A QUANTITATIVE MODEL
FOR THE OIL SECTOR OF KUWAIT

BY

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ABSTRACT

This thesis investigates the alternative options open to the Kuwaiti economy to link the Oil Sector to the overall development plans of the country. This is carried out in four stages:

First, the peculiar features of the Kuwaiti oil sector are discussed with reference to the models that have been specified to study and analyse the sector together with the general features of oil models tailored to fit oil producing 'surplus' economies, such as Kuwait.

Secondly, a detailed oil model for Kuwait is constructed reflecting the role of the economy's limited absorptive capacity in determining its development path. The proposed model is disaggregative, links the supply and demand for oil, and employs some oil prices as endogenous instruments for economic policy.

In the third stage, the alternative options are exercised by applying the Oil Model using two frameworks: an income-expenditure framework and a production framework. In applying both frameworks, the 'Oil Income' is used as the bridge to link development plans to the oil model.

Finally, analysis will be carried out to the model's possible uses. No simulation or policy suggestions will be made, as this would be outside the work's limits.
ACKNOWLEDGEMENTS

I wish to express my gratitude to my Supervisor, Dr. Ahmed El-Mokadem, without his close supervision and guidance this work would not have been completed. Thanks are also due to the previous Head of Department, of Economics, Professor Colin Robinson, who admitted me and to the current Head of Department, Professor Graham Bird, who supported me, when support was required. I am also grateful to various members and colleagues in the Department of Economics, University of Surrey, with whom I consulted so frequently.

I wish to record my gratitude to His Highness, the Emir of Kuwait, the Crown Prince and the Government of Kuwait who supported me during my studies in numerous ways, I am also grateful to the Kuwait Institute of Scientific Research who backed this study for a number of years.

Lastly, I am grateful to my wife who endured with me whilst I completed this work and to my parents who have always encouraged me throughout my education.
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CHAPTER 1

INTRODUCTION, OBJECTIVE, METHODOLOGY
AND PLAN OF STUDY
1.1 Introduction

1.2 Objective of the Study

1.3 Methodology

1.4 Plan of Study
1.1 INTRODUCTION

Kuwait is one of the Middle East countries which displays a number of unique characteristics. It is considered a capital-endowed economy where capital is attributed to a single depletable natural resource: namely oil. Despite the surplus capital, the economy's growth rate is constrained by the limited absorption capacity resulting from the smallness of the economy and the shortage of native labour. The general structure of the economy could be described as being 'dual' with a relatively sophisticated oil sector on the one hand and a still growing industry, insignificant agricultural sector and a profitable service sector on the other. This situation provides a challenge to development economists in that the economy of Kuwait does not fit in easily to any of the traditional broad classifications of either 'developed' or 'under-developed'. The rapidity of change has contributed to the blurring of this distinction, and Kuwait's economy combines extreme features of both classifications.

On the one hand, the economy is characterised by rising capital surplus. In no other country in the world has development proceeded with such speed as in Kuwait. The rate of economic growth since the mid-1950's has been high and relatively stable, averaging 7.7 per cent. The country has the highest per capita income, one of the highest earning rates, and a consistently favourable balance of payments position. All these are indicators of a developed economy. On the other hand, there are striking features of under-development. These include the inadequate indigenous supply of technical man-power and labour, the total reliance on imports of capital goods and consumer goods, and the over-dependence of the economy on a single product - oil. The country is also characterized by a narrow market which is due to the numerical size of the population and
the sophisticated tastes of Kuwaitis brought about by affluence.

Therefore, we can conclude that the Kuwaiti economy is characterised by some problems. The first problem which is of major significance is that of economic vulnerability, three dimensions of which may be identified. There is the vulnerability in the generation of income. As mentioned previously, oil is the main source of income in Kuwait. In addition to its exhaustible nature, oil is a raw material which, like any other primary product, is subject to a great deal of instability, the revenue from which is - to a very great extent - outside the control of the policy-maker. Sales are determined by world demand, while the price is either largely determined by OPEC, or, as is the case since 1979, by market considerations. The second source of income, which has recently been growing at a rapid rate, is income from investment overseas. Despite the fact that this is a very important source - paying off almost 40 per cent of the import bill - and may replace oil, it is subject to a great deal of uncertainty, which is particularly important in the extreme case of a "renties" economy. There is also the vulnerability associated with the structure of trade: whereas exports are primarily those of oil, the country is heavily dependent on imports. The third type of vulnerability relates to the heavy dependence on expatriate labour, which as mentioned previously accounts for more than 70 per cent of the total labour force.

Another serious problem is that oil revenues are far in excess of the country's current ability to spend domestically, a problem which is often referred to as "absorptive capacity". This is a very difficult concept to define and measure, but is essentially related to the productive base of the economy. The larger the productive base, the higher the absorptive capacity.
Some major constraints on absorptive capacity may be identified to include: factoral imbalance, sectoral imbalance, imbalance in the investment mix deficiency in the financial system and inappropriate development strategy. The first relates to an imbalance in factor endowments characterised by capital abundance on the one hand and limited arable land and a chronic shortage in skilled labour and managerial and administrative resources on the other. Factoral imbalance means limited industrial investment in countries like Kuwait. Sectoral imbalance is in the form of only one type of primary production having been developed. Agriculture remains for all practical purposes non-existent, and industry accounts for only a small share of gross national product.

In order to expand the absorptive capacity of the economy, it is not only the magnitude of investment that matters; a more crucial factor is the specific pattern of investment. Unless capital funds are channelled into productive investment or growth-inducive industries, the impact of investment on the economy may not be felt. It has been observed that entrepreneurs in the Middle East countries concentrate on quick-yielding investments such as real-estate and construction, which have much less growth-effect on the economy than industrial investment. This is particularly borne out of Kuwait, where real estate and construction account for a large proportion of the total domestic investment. However, factoral imbalance is very severe in Kuwait and limits the scope for productive investment. But as the share of industrial investment in total investment increases, the absorptive capacity of the economy will expand.

As noted by John Bridge, availability of capital does not guarantee the existence of a suitable or efficient banking mechanism or capital does not guarantee the existence of a suitable or efficient banking mechanism or capital market
such that savings might be loaned in an orderly fashion for internal investment. Such investment must be in the most productive lines capable of spurring further growth. Thus the savings-investment process in a development context cannot be divorced from the question of the need for an efficient financial mechanism. In the classical world there is no distinction between desired savings and planning investment; all earnings are necessarily invested.

The Keynesian economists argued, however, that there is nothing in an economy to ensure that all the funds paved are actually invested, as both savings and investments are influenced by different sets of factors. While the oil-exporting Middle Eastern countries have very high per capita savings the basic problem has been the transformation of these earnings into productive domestic investment. The problem is the lack of efficient financial institutions which can offer attractive investment outlets. The entrepreneurial function of the banking system may be very important, particularly in these countries where entrepreneurial skills are in limited supply. Private sector development depends to a large extent on the nature of financial services provided by the banking system. Deficiency in the financial system could be in the nature of the banks' lending policies. If short-term financial gains are available, there will be little incentive for banks to grant long-term rather than short-term finance; the banks' lending policies necessarily limit the level of industrial investment. To this extent deficiencies in the financial system can retard the absorptive capacity of the economy. There is positive correlation between absorptive capacity and development strategy. In fact development strategy could be used to expand the absorptive capacity of the economy. A given strategy of development may accentuate the detrimental impact of shortages and bottlenecks that beset the economy, where an alternative strategy may facilitate capital formation by economizing on scarce
It is obvious that an improvement in the quality and quantity of infrastructure will raise the productive base of the economy and hence the absorptive capacity. Analysis of the above constraints on absorptive capacity suggest that absorptive capacity is not a static concept. It is a dynamic concept in the sense that it is susceptible to changes either by exogenous factors or by deliberate policy. Increases in the supply of physical inputs or improvement in the quality of input and in the state of technology can bring about an increase in absorptive capacity. And hence the need for an appropriate development plan.

A third problem relates to the inadequacy of instruments of economic policy. The lack of taxation, the rigidity of interest rates, the absence of national debt, and the shortage of financial instruments in general have constrained government ability in controlling liquidity and inflation. Although this is essentially a short-term stability problem, it has serious implications in the long run. For, in a country like Kuwait, defects in the device of allocating and distributing oil income have serious consequences for the productivity of non-oil sectors and for the overall growth of the economy. Some defects have already been noted. The public employment policy being used as a distributional device has resulted in a distortion in the price of labour, made industrial employment less attractive and discouraged industrial investment.

Government land purchase policy has failed to achieve its main objective of stimulating private domestic investment, distorted the price of land and resulted in the transfer of a large portion of private saving abroad. Needless to say, a radical change in the system of allocation and distribution to the private sector is required. Financial
flows from the government must be specifically directed to productive investment, and the weak relation between efforts and reward must be corrected. In addition, a number of other problems could be enumerated.

For example, there is an attitude of apathy in public employment; speculation and profiteering in the private sector; the danger of dilution of the Kuwait identity; the deficiencies in the welfare systems; and inappropriate pricing of oil and gas for domestic requirements.

1.2 OBJECTIVE OF THE STUDY

The main objective of the study is to present a suitable framework for development in Kuwait which reflects the unique role of the oil sector by linking the oil sector to the overall development plans of the country. In other words, the objective is to reject the idea of treating the oil sector in isolation and leaving the rest of the economy and to stress the backward and forward linkage of the sector to the whole economy. This is done through the specification of a disaggregated model which reflects the actual linkage, using an income-expenditure framework to trace the role of the sector influenced by the economy's absorptive capacity and another through a production framework based on the assumption that the oil sector is part of the country's productive capacity.

1.3 METHODOLOGY

The study adopts a quantitative approach structuring an oil model for Kuwait in the specification stage and applying the model throughout, linking it to another two quantitative frameworks of development planning models.
The estimation of the specified oil model is carried out using Ordinary Least Squares (OLS). The small sample prevents the use of system estimation techniques such as three stage least squares or maximum likelihood methods.

1.4 PLAN OF STUDY

This chapter is followed by an analysis on the oil sector of Kuwait, its structure and problems and sheds some light on the main models structured to specify the oil sector in Kuwait.

Chapter 3 provides a brief survey of oil models to present a theoretical framework for the proposed model with its three basic dimensions: production, pricing and policy.

In Chapter 4, the specification of the model is discussed together with its estimated results using the small sample provided by the available data.

Chapter 5 provides a description of the model's application using the two selected alternative frameworks - the income-expenditure framework and the production framework.

In Chapter 6 the results are summarised, together with the model's conclusions and extensions for further research.
CHAPTER 2

KUWAIT OIL SECTOR
2.1 AN OVERVIEW OF KUWAIT OIL SECTOR

2.2 KUWAIT OIL MODELS
2.1 AN OVERVIEW OF KUWAITI OIL SECTOR

Kuwait can be viewed as being dominated by some factors which characterise its economic structure and development prospects such as a relatively small population, limited absorptive capacity and a heavy dependence on oil revenues. These characteristics categorise Kuwait as a surplus economy or 'rentier economy', where the oil sector dominates over the other sectors of the economy; therefore the Government plays a significant role in stimulating development and growth through its control over the oil revenues.

The Kuwaiti oil revenues increased from 564.5 million (KD) in 1970 to 4778.3 in 1980 recording a 23% increase per annum. However, the dramatic change in the world oil market had resulted in a fall in income to 2487 million (KD) in 1982 together with a fall in production levels of 1 million barrels per day (bd).

In the following, the Kuwaiti Oil Sector is analysed, shedding some light on its structure, problems, interaction and impact on the economy.

2.1.1 The Structure of the Oil Sector

The birth of the oil industry dates back to the 1930's when the Amir granted an exclusive concession to the Kuwait Oil Company to explore for and produce oil in Kuwait and its territorial waters up to 6 nautical miles from the shore. At this time KOC was jointly owned 50:50 by BP and Gulf. Oil was found in the late 1930's but due to the Second World War commercial production only started in 1946 - at a rate of 40,000 bd from the Burgan oilfield.
Further onshore discoveries were made at Magwa and Ahmadi in 1952 and other structures have since been discovered at Raudhatain, Sabriya, Managish and Umm Gudair.

An onshore concession for the Kuwaiti part of the Divided Zone was granted in 1948 to Aminoil, the American Independent Oil Company. Oil production was initially from the Wafra and South Fuwaris fields, followed by South Umm Gudair. The concession for the Saudi half interest was granted to Getty Oil. Production started in 1954.

A third concession covering the offshore areas of the Divided Zone, outside territorial waters, was granted to the Arabian Oil Company, which unlike Aminoil, also had the concession from the Saudi half-interest. Oil was discovered in 1960 - the Khafji field, and production commenced in 1961.

In 1960 the Kuwait National Petroleum Company was formed, with 60% government ownership and 40% private sector, to undertake local marketing of KOC refinery products.

The Kuwaiti government acquired a 60% state participation in KOC's concession in 1974 and took over fully in 1975. In 1977 Aminoil's concession in the onshore Divided Zone was terminated and a new company, the Kuwait Wafra Oil Company was formed. The activities of this latter company were merged with the relevant activities of KOC and KNPC in 1978.

As regards the offshore Divided Zone concession the Kuwaiti government now owns 60% of the Kuwaiti half.

The other important Kuwaiti companies in this sector are the Kuwait Oil Tanker Co (KOTC) and the Petrochemical Industries Co (PIC). The former was established in 1957 as
a privately owned company. In 1976 its capital was effectively doubled enabling the government to take a 49% share. In 1979 the State bought all the shares in private hands and now KOTC is a part of the general petroleum operations.

PIC was initially partially privately owned, like KNPC, but has for some years been 100% State-controlled. It is principally involved in the production of ammonia, urea and related products.

In 1980 the oil sector was reorganised and rationalized with the formation of the Kuwait Petroleum Corporation (KPC) as the Kuwaiti government's umbrella oil organisation. It was established in January 1980 with a capital of 1 billion KD to group all the heretofore disparate national oil companies under one roof and to rationalize their operations.

Thus KPC's subsidiaries (wholly owned) are:

KOC, which became the production and exploration subsidiary.
KNPC, which became the refining, local product distribution and LPG subsidiary.
KOTC, which became the crude and product shipping subsidiary, taking over product tankers previously owned by KNPC.
PIC, which maintained its jurisdiction over petro-chemical projects.

Two new subsidiaries were also created:

KOPEC, the Kuwait Overseas Petroleum Exploration Company (wholly owned) for the exploration and development of overseas oil fields.
Kuwait Petroleum Investment Company, a joint government
(70%) and private sector company to make petroleum-related investments abroad.

With this structure KPC is organised along the lines of a multinational integrated oil company and the previously overlapping functions of the different national companies eliminated - e.g. KNPC now controls all three refineries and is responsible for marketing both crude and oil products.

The Ministry of Oil is responsible for the overall supervision of the oil industry in Kuwait, the supreme Petroleum Council issuing policy guidelines under which KPC and its subsidiaries operate.

Oil Production

Oil is produced from the following oilfields:

Raudhatain
Sabriyah
Bahran
Magwa
Minagish
Umm Gudair
BurganAhmadi
South Umm Gudair (onshore Divided Zone)
Wafra (onshore Divided Zone)
South Fuwaris (onshore Divided Zone)
Hout (offshore Divided Zone)
Khafji (offshore Divided Zone)

Table 2.1 summarises the oil production from 1972-1982 - the data source is the Petroleum Economist, whose figures since 1978 include Kuwait's share of production from the Dividend Zone, both on and offshore. Annual total oil
production figures are very slightly different than those reported in OPEC's Annual Statistical Bulletin.

However they do show separately production from Kuwait's half of the onshore and offshore Divided Zone. These data are given in Table 2.2 for the years 1974-1980.

TABLE 2.1: HISTORICAL CRUDE OIL PRODUCTION

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<thead>
<tr>
<th>YEAR</th>
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<tr>
<td>1973</td>
<td>3,022.37</td>
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<tr>
<td>1974</td>
<td>2,548.33</td>
</tr>
<tr>
<td>1975</td>
<td>2,084.62</td>
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<tr>
<td>1976</td>
<td>2,150.08</td>
</tr>
<tr>
<td>1977</td>
<td>1,973.25</td>
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<tr>
<td>1978</td>
<td>2,097.34</td>
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<tr>
<td>1979</td>
<td>2,512.11</td>
</tr>
<tr>
<td>1980</td>
<td>1,653.96</td>
</tr>
<tr>
<td>1981</td>
<td></td>
</tr>
<tr>
<td>January</td>
<td>1,794.19</td>
</tr>
<tr>
<td>February</td>
<td>1,552.86</td>
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<tr>
<td>March</td>
<td>1,520.81</td>
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<tr>
<td>April</td>
<td>993.0</td>
</tr>
<tr>
<td>May</td>
<td>979.68</td>
</tr>
<tr>
<td>June</td>
<td>1,085.50</td>
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<tr>
<td>July</td>
<td>1,200.97</td>
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<tr>
<td>August</td>
<td>758.71</td>
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<tr>
<td>September</td>
<td>855.50</td>
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<td>October</td>
<td>986.94</td>
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<td>November</td>
<td>915.00</td>
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<td>December</td>
<td>867.74</td>
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<td>1982</td>
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<tr>
<td>January</td>
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<tr>
<td>February</td>
<td>840.00</td>
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<tr>
<td>March</td>
<td>845.00</td>
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<td>April</td>
<td>746.7</td>
</tr>
<tr>
<td>May</td>
<td>775.00</td>
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1 126.9 mbpd year average
### TABLE 2.2: HISTORICAL CRUDE OIL PRODUCTION FROM KUWAIT'S SHARE OF DIVIDEND ZONE

<table>
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<th>ONSHORE 000's b/d</th>
<th>OFFSHORE 000's b/d</th>
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<tr>
<td>1974</td>
<td>82.3</td>
<td>188.3</td>
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<td>1975</td>
<td>83.2</td>
<td>162.9</td>
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<tr>
<td>1976</td>
<td>81.1</td>
<td>152.2</td>
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<tr>
<td>1977</td>
<td>89.0</td>
<td>96.0</td>
</tr>
<tr>
<td>1978</td>
<td>81.4</td>
<td>156.2</td>
</tr>
<tr>
<td>1979</td>
<td>84.2</td>
<td>202.9</td>
</tr>
<tr>
<td>1980</td>
<td>78.8</td>
<td>196.1</td>
</tr>
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**Crude Oil Export Facilities**

Kuwait has several crude oil export facilities. The principal port is at Mina-al-Ahmadi which has traditionally handled crude produced from the biggest oilfield - Burgan. Some 10 miles offshore there is a Sea Island which can handle tankers of over 300,000 dwt. Production from the northern oil fields has been handled by a separate tank farm and loading facility - North Pier. The fourth port, Mina Abdullah, is located in the south, and was built to handle the onshore Divided Zone production by Aminoil. However this oil is very heavy and virtually all the output is processed at Mina Abdullah refinery.

Offshore Divided Zone production is exported through Ras al-Khafji terminal.
The country's first oil refinery, built in 1949 by KOC, is located at Mina-al-Ahmadi. Its present capacity is 250,000 bd. A second refinery was built by Aminol at Mina Abdullah to process the very heavy, high sulphur crude produced from the onshore Divided Zone. Its present capacity is 144,000 bd. Kuwait's third and presently most modern refinery, built by KNPC, is at Shuaiba and has a capacity of 200,000 bd.

The refining facilities in existence at the beginning of 1981 (data source Oil and Gas journal's 'Worldwide Report', December 1980) were:

**Mina al-Ahmadi**

- Crude oil distillation: 250,000 barrels per calendar day
- Catalytic reforming: 5,600 " " " "
- Lube oil: 4,210 " " " "

**Mina Abdullah**

- Crude oil distillation: 125,000 barrels per calendar day
- Vacuum distillation: 100,000 " " " "
- Catalytic hydro-desulphurisation: 35,000 " " " "

**Shuaiba**

- Crude oil distillation: 190,000 barrels per calendar day
- Vacuum distillation: 130,000 " " " "
- Catalytic reforming: 16,000 " " " "
- Catalytic hydrcracking (distillate): 67,000 " " " "
Catalytic hydrocracking
(residue) 54,000
Catalytic hydrotreating 100,000
Lube oil 537

Of these refineries only the Shuaiba plant is really modern and although in the past Kuwait was an important source of oil products, not only for the region but also for East Africa and West Asia, markets have dwindled and both Mina-al-Ahmadi and Mina Abdullah have had low utilisation factors.

Major investment programmes have now begun in order to modernise these latter two refineries as a first step in regaining export markets for oil products. Various reports have appeared over the last two years in different journals (Oil and Gas Journal, HPI Construction Boxscore, The Middle East) and special supplements (International Herald Tribune, July 1982, Financial Times, February 1981) concerning the details of these modernisation programmes and there are numerous anomalies. Taking the most recent reports the developments are:

Mina al-Ahmadi

Atmospheric distillation capacity will remain at 250,000 bd but downstream units will be added to upgrade the product output and the refinery will principally cater for the local market. JGC (the Japan Gasoline Corporation) was awarded the initial $500-700 million contract for phase one of the modernisation in late 1980 and a $1 billion contract in December 1981 for further upgrading under a second phase. Under this second phase, according to the journal 'The Middle East' JGC is to build an atmospheric residue desulphurisation unit, a hydrocracker, a vacuum distillation unit and a fluid catalytic cracker. Oil and Gas
Journal’s construction report, April 1982, lists the following units as being under construction:
- crude distillation 170,000 bd (to replace existing units)
- vacuum distillation 70,000 bd (79,000 bd total capacity)
- FCC 28,000 bd
- catalytic reformer 32,000 bd (to replace old unit)
- hydrocracker 35,000 bd
- hydroleforming 119,000 bd (residue desulfurization)
- hydrotreating 63,000 bd
- hydrogen production 156 MMscfd

Mina Abdullah

This refinery is to be upgraded into a modern export refinery with a crude capacity of about 300,000 bd. Santa Fe Braun will reportedly do the engineering design and construction management here. Some of the units originally intended for Mina Abdullah are apparently to be located at Mina al-Ahmadi. Again, according to OGJ’s April 1982 construction report, the new units will comprise:
- crude distillation 194,000 bd
- vacuum distillation 123,000 bd
- delayed coker 66,000 bd
- hydrocracker 61,000 bd
- hydroleforming 111,000 bd
- naptha hydrotreater 12,000 bd
- distillate hydrotreater 84,000 bd
- hydrogen 170 MMscfd
- coke 2,500 t/day

This refinery's main function will then be the production
Both of these refinery upgrading/expansion projects were completed in 1984.

Gas Processing

All the gas presently produced in Kuwait is associated with crude oil. The first processing facilities, consisting of a 100,000 bd condensate fractionator, were installed some years ago at the Mina al-Ahmadi refinery.

The Shuaiba NGL fractionator, which came on stream in 1980-81, reputedly cost $1 billion and consists of 3 production trains with a total capacity of 1,680 MMcf/d of gas. This plant was designed for a crude oil production of 3 million bd. With the reduced crude output only 2 of the 3 trains were reportedly in operation in 1981.

Kuwait has also been discussing with Saudi Arabia the implementation of the Southern Gas Project - to collect all the associated gas produced in the onshore Divided Zone and the offshore Divided Zone Khafji field which is presently flared - some 78 MMcf/d. Plans call for a gas-gathering system and a pipeline to the Shuaiba plant. Japan's JGC Corporation has reportedly been awarded a $34 million contract to install the gas gathering system for associated gas from the onshore Divided Zone Wafra field and pipeline to the Mina-al-Ahmadi gas processing plant.

An exploration programme is underway in Kuwait concentrating on deeper zones than the existing known oilfields. Interest is centered on the Permian Khuff strata, below 16,000 feet and there are hopes of discovering non-associated gas which could be treated at...
Shuaiba, thus avoiding to some degree fluctuations in that plant throughout due to changes in crude oil (and hence associated gas) production levels.

**Petrochemicals**

The Petrochemical Industries Co (PIC) has for some years operated an ammonia and urea plant, located at Shuaiba. Production capacities as at August 1980 (data source: Informations Chimie) were:

- ammonia (as N\textsubscript{2}) 569,000 t/yr
- urea 840,000 t/yr

A fourth ammonia train is planned and equipment contracts are already being placed. This will be a 1000 t/day unit and will replace the first unit built. Total ammonia capacity will then effectively be 1 million tonnes per year. This fourth unit was due to be completed in 1984.

Kuwait has long been considering the establishment of olefins and aromatics complexes and an updated market review is presently being undertaken. Details of the scheduled units proposed are given in Table 2.3 along with refinery projects under construction and proposed (data source: Hydrocarbon Processing HPI Boxcore, June 1982). The olefins plants would be based on natural gas feedstock and the BTX plant on naptha.

**Other Developments**

Apart from these ongoing developments in the oil sector in Kuwait there are new developments overseas, also oil-sector related. The establishment of two new organisa-
tions - Kuwait Overseas Petroleum Exploration Co and the Kuwait (International) Petroleum Investment Company - has already been mentioned.

KPC has already formed a 5-year joint venture with the American company AZL Resources, to search for hydrocarbons in the USA. Resulting from this joint venture small quantities of oil are already being produced in Montana.

The purchase by KPC in 1981 of Santa Fe International in 1981 is well-known. This gives access to oil concessions in the USA (offshore Louisiana and Texas, New Mexico), Canada, the South China Sea and also the Thistle oilfield in the North sea.

KPC also has a share in the International Energy Development Corporation in Switzerland, the other owners being Volvo, Sulpetro (Canada) and AZL Resources. IEDC has oil concessions in Angola, Australia, Oman, Tanzania, Turkey, Sudan and Zaire.

Additionally KOPEC has interests in concessions in China, Morocco, Oman and offshore Indonesia.

A joint venture with Pacific Resources, a Hawaiian refinery company is presently being considered, which could be a means of entry into refining and marketing in the USA.

Closer to home Kuwait is involved in or considering joint ventures with other Arab countries:

- with Saudi Arabia and Bahrain an ammonia/methanol plant in Bahrain
- with Tunisia for the phosphate project
- with Saudi Arabia and Bahrain the possibility of a heavy oil refinery in Bahrain
<table>
<thead>
<tr>
<th>Company</th>
<th>Plant Site</th>
<th>Project</th>
<th>Capacity</th>
<th>Est. Cost</th>
<th>Status</th>
<th>License</th>
<th>Engineering</th>
<th>Contractor</th>
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<td>Mina al Ahadi</td>
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<td>Chevron</td>
<td>Chiyoda</td>
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<td></td>
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<td>Chiyoda</td>
<td>Chiyoda</td>
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<tr>
<td></td>
<td></td>
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<td>UOP</td>
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<td>Chiyoda</td>
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<td>Chiyoda</td>
<td>Chiyoda</td>
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<td>US4</td>
<td>Benfield</td>
<td>JGC</td>
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<td>JGC</td>
<td>JGC</td>
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<td></td>
<td>Distillation, Crude</td>
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<td>Distillation, Vac</td>
<td>78.0 Mt/d</td>
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<td>Fluid Cat Cracker</td>
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<td>15.8 Mt/d</td>
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<td>IPP</td>
<td>JGC</td>
<td>JGC</td>
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<td></td>
<td>Resid Hydrotreater</td>
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<td>Union</td>
<td>JGC</td>
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<td></td>
<td></td>
<td>Resid Hydrotreater</td>
<td>33.0 Mt/d</td>
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<td>Union</td>
<td>JGC</td>
<td>JGC</td>
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<td>Resid Hydrotreater</td>
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<td>Union</td>
<td>JGC</td>
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<td>JGC</td>
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<td>Hydrogen</td>
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<td>FW</td>
<td>JGC</td>
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<td></td>
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<td>US4</td>
<td>Parsons RM</td>
<td>JGC</td>
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<tr>
<td></td>
<td></td>
<td>Sulfur</td>
<td>267.0 t/d</td>
<td>US4</td>
<td>Parsons RM</td>
<td>JGC</td>
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<tr>
<td></td>
<td></td>
<td>Sulfur</td>
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<tr>
<td></td>
<td></td>
<td>Sulfur</td>
<td>400.0 t/d</td>
<td>US6</td>
<td></td>
<td>JGC</td>
<td>JGC</td>
<td>JGC</td>
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<td>Offsites</td>
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<td>JGC</td>
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<td>Offsites</td>
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<td>JGC</td>
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<td>Treat Water Effluent</td>
<td>2.0 t/d</td>
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<td>Treat Water Effluent</td>
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<td>Topsoe</td>
<td>TPL</td>
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<td></td>
<td></td>
<td>Ammonia</td>
<td>1.0 Mt/d</td>
<td>100.0 K84</td>
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<td></td>
<td></td>
<td>Benzene</td>
<td>280.0 Mt/y</td>
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<td></td>
<td>Ethylene</td>
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<td>75.0 K84</td>
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<td>Ethylene Glycol</td>
<td>135.0 Mt/y</td>
<td>75.0 K84</td>
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<td></td>
<td></td>
<td>Styrene</td>
<td>340.0 Mt/y</td>
<td>575.0 K84</td>
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<td>Xylo, Ortho</td>
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<td>30.0 K84</td>
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<td></td>
<td>Polyethylene</td>
<td>135.0 Mt/y</td>
<td>575.0 K84</td>
<td></td>
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</tbody>
</table>

TABLE 2.3 : REFINING AND PETROCHEMICAL PROJECTS IN KUWAIT
Oil Tankers

Kuwait has the most extensive tanker fleet of Arab nations - comprising in 1981 eight VLCC's, four LPG tankers and three products tankers - but with existing firm orders with shipyards and the likelihood both of further new orders and second-hand purchases KOTC's fleet will expand substantially in the coming years. In line with the upgrading of refineries to produce high quality light oil products for exports is the increasing emphasis on products carriers in KOTC's fleet. By 1984 KOTC was operating a fleet of 37 tankers, comprising 19 product carriers, 14 crude carriers and 4 LPG tankers.

