ENERGY CONSUMPTION IN YEMEN

ECONOMICS AND POLICY (1970 - 1990)

by

Abdulkarim Ali Dahan

A Dissertation Submitted to the Faculty of the

DEPARTMENT OF MINING AND GEOLOGICAL ENGINEERING

In Partial Fulfillment of the Requirements
For the Degree of

DOCTOR OF PHILOSOPHY
WITH A MAJOR IN MINERAL ECONOMICS

In the Graduate College

THE UNIVERSITY OF ARIZONA

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As members of the Final Examination Committee, we certify that we have read the dissertation prepared by Abdulkarim Ali Dahan

entitled Energy Consumption in Yemen
Economics and Policy
(1970 - 1990)

and recommend that it be accepted as fulfilling the dissertation requirement for the Degree of Doctor of Philosophy

Prof. Deverle P. Harris	June 19, 95 Date
Prof. Michael Rieber	June 19, 95 Date
Prof. Richard T. Newcomb	June 19, 95 Date
	Date
	Date

Final approval and acceptance of this dissertation is contingent upon the candidate's submission of the final copy of the dissertation to the Graduate College.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

This dissertation examines the consumption of commercial energy, electricity and petroleum products in Yemen for the period 1970 - 1990. The main objectives are: 1) analyzing the energy consumption in Yemen; 2) investigating the determinants of demand for electricity and petroleum products ; 3) projecting the values of petroleum consumption for the years 1991 - 2000; and 4) recommending measures to curb the rate of increase in the demand for energy and to reduce the dependence upon imported oil.

This study found that economic growth in Yemen has had a major impact upon the demand for electricity and petroleum products, and that energy intensity had increased over time, indicating that economic growth of Yemen has been very energy intensive.

The models that have been chosen in this study are based on the theory of demand. According to this theory, the demand for a good is a function of own price, price of substitutes, and income. The estimates given by the model for aggregate electricity over the period 1975-1990 improved when the number of customers that have access to electricity was included in the demand equation. Income and the number of customers are the major determinants of electricity demand in Yemen; the estimated coefficient for price of electricity over the period

was not statistically significant at the 5 % level.

In the case of the demand for electricity by sectors, the results are more useful than for aggregate electricity demand. Electricity consumption for the residential, commercial and industrial sectors was well modeled as a function of only price and income. Demand for electricity in the agricultural sector, however, was described best by a stock adjustment model.

The estimated models for individual petroleum products showed that price for fuels and income are major determinants in explaining the variation in demand for these products.

Overall, this study found that the future energy outlook in Yemen calls for increasing electricity and petroleum consumption. Moreover, current fuel efficiencies and the estimated fuel demand equations indicate increasing fuel prices, given growth rates of population and per capita GDP. Thus, issues to be considered by energy policy include welfare and economic growth implications of increasing fuel prices, energy conservation, and expanded domestic petroleum production.

Variable Definitions

TPETC = Total petroleum consumption
DISL = Diesel oil
GSLN = Motor gasoline
LPG = Liqufied Petroleum Gas
KRSN = Kerosien
RSDUL = Residual fuel
TELC = Total electricity consumption
Ag = Agricultural consumption of electricity
RSDNT = Residential consumption of electricity
COM = Commercial consumption of electricity
INDUS = Industrial consumption of electricity
PE = Price of electricity
PA = Agricultural price of electricity
PC = Commercial price of electricity
PIN = Industrial price of electricity
PR = Residential price of electricity
PI = Fuels consumer price index
OTPTDSL = Output of electricity generated by diesel
OTPTRSD = Output of electricity generated by residual
Y = Real income of each economic sector
DISLELC = Quantity of diesel used to generate electricity
RSDELC = Quantity of residual used to generate electricity

CHAPTER 1

INTRODUCTION

The Oil Shocks of the 1970s

The increase in petroleum prices that took place during the 1970s drew attention to the immediate and long term effects of changes in prices and to the short-term availability of commercial sources of petroleum throughout the world.

The possibility for and impact of high oil prices were underestimated before the 1970s crisis, because energy had been becoming increasingly less costly throughout the 1960s and early 1970s. Therefore, the world was unprepared for the oil crisis that took place. Because of this lack of preparations, major impacts on the economies of both developed and developing countries followed the increase in oil prices, making it profitable to seek alternate plans for oil supply and economic development all over the world.

Problems such as lower GNP growth rates, accelerated inflation, and balance of payment deficits were encountered, causing hardship in many developing countries, especially the most import-oriented ones. As a result borrowing from international institutions to offset imbalances increased significantly.

The Problem in General

Yemen remained completely dependent on petroleum

imported from its neighbors. It was not until 1984 that discovery of domestic oil resources occurred. This complete dependency brought many problems to the economy of Yemen, reflected in a continuing and worsening deficit in the balance of trade, increased foreign borrowing, and increasing inflation[1]. These factors slowed overall economic growth and created the need for in-depth studies of the demand for energy for Yemen to assist policy makers in setting consistent plans and making decisions concerning efficient energy use.

Since the oil discovery in the mid 1980s, the government of Yemen has taken major steps not only to satisfy its domestic needs and to reduce the impact of imports, but also to become a petroleum exporting country. The presence of some domestic oil resources does not alter the need for broad economic studies to support analysis of energy policies, policies that reflect market efficiencies and optimize the economic welfare of Yemen. This study focuses on energy demand because that will be an important consideration in the deregulation of energy price and establishing optimal energy policies.

Yemen in Brief

Geographically, Yemen is located in the south western corner of the Arab Peninsula. The kingdom of Saudia Arabia is

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[1]During this period official exchange rates were held almost constant at 4.5 YR equal one US dollar.

its boundary on the north, the Red Sea on the west, Oman and the Gulf of Aden are its boundaries on the east and the south, respectively. The areal extent of the country is approximately 555,000 square kilometers. The resident population of the republic of Yemen was estimated at 11,951,960 in 1991, based on the census of 1986 and 1988.

Following the historical day of May 22nd 1990, when reunification between Yemen's divided parts, North and South, took place, hopes were high for achieving rapid economic growth and development in all areas in the economy and for raising the standard of living of all the people.

Like any other less developed countries (LDC), Yemen faces serious constraints which slow overall economic growth. Even though deliberate development policies with measurable success have been pursued since the early 1970s, Yemen's per capita income is still low; the level of investment and industrialization is low. Most foreign exchange has to be generated by workers abroad, mainly in Saudia Arabia and Gulf States, assisted also by grants and loans from abroad.

Over the last two decades both North and South Yemen have experienced changes in their socioeconomic structure. Economic activities have expanded all over the country. Development plans were initiated in the early 1970s, and the first, second and third development plans were adopted by both North and South Yemen.

Personal cash income has been increasing since the oil

crisis in 1974. Worker's remittances increased from 594 million YR in 1974 to 5,600 million YR in 1983 but decreased to 3,233 million YR in 1989[2]. These increments of income have been significant factors in alleviating Yemen's traditional problems of poverty, famine and rural underemployment, but at the same time they have created other problems and dependencies which require urgent attention in the future.

Motivation

To my knowledge, there are no published studies on Yemen, either North or South, that analyze energy consumption or investigate analytically its determinants. It was that realization which prompted this study of energy demand and the development of a series of behavioral equations, consistent with economic theory, that provide information concerning the energy consumption and the behavior of consumers in Yemen.

Early in this study, it became clear that a comprehensive model of Yemen energy consumption could not be constructed and estimated because of the unavailability of data on important determinants. Consequently, when models could be estimated, they are by necessity simple. The modeling objective is that the model be general enough in its structure to accommodate several different fuel types, and that it also be flexible enough in its structure to be amenable to the simulation of a

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[2]This decrease in worker's remittances resulted from the announcement of oil discovery, in Yemen, in 1984.

variety of possible future scenarios of economic activity.

Modeling in this study is not an end of itself; rather it is justified only to the extent that it facilitates the identification of future consumption possibilities and of useful energy policies for Yemen. Research objectives are elaborated upon in the next section.

Research Objectives

* To analyze the relationship between electricity, petroleum products consumption and economic growth in Yemen for the period 1970-90. During most of this period there were rapid increases in the prices of commercial energy due to the increases in the prices of imported fuel.
* To Examine the following questions: Is energy consumption responsive to economic determinants (variables), such as income and prices? What are the responses of energy components to change in per-capita income, industrial output, and price ? Is there any way to reduce inefficient use of energy without adverse effects on national growth targets? Seeking answers to these questions led me

to the main subject of my study.

* To project petroleum consumption under varying assumptions and to recommend efficient energy policies for Yemen consistent with the goals of economic growth.

Merits and Limitations of the Study

Lack of data prevents a broad and comprehensive study for the whole of Yemen, former North and South. So results are based only on data from former North Yemen where data exist.

This study is concerned primarily with commercial energy: electricity and petroleum products. The available data for electricity are quite accurate, the original source of these data being the Ministry of Power in Yemen. Data for petroleum products customarily display a lack of accuracy, even though they come through an international agency, the United Nations. This is in fact due to the non-existence of records of unofficially trucked in products from Saudia Arabia to North Yemen due to difference in prices between the two countries. Oil prices in North Yemen reflect world prices plus distribution costs.

Statistical time series used in this study come from different official sources, such as the publications of the Central Planing Organization, the Ministry of Power, the Ministry of Petroleum and Mineral Resources, other governmental agencies, and some international agencies, such

as the World Bank (WB), International Monetary Fund (IMF), and the United Nations (UN). It should be noted that even though the data for electricity are much more accurate than those for petroleum, they are still subject to limitations common to most LDC's. Another limitation of this study derives from the fact that reliable actual prices for individual petroleum product are either not recorded or poorly recorded.

Previous Studies

Most of the studies that have been initiated in the past concentrate on the economic development aspects of Yemen in general. Even though some of these studies address the energy economy in Yemen, they are in general qualitative. Quantitative analysis is almost non-existent.

This study is a first step toward quantitative analysis and is unique for Yemen. Even though much more work needs to be done, it is hoped that not only will Yemen policy makers benefit from this study, but also other countries with similar economic conditions and characteristics.

Study Outlines

A description of the economy of North Yemen, with emphasis on oil consumption is provided in chapter two and a literature review is represented in chapter three. Energy development in Yemen and the analyses of factors contributing to the overall increase in the consumption of commercial

energy during the past two decades are presented in chapter four. The relationship between energy consumption and economic growth is examined in chapter five. Chapter six examines the essence of the distributed lag (stock adjustment) hypothesis and formulates the models for total electricity consumption and sectoral electricity consumption. These are used to investigate the effects of income and price on energy consumption. Some empirical estimates of demand elasticities for various types of fuels consumed in Yemen are given in chapter seven. Chapter eight deals with the projected values of fuel consumption, and examines policy issues and options. Finally, this study concludes with a summary of findings and comments.

CHAPTER 2

ENERGY PERSPECTIVE AND THE ECONOMY OF YEMEN

Introduction

An overview of the economy of former North Yemen is the focus of this chapter. First, a few basic facts about the economy of Yemen are given. Then, a description of the most important producing sectors, such as agriculture, manufacturing, and transportation, are included, at the same time emphasizing the role of energy in each of them. Because of the importance of energy supply to the economy, it is also necessary to introduce the crude oil refining and electrical generation sectors.

Yemen's Economy

In the early 1970s after the civil war, major developments in the economy of Yemen were launched by both the government and the private sector. These gave the private sector an opportunity to participate in shaping the economy and to attract investors in different areas, based on a free enterprise market. Although large enterprises are owned by the government, most of the economic activities, light industries, rests in the hands of the private sector. The size of these enterprises ranges from very small one-person, businesses to large-sized enterprises such as textile and cement mills. In 1988, the private sector was responsible for 77 percent of gross capital formation in manufacturing, 88 percent in

wholesale and retail, 70 percent in construction, and 100 percent in realestate and business services[3].

The output level of the Yemen economy places Yemen in the low-income category of the LDCs. In 1990, real Gross Domestic product (GDP) amounted to 40,047 million Yemeni Rials, this is equivalent to $ 3,122 million[4] U.S dollars or a GDP per capita of 4,329 YR, equivalent to $ 337.5 U.S dollars. Table(2.1) shows the value-added contribution to the Gross Domestic Product by different activities during 1990. Also shown are the growth rates of these sectors from 1970-1990. Agriculture provides the second largest contribution to GDP, after government services, and is followed by wholesale and retail trade, manufacturing, and mining, respectively.

Exports, which are a major sector of the Yemen economy, is dominated by agriculture and related processing and petroleum[5]. In 1990, the value of total exports was 8,315,504 thousand Yemeni Rial, of which petroleum products accounted for 87.6 percent[6], 7,284,382 thousand YR, where agricultural products accounted for 5.33 percent. The composition of imports is mostly petroleum products, transport equipment, industrial machinery, manufactured goods, and chemicals. As of

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[3]Ali Hajari 1992 thesis, page 54.

[4]This value is based on the official market exchange rate of 12.826 Rial/$, the 1989 exchange rate.

[5]Export of petroleum started from 1987.

[6]Statistical year book 1992,page 274-278.

Table 2.1
Yemen Gross Domestic Products by Main Economic Sectors

Sector	Share of GDP (%) 1990	Annual growth rate (1970-1990)
Agricultural	22.6	15.35 %
Manufacturing	8.2	26.58
Mining	8.1	31.48
Construction	4.2	11.47
Electricity, water & gas	1.7	32.87
Whole sale & retail trade and business services	11.9	15.17
Trans.Stor. & communication	7.5	29.88
Financial & real state	6.1	18.07
Producer of gov.services	24.4	24.06
Other[7]	4.3	

Source: The share of GDP is from the Statistical Year Book of Yemen, 1992, page 247-249.
Data for annual growth rate comes from ESCWA Publications.

[7]Other includes: import duties, community, social and personal services, and producers of private, non profit services to households.

1990, the value of total imports reached 18,867,090 thousand YR, of which 8.53 percent was accounted for by petroleum, 1,609,362 thousand YR, and 16.28 percent by machinery and transportation equipment.

In 1990, total population of the country was 9.25[8] million, with an annual growth rate of 2.82 percent between 1971 and 1990. Total labor force was about 1.605[9] million in 1986, of which agriculture's share was 58.10 percent and industry 4 percent.

The banking system of the country is headed by the Central Bank of Yemen, which determines monetary policy and directs the operation of issuing new money and regulation of the credit and money supply of the country. The commercial banking system consists of domestic banks and foreign owned banks. The interest rate that these banks can charge for personal or commercial loans is regulated by the government; at present, it is fixed at about 17 percent[10].

The currency of North Yemen is the Yemeni Rial (YR), which currently has an official exchange rate of 12.826 Rial equal to one U.S dollar. All exchange transactions through the central bank of Yemen take place at this official rate, although up to the mid-80s a parallel market for dollars and

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[8]this represent former North Yemen only.

[9]Ali hajari 1992 thesis, page 142.

[10]Statistical year book, the Republic of Yemen 1992, page 241. This percentage represent 1992.

Rials had developed in many parts of the country. This was an informal market run by the private sector with the approval of the government. It provided small businesses and private consumers with the necessary foreign exchange, especially for overseas travel by Yemen residents. Since the mid 1980s this market by the private sector was abandoned by the government; the reason was that because of the decline of world oil prices during the 80s, remittances by Yemeni workers from abroad declined. As a result, the government took measures to rationalize imports in order to prevent serious foreign exchange shortages. The sources of this foreign exchange is Yemenis working abroad, mainly in Saudia Arabia and Gulf States, and from funds exchanged by tourists in Yemen. It was estimated that, the size of this market (tourists market) in 1990 was about $ 46,906,600 US dollars[11].

Yemen and Energy Crises of the 1970s

Although, the prices of crude oil and petroleum products increased during the 1970s, total petroleum consumption increased from 81,927 tons in 1970 to 161,875 tons in 1973 and to 674,535[12] in 1980. Because of insufficient foreign reserves, Yemen like many developing countries, suffered a severe oil payments problem. The total fuel bills of Yemen

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[11]Statistical year book, the Republic of Yemen 1992, page 11. It represent the whole country.

[12]The Economic Development of the YEMEN ARAB REPUBLIC.

increased from $ 7 million in 1973 to $ 132 million in 1979, and continued to increase to $ 184.1 million in 1982. To offset this price increase, a subsidy by the government of Yemen was granted to the Yemen Petroleum Company to market petroleum products at a lower price. As in many other developing countries, there was the need to borrow money from the international market to pay for these high oil prices. Also, foreign aid has been received from different oil producing countries such as Kuwait, Islamic Bank of Jaddah, Irag, and from the World Bank of Development. Although these assistances measures eased the impact of oil price increases, the trade deficit remained a problem table 2.2.

The following sections of this chapter briefly describe the oil consumption and the trend of the most important sectors of the economy of Yemen, emphasizing the structure of their energy use.

The Agricultural Sector

As in most LDCs, the economy of Yemen depends heavily on the agricultural sector. This sector accounted for about 22.6 percent of the Gross Domestic Product in 1990 and provided about 443,216 thousand YR from export earnings, of which fishery and coffee products accounted for more than 68 percent[13].

The diversity of crop production places the agricultural

[13]computed from statistical year book,1992,page 273.

Table 2.2
Trade deficit of Y.A.R (1970-1988)

Year	Export (MYR)	Import (MYR)	Deficit (MYR)	Real Deficit
1970	15	207	-192	-703
1971	23	241	-217	-714
1972	20	450	-430	-1287
1973	36	679	-643	-1616
1974	61	1039	-978	-2090
1975	49	1290	-1240	-2267
1976	35	2497	-2462	-3658
1977	50	3947	-3987	-5178
1978	33	5043	-5010	-5598
1979	61	7340	-7279	-7443
1980	103	9613	-9510	-9510
1981	217	8992	-8776	-8595
1982	179	9747	-9567	-8689
1983	122	8979	-8856	-7694
1984	171	8372	-8201	-6974
1985	385	8751	-8366	-6460
1986	235	8343	-8107	-5470
1987	581	13382	-12800	-8148
1988	8315	13312	-4997	-2933

Source: World Bank, world tables, 1990, pp.108-115.(Ali Hajari's 1992 thesis).

Note: In order to get the real deficit, the total deficit was divided by the GDP implicit price deflator. The source for GDP implicit price deflator is National Accounts Statistics:Analysis of Main Aggregates. Because of unavailable data, 1990 GDP implicit price deflator is assumed to be the same as 1989.

sector among the most widespread of the economic activities. The importance of this sector is reflected in the emphasis given it by government.

Cropping methods in Yemen still reflect traditional ways. Work in the agricultural sector is highly labor intensive. Although, mechanization and modern irrigation exist, they are at a low level compared to countries with similar characteristics. The reason for this is that mountainous terrain in many areas serves as a physical constraint to the application of mechanization and extensive new agricultural techniques.

Consumption of petroleum products by this sector has increased from 12,004 tons in 1973 to 59,867 tons in 1980 and to 70,473 in 1984[14](mostly due to diesel tractors and pumps).

Oil consumption in the agricultural sector has increased from mid 1980s. The reason is that, in 1984, the government of Yemen adopted a self sufficiency policy for this sector. This resulted in the prohibition of fruit imports in order to protect domestic production. This strategy brought about higher energy consumption by the agricultural sector throughout the country.

The Manufacturing Sector

Manufacturing industry in Yemen is among the most important sectors, as it plays major roles in economic

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[14]Arab Oil and Gas Directory,1986.

development. The share of industry to Gross Domestic Product (GDP) is increasing over time. GDP by this sector increased from 10.1 percent in 1970/71 to 18.5 percent in 1980/81. In 1981, industry accounted for 52,900 workers representing 4.4 percent of the total labor force. It is the most widespread type of business enterprise, ranging from small handicrafts shops to large-scale cement and textile factories.

Fuel consumption by industry increased from 36,039 tons in 1973 to 145,712 in 1980 to 202,354 tons [15] in 1983. Manufacturing output consists of processed food, textiles, chemicals, nonmetallic construction materials, metal, extraction, and wood products.

The Transportation Sector

It is known that the transportation sector is also an important sector for continued growth in a developing economy. Most transportation in Yemen is by motorized vehicles, such as trucks, buses, and passenger cars. Rapid expansion of the road net-work after the early 1970s brought an even more rapid increase in the number of vehicles. Yemeni workers abroad used part of their earnings to purchase trucks and taxis. Diesel and gasoline provide the base fuel for this sector. In 1973, consumption of petroleum products by this sector was 80,204[16] tons, representing about 50 % of total petroleum products. In

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[15]Arab Oil and Gas Directory,1986.

[16]Arab oil and gas directory , 1986 page 471

1982, highway transport accounted for about 57 percent[17] of imported petroleum products consumed in the country, of which most was gasoline. The bulk of the transportation services is for movement of agricultural products, the transportion of passengers, and the transportation of raw materials.

The trend of energy consumption in this sector probably will remain upward. Economic growth implies increasing economic activity, which in turn induces more transportation activity and, therefore, more energy consumption. It is possible that higher infrastructure taxes on petroleum products to support the costs of highway investment could lead to better efficiency in energy use by transportation systems. In any case, the expectation is for an increase in oil consumption in this sector, due to the increased economic activity resulting from future economic growth.

The Electrical Sector

Electrical power in North Yemen was first supplied by a private company (Sana'a Electric Company) in 1959, which later in 1975 changed its name to Yemen General Electricity Company (YGEC), owned by the public sector. It supplies most electricity consumed in the country, although there are some private generators.

The contribution of this sector to the economy of Yemen is very important. GDP by this sector has increased from 17

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[17]The Yemen country studies ,page 148

million[18] Yemeni Rial in 1975 to 661 MYR in 1989, and total labor force by this sector also increased from 1,500 workers in 1975 to 47,850 workers[19] in 1990.

This sector is the main source of power for small to large enterprises in manufacturing, commerce, and the residential sectors. It also provides almost all public lighting in the country.

The annual growth rate of electricity consumption during the period 1971-1991 was around 21.36 %, and this seems likely to continue in the coming years. Table 2.3 shows that total output by this sector increased from 43.3 gigawatt-hours in 1975 to 1239 gigawatt-hour[20] in 1991.

It should be noted that electricity generation in the Yemen Arab Republic requires imported fuel oil and diesel. Consumption of diesel oil increased from 11.6 thousand metric tons in 1975 to 64.1 in 1982, table 2.4, at an average annual rate of 22.33 %. Since 1983, consumption of diesel decreased from 56.6 thousand metric tons to 26.2 tons in 1990, the reason being replacement by heavy residual fuel oil. The demand for residual increased steadily from 3,600 tons in 1983 to 302,000 tons in 1990 as a result of YGEC's expanded activities and demand from cement facilities in Bajel and

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[18]Statistical Abstract of the Region of The Economic and Social Commission for Western Asia, various years, ESCWA.

[19]1982 - 1991 report by the ministry of power in Yemen.

[20]1982 - 1991 report by the ministry of power.

Table 2.3
Output of electrical generation (GWH)

Year	Thermal	Diesel	Total GWH
1975	--	43.3	43.3
1976	--	55.1	55.1
1977	--	70.8	70.8
1978	--	97.8	97.8
1979	--	141.2	141.2
1980	--	187.7	187.7
1981	--	228	228
1982	--	283.1	283.1
1983	115	241	356
1984	355	88	443
1985	445	81	526
1986	541	65	606
1987	634	69	703
1988	724	77	811
1989	849	95	944
1990	1028	113	1141
1991	1111	128	1239

Source: 1975-1991 reports, planing and statistical department in the Ministry of Power in Yemen.

Table 2.4
Fuels used to generate electricity
(000 MT)

Year	Diesel	Residual
1975	11.6	--
1980	44	--
1982	64.1	2
1983	56.6	36.2
1985	23.5	132
1990	26.2	302

Source: 1982-1991 report, by the Ministry of Power.

Amran[21]:

The Refining Sector

Because there was no refinery in North Yemen, all of its commercial energy was supplied completely by imported petroleum products up to 1985. Since early 1985, Yemen refines part of its products in its own refinery which came on stream in March, 1986. It processes about 10,000 barrels per day of crude oil, mostly from recently discovered oil fields.

The refinery consists of two modular units which are producing diesel oil, gasoline, LPG, and residual. In 1986, total annual capacity of the refinery was about 500 thousand metric tons, which has been constant since that time. Total Output increased from 337 thousand tonnes in the same year to 350 and 360 thousand tonnes in 1987 and 1989, respectively. Utilization rate of this refinery increased from 71% in 1986 to 80% in 1987, table 2.5.

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[21]Locations of cement plans.

Table 2.5
Refined product in North Yemen

Year	Capacity 000 mt	Output 000 mt	Utilization rate %
1986	500	337	71
1987	500	350	80
1988	500	354[22]	
1989	500	360[23]	
1990	9400	4025	--

Source : International Marketing Data and Statistics, various years.
Note : Values for 1990, for both Yemens.

