed forces and earnings in rural non-agriculture sector.

CHAPTER 6

CONCLUSIONS AND POLICY IMPLICATIONS

6.1. CONCLUSIONS

The broad objective of our study was to estimate demand functions for gasoline and light diesel in Kenya, while the two specific objectives were to identify their demand determinants and their corresponding elasticities.

The objectives have been accomplished by, first, identifying the demand determinants for each fuel and, second, calculating their corresponding elasticities using time series data from 1964 to 1985 to fit a log linear flow adjustment model.

The results for demand for gasoline lead to the conclusions that: first, gasoline demand is negatively related to its own price, though, it was found that, price as such is a statistically insignificant factor. Second, gasoline demand is highly positively related to the level of income (total earnings) but the impact of a rise in income on gasoline consumption is greater in the long run than in the short run. Third, there is a large and significant impact from previous levels of exogenous variables in the model on current consumption of of gasoline. Lastly, the oil price shock appears to have had no significant impact on the consumption of motor gasoline.

The results for demand for light diesel were that: first, light diesel consumption is negatively related to its own price, though price factor, just as for gasoline, is not a statistically significant factor. Second, light diesel consumption is highly positively and significantly related to the level of income (GDP) and the impact of an increase in the level of income is quite large in both the short run and long run. Third, demand for light diesel adjusts to changes in other explanatory factors with a lag. Lastly, light diesel and gasoline are substitutes such that a rise in the price of light diesel relative to gasoline leads to a significant decline in consumption of light diesel.[1] It should also be noted that for both the fuels, income is the dominant factor such that growth in the consumption of these two fuels will largely come from the growth in income.

6.2. POLICY IMPLICATIONS

6.2.1. Policy Implications on Demand for Gasoline

Several policies are implied by the results we obtained for demand for gasoline: first, the fact that income is found to be a statistically significant factor in determining demand for motor gasoline suggests that increase in income (total earnings) will increase the consumption of this fuel through increased demand for cars and increased demand for travel. Therefore, any policies directed at reducing gasoline consumption in the face of increasing incomes should also aim at reducing the stock of gasoline appliances (automobiles) or the pricing policy on automobiles should be such that it helps in the choice of fuel efficient vehicles.

Second, the results on price elasticity of demand suggests that the pricing policy alone cannot reduce its consumption. Therefore other policy measures should be used along with the pricing policy. These measures may include: imposition of significant taxes on gasoline and gasoline appliances to reinforce the administered prices; improved public transport services so that the high taxes on gasoline increases the total motorist costs of operation and consequent switching to public transport, and a comprehensive public education programme on fuel conservation.

6.2.2. Policy Implications on Demand for Light Diesel

The findings on light diesel demand lead to several policy suggestions. First, the results on price elasticity of demand for light diesel indicate that its own price is not a statistically significant demand determinant. This suggests that increasing the price of light diesel alone leads to a relatively much smaller increase in the overall transport costs. Therefore, if consumption of light diesel is to be restrained or if wasteful consumption practices are to be reduced, then additional measures are required a long with the pricing policy.

Second, the results imply that the large positive impact of high GDP growth will precipitate rapid increases in light diesel consumption. Therefore, as the economy grows, more of this fuel will be consumed. This suggests that measures that seek to reduce growth in light diesel demand relative to the growth in GDP should then cover replacement of existing light diesel consuming equipment with new, more fuel efficient types in the long run.

Lastly, the possibility of substitution between light diesel and gasoline suggests that the pricing policy should be such that it does not allow price diffrentials of these two fuels to be very large. Otherwise, the demand for the cheaper fuel can grow so fast that may entail need for direct imports of the fuel. Furthermore, it suggests need for improvement in the provision of public transport. Otherwise, its insufficiency may necessitate increased demand for private vehicles as income rises.

Generally, the findings of the study suggest that policies that increase incomes of consumers will increase demand for gasoline. Additionally, while that stimulate the level of economic activity indicated by the growth in GDP will increase the consumption of light diesel.

The fact that price was found not to be able on its own to reduce the demand for the two fuels suggests that other measures should be used along with the pricing policy if growth in demand for both the fuels is to be restrained. Therefore, this calls for a full range of measures to be coordinated systematically to reinforce this policy. For example, if import duties are adjusted to favour import of fuel efficient motor cars, pricing policy should then be used to reinforce this policy. This means that, placing high import duties on vehicles which have large, inefficient engines may have little effect on the consumption of gasoline, for example, if its price is sold at low prices.

6.3. Further Research

There is inadequate information on gasoline and light diesel demand. Since these fuels are complements of vehicles, there is need to understand the demand for vehicles in the country. In addition, there is need to distinguish between private and commerical demand, auto and trucks demand and even urban and rural-urban travel demand.

