THE ROLE OF SAUDI ARABIA IN THE WORLD OIL MARKET

1974-1997

Thesis submitted for the degree of Doctor of Philosophy at the University of Surrey
Department of Economics

by

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The importance of Saudi Arabia in the oil market is evident, but the motivations that contribute to the making of its oil policy are less clear. The primary purpose of this study is to find the framework that accounts for as many facts as possible, and in some cases to determine their influence on Saudi oil policy. This will be done through examining important factors affecting Saudi oil policy in the international market and analysing the oil-related decisions, that were formulated by the Kingdom of Saudi Arabia. These critically important decisions, such as how much oil to produce and at what price, are discussed in the light of views and information from prominent Saudi decision makers, Saudi officials, and international economic analysts, and compared with what has been revealed by the literature and the evidence of the market, to draw a conclusion about the Kingdom's oil policy.

A review of the political structure and the process of oil policy decision making is made to provide an understanding of the process in Kingdom of Saudi Arabia.

Fundamental changes in the world oil market, have been reflected in oil price volatility. Accordingly, a price that takes these changes into account must be found. Therefore, issues and concepts related to the price of oil are discussed and the time series to be included in the model is determined.
By testing hypotheses of the Saudi role in the oil market we have reached a conclusion that its oil policy seeks to maintain oil as a viable long-term source of energy. This comes from the long life expectancy of Saudi oil reserves. Consequently, Saudi Arabia is following an oil policy that optimises the long-term value of its reserves, protects its share of the market and keeps oil prices stable by pursuing an economically rational strategy.

Thus, Saudi Arabia played the role of swing producer between 1975 and 1985 to maintain stable oil prices, and by 1987 it had resorted to market sharing behaviour to maintain its share in the market. These two models were tested through multivariate system analysis using the Johansen procedures and testing of the time series properties such as seasonality, stationarity, exogeneity and cointegration.
I would like to express my deep and sincere gratitude to His Excellency Sheikh Ahmad Zaki Yamani for his generosity with his time and his explanation of decisions taken when he was the Minister of Petroleum (1962-1986) in the Kingdom of Saudi Arabia.

Also I would like to thanks His Excellency Minister of Petroleum in the Kingdom of Saudi Arabia (1986-1995). Sheikh Hisham Nazer, for time and help in allowing me access to information and to interview people in the Ministry. He took the time to answer questions about the period when he was Minister of Petroleum and Mineral resources.

Thanks are due to Mr. Suliman Al-Herbish the Saudi Arabian Governor to OPEC, for his comments and suggestions, Mr. Farouk Al-Husseini the advisor to Saudi Arabia’s Ministry of Petroleum and Mineral Resources from 1957-1996, for his time in providing detailed answers to my questionnaire.

Mr. Ian Seymour the Editor of the Middle East Economic Survey in Cyprus, allowed the use of the MEES files and answered questions that helped in clarifying some aspects of the oil market. I would like to thank him and also Dr. Walid Khaduri for his time and information and for arranging my visit to MEES.
My thanks also for His Excellency Dr. Khlid Al-Angary, the Minister of Higher Education in Saudi Arabia for his support for higher education which enabled many Saudi female students from entering different graduate programs both in Saudi Arabia and abroad.

Thanks goes King Saud University for granting me the scholarship for my graduate study and to the Saudi education attaché in London, Mr. Abdullah Al-Nasser for his concern for students.

Many thanks to all my family especially my mother, brothers Fahad and Nasser and to all friends and colleagues who had helped me to accomplish this work also.

Last but not least, I express my deep gratitude to my husband Professor Saad Al-Rajeh, my children Dalal, Mohammed and Yazeed for their encouragement, support, patience and endurance, during a long and exhausting process. Without them, it would not have been possible to accomplish this work.
I dedicated this work to

My Husband, Professor Saad Al-Rajeh,

and my children Dalal, Mohammed, and Yazeed
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ABBREVIATIONS

S/B  USA Dollar Per Barrel.

ADF  Augmented Dickey Fuller.

AIC  Akaika Information Criterion.

ANS  Alaskan North Slope.

API  American Petroleum Institute.

ARAMCO Arabian American Oil Company.

BLG  Basic Law of Government.

bn  Billion.

BP  British Petroleum.

BTU  British Thermal Unit.

CFD  Contract for Deliveries.

CFTC The Commodity Futures Trading Commission.

CIEC Conference International Economic Co-operation.

COM The Council of Ministers.

DOEEIA Department of Energy’s Energy Information Administration

DF  Dickey Fuller.

ECM  Error Correction Model.

HOQ  Hannan-Quinn Criterion.

fob free on board.[Export valuation].

GCC  Gulf Co-operation Council.

GDP  Gross Domestic Product.

GPW  Gross Product Worth.
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<th>Acronym</th>
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<td>GSP</td>
<td>Government Selling Prices.</td>
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<td>IEA</td>
<td>International Energy Agency.</td>
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<td>IMF</td>
<td>International Monetary Fund.</td>
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<td>IPE</td>
<td>International Petroleum Exchange.</td>
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<td>LR</td>
<td>Likelihood Ratio.</td>
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<td>Ma'aden</td>
<td>Saudi Arabia Minerals Company.</td>
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<td>MEES</td>
<td>Middle East Economic Survey.</td>
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<td>MINPET</td>
<td>Ministry of Petroleum and Minerals.</td>
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<tr>
<td>MMBD</td>
<td>Million Barrels per Day.</td>
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<td>NYMEX</td>
<td>New York Mercantile Exchange.</td>
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<td>OAPEC</td>
<td>Organisation of Arab Petroleum Exporting Countries.</td>
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<td>OLS</td>
<td>Ordinary Least Square.</td>
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<tr>
<td>OPEC</td>
<td>Organisation of Petroleum Exporting Countries.</td>
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<td>Petromin</td>
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<td>PIW</td>
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<td>PP</td>
<td>Phillips and Perron.</td>
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<td>Sabic</td>
<td>Saudi Arabian Basic Industries.</td>
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<td>SAMA</td>
<td>Saudi Arabian Monetary Agency.</td>
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<td>Samarec</td>
<td>Saudi Arabian Marketing &amp; Refining Company.</td>
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<td>SBC</td>
<td>Schwarz Bayesian Criterion.</td>
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<td>SIME</td>
<td>Singapore International Monetary Exchange.</td>
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<td>SPC</td>
<td>Supreme Petroleum Council.</td>
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<td>SPR</td>
<td>Strategic Petroleum Reserve.</td>
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<td>TCU</td>
<td>Target Capacity Utilisation.</td>
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VAR  Vector Auto-regressive.
VECM  Vector Error Correction Model.
WTI  West Texas Intermediate.
CHAPTER 1

INTRODUCTION

This thesis examines the formation of oil policy in Saudi Arabia against the background of changes which have taken place in the world oil market during the last three decades. Saudi oil policy can be subdivided into two strands; long-run objectives such as exploration and the development of additional productive capacity; and short-run such as price and output decisions. The latter are the concern of this study.

The importance of Saudi Arabia in the oil market is evident, but the motivations that contribute to the making of its oil policy are less clear. A number of studies were undertaken to analyse and discuss these motivations and the inherent uncertainty they generate. They attempted to explain the behaviour of OPEC and the Saudi Arabian role within OPEC, by employing the theory of the firm or the theory of exhaustible resources. By so doing, it reduced an extremely complex phenomenon exclusively to its economic dimension. Therefore the primary purpose of this study is to find the framework that accounts for as many factors as possible.

1.1 The Methodology

In order to understand the Saudi oil policy we will go through the following:

1.1.1 Interviews and Institutional Evidence:

A series of interviews with prominent Saudi decision makers and international oil experts were conducted, with the two Petroleum Ministers of the Kingdom of Saudi Arabia; His
Excellency Sheikh Ahmad Zaki Yamani and His Excellency Sheikh Hishem Nazer. Other interviews were with the Deputy Minister for Petroleum Affairs; His Royal Highness Prince AbdulAziz bin Salman Al-Saud; Mr. Suliman Al-Herbish Saudi Arabia's Governor to OPEC who worked in the Ministry of Petroleum and Minerals from 1964. Dr. Majid Al-Moneef, the Economic Consultant in the Ministry and Associate Professor of Economics in King Saud University, who directed me throughout the study. I also had an extensive interview with Mr. Farouk Al-Husseini, the Economic Advisor in the Ministry of Petroleum and Minerals from 1955 up to 1996, who had excellent insight into the oil decision making process during that period. I also benefited from the data I received from the Ministry and from the OPEC Secretariat. The interviews gave me a unique insight into the motivation of oil policy and the constraints which influenced the actual decisions. Throughout the thesis I will relate interviews to published opinions, assessments and views held during the period by industry analysts.

1.1.2 Econometric Analysis:

The primary evidence gathered in the interview process will be compared to economic theory using econometric analysis.

1.2. Plan of the Study

This study consist of nine chapters, the first is the introduction. In chapter 2, we shall review the Saudi petroleum policy making process. The structure of oil policy making which goes through several institutions such as the Ministry of Petroleum, the Supreme Petroleum Council, Aramco and other oil related companies in the Kingdom is discussed and the role of the King and the Council of Ministers in the process is highlighted. Also,
the role of each participant and the interlocking relationships of the different bodies are analysed.