The reported intention in the longer term is that up to 70% of Kuwait's oil output will eventually be carried in Kuwaiti-owned or chartered vessels. In the short term the aim is for 50% of Kuwait's crude exports to be carried in Kuwaiti vessels.

2.1.2 Problems Facing the Oil Sector

As shown in Table 2.1 Kuwait's oil production has fallen substantially since the peak of a little over 3 mmbpd in 1973. This reduction is the result both of government inspired conservation measures, the present production ceiling being 1.25 mmbpd, and of the worldwide over-supply situation. Concerning the latter has been the availability of similar quality oil to Kuwait's from other sources at lower prices.

The country's oil revenues are therefore expected to be lower than anticipated and some projects may be delayed due to the lower trade surplus.
However this can be considered as a problem of a cyclical nature linked to the state of health of the world economy. More fundamental problems concerning Kuwait's oil industry are linked to natural gas and refined petroleum products.

Kuwait has been a leader amongst oil producing countries in reducing the flaring of natural gas produced in association with crude oil and has been a pioneering producer and exporter of LPG's for some years - firstly with the natural gas liquids (NGC) fractionator at Mina-al-Ahmadi and subsequently with the very large NGL separation plant at Shuaiba.

All the reserves of natural gas in Kuwait are associated gas - thus the production level of gas is directly dependent on the crude production level. The Shuaiba plant was designed to handle gas associated with a much higher crude production level than even the present production ceiling of 1.25 mmbpd (which in itself is much higher than actual production levels). Consequently only two of the three fractionation trains at Shuaiba are in operation.

This shortfall in LPG production, together with Kuwait's wish to boost trade for its own ships under cif contracts led to the calling of 'force majeure' on LPG fob contracts, halving Japan's fob contract volumes. Following this, despite trade cuts, Kuwait found itself with a growing surplus of LPG which it tried to dispose of by linking crude oil sales contracts to a compulsory lifting of LPG. This happened in 1980. Since then with further drops in crude production Kuwait has been in the strange position of being LPG short and in order to meet domestic demand and the export cif trade having to buy LPG from Saudi Arabia.

One mooted project to reduce the shortfall in natural gas feed to the fractionation plant was to instigate a gas-
gathering system in the Divided Zone where production is shared with Saudi Arabia. A contract for the installation of a gas-gathering system for the onshore fields has reportedly been placed.

Clearly the ideal situation, which would enable Kuwait to avoid such problems, would be to discover non-associated gas. An extensive drilling programme is underway, but so far results have been negative.

A major problem area is that of refined products. Kuwait was a leading exporter of products to the Gulf area, East Africa and South-West Asia. However this business has now dwindled due to a number of reasons:

- Kuwait's relatively poor quality oil (heavy, high sulphur, high fuel oil yield on distillation)
- Two of its three refineries being old and unsophisticated have been very limited in upgrading ability
- Very rapid growth in domestic demand for refined products
- In international markets the stagnation of fuel oil demand and growing demand for high grade light products.

A major expansion and upgrading programme for Mina-al-Ahmadi and Mina Abdullah refineries has been established, detailed in the previous chapter, and work has already started at Ahmadi. By 1995 when these works are completed Kuwait will have the capacity to refine about 750,000 bd, of which some 650,000 bd is expected to be for export - i.e. about half of the total allowable crude production.

Linked to this intention of Kuwait's of increasing the part of total exports in terms of value-added refined products is the intention of increasing shipments on a cif basis - in the long term a figure of 70% has been mooted. The
Kuwait Oil Tanker Co's fleet, already the largest in the Middle East, is set for a massive expansion over the next few years, particularly as far as product tankers are concerned.

How successful this avowed policy will be is unclear. Major potential obstacles are:

- resistance on the part of consumer countries to importing refined products when their own refining facilities are under-utilised following the reduction in oil demand. Furthermore the cost of shipping products over long hauls in relatively small tankers is considerably higher than the cost of shipping crude. Even in the present situation of excess shipping capacity and depressed freight rates the market rates for the smaller categories of crude carriers and product carriers have remained much more buoyant than the rates for VLCC's and ULCC's.

It is likely that Kuwait's main targets for product exports will be developing countries in Asia and Africa. However here too resistance is likely to be encountered since these countries are also trying to maximise the valorisation of indigenous energy resources and minimise oil imports in order to improve their balance of payments position. They too are keen to increase the use of their own shipping for imports and increase the ratio fob:cif of their imports - UNCTAD conference.

Kuwait is not alone amongst OPEC countries in wishing to increase the proportion of value-added product exports. Saudi Arabia with its massive developments at Jubail and Yanbu is proposing to establish as joint ventures with a number of Western partners several export-oriented oil refineries and petrochemical plants. In consequence, quite
apart from possible consumer resistance to Kuwait's avowed oil policy, the country will face competition in the market place from fellow OPEC states.

Another problem area facing Kuwait regarding refined products is the rapidly growing domestic demand. In 1979 Kuwait already had one of the highest per capita energy consumptions in the world and compared with developed countries as follows:

<table>
<thead>
<tr>
<th>Country</th>
<th>Consumption Per Capita</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>63</td>
</tr>
<tr>
<td>Kuwait</td>
<td>52</td>
</tr>
<tr>
<td>West Germany</td>
<td>34</td>
</tr>
<tr>
<td>UK</td>
<td>29</td>
</tr>
<tr>
<td>France</td>
<td>26</td>
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<td>Japan</td>
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<td>Italy</td>
<td>19</td>
</tr>
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<td>Spain</td>
<td>15</td>
</tr>
</tbody>
</table>

Domestic consumption of petroleum products in Kuwait for the years 1978, 1979, 1980 are given in Table 2.4 and the production of petroleum products for these years given in Table 2.5. The data source is the OAPEC Bulletin (various issues). However there is considerable difficulty in ascertaining definitive data on Kuwait's energy consumption. Various data sources have been found which quote substantially different consumption figures. Thus the figures in Table 2.4 are essentially in line with data reported in the OPEC Annual Statistical Bulletin 1980, whereas the publicaton 'Energy in the Arab World', Volume III, 1980, gave the following data for Kuwait:
TABLE 2.4: DOMESTIC CONSUMPTION OF PETROLEUM PRODUCTS 1978-80

<table>
<thead>
<tr>
<th>Product</th>
<th>1978 (000's b/d)</th>
<th>1979 (000's b/d)</th>
<th>1980 (000's b/d)</th>
</tr>
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<tr>
<td>LPG</td>
<td>1.4</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Gasoline</td>
<td>16.8</td>
<td>18.7</td>
<td></td>
</tr>
<tr>
<td>Jet Fuel</td>
<td>6.5</td>
<td>8.2</td>
<td></td>
</tr>
<tr>
<td>Kerosene</td>
<td>0.7</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>Gas/Diesel oil</td>
<td>9.0</td>
<td>8.1</td>
<td></td>
</tr>
<tr>
<td>Fuel oil</td>
<td>0.7</td>
<td>1.6</td>
<td></td>
</tr>
<tr>
<td>Asphalt</td>
<td>1.7</td>
<td>2.5</td>
<td></td>
</tr>
</tbody>
</table>

Data source: OAPEC Bulletin, October 1980

Oil products consumption  
1966: 3.09 mm bbl = 8,466 bpd  
1977: 7.95 mm bbl = 21,781 bpd

Gas consumption  
1966: 6.11 mm boe = 16,740 bpd  
1977: 30.05 mm boe = 82,329 bpd

Electricity consumption  
1966: 57.00 mm bpe = 1,562 bpd  
1977: 3.2 mm boe

The 1977 oil products consumption figure of 21.8 mbd is somewhat different from that of 31.1 mbd reported in the OPEC Annual Statistics. According to the OPEC Bulletin of July 1981 Kuwait's oil products demand in 1980 amounted to 151,000 bd, excluding oil products, crude oil and gas used for electricity and water production and excluding gas used for industrial and other purposes. Yet another source, the
### TABLE 2.5: PRODUCTION OF PETROLEUM PRODUCTS 1978-80

<table>
<thead>
<tr>
<th>Product Type</th>
<th>1978</th>
<th>1979</th>
<th>1980</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>From refineries:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gasoline</td>
<td>20.4</td>
<td>23.4</td>
<td>21.7</td>
</tr>
<tr>
<td>Naptha</td>
<td>50.9</td>
<td>63.1</td>
<td>45.3</td>
</tr>
<tr>
<td>Kero/Jet Fuel</td>
<td>37.6</td>
<td>51.8</td>
<td>43.2</td>
</tr>
<tr>
<td>Gas Oil</td>
<td>74.6</td>
<td>71.7</td>
<td></td>
</tr>
<tr>
<td>Diesel Oil</td>
<td>8.1</td>
<td>12.8</td>
<td>75.5</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>159.8</td>
<td>181.2</td>
<td>144.4</td>
</tr>
<tr>
<td>Asphalt</td>
<td>1.9</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>Sulphur</td>
<td>1.0</td>
<td>1.1</td>
<td>26.8</td>
</tr>
<tr>
<td>Others</td>
<td>4.2</td>
<td>5.7</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>358.5</td>
<td>413.4</td>
<td>434.2</td>
</tr>
<tr>
<td><strong>From LPG plant:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Butane</td>
<td>18.1</td>
<td>39.9</td>
<td></td>
</tr>
<tr>
<td>Propane</td>
<td>19.8</td>
<td>59.9</td>
<td></td>
</tr>
<tr>
<td>Natural Gasoline</td>
<td>14.8</td>
<td>27.3</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>52.7</td>
<td>127.1</td>
<td>77.3</td>
</tr>
</tbody>
</table>

*Data source: OAPEC Bulletin, October 1980*
International Herald Tribune supplement on Kuwait in July 1982, reported a current oil products demand of around 90,000 bd.

A recent report in the 'Petroleum Economist' stated that, according to KNPC, the consumption of gasoline, diesel and Kerosene in 1981 amounted to 41.6 mbpd, an increase of 33% over the 1980 consumption of 31.2 mbpd. These figures are closer to the OPEC/OAPEC statistics, but not exactly in line since they are only for three products.

Comparison of Kuwait's production, consumption and export of refined products for 1979 gives the following:

<table>
<thead>
<tr>
<th></th>
<th>Production</th>
<th>Consumption</th>
<th>Export</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>23.4</td>
<td>18.7</td>
<td></td>
</tr>
<tr>
<td>Kerosene/Naptha</td>
<td>114.9</td>
<td>8.9</td>
<td></td>
</tr>
<tr>
<td>Distillate fuels</td>
<td>84.5</td>
<td>8.1</td>
<td></td>
</tr>
<tr>
<td>Residual fuels</td>
<td>181.2</td>
<td>1.6</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>135.4</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>539.4</strong></td>
<td><strong>41.3</strong></td>
<td><strong>423.6</strong></td>
</tr>
</tbody>
</table>

As can be seen in 1979 the difference between consumption and exports and production is about 75 mbpd, some of which must effectively be domestic consumption. Clearly the system of reporting statistics is not uniform and could usefully be improved to avoid such anomalies.

The cost of oil and gas products for domestic consumption is subsidised by the Kuwaiti government, undoubtedly explaining in part the very rapid increase in domestic consumption in recent years. In 1980 this subsidy
reportedly reached 126 million KD (compared with 15 million in 1975) according to the OPEC Bulletin, related to a supposed oil products consumption level of 151,000 bd.

Given the State's general policy on the conservation of natural resources it is clear that the policy on domestic consumption of gas and oil products needs review and it is reported that the government is considering the measures required to control this consumption and is studying the possibility of raising the price of fuels on the domestic market whilst channelling subsidies only to those parties who warrant it.

Forecasts of Kuwait's future energy consumption have been found for 1985 and 2000.

1985 consumption, according to 'Energy in the Coal World' is projected to be:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil products</td>
<td>98,000 bd</td>
</tr>
<tr>
<td>Gas</td>
<td>82,200 bd oe</td>
</tr>
<tr>
<td>Electricity</td>
<td>27,670 bd oe</td>
</tr>
</tbody>
</table>

These figures imply an annual average growth rate for electricity of 12%, oil products 22% - mainly due to the replacement of gas by fuel oil for electricity generation and a drop in the consumption of gas.

For the year 2000 forecasts of 239,000 bd of oil products and 168,500 bd o.e. of gas has been reported (OPEC Bulletin, January 1981).

A further problem concerning the oil sector, which is now receiving attention from the government, concerns the development of a national workforce. It is necessary to
increase its participation and raise technical standards in the various specialisations and vocations relating to the production and processing of crude oil, through education, training and the creation of wider job opportunities at all levels. Over the five year period 1975-80 the proportion of local employees in KOC, KNPC and PIC has increased from 27.7% to 36%. Over the same period the total workforce in these companies has increased from 6,710 to 11,476.

The existing training programmes include on the job as well as special courses of varying duration both in Kuwait and overseas. In the period 1978-80 about 200 Kuwaitis studied abroad. A comprehensive training institute, initially for 400 trainees, is presently under construction. Subsequently enrolment will be increased to 1,500.

With the programmed expansions in downstream activities - oil refining, petrochemicals etc - the oil-related labour force can be expected to expand substantially in the coming years. Furthermore, this downstream expansion together with (eventually) more sophisticated oil production techniques being required in Kuwait (tertiary recovery etc), the demand will be increasingly for skilled specialists and it is clear that for some years to come Kuwait will need a large expatriate labour force in the oil industry.

A study carried out by Nizar Nihad of OAPEC'S Training and Manpower Development Unit, based on Kuwait's third 5-year plan (1976/77 - 80/81) and backed up by an OAPEC survey concluded that:

- Arab oil producing countries will be able to strike some sort of balance between labour supply and demand only through long range (10-15 years) plans. The establishment of a regional Arab organisation unifying OAPEC countries and other Arab labour exporting countries for
the purpose of creating such a balance at the pan-Arab level is recommended.

- It is essential not only to design and adopt an ideal manpower plan but to implement and execute such a plan - involving the development of proper policies to establish adequate training centres as well as ways and means to attract natives to undergo such training.

- Specialised regional Arab organisations such as OAPEC have a major role to play in co-ordinating the manpower plans of their member countries. OAPEC has embarked on its training role with the establishment of the Arab Petroleum Training Institute in Baghdad in 1979.

- The recent rationalisation of the Kuwaiti oil industry with the establishment of the Kuwait Petroleum Corporation should help in the effective co-ordination of the activities of its member companies, including training and manpower development.

Brief mention of a few relevant statistics highlights the magnitude of the problem facing Kuwait despite its abundance of capital:

- a population that has grown from 75,000 to 1.4 million in 40 years

- a majority of the population, almost 800,000 are non-Kuwaitis

- about 50% of the population is under 15 years of age

- a labour force of which 70% are foreigners, only 8% women, and only 2% in the oil industry
- a high rate of illiteracy amongst both Kuwaiti and immigrants

Kuwait's oil wealth has enabled it to build a welfare state at least comparable to that of any developed country - but for Kuwaiti citizens only. This means they can now receive social welfare, a government pension, a free house, act as agent to buy or sell land and receive a guaranteed free education. In the private sector of industry foreign companies are obliged to have a Kuwaiti partner, which has enabled many Kuwaitis to make a very comfortable living without having to work very hard.

All this has meant that over the years a negative social attitude has developed with regard to hard work, to manual labour and also to the role of women. These attitudes will be difficult and slow to change, but until they do Kuwait will remain dependent in large measure on expatriate labour and thus the potential risk of instability and dissatisfaction amongst the foreign residents will remain.

Another oil-related problem is that of downstream developments into petrochemicals. Apart from the established ammonia/urea complex the Government has long considered the establishment of olefins and aromatics complexes, as described in the preceding chapter. However Kuwait's limited domestic market and lack of trained manpower would mean that such developments would need yet more imported labour and the bulk of the production would have to find export outlets - in competition with other OPEC states' facilities. Presently the government seems, wisely, to be concentrating more on the possibility of joint venture developments with neighbouring Gulf states.
2.1.3 The Oil Sector and the Kuwaiti Economy

Prior to the discovery of oil in the late 1930's and the onset of commercial production in 1946 Kuwait had a primitive economy based on fishing, pearls, boats and trade. The contribution of the oil sector to the country's economy can best be presented via a series of statistical tables, followed by a brief discussion of developments to date.

The evolution of Kuwait's crude oil production since its inception in 1946, including cumulative production, is shown in Table 2.6. The price development of export blend crude is shown in Table 2.7. In this table initially 'posted' prices are given and latterly the official selling price, with a brief period in 1974-75 when both systems were in use. The 'posted' prices were those set by the concessionaire companies as a basis for tax and royalty payments to the State. The official selling price is that set by the Kuwaiti government.

The State's oil revenues since 1950 are shown in Table 2.8 in Kuwaiti dinars to 1978/79 and latterly in US dollars. This series shows quite clearly the relatively slow build-up in income to 1973/74, effectively only due to increases in oil output, followed by the massive jumps in 1974/75, in 1977/78 and in 1979, due to substantial increases in the crude price.

The volume of Kuwait's crude oil and refined products exports, together with their value and the State's oil revenues are shown for the period 1960-1980 in Table 2.9.

The country's Gross National Product (at current market prices), the cif value of imports, the fob value of total exports, oil's share of total exports and trade balance are
TABLE 2.6: CRUDE OIL PRODUCTION IN KUWAIT SINCE COMMENCEMENT  
Units: 000's barrels

<table>
<thead>
<tr>
<th>Year</th>
<th>Daily average</th>
<th>Total</th>
<th>Cumulative</th>
</tr>
</thead>
<tbody>
<tr>
<td>1946</td>
<td>16.2</td>
<td>5,928</td>
<td>5,928</td>
</tr>
<tr>
<td>1947</td>
<td>44.5</td>
<td>16,228</td>
<td>22,156</td>
</tr>
<tr>
<td>1948</td>
<td>127.2</td>
<td>46,547</td>
<td>68,703</td>
</tr>
<tr>
<td>1949</td>
<td>246.5</td>
<td>89,790</td>
<td>158,493</td>
</tr>
<tr>
<td>1950</td>
<td>344.4</td>
<td>125,722</td>
<td>284,215</td>
</tr>
<tr>
<td>1951</td>
<td>559.9</td>
<td>204,910</td>
<td>489,125</td>
</tr>
<tr>
<td>1952</td>
<td>749.1</td>
<td>273,433</td>
<td>762,558</td>
</tr>
<tr>
<td>1953</td>
<td>861.9</td>
<td>314,592</td>
<td>1,077,150</td>
</tr>
<tr>
<td>1954</td>
<td>959.7</td>
<td>350,294</td>
<td>1,427,444</td>
</tr>
<tr>
<td>1955</td>
<td>1,103.6</td>
<td>402,828</td>
<td>1,830,272</td>
</tr>
<tr>
<td>1956</td>
<td>1,108.5</td>
<td>405,696</td>
<td>2,235,968</td>
</tr>
<tr>
<td>1957</td>
<td>1,171.6</td>
<td>427,627</td>
<td>2,663,595</td>
</tr>
<tr>
<td>1958</td>
<td>1,435.8</td>
<td>524,070</td>
<td>3,187,665</td>
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<tr>
<td>1959</td>
<td>1,441.1</td>
<td>525,995</td>
<td>3,713,660</td>
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<tr>
<td>1960</td>
<td>1,691.8</td>
<td>619,193</td>
<td>4,332,853</td>
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<tr>
<td>1961</td>
<td>1,735.0</td>
<td>633,280</td>
<td>4,966,133</td>
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<tr>
<td>1962</td>
<td>1,957.8</td>
<td>714,598</td>
<td>4,680,731</td>
</tr>
<tr>
<td>1963</td>
<td>2,096.3</td>
<td>765,150</td>
<td>6,445,881</td>
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<tr>
<td>1964</td>
<td>2,301.0</td>
<td>842,160</td>
<td>7,228,041</td>
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<tr>
<td>1965</td>
<td>2,360.3</td>
<td>861,527</td>
<td>8,149,568</td>
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<td>1966</td>
<td>2,484.1</td>
<td>906,702</td>
<td>9,056,270</td>
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<tr>
<td>1967</td>
<td>2,499.8</td>
<td>912,427</td>
<td>9,968,697</td>
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<tr>
<td>1968</td>
<td>2,613.5</td>
<td>956,549</td>
<td>10,925,246</td>
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<td>1969</td>
<td>2,773.4</td>
<td>1,012,306</td>
<td>11,937,552</td>
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<tr>
<td>1970</td>
<td>2,989.6</td>
<td>1,091,189</td>
<td>13,028,741</td>
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<td>1971</td>
<td>3,196.7</td>
<td>1,166,796</td>
<td>14,195,537</td>
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<tr>
<td>1972</td>
<td>3,283.0</td>
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<td>15,397,115</td>
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<tr>
<td>1973</td>
<td>3,020.4</td>
<td>1,102,446</td>
<td>16,499,561</td>
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<tr>
<td>1974</td>
<td>2,546.1</td>
<td>929,341</td>
<td>17,428,902</td>
</tr>
<tr>
<td>1975</td>
<td>2,084.2</td>
<td>760,733</td>
<td>18,189,635</td>
</tr>
<tr>
<td>1976</td>
<td>2,145.4</td>
<td>785,216</td>
<td>18,974,851</td>
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<tr>
<td>1977</td>
<td>1,969.0</td>
<td>718,685</td>
<td>19,693,536</td>
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<tr>
<td>1978</td>
<td>2,131.4</td>
<td>777,961</td>
<td>20,471,497</td>
</tr>
<tr>
<td>1979</td>
<td>2,500.3</td>
<td>912,610</td>
<td>21,384,107</td>
</tr>
<tr>
<td>1980</td>
<td>1,663.7</td>
<td>608,914</td>
<td>21,993,021</td>
</tr>
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</table>

Data source: OPEC Annual Statistical Bulletin 1980
TABLE 2.7: CRUDE OIL PRICE, KUWAIT EXPORT BLEND, F.O.B. LOADING PORT US $/BARRELL

<table>
<thead>
<tr>
<th>Date effective</th>
<th>Posted price</th>
<th>Official selling price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1953 1 April</td>
<td>1.500</td>
<td></td>
</tr>
<tr>
<td>16 July</td>
<td>1.720</td>
<td></td>
</tr>
<tr>
<td>1957 28 May</td>
<td>1.850</td>
<td></td>
</tr>
<tr>
<td>1959 13 February</td>
<td>1.670</td>
<td></td>
</tr>
<tr>
<td>1960 9 August</td>
<td>1.590</td>
<td></td>
</tr>
<tr>
<td>1970 14 November</td>
<td>1.680</td>
<td></td>
</tr>
<tr>
<td>1971 15 February</td>
<td>2.085</td>
<td>2.187</td>
</tr>
<tr>
<td>1 June</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1972 2 January</td>
<td>2.373</td>
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</tr>
<tr>
<td>1973 1 January</td>
<td>2.482</td>
<td></td>
</tr>
<tr>
<td>1 April</td>
<td>2.626</td>
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<tr>
<td>1 June</td>
<td>2.776</td>
<td></td>
</tr>
<tr>
<td>1 July</td>
<td>2.830</td>
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</tr>
<tr>
<td>1 August</td>
<td>2.936</td>
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</tr>
<tr>
<td>1 October</td>
<td>2.884</td>
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</tr>
<tr>
<td>16 October</td>
<td>4.903</td>
<td></td>
</tr>
<tr>
<td>1 November</td>
<td>4.957</td>
<td></td>
</tr>
<tr>
<td>1 December</td>
<td>4.822</td>
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<tr>
<td>1974 1 January</td>
<td>11.545</td>
<td></td>
</tr>
<tr>
<td>1 November</td>
<td>11.145</td>
<td>10.365</td>
</tr>
<tr>
<td>1975 1 October</td>
<td>12.151</td>
<td>11.300</td>
</tr>
<tr>
<td>1976 1 June</td>
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<td>11.230</td>
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<tr>
<td>1977 1 January</td>
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<td>12.370</td>
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<tr>
<td>1978 1 January</td>
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<td>12.270</td>
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<tr>
<td>1979 1 January</td>
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<td>12.830</td>
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<tr>
<td>20 February</td>
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<tr>
<td>1 April</td>
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<td>15 May</td>
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<td>16.400</td>
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<tr>
<td>1 July</td>
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<td>19.490</td>
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<tr>
<td>1 October</td>
<td></td>
<td>21.430</td>
</tr>
<tr>
<td>1 November</td>
<td></td>
<td>25.500</td>
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<td>1980 1 January</td>
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<td>27.500</td>
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<tr>
<td>1 May</td>
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<td>29.500</td>
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<td>1 July</td>
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<td>31.500</td>
</tr>
<tr>
<td>1981 1 January</td>
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<td>35.500</td>
</tr>
<tr>
<td>1 November</td>
<td></td>
<td>33.000</td>
</tr>
<tr>
<td>1982 1 January</td>
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<td>32.300</td>
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</table>

Data source: OPEC Annual Statistical Bulletin
<table>
<thead>
<tr>
<th>Year</th>
<th>Revenues (Millions KD)</th>
<th>Revenues (Millions US $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>4.9</td>
<td></td>
</tr>
<tr>
<td>1951</td>
<td>6.7</td>
<td></td>
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<td>1952</td>
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<tr>
<td>1953</td>
<td>60.2</td>
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<td>1954</td>
<td>69.3</td>
<td></td>
</tr>
<tr>
<td>1955</td>
<td>100.5</td>
<td></td>
</tr>
<tr>
<td>1956</td>
<td>104.3</td>
<td></td>
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<tr>
<td>1957</td>
<td>110.2</td>
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<td>1958</td>
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<td>1959</td>
<td>159.8</td>
<td></td>
</tr>
<tr>
<td>1960</td>
<td>158.6</td>
<td></td>
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<tr>
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</tr>
<tr>
<td>1962/63</td>
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</tr>
<tr>
<td>1964/65</td>
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</tr>
<tr>
<td>1965/66</td>
<td>216.1</td>
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</tr>
<tr>
<td>1966/67</td>
<td>231.7</td>
<td></td>
</tr>
<tr>
<td>1967/68</td>
<td>263.1</td>
<td></td>
</tr>
<tr>
<td>1968/69</td>
<td>246.5</td>
<td></td>
</tr>
<tr>
<td>1969/70</td>
<td>279.3</td>
<td></td>
</tr>
<tr>
<td>1970/71</td>
<td>297.7</td>
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</tr>
<tr>
<td>1971/72</td>
<td>354.1</td>
<td></td>
</tr>
<tr>
<td>1972/73</td>
<td>506.6</td>
<td></td>
</tr>
<tr>
<td>1973/74</td>
<td>530.9</td>
<td></td>
</tr>
<tr>
<td>1974/75</td>
<td>2,382.0</td>
<td>7,615.4</td>
</tr>
<tr>
<td>1975/76</td>
<td>1,686.7</td>
<td>7,951.7</td>
</tr>
<tr>
<td>1976/77</td>
<td>2,111.1</td>
<td></td>
</tr>
<tr>
<td>1977/78</td>
<td>2,181.8</td>
<td>7,615.4</td>
</tr>
<tr>
<td>1978/79</td>
<td>2,186.7</td>
<td>7,951.7</td>
</tr>
<tr>
<td>1979</td>
<td></td>
<td>16,863.0</td>
</tr>
<tr>
<td>1980</td>
<td></td>
<td>18,016.0</td>
</tr>
</tbody>
</table>

Notes: For years 1960-78 year ending 31 March
1959 revenue from 1.1.59 - 31.3.60

Data source: OPEC Annual Statistical Bulletin
<table>
<thead>
<tr>
<th>Year</th>
<th>Crude exports 000 b/d</th>
<th>Product exports 000 b/d</th>
<th>Value of petroleum exports $ millions</th>
<th>Oil revenues $ millions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>1,494.3</td>
<td>96.2</td>
<td>855.0</td>
<td>-</td>
</tr>
<tr>
<td>1961</td>
<td>1,546.3</td>
<td>95.6</td>
<td>853.0</td>
<td>461.9</td>
</tr>
<tr>
<td>1962</td>
<td>1,729.2</td>
<td>119.8</td>
<td>961.0</td>
<td>480.3</td>
</tr>
<tr>
<td>1963</td>
<td>1,790.7</td>
<td>185.0</td>
<td>1,029.0</td>
<td>521.4</td>
</tr>
<tr>
<td>1964</td>
<td>1,989.7</td>
<td>211.5</td>
<td>1,146.0</td>
<td>566.4</td>
</tr>
<tr>
<td>1965</td>
<td>2,035.3</td>
<td>233.7</td>
<td>1,160.0</td>
<td>598.2</td>
</tr>
<tr>
<td>1966</td>
<td>2,181.8</td>
<td>238.7</td>
<td>1,235.00</td>
<td>637.8</td>
</tr>
<tr>
<td>1967</td>
<td>2,202.2</td>
<td>219.8</td>
<td>1,233.0</td>
<td>714.7</td>
</tr>
<tr>
<td>1968</td>
<td>2,307.0</td>
<td>215.0</td>
<td>1,313.0</td>
<td>701.8</td>
</tr>
<tr>
<td>1969</td>
<td>2,441.7</td>
<td>190.1</td>
<td>1,387.0</td>
<td>759.1</td>
</tr>
<tr>
<td>1970</td>
<td>2,579.9</td>
<td>251.0</td>
<td>1,596.0</td>
<td>820.7</td>
</tr>
<tr>
<td>1971</td>
<td>2,775.2</td>
<td>234.2</td>
<td>2,143.0</td>
<td>954.3</td>
</tr>
<tr>
<td>1972</td>
<td>2,925.0</td>
<td>210.5</td>
<td>2,270.0</td>
<td>1,403.7</td>
</tr>
<tr>
<td>1973</td>
<td>2,641.6</td>
<td>205.7</td>
<td>3,033.0</td>
<td>1,734.7</td>
</tr>
<tr>
<td>1974</td>
<td>2,203.2</td>
<td>192.5</td>
<td>9,293.0</td>
<td>6,542.6</td>
</tr>
<tr>
<td>1975</td>
<td>1,803.4</td>
<td>140.5</td>
<td>7,886.0</td>
<td>6,393.1</td>
</tr>
<tr>
<td>1976</td>
<td>1,790.9</td>
<td>336.9</td>
<td>8,951.0</td>
<td>6,869.5</td>
</tr>
<tr>
<td>1977</td>
<td>1,624.8</td>
<td>313.3</td>
<td>8,821.0</td>
<td>7,515.7</td>
</tr>
<tr>
<td>1978</td>
<td>1,761.2</td>
<td>327.1</td>
<td>9,424.0</td>
<td>7,699.5</td>
</tr>
<tr>
<td>1979</td>
<td>2,083.1</td>
<td>423.6</td>
<td>16,673.0</td>
<td>16,863.0</td>
</tr>
<tr>
<td>1980</td>
<td>1,296.5</td>
<td>343.4</td>
<td>18,331.0</td>
<td>18,016.0</td>
</tr>
</tbody>
</table>

Data source: OPEC Annual Statistical Bulletin
Perusal of these statistics shows the dominance of oil in the Kuwaiti economy, according as it does for over 90% of the total value of exports. The non-oil exports thus represent only a small fraction of total exports. Further a major part of these non-oil exports are not goods of Kuwaiti origin but are re-exports. Exports of Kuwaiti origin are mainly fertilisers, chemicals, shrimp, building materials and metal pipes.