Therefore, further refinement of gasoline and light diesel demand analysis is necessary and calls for additional work which takes vehicles and travel demand into direct consideration.

BIBLIOGRAPHY

1. Adams, F.G., Graham, G.H. and Griffin, J.M., Demand Elasticities: Another view., Discussion Discussion Paper No. 274, Philadephia, University of Pennsylvania, Economic Research Unit, 1974.

2. Almon, S., "The Distributed lag Between Capital Appropriations and Expenditures," Econometrica, Vol. 33, No. 1, 1965, pp. 178-196.

3. Alt, C., Bopp, A. and Lady, G., "Short run Forecasts of Energy supply and Demand," in Bradley Askin and John Kraft, eds., Econometric Dimensions of Energy Demand and Supply, Lexington, Massachusetts, D.C., Heath and Co., 1976.

4. Atkinson, S. and Halvorsen, R., Interfuel Substitution in steam Electric Power Generation," Journal of Political Economy, Vol. 84, No. 5, 1976, pp. 959-978.

5. Balestra, P. and Nerlove, M., "Pooling cross section and Time series Data in the estimation of a Dynamic model: The Demand for Natural Gas," Econometrica, Vol. 34, 1966, pp. 585-612.

6. Berndt, E.R. and Wood, D.O., "Technology, Prices, and the Derived Demand for Energy," Review of Economics and Statistics, Vol. 57, No.3, 1975.

7. Ching Yaun Lin., "Global Patterns of Energy Consumption Before and After 1974 oil crisis," Economic Development and Cultural Change, Vol. 34, No. 4, 1984.

8. Darmstadler, J., Dunkerley, J. and Alterman, J., How Industrial Societies Use Energy: A comparative Analysis, Baltimore, John Hopkins University Press.

9. Fisher, F.M. and Kaysen, C., A study in Econometrics: The Demand for Electricity in the United States, Amsterdam, North Holland Publishing, Co., 1962.

10. Fisher, F.M., Supply and Cost in the United States Petroleum Industry: Two Econometric Studies, 1974.

11. Fuss, M.A., "The Demand for Energy in Canadian Manufacturing, Journal of Econometrics, Vol. 5, No. 1, 1977, pp 89-116.

12. Greene, D.L., Econometric Analysis of the Demand for Gasoline at the State level, Report ORNL/TM-6326, Oak Ridge, Tenn. Oak Ridge National Laboratory, 1978.

13. Griffin, J.M., Energy Conservation in the OECD 1980-2000, Cambridge Massechusetts, The MIT Press, 1979.

14. Griffin, J.M. and Gregory, P.R., "An Intercountry Translog Model for Energy Substitution Responses," American Economic Review, Vol. 66, 1976, pp. 371-378.

15. Halvorsen, R., "Residential Demand for Electric Energy," Review of Economics and Statistics, Vol. 57, 1975, pp.12-18.

16. Houthakker, H.S. and Taylor, L.D., Consumer Demand in the United States 1929-1970: Analysis and Projections, Harvard University Press, Massachuesetts, 1966.

17. Houthakker, H.S., Verleger, P.K. and Sheehan, D.P., "Dynamic Demand Analyses for Gasoline and Residential Electricity," American Journal of Agricultural Economics, Vol. 56, 1974, Pp. 412-418

18. Kennedy, M., "An Economic Model of the World Oil Market," The Journal of Economics and Management Science, Vol.5, No.2., 1974, pp. 540-577

19. Koyck, L.M., Distributed Lags and Investment Analysis, Amsterdam, North Holland Publishing Co., 1964.

20. McGillivray, R.G., "Gasoline Use in Automobiles", in Transportation Energy Conservation and Demand, Washington D.C., National Research Council, 1976, pp 45-56.

21. Mehta, J.S., Narasimham, G.V.L. and Swamy, R.A.V.R., "Estimation of a Dynamic Demand Function for Gasoline with different schemes of Parameter Variation," Journal of Econometrics, Vol.17, 1978, pp.263-279

22. Mureithi, L.P., Kimuyu, P.K. and Ikiara, G.K., The effects of Higher Energy Costson Balance of Payments, Employment, Technology Choice and Real Incomes in Kenya, World Programme Research Working Papers, ILO, Geneva, 1982.

23. Nerlove, M., "Estimates of the Elasticities of Supply of Selected Agricultural Commodities," Journal of Farm Economics, Vol. 38, 1956.