In chapter 3, Saudi Arabia's oil pricing and production decisions are discussed. In this chapter I try to provide a factual basis for the evaluation of the decisions made by Saudi Arabia by reviewing important decisions made during the period and drawing conclusions about each major event and the specific direction of Saudi policy as a whole during the period of the study.

In chapter 4 the relevant literature is reviewed which includes the economic models of OPEC behaviour and the role of Saudi Arabia. The first set of models are the ones that do not address specifically the role of Saudi Arabia such as the monolithic cartel and competitive models. The second set of models are those that address the role of Saudi Arabia, such as the different group cartels, two block cartel, and the swing producer model. Other theories of OPEC behaviour that might apply to Saudi Arabia are discussed namely the target capacity utilisation model, the fiscal constraint model and the property rights model. This is followed by a review of empirical tests that have been done for such models and finally a political interpretation of Saudi Arabia's behaviour in the world oil market. The economic models that describe the behaviour of Saudi Arabia will be evaluated with reference to the institutional evidence. Since Saudi Arabia is a major producer of oil it might use its production and pricing policies to achieve certain objectives. These objectives are discussed in light of each model and the expected oil policy and outcome according to that model. The models are evaluated in order to identify those which are supported by the observed data and the institutional evidence.
Chapter 5, introduces the relevant models to be empirically tested namely the Swing Producer and the Market Sharing models.

In chapter 6, oil prices and production data, which are used for econometric analysis are analysed. There have been fundamental changes in the structure of the world oil market, which are reflected in the oil price data sets. Consequently, to adopt one price series would be impossible. Accordingly, price data which take these changes into account must be found. At times the Saudi Arabian and OPEC marker price (Arabian Light API 34°) was relevant while at others the spot or the netback prices were more relevant in analysing the decision making. After 1987 formula prices tied to some world markers such as Dubai, WTI and Brent have been used to peg the price of Saudi crudes to the different markets. Consequently, issues and concepts related to the price of oil need to be discussed and the time series to be included in the model determined later. The source of all data presented in the study is the Secretariat of OPEC in Vienna and the Ministry of Petroleum and Minerals in the Kingdom of Saudi Arabia, otherwise the source will be mentioned. The differences in production data reporting especially after the introduction of quotas in 1982 is presented. The direct communication vs secondary sources production data is highlighted to illustrate the difficulty of selecting production data.

In chapter 7, the econometric method used in the estimation procedures is explained. Since many economic time series appear to be integrated of order one, when regressing the levels of such series and using the standard econometric procedures this would lead to spurious relationships. Therefore we will test the property of each time series and use the
method which applies to them. There has been a good deal of empirical work done involving cointegration tests and the estimation of models for cointegration variables in dealing with multivariate systems. With the structure and the dynamics of the oil markets, the behaviour of participants, and investigation of the short-run effects could be modelled through the use of the Error Correction Model (ECM). This could predicate the short run behaviour which is used to predict the theory. In testing the long-run relationship Johnaasen procedures will be adopted.

Chapter 8, presents the empirical results of the econometric tests and their interpretation.

Finally, chapter 9 provides a summary and conclusion of the study derived from analysis used along with suggestions for possible future research.
CHAPTER 2

PETROLEUM POLICY MAKING PROCESS

2.1 Introduction

To fully understand the working of Saudi Arabia's oil policy, it is necessary to identify the institutions in the Kingdom that played a principal role in formulating and executing the Saudi oil policy and to analyse the interrelationships between such institutions and their role in designing and carrying out such policies. Hence, it is essential to include the decision-making process as the framework of analysis as a politico-economical regulator of the market.

Because of the lack of written sources about the decision-making process and in order to provide an understanding of the role of the different institutions in that process, I benefited from interviews and discussions with prominent Saudi decision makers and participants in the Ministry of Petroleum. This gave me an insight into the elements and motivation of oil policy, the constraints which influenced actual decisions, and the direction of Saudi policy as a whole during the period.

Saudi Arabia's role in the international oil and market oil decision-making process evolved with developments both in the oil market and in the political structure of the Saudi state. The dominance of the majors in the international oil market throughout the first half
of the century and the negotiations of the concession agreement, as well as the infancy of the new Saudi state all contributed to the shaping of the government role in oil decision-making. However, any explanation of the formal system of the decision process should also include the informal system, such as the relation between the Ministers of Petroleum and the different rulers. To depend only on the official sources will enable us to take into account only the formal framework while the interviews and the discussions within the Ministry, seem to explain the informal framework of the decision-making process.

From the discovery of oil in 1938 until 1973 the oil policy of Saudi Arabia was concerned primarily with extracting the best fiscal terms from the concessionaire companies, such as the 50/50 agreement, expensing royalty, relinquishing concession areas and the participation negotiations. The Saudi government had no active involvement in the production or pricing policy, since those were determined by the international majors on a global basis. Oil pricing and production decisions were to a larger extent in the hands of the Aramco group of majors, which consisted of Exxon, Chevron, Mobil, Texaco.

"Prior to 1973, Saudi oil policy was almost entirely controlled by ARAMCO,...... To the extent that the kingdom did influence oil policy during this period, it consistently urged higher production levels and more exploration in hope of increasing government revenues. Since pricing seemed out of its control, the Kingdom urged production increase as the only way to meet its mounting needs for funds" (Golub, 1985, p 2).

In this period, the only time Saudi Arabia was involved in the international oil market was when it actively helped in the establishment of OPEC in 1960 as a negotiating umbrella to put Saudi Arabia and the other member countries in a stronger position visa
vis the international oil companies operating in those countries. Through OPEC’s royalty expensing initiative in 1965, Saudi Arabia was able to increase the payment by Aramco to the government and then to start the negotiations for participation in oil operations in 1972.

But unlike the other founding members of OPEC, Saudi Arabia's oil sector and policies were less affected by the political and ideological divide that characterised the post WWII decades. The early moves towards nationalisation in Iran and Iraq did not reach Saudi Arabia because of its free market orientation and the market strength of its concessionaire companies, the four owners of Aramco, who were among the seven sisters or “international majors”. Instead, Saudi Arabia favoured participation, as opposed to nationalisation to gain more control of the oil sector and decision-making.

After October 1973, Saudi Arabia's relationship with the oil companies changed and the government took greater control over pricing and production decisions. Higher oil prices after 1973 gave the government higher revenues to carry out development plans and to compensate companies for the later take-over. The transition of power after King Faisal’s death was smooth, with King Khalid assuming the throne, and Prince Fahad becoming the Crown Prince and the first Deputy Prime Minister. Fahad later succeeded to the throne. Thus, the principles of the oil policy remained the same during the three decades from King Faisal to King Fahad.

The structure and conduct of Saudi oil policy and the sophistication of its tools of administration evolved with the political development of the Kingdom. The decision-making process starts from the highest authority “the King” followed by the Council of
Ministers, the Ministry of Petroleum and Mineral Resources, Aramco and other oil
companies and international organisations involved in oil decision-making.

2.2 The Political Structure

To understand the process of petroleum decision-making we need to look at the
political structure of Saudi Arabia. The decision-making process emanates from the
political and administrative structure of the Kingdom. The Council of Ministers (COM), is
the decision-making body which passes legislation, while the role of the Consultative
Council (CC) is advisory and at times to initiate legislation.

2.2.1 The King

The Kingdom of Saudi Arabia came into existence in September 1932 when King
Abdelaziz Bin Saud unified the different regions of the Arabian Peninsula. He ruled
from 1902 until 1953 followed by his sons; King Saud bin AbdelAziz (1953-1964) King

Two important laws that established the King’s authority are the “Council of
Ministers Law” CML of 1958 and its amendments and the “Basic Law of Government”
(BLG) issued in March 1992. Article 44 of BLG identifies the three basic authorities;
judicial, executive and legislative. The legislative and executive authorities are exercised
by the King and the COM. The Consultative Council which was set up in 1993 is granted
authority to discuss, interpret and propose laws. The enactment of the laws is reserved for
COM and the King. The BLG sets the general role for the King.
"The King shall undertake to rule according to the rulings of Islam and shall supervise the application of Shari'ah, the regulations, and the State's general policy as well as the protection and defence of the country (BLG)" 8

The King exercises his authority in two ways: as the president of the Council of Ministers (COM) i.e. Prime Minister and in his capacity as King to whom decisions by the Council must be submitted for approval.

Different Articles in BLG address the role of the King in Council such as Articles 7, 19, and 20 as well as Article 55-62:

"The president of the Council of Ministers directs the general policy of the state, provides direction, co-ordination and co-operation between ministers. He assures consistency and unity in the work of the Council..., orders notification of government agencies of the Council decisions, supervises the Council, Ministers and other government agencies. He supervises the implementation of laws and regulations issued by the Council."

The King as President of the Council of Ministers provides instructions to the ministers for the conduct of their work. According to the 'Basic Law of Governments':

"Ministers and heads of independent authorities shall be responsible before the Prime Minister for their ministries and authorities. (BLG)"

He approves the major petroleum policy decisions, based on the discussions and recommendations of the Ministry of Petroleum and Mineral Resources which is responsible for the management of the country's resources and the co-ordination of the overall strategy.