Following cautious development policies and with the large oil revenues Kuwait has had a balance of trade surplus for many years. Development spending has been concentrated on infrastructure, principally education, health care, public works, electricity, water supply, communications and these are now well-developed. The major component in current spending is on defence. Even after these expenditures the scale of Kuwait's oil income is such that it cannot all be spent and a considerable surplus remains to be invested in reserves and overseas projects. Official reserves amounted to over $5.3 billion in January 1982, of which gold holdings were valued at $1.3 billion.

Additionally the country has substantial foreign investments, which are not recorded in official statistics, built up from the trade surpluses over a period of years. In May 1982 these foreign assets were estimated to be approximately $80 billion invested as follows:

With these overseas assets Kuwait is now earning a sizeable annual investment income of some $7-8 billion, which although not as large as its oil income ($18 billion in 1980) is nevertheless starting to approach it. This investment income is not, as mentioned earlier, included in government revenue figures and it has not been used for
### TABLE 2.10: KUWAIT, ECONOMIC INDICATORS 1961 - 1980

<table>
<thead>
<tr>
<th>Year</th>
<th>GNP ($ million)</th>
<th>Imports (cif) $ millions</th>
<th>Exports (fob) $ millions</th>
<th>Oil share of exports (%)</th>
<th>Balance of trade $ millions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1961</td>
<td>1,148.0</td>
<td>249.0</td>
<td>962.0</td>
<td>88.7</td>
<td>713</td>
</tr>
<tr>
<td>1962</td>
<td>1,288.0</td>
<td>285.0</td>
<td>1,077.0</td>
<td>89.2</td>
<td>792</td>
</tr>
<tr>
<td>1963</td>
<td>1,361.0</td>
<td>324.0</td>
<td>1,136.0</td>
<td>90.6</td>
<td>812</td>
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<tr>
<td>1964</td>
<td>1,571.0</td>
<td>322.0</td>
<td>1,251.0</td>
<td>91.6</td>
<td>929</td>
</tr>
<tr>
<td>1965</td>
<td>1,548.0</td>
<td>377.0</td>
<td>1,284.0</td>
<td>90.3</td>
<td>907</td>
</tr>
<tr>
<td>1966</td>
<td>1,910.0</td>
<td>463.0</td>
<td>1,342.0</td>
<td>92.0</td>
<td>879</td>
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<tr>
<td>1967</td>
<td>2,055.0</td>
<td>593.0</td>
<td>1,291.0</td>
<td>95.5</td>
<td>698</td>
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<tr>
<td>1968</td>
<td>2,220.0</td>
<td>611.0</td>
<td>1,382.00</td>
<td>95.0</td>
<td>771</td>
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<tr>
<td>1969</td>
<td>2,352.0</td>
<td>649.0</td>
<td>1,474.0</td>
<td>94.1</td>
<td>825</td>
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<tr>
<td>1970</td>
<td>2,201.0</td>
<td>625.0</td>
<td>1,693.0</td>
<td>94.3</td>
<td>1,068</td>
</tr>
<tr>
<td>1971</td>
<td>3,033.0</td>
<td>652.0</td>
<td>2,272.0</td>
<td>94.3</td>
<td>1,620</td>
</tr>
<tr>
<td>1972</td>
<td>3,648.5</td>
<td>797.0</td>
<td>2,557.0</td>
<td>92.7</td>
<td>1,760</td>
</tr>
<tr>
<td>1973</td>
<td>6,003.4</td>
<td>1,064.0</td>
<td>3,324.0</td>
<td>91.2</td>
<td>2,260</td>
</tr>
<tr>
<td>1974</td>
<td>10,603.7</td>
<td>1,552.0</td>
<td>9,857.0</td>
<td>94.3</td>
<td>8,305</td>
</tr>
<tr>
<td>1975</td>
<td>12,762.1</td>
<td>2,390.0</td>
<td>8,644.0</td>
<td>91.2</td>
<td>6,254</td>
</tr>
<tr>
<td>1976</td>
<td>13,112.2</td>
<td>3,324.0</td>
<td>9,844.0</td>
<td>90.9</td>
<td>6,520</td>
</tr>
<tr>
<td>1977</td>
<td>14,150.1</td>
<td>4,840.0</td>
<td>9,801.0</td>
<td>90.0</td>
<td>4,961</td>
</tr>
<tr>
<td>1978</td>
<td>15,309.1</td>
<td>4,595.0</td>
<td>10,427.0</td>
<td>90.4</td>
<td>4,832</td>
</tr>
<tr>
<td>1979</td>
<td>23,307.0</td>
<td>5,200.0</td>
<td>18,242.0</td>
<td>91.4</td>
<td>13,042</td>
</tr>
<tr>
<td>1980</td>
<td>26,700.0</td>
<td>7,285.0</td>
<td>19,956.0</td>
<td>91.9</td>
<td>12,671</td>
</tr>
</tbody>
</table>

Data source: OPEC Annual Statistical Bulletin, 1980
budget expenditures but has traditionally been reinvested. Much of these assets are effectively the two funds built up to provide for Kuwaitis in the years to come – the Reserve Fund for Future Generations and the State General Reserve. The former of these two funds, set up in 1976 with a capital of 850 million KD is inviolate and is to be replenished each year with 10% of the State General Reserve.

The 1981-82 budget stipulated an increased emphasis on savings and the two above-mentioned funds are reportedly to receive $7.8 billion this year, compared with $5.9 billion in 1980-81.

As shown in Table 2.1 crude oil production in the last few months has been considerably below the government imposed
ceiling of 1.25 million bd and is presently below 800 thousand bd - due to the present soft oil market. Average production for 1981 was 1.127 million bd. The new budget for fiscal year 1982/83 (starting June 1, 1982) projects a 41.8% drop in oil revenues from $17.7 billion last year to $10.3 billion. Overall this will cause a budget deficit of $1.085 billion KD 312.9 million) which will have to be made up out of reserves. This reduction in oil income is due to a combination of weak demand and falling prices.

If this forecast of oil revenues proves to be correct then Kuwait's income from investments will be almost as large and it is conceivable that within the next few years it will become the biggest single source of income. With Kuwait's growing involvement in overseas petroleum ventures, exploration and refining/marketing, its income from non-Kuwait oil could become significant in the longer term.

An increasing contribution to GN can also be expected from petrochemicals but this will remain small in comparison to oil given Kuwait's cautious industrialisation policy. When the refinery upgrading and expansion programmes discussed earlier are completed and if Kuwait succeeds in its objective of exporting an increasing proportion of its crude oil production in terms of refined products then with this increased "value added" its oil income should grow despite the reduced production level - provided that the very rapid growth in internal products demand can be slowed down.

In the very long term it seems clear that as oil production and exports stagnate and eventually dwindle Kuwait's income will be principally derived from investments overseas, some of which will be oil-related.
2.1.4 The Impact of the Oil-Economy Interaction on Kuwait

The impact to date of the oil sector on Kuwait has been essentially described in a quantitative manner in the previous chapter. Qualitatively we can say that the massive influx of revenues has made the country one of the richest in the world, the population has grown rapidly and includes a substantial non-Kuwait workforce and a sophisticated welfare state system has been put into place.

The economy is dominated by the oil sector, industrial diversification having been very moderate and the only source of income remotely rivalling that of oil is Kuwait's overseas investment portfolio. The country has emerged as a regional banking centre and via Kuwaiti institutions is developing its role as an international capital market.

A recent paper by an economic adviser to OAPEC examined the integration of the oil sector with the Arab economies. Although this analysis was general to all Arab oil exporting countries the conclusions are worthwhile noting that at least to some degree they are applicable to Kuwait.

The historical impact of the oil sector was traced over time and three distinct phases revealed:

- from the onset of oil production through to the end of the 1940's when the sector was "isolated" and completely dissociated from the rest of the economy in terms of financial contribution, decision-making and the oil-sector's role in development

- the 1950's and 1960's when, thanks to the increase in the volume of revenues, the sector became a financial pump primer
- the 1970's when integration between the oil sector and the rest of the economy became tangible.

However, closer analysis of this latter period shows that the integration so far achieved has serious gaps:

- the revenue-generating role of oil, which is seen to have benefitted development, has been associated with a rapid depletion of the resource. Oil revenues have financed a large volume of luxury goods, often excessive arms purchases, etc.

- the abundance of the oil revenues has sometimes made over-priced goods easily acceptable, particularly capital goods. Some projects have been accepted with less scrutiny than would have been the case were financial resources more limited.

- along with the large oil revenues have emerged increasing differences among income and wealth distribution patterns, which could lead to social and political unrest and instability.

- the easy flow of revenues and individual income has damaged the work ethic and has serious implications for the future.

- the acquisition of real technological capability has been retarded due to the thinking that true technological transfer could be effected through the importation of capital goods and technical skills. Technological capability can really only be acquired through more theoretical and applied scientific training, more experimentation and actual on-the-job experience.
Thus the pattern of development to date has a number of shortcomings:

- slowness in diversification (increased relative importance of oil revenues)

- very sluggish developments of the agricultural sector

- slowness in the industrialisation process, with respect to the manufacturing sector's contribution to GDP and its volume of employment

- exaggerated expansion of the service sectors.

2.1.5 Long Term Consideration of the Kuwaiti Economy

Before the 1973 change in petroleum prices, during the period 1966-73, the Kuwaiti economy was growing in real terms at a yearly rate of 5%, stimulated by the expansion of government expenditure (at a rate of over 10%), and no particular effort was made in the area of gross fixed capital formation (indeed capital formation in real terms during that period seems to have been declining). Soon after the increase in petroleum prices, Kuwait has known an unprecedent period of economic growth, as shown in Table 2.11. The following changes in oil prices experienced during the 1980's have been reflected in the growth rates as shown:

The aims of the sudden heavy effort in capital formation have been twofold:

- to develop and improve the country's productive and social infrastructure; concentration has been in housing
TABLE 2.11: MACRO-ECONOMIC INDICATORS OF KUWAIT (AVERAGE ANNUAL GROWTH RATES FOR THE PERIOD 1974-77)

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Growth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private consumption expenditure</td>
<td>18.8%</td>
</tr>
<tr>
<td>Government consumption expenditure</td>
<td>19.8%</td>
</tr>
<tr>
<td>Gross fixed capital formation</td>
<td>44.7%</td>
</tr>
<tr>
<td>Import of goods and services</td>
<td>25.3%</td>
</tr>
</tbody>
</table>

Source: ENI, Interdependence model.

and social infrastructure for a rapidly growing population and in fixed assets for some service producing sectors (e.g. transport)

- to start industrial production activities in order to increase locally generated value added and to prepare the economy for a sustainable path after the depletion of oil resources (with investments in manufacturing activities connected with oil production like petrochemicals and shipping).

As a matter of fact, since the pre-73 period, the dependence of the Kuwaiti economy on oil has increased, as a result of the low level of new investment, and the Mining and Quarrying (oil) sector which accounted for 56.5% of GDP (at current prices) in 1968 had grown to represent 64.0% in 1973. A reasonable objective of the post-73 period has been the decrease of this ratio (due essentially to the oil price change, the ratio increased suddenly in 1974 to 80.8% and has been declining ever since reaching 65.1% in 1977).

One first objective of a long term study of the Kuwaiti economy is the analysis of the possible future evolution of this ratio.
In the ENI-Interdependence project (a system of models of OAPEC and industrialised countries completed by Battelle and ENI in 1981 and which is regularly being updated), the analysis of this ratio has been made using two methodological tools:

- a very aggregated macro-economic model which differentiates between the oil and non-oil sectors of the Kuwaiti economy

- a set of scenarios representing different situations of the world environment and consequently different evolutions of oil prices and Kuwait's oil revenues.

In the Interdependence project two main scenarios have been tested:

- a conflict scenario (NSI), with reduction of oil exports and high and fluctuating oil prices, and with a very low rate of economic growth at world level and particularly in the industrialized countries

- a cooperation scenario (ICS), with a long term price and quantity agreement between oil producers and oil consumers and with a higher growth rate at world level.

The Kuwaiti economy is expected to be influenced by the world situation in a moderate way, showing a higher growth potential under scenario ICS.

However, it is interesting to note that for both scenarios the model of Kuwait shows very similar results for the future evolution of the oil/non-oil ratio, in real terms. The share of the oil sector was expected to decline to 55% of GDP in 1985 and to 45% in 1990, an evolution that shows consistently the trend towards a rapid development of
non-oil activities inside the Kuwaiti economy, and is consistent with the objective of Kuwait's five year plan.

| TABLE 2.12 : SHARE OF THE OIL SECTOR IN GDP (AT CONSTANT 1977 PRICES) |
|-----------------------------|-----------------|-----------------|
|                             | 1977   | 1985   | 1990   |
| Conflict scenario           | 65.1   | 54.8   | 45.0   |
| Cooperation scenario        | 65.1   | 53.4   | 46.3   |
| (at current prices)         |        |        |        |
| Conflict scenario           | 65.1   | 60.3   | 54.5   |
| Cooperation scenario        | 65.1   | 58.3   | 61.6   |

Source: ENI, Interdependence model

This analysis has been quantified with a model of Kuwait's economy which introduced the existing alternative, as a government policy option, of developing the non-oil sector or of accumulating financial assets abroad. In this way the model is a first indicator of possible development paths, and could constitute a first basis for the development of a more comprehensive policy oriented model for Kuwait. Such a complete model for the simulation of long term paths should be able to take into account the specific factors which favour the possible development of the non-oil sector, but also the constraints within which the country's decision making process has to operate, and in particular:

1. Manpower

Kuwait is a small country and its production is heavily dependent on foreign manpower. Over the past 20 years the ratio of non-Kuwaiti workers has been consistently above
50% of Kuwait's labour force (which doubled during the 1965-75 period and has been rapidly increasing since then). The long term policy of immigration, the real absorption capacity of the country are not independent from the growth alternatives considered for the non-oil sector.

In this respect it is interesting to note that manufacturing accounted in 1977 for less of the total labour force and that the services sector has been increasing relatively and in absolute terms, going from less than 70% of the labour force in 1965 to nearly 80% ten years later. How receptive is this labour structure to further development of the manufacturing sector? What are the alternatives in terms of new internationally competitive services sectors? A policy waiving intensive industrial development in favour of increased net lending abroad, in order to increase the share of net incomes from abroad for the formation of disposable national income, may also increase the relative size of the financial sector as a value added sector in the economy. How stable is a solution of this type in the world environment?

Geo-economic considerations, lack of water and agricultural land, condition a sustainable development of population, and introduces further limitations upon certain sectorial developments.

2. The markets and technology

Again as a result of its limited dimensions, the amount of activities oriented towards the internal market is limited and encounters some form of ceiling after the initial growth period (this is for instance the case with construction activities).
**TABLE 2.13 : FORECASTING RESULTS FOR OIL-PRICE SCENARIO B**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Year</th>
<th>BOP</th>
<th>DEA</th>
<th>GDP</th>
<th>GDPN</th>
<th>GNP</th>
<th>GR</th>
<th>M</th>
<th>OILQ</th>
<th>P</th>
<th>ROIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>1980</td>
<td>5,150.5</td>
<td>3,974.5</td>
<td>9,125.1</td>
<td>1,641.7</td>
<td>9,937.1</td>
<td>6,954.9</td>
<td>2,318.1</td>
<td>796.79</td>
<td>238.64</td>
<td>6,255.4</td>
</tr>
<tr>
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<td>1985</td>
<td>8,014.7</td>
<td>8,862.2</td>
<td>16,877.0</td>
<td>2,292.3</td>
<td>19,846.0</td>
<td>17,816.0</td>
<td>5,304.5</td>
<td>853.06</td>
<td>450.48</td>
<td>16,778.0</td>
</tr>
<tr>
<td></td>
<td>1990</td>
<td>11,666.0</td>
<td>19,833.0</td>
<td>31,549.0</td>
<td>3,276.2</td>
<td>42,399.0</td>
<td>34,502.0</td>
<td>12,038.0</td>
<td>914.82</td>
<td>1,026.4</td>
<td>32,953.0</td>
</tr>
<tr>
<td>B2</td>
<td>1980</td>
<td>5,246.0</td>
<td>3,774.5</td>
<td>9,020.5</td>
<td>1,641.7</td>
<td>9,832.5</td>
<td>6,865.6</td>
<td>2,195.9</td>
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<td>237.58</td>
<td>6,166.1</td>
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<td>1985</td>
<td>8,669.7</td>
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<td>16,229.0</td>
<td>2,292.3</td>
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<td>1990</td>
<td>14,069.0</td>
<td>15,219.0</td>
<td>29,288.0</td>
<td>3,276.2</td>
<td>40,138.0</td>
<td>32,029.0</td>
<td>9,186.6</td>
<td>864.58</td>
<td>1,013.7</td>
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<td>1980</td>
<td>4,835.8</td>
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All new production projects have to be considered in a broader geographic context, either in relation to the Gulf area (and this is the goal of GOIC's activities) or with broader zones, including Europe and the industrialized nations. This kind of development requires powerful marketing arrangements with foreign firms, not counting other arrangements for technology transfer and know-how. It appears therefore that in most sectors of possible development of non-oil activities Kuwait is highly dependent on foreign decision-makers, both in terms of markets and technology, and this is also a factor to be taken seriously.

2.2 KUWAIT OIL MODELS

The previous part sheds some light on the oil sector and the Kuwaiti economy as well as their clear interaction which stands as a theoretical background to the proposed model.

To structure a tailor-made model for Kuwait utilizing the different growth theories or approaches, a starting point would be to understand the unique characteristic of the country which could be summarised as being:

a. A capital surplus rather than a labour surplus economy
b. Serious shortage of indigenous labour
c. An advanced oil sector, with an exhaustible resource
d. A small domestic market which limits the economy's absorptive capacity.

The other starting point towards building and specifying the Kuwait oil-model should be to review any previous work that has been done for the same economy (i.e. Kuwait) or for other developing oil-exporting economies which could be
characterised as being a (rentier economy) as well, such as Saudi Arabia, United Arab Emirates, Libya, etc.

S. Sangarabalan's (1984) study of "Macroeconomic Planning in Kuwait" using an econometric simulation approach, is an example of a previous study for the Kuwaiti economy in particular (1).

Sangarabalan's oil model for Kuwait adopts a growth theory framework together with a depletion theory since Kuwait is highly dependent on oil; its exhaustible resource.

Using the studies of Hoel (1981) Dasgupte and Heal (1981) which considers most of the Kuwaiti characteristics except the fact of the shortage in endogenous labour as a guideline, he specified Kuwait overall balance equation as:

$$ C + W = F(K,R,L) + r(W-K) + p \times E $$

where:
- $W$ = Country's total wealth
- $C$ = Consumption
- $K$ = Capital stock (domestic)
- $R$ = Resource
- $L$ = Labour
- $E$ = Exports of resource
- $P$ = Price of resource
- $r$ = Rate of returning from foreign assets
- $F(K,R,L)$ = Output

The model is built within a general equilibrium framework, comprising a demand and a supply side, with the demand model based on a Keynesian income-expenditure approach and the supply model, with its three disaggregated sectors represented in terms of neoclassical production functions. The structure of the model includes some equations for stock variables such as foreign assets, oil reserves, etc.
In addition, the model was designed on the assumption of an open economy accounting for international trade while assuming no significant influence for the role of prices or technological progress. The suggested macro economic model for Kuwait appears as follows:

**The Demand Side**

\[
\begin{align*}
GDP_t &= PC_t + PI_t + GC_t + GI_t \\
GNP_t &= GDP_t - BT_t \\
PIN_t &= GNP_t - GR_t \\
GR_t &= GFI_t + OIN_t + TX_t \\
PFI_t &= RR_t \cdot PFA_{t-1} \\
GFI_t &= RR_t \cdot GFA_{t-1} \\
PS_t &= PIN_t = PC_t = PIN_t \\
GS_t &= GR_t = GC_t - GI_t \\
OLEX_t &= POL_t \cdot QOLX_t \\
BT_t &= OLEX_t + NOX_t - IM_t \\
BP_t &= OLEX_t + NOX_t - IM_t + GFI_t + PFI_t + GS_t + PS_t \\
PC_t &= f \left( PC_{t-1}, PIN_t \right) \\
PI_t &= f \left( PI_{t-1}, GI_t, PIN_t \right)
\end{align*}
\]
\[ \frac{G_{C_t}}{T_{P_t}} = f\left(\frac{G_{R_t}}{T_{P_t}}, \frac{G_{C_{t-1}}}{T_{P_{t-1}}}\right) \]

\[ G_{I_t} = f\left(G_{R_t}, P_{I_{t-1}}, G_{I_{t-1}}\right) \]

\[ T_{X_t} = f\left(D_{S_{P_t}}\right) \]

\[ I_{M_t} = f\left(G_{D_{P_t}}, I_{M_{t-1}}\right) \]

\[ N_{O_X_t} = f\left(\frac{G_{D_P}}{G_{D_P}}\right) \]

**The Supply Side:**

\[ G_{D_P_2} = f\left[(K_{S_T_2}) . (T_{L_F_2}) . (O_{L_{R}})\right] \]

\[ G_{D_P_3} = f\left[(K_{S_T_3}) . (T_{L_F_3})\right] \]

\[ G_{D_{P_R}} = f\left[(K_{S_T_R})^3 . (T_{L_{F_R}})\right] \]

\[ T_{K_L_2} = 0.02 \ T_{K_L} \]

\[ T_{K_L_3} = 0.026 \ T_{K_L} \]

\[ T_{K_L_R} = 0.954 \ T_{K_L} \]

\[ T_{K_L} = 0.2 \ (1 + K_{P_R}) . T_{K_P} \]

\[ N_{K_L_i} = T_{L_{F_i}} = T_{K_L_i} \]

\[ T_{K_P_t} = T_{K_P_0} (1 + 0.0355)^t \]

\[ I_{N_{K_P}_t} = I_{N_{K_P}} . (1 + 0.05)^t \]

\[ Q_{O_D} = Q_{O_L_X_t} + Q_{O_L_D_t} \]

\[ Q_{O_L_D_t} = f\left(Q_{O_L_D_{t-1}}, G_{D_P_t}\right) \]
\[ \text{ROL}_t = \text{ROL}_{t-1} - \text{QOD}_t \]

\[ \text{TFA} = \text{GFA}_t + \text{PFA}_t \]

\[ \text{GFA} = \text{GFA}_{t-1} + \text{GS}_t \]

\[ \text{PFA}_t = \text{PFA}_{t-1} + \text{PS}_t \]

where:

\( \text{GDP} \) = Gross Domestic Product

\( \text{GNP} \) = Gross National Product

\( \text{PIN} \) = Private Sector Income

\( \text{GR} \) = Government Revenue

\( \text{PC} \) = Private Consumption expenditure

\( \text{GC} \) = Government Consumption expenditure

\( \text{PI} \) = Private Investment expenditure

\( \text{GI} \) = Government Investment expenditure

\( \text{TX} \) = Tax income

\( \text{OIN} \) = Oil Income

\( \text{PFI} \) = Private Foreign Income

\( \text{RR} \) = Rate of Return on Foreign Assets

\( \text{PFA} \) = Private Foreign Assets

\( \text{GFA} \) = Government Foreign Assets

\( \text{PS} \) = Private Surplus

\( \text{GS} \) = Government Surplus

\( \text{GDP2} \) = Gross Domestic Product of Mining Sector

\( \text{GDP3} \) = Gross Domestic Product of Manufacturing Sector
GDPR = Gross Domestic Product of Residual Sector
KST2 = Capital Stock in Mining Sector
KST3 = Capital Stock in Manufacturing Sector
KSTR = Capital Stock in Residual Sector
TLF2 = Total Labour Force in Mining Sector
TLF3 = Total Labour Force in Manufacturing Sector
TLFR = Total Labour Force in Residual Sector
TKL = Total Kuwaiti Labour
TKL2 = Total Kuwaiti Labour in Mining Sector
TKL3 = Total Kuwaiti Labour in Manufacturing Sector
TKLR = Total Kuwaiti Labour in Residual Sector
KPR = Kuwaiti Participation Rate
NKLi = Non-Kuwaiti Labour in Sector i, \( i=2, 3, R \)
TKLi = Total Kuwaiti Labour in Sector i, \( i=2, 3, R \)
TLFi = Total Labour Force in Sector i, \( i=2, 3, R \)
TKP = Total Kuwaiti Population
INKP = Indigenous Kuwaiti Population
TFA = Total Foreign Assets
QOD = Annual Oil Production (volume)
POL = Price of Oil
ROL = Reserves of Oil (volume)
QOLD = Annual Domestic Oil Consumption (volume)
QOLX = Annual Oil Exports (volume)
OLEX = Annual Oil Exports (value)
NOX = Annual Non-Oil Exports (value)
IM = Annual Imports (value)
BT = Balance of Trade
The estimated macroeconomic models were then used for simulation by setting some exogenous growth rates for certain variables and investigates the impact on other important variables in the economy. Throughout thirty-eight simulations which have been checked for certain constraints such as minimum import requirements, positive balance of payments, non-negativity of labour, population etc the study pointed to some selected policies and their implications. The major results were:

- Higher growth in non-oil sector leads to an influx of expatriate labour and hence a large foreign population, while a high depletion policy with high growth rate for the mining sector does not

- High oil revenue results in a rise of foreign assets.

Having briefly reviewed the oil model of Kuwait as presented by S. Sanga, some weak points that the author pointed out were considered as guidelines in structuring our model for the oil sector in Kuwait. The shortcomings were:

1) The weak representation of the link between the population labour and sectoral output levels in terms of just simple fixed proportions.

2) The assumption of treating the oil price as being an exogenous variable which does not help clearing the relationship between the oil sector and the world oil market.

3) The inadequacy of the equation relating income to
foreign assets assuming that Kuwait will not move away from liquid assets into neutral investments and equity markets with a considerable increase in incomes from foreign assets.

El. Mallakh's (1981) model for Kuwait's absorptive capacity is another example for oil models applied to the case of Kuwait using a macroecometric model of the economy as its foundation(2). The model incorporates three phases. The first is a set of structural equations which describe the economy of Kuwait. The second is the estimation of the stochastic equations, then, combining the estimated equation with the identities, the whole system was utilized to forecast some policy variables in the Kuwaiti economy such as total consumption, investment, domestic absorptive capacity and the level of oil production. Finally, alternative scenarios were used with the forecasts, to measure the effectiveness of the absorptive-capacity constraints of Kuwait.