[22]United Nation's Publications.

[23]Same source as for footnote 22.

CHAPTER 3

REVIEW OF LITERATURE

Introduction

This chapter begins with a discussion of energy and economic development to establish a foundation for the investigation of the relationship between energy consumption and economic growth. Section two focuses on the demand for energy in LDCs, with emphasis on problems in analyzing demand for energy in those countries. Section three summarizes conventional models for electricity of use in the investigation of how consumption responds to changes in its determinants. These, according to theory, are primarily income and prices. Finally, an evaluation of existing models is made as a means of formulating the analytical apparatus of this study.

Energy and Economic Development

The long-term relationship between GDP and specific forms of energy consumption has received a lot of attention from economists. The reason for this interest is that industrialization and economic growth are closely linked with each other and that most capital using activities (commercial and industrial) require specific energy forms. This interest in the relationship of energy consumption and economic growth is also attributed to the fact that in energy short regions planners must assess the trade off between national growth

targets and increases in the import value of fuels contributing to balance of payments difficulties. Among the many studies of the relationship between economic growth and energy consumption is de Janosi and Grayson's (1977) survey of 30 developed and developing countries. The authors regressed the common measure of energy on GDP, assuming that energy consumption is price inelastic. Conditional on this assumption they found energy consumption and gross domestic product are highly correlated, and suggest that the income elasticity of energy consumption is influenced by a country's stage of development. However, since developed countries do not generally subsidize energy consumption it is not surprising that the authors found that the income elasticity of energy consumption is higher in the case of LDCs which are more frequently subsidized than in the developed countries.

Desai (1978), suggests also that the differences in income elasticities found between these two types of countries is emphasized by the fact that non-traded energy sources (firewood, animal wastes) are often excluded from the analysis. These excluded energy sources predominate in less-developed countries and often represent over a third of the total energy consumed.

When Desai included non-commercial energy in his study, he found that the aggregate energy consumption per dollar of GNP (intensity of use) does not show any specific trend. But

per-capita energy consumption is higher in developed countries than in less developed countries.

Thus, Desai's results indicate that energy consumption per dollar in industrial and transportation sectors is approximately the same in all countries regardless of the country's stage of development. Of course, in the agricultural sector, the intensity of energy use is higher in developed countries than in less-developed countries because agriculture is labor-intensive in LDCs, whereas in developed countries (DCs) it is highly mechanized. In summary, factors that account for differences in income elasticities of energy between DCs and LDCs include the levels of technical change, subsidies and efficiency, and the access to capital and education in the relevant sectors.

Energy Demand in LDCs

To have a complete understanding about the structure of energy demand in LDCs, it is really very important to see how these countries in the future open to world market influences and respond to price changes. Because studies frequently do not consider constraints on market efficiency in effect, demand side findings for developing countries in general are problematic. Accordingly, analyzing energy demand in one of the least of the LDCs, Yemen, requires care. The problems researchers face in analyzing energy demand for LDCs present barriers which leave some questions open.

A most serious problem is the limited data available on market prices of fuels. Retail and wholesales prices are seldom available. This makes it difficult to test hypotheses even when a satisfactory model exists to explain the role of prices.

Although, LDCs are using commercial energy, the very poor use large quantities of non-commercial energy, such as wood, agricultural and animal wastes, and they use animals for transport and motive power. Such energy sources are almost free, especially in the rural areas where cash markets may hardly exist.

A second problem arises from the fact that some industries are publically owned, and government may have management objectives that do not lead to profit maximizing decisions and competitive prices. Models representing industrial and residential consumers facing market prices, profit maximization, or cost minimization may not be applicable. In the industrial sector, for example, decisions may not be based on cost minimization or profit maximization, rather they might be based on some management objectives. The same may apply to the residential sector, where decisions may be based on the availability of supply rather than on own and substitute prices ,for example, electricity.

It has been argued that in LDCs income elasticity of energy consumption for the residential and transportation sectors usually is higher than it is in developed countries.

These two sectors represent the greater part of total energy demand. When income is increasing, some of this increase may not be allocated to larger homes or more light and heat in the existing homes. Expenditure on energy, like expenditure on food, will be a large fraction of the consumer's budget when income is low, but this fraction will be small when income is high. This behavioral pattern dictates that income elasticity of energy demand for light and heat is not constant, but instead varies with income.

Another argument is that urbanization migration in LDCs will contribute to more consumption of commercial energy by the households. In this area, energy is not free as in the case of the rural areas accustomed to non-commercial energy sources, such as wood animal and agricultural wastes, which are freely collected. In the case of rural areas, demand for energy will be price inelastic and also income inelastic.

In his study, Parikh (1977) noticed that in the rural area of India the use of firewood and animal wastes is not dependent on the total consumption levels of the household, where in the urban areas demand for energy is relatively income elastic. In urban areas, a large increase in the consumption expenditure will be assigned to housing and associated use of energy.

A third argument is that energy demand in LDC's could appear to grow more rapidly, based on the conclusion that in most of these countries, especially the very poor ones , non-

commercial energy such as firewood and animal wastes still represent a huge fraction of total energy consumed. Increased development is attended by industrialization and requisite consumption of commercial energy. Since consumption of commercial energy is low in LDC's, the increase attendant to economic growth results in high rates of growth in energy consumption.

A study by Pindyk (1979) showed that, in the industrial sector, the ratio of energy to GDP and GDP elasticities for energy demand are always lower in the case of LDCs. Pindyk (1979, p. 252) explains this " is due to the fact that much of the growth in output has occurred in agriculture and light industry where energy requirements have been small, and where labor- a relatively cheap factor can easily be substituted for energy". Finally, Pindyk (1979, p. 253) concludes that, "we expect the GDP elasticity of industrial energy demand in most of the developing countries to be below the value of 0.80 to 0.85 that we have estimated for some of the industrialized countries".

Studies on Electricity Demand

This section summarizes studies of electricity demand seeking to determine the elasticities of demand to own-price, the price of close substitutes and income in both the short run and long run. The object is to analyze how much electricity consumption responds to changes in prices and

income.

Modeling and estimating electricity demand differs from other types of demand analysis to the extent that electricity market contains features, such as the complementarity with capital goods, which make it necessary to distinguish the short run from the long run. Electricity is only an intermediate product. The review presented here includes models that recognize explicitly those features which distinguish price and income elasticities and serve as background for the analysis of the determinants of electricity consumption in Yemen.

In studying the residential consumption of electricity in the United Kingdom, Houthakker (1951) used cross-section data on 42 cities for the period 1937-1938. It was his realization that average price does not give information on the influence of tariff changes on demand. As a result of this study, he suggested the use of marginal price in the demand function instead of the average price.

Hawkins (1975) studied the determinants of the demand for electricity by residential, commercial and industrial users. In studying the demand for electricity in the residential sector, he described two equations. The first one explains average consumption, and the other explains the proportion of electricity consumed by customers with a gas connection. Two sets of models described commercial and industrial consumers. In the first model, commercial and industrial consumers were

assumed to be cost minimizers, and in the other model the demand for electricity is derived directly from the production function.

In describing commercial and industrial consumers behavior, Hawkins (1975) suggested two models. In the first model he relates the demand for electricity to factor prices and the level of output. In the second model, he relates demand for electricity to inputs, output, labor and capital. He concluded that industrial and commercial demand for electricity are sensitive to price of electricity and to industrial activities.

Fisher and Kaysen (1962) were the first to distinguish between the short and the long run demand for electricity by the residential sector. In their study, short run demand for electricity was identified by the utilization rate of the existing stock of electricity consuming capital goods, but in the long run it is identified by the size of the capital stock.

Houthakker (1980) used marginal price, and he concluded that it is possible to estimate satisfactory flow-adjustment models with a new procedure for calculating marginal electricity prices. His study proved to give a result superior to previous studies.

Garbacz (1984) developed a three equation model (demand,price, and appliance stock) to estimate national electricity demand using two stage least squares for

households by month. This study builds on the previous work to estimate elasticities by month and by region. It is hypothesized that elasticities vary substantially between the heating and cooling seasons. Previous work by Acton, Mitchell, and Sohlberg (1980); Parti and Parti (1980); Archibbald, Finifter, and Moody (1982); Murray et al.(1978); and Garbacs(1984) support this hypothesis, and Houthakker (1980), Halvorsen (1978), and Murray et al.(1978) also have found differences in elasticities by region.

Houthakker and Taylor(1970) estimated an equation for personal consumption expenditure for electricity based on their stock adjustment model of consumption (residential). This model consists of two equations : A behavioral relationship that specifies consumption as a function of stock, income and relative price; the other equation expresses the rate of change in stocks to consumption and depreciation. The authors concluded that both elasticity of income and price are slight in the short run, but very substantial in the long run.

Taylor (1977), studied energy demand in the residential and industrial sectors in Colombia. He postulated many models, describing the electricity demand function. In his demand equation for the industrial sector the estimated coefficient for price has a positive sign perhaps indicative of inefficient power expansion. The author gave no reason to explain this finding. However, Baxter and Rees (1968), studyed

electricity demand in the Industrial sector and rejected what they call the "aggregate energy approach". Rather, they suggested modeling the several fuels individually, along with capital and labor as arguments in the production function. The authors concluded that the chief determinants of growth in industrial electricity consumption are growth in output and changes in technology. In such cases, a relative price changes may not be an unambiguous observed determine of demand.

Wilson (1971) investigated electricity demand in the residential sector and found that his result differs from the result by Fisher and Kaysen, who found little or no influence of price on the long-run demand for electricity. In contrast, Wilson found a negative price elasticity and a negative income elasticity. Wilson used two different prices, the average price per kwh and the FPC typical bill. His result was reported using the latter price only, which resulted in a negative elasticity of income.

Mount, Chapman, and Tyrrel (1973) studied both the short-run and the long-run demand for three classes that consume electricity : residential, commercial and industrial. The main conclusion found long run price elasticities greater than one for all three cases; it becomes increasingly elastic as prices rise. In contrast, demand is generally inelastic with respect to income and, for residential and industrial classes, income elasticity approaches zero as income increases.

Anderson (1973) noticed some weaknesses in earlier

studies of residential gas and electricity demand. He studied two different classes of models ; in the first, he predicted stocks of energy - using equipment, and in the second he predicted energy consumption. In the second case, he specified demand to be a log-log function of income, prices of various sources of energy and several demographic variables.

Evaluation

The models and their corresponding empirical applications reviewed in the previous sections are based on neoclassical demand theory, assuming consumption is a function of its own-price, the price of all substitutes as well as goods consumed and income.

Some studies focused on the type of price (marginal or average) to be included in the demand model for electricity. The issue was: Is price a predictor of electricity consumption? Results by the previous studies showed that long run price elasticity is larger than the short run elasticity (see table 3.1). This is also true for income elasticity. Moreover, the empirical results indicate that electricity consumption is price elastic in the long run, as the long run price elasticities are greater than unity.

It is necessary to discuss the difference between short and long run demands for electricity. The fact is that electricity is not consumed as an end in itself, but rather it is consumed with complementary durable goods. Since the stock

Table 3.1
Price and Income Elasticities of Electricity Demands

Model	Price Elasticities		Income Elasticities	
	Short run	Long run	Short run	Long run
Residential				
Houthakker	-0.89	----	1.66	----
Hawkins	----	-0.55	----	0.92
Taylor	-0.07	----	0.5	----
Halvorsen	----	-1.14	----	0.51
Industrial				
Baxter & Rees	----	-1.50	----	1.21
Hawkins	----	----	----	0.85
Taylor	-0.73	----	0.16	----
Commercial				
Hawkins	----	----	----	0.79

of capital is fixed in the short run, the demand for energy depends upon the rates of diffusion and utilization of the associated capital stock. The stock of capital is variable in the long run, and the demand for e

nergy is, therefore, related to the demand for capital goods. Since most of the summarized studies are weakly motivated theoretically, the distinction between the short run and the long run is vague.

Econometrically, in all of the studies the authors regressed the quantity of electricity consumed on price and income. In order to explain the variation of the demand for electricity, some other variables such as, price of substitutes, temperature, and social factors were included in some of the studies. With few exceptions, the results of these regressions are reported without mentioning the magnitude of the D-W statistics.

Finally, most of the studies were concerned with whether or not price is a determinant of electricity demand, and overall they confirm that both price and income appear to be important determining factors in electricity and energy consumption.

CHAPTER 4

ENERGY AND ECONOMIC DEVELOPMENT IN YEMEN

Introduction

The increases in OPEC oil prices in 1973/74 and in 1979/80 had a great effect on the economies of both rich and oil importing less-developed countries (LDCs). For some of the latter the increases were a disaster. Since 1981, the previously high prices have moderated considerably: Down during 1981-1986, up somewhat during 1986-1992. Even with the moderate post 1980 prices of energy, energy cost pose a major problem for Yemen. The reasons are: 1) the lack of exports has prevented the accumulation of needed foreign exchange to pay a rising oil import bill ; 2) the economy continues to experience slow economic growth, balance of payments deficits and difficulty servicing external debt ; 3) exchange rate declines due to Yemen's inflations have contributed to higher import prices for energy products ; and 4) although Yemen to some degree has started producing and exporting oil, since 1984 and 1987 respectively, the economy is still dependent on imported energy. As a result of all these, an analysis of energy use and energy policy in Yemen is very important.

Overview of Non-Commercial Energy

Yemen relies completely on two types of primary energy sources, commercial and non-commercial, petroleum and fire wood respectively, including agricultural and animal wastes.

A large share of total energy consumption in the country comes from non-commercial energy sources. In the early 1980s, for example, about 60 percent of the total energy consumed was supplied by fire wood, especially in the rural areas.

An economic survey showed that by the mid 1980s, the country had lost much of its sparse cover of trees and shrubs; this resulted from unlimited cutting, which for decades exceeded regrowth. Economists argue that if this depletion rate continues, erosion problems will keep increasing and will lead to a complete loss of the country's woody vegetation. This might occur before the turn of the century.

It should be noted that even though fire wood is considered non-commercial energy because people in the rural areas collect their own, it is sold in towns and villages. The price of fire wood increased sharply after the early 1970s; this in turn brought an increase in the use of kerosine and LPG by households. The increased price of fire wood is a desirable development in view of the country's rapid loss of its spare vegetation. Economists argue that the government of Yemen should step ahead and limit the cutting of this source to some degree.

Development of Petroleum Consumption During 1970-1990

Total energy consumption in 1990 was 1073 thousand metric

tons, while in 1971 it was 70[24] thousand metric tons (table 4.1). It increased at an annual growth rate of 16.31 % (figure 4.1). This increase in growth rate included all types of petroleum products, such as gasoline, diesel, kerosine, LPG, jet fuel and residual fuel. Among those products, the highest growth rate was in residual fuel, LPG, diesel, and gasoline respectively and the lowest growth rate was in Kerosine, which increased at 7.46 % annually (table 4.2).

The total petroleum consumed per capita increased from 12.95 Kg in 1971 to 116 in 1990 (table 4.3). Thus, energy consumption per capita differs from type to type. Consumption of diesel, for example, was 60.54 kg in 1990, whereas consumption of kerosine was 11.43 kg in the same year.

Factors in the Increase of Energy Consumption

As mentioned in the previous section, total commercial petroleum consumption increased at a growth rate of 16.31 %, and most of this growth happened during the decade of the 1970s. The growth rate during this decade was 22.11 % compared to 11.16 % during the 1980s. There are two major reasons for this increase in the 1970s. First, civil war ended in early 1970; as a result, developments by government and private sector were given attention. Two development plans from 1973 to 1980 were undertaken by the government. Second, the

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[24]these values are based on data published by the statistical yearbook of United Nations.

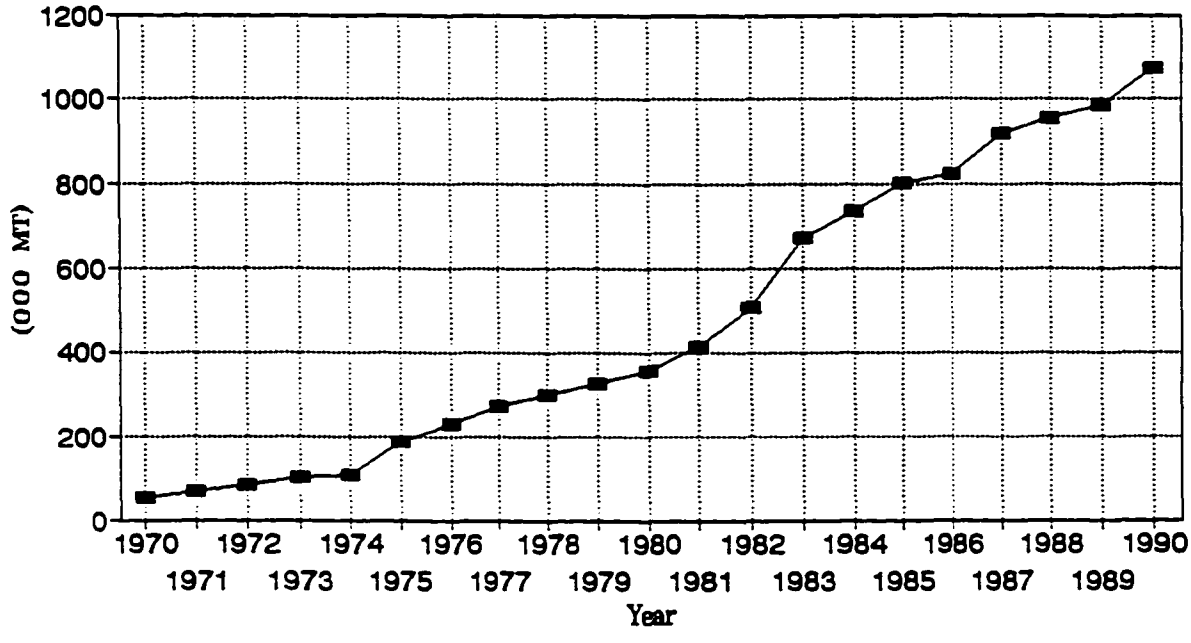
Table 4.1
Petroleum consumption in Yemen(1971 -1990)
(000 metric tons)

	Total consumption					% of total consumption				
	1971	75	80	85	90	71	75	80	85	90
Total	70	188	356	801	1073					
Products:										
Gasoline	22	47	65	190	185	31.4	25	18.3	23.7	17.2
LPG	--	--	15[25]	36	92	--	--	4.2	4.4	8.5
Diesel	30	48	190	360	560	42.9	25.5	53.3	44.9	52.2
Kerosine	18	82	57	115	82	25.7	43.6	16	14.3	7.6
Residual	--	11	40	180	144	--	5.9	11.2	22.5	13.4

Source: United Nation: Energy statistics yearbooks, various years.
LPG data were collected from reports by the statistical department in the Ministry of Oil and Mineral Resources in Yemen.

[25]This is for 1981.

Figure 4.1 Total Petroleum Consumption 1970-1990.



Source: United Nation: Energy Statistics Yearbooks, various Years.

Table 4.2
Annual growth rate in petroleum consumption
(1970 - 1990)

	1970-1980	1980-1990	1970-1990
Total petroleum	22.11 %	11.16 %	16.31 %
Petroleum products			
Gasoline	12.66	7.71	13.75
LPG	--	26.8[26]	--
Diesel	24.66	10.64	18.02[27]
Residual	44.18[28]	8.49	24.51[29]
Kerosine	9.95	4.48	7.46
Others			

Source: Calculated by the author based on the data in table 4.1.

[26]This growth rate represent data from 1981-1990.

[27]This represent data from 1973-1990.
[28]this for the period 1973-1980.
[29]This is for the period 1973-1990.

Table 4.3
Petroleum consumption per-capita (1971 - 1990)
Kg/capita

	Total consumption				
	1971	1975	1980	1985	1990
Total petroleum	12.95	30.95	50.58	100.69	116
Petroleum products:					
Gasoline	4.07	7.73	9.23	23.88	20
LPG[30]	--	--	2.15	6.6	11.89
Diesel	5.55	7.9	26.99	45.25	60.54
Residual	--	1.81	5.68	22.62	15.56
Kerosine	3.33	13.49	13.98	14.46	11.43
Others	--	--	--	--	--

Source: Same source as table 4.1 divided by total population, Ali Hajari's 1992 thesis. Populations for the years 1989 and 1990 are sighted from Yemen Statistical Year Book, 1992.

[30]The source of data for LPG consumption were obtained from report by the Ministry of Petroleum in Yemen, statistical department.

increase of oil prices during the seventies resulted in the emigration of Yemeni workers to neighboring countries, such as Saudia Arabia and Gulf States. This in turn increased private transfers, which allowed new investments in many areas in the economy.

In general, the following are the most important five factors that led to the development in consumption of commercial energy since the early 1970s (tables 4.4 and 4.5), respectively.

First, increase in the level of GDP. Real GDP increased from 8451 [31] million Yemeni Rial in 1971 to 40047 million YR in 1990 at a growth rate of 7.466 % annually (figure 4.2).

Second, increase in the rate of population. Total population increased from 5.404 million in 1971 to 9.25 million in 1990, a growth rate of 2.82 % annually. Although this rate of growth is high, the real GDP per capita increased from 1564 YR in 1971 to 4329 YR in 1990 (figure 4.3), and as a result of this increase, the demand for home appliances, automobiles and different equipment that use energy increased extensively.

Third, increases in workers' remittances from abroad, especially those in Saudia Arabia and Gulf States. Remittances or private transfers had increased from 129 MYR in 1971 to 3233 MYR in 1988, growing at an annual rate of 12.47% .

Fourth, changes in the structure of total GDP.

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[31]This is in real term.

Table 4.4
Factors in the increase of energy consumption in Yemen (1971-1990)

Variable	Unit	1971	1975	1980	1985	1990
Population	Million	5.404	6.075	7.039	7.956	9.25
GDP	MYR	8451	12676	17989	23891	40047
Per-capita GDP	YR	1564	2087	2556	3003	4329
Urbanization[32]	(000)	736	930	1315	1550	--
Privt trnsfr	MYR	129	1013	6118	6020	3233[33]

Source: GDP data are from National Accounts Statistics: Analysis of Main Aggregates, at current prices and then converted to real term using GDP implicit price deflator.
Urbanization data from ESCWA publications.
Population and private transfers from Ali Hajari's, 1992 thesis.

[32]These numbers are for both Yemens.
[33]This value represents 1988.

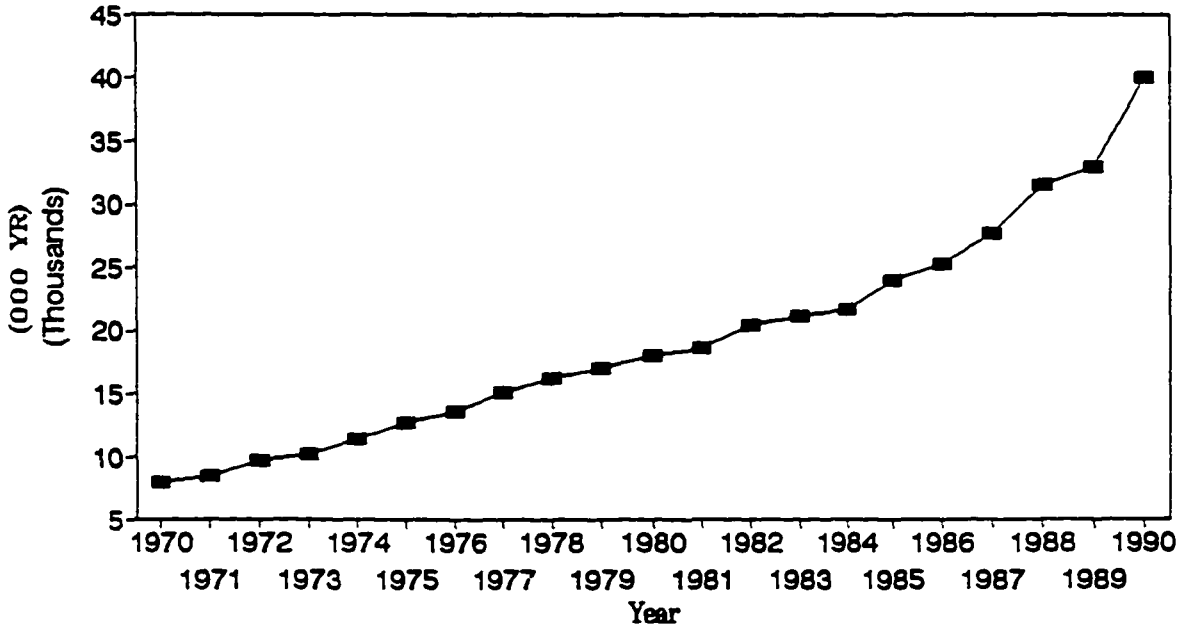
Table 4.5
Annual growth rate in the factors that affect consumption in Yemen (1971 -1990)

Variable	1971-1980	1980-199	1971-1990
Population	3 %	2.79 %	2.82 %
GDP	7.788	10.738	7.466
per-capita GDP	4.917	7.037	4.50
Private transfers[34]	49	(-6.6)	12.47
Urbanization[35]	7	(3.93)[36]	(5.55)[37]

Source: Computed by the author using the growth rate model, Same source as table 4.4.