"The general policy is concerned with handling the Kingdom's internal and external policy, which includes petroleum policy. Also the King as the Prime Minister is assisted in the performance of his duties by members of the Council of Ministers according to the rulings of this law and other laws." 9
2.2.2 The Council of Ministers (COM)

The central administration was established for the first time in Saudi Arabia in the 1930s. Two sets of developments helped to bring this about. First was the discovery of oil in 1938; the Kingdom had a source of income that could cover all of its needs and which had to be managed through a central government. The second was the increasing complexity of government affairs.10

The Council is the most important agent within the structure of the government. It derives its power directly from the King, and has responsibility over any matters concerning the Kingdom. It gives powers to the ministers to oversee foreign and domestic matters under the approval of the President of the Council of Ministers (COM). The law of the Council of Ministers stipulates that:

"No ministry may conclude any contract or agreement with any party except after obtaining the approval of the Council of Ministers thereto."11

The Council of Ministers should issue the regulations, instructions, and rules required to execute and supervise the execution of Royal Orders and Decrees, and the laws and decisions issued by the Council of Ministers direct the implementation of the budget through the Office of the Controller General.12

".... The Council of Ministers shall formulate and supervise the implementation of internal, foreign, financial, economic, educational and defence policies as well as all policies pertaining to the general affairs of the state."13

The King, as the president of the Council of Ministers, has a veto power over the Council's decisions. In addition, the first and second Deputies are responsible to the President of the Council. The Ministers are responsible to the Council of Ministers and its
President. Decisions are to be voted on by the majority of members present. These decisions are not final until sanctioned by His Majesty. According to its bylaws the Council is to meet monthly but the King can call for an extraordinary meeting. However, in recent years, the Council has been meeting weekly. The COM has recently been conducting most of its work through a “general Committee” which sends its recommendations to the Council on most matters for approval. (See figure 3.1)

2.2.3 Consultative Council

The Consultative Council, an advisory body on internal affairs, was created in August 1993, by a Decree from King Fahad, with 60 members appointed by the King. In July 1997 the number of members was increased to 90 to meet the “development requirement” of the Kingdom. The Consultative Council is to assist the government in drafting laws and regulations. The Council discusses what is sent to it by the King and makes its recommendations. It has the ability to initiate laws if 10 members of the Council suggest an idea to the King, which may be pursued further on this request.

"Decisions of the CC shall be submitted to the president of the COM who refers them to the COM to study them. If the COM agrees with CC decision they are issued after the King approves them. If the two councils disagree, the King decides on what he sees fit."

According to Article 15 of the BLG, the Consultative Council expresses its opinion on the general policies of the state that are referred to it by the President of the Council of Ministers, (i.e. the King). In particular, the Council may:

One. Discuss the general plan of economic and social development and voice its opinion on it.

Two. Study laws, regulations, concessions and international treaties and agreements and offer suggestions on them.
Three. Interpret laws.

Four. Discuss annual reports submitted by ministers and other government agencies, and offer suggestions on them.

2.3 The Structure of Oil Policy Decision-making

According to Article 14 of the BLG the state owns most national resources including oil:

".... To which State jurisdiction extends, as well as the revenues accruing there from shall be owned by the State as specified by the law... the law shall specify the means to be employed for the utilisation, protection and development of these resources in a manner conducive to the promotion of the State's interests, security and economy (BLG)."

Since hydrocarbon resources are state owned, the management of such resources, goes through several agencies starting with the Ministry of Petroleum and Mineral Resources, the Supreme Petroleum Council, Petromin and other institutions before it is implemented by the oil companies.

2.3.1 The Ministry of Petroleum and Mineral Resources (MINPET)

The Directorate of Oil and Mining Affairs was established in 1953, as part of the Ministry of Finance with Abdullah Al-Tariki as the General Director. In 1957 it was changed to the Directorate General of Petroleum and Minerals which then became the Ministry of Petroleum and Mineral Resources in December 1960, with Abdullah Al-Tariki as its first Minister.

The role of the Ministry of Petroleum and Mineral Resources (MINPET) is to give advice and recommendations on the petroleum policy of the Kingdom to the King and the
Council of Ministers. Even with the establishment of The Supreme Petroleum Council in 1973, the final word on the decisions on petroleum still needs the King’s approval.

The Ministry does not act as a policy maker, but formulates most of the policy decisions, with Aramco acting in an advisory capacity on technical issues such as exploration, development, gas utilisation, production, etc. After the policy has been formulated in the Ministry and approved by the King or the COM, the Ministry either implements it or directs Aramco to execute it. Even now (1997), with a Minister who has had 47 years of service in Aramco, and was the first Saudi president of Aramco the company still receives orders from the Ministry of Petroleum after each OPEC meeting, regarding the production allocation. For example, with regard to relations with OPEC, the Ministry monitors all the changes in the world, prepares for each OPEC meeting, reads and discusses all oil matters. It then gives advice to the Council of Ministers or directly to the King.

Most oil policy decisions took place in that administrative structure, although at times the personal relation between the King and the Minister of Petroleum and Resources for example relations between King Faisal and the second oil minister Zaki Yamani helped to expedite the implementation of the Ministry recommendations. Following the establishment of the Supreme Petroleum Council a few years before King Faisal’s death, petroleum issues had to go through the Council. During the reign of King Khalid there was direct contact between the Crown Prince, the defacto premier and the Ministers. When King Fahad acceded to the throne, he became more involved in petroleum decisions.²²
According to Minister Hisham Nazer, the decision-making process starts in the Ministry where all the oil and economic information is collected from the market, the oil companies and OPEC. The economic advisors in the Ministry prepare and evaluate different policy options for the Minister who presents the matter to the King directly or to the Council of Ministers. After the King’s approval, the policy would be taken to OPEC and the Minister would contact the King concerning any developments or changes resulting from the negotiations (see Figure 2.1). Furthermore, Nazer added that in some cases he
might call the king several times a day according to what was happening in the meeting of OPEC. On one occasion Zaki Yamani had to leave an OPEC ministerial meeting in December 1976 to consult with the King and Crown Prince Fahad in Jeddah.

*Figure 2.2: The Ministry of Petroleum and Minerals Resources Structure*

Some matters might be taken to the Council of Ministers or to a committee, as occurred in September 1975 when Saudi Arabia, Kuwait and Abu Dhabi called for the lowering of the official price. A committee was formed comprising the Minister of
Planning, the Governor of the Saudi Arabian Monetary Agency, the Minister of Petroleum and the Minister of Trade which made recommendations regarding the lowering of the oil price in 1975. These were taken to the OPEC meeting in December 1975 (MEES, September 1975).

Currently the Ministry of Petroleum and Mineral Resources formulates petroleum policies, such as the agreed production levels (quota) in OPEC, approves budgets for oil operation and capacity expansion, estimates the oil revenue component of the government budget, sends Saudi Aramco foreign downstream ventures suggestions to the government and formulates the domestic energy policy in relation to supply and pricing. The Minister reports to the King and the Council of Ministers. The structure of the Ministry changes with changes of Ministers. The current structure is depicted in Figure 2.2.

### 2.3.2 Supreme Petroleum Council (SPC)

The council was established in May 1973, under the chairmanship of King Fahad who was at that time the second Deputy Prime Minister. The members of the Council, were the Minister of Petroleum and Mineral Resources, the Minister of State for Foreign Affairs, the Minister of State and Head of the Central Planning Organisation, the Minister of State for Finance and National Economy, the Governor of the Saudi Arabian Monetary Agency, the Secretary General of the Council and the Deputy Minister of Petroleum and Mineral Resources.

There are divergent views as to the underlying political reasons for the establishment of the Council. In his semi autobiographical book about Minister Zaki
Yamani, Robinson (1988) attributed the establishment of the Council to the desire of the second deputy Prime Minister, and later King Fahad, to be more involved in the oil decision-making process which was (according to Robinson) monopolised by Yamani who enjoyed the trust of King Faisal. Others attributed it to the strong lobby of the Ministry of Finance to be more involved in the decision-making. But such views ignore political developments pertaining to oil and its relations during the time of the establishment of the Council. After 1967, oil had become highly politicised. Relations between the Saudi government and the four concessionaire companies of Aramco and the resulting fiscal arrangements were undergoing intense changes through the participation negotiations and the Tehran and Tripoli agreement of 1972. The nationalisation of the Iraqi petroleum company in 1972, and rising political tensions in the Middle East after the Arab-Israeli war of 1967, and later in 1973, necessitated reorganising the decision-making process so as to abstain more involvement and input from the Foreign and Finance Ministries. It is hard to imagine how major geopolitical changes, and changes in the oil market could have taken place without parallel changes in the decision-making process.

The Supreme Petroleum Council was a political and strategic necessity. Also, the setting up of supreme bodies was characteristic of the political development of the governing structure, especially during King Faisal’s reign. The supreme Council of Administrative Reform, and the Supreme Council on Education were all established prior to the Supreme Petroleum Council. Supreme Councils on Information, Manpower and Islamic Religious Affairs were then set up as part of that development.
The function of the Council when it was formed was to draw up Saudi Arabia's overall international oil policy and to submit its final recommendations to the King. The Council was formed to take into account political and international relations issues as well as economic concerns. The composition of the Council confirmed that its functions were not limited to purely economic matters since that would not have necessitate the formation of such a top-level body.