Absorptive capacity of Kuwait is defined as the utilization of the flow of goods and services in Kuwait for domestic consumption and investment:

\[ GDA = CP + CG + IP + IG \quad - - - - - - - (1) \]

Private consumption is specified in terms of disposable income as:

\[ CP = f ((GDPN + NGJ), D_{62}) \quad - - - - - - (2) \]

and government consumption as a linear function of government expenditures:

\[ CG = f (GOEX, D_{62}) \quad - - - - - - - (3) \]
Non-oil gross domestic product determines private investment as:

\[ IP = f(GDPN, D_{62}) \]  \( (4) \)

Government investment is explained by:

\[ IG = d_0 + d_1 GDPN + d_2 GOEX = d_0 + D_{62} \]  \( (5) \)

From the traditional GNP identity, GDP was specified as:

\[ GDP = GDA + BOP \]  \( (6) \)

Exports, oil export and non-oil exports were explained as:

\[ X = OILX + NOLX \]  \( (7) \)

\[ OILX = f(OIQX, OILP) \]  \( (8) \)

\[ OIQX = f(OILQ) \]  \( (9) \)

\[ NOLX = f(GDPN, M) \]  \( (10) \)

Imports were included in the non-oil export specification to explain the re-exports component on non-oil exports and was specified as:

\[ M = f(GDA) \]  \( (11) \)

Gross domestic product reflects the flow of goods and services in the Kuwaiti economy as:
GDP = GDPO + GDPN \hspace{1cm} (12)

where:

GDPN = GDPA + GDCN + GDCO + GDPE
+ GDPM + GDPS + GDPT \hspace{1cm} (13)

Considering the net factor income from abroad, GNP was specified in an identity as:

GNP = GDPO + GDPN - NFY \hspace{1cm} (14)

The value added to each supply sector in the economy other than the oil sector is estimated through a Leontief/Harrod-Domar production function as:

GDP_i = h_i L_i \hspace{1cm} (15)

where \( i = i \) 's supply sector

Since net factor income to the rest of the world in Kuwait has been positive until fiscal year 1975-1976, it was specified as a function of lagged foreign assets:

NFY = f (FA_{-1}, D_{62}) \hspace{1cm} (16)

and

GDPO = GNP - GDPN + NFY \hspace{1cm} (17)

As for oil production, it was specified as a linear function of current and lagged real value added in the mining sector as:

OILQ = f \left( \frac{GDPO}{OILP}, \left( \frac{GDPO}{OILP} \right)_{-1}, D_{62} \right) \hspace{1cm} (18)
The government sector in the model was specified through a set of models as:

\[
\begin{align*}
GR &= ROIL + RNOL - - - - - - - - \quad (19) \\
RNOL &= f (GDPN) - - - - - - - - \quad (20) \\
ROIL &= f (GDPO, GDPO_{-1}, D74) - - - - \quad (21) \\
NGJ &= GOEX - RNOL - - - - - - - - \quad (22)
\end{align*}
\]

To investigate the effects of absorptive-capacity constraints on monetary criterion and on the general price level, a set of equations were included in Mallakh's model as well as for the monetary sector and price sector:

\[
\begin{align*}
MONY &= f (CLPS, GVD, FA, D) - - - - \quad (23) \\
GVD &= f \left( (GR - GOEX) \right) - - - - - - \quad (24) \\
FA &= f (BOP, D62) - - - - - - \quad (25) \\
CLPS &= f (GDPN) = f (GDPN_{-1}, D62) - - - \quad (26)
\end{align*}
\]

As for price,

\[
P = f (MONY, PIM) - - - - - - - - \quad (27)
\]

which is a specification within the theory of markup pricing.

The supply side of the labour market in Kuwait was specified through two equations:

\[
\begin{align*}
L_i &= L_{iK} + L_{iNK} - - - - - - - - \quad (28) \\
L &= L_1 + L_2 - - - - - - + L_n - - - \quad (29)
\end{align*}
\]

where \( i = \) supply sector

\( n = \) number of sectors
An interesting point about Al-Mallakh estimation method for the model is the way he transfers the Kuwaiti model into Block-Recursive. With the big size of the model, including linear and related equations, a single equation method for estimation (OLS) was not possible. The method he used was that he grouped the model into three blocks (as shown below), with the equations in block one solved with no reference to block three, but the first block results should precede the solution of block two equations. The first and second block solutions precede the third block solutions, with the first block of equations not preceded by any block of equations.

**Block Recursiveness of the Kuwaiti Model**

<table>
<thead>
<tr>
<th>Block 1</th>
<th>Block 2</th>
<th>Block 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) CP</td>
<td>(4) OILX</td>
<td>(9) ROIL</td>
</tr>
<tr>
<td>(2) CG</td>
<td>(5) OIQX</td>
<td>(11) MONY</td>
</tr>
<tr>
<td>(3) IP</td>
<td>(8) OILQ</td>
<td>(12) GVD</td>
</tr>
<tr>
<td>(6) NOLX</td>
<td>(17) GDP</td>
<td>(13) FA</td>
</tr>
<tr>
<td>(7) M</td>
<td>(20) X</td>
<td>(18) GNP</td>
</tr>
<tr>
<td>(10) RNOL</td>
<td>(21) BOP</td>
<td>(31) GR</td>
</tr>
<tr>
<td>(14) CLPS</td>
<td>(290) GDA</td>
<td>(15) P</td>
</tr>
<tr>
<td>(16) GDA</td>
<td>(30) GDPO</td>
<td></td>
</tr>
</tbody>
</table>
Ordinary Least Squares was applied to the first and third block owing to their recursive nature, but since the second block has simultaneously related equations, another method of forecasting was used.

The forecasting horizon of the model covers 1978 to 1990 using a control solution, through two control scenarios based on alternative paths for the price of oil (OILP). All the exogenous variables of the model were projected to help simulating the model for solutions during the forecasting period. The most difficult projection was that for the labour force in the supply sectors, due to the lack of data, but the 1976-1981 development plan was used as a basis for labour force projection.

The model was estimated using the two control solutions based on: a growth of OILP at 16.89% and a growth of OILP at 11.89%

The interesting results were:

a) That Kuwait cannot maintain its oil-production policy of producing not more than 2 million barrels a day, because if Kuwait continues with the present trends in government expenditure, consumption investment, etc, it will be forced to expand its oil production beyond the current limit of 2 million barrels a day even with an oil price increase at the 1980's rate of 5 per cent.

b) Labour constraints on absorptive capacity are not effective
c) The domestic absorption of the country will increase over time and hence oil production will have to increase.

As described, the Al-Mallakh model portrays the Kuwaiti economy and captures the relation between oil production decisions and the absorptive capacity of the Kuwaiti economy but being specified in nominal terms, it does not allow prices to influence the model.

Political factors have not been built into the model - explicitly - although definitely reflected throughout the changes in the exogenous variables.

S. Al-Sabah's model for development planning in Kuwait (3) proposes a framework strategy for the country up to year 2000 aiming to maximize the non-oil domestic sector and minimize the non-Kuwaiti labour. The model could be described as being
a) an economy-wide model covers in its structure the entire economy rather than being a sector or project type method;
b) Dynamic, in its treatment of time seeks to derive alternative trajectories for the endogenous and instrument variables included;
c) Long term model, covering a planning period of more than 7 years.

The model is an optimizational one, and includes two main development objectives: A purely economic objective of maximizing non-oil income and a social political objective of minimizing the percentage of non-Kuwaiti in the labour force. These objectives are used to close the model.

Al-Sabah's model adopted the methodology employed in Motamen using a Keynesian income-expenditure framework. The
KUWAIT ABSORPTIVE CAPACITY MODEL: ESTIMATION RESULTS

FORECASTING MODEL

<table>
<thead>
<tr>
<th>Estimated Stochastic Equations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Private consumption:</strong></td>
</tr>
<tr>
<td>(1) CP = -35.295 + 0.1339(GDPN+NGJ) + 0.8399(CP) _1</td>
</tr>
<tr>
<td>( R^2 = 0.98 )</td>
</tr>
<tr>
<td>( F = 352.81 )</td>
</tr>
<tr>
<td>( DW = 1.62 )</td>
</tr>
<tr>
<td><strong>Government consumption:</strong></td>
</tr>
<tr>
<td>(2) CG = 0.882 + 0.3838GOEX - 76.228D62</td>
</tr>
<tr>
<td>( R^2 = 0.97 )</td>
</tr>
<tr>
<td>( F = 225.52 )</td>
</tr>
<tr>
<td>( DW = 2.26 )</td>
</tr>
<tr>
<td><strong>Private investments:</strong></td>
</tr>
<tr>
<td>(3) IP = -33.81 + 0.1044GDPN + 0.5479(IP) _1 + 40.20D62</td>
</tr>
<tr>
<td>( R^2 = 0.92 )</td>
</tr>
<tr>
<td>( F = 42.45 )</td>
</tr>
<tr>
<td>( DW = 1.49 )</td>
</tr>
<tr>
<td><strong>Oil exports:</strong></td>
</tr>
<tr>
<td>(4) OILX = -1195 + 1.50006OIQX + 3.9750ILP</td>
</tr>
<tr>
<td>( R^2 = 0.97 )</td>
</tr>
<tr>
<td>( F = 187.60 )</td>
</tr>
<tr>
<td>( DW = 1.25 )</td>
</tr>
<tr>
<td>(5) OIQX = 0.9988OILQ</td>
</tr>
<tr>
<td>( R^2 = 0.99 )</td>
</tr>
<tr>
<td>( DW = 2.37 )</td>
</tr>
<tr>
<td><strong>Nonoil exports:</strong></td>
</tr>
<tr>
<td>(6) NOLX = -41.296 + 0.09717GDPN + 0.1302M</td>
</tr>
<tr>
<td>( R^2 = 0.97 )</td>
</tr>
<tr>
<td>( F = 204.65 )</td>
</tr>
<tr>
<td>( DW = 3.87 )</td>
</tr>
<tr>
<td><strong>Imports:</strong></td>
</tr>
<tr>
<td>(7) M = -110.27 + 0.61098GDA</td>
</tr>
<tr>
<td>( R^2 = 0.99 )</td>
</tr>
<tr>
<td>( F = 1273.6 )</td>
</tr>
<tr>
<td>( DW = 1.69 )</td>
</tr>
<tr>
<td><strong>Oil output:</strong></td>
</tr>
<tr>
<td>(8) OILQ = 268.07 + 0.86629(GDPO/OILP) + 0.38956</td>
</tr>
<tr>
<td>( R^2 = 0.94 )</td>
</tr>
<tr>
<td>( F = 89.76 )</td>
</tr>
<tr>
<td>( DW = 2.79 )</td>
</tr>
<tr>
<td><strong>Government oil revenue:</strong></td>
</tr>
<tr>
<td>(9) ROIL = -438.92 + 0.2401GDPO + 1.0746(GDPO) _1</td>
</tr>
<tr>
<td>( R^2 = 0.95 )</td>
</tr>
<tr>
<td>( F = 115.92 )</td>
</tr>
<tr>
<td>( DW = 1.27 )</td>
</tr>
<tr>
<td><strong>Government nonoil revenue:</strong></td>
</tr>
<tr>
<td>(10) RNOL = -153.19 + 0.51935GDNP</td>
</tr>
<tr>
<td>( R^2 = 0.92 )</td>
</tr>
<tr>
<td>( F = 158.68 )</td>
</tr>
<tr>
<td>( DW = 1.43 )</td>
</tr>
</tbody>
</table>
Money Supply:
(11) \[ \text{MONEY} = 0.26169\text{CLPS} - 2.318\text{GVD} + 0.60816\text{FA} + 4.59260\text{DR} \]
\[ R^2 = 0.99 \quad DW = 1.53 \]

Government net deposits:
(12) \[ \text{GVD} = 72.11 + 0.1398(\text{GR} - \text{GOEX}) \]
\[ R^2 = 0.79 \quad F = 47.88 \quad DW = 1.43 \]

Foreign assets:
(13) \[ \text{FA} = 341.66 + 0.27666\text{BOP} - 152.28\text{D62} \]
\[ R^2 = 0.73 \quad F = 15.72 \quad DW = 0.85 \]

Claims on private sector:
(14) \[ \text{CLPS} = -446.36 + 0.62626\text{GDPN} + 0.6277(\text{GDPN}) + 97.718\text{D62} \]
\[ R^2 = 0.91 \quad F = 35.90 \quad DW = 1.06 \]

Price level:
(15) \[ \text{P} = 42.623 + 0.017113\text{MONEY} + 0.3903\text{PIM} \]
\[ R^2 = 0.99 \quad F = 778.59 \quad DW = 2.29 \]

(16) \[ \text{GDA} = \text{CP} + \text{CG} + \text{IP} + \text{IG} \]
(17) \[ \text{GDP} = \text{GDA} + \text{BOP} \]
(18) \[ \text{GNP} = \text{GDP} - \text{NFY} \]
(19) \[ \text{GOEX} = \text{IG} + \text{GEXO} \]
(20) \[ \text{X} = \text{OILX} + \text{NOLX} \]
(21) \[ \text{BOP} = \text{X} - \text{M} \]
(22) \[ \text{GDPN} = \text{GDPA} + \text{GDCN} + \text{GDCO} + \text{GDPE} + \text{GDPM} + \text{GDPS} + \text{GDPT} \]
(23) \[ \text{GDPA} = 1.224\text{LA} \]
(24) \[ \text{GDCN} = 1.144\text{LN} \]
(25) \[ \text{GDCO} = 5.679\text{LC} \]
(26) \[ \text{GDPE} = 11.93\text{LE} \]
(27) \[ \text{GDPM} = 7.977\text{LM} \]
(28) \[ \text{GDPS} = 3.066\text{LS} \]
(29) \[ \text{GDPT} = 6.606\text{LTR} \]
(30) \[ \text{GDPO} = \text{GDP} - \text{GDPN} \]
(31) \[ GR = ROIL + RNOL \]
(32) \[ NGJ = GOEX - RNOL \]
(33) \[ LA = LAK + LANK \]
(34) \[ LN = LNK + LNNK \]
(35) \[ LC = LCK + LCNK \]
(36) \[ LE = LEK + LENK \]

**Identities**

(37) \[ LM = LMK + LMNK \]
(38) \[ LS = LSK + LSNK \]
(39) \[ LTR = LTK + LTNK \]
(40) \[ L = LA + LN + LC + LE + LM + LS + LTR + LO \]

**Note:** t ratios are given in parentheses.

- \( R^2 \) = coefficient of determination, that is, what percentage of the variation in the dependent variable is explained by the regression.
- \( F \) = a measurement of the significance of \( R^2 \)
- \( DW \) = Durbin-Watson statistic, that is, a test statistic for autocorrelation.
AL-MALLAKH - LIST OF VARIABLES USED IN KUWAIT ABSORPTIVE CAPACITY MODEL

DEPENDENT VARIABLES:

BOP = balance of payments (X - M)
CG = government consumption
CLPS = commercial banks' claims on private sector
CP = private consumption
PA = foreign assets of the CBK
GDA = gross domestic absorption
GDCN = GDP from construction
GDCO = GDP from commerce (wholesale and rental trade)
GDP = gross domestic product
GDPA = GDP from agriculture, hunting, forestry, and fishing
GDPE = GDP from electricity, water, and gas
GDPM = GDP from manufacturing
GDPN = nonoil GDP
GDPO = GDP from mining and quarrying (proxy for oil GDP)
GDPS = GDP from finance, insurance, real estate, government, and other services
GDPT = GDP from transport, storage, and communication
GNP = gross national product
GR = total government revenue
GVD = government deposits with the CBK
IG = government investments
IP = private investment
L = total labour force (thousands)
LA = labour force engaged in agriculture, hunting, forestry, and fishing (thousands)
LC = labour force engaged in commerce (thousands)
LE = labour force engaged in electricity, water, and gas (thousands)
LM = labour force engaged in manufacturing (thousands)
LN = labour force engaged in construction (thousands)
LS = labour force in finance, insurance, real estate, and government services (thousands)
LTR = labour force engaged in transport, storage, and communication (thousands)
M = imports of goods and nonfactor services
MONY = quantity of money defined as currency plus demand deposits plus time and saving deposits
NGJ = net government injection
NOLX = value of nonoil exports
OILQ = oil output (millions of barrels per year)
OIQX = quantity of oil exported (million of barrels per year)
OILX = value of oil exports
P = price level (consumer price index, 1972 = 100)
RNOL = government nonoil revenue
ROIL = government oil revenue
X = exports of goods and nonfactor services

EXOGENOUS VARIABLES:

DD = dummy variable = ( 1 for 1969,1972-1973 & 1975-1977
       ( 0 for other years
D62 = dummy variable = ( 1 for 1967-1970
       ( 0 for other years
D74 = dummy variable = ( 1 for 1974-1977
       ( 0 for other years
D75 = dummy variable = ( 1 for 1975-1977
       ( 0 for other years
GEXO = government noninvestment expenditures
GOEX = government expenditures
LAK = Kuwaiti labour force engaged in agriculture (thousands)
LANK = non-Kuwaiti labour force engaged in agriculture (thousands)
LCK = Kuwaiti labour force engaged in commerce (thousands)
LCNK = non-Kuwaiti labour force engaged in commerce (thousands)
LEK = Kuwaiti labour force engaged in electricity (thousands)
LENK = non-Kuwaiti labour force engaged in electricity (thousands)
LMK = Kuwaiti labour force engaged in manufacturing (thousands)
LMNK = non-Kuwaiti labour force engaged in manufacturing (thousands)
LNK = Kuwaiti labour force engaged in construction (thousands)
LNNK = non-Kuwait labour force engaged in construction (thousands)

LO = labour force engaged in mining and quarrying (thousands)

LSK = Kuwaiti labour force engaged in services (thousands)

LSNK = non-Kuwaiti labour force engaged in services (thousands)

LTK = Kuwaiti labour force engaged in transport (thousands)

LTNK = non-Kuwaiti labour force engaged in transport (thousands)

NFY = net factor income to abroad

OD = other deposits

OILP = index of crude-oil prices (1970 = 100)

PIM = index of prices of Kuwaiti imports (1972 = 100)

Note: All variables, except where specifically indicated, are in millions of current Kuwaiti dinars (KD)
model is developed in three stages:

First, a macro model for the Kuwait economy is specified to characterise the country's constraints to growth. Within the adopted Keynesian framework, the model considers the economy from the expenditure side emphasizing the importance of both physical investment and human capital. As a modification to the Keynesian economics the economy is assumed, in the model, to consist of different producing sectors allowing for the dualistic nature of the economy. Therefore the model adopts a sectoral income-expenditure framework. The macroeconomic model which stands for the constraints in the optimization framework adopted incorporates total income $Y^{(1)}$, non-oil income $Y^{(2)}$, overseas assets revenues $Y^{(3)}$, capital accumulation $Y^{(4)}$, stock of foreign assets $Y^{(5)}$. The balance of payment $Y^{(6)}$, private consumption $Y^{(7)}$, total labour force $Y^{(8)}$ and non-Kuwaiti labour $Y^{(9)}$ as endogenous variables.

Second, the model's objective function is specified, as mentioned earlier in this part, aiming to reduce the vulnerability on the income side by maximizing non-oil domestic income as well as the vulnerability on the labour side throughout the minimization of foreign participation in the labour force.

Third, three optimization models were applied to Kuwait from 1975 to 1997 adopting the same objective function but using a different number of instruments (2, 3 and 4) with different weights.

The structure of the model takes the form:

$$\text{Optimize} = f\left( Y^{(2)}_t, Y^{(9)}_t \right) \quad t=1,...,T$$
Subject to:

\[
\begin{align*}
Y(1) & = Y(2) + Y(3) + E(1) \\
Y(2) & = a_1 Y(4)_{-1}^{a_2} Y(8)_{-1}^{a_3} \quad a_2 + a_3 = 1 \\
Y(3) & = a_4 Y(5)_{-1}^{a_5} \quad 0 < a_4 < 1, \quad 0 < a_5 < 1 \\
Y(4) & = Y(4)_{-1} + u(1) \\
Y(5) & = Y(5)_{-1} + Y(6) \\
Y(6) & = Y(1) - u(1) - Y(7) - E(2) \\
Y(7) & = a_6 Y(2) \\
Y(8) & = E(3) + Y(9) \\
Y(9) & = Y(9)_{-1} - \left[ E(5) - E(5)_{-1} \right] + u(2) \\
E(3) & = E(4) + E(5) \\
E(5) & = E(6) + E(7) \\
Y(10) & = \left[ E(1) + Y(3) \right] - \left[ \phi_1 Y(2) + \phi_2 u(1) \right] > 0
\end{align*}
\]

Where:

\[
\begin{align*}
Y(1) & = \text{Total income} \\
Y(2) & = \text{Income from non-oil sector}
\end{align*}
\]
\( Y(3) \) = Income from financial foreign assets  
\( Y(4) \) = Stock of capital, non-oil sector  
\( Y(5) \) = Stock of overseas financial assets  
\( Y(6) \) = Balance of payment (deficit or surplus)  
\( Y(7) \) = Private consumption  
\( Y(8) \) = Total labour  
\( Y(9) \) = Non-Kuwaiti labour  
\( Y(10) \) = Stock variable to check constraints  
\( E(1) \) = Oil income  
\( E(2) \) = Government consumption  
\( E(3) \) = Kuwaiti labour force  
\( E(4) \) = Male Kuwaiti labour force  
\( E(5) \) = Female Kuwaiti labour force  
\( E(6) \) = Female Kuwaiti participation rate  
\( E(7) \) = Female Kuwaiti population

**Instrumental variables:**

\( U(1) \) = Total (Private and Government) investment in non-oil sector  
\( U(2) \) = Change in non-Kuwaiti labour

The objective of this section is to shed some light on the recent work that has been concerned with the Kuwaiti economy and its development. In the following chapter a review of different oil models is presented as a background to specify the proposed Model for Kuwait.
CHAPTER 3

OIL MODELS : REVIEW
3.1 Oil Production Models

3.2 Oil Pricing Models

3.3 Energy-Policy Models
Increased energy consumption and the heavy dependence on petroleum products in all aspects, together with the unsettlement in prices have given additional impetus to energy planning as part of the whole economic development planning particularly in countries where oil revenues constitute the main source of government revenues. Various studies concerning energy in general and oil aspects in particular have shown that

a) Oil reserves are finite and present trends cannot be sustained for more than a few decades.

b) There are upper bounds to the local and global oil release rates ruled by Laws of Therme-dynamic and heat transfer.

c) A new energy technology takes at least two decades to go into wide spread utilisation.

d) No single energy source is easily/economically adaptable to all types of end uses.

e) The share of the oil sector in gross national product, for producing and consuming countries, has become so substantial that even a fractional change in oil prices can dramatically affect economic growth.

These facts have urged the development and improvements of energy models. A survey of literature shows that these models can be classified according to whether they are national or international, single or multi-fuel, coupled or uncoupled with the general economy.

Another type of classification would be involving the principal objective of the model, such as whether the model is for forecasting or optimisation.
The mathematical techniques that can be employed could vary considerably as well, ranging from econometric models, to simulation, heuristic and mathematical programming. Each of these techniques also covers a variety of methods.

Econometric models may include regression analysis, input-output analysis, equilibrium economics, while mathematical programming models include linear, dynamic, non-linear and stochastic models.

The model proposed in this work for Kuwait is a disaggregative allocative oil model, which incorporates both supply (production) and demand (uses) of Kuwaiti oil in a quite disaggregative base differentiating between domestic uses and external uses of the oil produced. The oil model is linked to the Kuwaiti economy in two alternative frameworks that stress the interaction between the oil sector, as the major driver of economic development and the Kuwaiti economy.

In the following, a brief review of oil models is presented as a background to the proposed model for Kuwait.

3.1 OIL PRODUCTION MODELS

Oil is a commodity which infuses itself into almost all facets of daily life and the nation's economy. Therefore relating its PRODUCTION to economic planning both at the macro, and if possible, the sectoral level, is crucial.

Kuwait is considered the world's highest per capita income. The oil and gas resources with the relatively small population of Kuwait help create this situation. The oil

* For detailed review of energy models as classified in this chapter refer to references: (4) (5) (6) (7) (8)
price increase in the 1970's did nothing more than exacerbating an existing problem in the country which has been for three decades a surplus-funds country, i.e. the absorptive capacity.

The close interaction between the oil sector and the economic development in Kuwait justifies the selection of the "ABSORPTIVE CAPACITY CONCEPT" as a framework to specify the oil production model for Kuwait.

Before setting the structure of the proposed oil model, the concepts of absorptive capacity and optimal depletion are first explained, followed by a brief survey of oil production models.

**Economic theory and oil production decision**

In cases of renewable resources, economic theory states that marginal cost (MC) consists entirely of the marginal production cost (MPC) i.e. capital, labour and material costs of producing the last unit of output.(9)

In the case of a nonrenewable resource, such as oil, the decision to produce a barrel of oil today precludes the possibility of leaving it in the ground to be produced some time in the future. This means that production decisions result in an opportunity cost which should be recognized as part of the production cost when taking a decision to produce a barrel of oil.

Consequently, (MC) in period t should be modified to include (MPC_t) and the opportunity or user costs (U_t).

\[ MC_t = MPC_t + U_t \]
where \((U_t)\) is calculated by subtracting \((MPC)_t\) from marginal revenues

\[(b) \quad U_t = MR_t - MPC_t\]

If the production decision is to maximise long run profit then:

\[(c) \quad U_o = U_1 = U_2 \quad \ldots \quad = U_T\]

To account for the changing value of a dollar, user costs should be discounted at the rate of discount \((r)\):

\[(d-1) \quad U_0 = \frac{U_1}{1+r} = \frac{U_2}{(1+r)^2} = \frac{U_3}{(1+r)^3} \quad \ldots \quad = \frac{U_T}{(1+r)^T}\]

Therefore:

\[(d-2) \quad \begin{cases} U_1 = U_o (1 + r) \\ U_2 = U_1 (4r) \\ \vdots \\ U_T = U_{T-1} (1 + r) \end{cases}\]

The production decision is then taken in order to schedule production over time such that equation \((d-2)\) holds for the last barrel produced in any period.

**The Concept of Absorptive Capacity and Deplilion**

The concept of absorptive capacity of the petroleum exporters has always been connected with their financial surpluses and has more to do with absorption than with absorptive capacity. The definition of the concept,
therefore, is that if a petroleum exporting country shows no surplus in its external balance, this means its absorptive capacity is adequate, and a better situation would be if a deficit is realised, since this indicates that the country's absorptive capacity is in excess of its earnings ability i.e. high. Consequently, the worries start only if surpluses develop. In this case, the interest would be calculated only on how to reduce or eliminate that surplus, to ensure that oil is sold because its revenues are needed to finance clearly defined objectives.

From the above, this popular view of absorptive capacity reflects the country's ability to dispose of its petroleum earnings so as to preclude the existence of any surplus.

This simple and naive definition to a concept as important as the absorptive capacity imposes many weak points:

- No questions are raised about the level of earnings or the pattern of spending or even the utility of the various spending aspects.

- It ignores the productivity of domestic investment and avoids any consideration of optimal extraction rates.

- It concentrates on one side of the problem, that is how to extend or expand the imports of the exporting country to eliminate any financial surplus?

If we accept the conceptual poverty of this approach and take Absorption to mean Expenditure, the question then is how could an oil exporter with financial surplus - a so called capital surplus state - increase their expenditure?

The obvious ways would be through increasing consumption, or domestic investment or foreign aid.
As for Consumption, economic theory states that it is fairly inelastic to income especially in higher income countries with financial surpluses. This imprudent consumption has no bounds and reflects the new style of life the surplus nations have become accustomed to.

Public expenditure on defence is another category of consumption which is infinite in size and has high absorption potential. This type of expenditure may reflect high absorption, but it may also jeopardise oil resources.

Domestic Capital formation is an expenditure that should be undertaken through a rational criteria. Every investment should be analysed assessing its opportunity cost of capital. In practice, national security might temper such criteria.

Foreign aid, through donations and grants, provides a convenient outlet for the surplus country.

As a matter of fact, the above alternatives to increasing absorptive capacity (i.e. absorb surplus) does not stem from the surplus countries own point of view. The emphasis is placed on eliminating the surpluses and not on the rational management of the scarce resource, oil, in pursuit of social and economic development.

To account for that, it is important to apply another definition of the concept of absorptive capacity, that is by relating the concept of absorptive capacity of a country to its ability to absorb capital PRODUCTIVELY.

Even if funds for investment were available - in the form of financial surpluses - lack of complementary resources such as: local skills, manpower, work habits, or inadequate markets could depress the return to investments and impare capital formation, which will in turn affect income growth
and imports growth as well.

Actually, the only way out in such situations to improve imports is through removing the constraints on development by factors other than capital, i.e. the factors creating limited absorptive capacity.

A point to be noted in that respect, is that expanding absorptive capacity in this sense is a complex, time-consuming process which will have a smaller and slower impact on the surplus than increasing consumption or foreign aid. The difficulty is that the productivity of domestic capital is related in a sense to other decisions such as: the quantity of oil they produce and the selling price of that oil.

The optimal approach is to try to link, under assumptions of rationality, demand for goods and services they purchase, in exchange for oil revenues, with the production of oil, treating surplus countries as "optimizers" aiming at realizing their own self-interest.

If we look at Kuwait as one of the surplus countries, we find that the oil in its possession is limited and nonrenewable. They cannot produce oil, they can only extract it from the ground.

If they extract more today, they will have less to extract tomorrow, and the crucial question remains: How much should they extract and sell today?

The complexity of answering such a question is that the revenues or earnings derived from oil sales is in fact the product of selling an Asset, therefore consuming it means disinvestment. Therefore, oil surpluses should not be considered as surpluses on the current account in the balance of payments, since the selling of oil is actually
an act of liquidating an asset.

The production of oil has to be within a concept that accounts for all these facts. As Kuwait draws its valuable and diminishing resource, oil, out of the ground it should be considering the return they will be earning on turning this asset into other forms of wealth.

Therefore, they should not accept lower returns on the new investments than they would earn by leaving their oil under the ground where it would appreciate as its scarcity increases over time.

Returning to the "Oil Production Policy" we ask: How much oil should Kuwait, as a financial surplus, extract and sell if it is focusing on its own self-interest?

They will definitely have to sell some oil to provide for their consumption needs which should be quite modest. Once these needs have been attained, Kuwait should be comparing carefully between its expectations concerning oil prices in the foreseeable future and the yield they can realise on alternative investments.