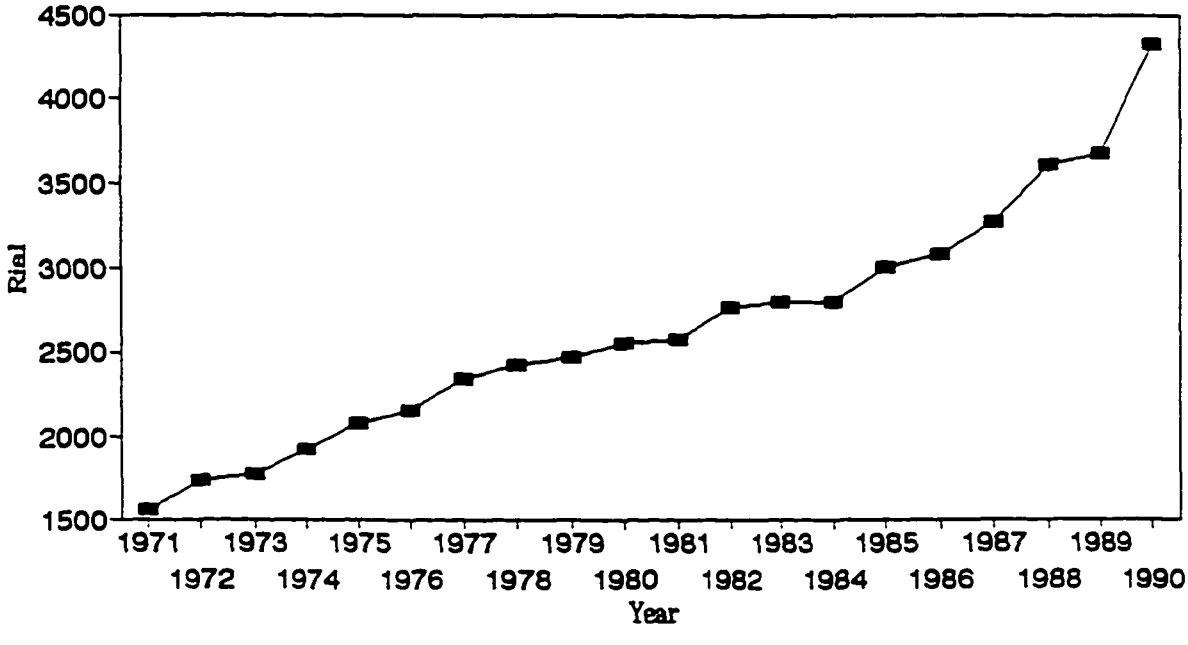
[34]This growth rate represent both south and north yemen.
[35]This represent both south and north.
[36]it represent data from 1980-1987.
[37]it represent data from 1971-1987.

Figure 4.2 Yemen Real Gross Domestic Product (GDP) 1970-1990.



Source: National Accounts Statistics: Analysis of Main Aggregates.

Figure 4.3 Per-Capita Real Gross Domestic Product 1971-1990.



Source: Same source as figure 4.2 divided by total population, Ali Hajari's 1992 thesis.
Population for the years 1989 and 1990 are sighted from Yemen Statistical Year Book, 1992.

Agricultural and industrial activities have increased since 1970. Total GDP by these two sectors increased from 939 MYR in 1971 to 22687 MYR in 1990[34]. As a result of this, consumption of energy in industrial and agricultural activities increased.

Fifth, urban migration also contributed to a more rapid growth rate of household commercial energy demand. Urban population in Yemen increased from 737 thousand in 1971 to 1,550 thousand in 1985, an annual rate of 5.55 %[35].

Oil Development and the Discovery of the 1980s

Oil exploration in North Yemen started in the early 1950s, when an agreement between the Yemen government and a West German firm was made to carry out geophysical and geological surveys. That effort ended in 1955, when an American firm was given exploration rights over 40,000 sq km. In 1959, a concession of 10,000 sq km was awarded to the American Overseas Investment Corp, but there was no drilling activity reported. Three years later, three or four wells were drilled near Hodidah, the main port of the country. Unfortunately, the wells turned out to be dry. This concession came to an end when the civil war broke out in the mid 1960s, which then lasted until 1970.

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[34]These values are at current prices.

[35]This growth rate represent data for both south and north for the period 1971-1987.

In 1964, after the revolution in the North, the Yemen Fuel Company (YFC) was formed to take over oil operations in the country and also to handle the import and distribution of petroleum products.

An agreement for Red Sea exploration was made in 1974 between the Yemen fuel company, American Sante Fe International Corporation and Japanese Toyo Menka Kaisha, but drilling produced no positive findings. At the same time the Yemen Fuel Company made an aerial survey in many different areas, such Aljof and Marib[40]. Samples were collected from these areas and sent to laboratories which later proved to include huge amount of carbonates. The petroleum potential of these areas caught the attention of international companies, such as the American Company Hunt, which later became the first major oil explorer in the country.

A six-year production-sharing agreement between the Yemen Fuel Company and Hunt Oil Company of the US was signed in September, 1981. This agreement covered an area of 14,600 sq km. Exploration activities started at the end of 1982. All capital necessary for development of any finding was provided by Hunt, and in return for that, Hunt will take about 30 % of the production for over 20 years. The other 70 % will be divided between the government of Yemen and the company, at 46.7 % and 23.3 %, in favor of the government of Yemen.

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[40]oil was found in these two areas later.

On January 31, 1984, Hunt drilled its first well, Alif, in Marib, about 230 km north east of the capital of Yemen, Sana'a.

By July of the same year Hunt announced that Alif had struck oil. The Alif well was drilled to a depth of 13,720 feet, and it was tested to pump about 4162 b/d of a 39.8 API oil. An additional test resulted in 3669 b/d of a 44 API oil at a depth of 5701 to 5721 feet. Three wildcats were also drilled in the area. Two of them yielded hydrocarbons. By the end of 1985, it was reported that reserves in the region were estimated at about 400 million barrels, which then reached 1 billion barrels in 1987. A pipe line to connect production regions and an exporting terminal on the Red Sea started to operate at the end of 1987. By early 1988, production from Alif field reached 150,000 b/d, which jumped to 175,000 b/d in June of the same year when production from another field, Azal, came on stream. By August 1989, production had jumped to 200,000 barrels per day, which was expected to rise to 400,000 barrels per day by 1993[37].

On the basis of that commercial finding and as a result of the economic and political stabilities that Yemen enjoyed during that period, requests for exploration rights by several world exploration companies increased, which then were given to Exxon, Total, and British petroleum in different regions of the country.

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[37]Ali hajari 1992 thesis, page 48.

CHAPTER 5

ENERGY CONSUMPTION AND ECONOMIC GROWTH IN YEMEN

Introduction

The purpose of this chapter is to analyze the relationship between energy consumption and economic growth in Yemen for the period 1970-1990. During most of this period there were rapid increases in the price of imported fuel. First, we analyze the relationship between energy consumption and economic growth for aggregate electricity consumption and petroleum products consumption. Rapid economic growth in LDCs generally contributes to large increases in energy demand Pindyk (1979). Second, we analyze the country's intensity of use of both electricity and petroleum products to investigate how Yemen's intensity varies with income and changes in this relationship across time.

Relationship Between Economic Growth & Energy

There was a strong relationship between gross domestic product and the demand for energy before the energy crises of 1973, and energy predictions were based on this strong relationship. Of course, this relationship changed after 1973, when petroleum prices changed significantly. Those price changes brought changes in the development structure of the world economy, especially in the industrial countries. These changes favored products and industries that use less energy, and this in turn generally decreased the consumption of

commercial energy per unit of GNP.

The relationship between income(GDP) and commercial energy consumption in Yemen can be described more formally by estimating the income elasticities of demand for energy through regression analysis. The income elasticities give the percentage increase in energy consumption associated with a given percentage increase in GDP.

Electricity Consumption and Economic Growth

Based on the results of equation (5.1) and (5.2), presented below, with t statistic in parenthesis, the demand for electricity (TELEC) is elastic (2.4)[38] with respect to (GDP) and has increased at an average rate of 21.65 % annually. The annual growth rate is computed from equation (5.2), as the antilog of the coefficient of the trend variable (a) minus one:

$$r = (e^{a} - 1)(100)$$

given $a = 0.196$

$$r = (e^{a} - 1)(100) = 21.65\ \%$$

$$\mathbf{(TELEC)} = -303.174 + 0.027\ \mathbf{(GDP)} \qquad \mathbf{(5.1)}$$

$$(-5) \qquad (11.7)$$

Adj $R^2 = 0.981$, **D-W** = 2.167 , (1970-1990)

$$\mathbf{ln(TELEC)} = 2.616 + 0.196\ \mathbf{t} \qquad \mathbf{(5.2)}$$

$$(12) \qquad (14)$$

---

[38]The elasticity is evaluated at the mean of GDP.

Adj R^2 = 0.993 , **D-W** = 1.476 , (1970-1990)

After correcting equations (5.1) and (5.2) for autocorrelation, all coefficients are statistically significant and well determined at the 5 % level of significance. Equation (5.1) shows that about 98 % of the variation in the demand for electricity is explained by income. The impact of income on electricity is indicated by the elasticity of 2.289, which is evaluated at the mean of GDP. This value implies that as income increases by one percent, electricity consumption increases by 2.289 %. Actual and fitted data are depicted in figure 5.1.

The intensity of use, defined as (TELEC/GDP) has increased at 12.75 % annually (figure 5.2). Mathematically, intensity of use (IU) is calculated according to the simple model:

$$IU_t = \frac{d_t}{Y_t}$$

where:

d_t = demand for electricity at time **t**.

Y_t = Total GDP at time **t**.

$$\mathbf{(TELEC/GDP)} = -\underset{(-13)}{0.0072} + \underset{(36)}{0.00132}\ \mathbf{t} \qquad \mathbf{(5.3)}$$

Adj R^2 = 0.99 , **D-W** = 2.827 , (1977-1990)

This result indicates the extent to which the ratio of

Figure 5.1 Actual & Fitted Electricity Consumption vs GDP 1970-1990.

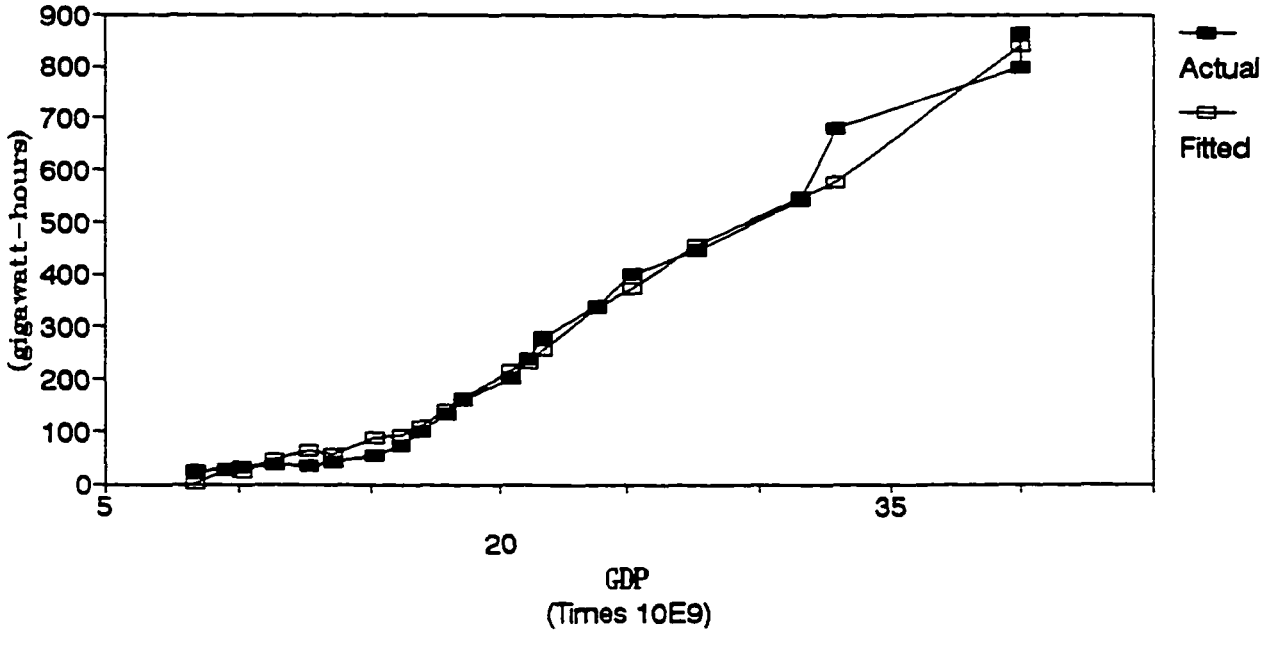
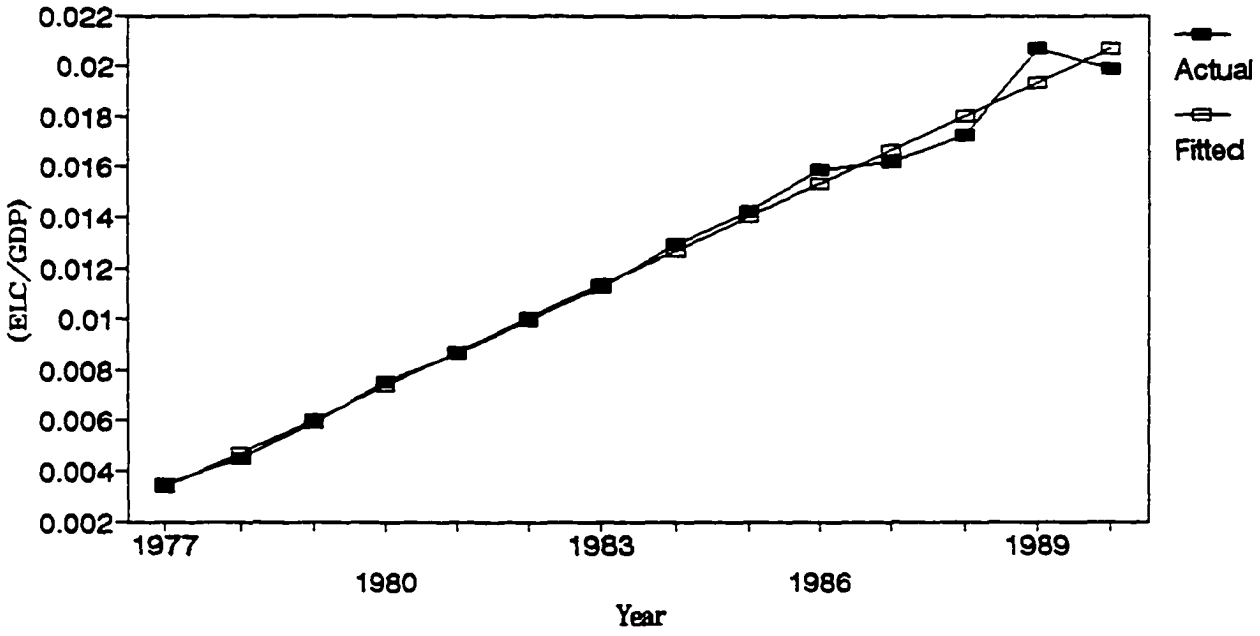


Figure 5.2 Ratio of Electricity Consumption to GDP 1977-1990.



electricity consumption to GDP is increasing over time.

The electricity intensity of use also increases as income increases (equation 5.4). After correcting for autocorrelation, the model fits the data satisfactorily:

$$\mathbf{(TELEC/GDP)} = -0.113 + 0.012\ \mathbf{ln(GDP)} \qquad (5.4)$$

$$(-3.7) \quad (4.1)$$

Adj $\mathbf{R^2}$ = 0.956 , **D-W** = 1.848 , (1970-1990)

The actual and fitted intensity of use are shown in figure 5.3.

Petroleum Consumption and Economic Growth

After correcting for autocorrelation, the simple translog model is employed (equation 5.5), which proved to fit the data well. All coefficients are statistically significant and well determined at the 5 % of significance.

GDP explains about 98 % of the variation in demand during the period 1970-1990. The elasticity of demand with respect to GDP is about 2.05 at the mean of GDP. The actual and fitted data are shown in figure 5.4.

$$\mathbf{ln(TPETC)} = -104 + 20.455\ \mathbf{ln(GDP)} - 0.942\ \mathbf{In(GDP)^2} \qquad (5.5)$$

$$(-3.7) \quad (3.65) \quad (-3.3)$$

Adj $\mathbf{R^2}$ = 0.984 , **D-W** = 2.147 , (1970-1990)

Petroleum consumption has grown at an annual rate of 16.31 %.

Figurte 5.3 Actual & Fitted Electricity Intensity of Use vs GDP 1971-1990.

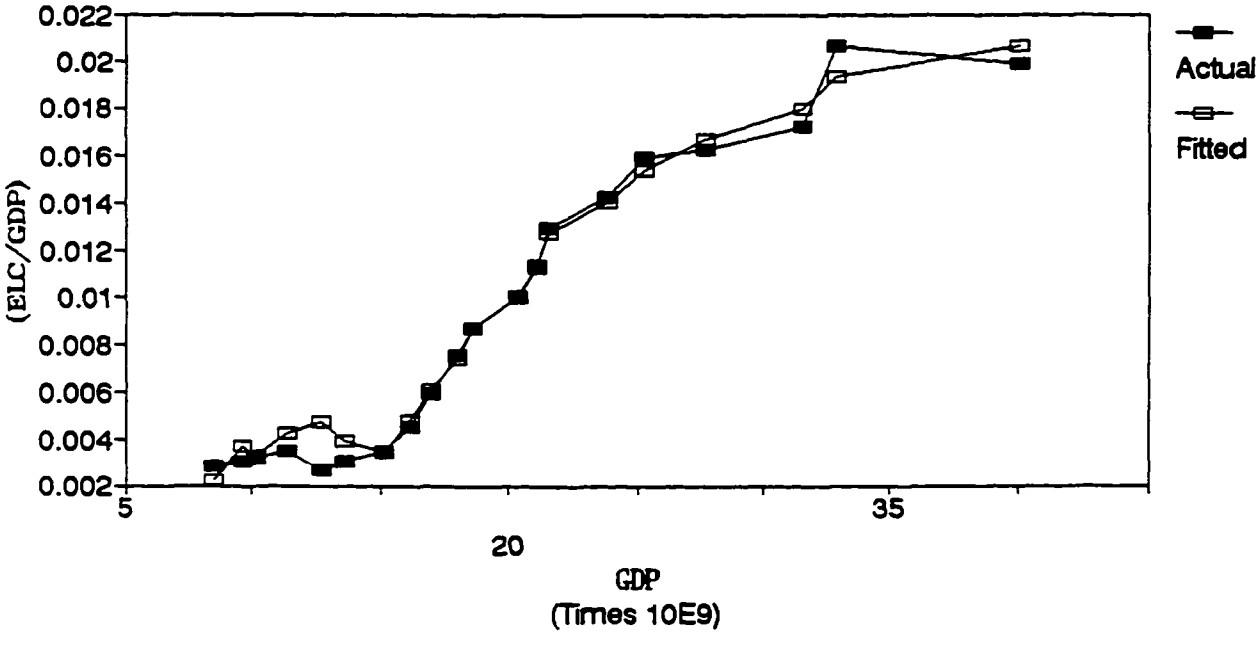


Figure 5.4 Actual & Fitted Petroleum Consumption vs Real GDP 1971-1990.

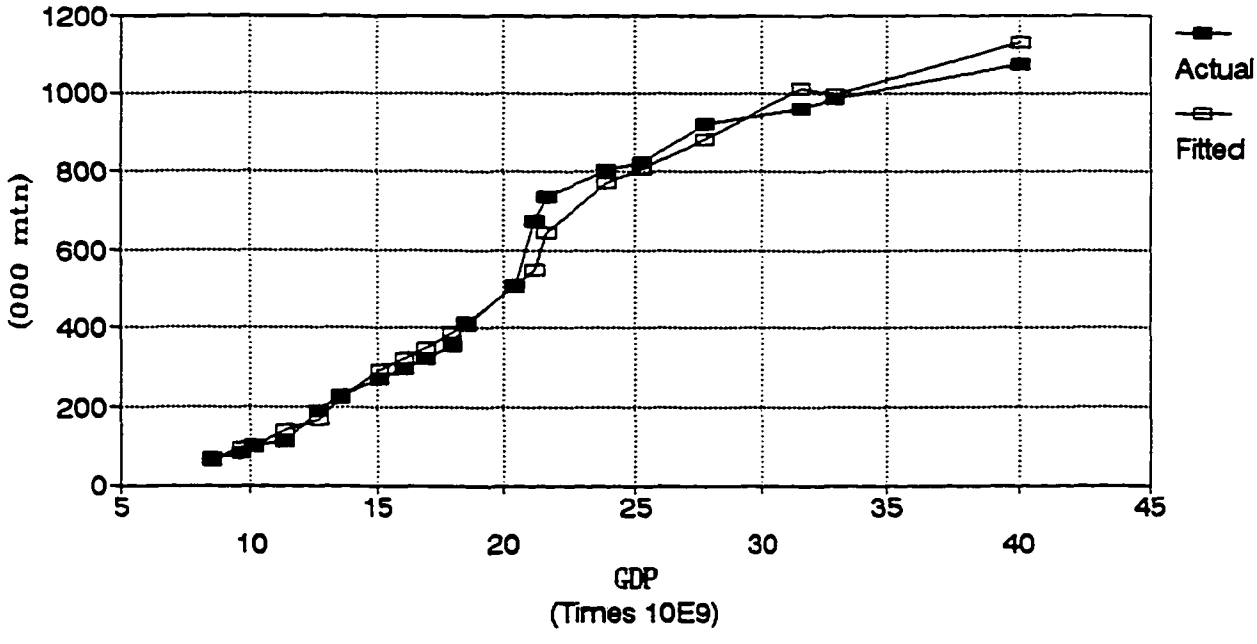


Figure 5.5 shows that the intensity of use of petroleum over time increased for the period 1971-1984 at an annual rate of 11.07 %, and then from 1984 to 1990 the intensity of use decreased at a rate of 3 % annually. This decrease in intensity of use can be explained by the fact that, in 1984, the government of North Yemen adopted a self sufficiency goal for the agricultural sector. This resulted in the prohibition of the import of fruit to protect domestic production. This policy resulted in an increased share of GDP by this sector compared to an almost constant level of energy use, so the share of energy consumption to GDP decreased.

The relationship between intensity of use and GDP is described best by a simple translog model (equation 5.6), which, after correction for autocorrelation, shows a significant effect of GDP (economic growth) on intensity of use with an income (GDP) elasticity of 1.07 at the mean of GDP. The actual and fitted data are shown in figure 5.6.

$$\ln(TPETC/GDP) = -104.264 + 19.51 \ln(GDP) - 0.944 \ln(GDP)^2 \quad (5.6)$$

$$(-3.7) \quad (3.48) \quad (-3.35)$$

Adj R^2 = 0.943 , D-W = 2.147 , (1970-1990)

This result indicates that as income increases the intensity of use for petroleum increases up to an income level of approximately 21,653 MYR, after which IU declines.