The Supreme Council from its establishment in 1973 up to 1977, during which time decisions went through the Council, chaired by then Prince Fahad, and were possibly discussed in the Council of Ministers. Later, though the Council exist, decisions were discussed directly between the Minister and King Fahad. With the establishment of the Saudi Aramco Supreme Council the functions of the Supreme Petroleum Council were reduced further. My interviews with ex Ministers Yamani and Nazer indicated that the SPC has been ineffective for the last 10-15 years at least.

According to the Washington Post, one of the early issues that faced the SPC was to decide appropriate production reductions during the Arab Oil Embargo in October 1973. However, during my interview with Sheikh Yamani (1996) he indicated that the Council was not involved. That decision was taken by a committee made up of the most influential royal family members. Some sources stated that the Council was involved in the take-over of Aramco by the Saudi government in 1976. However, Yamani stated that the negotiations for the take-over had originated before 1973 in the Ministry under the direction and full support of King Faisal.
2.4 SAUDI ARAMCO

The Saudi Arabian Oil Company, also known as Saudi Aramco, was established by Royal Decree in November 1988 as the last step in the take-over by the Saudi government of the assets of the Aramco concessionaire companies, (Chevron, Texaco, Exxon, and Mobil). The original concession started in 1933 with the Standard Oil Company of California (Socal), today's Chevron, and gave the company the right to exploit hydrocarbons in the Eastern province of Saudi Arabia. In 1936, the operation required further marketing facilities which were supplied through the Texas company (Texaco) which had become part owners of the company then called Gasco. By 1938, the lease for the production of oil had been increased to 66 years and extended to cover more Saudi land.

By 1944, the company's name had changed to Arabian American Oil Company (Aramco). In 1948, two other major American oil companies acquired an interest in Aramco: Standard Oil of New Jersey (today's Exxon) and Socony Vacuum (known now as Mobil). The distribution of Aramco ownership between these four major oil companies until 1972 was as follows: Texaco (30%) Chevron (30%), Exxon (30%) and Mobil (10%).

2.4.1 The Development of the Fiscal Relationship Between Aramco and the Saudi Government:

The evolution of relations between the government and Aramco included the following: (a)- The 50/50 profit sharing agreement in 1951. (b)- Royalty expensing. (c)-

a) The 50/50 Profit Sharing Agreement in 1951:

The original concession agreement of 1933, established royalty payments as the government's basic compensation for the company's development of oil resources. Due to the enlargement of the area of the concession and following the introduction of the fifty/fifty profit sharing by Venezuela, Saudi Arabia signed in 1951 the agreement of 50/50 profit sharing with its concessionaire companies whereby, in addition to paying royalties at the rate of 20 cents/B, Aramco was required to pay a 50% income tax on its profit.

b) Royalty Expensing:

OPEC was established in 1960 and its first test of strength was in 1965 to get the companies to agree to include the royalty payment as part of expenses rather than including it in the government share. This led to an increase in the Saudi government take per barrel. During the 1960s Aramco was asked to relinquish some of the undeveloped concession areas. Later on the Saudi government entered into price negotiations with the companies along with other producers in a collective effort leading to the Tehran I and II agreements of 1971 and 1972.

c) Participation Agreement in 1972 and Government Take-Over of Aramco in 1976:

On June 1968 OPEC resolution XVI.90 stated that OPEC members could acquire a reasonable participation in the ownership of the concession-holding companies on the
ground of the principle in international law of changing circumstances. On January 1971 UN resolution XXV 2692 concerning permanent Sovereignty over natural resources was passed. From 1968 onwards the main aim of the Saudi government was to achieve state participation in the upstream and downstream operations of Aramco.

By February 1972 talks on this subject had led only to an offer by the parent companies to concede 50% state participation in the future development of certain unexploited proven reserves within their concession area. The government's rejection of this offer was accompanied by a threat from King Faisal to secure "effective participation" in Aramco's existing operations though unilateral legislative action. (Yamani (1996)). The Aramco parent companies subsequently accepted the principle of minority state participation and entered into negotiations along with the other companies operating in the Gulf countries (except Iran and Iraq who favoured their own nationalisation) with Saudi Arabia representing the governments of the Gulf countries. The negotiations led to the signature in October 1972 of the General Agreement on Participation in respect of oil concessions of the Gulf countries.

The agreement between Saudi Arabia and Aramco, concluded on December 20, 1972, provided for 25% state ownership of the company's upstream producing assets with effect from 1 January 1973. In May 1973, Petromin was designated to sell the government's share of the oil under the General Agreement. Whereas Saudi Arabia's December 1972 agreement envisaged the achievement of 51% majority state control after nine years (i.e. on 1 January 1982), it was clear by mid-1973 that a far more rapid assertion of state control over the operations of concessionaire companies was occurring in other
OPEC countries notably Iraq, Kuwait and Libya. By October 1973, the power of OPEC increased in the oil market and so did the transfer of pricing and production decisions to the producer government. Taxes rose to 85% and royalty to 22%.29

On 10 June 1974, an agreement was signed to increase the level of state participation to 60% with effect from 1 January 1974. In late November 1974, after strong pressure from the Saudi government, the Aramco parent companies accepted the principle of 100% take-over, and in July 1976 they had reached agreement with the government effective from 1 January 1977, on the main conditions under which Aramco’s role was to be changed to that of a contractor, and its concessionaire status terminated. Government ownership of Aramco assets and facilities with Aramco establishing a separate account for the government was accepted. The parent companies then received additional payments which were understood to represent the difference between the net book value of 60% of Aramco’s upstream producing assets in addition to the earlier payment that was paid in August 1973 on the basis of the updated book value of 25% of these assets. Negotiations between the parent companies and the government on most outstanding issues were completed in July 1980. The shareholders of Aramco voted to transfer all its assets to the Saudi government. The final payments were received by the companies in respect of the net book value of their remaining 40% interest in Aramco’s producing assets.

From then on Aramco held the assets on behalf of the government. However, no formal agreement was signed. Aramco continued to operate and manage the oil and gas fields in the Kingdom on behalf of the government until 1988 when Saudi Aramco took over those responsibilities. The situation of the company was rather unusual, for though it
was owned by the government, it was legally registered in Delaware, USA. The assets were owned by the Saudi government, but Aramco was technically owned by the companies and not the Saudi government. This was in spite of the fact that the managerial dividends (divided between the companies according to the percentage of ownership (30%, 30%, 30% 10%)) were paid by the government from January 1976 to the time of the complete ownership in 1988.30

d) Establishing Saudi Aramco in 1988:

In November 1988, the Council of Ministers approved the Articles of Aramco incorporation and a Royal Decree establishing Saudi Aramco was issued on 13 November 1988. All outstanding assets transfer issues between Aramco and subsidiaries and Saudi government were resolved by January 1990.

2.4.2 Decision-Making in Saudi Aramco

The Royal Decree establishing the Saudi Arabian Oil Company (Saudi Aramco) laid out the Articles of incorporation of the company.31 The Articles contain the legal status, spheres of activities, financial and administrative status and the fiscal arrangements with the government.

The articles of incorporation of Saudi Aramco, give it rights to engage in all oil related activities in the Kingdom and abroad (Article IV). Although owned by the government (Article I), the articles specify its commercial nature (Article VI). It sets the capital of the company at 60 billions Saudi Riyal subscribed by the government
represented by its rights and assets which were managed by the Arabian American Oil Company (Article VII).

Articles VII to X specify the company’s funds and finances and the allocation of income. Its funds are to be obtained from the capital reserves, other real property, loans and income. Article (Xb) sets the conduct of the financial obligations of the company:

After deducting all general expenses and costs, including depreciation, in accordance with recognised accounting principles, royalty, income taxes and any other fiscal obligations, the remaining cash funds, after providing for approved capital investments, shall be paid on a current basis to the Saudi Arabian Monetary Agency to the account of the Ministry of Finance and National Economy. The Ministry of Finance and National Economy and the Ministry of Petroleum and Mineral Resources shall agree on the banks through which such funds will be deposited and on the payment dates (Article X(b)).

The articles of incorporation give the company the privileges and rights provided in the old concession agreement of 1933 and all its supplementary documents and agreements (Article XXIV). In addition, the same fiscal and tax arrangements that applied to the concession agreement apply to the company, as well as the subsequent agreement in terms of royalty payments and income tax (Article XI).

Concerning relations with the government, the Articles assign the Ministry of Petroleum to oversee all technical and financial activities of the company and to ensure that the corporation fulfils the government oil policies. It assigns the Bureau of the Controller General the role of reviewing the company’s accounts (Article XXVIII).

The Ministry of Petroleum and Mineral Resources shall oversee all technical activities of the Corporation and shall monitor all its revenues and expenditures. The Ministry of Petroleum and Mineral Resources shall see that the corporation fulfils the
Government's oil policies and that the Corporation continues to conduct its operations in a diligent, efficient and accordance with first-class oil industry practices to insure conservation of the petroleum resources (Article XXVII).

The Articles establish a Supreme Council for the corporation and outline its responsibilities in articles XII to XV to determine the company’s general policy. It consists of ten members appointed by Royal Decree who endorse the five year business plan, and capital investment, appoint the President, appoint the editor and approve the company’s balance sheet and the annual report of the Board of Directors.