24. Pindyck, R.S., The structure of World Energy Demand, Cambridge, Massechusetts, The MIT Press, 1979.

25. ________., "A dynamic Model of OPEC Trade and Production," Journal of Development Economics, 1975, pp. 319-335.

26. ________., "International Comparisons of the Residential Demand for Energy," European Economic Review, Vol. 13, 1980, pp. 1-24

27. Ramsey, J., Rasche, R. and Allen, B., "An analysis of the Private and Commercial Demand for Gasoline," Review of Economics and Statistics, Vol. 57, 1975 pp. 502-507.

28. Republic of Kenya., Development Plan 1974-78, The Government Printer, Nairobi, 1973.

29. ________________., Development Plan 1979-83, The Government Printer, Nairobi, 1978.

30. ________________., Development Plan 1984-88, The Government Printer, Nairobi, 1983.

31. ________________., Budget 1984-85, The Government Printer, Nairobi, 1984.

32. ________________., Sessional Paper No. 1 of 1986 on Economic Management for Renewed Growth, Government Printer, Nairobi, 1986.

33. Schipper, L., Hollander, M.J., Milukas, M., Alcamo, J., Meyers, S. and Noll, S., Energy Conservation in Kenya: Progress, Potentials and Problems, Energy and Environment Division, Lawrence Berkeley Laboratory, University of California, 1981.

34. Senga, W.M., House, W.J. and Manundu, M., Assessment of Commercial Supply and Demand in Kenya, IDS Consultancy Report, 1980.

35. Shur, S.H. and Netshert, B.C., Energy in the American Economy 1850-1975, Baltimore, John Hopkins University Press, 1960.

36. Sweeney, J.L., "The Demand for Gasoline in the United States. A vintage Capital Model," in Workshops of Energy Supply and Demand, Paris IEA/OECD, 1978, pp240-277.

37. Taylor, L.D., Blattenberger, G.R. and Verleger, P.K., The Residential Demand for Energy, Vol. 1, Report A-235, Palo Alto, California, Electric Power Research Institute, 1977.

38. Trehan, R.K., Leigh, J.G. and Park, W.R., Energy and Development: A preliminary Analysis for Less-Developed Countries, Macleans, Virginia, MITRE incl., 1980.

39. Tuschack, T.S., Kenya's Energy Situation and Options for the Future, Nairobi, UNEP (mimeo), 1979.

40. World Bank, Energy Options and Policy Issues in Developing Countries, World Bank Staff Working Papers, No. 350, 1979, pp.9

APPENDIX

DATA USED IN THE REGRESSION

Year	Sales(million litres)		Price(KSh/litre)		CPI 1976 Prices	GDP	Total
	Motor Gasoline	Light Diesel	Motor Gasoline	Light Diesel		GDP 1976 Prices K£ million	Total Earnings K£ million
1964	161 754	114 058	0.92	0.66	47.7	701.8	105.2
1965	161 654	118 759	0.98	0.72	49.2	707.0	114.2
1966	169 996	134 729	1.02	0.76	50.9	801.2	127.2
1967	183 589	148 385	1.03	0.77	51.3	847.2	136.8
1968	196 767	176 919	1.03	0.77	52.6	912.6	146.3
1969	212 830	183 885	1.03	0.77	52.7	970.8	153.6
1970	235 148	190 027	1.03	0.75	54.4	1037.4	168.5
1971	271 462	248 539	1.09	0.82	57.8	1104.7	188.1
1972	292 537	277 792	1.09	0.82	59.3	1137.5	206.9
1973	321 041	302 549	1.28	0.84	64.0	1192.6	232.1
1974	311 489	297 899	1.92	1.16	75.7	1221.9	274.3
1975	324 974	303 718	2.47	1.36	89.0	1248.0	312.3
1976	333 553	340 806	2.56	1.77	100.0	1278.1	379.6
1977	369 647	368 730	2.75	1.94	112.5	1390.3	431.4
1978	393 299	365 012	2.89	2.18	126.7	1476.5	482.8
1979	412 212	413 187	3.48	2.41	137.3	1539.5	563.5
1980	422 487	487 308	4.73	3.23	154.9	1590.7	664.1
1981	412 606	455 373	6.30	4.44	174.4	1675.7	788.7
1982	372 780	436 877	7.30	5.48	213.3	1733.1	853.0
1983	349 730	463 180	7.76	5.48	244.2	1800.8	958.2
1984	356 657	500 339	8.34	5.94	266.4	1823.5	1074.8
1985	380 548	530 530	8.34	5.94	295.0	1913.4	1180.1
1986	418 705	569 945					

Source: Economic Survey, Statistical Abstracts and Development Plan, Central Bureau of Statistics, Various Issues.