As maximizers, they should not be biased to domestic investment over lending abroad. However, their production should not exceed that necessary to cover consumption unless there existed a clear yield advantage in doing so.

Moreover, if we accept the notion that oil cannot be produced, then we don't have to expect its price to be equal to its cost of extraction. In spite of that, Kuwait and other producing countries do in fact extract and sell more oil and charge lower prices than what would maximize its revenues, and generates more revenue than they can profitably invest either in their economies, limited by their absorptive capacity, or outside.
Having reviewed the theories behind oil production, it would be necessary to survey, in brief - oil production models as a necessary background, together with the theoretical base to structure Kuwait oil production model.

Absorptive Capacity, Prices and Oil-Production Policies

An historical perspective:

There exists a clear and critical relationship between absorptive capacity constraints and oil-production policies in Kuwait. Production policies have an inevitable impact on the acceleration of the absorption problem in Kuwait and at the same time is influenced and conditioned by the ability of the economy to absorb oil revenues accumulated from previous production policies as well as the opportunity for investing surplus funds created by increased oil revenues and dwindling domestic investment opportunities.

The price of crude oil is yet another factor that affects production decisions. Since the economic and political agents in the oil industry differ, an optimal production or pricing policy should differ too. The producing/exporting countries, as Kuwait, would like to export their production with the highest possible price at the lowest level of production. The oil companies are interested in only maximizing returns on their investments. The oil consuming/importing countries would be interested, on the contrary, in getting more crude oil at the lowest possible price.

Al-Janabi referred to the link between production and pricing of oil and stated that, for global optimization the price of the raw material and the price of the final product must be related to each other and the distribution of revenue, rent, or net income, from the resource must be rational or reasonable. There must be a direct link between
the producer of the resource and the price, so that the producer will distribute production over time under the impact of price in an optimal manner. Also, the time path of the price must increase over time, representing some kind of discount rate. In a situation where these two criteria are not, or cannot be, fulfilled, it is not very meaningful to talk about global optimization.

Prior to the Tehran agreement of 1971, the production and marketing of oil were in the hand of oil companies. After 1971, the oil industry changed from a buyer's market to a seller's market, and from the macroeconomic theory's point of view, the supply side of the oil market changed from a kinked-demand type of oligopoly to semicartel type of structure.

**Oil Production Policies in Kuwait**

Kuwaiti oil production decisions are taken within some avenues; that is the fact that Kuwait has an influence on the decision of OPEC as a founding member, as well as the reality that Kuwait is free to manipulate the extent of the duration of their production policies from the OPEC ones.

Conservative production policies have been adopted by Kuwait since 1972 when its production reached a peak of 3.86 million barrels a day. In 1975 the production limits were set to 2 million barrels per day.

In spite of all the implications that might be derived from this production policy of Kuwait, the motivation behind it was, actually, the serious limitation which exists in the domestic economy to absorb the oil revenues created through production policies. Figure 3.1 highlights this fact.
It was also argued that the production cut was for another purpose, that is to enable the oil companies to sell the Kuwaiti heavy type crude.

Political consideration has always been another determinant of oil production policies in Kuwait. The unstable market for investing surplus funds, the unsettlement in the world economy and other ever-changing factors biased Kuwait production decisions and policies towards more conservative ones that guarantee the savings of some natural resources for future generations.

Despite Kuwait success in running its foreign investment, the production policy still implies that Kuwait believes
that leaving oil in the ground will be more valuable than producing the crude oil now especially with the ever increasing rate of inflation and world political unsettlement.

The Absorptive Capacity of Kuwait

El-Mallakh (10) composed the different definitions of absorptive capacity in quite a broad one as being "The country's ability or the domestic economy's ability to absorb resources at an acceptable rate of return within a given period".

For an oil producing country, the concept might reflect the ability to absorb oil revenue, or the ability of the government, to whom the oil revenues accrue, to spend the oil revenue in a productive way. To reflect the limited domestic market in these countries, a fashionable definition interprets absorptive capacity in terms of the ability to utilise foreign exchange effectively.

In the case of Kuwait, the economic development and the social wellbeing of the country depends on the way the government invests its surplus funds. These should not pay for themselves only but also generate sufficient funds for further development. This means that an attempt to increase Kuwait's absorptive capacity should be through increasing the marginal efficiency of the investment in all products. This could be done only by improving the cooperative factors of production which we referred to before.

Before analysing the absorptive capacity of Kuwait, we should first emphasise what we mean by the concept and its component:
If we adopt a Keynesian framework and assume that the economy could be described as:

\[ Y = C + I + G + X - M \quad (1) \]
\[ Y = C + G + S \quad (2) \]
\[ I = I_p + I_g \quad (3) \]
\[ M = M_c + M_k \quad (4) \]
\[ X = X_o = X_n \quad (5) \]
\[ S = S_p + S_g \quad (6) \]

where

- \( C \) = private consumption
- \( G \) = government consumption
- \( I \) = total domestic investment
- \( I_p, I_g \) = government and private investment
- \( M, M_c, M_k \) = total imports, imports for consumption, imports for capital formation
- \( S, S_g, S_p \) = total saving, government and private saving
- \( X, X_n, X_o \) = total exports, nonoil and oil exports
- \( Y \) = gross domestic product

Setting equation (1) equals equation (2) we get:

\[ C + I + G + X - M + C + G + S \]

Rearranging terms yield the equation:

\[ I = S + M - X \quad (7) \]

which implies that investment (the cour interest of the absorptive capacity concept) is financed through saving (S) and net capital flow (M-X). In order to reflect the persistent balance of payment surplus, the investment equation could be rearranged to give:

\[ S - I = X - M \quad (8) \]
Since the net capital outflow equals the difference between domestic savings and investment, then from equation (2) we get:

\[ S = Y = C = G \]

If (S) is known, or the absorption concept is not applied to government or private consumption (G , C) then the determination of I, measures the absorptive capacity.

Following the definition of absorptive capacity being the maximum utilization of the flow of goods and services for domestic consumption and investment, absorptive capacity will equal C + G + I.

Cooperant Factors in Kuwait

These factors are normally referred to as absorptive capacity constraints, as they play a role in inhibiting the economy's productivity leading to limited absorptive capacity such as limited physical characteristics, lack of resources other than gas and oil, workforce problems, inefficient long-range development plans and political and social problems.

In the case of Kuwait, these cooperant factors are quite clear. The agriculture sector in Kuwait has a limited economic importance owing to the low quality of soil, scarcity of water as well as the unfavourable hot and highly humid climate conditions. These conditions forced agriculture to depend heavily on desalinated water and fertilizers, a thing which could not be a solution to cultivate a hot sand land as in Kuwait.

Oil and gas are the only natural resource which have now become the life blood of the Kuwaiti economy after the emergence of the oil industry which stifled the fishing and
pearling industries.

The emergence of the oil sector creates extensive infrastructural activities, but the inadequate, limited labour force impedes capital absorption.

As a matter of fact this problem creates other social and political problems. The dependence of Kuwait on foreign labour creates inevitable social and political conflicts between local and foreign participants in the Kuwaiti labourforce. The role of women in the economic and social system of Kuwait is another factor in determining the Kuwaiti labour supply and productivity.

Modelling the Absorptive Capacity of Kuwait

Abolfathi, Keynon, Hayes and others (11) based their estimation on Government spending and measure the responses of the economy to alternative spending patterns together with some constraints imposed to the model to measure their impact on development. They set oil revenues dependent on oil production and price levels, therefore allowing them to vary over time.

By estimating Government expenditures, they determine the contribution of private and public services to GNP which was estimated independently of the sectors. Non-oil GDP reflects industrial output. The model accounts explicitly for labour, government expenditure and other constraints in forecasting absorptive capacity and GNP of Kuwait which has been carried out using three scenarios: low, high and best. The low level of forecasts are based on a very stringent level of constraint. The high forecasts assume no labour constraint assumption, but with the other constraints holding. The midway between the two extremes is the best
scenario which reflects the most likely path which GDP and imports of Kuwait would follow: (Tables 3.1, 3.2)

**TABLE 3.1: Kuwait: Sectoral Distribution of GDP for Best Estimate (percentage)**

<table>
<thead>
<tr>
<th></th>
<th>1975</th>
<th>1980</th>
<th>1985</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>0.16</td>
<td>0.16</td>
<td>0.13</td>
</tr>
<tr>
<td>Petroleum</td>
<td>70.99</td>
<td>52.47</td>
<td>35.50</td>
</tr>
<tr>
<td>Industry</td>
<td>4.33</td>
<td>7.02</td>
<td>9.53</td>
</tr>
<tr>
<td>Services</td>
<td>20.06</td>
<td>32.46</td>
<td>43.79</td>
</tr>
<tr>
<td>Public services</td>
<td>4.44</td>
<td>7.76</td>
<td>10.93</td>
</tr>
<tr>
<td>Total GDP (in billion 1975 U.S. dollars)</td>
<td>1.59</td>
<td>14.00</td>
<td>20.39</td>
</tr>
</tbody>
</table>

**TABLE 3.2: Kuwait: Projected Shares of Imports, by Country of Origin (billion 1975 U.S. dollars)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Western Europe</th>
<th>United States</th>
<th>Japan</th>
<th>Communist Countries</th>
<th>Total Imports</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975</td>
<td>1.008</td>
<td>0.323</td>
<td>0.458</td>
<td>0.222</td>
<td>0.880</td>
</tr>
<tr>
<td>1976</td>
<td>1.067</td>
<td>0.343</td>
<td>0.484</td>
<td>0.235</td>
<td>3.050</td>
</tr>
<tr>
<td>1977</td>
<td>1.070</td>
<td>0.344</td>
<td>0.486</td>
<td>0.235</td>
<td>3.060</td>
</tr>
<tr>
<td>1978</td>
<td>1.098</td>
<td>0.353</td>
<td>0.498</td>
<td>0.242</td>
<td>3.140</td>
</tr>
<tr>
<td>1979</td>
<td>1.098</td>
<td>0.353</td>
<td>0.498</td>
<td>0.242</td>
<td>3.140</td>
</tr>
<tr>
<td>1980</td>
<td>1.151</td>
<td>0.370</td>
<td>0.522</td>
<td>0.253</td>
<td>3.290</td>
</tr>
<tr>
<td>1981</td>
<td>1.214</td>
<td>0.390</td>
<td>0.551</td>
<td>0.267</td>
<td>3.470</td>
</tr>
<tr>
<td>1982</td>
<td>1.29</td>
<td>0.415</td>
<td>0.586</td>
<td>0.284</td>
<td>3.690</td>
</tr>
<tr>
<td>1983</td>
<td>1.364</td>
<td>0.438</td>
<td>0.619</td>
<td>0.300</td>
<td>3.900</td>
</tr>
<tr>
<td>1984</td>
<td>1.434</td>
<td>0.461</td>
<td>0.651</td>
<td>0.315</td>
<td>4.100</td>
</tr>
<tr>
<td>1985</td>
<td>1.497</td>
<td>0.481</td>
<td>0.679</td>
<td>0.329</td>
<td>4.280</td>
</tr>
</tbody>
</table>
El-Mallakh, Khadim and Paulson (12) applied an econometric approach in estimating the absorptive capacity of the Kuwaiti economy which was defined as

\[ AC = IM_C + IM_i + R \]

Where: \( AC \) = domestic absorptive capacity of foreign exchange  
\( IM_C \) = imports of goods and services other than services of resident foreign labour  
\( IM_i \) = investment goods imports  
\( R \) = remittances of expatriate labour abroad

Assuming that \( IM_C \) and \( IM_i \) are stochastic components of the absorptive-capacity relation, the model includes:

\[ IM_C = f(NNP) \]
\[ IM_i = f(GNPN) \]

Where: \( NNP \) = net national product  
\( GNPN \) = non-oil gas national product.

Both exogenous variables \( NNP \) and \( GNPN \) determine the values of the dependent endogenous ones, \( IM_C \) and \( IM_i \).

\( GNPN \) was assumed to grow by 8% with oil revenues constant at the 1974 level of 8.25 billions. \( NNP \) for 1975, 1980 and 1985 was estimated (nonstochastically) assuming a depreciation rate of 6% to the non-oil sector only.

Combining the identity and the two stochastic equations, absorptive capacity of Kuwait for 1975, 1980 and 1985 was projected as shown in Table 3.3:

The absorptive capacity models for Kuwait centre their attention on the value-added concept of GDP and ignores
TABLE 3.3: Domestic Foreign-Exchange Requirements of
Kuwait, 1975-1985 (million 1974 dollars)

<table>
<thead>
<tr>
<th>Year</th>
<th>Consumption-Goods Imports</th>
<th>Capital-Goods Imports</th>
<th>Remittances Abroad</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975</td>
<td>910.17</td>
<td>639.95</td>
<td>732.6</td>
<td>2,283</td>
</tr>
<tr>
<td>1980</td>
<td>1,038.0</td>
<td>933.72</td>
<td>906.3</td>
<td>2,878</td>
</tr>
<tr>
<td>1985</td>
<td>1,226.0</td>
<td>1,365.24</td>
<td>1,129.6</td>
<td>3,721</td>
</tr>
</tbody>
</table>

intermediate goods demanded by the supply side of the economy during the production process.

Oil Production Models

In the following, three oil models are discussed as examples of oil production models. Each follows a different approach and applies different techniques. These models are: A. Ezzati's oil and gas model for the USA, Ezzati's supply model for OPEC and the Birmingham energy model.

USA Oil and Gas Supply (13)

This model is an engineering model for oil and gas production which is applicable only to cases where oil and gas is a private, profit-oriented enterprise. It determines the minimum acceptable selling price which covers costs plus a certain rate of return on investment, and corresponds to a certain level of production.

Oil and gas production curves are expressed as functions of minimum acceptable selling prices:

The figure shows that when the price is $4, 4 million bbL/D
will be produced, when prices go up to $8, the production increases from 4 to 10 million bbl/D and so on.

The oil and gas production activities are divided into exploration, development and actual production with investment decisions associated with each.

FIGURE 3.2: Crude Oil Supply Curve

The model started by translating exploration activities into new oil in place. The finding rate (FR) is:

$$FR = Y_o e^{-(Y_o/A)(FT)}$$

where

$$Y_o = Y \text{ intercept, i.e. an initial finding rule (bbl/ft)}$$
A = Remaining discoverable resources (bbL)

FT = Cumulative exploratory footage drilled (ft)

This indicates that the FR declines exponentially as FT increases as follows:

FIGURE 3.3: Finding Rate Curve

To reflect the impact of the depths of resources on exploratory expenditure, the cost per foot drilled was assumed to be a function of depth:

\[ \text{EXPW} = (WD)(ADCF) \]

\[ ADCF = f(WD) \]

\[ WD = f(CEXFD) \]

Where:

WD: well depth

CEXFD: cost of exploration

ADCF: average drill cost per foot

EXPW: expenditure per well

Oil in place was then translated into proved or recoverable reserves and resources (R) were translated into production \( (Q_t) \) through the equation:
\[ Q_t = \alpha R e^{-\lambda t} \]

where:

\[ \alpha = \text{declining rate (using } Q/R \text{ ratio as a proxy for it)} \]

In order to set the minimum acceptable price, the following equations were solved for the price of oil \((P_0)\):

\[
I_e = \left\{ \left[ (P_0 Q_e) + CR_e \right] (1 - Y) \right\} - C_e
- \left\{ \left[ (P_0 Q_e) + CR_e \right] (1 - Y) - C_e - NC_e \right\} \cdot TR
\]

where:

- \(C_e\) = PVE annual cash expenditures
- \(NC_e\) = Annual noncash expenditures
- \(TR\) = marginal tax rate
- \(Y\) = joint ad valorem, severance, and royalty rate
- \(I_e\) = investment expenditures=capitalized investment + (1-TR) expense investment
- \(P_0\) = price of oil
- \(Q_e\) = quantity of oil produced
- \(CR_e\) = annual revenue from nonoil hydrocarbon resources

\[
\left[ (P_0 Q_e + CR_e) \right] (1-Y) = \text{present value equivalent of annual revenues}
\]

The ultimate exploratory drilling is estimated as a function of price in all regions. Each region has a unique relationship between demand for drilling and price, therefore the total demand for drilling at price \(P_1\) is the summation of the exploratory drillings at that price:

\[
D_1 = 0a + Ob + Oc + Od = \sum_{i,j} d_{i,j}
\]
where: \( j = \text{number of regions} \).

Considering the economic life and capacity of rigs, exploratory drilling is allocated over time and the response of drilling to price is estimated.

**OPEC Oil production Model: (13)**

A. Ezzati presents that model using a dynamic, multi-sectoral, linear programming approach to estimate OPEC optimal oil production policy and price strategy. It incorporates both the demand and supply side of OPEC crude oil linked to the macroeconomic requirements of OPEC's member countries. His innovation was his interesting combination of econometric and optimization techniques in an integrated framework incorporating demand, supply and economic considerations.

The general structure of the model consists of: (a) an objective function to maximise the joint weighted social welfare function of OPEC member countries over time; and (b) a set of constraints in the form of macroeconometric models for each OPEC country linked to the demand for OPEC oil, non-OPEC supplies, prices, OPEC revenue and production of oil. The mix of econometrics and optimization techniques is in estimating the macroeconomic models as equalities and then using them as inequality constraints in the linear programming model. This approach is useful for developing countries in particular, where the countries are experiencing a sudden inflow of foreign exchange which will naturally accelerate their growth. Therefore, using historically estimated equalities based on the structure of a period which has been completely altered will constrain their future economic growth. Briefly, the structure of the model works as follows:
An objective function: To maximize the joint weighted social welfare function of the OPEC members which incorporates (a) the weighted sum of the OPEC members' utility function, based for each country on the present value of future consumption over the planning period*. (The weights assigned to each country are determined with regard to its oil reserves, population, etc); and (b) the rate of growth in gross national production in the post-planning horizon, for each country.

Subject to a set of different groups of constraints:

1. Petroleum constraints: determines demand for OPEC oil, oil revenue in each country, the value of petroleum produced and exported, the quantity of oil produced and quantity of oil consumed.

2. Macroeconomic constraints: to specify the major component of demand using a Keynesian framework. These constraints are structured to reflect the importance of the oil sector in accelerating economic development according to each country's ability to absorb this revenue. Estimating these equations generates investments, consumption, imports, exports, etc.

3. Definitional equation: to guarantee the consistency of the model.

4. Policy constraints: which are not part of the model's structure, but are used as a mechanism to include energy policies and development policies of the OPEC members in the model. They are also used in sensitivity analysis by altering their values according to assumed alternative policies. Examples of

* The discount rates used are based upon the time preference concept of assigning a high discount rate in later years, assuming a diminishing marginal utility
these types of constraints are constraints on total investment level, consumption, foreign investment and so on.

The model, as described, does not consider OPEC as a monolith or as a two part cartel. It employs an interactive cartel approach by making the decisions on the grounds of individual members of OPEC. Oil production requirements are determined for individual OPEC member countries at different price levels to maximize the net present value of their future consumption. As the members vary in their economic infrastructure, absorptive capacity, political approaches and volume of oil reserves, OPEC's characteristics are diversified not uniform and not unanimous which results in differences in price and production behaviour.

The model examines OPEC's future stability which was assessed by comparing OPEC's behaviour as a heterogeneous group, with different needs for development and different limits to absorptive capacity. The countries with limited capacity can exert an upward pressure on crude prices through a reduction in output, while high absorption countries would tend to exert a downward pressure by increasing oil production levels to guarantee their revenue needs. This implies that OPEC Price and Production Policies will be heavily influenced by the individual member's ability to absorb oil revenues.

As a monopoly, OPEC will select the price and production strategy so as to maximize its net revenue. This assumption is not realistic, because OPEC as an organisation is loose, the members objectives are to increase, and not maximize, revenues i.e. self-motivated when the market is favourable and to prevent declines, not minimize, revenues when an unfavourable market prevails. This Cartel theory in which both the similarities and differences among OPEC members will be reflected in their future price and production
strategies is more applicable in these circumstances. One way to achieve this, according to Ezzati, is to establish a "Joint OPEC Future" from which side payments with low interest rates could be made to members to discourage them from producing more than their quota. Another way is to try to enhance a greater political unity, where conflicts are over-ruled and these two factors could, as he argues, bring OPEC Cartel closer to OPEC monopoly.

A major shortcoming of Ezzati's model is that oil demand and non-OPEC oil supply (the difference between them constitutes demand for OPEC oil) do not include short or long run adjustment lags.

By operating the model, production requirements were estimated for each member of OPEC. Demand for OPEC oil was calculated as a total and then allocated to individual members based on their relative shares in 1974 production.

The Birmingham Energy Model (14)

M. Carey, S.C. Littlechild, and P.G. Soldatos specify that the model incorporates the overall British energy system using a disaggregated framework.

It is an optimization model with a quadratic objective function to maximize the net present value of energy production and consumption, i.e. to maximize the difference between the expected benefits of energy consumption and the capital and operating costs of supplying energy to cover this consumption. The optimization process is carried out, subject to a set of constraints; demand, peak capacity of electricity, capacity and reserves constraints. The solution of the model determines the optimal production and investment policy which minimizes the present value of production and investment cost. The model works under some
assumptions: (1) the supply side is represented by four fuels: coal, oil, gas and electricity where coal, oil and gas could be used as a final demand or to generate electricity; (2) coal can be used to make synthetic oil or gas and uranium is used in nuclear energy; (3) there exist ten different processes to produce energy; and (4) imports and exports of gas, coal and oil are allowed. The time horizon of the model consists of nine periods each of five years, i.e. the model covers the period 1976 to 2021.

The general structure of the model could be simplified as follows*

The objective function is to maximize over a 45 year horizon the consumers' benefits from different fuel consumption as reflected in the demand function, minus the costs of meeting this consumption either from domestic sources or from imports.

Subject to the following constraints:

1. Supply equals demand:
   \[ \text{output of each fuel} \geq \text{final demand} + \text{any requirements for the fuel of using the fuel to produce any other fuel} \]

2. Production capacity:
   The output of each process \( \leq \) the capacity of the process

3. Capacity to meet peak demand:
   The peak capacity of a fuel \( \geq \) peak demand for that fuel

* As the mathematical equations of the model include too many details and notations, only a short general description of the elements of the model and its overall structure is given.
4. Reserves constraint:
   Production of oil and gas $\leq$ oil and gas reserves

5. Distribution capacity constraint:
   Distribution capacity peak demand for gas and for gas and electricity $\geq$ electricity

6. Importing/Exporting constraints:
   Imports/exports capacity for gas $\leq$ available capacity

The Birmingham model as briefly presented is a large-scale planning model for the British energy sector. It is presented in a disaggregative way, fuel by fuel and from both aspects; demand and supply. This, in fact, widens its scope and makes it difficult to get any details in specific areas which is normally the drawback of large energy system models, where the whole complex system is structured in one model which cannot be but a simplification of reality. This point could be attended to by using different models for each major aspect of the energy system to maintain the desired detailed analysis. The modules could then be integrated in an overall framework to account for their possible interaction.

The other point to be noted is that the model does not include any demand function. The energy demand estimates are taken as given assuming they are exogenously determined. The 1975 fuel demand is used with a growth rate of 3% per annum. This point, as noticed in Boffman's model too, impairs the power of the energy system model. The model has no role in deciding a price policy for the sector. The price of each fuel is set as equal to the marginal opportunity costs of increasing its supply. This point, as the author argued, diverted the consumer, through the model solution, towards cheap fuels and away from expensive ones.
3.2 OIL PRICING MODELS

The world attention has been riveted for the last fifteen years on the importance of energy in the global economy. The oil price shocks in 1975 and 1979 have created unstable energy prices, high inflation rates, world recession and many other problems which changed the world economic structure dramatically.

Economic Framework of Exhaustible Resources

Economic theory states that to maximize welfare or national income, the price of a commodity should be equal to its marginal social cost i.e. the value of the resources needed to produce the last unit of the commodity. If the retail price is subsidised, additional consumption will be encouraged, but if the retail price includes taxes, less will be produced and consumed as the marginal benefit will exceed the marginal social cost. This pricing system is often referred to as "first best" pricing while prices prevailing in the real world is considered "Second Best" pricing.

Because oil in the ground is not productive, the only way producers can earn a return on it is through capital gains resulting from the price increase. In an equilibrium with some positive extraction of oil, oil prices in the ground must be rising at the market rate of interest. If the oil price is rising faster, producers will hold it all off the market. But if the price is rising slowly, producers will sell the crude oil and hold a market asset instead. This concept is referred to as the Hotelling Rule*.

Hotelling and Solow (16) showed that this rule is a

* Hotelling's r-percent growth rule has come to be viewed as the fundamental principle of exhaustible resource economics. (15)
necessary condition for the maximization of the present value of consumers' or producers' surplus in a partial equilibrium framework. When the basic requirement of pricing oil is exhausted demand is just choked off by the rise in price.

Determination of the efficient price of a depletable domestic energy source as 'Oil' is based on the general economic theory of exhaustable resources. The theory suggests that the cost of using a depletable domestic resource today must equal the discounted present value of the cost of that resource or its substitute in the future. If the reserves of the exhaustible resource are known and fixed, and its extraction costs are constant and less than a substitute's price, the switch to the substitute of that resource will occur only when the original resource is physically exhausted. The price of the substitute fuel, at this future point, will represent the marginal or opportunity cost of the last unit, say barrel, of the resource.

The difference between this opportunity cost and the resource's extraction costs at this future point is the "Scarcity Rent" which reflects the value of the resource in the ground or the scarcity premium or user cost. If extraction and other costs are constant, the scarcity rent grows at the social discount rate. Thus the path of the rent for 'Oil' between the initial year and the year of exhaustion is derived by discounting the scarcity rent in the time of extraction by the social discount rate. The scarcity rent will be a function of reserves and oil demand levels, the price of oil substitutes and the discount rate.

If the reserves are infinite, which is not a practical case, the scarcity rent will be equal to the extraction costs. If reserves are quite small relative to demand level, which indicates a near exhaustion point, the
scarcity rent at the beginning of extraction will be close to the price of oil substitutes less extraction costs. Practically, the scarcity rent falls between the two extremes since oil reserves are generally large though finite.

The problem in applying this theory in pricing oil is the inability to divide, precisely, between the supply cost of oil extraction and the scarcity rent components of the efficient price.

Price Determinants

As a matter of fact, USER COSTS play an influential role in oil price determination whether we assume monopoly or competition. There are some factors influencing oil producer's perceptions of users costs or what we previously referred to as Scarcity Rent.

Attributing a scarcity rent to oil requires information about the expected magnitude of oil reserves in the ground and not only the existing one. Assuming a Hotelling-type competitive market with Zero production cost, the following observation regarding the link between oil reserves and scarcity rent could be demonstrated as in Figure 3.4.

- If a producer's expectation about user costs remains unchanged, as represented on the figure by period \((0\) to \(t_o)\), the oil price rises at the rate of interest.

- If geologists, i.e. future exploration, increase the estimation of oil reserve base, as represented by \(t_o\), the scarcity value of oil will be reduced resulting in a sharp decline in user costs.
FIGURE 3.4: Price paths under alternative resource base assumptions

Price
($/bbl)

Low
Reserves

Large Reserves

0

\(t_0\)

\(t_1\)

Time

- Assuming no other change in reserves expectation (period \(t_0\) to \(t_1\)) oil prices will have to rise again at the rate of interest.

- When oil producers become sure that the resource base is becoming smaller than expected, prices will definitely shoot upward and thereafter rise with the rate of interest as long as there is no change in their expectations again.

Oil substitutes have a significant impact on the pricing of oil. Assuming that the reserves of these oil substitutes become infinitely elastic at a price \(P^*\) and that they have large reserve bases to the extent that their user costs are zero, this will mean the availability of unlimited supply at that price \(P^*\). This will result in a remarkable alteration in the price path of oil as Figure 3.5 shows.

The price will no longer continue to rise at the rate of
interest. It will continue increasing at rate \((r)\) until it reaches \(P^*\) where the substitutes or the backstop fuel meets all demand at price \(P^*\). In this case oil producers would like to dispose of all their oil before \(t_0\) when user cost would not rise. Practically, oil production will continue even after \(t_0\), since oil fields cannot be exhausted instantaneously and with the possibility of the backstop fuel being insufficient to cover demand levels. This will even create an environment for oil prices to overshoot at \(t_0\) (represented by the dotted line \((t_0\) to \(t_1\)). After that, oil prices will remain constrained to the level of price \(P^*\).

**FIGURE 3.5: Oil prices with a backstop fuel**

![Graph showing oil prices with a backstop fuel]

Discount rate, or the market rate of interest is another significant determinant of oil price. Inflation rates are
quite uncertain and unpredictable. This makes it necessary to set and forecast oil prices in dollars of constant purchasing power, i.e. to work the real price of oil which reflects the oil price deflated by the general price index. The effect of changes in real discount rate could be detected from Figure 3.6.

The figure demonstrates the employment of a high discount rate of 25% from period 0 to $t_o$ on the grounds of a reason such as expecting nationalization. When the expectation becomes untrue and the risk becomes lower, a reduced discount rate of 5% was used. When the discount rate reached zero, period $t_1$, the user costs become equal over time.

FIGURE 3.6: Price paths under alternative discount rates

Even in a competitive market the oil price path depends on the price elasticity of demand on the assumption that demand levels or conditions affect marginal revenues which
in turn determines user costs. In the short run, price elasticity for oil is known to be quite inelastic. As Figure 3.7 implies, the price path begins at price $P_0$ and rises thereafter at the discount rate during period $0$ to $t_o$ when a low elasticity prevails. If we assume that in period $t_o$ producers of oil expected long run demand to be more price elastic resulting in an abrupt downward adjustment in user costs, although the oil price will continue to rise at the discount rate, the base from which it rises will be much lower and the price path of oil will always be below the original price path.