Articles XVI-XXI concern the functions of the Board of Directors of the company and its responsibilities, and articles XXII and XXIII set the broad functions of the president of the company. The Board is to discharge the company's functions. It is empowered to nominate the president, approve the corporation’s internal, financial, administrative, technical and personal policies and approve the establishment of corporate subsidiaries. It authorises loans and the investment of the company’s assets, reviews the business plan, and prepares the annual report for submission to the Supreme Council.

a) The Supreme Council of Saudi Aramco:

Chaired by the King, this was established when the Royal Decree was signed in 1988. The Ministry or Aramco would formulate policy towards the international oil market and downstream operations, as well as domestic energy issues. Then it would get the approval of the Council or the King. For example, if Saudi Arabia wanted to invest in the downstream, the subject would be studied by Aramco and the Ministry and then be referred to the Supreme Council or the King for approval. The Council was given
authority to approve the company’s 5-year work plan and 5-year plan for future capital investment, to appoint the president of Saudi Aramco, to approve the board of directors’ annual report, and to decide on all other matters presented by the board.

b) Saudi Aramco’s Board of Directors:

According to the Royal Decree of 1988, the Saudi Aramco board of directors is to be chaired by the Minister of Petroleum and Mineral Resources. The members are nominated by the Minister and appointed by Royal Decree. Four out of the eight members are executives in charge of managing the company, one of whom is the president of the company. The current board has 11 members including two ministers and the rector of King Fahad University for Petroleum and Minerals. The three non Saudis in the Board are the former chairmen of Exxon Corp. and Chevron Corporation and one is the vice-president of a US Bank.

c) Management Structure:

Up to 1996 the company was divided into four business centres, each of which was co-ordinated and directed by an Executive vice-president (Production Operations, Manufacturing Operations, Finance Affairs, and International Operations). Saudi nationals hold nearly all of the company’s management positions. By 1996 a number of changes in Saudi Aramco’s organisational structure were implemented (see Figure 2.3) reducing the management to three business centres headed by Executive Vice Presidents (EVP). These three centres are Production Operations, Manufacturing Operations and Financial Affairs.
Source: Saudi Aramco.
d) Business Plan:

The “Business Plan” of the company articulates its strategies for five years. It is renewed annually followed by a one year back out and the addition of the next year. For example in 1997, the year 2003 is added to the year’s plan and 1997 deleted from it. The Business Plan is comprehensive including world oil outlook, the production capacity, crude oil and gas programme, appropriation and capital expenditure, manpower, internal demand for petroleum products, and the oil price. It is presented to the Executive Committee of the Board before being presented to the Board itself. It is usually revised or amended depending on the business environment of the company.32

2.4.3 The Vertical Integration of Aramco:

Aramco started as an upstream oil company and continued to operate in the Saudi upstream sector until its full acquisition by the government of Saudi Arabia and the establishment of Saudi Aramco. Before that, the only downstream operation it had was the Ras Tannura refinery. All refining and distribution within Saudi Arabia was entrusted with the state government organisation Petromin and later SAMARC. It entered into gas utilisation and delivery in the mid seventies upon a decision by Supreme Petroleum Council to utilise the until then flared associated gas. Aramco was given the mandate to construct and operate the Master Gas System (MGS) in Saudi Arabia and deliver the gas to the users in electricity water desalination and petrochemical industries. The later which was envisioned to be a downstream industry to be undertaken by Petromin, ended up under the Ministry of Industry, and a new state company, SABIC, was set up in 1977 to utilise the gas into its petrochemical derivatives.
After the establishment of Saudi Aramco, it embarked into foreign downstream ventures and started with the joint Venture, Star enterprise, with Texaco with two refineries and distribution outlets in the Southern and Eastern coasts of the US. With a more than 600,000 BD refining capacity and 10,000 distribution outlets. It also acquired a 35% share in South Korea Ssangyong refinery and distribution interests, and continued along the path of vertical integration with the aim of securing market outlets for its crude. The details of Saudi Aramco foreign downstream ventures are detailed in table 2.1:

Table 2.1: Saudi Aramco Foreign Downstream Ventures.

<table>
<thead>
<tr>
<th>Foreign Location</th>
<th>Downstream location</th>
<th>Interests of Saudi Aramco installed capacity</th>
<th>share %</th>
<th>Distribution outlets</th>
<th>Companies</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA (1988)</td>
<td>Delaware City</td>
<td>150</td>
<td>50</td>
<td>10,000</td>
<td>Star Enterprise</td>
</tr>
<tr>
<td></td>
<td>Convent</td>
<td>220</td>
<td>50</td>
<td></td>
<td>Star Enterprise</td>
</tr>
<tr>
<td></td>
<td>Port Arthur</td>
<td>245</td>
<td>50</td>
<td></td>
<td>Star Enterprise</td>
</tr>
<tr>
<td>S.Korea (1991)</td>
<td>Onsan</td>
<td>525</td>
<td>35</td>
<td>1125</td>
<td>Ssangyong</td>
</tr>
<tr>
<td>Philippines</td>
<td>Bataan</td>
<td>165</td>
<td>40</td>
<td>964</td>
<td>Petron</td>
</tr>
<tr>
<td>Greece</td>
<td>Carinthg</td>
<td>100</td>
<td>50</td>
<td>619</td>
<td>M.Hellas</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1405</td>
<td>43.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Table 2.2: Ranking of Top Ten Companies Upstream and Downstream 1996.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Prod. MMBD</th>
<th>Refining Capacity MMBD</th>
<th>product Sales MMBD</th>
<th>Overall Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>S. Aramco</td>
<td>8.797</td>
<td>SHELL</td>
<td>6.316</td>
</tr>
<tr>
<td>2</td>
<td>NIOC (Iran)</td>
<td>3.781</td>
<td>EXXON</td>
<td>4.733</td>
</tr>
<tr>
<td>3</td>
<td>PEMEX (Mexico)</td>
<td>3.277</td>
<td>SINOPEC</td>
<td>3.368</td>
</tr>
<tr>
<td>4</td>
<td>PDV (Venezuela)</td>
<td>2.967</td>
<td>MOBIL</td>
<td>2.899</td>
</tr>
<tr>
<td>5</td>
<td>CNPC (China)</td>
<td>2.828</td>
<td>Mobil</td>
<td>2.297</td>
</tr>
<tr>
<td>6</td>
<td>SHELL (Netherlands)</td>
<td>2.213</td>
<td>S. ARAMCO</td>
<td>1.970</td>
</tr>
<tr>
<td>7</td>
<td>. KPC (Kuwait)</td>
<td>2.100</td>
<td>BP</td>
<td>1.965</td>
</tr>
<tr>
<td>8</td>
<td>EXXON (USA)</td>
<td>1.615</td>
<td>CHEVRON</td>
<td>1.561</td>
</tr>
<tr>
<td>9</td>
<td>SONATRACH (Algeria)</td>
<td>1.345</td>
<td>TEXACO</td>
<td>1.532</td>
</tr>
<tr>
<td>10</td>
<td>NNPC (Nigeria)</td>
<td>1.335</td>
<td>PEMEX</td>
<td>1.481</td>
</tr>
</tbody>
</table>

Note: The overall index combine six criteria: reserve, production of oil, Gas, refining capacity, and product sales.

The big boast in Saudi Aramco's vertical integration drive came in 1993 when it acquired the downstream assets of Petromin owned SAMARC. It acquired 1.7 MMBD of domestic refining capacities and bulk plants with three domestic refineries and three joint ventures refineries with Shell, Mobil and Greek concern but subsequently bought the shares of the Greek interests in Rabigh Refinery. This acquisition increased Saudi Aramco's wholly owned and joint venture refining capacities to 2.0 MMBD with crude access of 3.0 MMBD. This drive downstream increased the integration index of Saudi Aramco to 35 percent and was sixth in refining and seventh in distribution world-wide according to PIW classification. It is ranked the first in upstream and in overall PIW index as shown in Table 2.2:

2.5 Other Saudi Oil-Related Companies and Organisation

There are two other major state companies or organisations. These are the General Petroleum and Mineral Organisation (Petromin) and the Saudi Arabian Basic Industries (Sabic).

2.5.1 General Petroleum & Mineral Organisation (Petromin)

In 1962, the General Petroleum and Mineral Organisation (Petromin) was formed by Royal Decree (25/6/1382 H). The objective of establishing Petromin was

" diversification of the sources of income to avoid the political and economic risks which may result from dependence on one source, namely petroleum."

33
Petromin was established to use petroleum as a base from which to create new industries, and to integrate petroleum activities more into the economy. Since its establishment it has been involved in the development of the petroleum and mining sectors. In the downstream oil sector, it established many refinery and lubricating plants and was the main agent for local distribution of refined products. In the mining sector it set up two gold mining projects. It also set up two oil servicing companies for drilling and physical survey.

Petromin was originally envisaged to be the state oil company. It was entrusted with managing the share of the government in Aramco. But when Saudi Aramco was established as a state oil company the future of Petromin came into question. In order to restructure it along business lines, the refining and distribution interests were separated off between 1989 and 1993, into Saudi Arabian Refinery and Marketing Company (Samarec\(^\text{34}\)) which was initiated by the Petromin Board of Directors and continued to function until the refinery interests of Samarec were transferred to Aramco in September 1993.