Figure 5.5 Ratio of Petroleum Consumption to Real GDP. 1971-1990

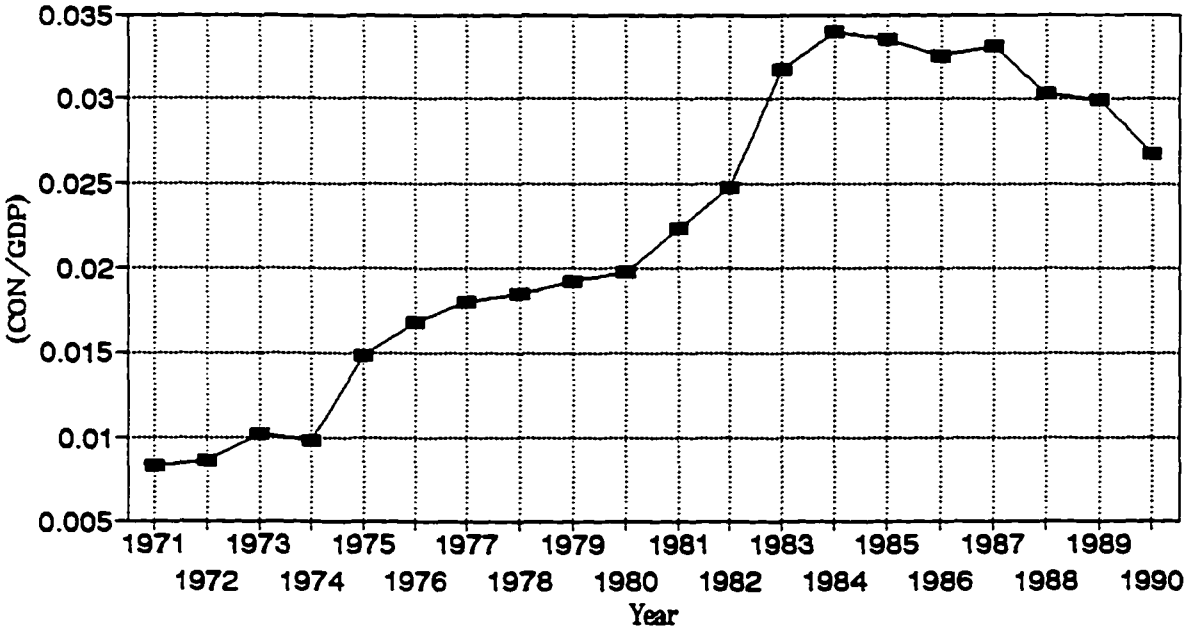
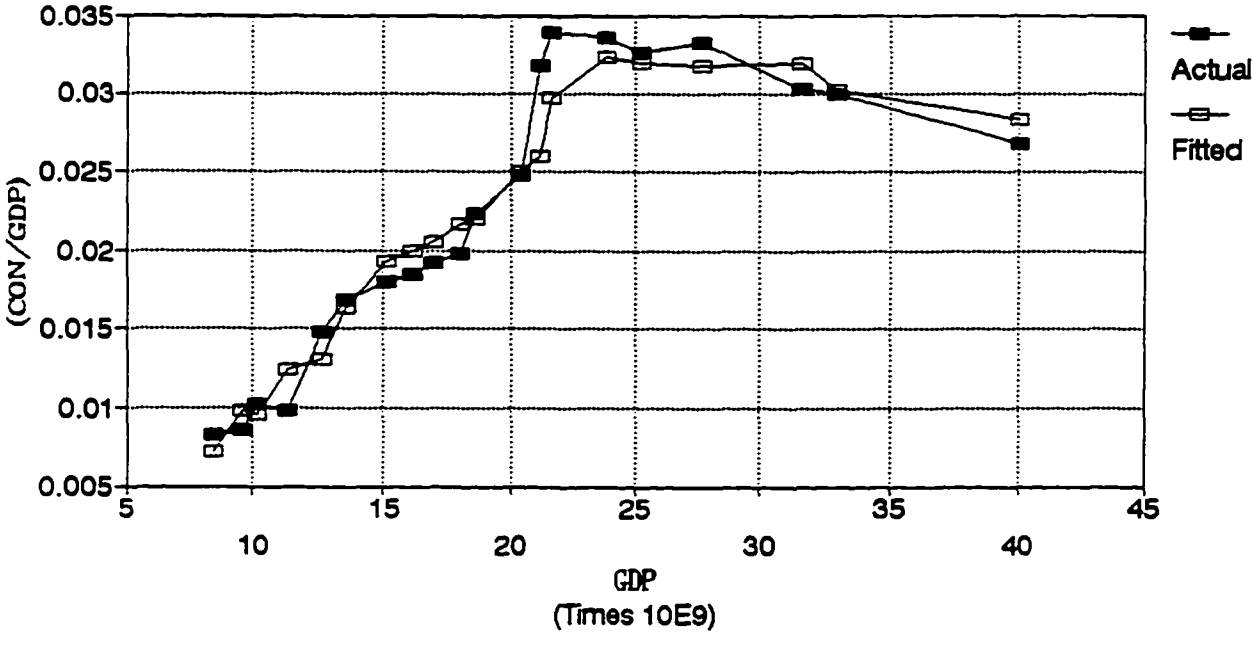


Figure 5.6 Actual & Fitted Petroleum Intensity of Use vs GDP 1971-1990.



Summary of Findings

In general, our findings support the result reported by Ibrahim Ibrahim (1985) that in the less developed countries economic growth is the main factor in explaining changes in the demand for commercial energy, petroleum, for 13 developing countries for the period 1970 - 1985. Ibrahim also found that the elasticity of demand with respect to (GDP) is greater than one for all the countries under his study.

The intensity of use of electricity shows an increasing trend over time, and this result supports our previous result that the elasticity of demand with respect to income is greater than one. The intensity of use of petroleum shows an increasing trend up to the mid 1980s, after which it declines for reasons described earlier.

Although, the values of R^2 are high, the values of the D-W statistic, in some equations, are still low, even after the Cochran Orcutt correction for autocorrelation. This result indicates that, beside the gross domestic product there are some other factors that affect the demand for commercial energy in Yemen. So, the result above is measuring only the relationship between the gross domestic product and commercial energy consumption when the effects of other factors are omitted from the equation. The preferred solution to the autocorrelation problem is to include the missing variables in the model. This is examined in the coming sections.

CHAPTER 6

THE DEMAND FOR ELECTRICITY

Introduction

This chapter examines the essence of the distributed lag (stock of adjustment) hypotheses both theoretically and empirically. As one of the main objectives of this study is to construct and estimate a simple econometric model for energy consumption in Yemen, the model must be simple because of severe data limitations on useful economic variables.

The format of this chapter is as follows: Section 2 is a historical review of electricity consumption in Yemen. Section 3 reviews the theory of stock adjustment and formulates a total aggregate electricity consumption function and individual sectoral consumption functions. Section 4 includes empirical estimates of elasticities, and finally the chapter ends with a summary of findings .

The total electricity function is estimated for the period 1975 - 1990, but functions for each sector are estimated only for the shorter period 1981 - 1992.

Historical Overview

It was in 1959 that the first electrical service was introduced in North Yemen. That service was offered by a local private company called Sana'a Electrical Company for lighting Sana'a, the capital, and its suburbs. Other private companies introduced electricity to other main cities, like Taiz and

Hodidah. The costs of fuel were high, especially after the 1973/74 oil crisis. As a result, distribution of electrical services were limited, and the lack of capital prevented the expansion necessary to meet demand. To respond to those crises the government of North Yemen established, in 1975, a public utility called the Yemen General Electric Corporation (YGEC), which absorbed and supervised private companies.

To expand its services, Yemen General Electric Corporation established a power generating station in Hodidah. Some of the major cities, such as Hodidah, Sana'a, Taiz, Amran, and Saadah then were connected with high voltage lines.

In september 1983, a second power station, at Ras Al Kateeb, started to operate with a total capacity of 150 megawatts. This hydro facility utilizes tidal motion for generation and has relatively low unit production costs.

Similar to the Ras Al Kateeb facility, a second hydro plant, in Mocha, came into service in 1983, with a total of 160 megawatt capacity. With these major developments, it was hoped that they would contribute much to meet the demand in most of the southern region of North Yemen.

As is typical of many LDCs, irregularity of electrical current has made industrial enterprises in North Yemen buy small diesel generators and generate their own electricity. Also, because of the unavailability or very expensive electrical connections, part of the population is still dependent on kerosine or diesel, using small generators for

lighting , and wood and butane for cooking.

Electricity Consumption in Yemen

In Yemen, two different groups consume electricity: residential and productive. Productive consumers are included in sectors that represent the supply side elements of the country,s economy. Productive consumers comprise commercial, agricultural, industrial and others. More than one subsector is included in each sector; for example, agricultural includes agriculture, forestry and fishing. Mining, quarrying, and manufacturing are included in the industrial sector. The sector defined as "others" includes government services, pumping water, and street lighting.

During the period under study, 1971-1990, the total demand for electricity in Yemen increased at an annual rate of 21.36 %. Total consumption increased from 41.5 gigawatt hours (GH) in 1975 to 863 GH in 1991. Consumption by the residential sector increased from 115.2 GH in 1982 to 373.6 GH in 1991; the commercial sector increased from 41 GH in 1982 to 211 GH in 1991; agricultural and industrial sectors increased from 2 and 29 GH, respectively in 1982 to 7.7 and 205.1 GH in 1991; and the sector defined as others increased from 15.8 GH in 1982 to 65.6 GH in 1991 (table 6.1). Consumption within the residential, commercial, agricultural, industrial, and other economic sectors increased at annual rates of 13.67 %, 19.55

Table 6.1
Electricity consumption in Yemen (1971 - 1991)
(Gigawatt-Hours)

	1971	1976	1982	1986	1991
Total electricity		41.5	203.8	402.7	863
Sector:					
Residential	--	--	115.2	192.9	373.6
Commercial	--	--	41	96	211
Agricultural	--	--	2	5.6	7.7
Industrial			29	81	205.1
Others[39]	--	--	15.8	27.	65.6

Source: Annual reports by the Ministry of Power in Yemen, 1975 - 1991.

[39]This includes public buildings, pumping water, and street lightning.

%, 12.37 %, 27.52 % and 15.68 % respectively (table 6.2)[40].

The Stock of Adjustment Theory of Demand

In this section, a model to estimate the total demand for electricity and the demand for electricity by sector is described. This model is built according to the stock adjustment theory of demand. This structure is adopted because it allows for distinguishing short and long run effects of changes in price, income and other explanatory variables on the demand for electricity.

Stock of adjustment theory of demand assumes that at price P_t and income Y_t the consumer has a desired level of consumption Q^*_t, but the actual change in consumption $Q_t - Q_{t-1}$ is proportional to the difference between the desired consumption Q^*_t and Q_{t-1} :

$$Q^*_t = B_o + B_1P_t + B_2Y_t + U_t \qquad (6.1)$$

$$Q_t - Q_{t-1} = s(Q^*_t - Q_{t-1}) \qquad (6.2)$$

where:

$0 < s < 1$ the speed of adjustment

By substituting (6.1) in (6.2) we have:

$$Q_t - Q_{t-1} = s(B_o + B_1P_t + B_2Y_t + U_t - Q_{t-1}) \qquad (6.3)$$

By arranging equation (6.3) we get:

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[40]all values by type of sectors represent the period from 1982-1991.

Table 6.2
Annual growth rate in electricity consumption
(1971 - 1991)

	1971-1981	82-86	86-91	82-91	71-91
Total electricity	20.86%			18.05%	21.36%
Sector:					
Residential	--	14.60	13.73	13.67	--
Commercial	--	24.81	18.39	19.55	--
Agricultural	--	31.44	5.26	12.37	--
Industrial	--	30.24	25.52	27.52	--
Others	--	11.5	16.75	15.68	--

Source: Same source as table 6.1, using the annual growth rate model to calculates growth rates.

$$Q_t = sB_o + sB_1P_t + sB_2Y_t + (1-s)Q_{t-1} + sU_t \quad (6.4)$$

$$Q_t = a_o + a_1P_t + a_2Y_t + a_3Q_{t-1} + e_t \quad (6.5)$$

where:

$$a_o = sB_o \quad (6.6)$$

$$a_1 = sB_1 \quad (6.7)$$

$$a_2 = sB_2 \quad (6.8)$$

$$a_3 = (1-s) \quad (6.9)$$

$$e_t = sU_t \quad (6.10)$$

The model also can be formulated in logarithms as:

$$\ln Q_t = a_o + a_1 \ln P_t + a_2 \ln Y_t + a_3 \ln Q_{t-1} + e_t \quad (6.11)$$

If we let N and $\hat{N}$ denote the elasticities in the short run and the long run, then for the log-log version (6.11), we have:

$$N_y = a_2 \quad (6.12)$$

$$N_p = a_1 \quad (6.13)$$

$$\hat{N}^Y = \frac{a_2}{1-a_3} \quad (6.14)$$

$$\hat{N}^p = \frac{a_1}{1-a_3} \quad (6.15)$$

When this model is not appropriate or is statistically nonsignificant, the following model will be used instead:

$$Q_t = f(P_t , Y_t , X_t) + e_t \quad (6.16)$$

where:

P_t = price

Y_t = income

X_t = any other variable affecting demand

e_t = error term

Elasticities Estimation

Before discussing estimates, it is important to note that, the price that has been used so far in estimating the total demand for electricity is the average price. Prices for electricity in North Yemen[41] remained constant from 1975 to 1981, 1.10 Rial/kh. Since 1981, there were some changes which ended with an average price of 1.30 Rial/kh. In 1984, tariffs for industrial, commercial, and agricultural sectors were specified as 0.75 Rial/kh. In 1985, modification in these tariffs resulted in 0.65 Rial/kh for the commercial and industrial sectors, whereas, 0.75 Rial/kh remained the same for the agricultural sector.

All equations are estimated using the ordinary least square (OLS), with t-ratios in parentheses under the corresponding coefficient estimates. These equations have been estimated first for the total electricity consumed in the country[42] for the period 1975-1990 and then for each of the major economic sectors: (residential, commercial, agricultural, and industrial) for the period 1982-1990.

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[41]This is current prices.

[42]this is only for north yemen.

Total Electricity Consumption

The total electricity demand function was estimated following the classical theory of demand. In its simplest form, the demand for electricity is specified as a function of the price of electricity (P), income (GDP), and the number of customers (CSTMR) that have access to electricity. The log-log version of the simple model was found to best fit the available data.

$$\ln(TELC) = -6.79 - .18\ \ln(PE^{47}) + .74\ \ln(GDP) + .97\ \ln(CSTMR) \quad (6.17)$$

$$(-5.4) \quad (-2.1) \quad (5.3) \quad (20)$$

$$\text{Adj } R^2 = 0.998 \ , \ \text{D-W} = 2.103 \ , \ (1975\text{-}1990)$$

Examining this result, all estimated coefficients have the right sign as indicated by economic theory. Estimated coefficients are highly significant at the 5 % level except that for price of electricity. The Cochran Orcutt procedure was employed to correct for autocorrelation. Although the sign of the estimated coefficient of price is negative, as dictated by theory, the coefficient is not statistically significant at the 5 % level. Even so, price is included in the model because of its theoretical value to the model. The elasticity of demand with respect to GDP is 0.743, and the demand for electricity with respect to number of customers is nearly

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[47]Price is in real term after deflated by the GDP deflater.

elastic, 0.974. The actual and fitted total electricity consumption is depicted in figure 6.1.

Electricity Consumption by Sectors

Residential Sector[44]:

$$\ln(RSDNT) = -6.775 - 0.357 \ln(PR) + 1.217 \ln(GDP) \quad (6.18)$$

$$(-6.28) \quad (-5.19) \qquad (9)$$

Adj R^2 = 0.970 , D-W = 2.356 , (1982 - 1990)

Commercial Sector:

$$\ln(COM) = -6.8 - .57 \ln(PC) + 1.37 \ln(Y) \quad (6.19)$$

$$(-4.8) \quad (-3.7) \qquad (7.8)$$

Adj R^2 = 0.962 , D-W = 2.179 , (1982-1991)

Agricultural Sector:

$$\ln(AG) = -.88 - 1.02 \ln(PA) + .24 \ln(Y) + 0.127 \ln(AG_{t-1}) \quad (6.20)$$

$$(-2.1) \quad (-18.7) \qquad (4.6)$$

Adj R^2 = 0.997 , D-W = 1.812 , (1982-1991)

Industrial Sector:

$$\ln(INDUS) = -13.99 - .076 \ln(PIN) + 2.24 \ln(Y) \quad (6.21)$$

$$(-6.9) \quad (-.29) \qquad (8.8)$$

Adj R^2 = 0.952 , D-W = 2.427 , (1982-1991)

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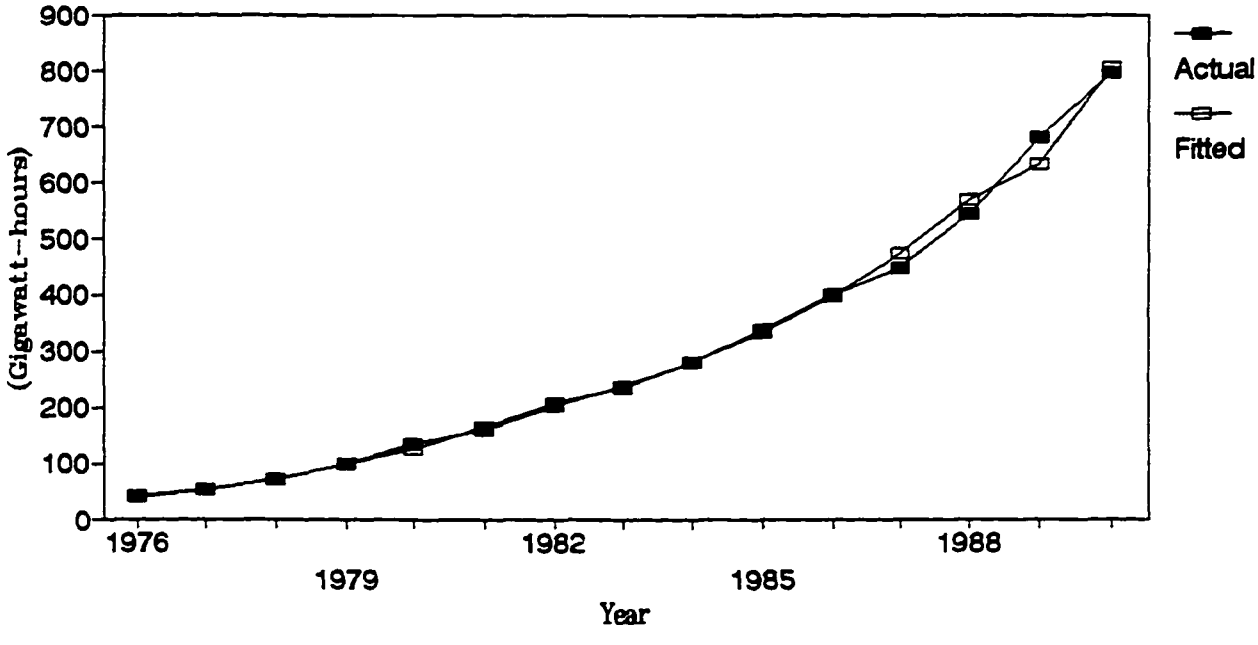
[44]This equation was estimated as consumption per-capita, and because of unavailable data for the price of electricity in this sector, price of electricity in the commercial sector was used as proxy.

Figure 6.1 Actual & Fitted Total Electricity Consumption 1975-1990.



Consumption of electricity by each economic sector was estimated using log-log models, which showed good fits for all sectors. The actual and fitted data are depicted in figures 6.2, 6.3, 6.4, and 6.5, respectively. All coefficients have expected signs indicated by economic theory and are well determined at the 5 % significant level, except for the price of electricity in the industrial sector. The demand for electricity in the agricultural sector is price elastic and well determined at the 5 % level of significance. Although prices for commercial and industrial sectors have the correct signs, price for the industrial sector is nonsignificant at the 5 % level. Even so, price was left in the equation on conceptual and theoretical grounds.

Summary of Findings

In general, D-W statistics indicate the absence of serial correlation and overall, the models fit and explain electricity demand, in Yemen, satisfactorily.

The price of electricity in Yemen was relatively constant[45] over most of the period between 1975 - 1990; it has no significant effect on restraining total electricity demand. The coefficient of average price for total electricity was estimated for the period 1975 - 1990, although it has the correct sign, it is not significant at the 5 % level; nevertheless it was kept in the estimated equation for

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[45] In current term.

Figure 6.2 Actual & Fitted Residential Electricity Consumption 1982-1990.

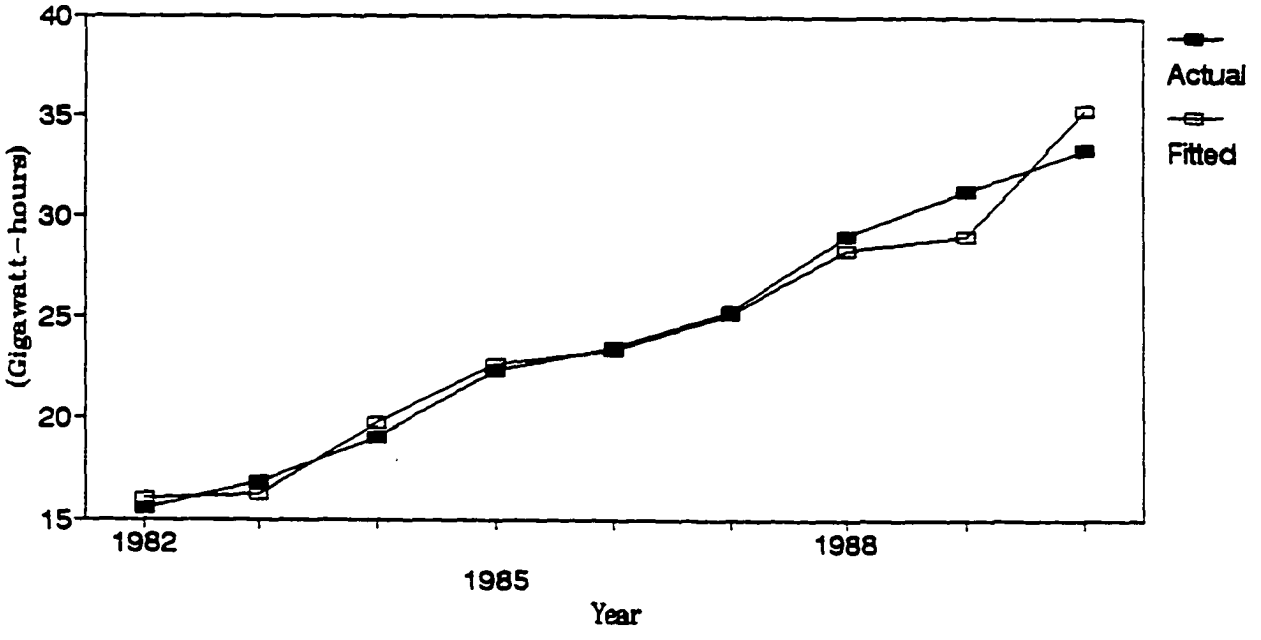


Figure 6.3 Actual & Fitted Commercial Electricity Consumption 1982-1990.

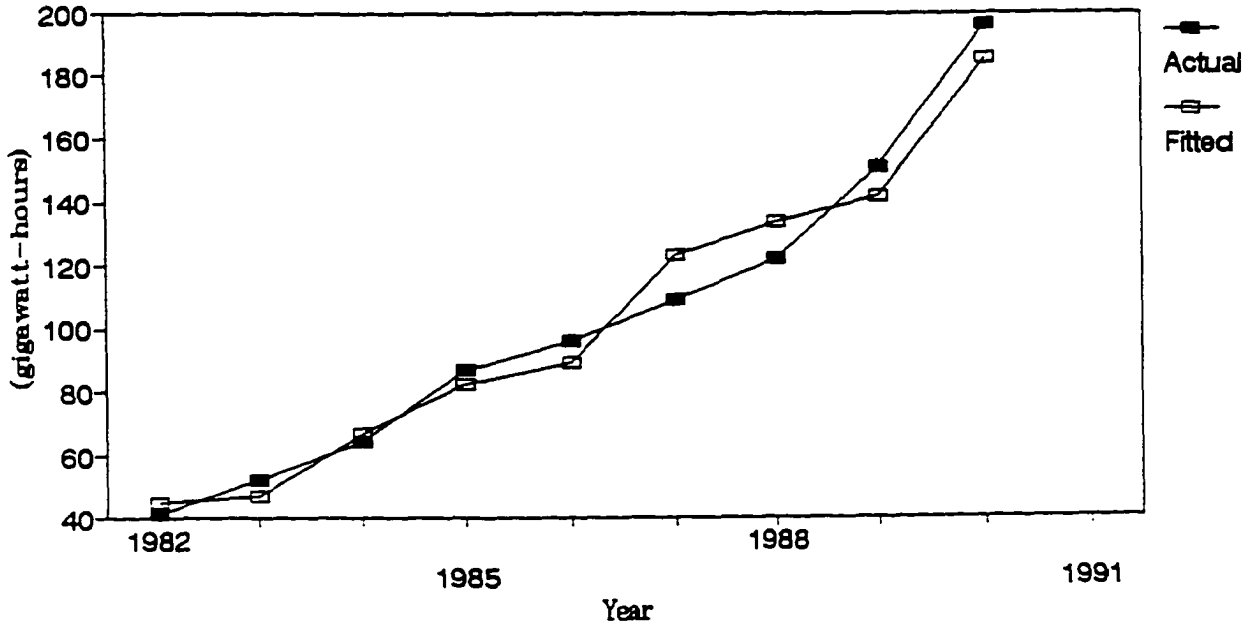


Figure 6.4 Actual & Fitted Agricultural Electricity Consumption 1983-1990.