FIGURE 3.7: The importance of the price elasticity of demand

The growth in oil demand resulting from world economic growth is another influential factor to determine the oil price path. As important as the effect of prices on
consumption is income, represented in the case of oil consumption by the rate of economic activity. In Figure 3.8 a strong correlation between energy consumption and the standard of living is detected. Therefore, if oil producers expected rapid long run growth rates user costs will hick. As illustrated in the figure, period 0 to $t_o$ portrays the oil price path assuming or expecting high economic growth rates. Period $t_o$ into the future signals a period in which economic growth projections are scaled down as shown.

**FIGURE 3.8**: Economic Growth Projections

The conclusion from the previous discussion, is that the determination of an oil price path requires expectations regarding all the influencing factors. The point to be noted is that the changes occurring to any of them are not independent, but affects and is normally affected by changes in the other determinents which consequently exacerbate oil price uncertainty.

Oil pricing is a very important tool for oil demand management, especially, in the long run. The pricing and
investment decisions should be closely related. Oil production usually requires large capital investment with long lead times and lifetimes. Therefore, once the investment decision is made, there is a lock-in effect with respect of production. Thus, oil prices should be related to the long-run planning horizon.

The objectives of oil pricing are quite related and should not be independent from many other objectives. Economic growth objectives require that the pricing policy of oil should promote economically efficient allocation of resources both within the oil sector and between it and the rest of the economy. Social objective recognises that every citizen has a basic right to be supplied with his minimum energy needs, which implies the need and urgency of subsidised oil prices at least for low-income consumers. Financial objectives related to the viability and autonomy of the oil sector would be affected by oil pricing policies that permit institutions (government owned) in the different oil sub-sectors to earn a fair rate of return on assets and self finance and an acceptable portion of the investments required to develop future oil resources. Conservation is another objective of pricing policy aimed at prevention of unnecessary waste of oil. These objectives, together with the need for price stability, prevention of consumers from large price fluctuations, promotion of regional development are all socio-political, legal, economic and environmental constraints that should be accounted for in setting an oil price policy.

What makes this task so difficult is that the different objectives interacted with oil pricing are often not mutually consistent, which requires an integrated oil pricing structure flexible enough to permit trade-offs among them. A suggested flexible pricing framework could be implemented and carried out in two stages: In the first a set of prices that strictly meets the economic efficiency
objectives is determined, based on a consistent and rigorous framework. The second stage works to adjust these efficient prices to account and be consistent with all other objectives with the adjustment being determined by the relative importance assigned to the different objectives.

This suggested approach is quite useful, as it helps to know which set of oil prices reflect the least cost solution of producing oil. Only if it is known what this set of prices is can an assessment be made of the costs that the various other distributional or nonquantifiable objectives may have. The efficient prices of oil provide a yardstick that can be used to measure the consequences and economic costs of introducing these other goals. If these factors or goals are directly incorporated into the set of oil prices, there is no way of measuring resulting losses in economic efficiency.

Basic Pricing Objectives

The basic objectives that must be considered in oil pricing are (a) economic efficiency, (b) social equity and (c) financial viability. (18)

A fundamental objective in oil pricing is that prices to oil users should reflect the fall, long-term, marginal social opportunity costs of their use. This requires that shadow prices should be applied whenever real values diverge from market prices. The problem is that in spite of the acceptance and understanding of the shadow price principle, data about the magnitude of the various shadow pricing coefficients is not available. Oil prices should also reflect the value of the resources consumed in their next best alternative use, which could be, in the case of petroleum products, the export price (f.o.b.) or import price (c.i.f.) adjusted for any quantity or quality
differential and additional transportation costs. To guarantee efficiency objectives, oil prices should reflect their foregone current or potential future net value which measures the future net economic value of oil that are produced now and must be replaced by higher cost alternatives later. This economic value is actually determined by five types of opportunity costs: the long run marginal costs of supply, the foregone future net value of the depleted resource, the net value of the resources in alternative uses, the net value of the resource as a current substitute for other energy resources and the net value of the resource in uses that would not occur if alternative, higher cost energy or feedstock materials had to be utilized.

Socio-political objectives are in favour of subsidized prices for oil. The points to be noticed in this respect are that the low price usually referred to as 'lifeline' rates may deviate from economic efficiency criteria. Also the amount of subsidy should be balanced by the government in order to prevent jeopardizing the financial viability of the producing organisation. Nevertheless, large subsidies accompanied by losses are sometimes economically justified if the demand from new users is expected to increase to a sufficient level enough to ensure adequate capacity utilization to recapture the initial subsidy.

Oil pricing has two major financial objectives, the financial viability of oil producing organizations and the general revenue goals of the government. The insufficient revenue flows to oil producing organizations results in unreliable oil supplies which are far more costly to an economy than higher oil prices. Taxation, on the other hand, is a cost-efficient device to collect needed government revenues if the demand is relatively inelastic.

Having briefly reviewed the theoretical framework of the
pricing issue, some selected oil pricing models are surveyed before structuring the model for Kuwait.

Oil Pricing Models

Oil pricing models could be categorised according to the way they analyse the pricing behaviour of oil producing countries. In this respect we can distinguish between three main approaches in determining the oil price path; the energy balance approach, simulation models and optimization models. (19)

In the following, three models will be examined, and a quick review of some other oil price models is presented.

The Hnyilicza and Pindyck model (20)

This study is based on a paper by Pindyck (1976). It examines the cartel in two parts: a block of "savers" (Saudi Arabia, Iraq, Libya, Bahrain, Qatar) and a block of "spenders" with a higher discount rate (Iran, Venezuela, Indonesia, Algeria, Nigeria, Equador). It computes the optimal bargaining solution for the two part cartel using results from the theory of cooperative games developed by Nash. The solution is computed under two assumptions on output shares, when shares vary over time and when they are fixed.

The optimal price path initially, when only spenders are producing, starts at $14.85, then falls slowly to $10 after 8 years. In the next three years the price fell to $4.86 and in 1986 jumped back up to $14. During the rest of the time prices declined, then will rise slowly to $20.34 in the year 2010.
This study has its strength in the fact that it looks at the OPEC countries as two blocks, which is more realistic than considering them as a monolith. It also incorporates short-term adjustment lags into the model.

However, dividing the cartel into two parts, savers and spenders, is not very realistic because among the saver block there are differences in philosophy, oil reserves and saving capability. Lumping Iran and Libya in one group with Saudi Arabia hardly reflects a uniformity of outlook. The model also does not account for the threats of viable substitutes for oil as a critical factor in the pricing strategies of OPEC countries, especially the saver block. The model works as follows:

(i) Solve continuously for different values of the outcome weight to obtain the locus of possible bargaining solution in the space of realized objectives shown in Figure 3.9 as \((W_1 W_2)\).

(ii) Obtain the threat point, either the outcome that would result if cooperation between cartel members is not possible. The threat point is presented as \((W_{10}^o W_{20}^o)\).

(ii) Find the Nash solution using Nash-Cournot theory by maximising the rectangle between the efficient bargaining frontier and the threat point. The Nash solution is \((W_1^* W_2^*)\).

(iv) Then compute the optimal path for the outcome weight and for the time varying shares of output.

To maximize the sum of weighted profit of OPEC, Pindyck suggested the following:

(a) The oil output of the saver countries must remain at
FIGURE 3.9: POSSIBLE BARGAINING SOLUTION IN THE SPACE OF REALIZED OBJECTIVES

OUTPUT

diagram of output space with axes $W_1$ and $W_2$, showing efficient bargaining frontier and Nash solution.
zero for the first fifteen years (starting from 1975).

(b) When the reserves of the saver countries are depleted the spender countries should take over production.

Despite the above remarks and the way the model's conclusions have been obtained, two conclusive points with normative implications should be stressed first, a recognition of the particularities and different interests of the individual producers has to be included in any modelling effort. Second, output allocation among OPEC members is a meaningful and highly operative policy tool, as opposed to the highly inefficient (as imposed by computational difficulties) pricing strategies. There is no need for extreme solutions of fixed output quotas or of bang-bang nature to be adopted, but a midway 'compromise' policy is likely to reduce the possibility of substantial loss of welfare, attributed to the 'sovereign atherosclerosis'! The above two conclusions constitute the main strong points of the Hnyilicza-Pindyck approach to the OPEC behaviour.

Model building as such does not seem to be a satisfactory approach to the behaviour of OPEC, possibly for the mere reason that there is no collusive behaviour of the organisation as such. And there are far more reasons for obstention from any optimization models. However, even though model building is beyond our scope, it seems useful to provide some suggestions, concerning the necessary 'ingredients' of any such attempt, the macroeconometric models of all individual members of OPEC, the oil and non-oil sectors, the institutional and economic policies, the OPEC domestic oil consumption, lag adjustments nd dynamic relationships, market particularities (residual derivative demand and its implications), heterogeneity of
the commodity are some of the indispensable prerequisites of any operational model. In absence of an overall pricing pattern, output allocation seems to be the most adequate control variable. In general, an interactive cartel approach seems to be justified, but it should always be kept in mind that, due to the abstractions dictated by the need for manageability, it is hardly probable that a model with sufficient explanatory, predictive and prescriptive power is possible.

The Gately and Kyle model (21)

This model uses the world energy market that incorporates price expectations and lagged adjustments of demand and supply. It examines the implications of various price-paths that could be selected by OPEC. It further discusses a variety of rule-of-thumb pricing strategies, where OPEC sets prices in response to available market signals.

The authors identified a consensus that the price of oil was higher than that considered by OPEC and that prices would soon fall. On the other hand consuming countries opine that oil prices are low and may rise.

The model assumes OPEC as a monolithic group, acting as a price-setting supplier in the world energy market. Two approaches were used:

(a) Dynamic simulation model to evaluate output and profits

(b) Price was evaluated according to rule-of-thumb pricing strategy.

It goes on to say that OPEC is a Residual or Swing supplier
FIGURE 3.10: SUPPLY AND DEMAND CURVES

S.R. supply curve

\( \bar{P}_{dt} = \bar{P}_{st} = P_{t}^{*} \)

L.R. supply

S.R. demand curve

L.R. demand

\( s_{t}^{*} \)

\( d_{t}^{*} \)
FIGURE 3.11: SUMMARY OF MODEL

\[ P = P_{at} \]

\[ \bar{P}_{dt} = \bar{P}_{st} \]

\[ P^{ll} = \bar{P}_{c} \]

FIGURE 3.12: PRICE INCREASE, REVISED DEMANDS AND NON-OPEC SUPPLY INCREASES

Market disequilibrium

\[ P_t \neq \bar{P}_{dt} = \bar{P}_{dt} \]

\[ \text{Market disequilibrium} \]

\[ P_t^* > \bar{P}_{dt} > \bar{P}_{st} \]
of crude oil as propounded by Ezzati. The model can be summarised in diagrams 3.10 and 3.11.

Figure 3.10 deals with long run demand and supply curves in equilibrium when actual price \( P^*_t = \) demander's capital stock adjusted price \( P_{dt} \) and suppliers capacity adjusted price \( P_{st} \).

Figure 3.12 shows when prices increase to \( P^1_t \), demand is revised to \( P^1_t \) and non-OPEC supply increases to \( S^1_t \).

MacAvoy and Pindyck (22)

introduced an econometric simulation model for the natural gas industry in the United States in an attempt to measure the effect of alternative gas policies on the price of gas. The model consists of a set of simultaneous equations specified into functional modules. In the exploration and discovery model, total explored wells of gas are estimated as a function of previous revenue, previous average costs and average risk measured by the variance of previous success rates. The average discovery sizes of non-associated and associated gas are also determined as a function of past prices of gas and oil, past drilling costs and the cumulative number of wells drilled. To determine the extensions of associated and non-associated gas, separate equations are specified to relate the expected extensions to drilling activities and previous new discoveries. Finally, an accounting identity is specified to determine additions to reserves as the sum of new discoveries plus extensions and revisions. The production model estimates the production of gas as a function of reserve base and field prices. The marginal cost of production depends on the relation between the reserve level and production level, the higher the ratio the lower the marginal cost. The demand model consists of a set of
wholesale demand equations for the industrial, residential and commercial sectors. Demand levels are estimated as a function of some indicators of the market size such as population or income, prices of alternative fuels and the wholesale price of gas which is dependent on the wellhead price and a pipeline mark-up price.

The flows of natural gas between producing and consuming centres are specified through a network model based on an input-output table for the coefficients between each producing and consuming centre, with the differences between the flow of production and the demand level measuring excess demand for gas.

Tyner Model (23)

This is one of the major studies for developing countries in the area of evolution of petroleum leasing policies and agreements. Tyner used as an approach an analytical model based on Monte Carlo simulations for the evaluation of petroleum leasing policy in India. His generalized leasing model is applied to compare the Indian production sharing leasing system with the following systems in use or proposed in other parts of the world: US bonus bidding system, annuity capital recovery profit share system, British type profit share system, variable rate royalty system and Peruvian leasing system. His conclusions are that in its own institutional setting, the Indian system appears to be superior to the other alternatives and currently "the Government of India is doing a better job of collecting economic rent than the other countries evaluated." His suggestions are that India should continue to lease offshore areas to foreign companies using the current system (or any other capital recovery system) in which the return to capital is allowed by permitting recovery for three times the original cost through cost oil
and profit oil. In his analysis, the mean of the annual price change distribution was set equal to zero which implies that the expected real price would not change through time (although the actual prices would). It is not clear how sensitive the results would be to changes in the real price of crude oil over time.

Siddayao model (24)

Siddayao (1978) has analyzed the various economic and political factors relating to the use of off-shore petroleum resources of Southeast Asia. The study points out that the problem of disputes relating to off-shore petroleum resources may not be considered separately from a nation's energy policy within the framework of its economic development programme. In the context of rising import costs of oil, the author has examined the cost to a nation's economic well-being of non-access to potential petroleum resources within its boundaries. The study has demonstrated the economic benefits of cooperation in petroleum exploration in the Asian countries and has also emphasized the importance of a climate of stability concerning property rights for attracting foreign investments in petroleum exploration and development.

Delucia and Jacoby model (25)

This model was applied to Bangladesh in 1980. It presents an integrated framework for analyzing pricing and investment decisions in the energy sector. Figure 3.13 shows the various models and linkages in the BES* along with the judgements on inputs and side analyses done for consistency checks. As shown in the middle panel of the

* BES: Bangladesh Energy Study
FIGURE 3.13: MODELS AND INFORMATION FLOWS IN THE BANGLADESH ENERGY STUDY

- uptake of modern inputs
- technical progress
- capital constraints

- incremental capital-output ratio
- non-agricultural exports and imports
- import substitution

- time path of adoption of conservation measures
- patterns of auto-generation
- scale of rural electrification

- economic parameters and prices
- adequacy of gas reserves
- rate of fuel switching
- candidate investment plan components

- coordination of short-term and long-term forecasts
- influence of relative prices of fertilizer and energy

- size of agriculture within overall investment
- influence of energy plans on foreign balance

- comparison with other countries
- consistency with ongoing planning in other sectors

- coordination of electric and fuels/fertilizer investments
- capacity to absorb many major capital projects
Figure, the overall demand study uses a combination of an agriculture sector study, a macroeconomic forecasting exercise, and an estimation of the energy demand associated with particular levels of economic activity. The supply analysis involves the joint use of a model for the electric system and one for fuels and fertilizers.

The agricultural model results are used in the overall analysis in three ways. First, estimates of foodgrain production, output of export crops, and value-added in the agricultural sector became inputs to the analysis of the macroeconomy. Second, a major part of total demand for commercial energy is due to fertilizer and pumping demands in agriculture, and these quantities became part of the overall farm sector analysis. Third, the production of traditional energy sources (e.g. rice and jute waste) is influenced significantly by patterns of growth and crop mix, and these outputs of the agricultural analysis became an important input to the supply analysis.

The Cremer-Weitzman Model (26)

The Cremer-Weitzman (1976) model employs two types of economic agent: OPEC and "the competitive fringe". The net OPEC demand here is explicitly derived as the difference between the total demand and the competitors' production. OPEC chooses the price so as to maximize its discounted profit given their cumulative cost function and capacity constraint. Saudi Arabia is not considered separately as a price setter. Instead the study considers OPEC as consisting of the oil producing countries in North Africa and the Persian Gulf, because the authors believe they constitute the "monopoly kernel of OPEC".

Cremer-Weitzman predict that prices do not increase significantly during the first twenty years, but increase
sharply in later periods. If the fringe is able to increase capacity without limit, prices would be dampened in the first twenty years but would remain practically unchanged for later years. The authors also perform sensitivity analyses with respect to discount rates for OPEC and the fringe and the assumed demand growth rates. Moderate changes in costs and reserves have negligible effect on prices and production.

The macroeconomic analysis results give estimates of national economic growth to the year 2000, along with a breakdown of likely growth by economic sector. In the energy demand analysis these results are combined with energy input-output coefficients for the various industrial sectors, and with analyses of energy demand for transportation, household, and commercial components of the economy. The end-product is an internally consistent energy forecast by region of the country, broken down into demand for electric power (kWh) and demand for nonelectric energy (Btus), and including sufficient characterization and end-user demand to allow fuel-specific supply analysis.

The last stage in the sequence of BES studies is the analysis of the electric power and fuel and fertilizer systems. Electric sector modelling is one of several methods used for studying power systems and planning capacity expansion. One output of this model is the demand of the electric power sector itself for natural gas, coal, and oil-based fuels. These data, plus other fuel demands, are input to another model of the system that provides natural gas production and transmission, oil refining, and oil transportation. At this stage in the analysis, the importance of the interaction among different parts of the energy system becomes evident. For example, the possible construction of a natural gas pipeline to Chittagong, an investment which is ultimately dependent on plans for the number and location of new fertilizer plants and heavily
influenced by the associated changes that will be called for in the location and size of electric generation plants and transmission lines.

The models and various scenarios for key economic parameters such as the discount rate are combined for an assessment of alternative development schemes. First, the country is divided into market areas. This is done because, in Bangladesh, the transport link between areas is of particular interest. For imports and exports, the appropriate international markets must be identified.

Energy demand estimates are then disaggregated according to fuel type and the internal breakdown of market regions. The two supply analysis models shown in Figure 3.13 are designed to deal with these markets and product definitions. Both are simulation models with imbedded optimization (mathematical programming) procedures to estimate system operating costs. The two systems models are designed to make it easy to test alternative patterns of system investments, while allowing flexibility in testing alternative judgements about input assumptions.

Alternative investment schemes were evaluated in an interactive procedure. For the electric and fuel systems, several overall national investment programmes were constructed in order to compare schemes with and without some element, so that the relative economics of that element could be studied. The procedure involves the construction of an investment programme, simulating its costs, comparing it with others, revising or defining other alternatives, simulating again, etc. Over fifty separate sector investment schemes were analyzed during the study.
Pindyck Model (27)

In 1978 Pindyck developed another dynamic optimal pricing model for a monopolistic oil cartel, with an objective to maximize discounted profits. The demand equation is based on aggregate time series data and allows for a simple one-year adjustment lag, as well as an autonomous demand growth. Average costs are supposed to increase with resource depletion, so exhaustion constraint is not introduced explicitly. Adjustment lags in the model result in projecting that the optimal price strategy would be to increase prices initially, then reduce and increase them gradually as the cost considerations predominate.

Eckbo model (28)

In another model he uses two OPEC views to examine the optional price tractory: a monolithic-OPEC version, and another version where OPEC is divided into three subgroups: the "core", the "price-pushers", and the "expansionist fringe". A variety of market sharing rules are also examined. These simulations point to potentially severe problems of output restrictions for OPEC.

Other studies on optimal OPEC pricing and production behaviour include Ezzati (1978), Ben-Shahar (1976), Bohi-Russell (1975), Tourk (1977), Kosobud and Stokes (1980 a, b), and Fixler and Ferrar (1975). The two surveys by Hammoudeh (1980), presents some of the results of the models of OPEC price behaviour. With the exception of Ezzati, the "final price" projections for years ranging from 1990 to 2047 are uniformly at or below actual prices in 1980.
Kalymon model (29)

In Kalymon (1975), optimal price trajectories are derived both for monolithic-OPEC and for several sub-OPEC coalitions. The objective function is the present value of net benefits accruing to the price-setting residual supplier, which is the sum of net revenue from oil sales to both domestic and foreign consumers and the consumers' surplus obtained by domestic buyers. This separation of demand functions permits an examination of optimal price discrimination policies. The results show both domestic and export prices increasing steadily, reaching the substitution price (of the "backstop, fuel, specified exogenously) within a planned exhaustion period of fifty-two years. The sensitivity analyses he has performed for the equilibrium prices show that the discount rate, substitution price, and export market growth are the crucial parameters.

Munasinghe model (30)

This model is based on the idea that since investment decisions in the oil sector are closely related to the pricing of energy outputs, the same SHADOW PRICING approach used in the cost-benefit analysis of energy projects should be used for the purpose of consistency.

Shadow prices are used instead of market prices, to represent the true economic opportunity cost of resources. In the idealized world of perfect competition, the interaction of automistic profit-maximizing producers and automistic utility-maximizing consumers yield market prices that reflect the correct economic opportunity costs, and scarce resources including energy will be efficiently allocated. However, in the real world, distortions may result from monopoly practices, external economies and diseconomies, interventions in the market process through
taxes, import duties, and subsidies, etc. and these distortions cause market prices for goods and services to diverge substantially from their shadow prices or true economic opportunity costs. Therefore shadow prices must be used in investment and output pricing decisions to ensure the economically efficient use of resources. Moreover, if there are large income disparities, prices must be further adjusted to achieve socially equitable energy pricing policies for poor households.

The process of establishing an efficient economic price in a given energy subsector may be analyzed in two steps. First, the marginal opportunity cost (MOC) or shadow price of supply must be determined. Second, this value has to be further adjusted to compensate for demand side effects arising from distortions in the prices of other goods, including other energy substitutes. From a practical viewpoint, an optimal pricing procedure that begins with MOC is easier to implement, because supply costs are generally well-defined (according to technological-economic considerations), whereas data on the demand-side are relatively poor.

In Figure 3.14, the marginal opportunity cost of supply in a given energy subsector is the curve MOC(Q). For a typical non-trade item like electricity, MOC, which is generally upward sloping, is calculated by first shadow pricing the inputs to the power sector, and then estimating both the level and structure of marginal supply costs (MSC) based on a long-run system expansion programme. For tradeable items like crude oil and for fuels that are substitutes for tradeable items at the margin, the international or border prices of the tradeables (i.e. cif price of imports or fob price of exports, with adjustments for internal transport and handling costs) are appropriate indicators of the MOC. The use of border prices does not require the assumption of free trade, but implies that the numerator or unit of value
FIGURE 3.14: EFFICIENT PRICING WITH SHADOW PRICES
for shadow pricing is essentially uncommitted foreign exchange (converted into local currency at the official exchange rate). After identifying the correct supply curve, the next step is to examine demand-side effects, especially second best corrections that account for the distortions in the economy.

The general theorem of the second-best shows that if the price of a given fuel is not set at its MOC, then the efficient price of a close substitute must also diverge from its own MOC. In Figure 3.14, the market-priced demand curve for the form of energy under consideration is given by the curve PD(Q), which is the consumers' willingness to pay. Consider a small increment of consumption ΔQ at the market price level p. The traditional optimal pricing approach attempts to compare the incremental benefit of consumption due to ΔQ, that is, the area between the demand curve and the X-axis, with the corresponding supply cost, that is the area between the supply curve and X-axis. However, since MOC is shadow priced, PD must also be transformed into a shadow-priced curve to make the comparison valid. This is done by taking the increment of expenditure p. ΔQ and asking what is the shadow priced marginal cost of resource used up elsewhere in the economy if the amount p. ΔQ (in market prices) is devoted to alternative consumption or investment.

Supposing that the shadow cost of this alternative pattern of expenditure is b(p. ΔQ), where b is called a conversion factor, then the transformed PD curve, which represents the shadow costs of alternative consumption foregone, is given by bPD(Q). In Figure 3.14, it is assumed that b > 1. Thus at the price p, incremental benefits EGJL exceed incremental costs EFKL. The optimal consumption level is Q opt, where the MOC and bPD curve cross, or equivalently, where a new pseudo-supply curve MOC/b and the market demand curve PD intersect. The optimal or efficient selling price to be charged to consumers (because they react along the market
demand curve PD, rather than the shadow-priced curve bPD) will be $P_e = \frac{MOC}{b}$ at the actual market clearing point B. At this level of consumption, the shadow costs and benefits of marginal consumption are equal, that is, $MOC = bPD$. Since b depends on user specific consumption patterns, different values of the efficient price $P_e$ may be derived for various consumer categories, all based on the same value of MOC.

The above analysis can be clarified by considering several specific practical examples. First, suppose that all the expenditure ($PQ$) is used to purchase a substitute fuel, that is, assume complete substitution. Then the conversion factor b is the relative distortion or ratio of the shadow price to market price of this other fuel. Therefore $P_e = \frac{MOC}{b}$ represents a specific second-best adjustment to the MOC of the first fuel, to compensate for the distortion in the price of the substitute fuel.

Next, consider a less specific case in which the amount ($PQ$) is used to buy an average basket of goods. If the consumer is residential, b would be the ratio of the shadow price to the market price of the household's market basket (here, b is also called the consumption conversion factor). The most general case would be when the consumer was unspecified, or detailed information on consumer categories were unavailable, so that b would be the ratio of the shadow exchange rate (SER) to the official exchange rate (OER), also called the standard conversion factor SCF. This represents a global second-best correction for the divergence between market and shadow prices averaged throughout the economy.

A general expression for the socially optimal price in the subsector for energy type A can be developed based on shadow prices (to compensate for distortions in the economy).
A general expression for the socially optimal price in the subsector for energy type A can be developed based on shadow prices (to compensate for distortions in the economy).

For a general equation, results for optimal energy pricing are derived for cases that reflect the following:

1. A perfectly competitive economy (classical result).
2. Efficient prices, including second-best considerations.
3. Subsidized social prices or lifeline rates for poor consumers.

The supply and demand for a form of energy A is shown in Figure 3.15, where S is the supply curve represented by the marginal cost of supply (evaluated at domestic market prices), and DE is the corresponding demand curve for a specific customer. Starting with the initial combination of price and consumption \((P,Q)\), consider the impact of a small price reduction \((dP)\), and the resultant increase in demand \((dQ)\) on the net social benefits of energy (A) consumption.

Before evaluating the net social benefit of this price change, the shadow pricing framework may be defined. First, suppose the marginal cost of supply \((MC)\) is calculated without shadow pricing), i.e. in market prices \(a_p\) is defined as the energy A conversion factor \((ACF)\), which transforms MC into the corresponding real economic resource cost (i.e. with correct shadow pricing) then the marginal opportunity cost is \(MOC = a_p MC\).

Second, a specific social weight \(w_c\) is to be assigned to each marginal unit of consumption (valued in market prices) of a given individual \(i\) in the economy. For example, if this user of energy A is poor, the corresponding social weight may be much larger than for a rich consumer, to
FIGURE 3.15: SUPPLY AND DEMAND IN ENERGY SUBSECTOR 'A'
reflect society's emphasis on the consumption of low income groups. Third, if the given individual's consumption of goods and services, other than in the energy A subsector (valued in market prices), increases by one unit, then the shadow-priced marginal cost of economic resources used (or the shadow cost to the company) is \( b_i \).

As a result of the price reduction, the consumer is using \( dq \) units more of energy A, which has a market value of \( pdQ \) (i.e. area IFGH). However, the consumer's income has increased by the amount \( pQ - (P - dp)(Q + dQ) \), and assuming none of it is saved, this individual's consumption of other goods and services will increase by the amount \( Qdp = pdQ \), also valued in market prices (i.e. area BEFG minus area IFGH). Therefore, the consumer's total consumption — that is, energy A plus other goods — will increase by the net amount \( Qdp \) in market prices. This is the traditional increase in consumer surplus benefits. The shadow value of this increased consumption is \( W_c(Qdp) \), where \( W_c \) is the social weight appropriate to this consumer's income/production level.

Next, the resource costs of these changes in consumption must be considered. The shadow cost of increasing the supply of energy A is \( a_pMCdq \) (i.e. \( a_p \) times area IJKH), and the resources used to provide the other additional goods consumed \( b_c(Qdp - pdQ) \), where \( a_p \) is the conversion factor of energy A, and \( b_c \) is the conversion factor for other goods consumed by this consumer. Finally, the income change of the producer of energy (A), if any, must also be considered, although this effect may be ignored if we assume quite plausibly that the producer is the government.

The total increase in net social benefits due to the energy price decrease is given by:

\[
NB = W_c(pdQ) - a_p(MCdq) + (W_c - b_c)(Qdp = pdQ) \quad (1)
\]
\[
\frac{dNB}{dP} = Q (W_c - b_c) + nb_c = n(MC/p)
\]

(2)

where \( n = \frac{(pdQ/Q, dp)}{dp} \) is the elasticity of demand (magnitude).

The necessary first-order condition for maximising net social benefits, in the limit, is \( d(NB)/dp = 0 \).

This yields the optimal price level:

\[
P^* = aP_{MC} / b_c + (W_c = b_c/n)
\]

(3)

This expression may be reduced to a more simple form, by making some simplifying assumptions.