Thus, Petromin was reduced to managing the government interests in the Lubricating plants Lubref and Petrolube as well as the mining sector. When the assets of Lubref and Petrolube were transferred to Saudi Aramco in 1996, and the Saudi Arabian Mining Company (Ma’aden) was established in 1997, the future of Petromin became precarious. This prompted the Council of Ministers to ask the Ministry of Petroleum to present its views as to the future role of Petromin after its initial functions were taken up by Aramco and Ma’aden. Until now (April 1998) no official word on the future of Petromin is yet available. But media reports\(^\text{35}\) suggested that the Ministry of Petroleum will recommend
to the COM the dissolution of Petromin and the transfer of its remaining personnel to the Ministry, Aramco or Ma'aden.

2.5.2 Saudi Arabian Basic Industries (Sabic)

Sabic was created by Royal Decree in 1976 and placed under the Ministry of Industry and Electricity. Its objective is to expand the Kingdom’s industrialisation beyond oil. The company is 70% owned by the government, and 30% by the private sector. Sabic is a holding company and involved in the manufacturing and sales of petrochemicals through numerous joint and minority-owned ventures and wholly owned projects. It has marketing subsidiaries in Hong Kong, London, Singapore and Houston. It obtain its feedstocks and energy needs from Aramco in the form of methane, ethane and NGLs and processes them into basic petrochemicals and fertilisers.

2.6 Conclusion

The petroleum decision-making in the Kingdom of Saudi Arabia emanates primarily from the King, the Council of Ministers (COM) and the Ministry of Petroleum and Mineral Resources. Between 1974-1986, the Ministry of Petroleum and Mineral Resources made recommendations to the King or the COM or the Supreme Petroleum Council concerning oil policy, including oil production levels, investments in the petroleum industry, and oil pricing. However, by the late 1980s a greater role had been given to Saudi Aramco, i.e. to suggest policies pertaining & to the oil industry including foreign downstream investments, expanding production capacity and other matters.
Notes

1 See section 2.4.1 for more detail of such concepts.
2 The Saudi Arabian government was not involved in the pricing or level of output that influenced the international prices until the formation of OPEC; however the Agreement between Aramco and the Saudi government in 1954 to increase the price (shown in its sales account for the period 1951-1953) by 24% and to pay additional taxes and the offshore Natural Zone concession agreement with the Japanese Arabian oil company (1957), and the Refinery Licence law of 1960 (See Stevens (1975)).

3 The international majors described as the seven sisters (BP, Chevron, Exxon, Gulf, Mobil Shell and Texaco) who used to have control over the world oil market until the early seventies.
4 See Section about Saudi Aramco in this Chapter.
5 King Faisal's death on 25 March 1975 (See Appendix 4).
6 The history of modern Saudi Arabia begins in the year 1902 when AbdulAziz Bin Saud (known as Ibn Saud in the West) and a group of his followers captured the city of Riyadh. During the next twelve years, AbdulAziz led his people to unite large parts of the Arabian Peninsula. On 22 September 1932, the areas under the control of King Abdul Aziz came to be known as the Kingdom of Saudi Arabia.
7 Article 15 of BLG.
8 "The Basic Law of Government" was issued on 27/8/1412H (March 1992) along with the law of the Consultative Council and the Law of the provinces. (Article 55)
9 Article 56 (BLG).
10 By 1950, three Ministries had been established: Ministry of Foreign Affairs, Ministry of Finance, and the Ministry of Defence. By 1954, other Ministries were established including Interior, Communications, Education, Agriculture, Commerce and Health. The Directorate General of Petroleum and Minerals with other agencies and departments, followed in 1958.
11 According to Article 18 the Council rules issued in 1958 and its amendments. Um al-Qura (Makkah) 16 October 1953. In Soliman(1970). On 9 October 1953, a Royal Decree was issued to set up the Council of Ministers.
12 Article 8 of the Basic Law of the COM system (1953).
15 Until October 1975 the Council of Ministers consisted of fourteen ministers. But it was expanded by a royal decree into 23 ministers. And in August 1995 the number was increased to 29.
17 This information comes from Dr. Othman Al-Rowaf, an Associate Professor of Political Science in King Saud University and a member of the Consultative Council (CC) since July 1997.
18 Article 23 BL of the CC.
19 Article 17 BL of the CC.
20 Article 14 of the BLG.
21 see Appendix 1 and Appendix 4 for more detail.
22 During an interview with former Minister Yamani (12/December/1996) he mentioned that in the OPEC conference (December 1973) in Iran, though he left several messages for King Faisal, he was not able to contact him. Yamani said that he had to agree to the pressure of Iran and other members of OPEC to raise the oil price up to $11.651/B. The King explained that he wanted Yamani to take this decision to raise prices himself.
23 Nazer Interview 14/Feb/1997.
24 This chart was constructed using information from the Ministry’s Public Relations with the help of Dr. Al-Moha the Director of Public Relation and staff in his office. June 1997.
25 Article 18 of the Basic Law of COM.
28 Um al-Qura (Makkah) 3236 16/4/1409 H.
29 See appendix 3 for details of OPEC decisions.
30 The source is interviews with Yamani 12 December 1996 and other people from the Ministry of Petroleum 1995 through 1997.)
31 Articles of Incorporation of the Saudi Arabian Oil Company, Approved by Royal Decree no. M/8 4 Rabi' II 1409 (13 November 1988).
32 Aramco Report (several issues).
33 Petromin Reference. Petromin, MINPET.
34 Samarec has never been an entity. It was set up by the Board of Petromin. No Royal decree was issued for its establishment.
CHAPTER 3

ANALYSIS OF SAUDI ARABIA'S OIL DECISIONS

3.1 Introduction

Having explained the petroleum decision-making process and its agents in the Kingdom of Saudi Arabia, in this chapter I will discuss the decisions taking by Saudi Arabia since 1974, and the motivations behind its behaviour in the world oil market. I will try to provide a factual basis for the evaluation of the decisions made by Saudi Arabia, by reviewing important decisions made in the oil market and analysing them in the light of current literature and the results of the interviews I conducted.

The international oil market has had a long history of cartel behaviour. From the mid-1920s to the early 1970s the oil market was controlled by international companies “the majors” and since the 1970s OPEC has taken over pricing decisions. Within OPEC member countries do not have equal importance. Saudi Arabia, with proven reserves in 1996 of over 261 billion barrels, constituting 25% of the world total, plays a very significant role both in OPEC and in the international oil market. Even more importantly, the Kingdom has had the ability to vary its production from as low as 3.6 MMBD in mid 1985 to as high as 10.3 MMBD in 1981. This range of possible levels, has permitted Saudi Arabia to change its production according to its objectives.
Thus the importance of Saudi Arabia's oil policy has stemmed from three distinctive sources. First the nature of oil as an exhaustible and tangible commodity, where its production is situated in areas outside the major areas of consumption. Second, the nature of the oil market, which has been transformed from the control of international companies to governments of the producer countries via OPEC, and into the more competitive features prevailing now. The third source is the nature of Saudi Arabia's oil resources. It is the largest reserve holder and producer whose oil, unlike other producers, reaches all markets in Europe, North America and the Far East.

Prior to 1973, Saudi Arabia did not have much say in its production and pricing decisions. At times it was able to pressure the companies to increase production, but this depended on the agreement of Aramco owners. However, after the unilateral increase in oil prices by Gulf countries in 1973 and later by OPEC, a profound structural change occurred in the oil market. Saudi Arabia, along with other exporting countries took control of the oil industry upstream and the majors controlled it downstream.

Within the development of the oil market and its relations, Saudi oil policy has gone through four phases:

1. **Price Fixing Regime.** (January 1974- February 1982)

This period is divided into two sub-periods: First, January 1974 up to October 1978, which represented a period of stable oil prices. After the price jump from $3.08/B to $11.65/B in January 1974, it reached $14.6 in November 1978 at an annual rate of increase of 5% only. The rate of real price increase was even
lower if not negative. Second, the disruption of Iran’s oil production in November 1978 and the Iran/Iraq war in October 1981, followed by the start of the decline in oil demand and the increase of non-OPEC supply.

2. **Fixing Ceiling, Quotas and Prices** (March. 1982 up to August 1985)

   This period begins with the allocation of output in March 1982 and continued until the Saudi Arabian adoption of Netback Pricing.

3. **Free Pricing and Production** (September, 1985 to December 1986)

   This period witnessed the oil price collapse and Saudi Arabia’s attempt to regain its market share through netback pricing.

4. **Volume Fixing, Flexible Pricing** (January 1987 to present)

   This period is marked by the use of market-related oil prices with the use of formula prices and fixed quotas. The regime was interrupted from August 1990 to 1992 when a period of flexible prices and volume resulted from the crisis of the Iraqi invasion of Kuwait.