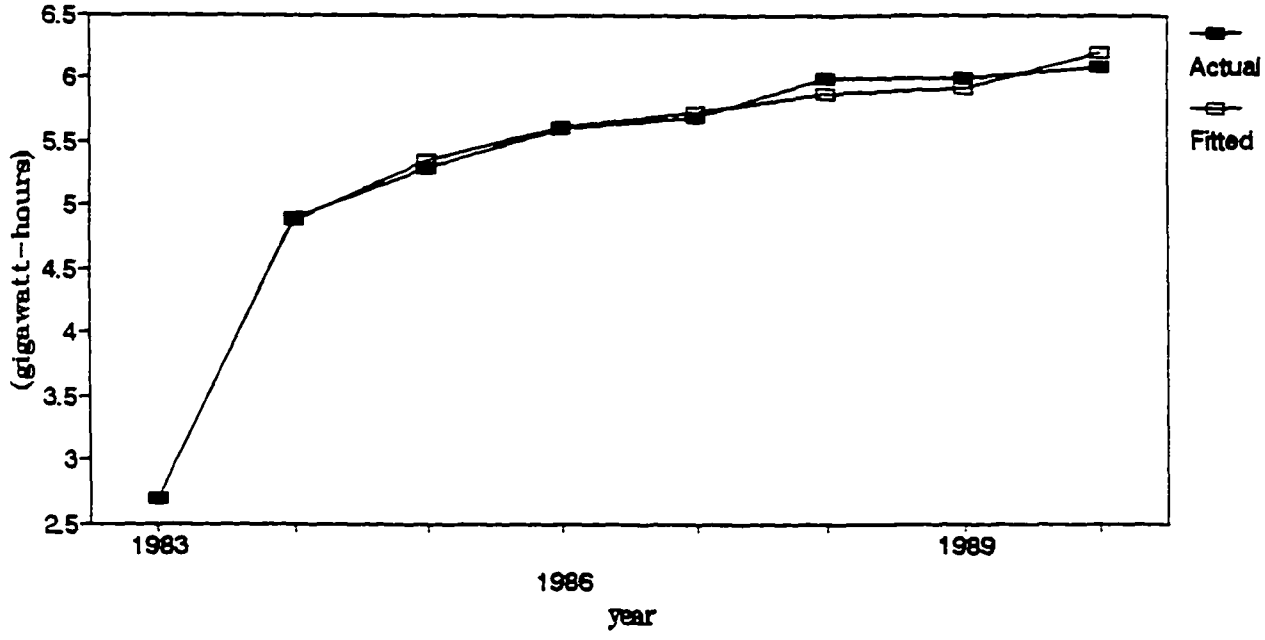
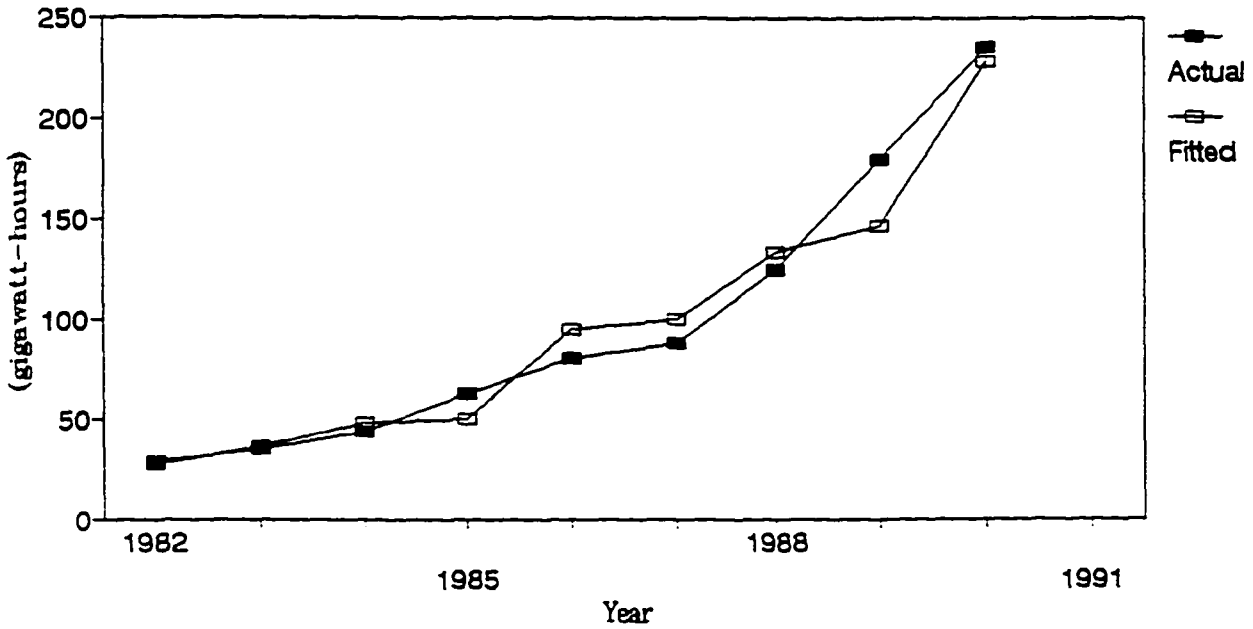


Figure 6.5 Actual & Fitted Industrial Electricity Consumption 1982-1990.



conceptual completeness. An attempt to account for the effect of price of electricity in the residential sector was made, but the requisite data were not available; consequently, the price in the commercial sector was used as a proxy. The only statistically significant effect of electricity prices was found in the commercial and agricultural sectors with elasticities of (-0.57) and (-1.02) respectively.

CHAPTER 7

THE DEMAND FOR PETROLEUM PRODUCTS

Introduction

This chapter presents some empirical estimates of demand elasticities for various type of fuels consumed in Yemen. Because of data limitations, the models are simple and are consistent with economic theory. These equations were estimated for the northern states (former North Yemen).

Equations are estimated for each of five petroleum products: gasoline, diesel fuel, LPG, kerosine, and residual fuel. Most of these products are consumed in the residential and industrial sectors. The quantity data were obtained from the U.N.'s Energy Statistics for the period 1970 -1990 , and from annual reports by the Ministry of Power in Yemen.

Historical Overview

Yemen is one of the poorest LDCs because it had been isolated from the outside world for many decades. Isolation has been especially true of North Yemen. Until the 1950s, Yemen had a very limited use of commercial energy such as kerosine. Other types of commercial energy have been almost non-existent, except for generated electricity for the royal families. Almost all types of energy consumed up to that time came from different sources of non-commercial energy, such as firewood, charcoal, agricultural and animal wastes, which represented the dominant energy sources in the country.

Although commercial energy was used during that time, it represented a very small share of total energy consumed.

It is almost 35 years since the first links of a modern transport network were constructed in North Yemen. That was in the late fifties when primitive tracks, suitable only for four wheel drive vehicles and animal transport, connected major towns and were the only means of land transport. Commercial and private transport were very limited, and the number of private and passenger cars, for example, were countable on the fingers of one's hand.

Since the beginning of the 1960's , especially after the 1962 revolution in the North, demand for commercial energy began to increase gradually in the main cities, where electricity and transportation networks were started. Development programs were constrained by the civil war, which lasted for almost nine years. Since the beginning of the 1970s, developments in many areas were constructed by the government and private sectors, which allowed for the use of commercial energy especially in the agricultural and industrial sectors. As a result, demand grew for commercial and private transport stocks, as the transportation network expanded all over the country.

Importation and distribution of petroleum products were part of the Yemen Petroleum Company's responsibilities. In 1978, this company became a subsidiary of the newly formed and government owned Yemen Oil and Mineral Resources Corporation,

(YOMINCO).

Petroleum Consumption

Up to this moment, many different types of petroleum products have been used in different areas. Products such diesel, gasoline, kerosine, LPG and residual fuels are the dominant commercial energy products in the country.

Diesel is the largest component petroleum product consumed in the country; in 1990 diesel accounted for about 52.2 % of total products consumed. Diesel oil is generally used as a fuel for internal combustion in diesel engines, as "a burner fuel in heating installations, such as furnaces, and for enriching water gas to increase its luminosity"[50]. In Yemen, diesel oil has been used in commercial transportion, agriculture, generating electricity and in previous years for pumping water.

Motor gasoline is the second largest fuel used in the country. In 1990, it accounted for 17.2% of the total products consumed, and it was used totally by the transportation sector, especially by passenger cars, private cars, and taxis.

In 1990, 82 thousand metric tons of kerosine were consumed in the country. The growth rate in kerosine consumption is the lowest among the products: 7.46% annually. In general, kerosine is used mostly as" an illuminant and as

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[50]" " definitions by the United Nations.

a fuel in certain types of spark ignition engines, such as those used for agricultural tractors and stationary engines". In Yemen, kerosine is used mostly in the residential sector for cooking and lighting purposes, especially in the rural areas were electricity connections are limited or nonexistent. In recent years, the use of kerosine has been decreasing, the reason being the shift to LPG for cooking and diesel for lighting, using small diesel generators, especially in villages and rural areas.

The highest growth in the consumption of petroleum products in Yemen is in the use of LPG; consumption of this product grew at 26.8 %. The growth rates for the other products are, residual 24.51%, diesel 18.02%, gasoline 13.75%, and 7.46% in kerosene. Although LPG is used mostly in the residential sector in urban areas, its use is spreading all over the country. At some point in the future, it will replace the use of kerosine, especially for cooking.

Residual fuel was reported to be the third largest product consumed in the country; for example, in 1990 it accounted for 13.4 % of the total petroleum consumed. This product is commonly used by "ships and industrial large-scale heating installations as a fuel in furnaces or boilers"; it is also known as Mazot. In Yemen, Mazot is used mostly in generating electricity and in industrial processes, especially in the large-scale industries such as the production of cement.

Model Form

Simple log-linear models with a Koyck lag to explain the dynamic adjustment of demand to changes in income and price will be estimated in the form:

$$\ln Q_t = a + B \ln Y_t + C \ln P_t + D \ln Ps_t + \$ \ln Q_{t-1} + e_t \quad (7.1)$$

Where:

Q_t = quantity consumed of type of fuel per capita.

Y_t = GDP per capita.

P_t = price of type of fuel.

Ps_t = substitute price.

Q_{t-1} = lag one year.

e_t = error term.

When this model is not appropriate or the stock adjustment term is not statistically significant, a simple linear model is used instead.

Prices for each of each individual product weren't available for the total period under study ; therefore, an index of prices which represent the consumer prices of fuel, is used instead. Using this price index obviates modeling the effect of substitution between specific types of fuels, which in fact is significant in energy demand in general.

Elasticities

The elasticities reported are to be considered as general indicators rather than the exact estimates, since they are based on a crude and simple model of demand and a price index.

Time Trends

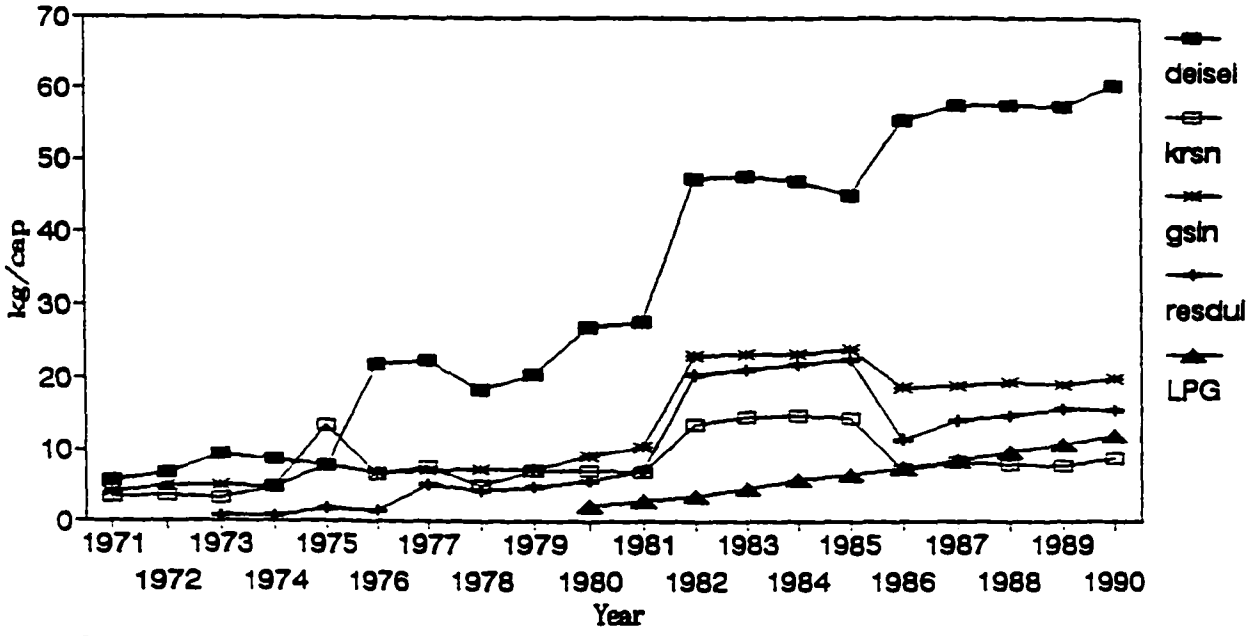
Before discussing the estimated equations, it is useful to examine the behavior of petroleum product prices and consumption of each product over time. The per capita consumption of each of petroleum product over time is shown in figure 7.1, and a price index representing consumer price for fuel is shown in figure 7.2.

The price index increased during the estimation period. The growth of the money supply during the 1970s permitted such an increase. In order to ease inflation the government of North Yemen allowed the foreign exchange provided by worker's remittances to permit such a policy. The increase in fuel prices during the 1980s is due to the restriction of imports imposed by the government. This in its turn escalated inflation, which could be a serious threat to the economy of Yemen. Per capita consumptions of diesel, gasoline, kerosine, LPG, and residual have been growing at annual rates of 12.03 %, 8.78 %, 5.84 %, 22 % and 12.93 % respectively. This increase in consumption is due to the increase in real per capita GDP, which has been growing at an annual rate of 4.5 %.

Petroleum Consumption by type of fuel

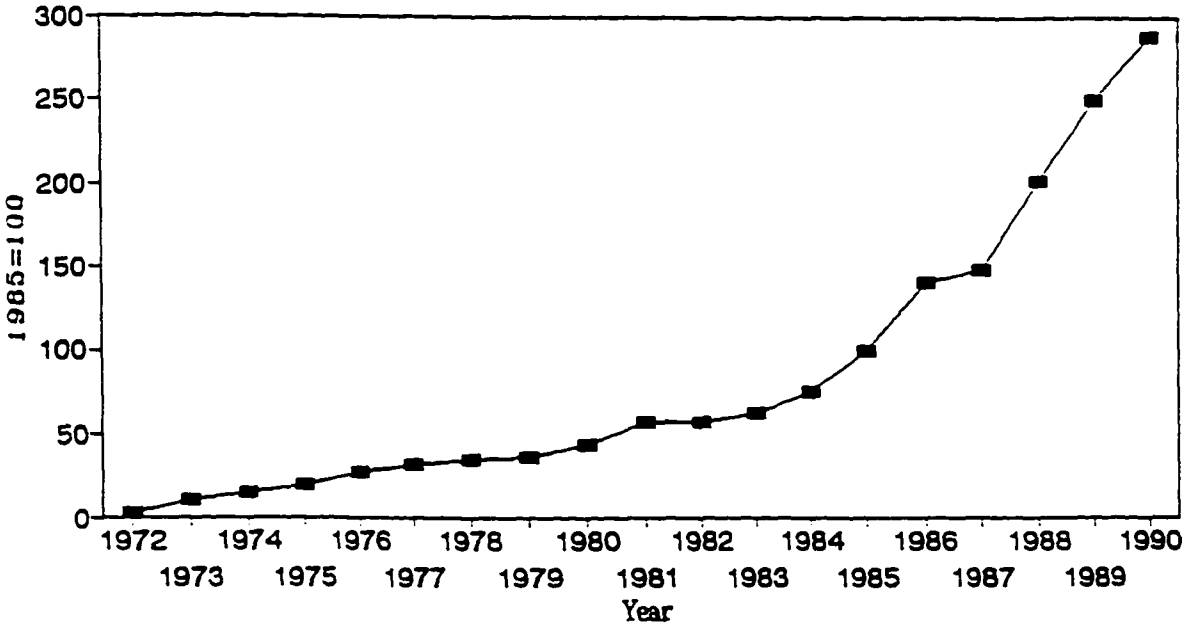
Simple log-linear model and log log models were found to best fit the consumption data for diesel and LPG, equations

Figure 7.1 Per-Capita Petroleum Products Consumption 1971-1990.



Source: United Nation: Energy Statistics Yearbooks. All values are divided by total population. LPG data are collected from reports issued by the statistical department in the Ministry of Oil and Mineral Resources in Yemen.

Figure 7.2 Consumer Fuel Price Index 1985 = 100



Source: Yemen Arab Republic Statistical Year Books: The Statistical Abstract of the Region of Economic and Social Commission for West Asia.

Note : Because of the different price indexes, the following equation was applied to establish a consistent price index:

$$K = \frac{IA_{1981}}{IB_{1981}} = \text{the multiplier}$$

(7.2) and (7.3), respectively. Initial estimates of these equations show that all coefficients are well determined at the 5 % level of significant except for the constant term in the demand for diesel, which was found to be nonsignificant. Thus, the equation for diesel was re-estimated with the constant suppressed, giving equation (7.2). Equation (7.2) is the result of procedures to correct for autocorrelation. The equations explain demand satisfactorily. The actual and fitted data are shown in figures 7.3 and 7.4, respectively.

Demand for Diesel:

$$\ln(DISL) = -0.0072\ (PI) + .001174\ (GDP) + .0237\ (DIS_{t-1}) \quad (7.2)$$

$$(-5.3) \qquad (18) \qquad (3.54)$$

Adj R^2 = 0.881 , **D-W** = 2.37 , (1972-1990)

Demand for LPG:[51]

$$\ln(LPG) = -5.57 - .248\ln(PI) + .855\ln(GDP) + .957\ln(LPG_{t-1}) \quad (7.3)$$

$$(-3) \quad (-3.5) \qquad (3.4) \qquad (13.9)$$

Adj R^2 = 0.994 , **D-W** = 2.725 , (1980-1990)

Linear models were found to best fit the data on demand for gasoline, kerosene and residual, equations (7.4), (7.5) and (7.6) respectively. All estimated coefficients are well determined at the 5 % level of significance with signs

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[51]The data for this product were collected from the Ministry of Mineral and Oil Resources in Yemen.

Figure 7.3 Actual & Fitted Per-Capita Diesel Consumption 1972-1990.

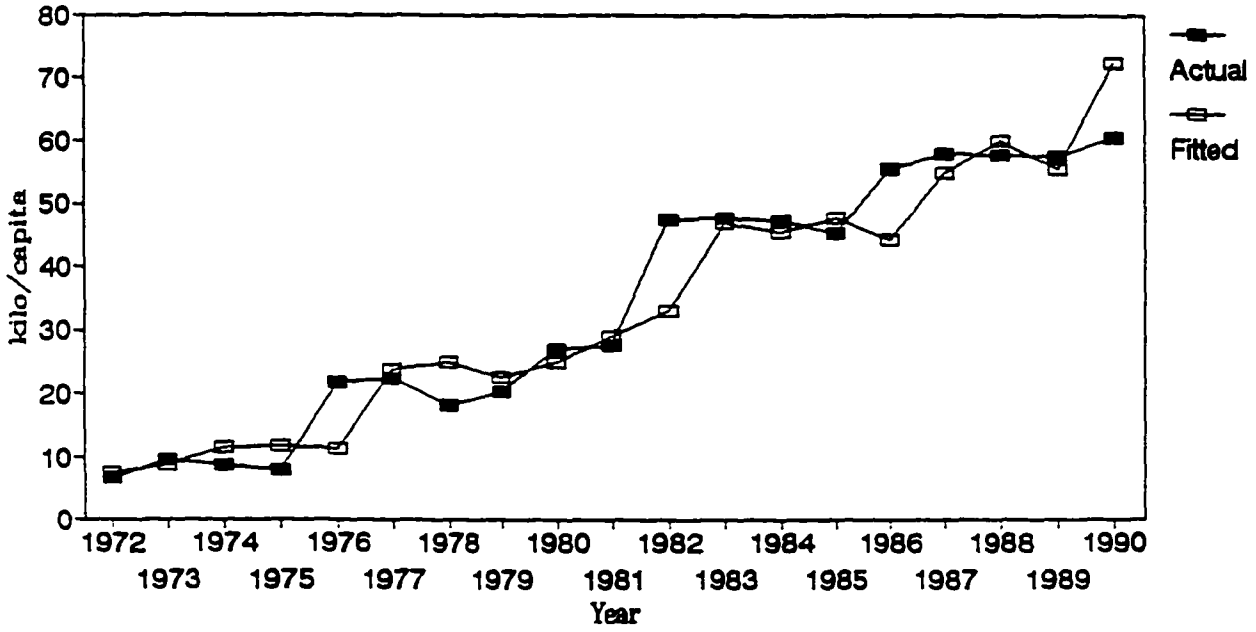
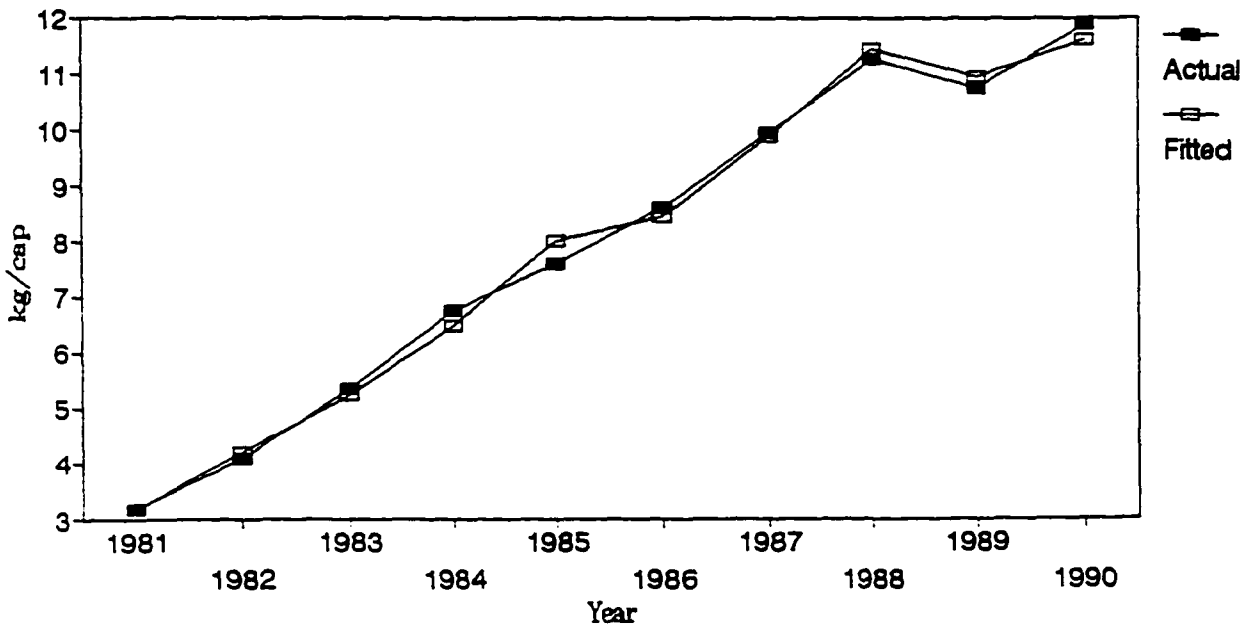


Figure 7.4 Actual & Fitted Per-Capita LPG Consumption 1980-1990.



expected from economic theory. Although the procedures for autocorrelation were employed, the value of the D-W statistic in equation (7.5) is still low, (1.275), indicating significant autocorrelation still remains. Actual and fitted data are depicted in figures 7.5, 7.6, and 7.7 respectively.