Assume income transfer effects ignored, because marginal social benefit of consumption is equal to the marginal social cost to the economy of providing this consumption.

Therefore, \( W_c = b_c \), and equation (3) becomes:

\[
P^* = \frac{(aP_{MC})}{b_c} = \frac{MC}{b_c}
\]

(4)

The above equation shows the optimal efficient allocation of resources, neglecting income distributional considerations, i.e. no social weighting.

A main practical advantage of the above simplification is that equation (4) does not include the price elasticity (n), therefore \( P^* \) can be obtained without the need for estimates of (n). Given that energy prices in Egypt have been kept administratively almost unchanged for the last thirty-three years, any attempt to estimate the different fuels price elasticities can hardly be logically acceptable. Using data of nominal prices wrong a priori
sign, i.e. a positive elasticity sign indicating a meaningless positive relation between prices and demand as the relevant real fuel prices have declined instead of increasing over the last three decades in Egypt. Even deflating the nominal prices and using their real equivalences as a data base in the estimation of the elasticities, would not provide a final solution. These estimates still cannot be considered as satisfactorily accurate measures of the specific response of fuels' consumption to the changes in their prices in the Egyptian case, where the change of demand was mainly due to a combination of factors other than price changes, such as the growth of GDP, economic and social structural conversions, changes in the consumption and production patterns, etc. Accordingly, the ceteris paribus assumptions necessary for the validity of the elasticity concept does not hold. Moreover, most of the fuels price elasticities estimates obtained by previous studies for Egypt are insignificant. These estimates also bridge an enormous range, with the disparity between the highest and lowest estimates spanning more than four orders of magnitude.

As mentioned above, the marginal opportunity cost of energy \( A(MOC) \) may usually be evaluated in a straightforward manner e.g. the international border price for a tradeable fuel, or, in the case of a non-tradeable such as electricity, by applying the appropriate shadow prices to the least cost mix of technically determined inputs used in production). However, the conversion factor \( b_c \) depends crucially on the type of consumer involved.

For residential consumers of energy \( A, b_c \) represents the consumption factor (CCF), which reflects the resource cost or shadow value of one (market-priced) unit of the household's marginal consumption basket. If the CCF 1, then \( P^*_e < MOC \).
Another case illustrates the application of equation (4) which is correct for economic second-best consideration arising from energy substitution possibilities. As an extreme case, suppose all expenditures diverted from energy A consumption will be used to purchase alternative energy which is subsidized by the government. In this case, $b_c$ is the ratio of the marginal opportunity cost of alternative to its market price, and may be written $b_c = \text{MOC}_{ae}/P_{ae}$; thus from equation (4)

$$P^*_e = \frac{\text{MOC}(P_{ae}/\text{MOC}_{ae})}{P_{ae}}$$

(5)

The logic of this expression may be clarified by considering the case when the actual $p < P^*_e$. Then the shadow cost of one unit of expenditure on energy A is $\frac{\text{MOC}}{p}$, while if the sum were used to purchase alternative energy the shadow cost would be $\text{MOC}_{ae}$. Since $p < P^*_e$, $\frac{\text{MOC}}{p} < \frac{\text{MOC}_{ae}}{P_{ae}}$, and the country is better off if less energy A is used, then $P$ should be increased to the value $P^*_e$.

Since the alternative energy is priced below its border marginal cost, i.e. $b_c > 1$, then $P^*_e < \text{MOC}$ also. Therefore, the subsidization of substitute energy prices will result in an optimal energy A price that is below its shadow supply cost.

If it is not possible to determine the consumption patterns of specific consumer groups, $b_c$ could be defined very broadly as the average conversion factor for all energy A users, e.g. the SCF, which represents the ratio of the shadow price to the market price of the household's market basket.
3.3 ENERGY POLICY MODELS

Analysis and modelling of the overall energy system, including supply and demand from all end-use sectors as well as all fuels and energy forms, is useful both to forecast total energy demand and to situate energy planning in larger contexts of public policy. These analyses often highlight the question of interfuel substitution and resource definition in a more comprehensive framework. Depending upon the focus, coverage and size, these studies can range from energy balance studies to sectoral models. The borderline is not always clear, since models or their components are developed with a variety of purposes in mind or can be adapted as needs arise.

A particular variant of energy policy models is the integrated energy/economic models - those produced by coupling energy system models with macroeconometric or input-output models of the overall economy. Whereas in many sectoral or energy system models output demands are required to be specified exogenously as model inputs, one has to recognize that these demands are linked to the macroeconomic structure and trends of the overall economy, including demographic structures and taste patterns. The combination of process analysis-type energy system models and macroeconomic models thus helps identify relationships between the energy sector and the economy. These models are also used to analyze the relationships between economic growth and energy in a short to medium term horizon.

The process type of energy system model encompasses all alternative fuels and energy sources and frequently employs network analysis in order to represent technical details and to capture the interfuel substitution possibilities. The network is used to represent the spatial or interregional flows of energy as well as the alternative processes and fuels that may be used in specific demand
sectors. This representation of the energy system may be augmented with optimization or simulation techniques or used simply as a framework to exhibit information and options.

**RES model** (31)

The Reference Energy System (RES) approach was developed by Hoffman (1974) and applied to the assessment of new energy technologies and policies. This approach gives a network description of the energy system in which the technical, economic, and environmental characteristics of all processes involved in the supply and utilization of resource and fuels are identified. All steps in the supply chain (the extraction, refining, conversion, storage, transmission, and distribution activities) are included along with the utilizing device (combustor, air condition, internal combustion engine, etc.) The system is used to evaluate the role of new technologies and the possibilities of interfuel substitution. Substitution is heavily dependent on the characteristics of utilizing divides, and these devices are represented in the network for all functional end-users such as space heating, air conditioning, and automotive transport. The resource, economic, and environmental impacts of new energy technologies are determined by inserting them into the reference system at appropriate levels and efficiency and recalculating the energy flows, cost, and emissions.

**BESOM model** (32)

The Brookhaven Energy System Optimization Model (BESOM), developed by Hoffman & Cherniavsky (1974, for example), was designed to determine the optimal allocation of resources and conversion technologies to end-uses in the format of
the Reference Energy System. This model focuses on the technical structure of the energy system including the conversion efficiencies and environmental effects of supply and utilizing technologies. It is currently applied at the national level. The model may also be formulated for regional or interregional analysis. A wide range of interfuel substitutability is incorporated in the model, and the load-duration structure of electrical demands may be expressed. The model is quantified for a future point in time. The energy sources compete in the optimization process to serve specific functional demands such as space heat, petrochemicals, and automotive transport. The energy demands to be satisfied and the constraints on specific energy sources and environmental effects are specified exogenously. These may be input as either fixed or price-sensitive constraints. The energy sources provided in the model include a number of alternative central-station electric systems, general-purpose fuels delivered directly to the consumer, and special systems such as solar energy and decentralized electric generators. The optimization may be performed with respect to dollar cost, social cost, environmental effects, resource consumption, or some combination of these factors. The model has been applied to study the optimal implementation made for new energy technologies, break-even costs for new technologies, and strategies of interfuel substitution to conserve scarce resources.

Nordhaus and Mann Model (33)

The Nordhaus model covers five regions of the world and nine time periods and includes all major competing resources. The backstop technology that is introduced provides a long-term substitute of possibly higher cost but almost infinite availability, which can be used to replace scarce or finite resources when they run out. This backstop
technology has been taken to be the nuclear breeder reactor producing electricity and hydrogen for electric and non-electric demands, respectively. The cost and efficiencies of all resources and technologies are reflected in the model along with demand and resource constraints. This model has been used to study the optimal allocation of scarce resources over time and, specifically, to evaluate current fuel production costs and the scarcity cost premium associated with the requirement that a more costly form of energy must be substituted at some future time for any scarce resources that are used at an earlier date.

ETA-Macro Models (34)

Manne's ETA (for Energy Technology Assessment) and ETA-MACRO models were used by several energy research projects, including nuclear Energy Policy Study Group (NEPSG, 1977) and Modeling Resource Group (MRG) of the CONAES study (NAS, 1978, 1979). ETA-MACRO is a single integrated model incorporating resource depletion and transition to new energy technologies, price-induced conservation, and effects of rising energy costs upon physical capital accumulation over time. It has two sub-models: (a) ETA, a process analysis for energy technology assessment; and (b) a macroeconomic growth model allowing interfactor substitution. ETA is concerned with finding equilibrium patterns of development in the energy industry. The supply side is modeled as an LP specification of the alternative technologies, using two forms of energy: electricity (without regard for time variations), and non-electric energy (combining liquid and gases on a Btu basis). The possible technologies for generating electricity are fossil fuel, hydro and others, LWR (light water reactor), LMFBR (liquid metal fast breeder reactor), and an unspecified "backstop technology". Cost constraints,
straints on capacity growth, or other policy constraints (import controls, depletion regulations, etc.) specify the complete supply picture. Demands for the two types of energy are estimated using assumed values of own-elasticities.

By itself, ETA can be used to simulate responses to policy recommendations such as a nuclear moratorium in the US or postponing development of breeder reactors (NEPSG, 1977) or specified imports/depletion controls (NAS, 1980). The macro model uses a four factor aggregate production function (capital (K), labour (L), electricity (E), non-electric energy (N)), with unitary elasticity of substitution between two pairs of factors, K-L and E-N, and a constant elasticity of substitution between these two pairs. A seventy-five year planning horizon, 1975-2050, is employed, divided in sixteen five-year periods. A "putty-clay" model is employed to take into account the short-run and long-run interfactor substitution responses to higher energy prices. This model is optimized intertemporally over the planning period using different discount rates and different values of the elasticity of substitution (between energy inputs and K-L inputs). In the particular policy scenario analyzed for the CONAES study, it is found that a "no nuclear" policy would have negligible macroeconomic effects, but considerable impacts within the energy sector. A higher elasticity of substitution would make the macroeconomic impact even smaller, since energy demand growth is smaller, depletion is slower, and there is more time for a transition to future high cost alternative energy sources.

Analyses of relationships between aggregate economic growth and energy consumption are used to project future energy demands, to compare either historically or cross-sectionally) the variations in aggregate energy intensity, and to analyze the impacts of availability and price of energy inputs at the macroeconomic level. Here we discuss
some of the conceptual issues involved in energy/economic interactions, the relationship between energy consumption and economic growth and projections of aggregate energy demand in developing countries based upon energy/output ratios (assumed or estimated).

Brendt and Wood model (35)

Brendt and Wood (1977) have laid out the conceptual issues involved in aggregate energy economic growth projections. In modelling the relationship between aggregate energy demand and output growth, there are two extreme alternative assumptions that can be employed: one is that output (for example, GNP) and energy demand are related by a fixed or time-trended ratio. In this case only one level of energy demand is consistent with a (exogenously forecast) level of output. This assumption ignores (a) price-induced compositional changes in GNP, i.e. reduction in the utilization rate of the existing capital stock in energy-intensive applications with corresponding unemployment, and increases in utilization rates elsewhere to produce substitute outputs; (b) within the limits of technical possibilities of substitution between existing capital stock and energy inputs, improvement of energy efficiency by retrofitting and similar measures; (c) substitution of other inputs for the capital-energy composite (determined by (b)), again constrained energy efficient capital stock, with the related increase in substitution of other factors (referred to in (c) above. In the very short run it may be justified to ignore (b), (c) and (d), though (a) should not be ignored.

The alternative assumption is that the ratio between energy demand and output level is quite flexible so that different energy demand levels (within a range) can be consistent with a given level of output. This assumption ignores, in
contrast to the points raised in (a) to (d) above, that (e) technical substitution possibilities may be quite limited, depending on the time horizon and particular applications, so that desired compositional changes; substitution between capital, energy, and other inputs; and changes for increased efficiency may not be forthcoming; and (f) even when substitution possibilities are present, some of the substitution is likely to involve new capital equipment with different technological characteristics which, while reducing the energy/other inputs ratio and the total costs of production, may increase the total demand for energy if the output increases are large enough.

Berndt and Wood (1977) also introduce a concept of "utilized capital" - the aggregate of capital and energy - to analyse relationships between this and other inputs in production. Under the separability assumption of capital (K) and labour (L) from energy (E) and other material inputs (M), the K-L substitution does not depend upon E and M, and both K and L substitute equally with E and M. Similarly, the assumption of separability of (K and E) from (L and m) means that the K-E substitution does not depend upon L and M, and that both K and E substitute equally for L and M.

Using this framework, it is clear that to study the question of aggregate energy demand and economic growth empirically, one should study various elasticities of substitutions - $E_K' E_L' E_M'$ as well as $(K, E)L$ and $(K, E)M$. Most of the econometric studies on interfactor substitution that Berndt and Wood have reviewed use historical data prior to energy price increases in early 1970s, and assumed instantaneous adjustment. Except for Hudson-Jorgenson (36), and Hnyilicza (1976), the studies have only used manufacturing sector data, so that the effect of compositional changes in output is not analyzed.
This review gives a satisfactory theoretical background to oil and energy modelling in general covering most of its significant aspects. In the following chapter an attempt to tailor-make an oil model for Kuwait is presented using some of the reviewed model's methodologies but modified to suit the oil sector of Kuwait and its strong interaction with the rest of the economy.
CHAPTER 4

MODELLING THE OIL SECTOR OF KUWAIT
4.1 The Oil Model of Kuwait: Specification

4.2 The Oil Model of Kuwait: Estimation
The development of a comprehensive energy model for the Kuwait oil sector is the main core of this work. Undoubtedly the development of such a model encounters many obstacles and practical constraints. The small size of the country, its severely limited non-oil physical resources and the outward looking attitude of its population arising from its historical attachment to mercantile and maritime activities make Kuwait an ideal example portraying the Absorptive Capacity role in determining the development path of the economy.

The Model

The oil model for Kuwait has three basic characteristics.

a) It is a disaggregative, allocative model, which analyses the oil sector in a disaggregation way by distinguishing between crude and petroleum products. Allocative in the sense that the oil produced is allocated between export demand, either for crude or domestically refined products and domestic uses for refined petroleum products, and disaggregating the demand to domestic and for export purposes.

b) It links the supply and the demand for oil, through the link of oil production determined by reserve's size and the absorptive capacity of the economy to the demand side of crude oil for export purposes and petroleum products either for domestic uses or export purposes.

c) It employs both; crude oil price and domestic prices for petroleum products as instruments for economic policy.
d) It treats the price variables of crude and petroleum products as being endogenous, and determined by the government which set the crude price to change in the case of crude oil prices, and by using gasoline prices as a base to set the other petroleum products' price.

4.1 THE OIL MODEL OF KUWAIT: SPECIFICATION

In the introduction, we emphasise that the methodology used to achieve the objective of the study is based on the 'model building approach'. Employing the absorptive capacity concept, therefore, the suggested oil model is placed within these broad definitions. The model, although not claimed to be a complete optimal model, but accounts for the specific characteristics of the Kuwait economy and its oil sector, uses the limited information available.

The modelling efforts in general and the models applied to the Kuwaiti economy in particular have been the broad guidelines in specifying the model. Modifications were required to adapt the modelling framework to the specific characteristics of Kuwait, as well as the modification needed to reflect the objective of the specified model. It was clear that the role of the oil sector in the Kuwaiti economy with all its peculiarities needs a 'tailor-made' model which reflects the critical role of the sector and its strong link to the development path of the economy on a disaggregation level which adds to the value of the model and allows to account for the different requirements of the demand side of the model (domestic and export purposes).

A quick review of how the oil sector in Kuwait has been treated and analysed in previous modelling efforts for the Kuwaiti economy would be a good departing point to the specification of the model suggested for the analysis of the oil sector in Kuwait.
S. Sanga's macro-economic model for Kuwait and R. Al-Mallakh's model for the absorptive capacity of Kuwait, as well as S. Al Sabah's model for economic development in Kuwait treated the oil sector in an aggregation way, which does not allow the specific feature of the demand-supply interaction to be reflected in the result.

In Sanga's model, the disaggregation appears only in the supply side of the model which was disaggregated into nine sectors: agriculture, mining, manufacturing, construction, water and gas, trade, communication, finance and services, with each sector represented in terms of 'Leontief' production function. This shows that the disaggregation here was only to the supply side of the economy and not the oil sector. The oil sector was treated in aggregation with the demand of oil estimated as an identity which measures the demand for oil as the sum of oil required for export purposes and oil required for domestic consumption. As the oil required for domestic use, it was treated in aggregation as well as a function of lagged variable of demand and gross domestic product.

R. Al-Mallakh treated the oil sector in aggregation too. The demand for oil was represented by total oil export which was considered as being determined by oil production and price. The oil supply or production was specified as a linear function of current and lagged real value added in the mining sector of the economy.

The development model for Kuwait presented by S. Al-Sabah treated the oil sector from the revenues generated point of view. Oil income was expressed in the model as a function of oil produced in aggregation with no details about the supply or demand side of the oil sector, and oil prices were assumed exogenous to the model. The sector was

* The outline of these models is presented in Chapter 2.
considered only as a component of total income together with non-oil income and external assets revenue.

Specification of the Oil Model for Kuwait

In this section, the structure of the Kuwait oil model is presented. Theoretical background of the model is first discussed followed by the specified equations of the proposed model.

Structure of the Oil Sector Model

The structure of the proposed oil model reflects the four major characteristics mentioned earlier, namely; being disaggregative, allocative, including demand and supply of oil, and using the price of crude and petroleum product, endogenously, as instruments for economic policy. This could be simply portrayed as shown in the following diagram.

The Oil Sector Model comprises two sub-models:

(1) The Oil Supply Model
(2) The Oil Demand Model

1. The Oil Supply Model

The main assumption underlying this model is that for a given level of oil reserves, oil supply or production is determined by the level of absorptive capacity. This assumption is expressed in the following:
1.1 Total oil production $Y(1)$ at time $t$ is determined by the desired level of expenditure $Y(2)^*$ at time $t$.

\[ Y(1) = \alpha_1 + \beta_1 Y(2)^* \]

1.2 The desired level of expenditure is generated by a Koyck-type distributed lag model.

\[ Y(2) = \sum_{i=0}^{\infty} \lambda^i Y(2)_{t-i} \]

where; the reduced form equation is given by:

\[ Y(1) = \lambda(1 - \alpha_1) + \beta_1 Y(2) + \beta_2 Y(1)_{-1} \quad 0 \leq \lambda \leq 1 \]

1.3 Total expenditure $Y(2)$ consists of investment in the oil sector $X(1)$, investment in non-oil $X(2)$, private consumption $Y(3)$ and government expenditure $X(3)$.

\[ Y(2) = X(1) + X(2) + Y(3) + X(3) \]

Therefore,

1.4 Oil production, i.e. supply, $Y(1)$ is derived from equation 1.1 and 1.2 as,

\[ Y(1) = \lambda(1 - \alpha_1) + \beta_1 Y(2) + \lambda Y(1)_{-1} \quad 0 \leq \lambda \leq 1 \]

1.5 Oil production estimates are constrained by the level of reserves $X(4)$ during the planning horizon ($H$) in a form of an output/reserve constraint.
The oil supply side of the model is summarised as:

\[ \sum_{i=1}^{H} Y_{(1)}_i \leq X_{(4)} \quad i=0, \ldots, H \]

\[ Y_{(1)} = \beta_1 Y_{(2)} + \beta_2 Y_{(1)}_{-1} \]

\[ Y_{(2)} = X_{(1)} + X_{(2)} + Y_{(3)} + X_{(3)} \]

\[ \sum_{i=1}^{H} Y_{(1)}_i \leq X_{(4)} \]

2. The Oil Demand Model

The theory adopted in specifying this part of the oil model which analyse the uses of the oil production generated from the previous part of the model is that:

Crude oil produced at any point of time is used or allocated for domestic as well as export purposes. The criteria used for this allocation is to fully satisfy export demand either for crude oil or domestically refined petroleum products while constraining the domestic demand for petroleum products to the residual difference between oil supply, i.e. production, and export demand for crude and refined products.

To implement this policy of satisfying export requirements and restricting domestic demand, the policy maker can use two instruments:

a) The export price of crude: which determines the export quantity of the crude.
THE OIL MODEL FOR KUWAIT

Reserves → Oil Production

Absorptive Capacity →

- Export USE
- Domestic USE

Petroleum Products

- Crude Oil
- Petroleum Products

Crude Price

Price of gasoline
b) **Domestic price of gasoline:** which determines, in turn, the domestic consumption of all petroleum products via determining the structure of domestic products' prices.

The export prices of petroleum products are determined in relation to the price of the Marker Crude. The demand functions are all based on Standard Demand Specification.

Therefore, the specification of the Demand module is divided into two parts according to oil uses:

- A) Export use
- B) Domestic uses

### 2A Export Uses

2A-1 The quantity of crude oil allocated for export purposes \( Y_4 \) is assumed to be dependent on the export price of the Kuwaiti crude \( X_5 \)

\[
Y_4 = \alpha_2 + \beta_3 X_5
\]

2A-2 Quantity exported of petroleum products \( Y_5 \) is calculated as the sum of the amount of crude oil needed to produce or refine the exports of the products accounted for in the model such as gasoline, kerosene, gas oil and fuel oil plus exports of products not accounted for in the model \( X_6 \) such as lubricates, etc.

\[
Y_5 = \sum_{i=6}^{9} \delta_i Y_i + X_6
\]

Several specifications using different explanatory variables were used in different mathematical forms to
specify export functions for petroleum products. The specification using own export price and \( X(7) \) and \( X(8) \) fuel oil exports proves to be appropriate for gasoline \( Y(6) \) and kerosene \( Y(7) \) exports:

\[
2A-3 \quad Y(6) = \beta_4 X(7) + \beta_5 Y(9) \\
2A-4 \quad Y(7) = \beta_6 X(8) + \beta_7 Y(9)
\]

Gas oil export quantity \( Y(8) \) was best specified as determined by own export price \( X(9) \) and oil production \( Y(1) \)

\[
2A-5 \quad Y(8) = \beta_8 X(9) + \beta_9 Y(1)
\]

Different specifications have been tested for the export function of fuel oil and most of it proves to be quite insignificant. The best was the function specified fuel oil export \( Y(9) \) as being a function of the export price of the Kuwaiti crude \( X(5) \)

\[
2A-6 \quad Y(9) = \beta_{10} X(5)
\]

2B Domestic Uses

The domestic uses of oil in Kuwait is mainly for the electricity generation sector (48%), the oil sector activities (31%), the transportation and residential sector (21%). The total energy consumption in 1986 reached 74.1 million/bbl of crude equivalent, i.e. about 203,000 bd. The increase in Kuwaiti population with about 3.5% a year, the 1% expected increase in
personal income with the constant price of petroleum products, all these factors are expected to increase total consumption on domestic uses from 74 million/bbl in 1986 to about 96.7 million/bbl of crude equivalent in year 2000.

With this continuous increase in domestic uses, government policies tend towards more conservative policies trying to constrain domestic consumption to the required level of development with the objective of minimising the waste and releasing as much as possible of oil production for export uses either as crude or refined product.

The specification of this part of the Kuwait oil model accounts for this fact and tries to achieve it by constraining the domestic uses, i.e. demand or domestic consumption of petroleum products only to the residual difference between oil supply and export uses or demand for crude and petroleum products using the two instrumental variables; crude price and petroleum product prices.

Domestic uses or demand for petroleum products, represented by the basic products such as gasoline, kerosene, gas oil and fuel oil were specified in different ways, adopting different theories and using different explanatory variables. The following functions for domestic demand were selected:

2B-1 Domestic consumption of gasoline \( Y_{(10)} \) is determined by the difference between its export price and \( X_{(7)} \) domestic price \( X_{(10)} \), and non-oil income \( Y_{(11)} \).

\[
Y_{(10)} = \alpha_3 + \beta_{11} \left[ X_{(7)} - X_{(10)} \right] + \beta_{12} Y_{(11)}
\]
Domestic consumption of Kerosene $Y_{12}$ and gas oil $Y_{13}$ were best specified using their own domestic price $Y_{14}$ and $Y_{15}$ respectively and non-oil income to represent the level of economic activity:

\[ Y_{12} = \alpha_4 + \beta_{13} Y_{14} + \beta_{14} Y_{11} \]

\[ Y_{13} = \alpha_5 + \beta_{15} Y_{15} + \beta_{16} Y_{11} \]

Domestic consumption of fuel oil $Y_{13}$ was assumed to be determined by the level of economic activity represented by income generated from the non-oil sector, as the price variable proves to be quite insignificant.

\[ Y_{16} = \alpha_6 + \beta_{17} Y_{11} \]

As mentioned earlier in this chapter, domestic prices of refined petroleum products and export price of Kuwaiti crude are treated as exogenously determined and is employed in the oil model as instrumental variables to derive government policies.

Domestic price of kerosene $Y_{14}$ and gas oil $Y_{15}$ were specified assuming their dependency to the domestic price of gasoline $X_{10}$, which is used as a base price deriving other petroleum product prices and the ratio between own-export price $X_{8}$ and $X_{9}$ respectively and export price of Kuwaiti crude $X_{5}$.

\[ Y_{14} = \alpha_7 + \beta_{18} X_{10} + \beta_{19} \left[ \frac{X_{8}}{X_{5}} \right] \]

\[ Y_{15} = \alpha_8 + \beta_{20} X_{10} + \beta_{21} \left[ \frac{X_{9}}{X_{5}} \right] \]
To constrain the level of total domestic consumption to the level of crude left for this purpose $Y_{(17)}$ and achieve the policy target of releasing as much as possible crude for export uses, two other specifications were used:

$$2B-6 \sum \alpha_i Y_{i} + X_{(11)} \leq Y_{(17)}$$

where $i=10, 12, 13,$ and $16$

and the crude left for domestic uses, is the difference between crude production and crude exports:

$$Y_{(17)} = Y_{(1)} - Y_{(4)}$$

Having selected the most acceptable specification of the model's equation, the oil model for Kuwait appears as follows:

**The Structure of Kuwait Oil Model**

**Oil Supply equations**

$$Y_{(1)} = \alpha_{1} + \beta_{1} Y^{*}_{(2)}$$

$$Y^{*}_{(2)} = \sum_{i=0}^{\infty} \lambda^{i}_{i} Y_{(2)}_{-1}$$

$$Y_{(2)} = X_{(1)} + X_{(2)} + Y_{(3)} + X_{(3)}$$

$$Y_{(1)} = \lambda_{1} (1 - \alpha_{1}) + \beta_{1} Y_{(2)} + \beta_{2} Y_{(1)}_{-1}$$

**Oil Demand equations**

$$Y_{(4)} = \alpha_{2} + \beta_{3} X_{(5)}$$

$$Y_{(5)} = \sum_{i=6}^{9} \gamma_{i} Y_{i} + X_{(6)}$$
\[ Y(6) = \beta_4 X(7) + \beta_5 Y(9) \]
\[ Y(7) = \beta_6 X(8) + \beta_7 Y(9) \]
\[ Y(8) = \beta_8 X(9) + \beta_9 Y(1) \]
\[ Y(9) = \beta_{10} X(5) \]
\[ Y(10) = \alpha_3 + \beta_{11} X(7) - X(10) + \beta_{12} Y(11) \]
\[ Y(12) = \alpha_4 + \beta_{13} Y(14) + \beta_{14} Y(11) \]
\[ Y(13) = \alpha_5 + \beta_{15} Y(15) + \beta_{16} Y(11) \]
\[ Y(16) = \alpha_6 + \beta_{17} Y(11) \]
\[ Y(14) = \alpha_7 + \beta_{18} X(10) + \beta_{19} \left[ \frac{X(8)}{X(5)} \right] \]
\[ Y(15) = \alpha_8 + \beta_{20} X(10) + \beta_{21} \left[ \frac{X(9)}{X(5)} \right] \]

Constraints

\[ \sum_{i=1}^{H} Y_{i} \leq X_4 \]
\[ \sum \gamma_i Y_{i} + X(11) \leq Y(17) \]

where \( i = 10, 12, 13, \) and \( 16 \)

List of Variables

\[ Y(1) = \text{Oil production} \]
\[ Y^*(2) = \text{Desired level of expenditure} \]
\[ Y(2) = \text{Total expenditure} \]
\( Y(3) \) = Private consumption  
\( Y(4) \) = Crude allocated for export purposes  
\( Y(5) \) = Exports of petroleum products  
\( Y(6) \) = Exports of Gasoline  
\( Y(7) \) = Exports of Kerosine  
\( Y(8) \) = Exports of Gas oil  
\( Y(9) \) = Exports of Fuel Oil  
\( Y(10) \) = Domestic consumption of Gasoline  
\( Y(12) \) = Domestic consumption of Kerosene  
\( Y(13) \) = Domestic consumption of Gas oil  
\( Y(14) \) = Domestic price of Kerosene  
\( Y(15) \) = Domestic price of Gas oil  
\( Y(16) \) = Domestic consumption of Fuel oil  
\( Y(17) \) = Crude left for domestic consumption  
\( X(1) \) = Investment in oil  
\( X(2) \) = Investment in non-oil  
\( X(3) \) = Government expenditure  
\( X(4) \) = Crude oil reserves  
\( X(5) \) = Export price of Kuwaiti crude  
\( X(6) \) = Exports of products not accounted for  
\( X(7) \) = Export price of Gasoline  
\( X(8) \) = Export price of Kerosene  
\( X(9) \) = Export price of Gas oil  
\( X(10) \) = Domestic price of Gasolene  
\( X(11) \) = Domestic consumption of products not accounted for in the model.
4.2 THE OIL MODEL OF KUWAIT: ESTIMATION

Using a sample data from 1970-1983(*), the specified oil model for Kuwait was estimated and the estimated results appeared as follows for the behavioural equations:

1. \[ Y(1) = 0.0424 Y(2) + 0.8807 Y(1) \_1 \]
\[ R^2 = 55.4 \]
\[ F = 330.38 \]
\[ DW = 1.32 \]

2. \[ Y(4) = 1000.93 - 23.316 X(5) \]
\[ R^2 = 83.6 \]
\[ DW = 1.35 \]

3. \[ Y(6) = -0.0128 X(7) + 0.0244 Y(9) \]
\[ DW = 2.23 \]

4. \[ Y(7) = 0.129 X(8) + 0.0521 Y(9) \]
\[ DW = 2.46 \]

5. \[ Y(8) = 0.368 X(9) + 0.0226 Y(1) \]
\[ DW = 1.55 \]

6. \[ Y(9) = 0.441 X(5) \]
\[ DW = 1.58 \]

(* The data used is all listed in the Appendix)
10. \[ Y_{(10)} = 1.79 + 0.0171 \ [X(7) - X(10)] + 0.00216 \ Y_{(11)} \]
\[ (14.86) \quad (2.03) \quad (18.10) \]

\[ R^2 = 99.1 \]
\[ DW = 2.06 \]

\[ Y_{(12)} = 0.29558 - 0.002694 \ Y_{(14)} - 1.075 \ Y_{(11)} \]
\[ (27.53) \quad (-0.94) \quad (-1.61) \]

\[ R^2 = 33.7 \]
\[ DW = 2.14 \]

\[ Y_{(13)} = -1.90 + 0.446 \ Y_{(15)} + 0.00207 \ Y_{(11)} \]
\[ (-3.47) \quad (6.48) \quad (5.36) \]

\[ R^2 = 92.9 \]
\[ DW = 1.73 \]

\[ Y_{(14)} = 0.135 + 0.000194 \ Y_{(11)} \]
\[ (2.74) \quad (4.88) \]

\[ R^2 = 71.7 \]
\[ DW = 1.45 \]

\[ Y_{(14)} = -2.63 + 0.562 \ X_{(10)} + 0.00572 \ [X(8)/X(5)] \]
\[ (-5.30) \quad (19.13) \quad (2.89) \]

\[ R^2 = 97.1 \]
\[ DW = 1.54 \]

\[ Y_{(15)} = 14.5 + 1.33 \ X_{(10)} + 4.01 \ [X(9)/X(5)] \]
\[ (-4.49) \quad (13.47) \quad (2.16) \]

\[ R^2 = 94.1 \]
\[ DW = 1.47 \]
The results reflect the limitations imposed on the sample used and the adopted estimation method. For most variables, data was only available on an annual basis which in turn limited the analysis to using annual time series data. The behavioural equations of the model were estimated using ordinary least squares and two stage least squares and two stage least squares to account for the simultaneous nature of the model.