3.2 **Price Fixing Regime: January 1974-February 1982**

   Between 1970 and 1973, due to the increasing demand for OPEC oil, production in Saudi Arabia and other OPEC countries rose dramatically to the extent that Saudi Arabia’s oil production increased fourfold (Table 3.1) from 2.2 MMBD in 1965 to 7.6 MMBD in 1973; an annual rate of increase of 30% (see Figure 3.1).
Table 3.1: Crude Oil Production of Saudi Arabia, 1965-1974 MMBD

<table>
<thead>
<tr>
<th>Year</th>
<th>Production</th>
<th>Year</th>
<th>Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>1965</td>
<td>2.2053</td>
<td>1970</td>
<td>3.7991</td>
</tr>
<tr>
<td>1966</td>
<td>2.6018</td>
<td>1971</td>
<td>4.7689</td>
</tr>
<tr>
<td>1967</td>
<td>2.8050</td>
<td>1972</td>
<td>6.0163</td>
</tr>
<tr>
<td>1968</td>
<td>3.0429</td>
<td>1973</td>
<td>7.5962</td>
</tr>
<tr>
<td>1969</td>
<td>3.2162</td>
<td>1974</td>
<td>8.4797</td>
</tr>
</tbody>
</table>

Source: OPEC Secretariat

Saudi Arabia’s capacity also increased from 4 MMBD in 1968/69 to 9.1 MMBD by the end of 1973. Being the biggest actual and potential producer in OPEC, Saudi Arabia bore the brunt of political pressure from the industrialised countries to lower prices in the aftermath of the first energy crisis in 1973/1974.

3.2.1 Price Stability: January 1974 to October 1978

The price adopted by OPEC in January 1974, represented a compromise between the various tendencies among its member countries. Iran favoured a large price increase from $5.11 in October to $11.65/B. Although Saudi Arabia favoured a modest increase, it went along with the large one but resisted any further price increase. During the May, June and September, OPEC conferences in 1974, Saudi Arabia argued for lower prices due to the declining demand while other members argued for an increase. In August 1974, Saudi Arabia threatened to hold a major crude oil auction but this action was never executed. Finally prices were kept frozen throughout the year.

By the end of 1974, the whole of OPEC had agreed to freeze prices at $11.65/B until the end of September 1975. The industrialised countries were suffering from economic recession. The Saudi Supreme Petroleum Council set a production ceiling on its oil production at 8.5 MMBD. But production declined from an average of 8.5 MMBD...
in 1974 to 7.6 MMBD in January, to 6.3 MMBD in March, and averaged out at 6.83 MMBD throughout 1975, a drop of 16.6% on 1974\(^3\) (see Table 3.2).

**Figure 3.1 :** Crude Oil Production of Saudi Arabia, 1965-1974 MMBD.

![Crude Oil Production Graph](image)

Though refusing to agree to a formal production quota agreement within OPEC, Saudi Arabia went along with a production cutback to help prop up the price of crude in the face of decreasing demand. In February 1975, Saudi Arabia cut its crude oil production to 6.5 MMBD, a fall of 23.5 percent from the 1974 level.

In analysing the behaviour of Saudi Arabia during this period, many studies refer to OPEC as a group of producers who were acting in a monopolistic fashion, with Saudi Arabia acting as the swing producer selling less at the going price in order to protect that price. Thus, the Dominant Producer view of the oil market was first coined during that period. Although OPEC seemed to fix the price, Arab Light was the only crude that was
actually fixed. This meant that Saudi Arabia's crude exports always had to be lifted at the
official selling price. In a glutted market this is generally higher than the market's going
prices thus making more swing in the volume of Saudi output in response to changes in the
oil price (Mabro 1975 among others).

**Table 3.2: Crude Oil Production for OPEC Members in 1974 and 1975.**

<table>
<thead>
<tr>
<th>Country</th>
<th>1973</th>
<th>1974</th>
<th>1975</th>
<th>% Change in Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algeria</td>
<td>1097.3</td>
<td>1008.6</td>
<td>982.6</td>
<td>-08.0</td>
</tr>
<tr>
<td>Gabon</td>
<td>150.2</td>
<td>201.5</td>
<td>223.0</td>
<td>+34.0</td>
</tr>
<tr>
<td>Indonesia</td>
<td>1338.5</td>
<td>1374.5</td>
<td>1306.7</td>
<td>+02.6</td>
</tr>
<tr>
<td>Iran</td>
<td>5860.9</td>
<td>6021.6</td>
<td>5350.1</td>
<td>+02.7</td>
</tr>
<tr>
<td>Iraq</td>
<td>2018.1</td>
<td>1970.6</td>
<td>2261.7</td>
<td>+02.3</td>
</tr>
<tr>
<td>Kuwait</td>
<td>3020.4</td>
<td>2546.1</td>
<td>2084.2</td>
<td>-15.7</td>
</tr>
<tr>
<td>Libya</td>
<td>2174.9</td>
<td>1521.3</td>
<td>1479.8</td>
<td>-30.0</td>
</tr>
<tr>
<td>Nigeria</td>
<td>2054.3</td>
<td>2255.0</td>
<td>1783.2</td>
<td>+09.7</td>
</tr>
<tr>
<td>Qatar</td>
<td>570.3</td>
<td>518.4</td>
<td>437.6</td>
<td>-09.1</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>7596.2</td>
<td>8479.7</td>
<td>7075.4</td>
<td>+11.6</td>
</tr>
<tr>
<td>UAE</td>
<td>1532.6</td>
<td>1678.6</td>
<td>1663.6</td>
<td>+09.5</td>
</tr>
<tr>
<td>Venezuela</td>
<td>3366.0</td>
<td>2976.3</td>
<td>2346.2</td>
<td>-11.5</td>
</tr>
<tr>
<td>Total</td>
<td>30779.7</td>
<td>30729.2</td>
<td>26994.1</td>
<td>+0.16</td>
</tr>
</tbody>
</table>


This view was shared by Adelman who explained the changes in the oil market as a
result of OPEC acting as a cartel and Saudi Arabia as "the restrictor of the last resort" (Adelman 1976, p.381). However, Gately (1984) explained such behaviour as corresponding to a target revenue model where the cut in output would lead to an increase in OPEC members' revenue resulting from the higher prices.

Others argued that since Saudi Arabia was the largest exporter with the biggest financial surplus, it always emphasised that it was not cutting production deliberately as part of any preconceived plan, but was only allowing it to fall in response to the neutral trend of market forces (Seymour 1980). This was certainly true as far as it went, but the
very fact that Saudi Arabia allowed, and perhaps encouraged, such a steep drop in export lifting by the Aramco companies was a very positive action in support of OPEC.

According to the recollection of Mr. Farouk Al-Husseini⁶ it was not only Saudi Arabia who reacted to the decline in world demand, other OPEC producers reduced their production in 1975 as well. If we look to the data, while OPEC production in 1975 declined by 3.5 MMBD (12.2%), Saudi Arabia’s production declined by 1.4043 (16.6%). All members of OPEC decreased their output except Iraq and Gabon (see Table 3.2). However, Saudi Arabia lowered its production by a higher proportion than others, where its share of OPEC production decline was 39.3% while its share of total OPEC production amounted to 27.6%. Al-Husseini added that while Saudi Arabia sold at the price of the fixed Arabian Light marker crude, other individual members could change their oil prices according to differentials, and were able to change their differentials according to market conditions. They would lower the prices by increasing differentials to increase sales of their output. For example, Libyan exports fell from 1.95 MMBD in May 1974 to 0.95 MMBD in November of that year (50%). Later Libyan exports rose from 1.14 MMBD in May 1975 to 1.52 MMBD and 2.10 MMBD in June. Abu Dhabi’s oil exports fell from 1.22 MMBD in December 1974 to 0.75 MMBD in February 1975 and then started to climb fast, reaching 1.83 MMBD in July 1975. Iraq enjoyed a steady growth in exports through the whole period. During the earlier period exports fell due to the decline in demand. Later on, members of OPEC adjusted their differentials to the lower price of their own crude resulting in an increase of their output.
Therefore, the first practical test of the cartel behaviour after the 1973/74 power shift came in 1975 when Saudi Arabia’s exports were subjected to fluctuations that resulted from changes in relative prices. The decline of Saudi Arabia’s output came partially from the actions of other OPEC producers as well as the declining aggregate demand for OPEC oil in absolute terms. Since prices were fixed, the decline in demand would ultimately affect the output of the cartel. The decline in output depended on the flexibility in adjusting differentials and other marketing aspects.

Figure 3.2: World Oil Consumption and Saudi Oil Production (Million tonnes) 1965-1994.

As to Saudi Arabia’s production behaviour then, it is clear now that the 8.5 MMBD allowable ceiling set by the Saudi government was an annual average, so that initial shortfalls could be made up during the year if market conditions permitted; provided that
the average for the whole year did not exceed 8.5 MMBD. Subject to this ceiling Aramco
parent companies were left to programme their lifting of Saudi crude according to
prevailing market demand, without government intervention. Therefore, with world-wide
recession at the time, consumption of oil fell as consumers began to respond to higher
prices. Thus, demand for OPEC oil fell from 30.7 MMBD in 1974 to 27.6 MMBD in
1975. During this period, the production of Saudi Arabia declined from an average of 8.5

Although the decline in Saudi production averaged 1.5 MMBD of the 3.7 MMBD
OPEC production decline in 1975 over 1974, this decline was voluntary, Saudi Arabia
opposed any programmed cut in production to raise the price of oil. In the XLIII
Ministerial Conference of OPEC on 26 February 1975, other members (notably Algeria,
Iraq and Libya) proposed that OPEC members cut back their oil production to deal with the
falling oil demand in the main consuming countries (see Figure 3.2). Saudi Arabia refused
such a proposal and accordingly any production programming as a policy of increasing oil
prices. It even campaigned with no avail within OPEC to bring about a reduction in prices.
The oil price stayed stable throughout 1974, until 1976. The reasoning behind this price
behaviour varied. Adelman (1995) argued that Saudi Arabia wanted to increase its share in
the market especially at times of declining demand. It was the only country abiding by the
reference marker price of Arab Light. Saudi Arabia's official stand was that higher prices
would reduce demand and weaken OPEC's position. But Saudi Action in 1975 of
lowering production contradicted this hypothesis of increasing share. If Saudi Arabia
controlled output instead of fixing prices the very marked monthly variations in demand
that have characterised the world petroleum markets since mid 1974 would have led to very unstable prices.