Demand for Gasoline:

$$\mathbf{GSLN} = -16.07 - 0.063\ \mathbf{(PI)} + 0.01\mathbf{(GDP)} + .715\ \mathbf{(GSLN_{t-1})} \quad \mathbf{(7.4)}$$

$$(-2.11) \quad (-2.2) \quad (2.45) \quad (5)$$

Adj $\mathbf{R^2}$ = 0.848 , **D-W** = 1.80 , (1972-1990)

Demand for Kerosene:

$$\mathbf{KRSN} = -17.136 - 0.091\ \mathbf{(PI)} + 0.0124\ \mathbf{(GDP)} \quad \mathbf{(7.5)}$$

$$(-2.38) \quad (-3.19) \quad (3.56)$$

Adj $\mathbf{R^2}$ = 0.384 , **D-W** = 1.275 , (1972-1990)

Demand for Residual:

$$\mathbf{RSDUL} = -33.0 - 0.113\ \mathbf{(PI)} + 0.017\ \mathbf{(GDP)} + 0.608\ \mathbf{(RSDUL_{t-1})} \quad \mathbf{(7.6)}$$

$$(-2.36) \quad (-2.43) \quad (2.57) \quad (3.74)$$

Adj $\mathbf{R^2}$ = 0.763 , **D-W** = 1.968) , (1974-1990)

Petroleum Consumption for Generating Electricity

Finally, equations (7.7) and (7.8) are estimated models for the demand for products (diesel and residual) used in the generation of electricity, where OTPTDSL and OTPTRSD are

Figure 7.5 Actual & Fitted Per-Capita Gasoline Consumption 1972-1990.

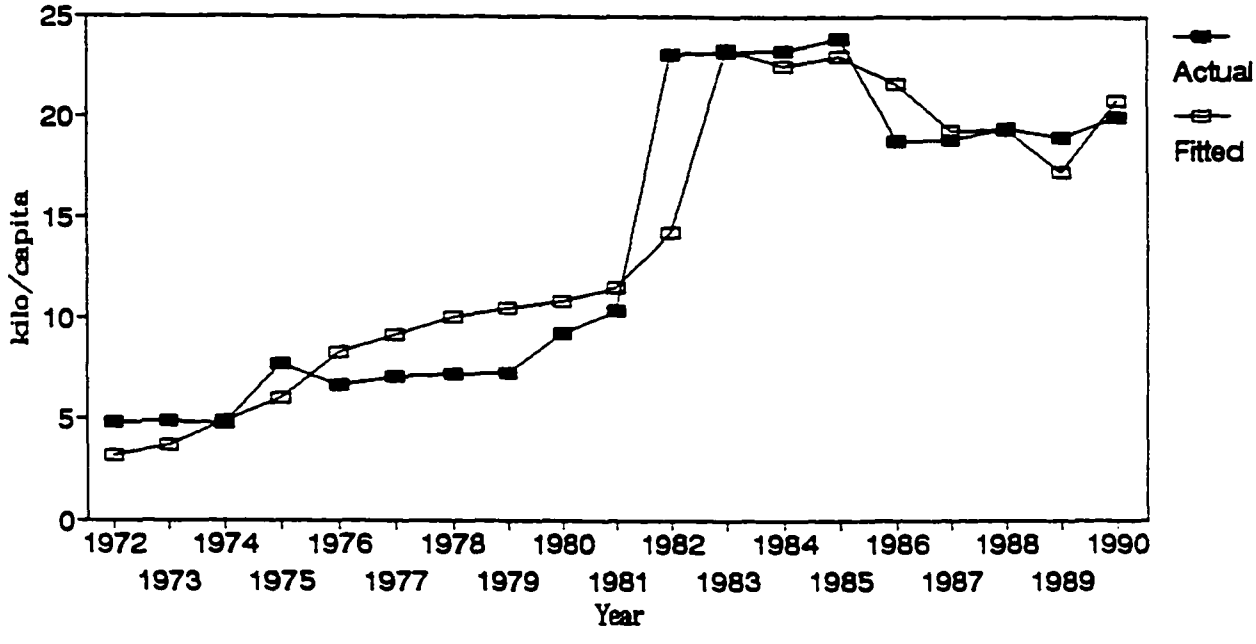


Figure 7.6 Actual & Fitted Per-Capita Kerosine Consumption 1972-1990.

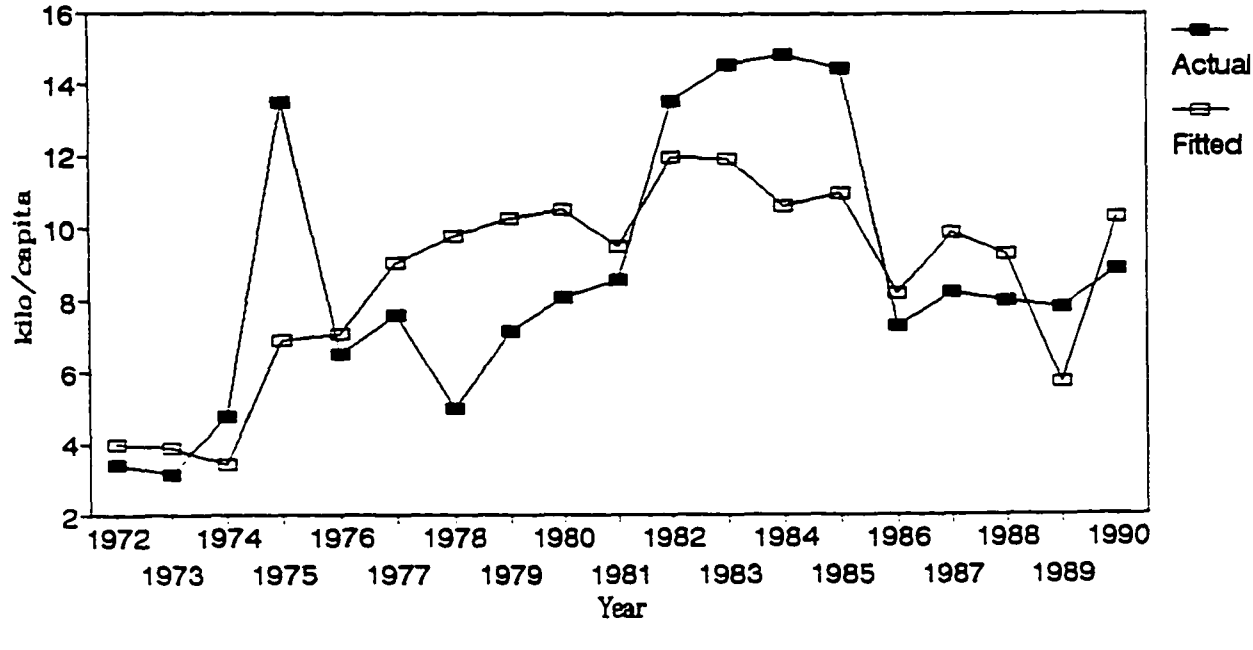
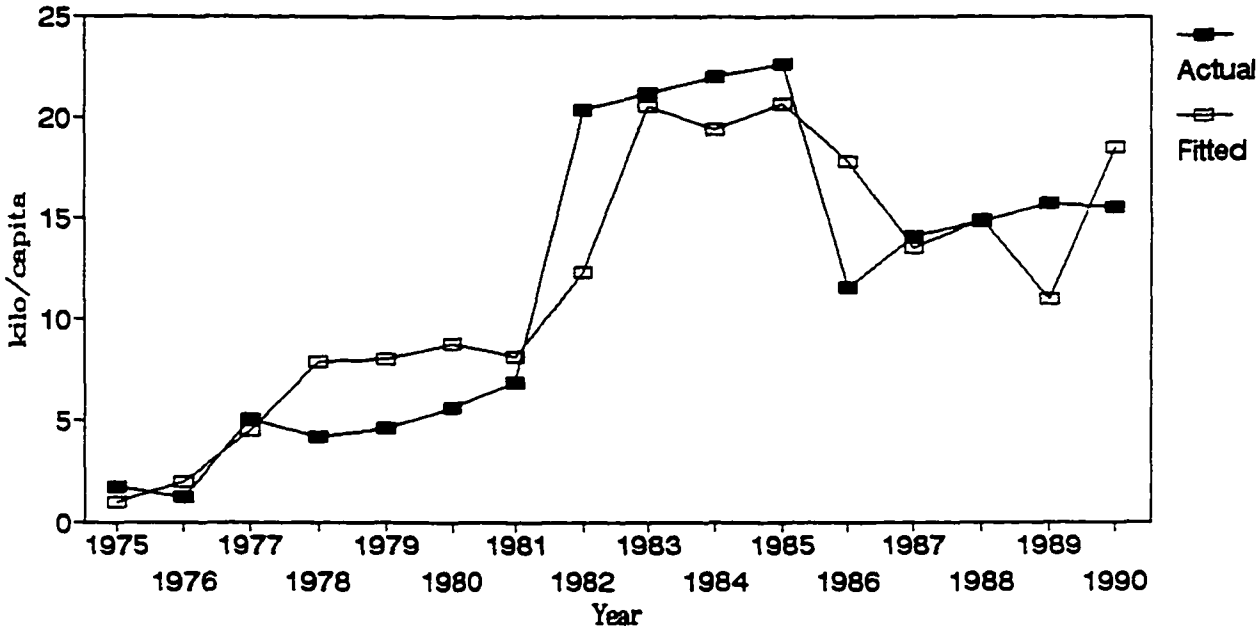


Figure 7.7 Actual & Fitted Per-Capita Residual Consumption 1975-1990.



produced electricity from diesel and residual, respectively. This time, because of availability of data, output in the electricity sector generated by each fuel is used as a shift variable instead of GDP.

The Demand for Diesel Fuel

DISLELC = - 107.6 - 0.52 **ln(PI)** + 29.9 **ln(OTPTDSL)** **(7.7)**

(-5.58) (-0.26) (9.5)

Adj $\mathbf{R^2}$ = 0.917 , **D-W** = 1.886 , (1975-1990)

The Demand for Residual Fuel

ln(RSDELC) = -3.86 -.84 **ln(PI)** + 2.07 **ln(OTPTRSD)** **(7.8)**

(-28) (-13) (39.9)

Adj $\mathbf{R^2}$ = 0.999 , **D-W** = 2.977 , (1983-1990)

Coefficients have the correct signs, as indicated by economic theory, and all coefficients are statistically significant at the 5% level, except for price in the diesel equation. Even so, price was retained in the equation. Demand elasticities for diesel and residual with respect to output are 0.82 and 2.07, respectively, whereas price elasticities are (-0.045) and (-0.84); those elasticities are evaluated at the means of output and price. Actual and fitted values are depicted in figures 7.8 and 7.9, respectively.

Figure 7.8 Actual & Fitted Diesel in Generating Electricity 1976-1990.

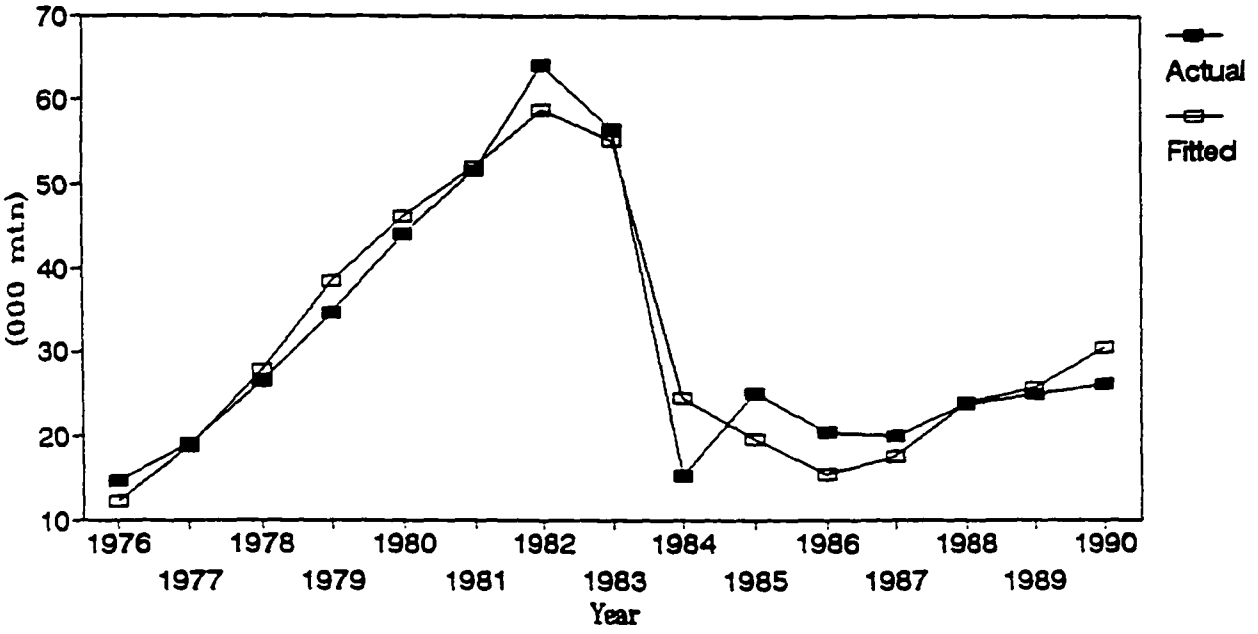
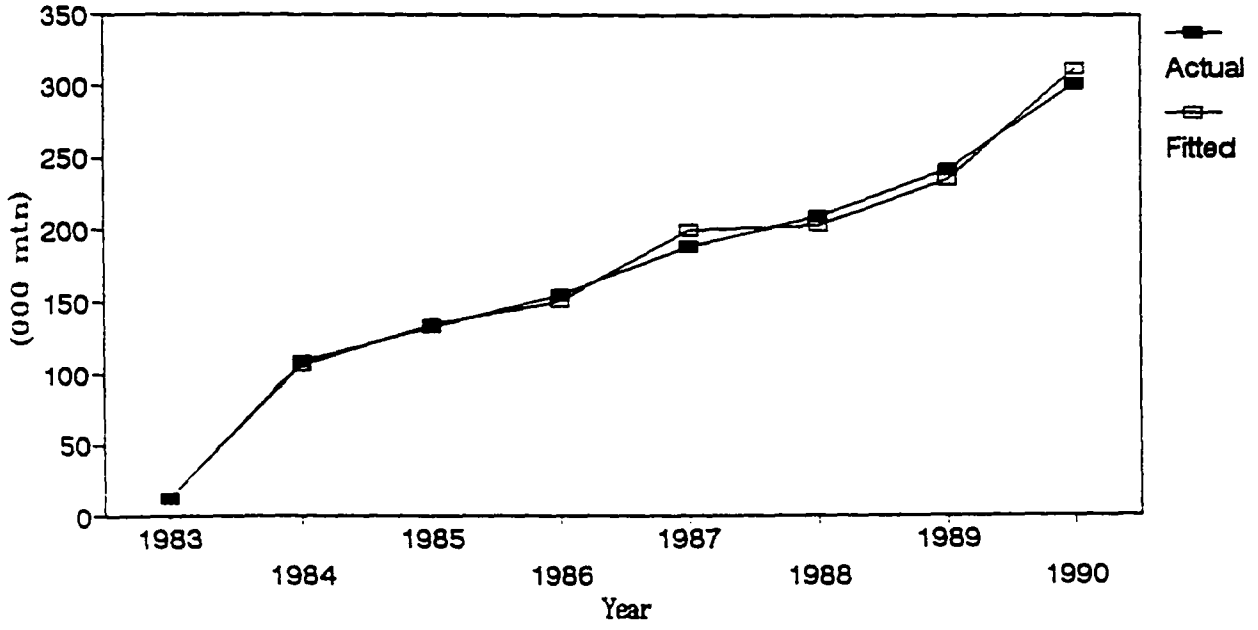


Figure 7.9 Actual & Fitted Residual in Generating Electricity 1983-1990.



Summary of Findings

In general, the demand equations were estimated for each of five petroleum products: diesel, gasoline, kerosine, LPG (much of which are consumed by the residential sector) and heavy (residual) fuel, which is consumed by the industrial sector. Elasticities were evaluated at the means of prices and income.

Looking to the estimated results, one can observe that the demand for diesel product is price-index inelastic (-0.609), but highly income elastic (3.17), as expected. This result supports the argument raised in previous chapters by Pindyk (1979) that this product is mostly used by the residential sector. The constant term was found nonsignificant; consequently, it was dropped from the analysis. The demand for gasoline also is highly income elastic 1.98 but price-index inelastic (-0.387). The demand for LPG product, which is used in the residential sector, is not income elastic 0.855, and it also is price-index inelastic (-0.248).

The estimated results for kerosine indicate that the demand for this product is price-index inelastic (-0.87), but highly income elastic (3.85). Both of these elasticity estimates are statistically significant at the 5 % level.

The estimated model for residual fuel shows highly significant coefficients; estimated price-index and income elasticities are (-0.84) and 3.965, respectively.

CHAPTER 8

ECONOMIC SCENARIOS AND ENERGY POLICY CONSIDERATIONS

Introduction

As mentioned in the beginning of this study, objectives include analysis of the energy consumption in Yemen, investigation of the determinants of demand for commercial energy (electricity and petroleum products), and commentary on selected energy policies.

Previous chapters dealt with the first two objectives, analyzing energy demand and investigating its determinants. In this chapter our objective will be to provide a basis for the analysis of energy policy by establishing projections of future petroleum consumption. The projection period covers the years 1991 - 2000. The assumptions upon which projections are based are discussed below.

This chapter is divided into four sections: the first gives a brief discussion of the findings on the previous chapters; the second section highlights the method employed to make projections of exogenous and endogenous variables; the third section examines selected energy policies in view of the projections; and finally, summary, and conclusions are presented in section four.

Background

It is really hard to predict future energy consumption in Yemen for two reasons: (1) for most of the observed period

prices of energy sources were not permitted to be passed through consistently to users. Therefore equations are not unbiased estimators of true elasticities. (2) given the current economic and political instability, future energy use is highly dependent upon economic growth, and the drag on future economic growth from the degree of regulations is highly uncertain. Under (1) we see that previous chapters showed that income elasticities of energy demand tend to be high, especially in the residential and transportation sectors, while price elasticities were found to be quite low in most cases. Thus, rapid economic growth in Yemen could contribute to large increases in energy consumption. Predicting future energy consumption requires predicting economic growth. Under (2) we see that in the aftermath of the recent war, economic growth in the coming years is highly uncertain because of the impact of the war on some of the economic structures in the country. Some investments will be diverted to rebuild war devastation.

Projection of the Exogenous and Endogenous Variables

As stated in the foregoing, in order to project efficient petroleum consumption, it is necessary to have future values of income and prices, the major determinants of energy consumption. But, because of current political instability, price elasticities are unknown and future income for Yemen is very uncertain and difficult to forecast. Consequently energy

consumption will be estimated for three possible scenarios for economic growth.

Overview of Projection Methodology

The projection methodology employed in this study is very simplistic in that projections are basically driven by scenarios for:

population growth rate, **r**;

per capita income growth rate, **g**; and

intensities of use, **IU**, for specific petroleum commodities.

Given scenarios r^*, g^*, and IU^*_{it}, the future consumption of the ith petroleum commodity in year t, C_{it}, is estimated as follows:

$$C^*_{it} = IU^*_{it} \cdot Y^*_t$$

where

$Y^*_t = y^*_t \cdot N^*_t$, and

$y^*_t = y_0 e^{g^* t}$

$N^*_t = N_0 e^{r^* t}$

N_0, y_0 = population and percapita income for 1990 (t=0). Thus, useful projections of C_{it} require that the scenarios for r^*, g^*, and IU^*_{it} are relevant in exploring possible future states.

Given a projection of C_{it} that is based upon the foregoing model, the price index implied by this projection and the

associated projection of income, Y_t, is estimated using the previously estimated demand equations. These demand equations describe the per capita demand for the ith petroleum product, c_{it}, as a function of the fuel price index, PI_t, and income, Yt, respectively :

$$c_{it} = f(PI_t, Y_t; B),$$

where:

B is a vector of estimated parameters.

Let C^*_{it} be a projection obtained by multiplying IU^*_{it} by Y^*_t . Then, projections of PI_t are obtained by equating the projected C^*_{it} to the product of Y^*_t and per capita demand, determined by evaluating the demand function on Y^*_t:

$$C^*_{it} = Y^*_t \cdot f(PI_t, Y^*_t; B)$$

Solving for PI^*_t,

$$PI^*_t = f^{-1}(C^*_{it}/Y^*_t, Y^*_t; B)$$

Therefore, scenarios on growth rates of percapita income and population and a scenario on intensity of use are the bases for projections of consumption and of the associated price index for each of the petroleum commodities.

Projections made by the foregoing methodology are very crude, as they ignore some very important economic factors and relations. For example, GDP is independent of fuel prices, as represented by a price index. That is, GDP influences consumption, hence price, but price does not affect GDP. Moreover, intensity of use is treated as independent of fuel prices. A more comprehensive analysis would take into

consideration these inter-relation. Additionally, even though the demand for each petroleum product is modeled as a function of the fuel price index, the projection methodology results in different values of the projected price index for the various fuels. Obviously, this violates the notion of price as a fuels price index. The only defense for the use of such a simplistic projection modethodology is that the data required for a more comprehensive analysis are not available. In essence, the decision was made to use available data to examine possibilities, conditional upon the strong assumptions.

Models Re-Estimated for Projection

The first attempt at projection and price estimation revealed a problem with the demand equation for diesel, as described in chapter 7. Although this equation is a good fit to consumption data on the base period, i.e. the data used to estimate its parameters, it is not a useful model for projection. When the determinants differ greatly from their values on the base period, as is the case for the scenario values used for projection, the estimated demand equation produces extreme values. Consequently, a new model was estimated for the projection of diesel consumption, one which employed a constructed price index, P^*_t:

$$P^*_t = f(P_t, P_{t-1}, P_{t-2})$$

$$P_t^* = 0.165\ P_t - 0.179\ P_{t-1} + 1.0137\ P_{t-2}.$$

Where the estimated coefficients for prices are normalized

least squares estimates.

Using the constructed price index, P^*_t, the following demand equation was estimated for total diesel:

$$\mathbf{TOTDISE}_t = -3094.74 - 0.582\mathbf{P}^*_t + 331.773\ln(\mathbf{GDP})_t + 0.509\mathbf{TOTDISE}_{t-1}$$

(-2.44) (-1.057) (2.473) (2.363)

Adj R^2 = 0.946 , **D-W** = 2.076

PROJECTIONS

Basic Conditions for All Scenarios

All scenarios examined in this study assume that population will continue to grow to the year 2000 at its 1970-1990 rate: 2.81 %.

The assumption is made for all scenarios that 1990 intensities of use for the fuels will continue over the projection period:

Diesel = 0.014 TON/MYR

Gasoline = 0.005 TON/MYR

Kerosine = 0.002 TON/MYR

LPG = 0.002 TON/MYR

Residual = 0.004 TON/MYR

Scenario 1

The first scenario is based on the assumption that per capita income will continue to grow at its 1970-1990 growth rate. The projected values of population, per-capita income,

and income are presented in table 8.1.

Table 8.1
Projection of population and GDP 1991-2000

Year	Population (Million)	GDP/cap (YR)	GDP (MYR)
1991	9.770	4024	39314
1992	10.046	4209	42284
1993	10.341	4403	45531
1994	10.63	4605	48974
1995	10.937	4817	52684
1996	11.247	5039	26674
1997	11.567	5271	60970
1998	11.907	5514	65655
1999	12.243	5768	70618
2000	12.593	6033	75974

Using the simplistic projection methodology described above, the projected values of GDP are converted to petroleum fuel consumption by multiplying the GDP values by the scenario values of intensity of use, IU, for each fuel.

Tables 8.2, and 8.3, show the projected consumptions for the fuels, as well as per capita values.

Table 8.2
Projected consumption of petroleum products, 1991-2000
(000 MT)

Year	Diesel	Gsln	Krsn	LPG	Rsdul
1991	550	197	79	118	157
1992	592	211	85	127	169
1993	637	228	91	137	182
1994	686	245	98	147	196
1995	738	263	105	158	211
1996	793	283	113	170	227
1997	854	305	122	183	244
1998	919	328	131	197	263
1999	989	353	141	212	282
2000	1063	380	152	228	304

Table 8.3
Projected per-capita consumption of petroleum products, 1991-2000
Kg/c

Year	Diesel	Gsln	Krsn	LPG	Rsdul
1991	57	20	8	12	16
1992	59	21	8	13	17
1993	62	22	9	13	18
1994	65	23	10	14	18
1995	67	24	10	14	19
1996	71	25	10	15	20
1997	74	26	11	16	21
1998	77	28	11	17	22
1999	81	29	12	17	23
2000	84	30	12	18	24

Using the results of chapter 7, the previously estimated demand equations were used to estimate the price indexes implied by the projected consumptions, given projected per capita GDP and population. Projected total and per capita consumptions are presented in figures 8.1 and 8.2. Implicit prices for projected consumptions of petroleum products are shown in table 8.4 and figure 8.3.