The reported results represent only a sample of the results. The most striking feature of the results for most equations is the similarity between the results from the alternative estimation method adopted. This may be due to the small size of the sample used for estimation, since the superiority of 2SLS to OLS is conditional on having a large sample as its properties are asymptotic(*).

The similarity of results may be due also to the large time trend element present in most variables which in its turn make the instrumental variables used in the second stage of estimation appear very close to the actual values of the true variables. Consequently, the presented results are restricted to the OLS estimates.

The significance of the explanatory variables in the model's equation is statistically tested with the use of the students t distribution. The degree of total explanatory power of all exogenous variables is measured by $R^2$. Durbin-Watson statistic is calculated to test the degree of autocorrelation in the model as being estimated based on time-series data.

The estimated results of the supply equation in the Kuwait

(*) For a discussion of the properties of the 2SLS estimates see J. Johnston (1972).
oil model appeared quite satisfactory with the sign of the explanatory variable $Y_{(2)}$ being right but with a low magnitude reflecting the early development stage of the economy and the low absorptive capacity measured by the desired level of expenditure. The lagged variable introduced to dynamise the equation prove to be significant with a reasonable magnitude.

The demand side of the model represented by the selected equation appeared reasonably satisfactory particularly from the econometric test of significant as DW tests show. The export equations of the demand level follow the classical assumption which stress the direct effect between export prices and export quantities. The exports of crude oil equation appeared with the wrong sign of the price variable (i.e. negative while it is assumed to be positive). This reflects the expected reaction of the oil market, as the increase in export price emphasised demand level and therefore increased export quantities. Export equations of gasoline, kerosene and gas oil appeared satisfactory from the statistical and econometric tests point of view, with reasonable t-ratios and DW results. The domestic demand equations employ a simple income-price assumption and appeared statistically significant with a reasonable explanatory power and accepted DW results. As for the domestic price equations for kerosene and gas oil, the results looked satisfactory too with a high $R^2$ reflecting a good explanatory power.

The estimated results as such are acceptable and reasonable compared to the small sample size used, and therefore could be used in the application stage which is presented in the following section.

Although most of the equations estimated have adequate results statistically, a significant economic interpretation of the obtained results is truly difficult. The time
series data base for estimation provides short run parameters which could not be used satisfactorily for forecasting purposes, this while the high $R^2$ for most equations implies that most of the variation in the dependent, endogenous variables of the model is explained by the specified equation for each of them. It seems therefore, that an econometric framework standing alone would in fact have a limited role in assisting the analysis of the macroeconomics of Kuwait or in providing a strong, reliable basis for forecasting the role of its oil sector in development plans enhancement. In the following chapter, two application forms for the oil model is suggested using different frameworks though still adopting the same assumption of using the absorptive capacity concept to highlight the interaction between the Kuwaiti oil sector and the rest of the economy.
CHAPTER 5

THE OIL MODEL OF KUWAIT: APPLICATION
5.1 An Income-Expenditure Framework

5.2 A Production Framework
The application stage of the 'Oil Model for Kuwait' is conducted to achieve the main objective of the study namely; linking the oil sector to the overall development plans of the country. In achieving that, the oil model is applied using two frameworks based on the two studies, mentioned earlier, of the Kuwaiti development planning; S. Sanga's and S. Al-Sabah's study. For both applications' framework the 'Oil Income' equation is used as the bridge to link development plans to the oil model. In the following, the two frameworks are presented linked to the oil model to give two alternative comprehensive development models for Kuwait. Given the following list of variables, the application stage of the model appears as follows:

5.1 APPLICATION OF THE OIL MODEL FOR KUWAIT USING A PRODUCTION FRAMEWORK

In this part, the proposed oil model is embedded in a framework derived from Sanga's macroeconomic model for Kuwait.

As described earlier, the model is structured within an equilibrium framework comprising both demand and supply. The supply side, in particular, is represented in terms of neoclassical production functions for the three disaggregated sectors of the economy.

Using the oil income variable as the bridge for the linking objective, the integrated model for Kuwait could be specified in its functional form as follows *

\[ Y(27) = Y(3) + Y(28) + X(3) + Y(29) \]

* The oil model is presented in this framework with the numerical values of the parameters.
\begin{align*}
Y_{(30)} &= Y_{(27)} - Y_{(31)} \\
Y_{(3)} &= -42.6 + 0.35 Y_{(3)} - 1 + 0.521 Y_{(32)} \\
Y_{(32)} &= Y_{(30)} - Y_{(33)} \\
Y_{(28)} &= 43.33 + 0.66 Y_{(28)} - 1 + 0.1 Y_{(29)} - 0.008 Y_{(32)} \\
Y_{(29)} &= -55.3 + 0.134 Y_{(33)} + 0.34 Y_{(28)} - 1 + 0.51 Y_{(29)} - 1 \\
Y_{(33)} &= Y_{(34)} + Y_{(18)} + Y_{(35)} \\
Y_{(35)} &= 0.021 + 0.011 Y_{(27)} \\
Y_{(34)} &= X_{(12)} \ast X_{(13)} - 1 \\
Y_{(36)} &= 34.88 + 0.23 Y_{(27)} + 0.64 Y_{(36)} - 1 \\
Y_{(37)} &= Y_{(38)} + Y_{(39)} \\
Y_{(39)} &= 163.1 + 2299.4 X_{(14)} \\
Y_{(38)} &= X_{(15)} + X_{(16)} \\
Y_{(18)} &= Y_{(1)} \ast X_{(5)} \\
Y_{(1)} &= 0.0424 Y_{(2)} + 0.8807 Y_{(1)} - 1 \\
Y_{(4)} &= 100.93 = 23.316 X_{(5)} \\
Y_{(6)} &= -0.0128 X_{(7)} + 0.0244 Y_{(9)} \\
Y_{(7)} &= 0.129 X_{(8)} + 0.0521 Y_{(9)} \\
Y_{(8)} &= 0.368 X_{(9)} + 0.0226 Y_{(1)} \\
Y_{(9)} &= 0.441 X_{(5)} \\
Y_{(10)} &= 1.79 + 0.0171 \left[ X_{(7)} - X_{(10)} \right] + 0.00216 Y_{(11)}
\end{align*}
\[
Y(12) = 0.29558 - 0.002694 Y(14) - 1.075 Y(11)
\]
\[
Y(13) = 1.90 + 0.446 Y(15) + 0.00207 Y(11)
\]
\[
Y(16) = 0.135 + 0.000194 Y(11)
\]
\[
Y(14) = -2.63 + 0.562 X(10) + 0.00572 \left[ X(8) / X(5) \right].
\]
\[
Y(15) = 14.5 + 1.33 X(10) + 4.01 \left[ X(9) / X(5) \right].
\]
\[
Y(2) = X(1) + X(2) + Y(3) + X(3).
\]
\[
Y(5) = \sum_{i=6}^{9} Y_i + Y_i + X(6).
\]

Conditional Constraints:
\[
\sum_{i=1}^{H} Y(1)_i \leq X(4)
\]
\[
\sum Y_i Y_i + X(11) \leq Y(17)
\]
where \( i = 10, 12, 13 \) and 16

where:
\[
Y(18) = \text{Oil income}
\]
\[
Y(27) = \text{Gross domestic product}
\]
\[
Y(28) = \text{Private investment}
\]
\[
Y(29) = \text{Government investment}
\]
\[
Y(30) = \text{Gross national product}
\]

* The variables of the Kuwait oil model are as defined in 4.1.
\[ Y(31) = \text{Balance of trade} \]
\[ Y(32) = \text{Private income} \]
\[ Y(33) = \text{Government revenues} \]
\[ Y(34) = \text{Government foreign income} \]
\[ Y(35) = \text{Tax income} \]
\[ Y(36) = \text{Imports} \]
\[ Y(37) = \text{Exports} \]
\[ Y(38) = \text{Oil exports value} \]
\[ Y(39) = \text{Non-oil exports value} \]
\[ X(12) = \text{Rate of return on foreign assets} \]
\[ X(13) = \text{Government foreign assets} \]
\[ X(14) = \text{GDP manufacturing/GDP} \]
\[ X(15) = \text{Value of exported crude oil} \]
\[ X(16) = \text{Value of exported product} \]

In this framework, the objective is the same, that is to show the strong link between the oil sector and the rest of the economy, setting a major assumption that oil production is actually part of the productive capacity of the Kuwaiti economy and that its production should be linked to the production of the rest of the economy. Therefore, the production framework employed in Sanga's work is adopted in a disaggregated way where productive capacity of the economy could be seen as including manufacturing production, oil production, non-manufacturing production, and so on. The integrated model in this sense will be realising the linkage objective between the oil sector and the rest of the economy throughout a production framework, as it could be detected from the model.
5.2 APPLICATION OF THE OIL MODEL FOR KUWAIT USING AN INCOME-EXPENDITURE FRAMEWORK

In this section, Al-Sabah development planning model for Kuwait is used. The model is an economy wide model dealing with the entire economy rather than a sectoral or a project-type model. It covers a planning horizon of more than seven years aiming to assist in the design of a framework for development planning.

The model is based basically on the work of Motamen, (37) employing a Keynesian income-expenditure framework. The model is developed in two stages; a macro-model of the Kuwaiti economy, and an objective function. The application of the model to our proposed oil model involves the macro-model only, which follows a Keynesian framework but tailor-made to suit the dualistic nature of the Kuwaiti economy. In other words, a sectoral income-expenditure approach is adopted including a self-evident identity together with one behavioural and two technical/behavioural relationships.

Linking the oil sector model to the development model of Al-Sabah, the integrated model for Kuwait appears as follows:

\[ Y(19) = Y(18) + Y(11) + Y(20) \]
\[ Y(18) = Y(1) * X(5) \]
\[ Y(1) = \beta_1 Y(2) + \beta_2 Y(1)-1 \]
\[ Y(2) = X(1) + X(2) + Y(3) + X(3) \]
\[ Y(4) = \alpha_2 + \beta_3 X(5) \]
\[\begin{align*}
Y(5) &= \frac{9}{i=6} \gamma_i Y_i + X(6) \\
Y(6) &= \beta_4 x(7) + \beta_5 Y(9) \\
Y(7) &= \beta_6 x(8) + \beta_7 Y(9) \\
Y(8) &= \beta_8 x(9) + \beta_9 Y(1) \\
Y(9) &= \beta_{10} x(5) \\
Y(10) &= \alpha_3 + \beta_{11} [x(7) - x(10)] + \beta_{12} Y(11) \\
Y(12) &= \alpha_4 + \beta_{13} Y(14) + \beta_{14} Y(11) \\
Y(13) &= \alpha_5 + \beta_{15} x(15) + \beta_{16} Y(11) \\
Y(16) &= \alpha_6 + \beta_{17} Y(11) \\
Y(14) &= \alpha_7 + \beta_{18} x(10) + \beta_{19} [x(8) / x(5)] \\
Y(15) &= \alpha_8 + \beta_{20} x(10) + \beta_{21} [x(9) / x(5)] \\
Y(11) &= \alpha_9 \gamma(21)_{-1} \gamma(22)_{-1} \\
Y(21) &= \gamma(21)_{-1} + \gamma(23) \\
Y(23) &= \gamma(11) \beta_{24} \gamma(20) \beta_{25} \gamma(23)_{-1} \beta_{26} \\
Y(20) &= \gamma(24)_{-1} \beta_{27} \\
Y(24) &= \gamma(24)_{-1} + \gamma(25) \\
Y(25) &= \gamma(19) - \gamma(23) - \gamma(3) - x(3) \\
Y(3) &= \alpha_{10} \gamma(11) \\
Y(22) &= \gamma(26) + \gamma(27)
\end{align*}\]
\[ Y(22) = Y(26) + Y(27) \]
\[ Y(26) = X(17) + Y(28) \]
\[ Y(27) = Y(27)_1 - \left[ Y(28) - Y(28)_1 \right] + X(13) \]
\[ Y(28) = X(14) + X(15) \]
\[ Y(29) = Y(20) + Y(18) - \left[ \phi_1 Y(11) + \phi_2 Y(23) \right] \]

**Conditional Constraints:**

\[
\sum_{i=1}^{H} Y(1)_i \leq X(4) \\
\sum Y_i + X(11) \leq Y(17) \\
Y(24) \geq \text{Zero}
\]

where:

- \( Y(1) \) = Oil production
- \( Y(2) \) = Total expenditure
- \( Y^*2 \) = Desired level of expenditure
- \( Y(3) \) = Private consumption
- \( Y(4) \) = Crude oil allocated for export purposes
- \( Y(5) \) = Exports of petroleum products
- \( Y(6) \) = Gasoline exports
- \( Y(7) \) = Kerosene exports
- \( Y(9) \) = Fuel oil exports
- \( Y(8) \) = Gas oil exports
\( Y(20) \) = Domestic consumption of gasoline
\( Y(11) \) = Non-oil income
\( Y(12) \) = Domestic consumption of Kerosene
\( Y(14) \) = Domestic price of Kerosene
\( Y(15) \) = Domestic price of gasoil
\( Y(13) \) = Domestic price of Gas oil
\( Y(16) \) = Domestic price of Fuel oil
\( Y(17) \) = Crude left for domestic consumption
\( Y(19) \) = Total income
\( Y(18) \) = Oil income
\( Y(20) \) = External assets revenues
\( Y(21) \) = Capital formation
\( Y(22) \) = Total labour force
\( Y(23) \) = Investment in non-oil
\( Y(24) \) = Stock of external assets
\( Y(25) \) = Balance of payment (surplus or deficit)
\( Y(26) \) = Kuwaiti labour
\( Y(27) \) = Non-labour
\( Y(28) \) = Female Kuwaiti labour
\( Y(29) \) = Import requirements for consumption and investment
\( X(1) \) = Investment in oil sector
\( X(3) \) = Government consumption
\( X(4) \) = Crude reserves
\( X(5) \) = Export price of Kuwait crude
\( \sum \gamma_i y_i \) = Crude needed to produce gasoline, kerosene, gas oil and fuel oil exports
\( X(6) \) = Exports of product not accounted for in the
model such as lubricates

\[ X(7) = \text{Export price of gasoline} \]
\[ X(8) = \text{Export price of Kerosene} \]
\[ X(9) = \text{Export price of Gas oil} \]
\[ X(10) = \text{Domestic price of Gasoline} \]

Crude needed to produce gasoline, Kerosene,

\[ \sum_{i=1}^{n} \gamma_i y_i = \text{Gas oil and Fuel oil for domestic uses} \]

\[ X(11) = \text{Domestic consumption of products not accounted for in the model} \]

\[ X(17) = \text{Mail Kuwaiti labour} \]
\[ X(18) = \text{Work permits} \]
\[ X(19) = \text{Percent of Kuwaiti female labour} \]
\[ X(20) = \text{Participation of Kuwaiti female labour} \]

S. Al-Sabah does not use sophisticated statistical techniques due to the lack of reliable time series data. She applied various methods benefiting from evidence shown in similar studies (39) as well as consulting responsible informed officials and academics.

For example, to estimate the parameters of the non-oil income equation, data for capital stock, labour force in 1974 and non-oil income in 1975 was used to set the equation

\[ Y(11) = \alpha Y(21)_{-1}^{\beta_{22}} Y(22)_{-1}^{\beta_{23}} \]

As:

\[ 643 = \alpha (691)^{\beta_{22}} (289.743)^{\beta_{23}} \]

Then find the values of the parameters which satisfies the
specified equation for 1975. The parameters were assumed to have the values:

\[ \alpha_9 = 1.2 \quad \beta_{22} = 0.7 \quad \text{and} \quad \beta_{23} = 0.3 \]

Therefore:

\[ Y(11) = 1.2 Y(19)_{-1}^{0.7} Y(22)_{-1}^{0.3} \]

The other three behavioural equations in the model were estimated as:

External assets income:

\[ Y(20) = Y(24) \beta_{27} \]

\[ = Y(24)_{-1}^{0.13} \]

Private consumption:

\[ Y(3) = 10 Y(11) \]

\[ = 0.67 Y(11) \]

and Minimum imports requirement:

\[ Y(29) = Y(20) + Y(18) - [\phi_1 Y(11) + \phi_2 Y(23)] \]

\[ = Y(20) + Y(18) - [0.5 Y(11) + 0.8 Y(23)] \]

The model as specified in this application framework aims at linking the oil sector to the development target of the

* The estimated parameters of the original oil model are as presented in the previous chapter and in 5.1.
economy treating the oil sector as endogenous rather than exogenous or determined as quasi endogenous as in Al-Sabah's work. Therefore, the main idea driving the specified oil model still holds, namely, using the absorptive capacity of the economy as a determinant for oil production. This application framework rejects the idea of the oil sector being in isolation of the economy and adopts the concept of backward and forward linkage of the oil sector to the rest of the economy.
CHAPTER 6

ANALYSIS AND CONCLUSION
The alternative application forms of the proposed oil model uses the concept of "Absorptive Capacity" to portray the strong link between the oil sector and the Kuwaiti economy employing a basic assumption which states that:

\[
\text{Oil production} = f(\text{desired expenditure})
\]

and

\[
\text{Desired expenditure} = f(\text{development plans})
\]

therefore, stressing the strong link between the oil sector with its production capacity and the economy's absorption capacity. This is done in the application stage of the model in two forms:

The first linked the sector to a development model on the grounds that the oil sector is the basic generator of income and at the same time its productivity is affected by the desired level of expenditure (the income-expenditure framework).

The second demonstrated the interaction by linking the oil production to the productivity of the other sectors in the Kuwaiti economy employing a production function in a disaggregated base. (A production framework).

The estimated form of the alternative application framework has been presented in the previous chapter. As stated earlier, the objective of the study is to suggest a modelling form for the Kuwaiti oil sector that treats it endogenously, linked to the rest of the economy and not in isolation. The application stage realises this objective and presents the proposed disaggregated oil model within two alternative frameworks stressing in each the strong link between oil production and development in Kuwait.
The application form of the model as such could be used to a further stage assuming the availability and accuracy of the required data.

First, it could be applied for POLICY using an optimization framework to provide satisfactory simulations appropriate for policy requirements employing a rational approach rather than just trial and error. The optimization exercise required structuring an objective function which could, for example, attempt to maximize non-oil income or minimize oil domestic consumption by the end of a planning period. Some instrumental variables could be used to drive the optimization such as investment allocated to non-oil sector, price of crude oil or crude oil production.

The first policy instrument, investment in non-oil, would ensure a balanced development for the economy with its oil and non-oil sectors rather than focusing on the oil sector leaving the rest of the economy. The second and third instrumental policy variables, price or production of crude oil, is to operate an oil income which drives the whole development path in Kuwait. The only difficulty in using the estimated model employing the income-expenditure framework and adopting an optimization technique is the selection of the precise weights for the objective function.

The dynamic optimization use of the oil model will be to reach solutions for optimal trajectories for the instrumental and target variables given some exogenous assumptions, an exercise which is greatly affected by the weights of the objective function. The difficulty in setting the appropriate weights could be overcome if the policy-maker starts by setting views on the trajectories then corrects the path in a way which will automatically adjust the weights of the objective function producing simulations close to what is required.
To use the proposed model for policy, an optimization model, as explained earlier, as in Al-Sabah's work where three models were used, could be employed. In any case, assumptions should be made concerning the percentage growth rate of each exogenous variable as well as the instrumental variables where desired percentage and weights should be assigned. This should be straightforward for any instrumental variables used. The point to be stressed in this respect is that treating the oil income endogenously, throughout the use of oil production or oil prices as instruments, requires a pragmatic approach rather than a modelling one. This could be done by assuming a scenario for crude oil price and defining crude oil production as an instrument. Doing that, a desired scenario for production should be assumed so that the optimization iterations solve for the price of crude oil. If an assumption is made that the desired path for crude oil production is achieved crude production will be considered exogenous and the model could solve for the optimal trajectory for crude oil prices. This will help determine the level of crude oil prices which achieves the desired scenario of crude oil production.

For a country such as Kuwait, a critical objective which could enhance the achievement of other social and political objectives could be to maximize the income generated from the non-oil sector, therefore ensuring a balanced development path for the economy. This does not mean neglecting the oil sector as the major income generator, but this policy will help build up a domestic economic sector which can complement the oil sector during its life and stand as a replacement after its era ends.

The heavy dependence of the economy on oil revenues (95% of foreign earnings, 90% of government revenues, 60% of national income) implies a significant risk in both the short and long term.
The realization of such a policy implies maximization of private consumption expenditure, building up the capital stock in the non-oil sector. A quadratic objective function would be suitable to such an optimization exercise, (38) specified as the weighted sum of squares of the deviations of each variable from some desired path. Optimization runs could be attempted using different weights at each time period assigning zero weight to variables which are unimportant to the adopted objective.

If we let $Y$ stand for income in non-oil domestic sector, the objective function would take the from:

$$\text{OPTIMIZE} = f(Y)_t \quad t=1 \ldots T$$

and the constraints would be represented by the different equations in the macroeconomic model which characterises the constraints of the economy.

Some instrument variables would be required for the policy optimization framework such as private investment and government investment in the non-oil domestic sector which will drive the model towards the objective of maximizing the non-oil domestic sector's income.

Using the oil model in that way provides a powerful framework for long term planning in Kuwait. However, the application of the model in the context of policy is conditional on the availability of reliable data.

A second use of the proposed oil model could be for carrying out various long term PLANNING and FORECASTING options that are open to Kuwait using a simulation technique. For example, various forecasts under various assumptions could be compared to a control situation or scenario for oil price paths. For forecasting purposes, assumptions should be placed regarding the exogenous
variables of the model to generate what is called ex-ante forecasting, i.e. forecasting the future or the behaviour of the model's endogenous variables outside the sample area. The accuracy of such predictions is subject to the stochastic nature of the model, the possible change in the structure of its equations and the assumptions set for the exogenous variables which drive the forecasting exercise.

To use the model in predicting a long term plan, some key endogenous variables or 'targets' have to be determined together with their associated desired growth rates. The achievement of such growth rates is made through some controllable variables called 'instruments'. This could be achieved through the application of the oil model in two ways:

The first by setting a priori certain desirable target values and trying to find the instrument values which help to achieve those targets, making sure that the number of targets must equal the number of instruments.

The second, by setting the maximum values attainable for the target variables and trying to achieve those values throughout the appropriate instruments, which does not require the number of target variables to be equal to the number of instrumental variables.

For the case of Kuwait, the estimated oil model could be applied for forecasting using a dynamic simulation approach*. This is done by selecting some exogenous growth rates for certain variables and investigating their effect on target variables. The policy or instrument variables could be sectoral growth rates for the supply side of the

* Dynamic simulation means obtaining a series of forecasts through time in which only the initial values of lagged endogenous variables and exogenous variables value are used from outside the model.
Kuwaiti economy, oil price, rate of return on foreign assets, oil depletion rate, investment in the oil sector, investment in non-oil sectors, government expenditure, export price of Kuwaiti crude oil and domestic price of gasoline**.

Growth rates for the policy variables could be set by observing past growth rate, although for the case of Kuwait in particular, the sectors have been growing at a very rapid rate between 1973-1980 a case which is unlikely to continue. Another way is to use expectations or other studies figures as well as growth rates of government plans. In all cases, more than one value could be assigned to each variable e.g. low, moderate and high. The lack and inaccuracy of data would stand as an obstacle to adopt a standard case and compare the simulation runs to it, but with the availability of data this could be done yielding much reliable results.

The simulation runs could be checked for certain constraints such as minimum imports requirements, positive balance of payment, non-negative values for population, labour, oil production, level of reserves, crude left for domestic consumptions purposes etc.

Sensitivity analysis would be required to investigate the robustness of the model although it might increase the number of simulations to an unmanageable dimension.

Conclusion

Planning for an adequate production and consumption of oil has always been an important component of national planning in Kuwait. The dramatic fluctuation of oil prices and the

** The use of such variables is explained in Chapter 4 (4.1)
changes in the future energy supply and demand pattern call for a comprehensive approach to oil planning in a country such as Kuwait, in both medium and long term. This requires a review of past and present trends to be able to evaluate and predict future development of oil supply and demand. An integrated planning framework based on the identification of future targets and the procedure of how those targets can be achieved is required. It is necessary, and rather essential, for Kuwait to have a clear view of its crude oil policy options. Thus, an integrated plan becomes a matter of urgency to link the oil sector plan to the development plans of the rest of the economy. This could be achieved through a scenario building methodology, a system of quantitative models or an integrated scenario/modelling system where scenarios help to define the exogenous variables values and the model provides results in terms of value of the endogenous variables which are used to modify the hypothesis made in the scenarios, an approach which has been suggested in this study.

The proposed planning framework for the oil sector in Kuwait adopts the idea that the oil sector cannot be treated in isolation and this was the reason that justified the inclusion and integration of it to macro-economic models. The two adopted applications are useful for the simulation of events and policy decisions and for the assessment of their possible future impacts on a national level, in aggregation and sectorial terms.
APPENDICES

DATA USED

FOR

ESTIMATION
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* Kerosene, Gas/Diesel Oil figures excludes bunkers quantities
### Diesel - Gas Oil

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## EXPORT PRICES OF PETROLEUM PRODUCTS

($ - barrel)

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## PRICE OF MARKER CRUDE OIL

**S.A (Light 34°)**

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**Source**

1) Yearbook of World Energy Statistics. UN 1981.
**EXPORT PRICE OF KUWAIT**

(Crude Oil 31°-31.9°)

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<th>Year</th>
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### EXPORT PRICES OF PETROLEUM PRODUCTS

($ - barrel)

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* Gasoline Prices were calculated as a simple average of premium gasoline and regular gasoline.
### OIL EXPORTS (M.bb)

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(1) Petroleum products exports includes bunkers and exports of LPG.
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## DOMESTIC PRICE OF GASOLINE

**(Fils/Litre)**

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* \[ * = (P_{11} + P_{12})/2 \]

** \[ ** = \frac{\sum_{i=1}^{n} W_{ij} P_{ij}}{\sum_{i=1}^{n} W_{ij}} \]
### Domestic Consumption and Price of Kerosene

#### 1980 - 1983

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## CONSUMPTION AND PRICE OF GAS OIL/DIESEL*

**1970 - 1983**

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* is the sum of power station and transport consumption
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## WEIGHTED PRICE OF GASOLINE

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REFERENCES
REFERENCES


(10) See reference (2) above.


(19) Himona, I., Unpublished PhD, Economics Department, Surrey University, 1986.


(27) Pindyck, R.S., *Higher Energy Prices and the Supply of Natural Gas*, ES & P, 19..?.


(52) Hoffmann, L., Energy Demand in Developing Countries: Approaches to Estimation and Projection, in Workshop on Energy Data for Developing Countries, Vol. 1, 1979.