Table 8.4
Projected Index prices 1991-2000
1985 = 100

Year	Diesel	Gsln	Krsn	LPG	Rsdul
1991	258	293	272	287	293
1992	219	307	297	252	291
1993	220	332	313	399	325
1994	217	360	329	334	347
1995	212	390	358	539	384
1996	205	420	366	464	409
1997	190	453	386	544	404
1998	173	471	418	645	473
1999	152	518	440	963	517
2000	127	555	475	871	548

Figure 8.1
Projected Fuel Consumptions

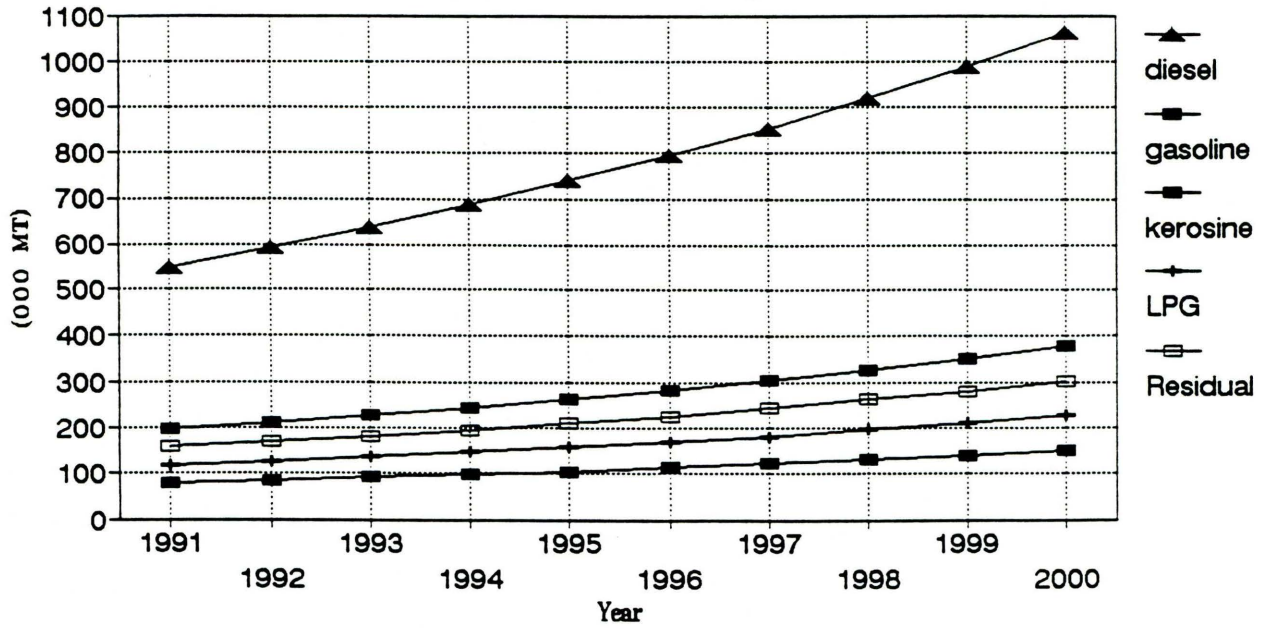


Figure 8.2
Projected Per Capita Fuel Consumptions

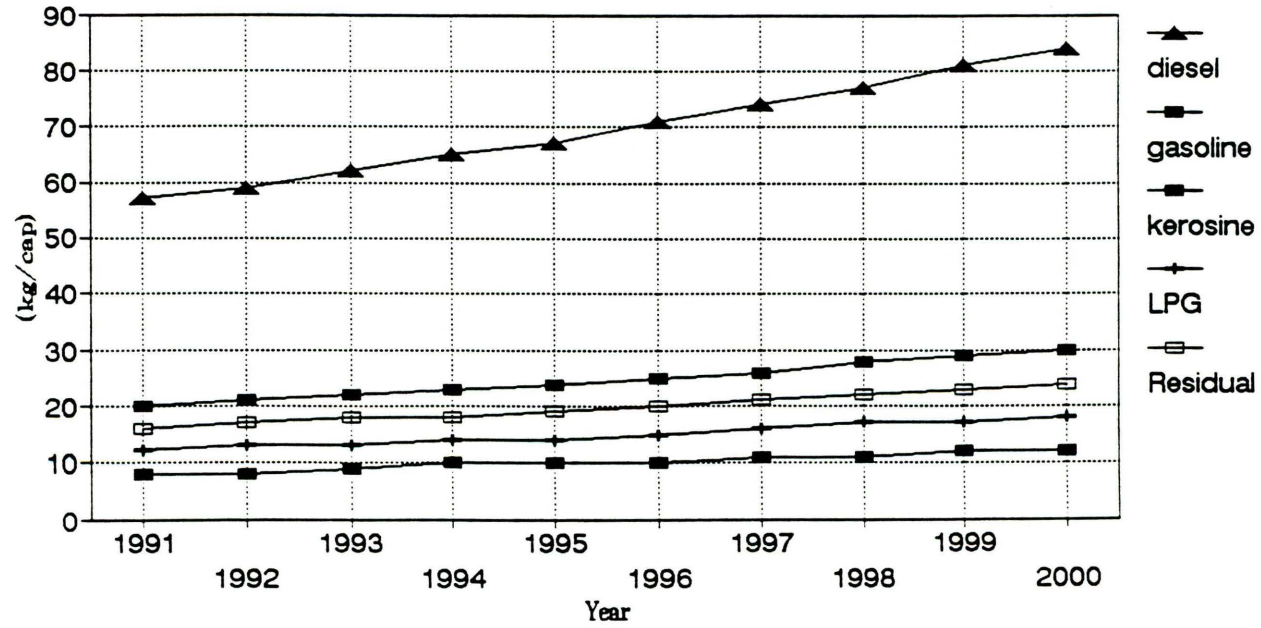
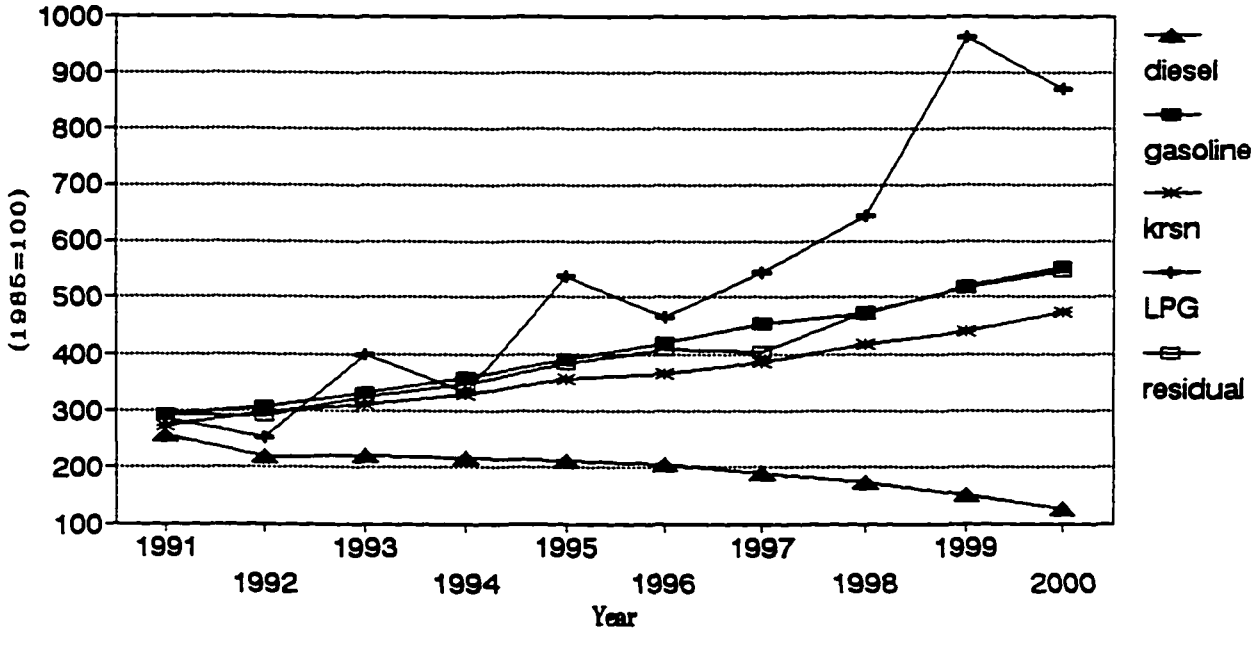


Figure 8.3
Projected Petroleum Index Prices



Scenario 2

The second scenario is of a high growth rate of per capita GDP : 8.9 %. This is the growth rate (g*100) in per-capita GDP (y) during the period 1987 - 1990 :

$$Y_{1990} = Y_{1986}\ (1+g)^4$$

$$4329 = 3079\ (1+g)^4$$

$$1.406 = (1+g)^4$$

$$g = (e^{\ln(1.406)/4}) - 1 = (e^{0.085}) - 1 = 0.089$$

$$8.9\% = 100(g)$$

This high growth rate is in part due to the discovery of oil in Yemen and the exporting of crude oil.

Population growth rate and intensities of petroleum products use are the same as they were for scenario 1 . The projections of GDP, fuel consumptions, and price indexes for this scenario are shown in tables 8.5, 8.6, 8.7, and 8.8 and figures 8.4, 8.5, and 8.6.

Table 8.5
Projection of GDP and GDP-percapita, 1991-2000

Year	GDP (MYR)	GDP/cap (YR)
1991	51312	5252
1992	57674	5741
1993	64890	6275
1994	72945	6859
1995	82006	7498
1996	92180	8196
1997	103629	8959
1998	116593	9792
1999	131049	10704
2000	147338	11700

Table 8.6
Projected fuel consumptions, 1991-2000
(000 MTN)

Year	Diesel	Gsln	Krsn	LPG	Rsdul
1991	718	257	107	154	205
1992	807	288	115	173	231
1993	908	324	130	195	260
1994	1021	365	146	219	292
1995	1148	410	164	246	328
1996	1291	461	184	277	369
1997	1451	518	207	311	415
1998	1632	583	233	350	466
1999	1835	655	262	393	524
2000	2063	737	295	442	589

Table 8.7
Projected fuel consumptions, per-capita
Kg/cap

Year	Diesel	Gsln	Krsn	LPG	Rsdul
1991	73	26	11	16	21
1992	80	29	11	17	23
1993	88	31	13	19	25
1994	96	34	14	21	27
1995	105	37	15	22	30
1996	115	41	16	25	33
1997	125	45	18	27	36
1998	137	49	20	29	39
1999	150	53	21	32	43
2000	164	59	23	35	47

Table 8.8
Projected petroleum index prices 1991-2000
1985 = 100

Year	Diesel	Gsln	Krsn	LPG	Rsdul
1991	121	393	406	228	398
1992	173	491	473	749	481
1993	144	578	524	812	555
1994	105	646	592	1097	635
1995	53	734	669	1808	716
1996	-16	815	753	1845	810
1997	-98	918	835	2980	915
1998	-118	1032	926	4023	1030
1999	-326	1159	1039	4447	1148
2000	-473	1267	1153	6634	1284

Implications of Negative Deisel price Index

Projection of diesel consumption and prices for the high growth scenario and the 1990 intensity of use results in large projections of diesel consumption. When these projected consumptions are considered with respect to the deisel demand equation, along with projected high-growth GDP values, they imply decreasing prices, eventually becoming negative.

There is more than one possible explanation for this result, First, estimation of the diesel demand equation was the most problematic of all the fuels. Probably, this is due in part to the use of a fuels index as the price for diesel. In addition, specification of the model may be inadequate,

Figure 8.4
Projecte Fuel Consumptions

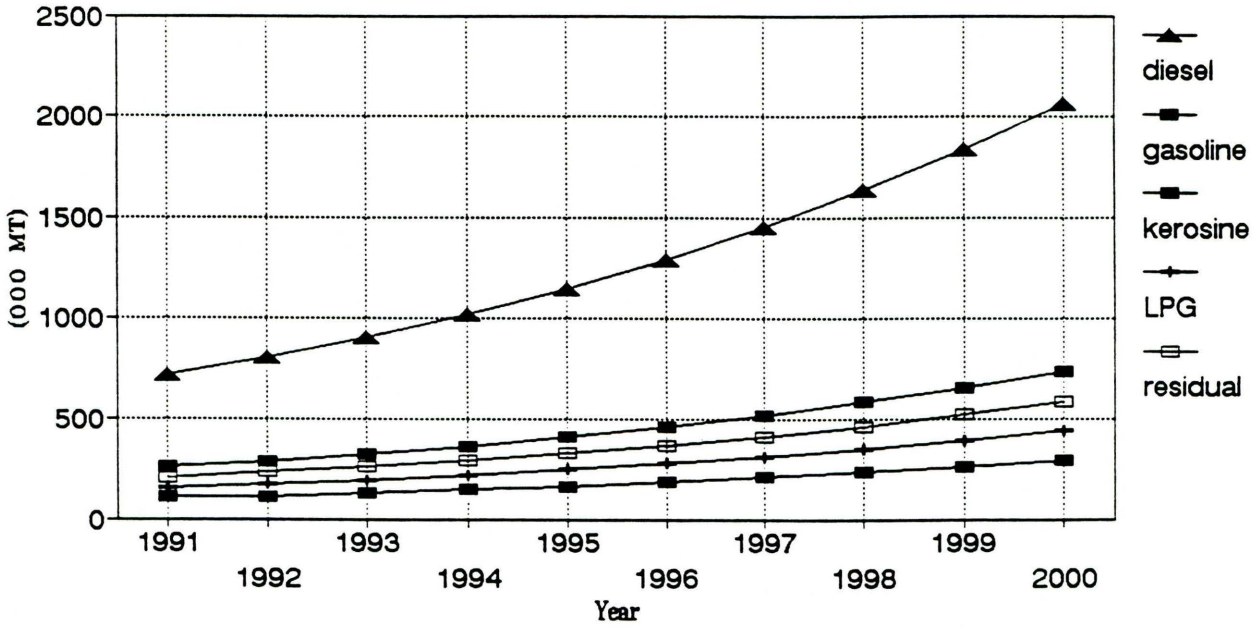


Figure 8.5
Projecte Per Capita Fuel Consumptions

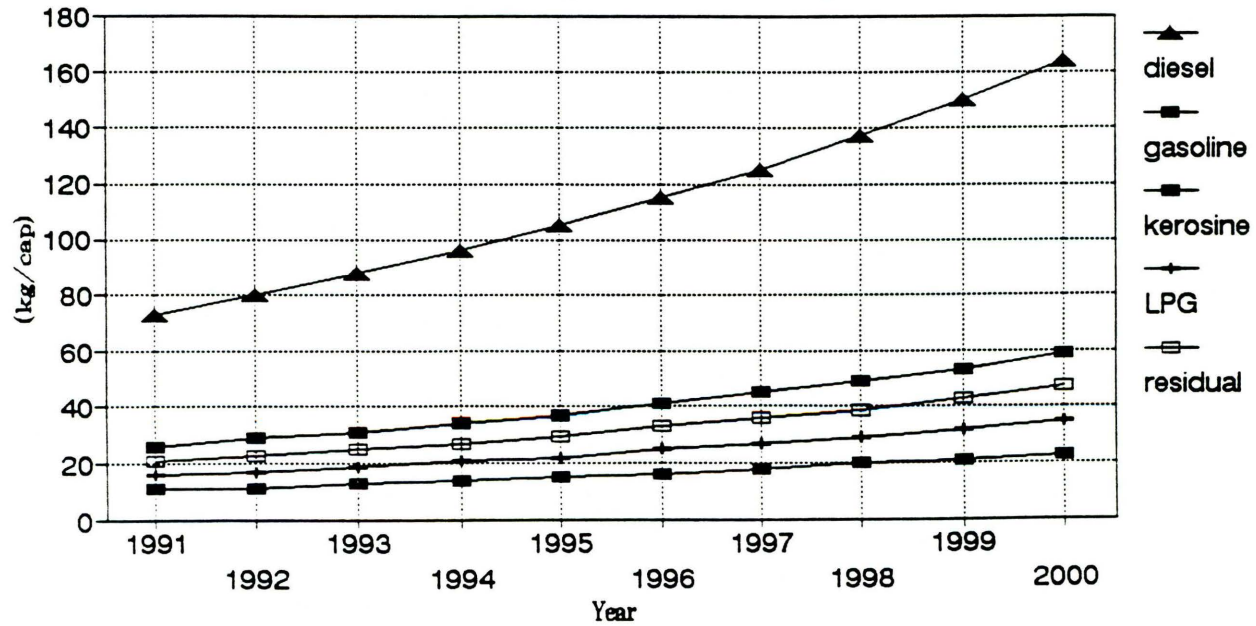
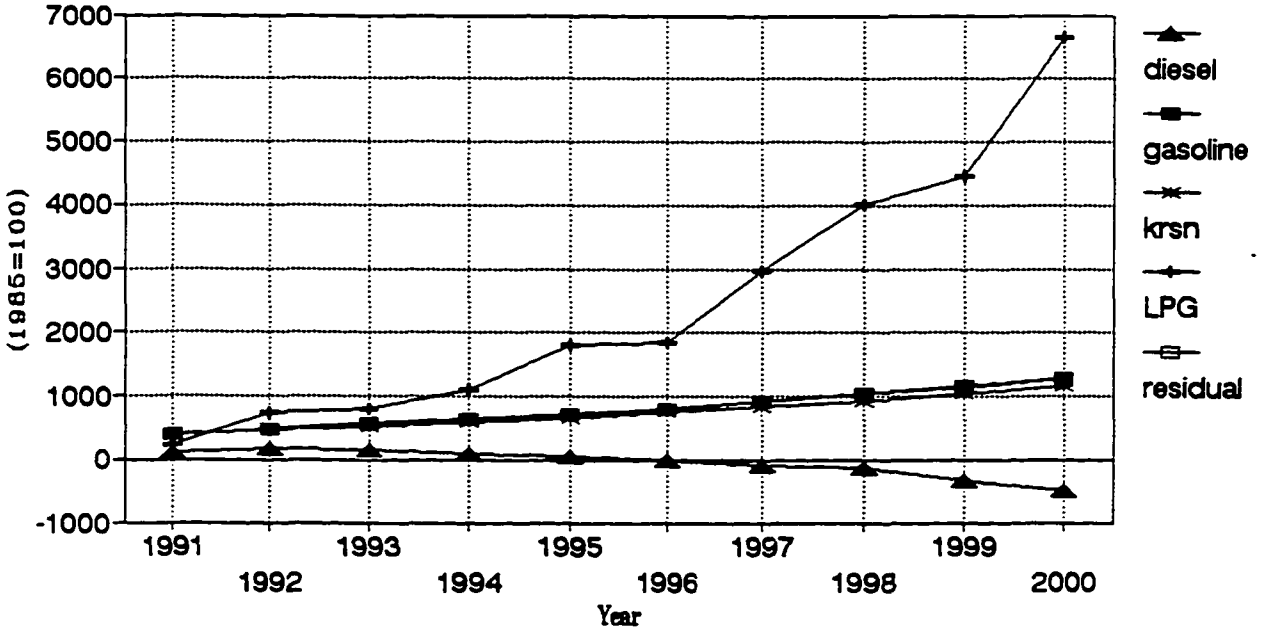


Figure 8.6
Projected Petroleum Index Prices



although an expanded specification was not possible because of lack of data.

Suppose, however, that the projected prices are taken at face value. This would suggest that the large consumptions projected for the high-GDP scenario are inconsistent with the demand for diesel as here modeled: The model of demand implies that very low, even negative, prices would be necessary for the consumption of these large projected quantities. Of course, unless diesel production were to be subsidized by government, the consumptions would not be supplied at these low prices. Thus, for the simultaneous occurrence of the high GDP scenario and the large projected diesel consumptions, other conditions would be necessary. To explore this further, let us ask the question: What efficiency of diesel use would be necessary to resolve these differences? Assume that the necessary diesel supply requires a price path similar to that for gasoline for the high-growth scenario. Then, let us plot the ratio of intensity of use for that price to that used for all basic scenarios; values of this ratio are listed in table 8.9. The time path of this ratio depicts the decrease in intensity of diesel use, or the increase in efficiency in diesel use, that would be necessary to meet consumption implied by projected income and satisfy the imposed price path.

Table 8.9
Ratio of intensity of use

Year	ratio
1991	0.84
1992	0.799
1993	0.752
1994	0.703
1995	0.652
1996	0.599
1997	0.547
1998	0.494
1999	0.443
2000	0.393

The annual efficiency rate is calculated based on the following model:

$k_t = 0.84\ e^{-0.084\ t}$

$t = 1991$, where

-8.4 % is the average annual rate:

$0.353 = 0.84\ e^{r9}$

$\ln(0.393/0.84) = r.9$

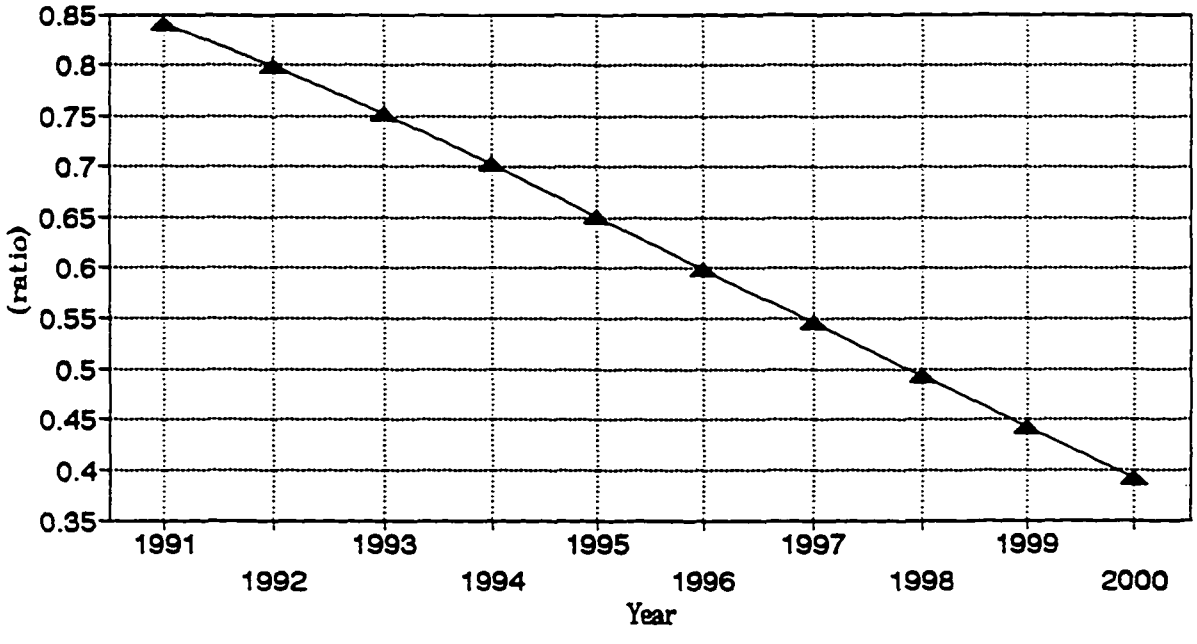
$r = - 0.084 = -8.4\ \%$

This result indicates that, given the high GDP growth rate and an increasing price trend for diesel, efficiency of use would need to improve by 8.4 % annually. Or, alternatively stated, the intensity of use of diesel would have decrease at an annual rate of -8.4 % (see figure 8.7).

Scenario 3

Scenario 3 differs from scenario 2 in that per capita GDP

Figure 8.7
Diesel Intensity of Use



growth rates are different for each of the years of the projection period and that these rates are lower than the high growth rate scenario. The rationale for this scenario is that the high 1980 growth rate in per capita GDP (8.9%), which was partially due to the initiation of domestic production of petroleum, will not continue throughout the projection period. This rate combined with the basic population growth rate scenario gives a GDP growth rate of over 11 %. As such a rate of growth is not likely over a long period of time, scenario 3 requires the per capita GDP rate to gradually decline from the high of 8.9% to what is still a good per capita GDP growth rate, 4.5%, in the year 2000. Letting **g** be the annual rate of growth in per capita GDP,

$$g_{k\text{-}1980} = 8.9\ e^{-0.057(k-1980)}\ ,\ k = 1980,\ 1981,\ldots,2000$$

Thus,

$$y_t = y_0\ \exp(g_t\ .(t - 1990))\quad ,\ t = 1991,\ldots,2000$$

where

y_0 = per capita income in 1990

The projections are presented in tables, 8.10, 8.11, 8.12, and 8.13 and figures 8.8, 8.9, and 8.10, respectively.

Table 8.10
Projected GDP and GDP per-capita
(1991-2000)

Year	GDP (MYR)	GDP/cap (YR)
1991	38035	3893
1992	38948	3877
1993	39937	3862
1994	40923	3848
1995	41932	3834
1996	42986	3822
1997	44059	3809
1998	45223	3798
1999	46376	3788
2000	47576	3778

Table 8.11
Projected fuels consumption
(1991-2000)

Year	Diesel	Gsln	Krsn	LPG	Rsdul
1991	532	190	76	114	152
1992	545	195	78	117	156
1993	559	200	80	120	160
1994	573	205	82	123	164
1995	587	210	84	126	168
1996	602	215	86	129	172
1997	617	220	88	132	176
1998	633	226	90	136	181
1999	649	232	93	139	186
2000	666	238	95	143	190

Table 8.12
Projected per-capita fuels consumption
(1991-2000)

Year	Diesel	Gsln	Krsn	LPG	Rsdul
1991	54.45	19.4	7.77	11.66	15.55
1992	54.25	19.41	7.76	11.64	15.52
1993	54.05	19.34	7.73	11.60	15.47
1994	53.87	19.27	7.71	11.56	15.42
1995	53.67	19.20	7.68	11.52	15.36
1996	53.52	19.12	7.64	11.15	15.29
1997	53.34	19.00	7.60	11.41	15.21
1998	53.16	18.98	7.55	11.42	15.20
1999	53.00	18.94	7.59	11.353	15.19
2000	52.88	18.89	7.54	11.355	15.00

Table 8.13
Projected fuel price indexes
1985 = 100

Year	Diesel	Gsln	Krsn	LPG	Rsdul
1991	270	282	257	288	242
1992	213	272	255	270	238
1993	238	271	253	260	236
1994	240	269	251	267	234
1995	243	267	250	254	232
1996	244	266	248	283	230
1997	245	265	247	227	229
1998	245	262	246	243	227
1999	246	261	244	217	225
2000	245	260	243	154	225

Interestingly, except for LPG, scenario-three projected price indexes are very similar for all fuels. All show a slight decline in price indexes over the projection period and similar annual price index values, except for LPG. This

Figure 8.8
Projected Fuel Consumptions

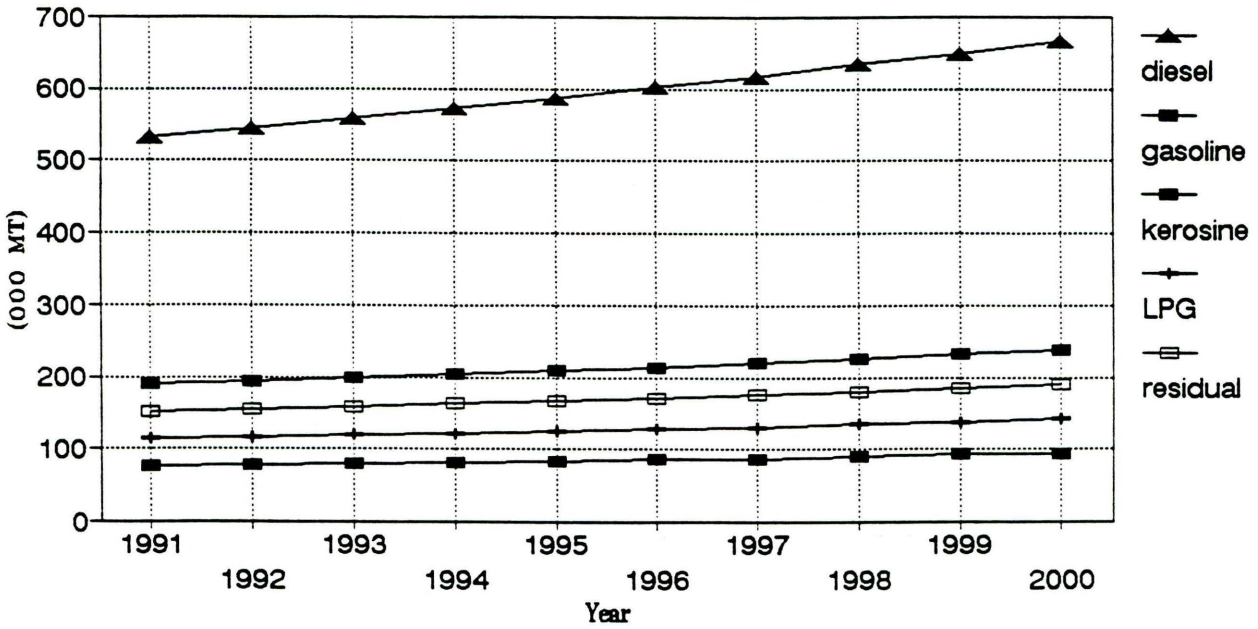


Figure 8.9
Projected Per Capita Fuel Consumptions

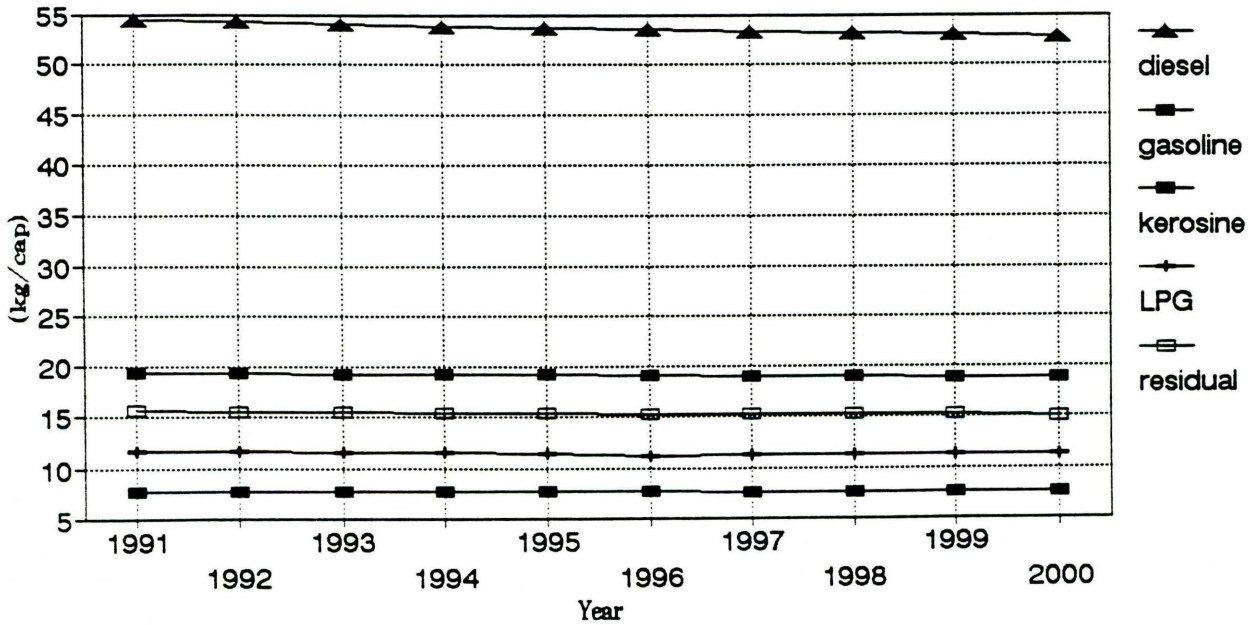
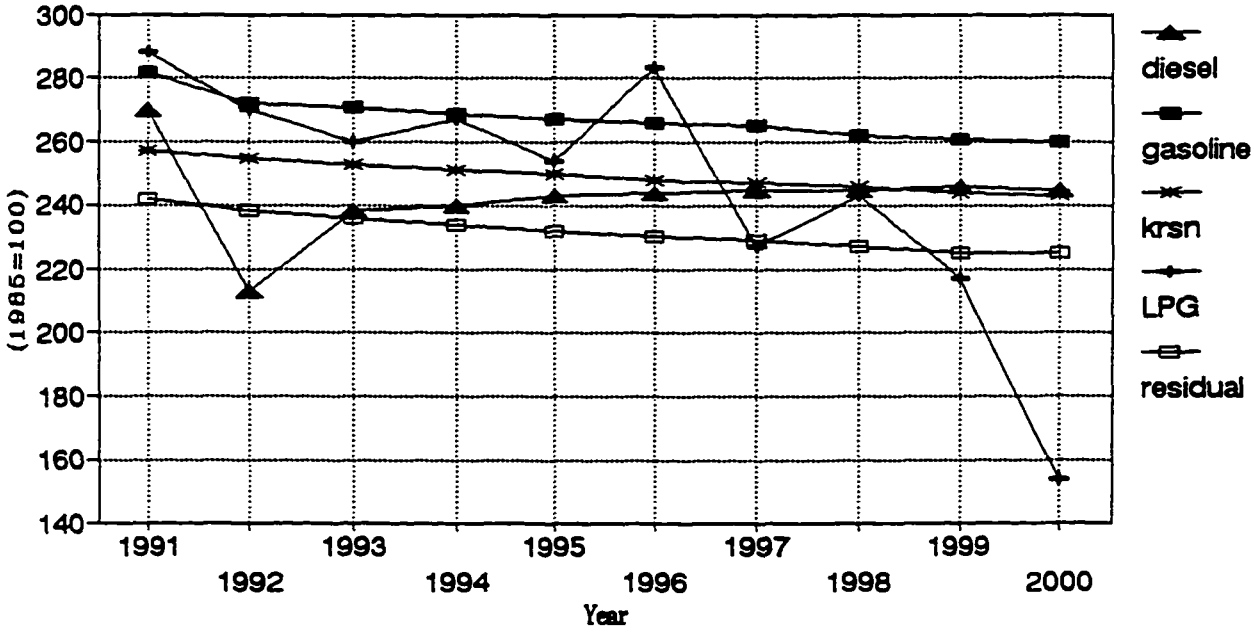


Figure 8.10
Projected Petroleum Index Prices



similarity is important in that all demand equations employ the same price index instead of specific fuel prices. Even so, when the demand equations are used to solve for the price index which is required, given projected GDP and consumption, the equations generally give different values of the price index. That all price indexes for scenario 3 are quite similar may indicate that scenario-three values of per capita GDP combined with the intensity of use values are fairly compatible with the estimated demand equations.

Scenario 4

After unification of North and South Yemen in 1990, people, especially from the South, were concerned about high fuel prices. Those who came from a socialist system feared the loss of their economic welfare due to the high fuel prices. Scenario 4 examine the implications of lower fuel price. Specifically, prices for the projected period will continue to be at their 1990 level. The scenarios for population growth and intensity of use are the same as those for scenarios 1 and 2.

Projected fuel consumptions for scenario 4 are provided in table 8.14 and displayed in figure 8.11. Basically, the high growth rate of GDP combines with constant prices to give large per capita fuel consumptions.

Table 8.14
Projected per-capita fuels consumption, 1991-2000

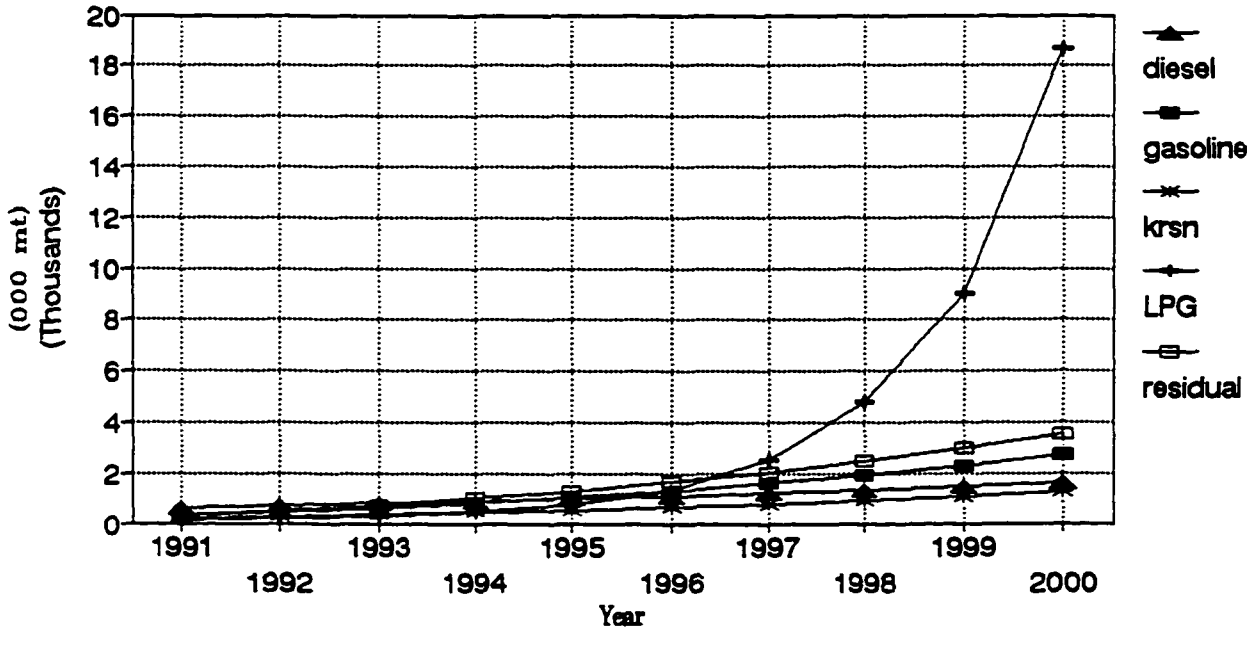
Year	Diesel	Gsln	Krsn	LPG	Rsdul
1991	64	33	22	15	33
1992	74	47	28	20	52
1993	80	62	35	29	73
1994	86	79	42	44	95
1995	92	97	50	71	120
1996	99	117	58	121	147
1997	106	139	68	219	176
1998	113	163	78	403	208
1999	121	189	89	735	243
2000	128	218	102	1480	281

Economic Perspective on Projections

Although growth rate is high in scenario 2, it is expected, since oil exportation started in 1987 and is expected to continue, perhaps even increase. The export of oil resulted in the increase of GDP by the value of exportation, which reached (7,284,382) thousands Yemeni Rial in 1990. Because of the inconsistancy between economic growth, consumption and prices, in scenario 2, scenario 3 is probably the most realistic projection, since price indexes are quite similar, which may indicate that per capita GDP values combined with the intensity of use values are fairly compatible with the estimated demand equations.

Since Yemen will no longer continue depending completely on imported oil and since part of its consumption is supplied domestically, GDP per-capita will also increase. This increase in GDP per-capita will imply a substantial increase in demand

Figure 8.11
Projected Fuel Consumptions



for petroleum products which, in turn, implies a substantial rate of growth in the Yemen economy. However, projections for scenarios 1 and 2 are for high fuels consumption and high fuel prices. Everything else being equal, these high prices could cause an economic hardship for Yemeni citizens. Moreover, there remains the unanswered question of: are high prices compatible with high economic growth? As indicated previously, the question cannot be answered by this study: necessary data are not available to model the complex relation of economic growth to energy consumption and prices.

Scenarios 2 and 4 are based on the assumption that projected quantities and prices are either not compatible with high economic growth or are not desirable for welfare reasons.

For all scenarios, as the level of GDP increase, consumptions are projected to rise. Between 1971 and 1990, annual consumption increased from 70 thousand metric tons to 1,073 thousand metric tons. The corresponding average annual increase between 1991 and 2000 implied by the forecasting exercises range from 1,308 thousand metric tons to 8,853 thousand metric tons .

As a result of our previous analysis, if we assume the value per ton of imported oil in 1990, 971 YR, and the capacity of the small refinery, in the North, remained constant during the predicted period, then the value of imported petroleum will increase from 1,033,144 thousand YR,

scenario 3, in 1991 to 27,019,046 thousand YR, scenario 4, in the year 2000.

Some Specific Policy Issues or Objectives

In this section, I will identify economic issues that are important in interpreting the empirical results in previous chapters and in selecting policy options. As for energy policies, foremost among economic issues are economic growth, social welfare, and balance of payments. For example, The Yemeni Government has been interested in simultaneously curbing the rate of increase in the demand for petroleum products and reducing the dependency upon imported oil, which may in turn improve the balance of payment deficit for Yemen, depending upon economic growth. Whatever policies are selected and promulgated, they should also be supportive of economic growth and social welfare.

In chapter 5, we noted that the effect of economic growth on energy consumption runs in both directions. Changes in economic growth (GDP) are important determinants of changes in energy demand . As noted, increasing GDP by one percent might result in less than or more than a one percent increase in energy consumption, depending on the particular sector of use. But, economic growth is dependent to some degree on the availability of inexpensive energy and consumption. Especially important is the extent to which an increase in the price of energy tends to reduce growth in the productive capacity of

the economy.

When any factor of production, becomes more scarce, that is more costly, production will either decrease or become more costly, at least in the short-run. To the extent that there are good substitutes for the scarce factor and substitution is easy, production may change very little in response to the increased factor price. Moreover, long-run changes in technology may compensate for productivity loses due to a persistent increase in factor price.

Shortages of energy which might result from price controls by government can force a production cutback in some industries and create bottlenecks in the overall flow of intermediate goods. When this happens, it can bring much greater impacts on employment and economic output, especially in the short run.

It should be noted that in the case of LDCs, growth cannot be achieved without incurring a deficit in the balance of payments, especially when resources are limited. If, for example, energy is imported, in which case a higher price means an increase in import expenditures, if that, in the long run, has not been matched by an export increase, this will keep the economy of Yemen vulnerable to increasing deficits.

Discussion of Selected Policies

In general, it should be noted that Yemen energy policy should first support and facilitate economic growth and social

welfare. Other policy objectives may be to reduce the consumption of petroleum products as much as possible without effecting national economic growth, and, second, to increase domestic supply of energy resources to substitute for imported oil in order to fulfill our energy needs. The following are two actions that could to be taken by policy makers:

1) Conservation policy and;

2) development of alternative sources of energy.

Conservation Policy

This measure tends to reduce the growth rate of energy consumption. Conservation to a household means changing his or her behavior in using energy intensive activities, for example, cooling and driving in the short term, whereas for a firm, it is the efficient use of its inputs.

How to Achieve Conservation

Growth in the economy of Yemen, which is most likely, implies increased consumption of commercial energy, everything else being equal. Unless this increased consumption is matched by increased domestic supply, which isn't likely, conservation will be important. As the analysis of scenario 2 indicated, high economic growth can not be achieved without significantly improved efficiency of energy use, given current domestic supply and imports.

There are important opportunities to conserve energy in

both the traditional and commercial sectors. Whether it will be possible to take advantage of these opportunities depends upon how much the government of Yemen is willing to put serious emphasis on conservation and its implementation in future economic plans.

The nature of these incentives will vary according to the degree of economic planing to achieve conservation. In many developing countries, some reliance is placed on pricing as an allocating device, whereas in some countries conservation is achieved almost entirely by physical controls, quotas, for example.

In their studies in 1981, Dunkerley, Ramsay, Gordon, and Cecelski indicated that efficient use of energy requires that it become more expensive. Underpriced petroleum products and electricity encourage consumers to use more and more energy.

Efforts by the government of Yemen to provide to local organizations and the public at large information about well-conceived forms of energy conservation seem worth their small cost. The government has the budget capability to conduct and sponsor promising energy R and D activities.

Improved access by owners of residential and commercial property to accurate physical and economic information (say, from engineering or architectural experts) on costs and benefits associated with changes in insulation, in space systems, or in other energy use practices is highly desirable. Also mobilization of comprehensive information on energy

conservation will enable state and local government units to subject their own expenditure decisions to the test of economically rational energy use. Builders and contractors on such public projects as schools, hospitals, and office buildings could be induced to give an economic accounting of their proposed plans as they relate to energy use. This should apply especially to insulation practices, space conditioning equipment, and lighting.

Development of Alternative Sources of Energy

In Yemen, a big share of the population, especially in the rural areas, relies mostly on traditional fuels for energy use especially for cooking. The fuels are usually collected and used directly by family members without entering money markets. They include : 1) wood fuels- firewood and charcoal; 2) residue fuels-dung from cattle or other animals; and 3) crop waste such as wheat straw.

Wood is the primary fuel used in rural areas, with charcoal being more popular in urban areas because of its convenience and ease of transport. Crop residues and dung are usually resorted to only where wood fuels are unavailable or too costly.

So, the prospects for increasing prices of petroleum products provide an incentive to reconsider non-commercial fuel as an alternative source of energy. The objectives of this policy must be:

1) The establishment of forests consisting of fast-growing species of trees designed for firewood consumption in order to meet a clearly defined part or, if possible, all of foreseeable domestic fuel needs.

2) Achieving continuity and reliability of supply of non-commercial fuel so as to encourage the public in the use of that source of energy.

The achievement of these goals will come as a result of government intervention in the form of subsidies because of the externality associated with the establishment of forest plantations and because investors usually are risk averse when investing in long term projects.

Commentary on Policy Options

It should be noticed that the key of conservation policy is the extent to which the demand for electricity and petroleum products respond to their prices and the extent to which other factors can be substituted for them. Our empirical results showed that on average, demand for electricity and petroleum products, will decline by 0.44 % and 0.43 % respectively, following a 1 % increase in price.

Beside energy pricing, other measures may be needed to reach conservation objectives. Such measures include subsidies to consumers, regulation of the energy efficiency of major energy-using appliances, and rationing. It is known that in some developing countries price manipulation and subsidies may

be the only available way to provide relief even though they benefit others along with the poor.

Also in order to reduce the amount of commercial energy consumed in the country, an extra tax or tariff on imported products (especially automobiles) may, therefore, be indicated.

Another option is to the use of non-commercial energy (wood, animal waste, and charcoal) as a substitute for commercial energy, especially for cooking, in the residential sector. This strategy will not be sufficient in the long run, since non-commercial fuel is also becoming scarce due to the lack of access to forest lots, but it will help somewhat in the short run.

Another important means to mitigating the cost of importing refined products is to increase refinery output capacity. This in fact will come as a result of either, expanding the existed refinery in Marib[52] or, by rebuilding the damages in the refinery of Aden[53], which resulted from the May 1994's war.

Acceleration in the development of commercially found

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[52]This is the only refinery in the former North Yemen.
[53]This refinery is one of the bigst refinery in the middle east, it was built between 1952 and 1954 by British Petroleum to replace its main Iranian refinery when the Mossadeq government in Iran nationalized oil. Its maximum capacity, when it started, 7.5 million tons a year.Most of the refinery's work is done on contract for foreign buyers.

natural gas[54] will facilitate substitution for other fuels, especially in the residential sector, and reduce the amount of imported products. Accordingly, additional exploration for mineral fuels, such as petroleum and natural gas, should be promoted.

To reduce the deficit in the balance of payment, in general, more emphasis on the development of export-oriented industries should be made.

For the adoption of other viable energy forms and for more efficient energy use, the government of Yemen should get involved in such research as needed in these areas.

Finally, it should be noted that identifying the optimum mix of policies will require a broader, more comprehensive economic analysis than was possible in this study. With more and better data and extended analyses, policies can be identified and promulgated that increase the economic and social welfare of Yemen. These policies will include some mix of more efficient use of commercial energy, reduction in imported products, development of other energy sources, and consequently the improvement in the balance of payments in general.

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[54]In 1988, President Ali Abdullah Saleh revealed that the reserves are estimated at 5.5 trillion ft^3.

CHAPTER 9

SUMMARY COMMENTS

The results of this study show that economic growth has a strong impact on the demand for electricity and petroleum products. The demand for total electricity and total petroleum is highly elastic with respect to income, and both the electricity and petroleum intensities of the economy have increased overtime. These results, in general, indicate that the economy of Yemen is becoming more energy intensive. Projection scenarios for per capita GDP and intensity of use show large increase in fuels consumption by the year 2000. Since Yemen still depends partly on imported energy, this will keep the economy vulnerable to external economic shocks, such as the 1970s crisis by OPEC, even though, domestic resources have been developed since the mid of 1984. Whatever action is taken by the government if it is not taken seriously, Yemen will continue to be dependent on imported energy. Considering the uncertainty in the world economy, heavy import dependency on petroleum and petroleum products could be disastrous to Yemen's economy.

Oil imports, and their effect on deficit in the balance of trade, could possibly be reduced without limiting output capacity by using more efficient methods of production, by encouraging more energy conservation, and by substituting other domestic fuels for some of the imported fuels,

particularly oil and oil products. In order to achieve this goal, the cooperation of the Yemen Government and Yemen citizens will be needed to enact the proper energy policies, or to provide the necessary incentives to make these changes possible.

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