A year later during the OPEC conference in Doha, Qatar in December 1976, Saudi Arabia together with the UAE, decided to hold their price increase for the whole year of 1977 to 5% as against the majority decision of the other 11 OPEC members in favour of a 10% rise as of January followed by a 5%, increase in July of 1977. The OPEC press release recorded the first public split:

"Eleven countries, within the conference, decided to increase the price of $11.51 per barrel (former price of the Marker crude) to $12.70 per barrel as of January 1st 1977, and to $13.30 as of July 1st 1977. The price of all other crude shall be increased by the same amounts. Saudi Arabia and United Arab Emirates decided to raise their prices by five per cent only." (OPEC, 1996)

In order to back up their decision, Saudi Arabia increased its production from an average of 8.7 MMBD in 1976 to an average of 9.4 MMBD in 1977 the production profile for 1977 is shown in Table 3.3 where production increases from 8.5 MMBD and a maximum for the year in April at 10.2 MMBD but Saudi Arabia was not able to raise its production to the full capacity for technical reasons, due to a series of fires in some facilities.

But by mid 1977, OPEC met again and Saudi Arabia agreed to raise its price by 5% in return for the other members accepting of a price freeze at the existing level instead of implementing another increase of 5%. The reasons for this behaviour are varied. Adelman (1978) explained the Saudi Arabian behaviour as an attempt to defend its market share. The official Saudi position was to promote world wide economic recovery and to
combat world inflation. Others say the behaviour helped to strengthen the Saudi position at the then North-South dialogue. The ministerial meeting of the Paris Conference on International Economic Co-operation (CIEC) was held on 15 December 1976. This indicates that Saudi Arabia could use the price of oil as a bargaining tool in other negotiations and not just as a market mechanism in order to influence the negotiations in favour of producing countries.

Table 3.3: Saudi Crude Oil Production and the Spot Oil Prices for Arabian Light API 34° from January 1977 to December 1977. (Thousands Barrels per Day).

<table>
<thead>
<tr>
<th>Month</th>
<th>Saudi production</th>
<th>Arabian Light Price</th>
<th>Month</th>
<th>Saudi production</th>
<th>Arabian Light Price</th>
<th>Month</th>
<th>Saudi production</th>
<th>Arabian Light Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan.</td>
<td>8482.2</td>
<td>12.235</td>
<td>May.</td>
<td>8459.6</td>
<td>12.610</td>
<td>Sep.</td>
<td>8682.0</td>
<td>12.605</td>
</tr>
<tr>
<td>Feb.</td>
<td>9616.0</td>
<td>12.600</td>
<td>Jun.</td>
<td>9555.4</td>
<td>12.612</td>
<td>Oct.</td>
<td>8648.1</td>
<td>12.612</td>
</tr>
<tr>
<td>Mar.</td>
<td>9840.8</td>
<td>12.543</td>
<td>Jul.</td>
<td>9795.1</td>
<td>12.666</td>
<td>Nov.</td>
<td>8930.6</td>
<td>12.670</td>
</tr>
<tr>
<td>Apr.</td>
<td>10207.3</td>
<td>12.562</td>
<td>Aug.</td>
<td>8623.9</td>
<td>12.652</td>
<td>Dec.</td>
<td>9616.7</td>
<td>12.683</td>
</tr>
</tbody>
</table>

Source: OPEC Secretariat.

But while members of OPEC requested a higher official price of the marker they insisted on differentials to reduce their own market prices. As a consequence, prices for the 34° API Arabian Light marker crude remained unchanged. Thus other members of OPEC had the flexibility to reduce the price of their crude, while Saudi Arabia had to sell at the official price of OPEC even with the decline in demand for its oil.

The price unification of 1977 was the result of the following factors; the capacity of the Saudi production facilities could not reach the 11.8 MMBD that Saudi Arabia was hoping to utilise in backing up its decision on low prices; an accident in the facilities resulting from a spell of extremely bad weather prevented physical access to the terminals and the fire in the oil facilities mentioned earlier led the Saudis to agree to the 5%
increase. Moreover, Saudi production could not be sustained at the high level of 10.2 MMBD reached in April 1977. Therefore, Saudi Arabia recognised that by itself it could not influence crude prices, because of its limited sustainable oil production capacity.

3.2.2 The Crisis Period: November 1978- February 1982

Later in 1978, Iran’s production began to fall rapidly as a result of revolutionary turmoil and strikes by the workers in the oil fields. From October to December 1978, the spot oil price jumped from about $13/B to nearly $15/B (see Table 3.4). Saudi Arabia’s production increased from 9.2 MMBD in October 1978 to 10.4 MMBD in December of that year (see Table 3.5).

Table 3.4: Oil Monthly Average Official Prices and Spot Prices $/B for the Light crude (Arabian Light API 34).

<table>
<thead>
<tr>
<th>Month</th>
<th>Official</th>
<th>Spot</th>
<th>Diff</th>
<th>Month</th>
<th>Official</th>
<th>Spot</th>
<th>Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct. 78</td>
<td>12.704</td>
<td>13.122</td>
<td>-0.418</td>
<td>Jul. 80</td>
<td>28.000</td>
<td>34.162</td>
<td>-06.162</td>
</tr>
<tr>
<td>Nov. 78</td>
<td>12.704</td>
<td>14.650</td>
<td>-01.946</td>
<td>Aug. 80</td>
<td>30.000</td>
<td>31.387</td>
<td>-01.387</td>
</tr>
<tr>
<td>Feb. 79</td>
<td>13.339</td>
<td>23.166</td>
<td>-09.800</td>
<td>Nov. 80</td>
<td>30.000</td>
<td>41.312</td>
<td>-11.312</td>
</tr>
<tr>
<td>Apr. 79</td>
<td>14.546</td>
<td>21.250</td>
<td>-06.704</td>
<td>Jan. 81</td>
<td>32.000</td>
<td>38.850</td>
<td>-06.850</td>
</tr>
<tr>
<td>May 79</td>
<td>14.546</td>
<td>29.250</td>
<td>-14.704</td>
<td>Feb. 81</td>
<td>32.000</td>
<td>36.800</td>
<td>-01.800</td>
</tr>
<tr>
<td>June 79</td>
<td>18.000</td>
<td>35.000</td>
<td>-17.000</td>
<td>Mar. 81</td>
<td>32.000</td>
<td>36.680</td>
<td>-04.680</td>
</tr>
<tr>
<td>July 79</td>
<td>18.000</td>
<td>33.000</td>
<td>-15.000</td>
<td>Apr. 81</td>
<td>32.000</td>
<td>35.437</td>
<td>-03.440</td>
</tr>
<tr>
<td>Aug. 79</td>
<td>18.000</td>
<td>31.125</td>
<td>-13.125</td>
<td>May. 81</td>
<td>32.000</td>
<td>33.312</td>
<td>-01.310</td>
</tr>
<tr>
<td>Sept. 79</td>
<td>18.000</td>
<td>35.000</td>
<td>-17.000</td>
<td>Jun. 81</td>
<td>32.000</td>
<td>31.750</td>
<td>+00.250</td>
</tr>
<tr>
<td>Oct. 79</td>
<td>18.000</td>
<td>38.000</td>
<td>-20.000</td>
<td>Jul. 81</td>
<td>32.000</td>
<td>31.783</td>
<td>+00.217</td>
</tr>
<tr>
<td>Nov. 79</td>
<td>24.000</td>
<td>41.166</td>
<td>-17.166</td>
<td>Aug. 81</td>
<td>32.000</td>
<td>32.125</td>
<td>-00.125</td>
</tr>
<tr>
<td>Dec. 79</td>
<td>24.000</td>
<td>41.000</td>
<td>-17.000</td>
<td>Sept. 81</td>
<td>32.000</td>
<td>32.030</td>
<td>-00.035</td>
</tr>
<tr>
<td>Jan. 80</td>
<td>26.000</td>
<td>36.700</td>
<td>-10.700</td>
<td>Oct. 81</td>
<td>32.000</td>
<td>32.912</td>
<td>-00.912</td>
</tr>
<tr>
<td>Feb. 80</td>
<td>26.000</td>
<td>36.000</td>
<td>-10.000</td>
<td>Nov. 81</td>
<td>34.000</td>
<td>34.312</td>
<td>-00.312</td>
</tr>
<tr>
<td>Mar. 80</td>
<td>26.000</td>
<td>35.937</td>
<td>-09.937</td>
<td>Dec. 81</td>
<td>34.000</td>
<td>34.160</td>
<td>-00.160</td>
</tr>
<tr>
<td>Apr. 80</td>
<td>28.000</td>
<td>35.855</td>
<td>-07.855</td>
<td>Jan. 82</td>
<td>34.000</td>
<td>34.062</td>
<td>-00.062</td>
</tr>
<tr>
<td>May 80</td>
<td>28.000</td>
<td>36.212</td>
<td>-08.212</td>
<td>Feb. 82</td>
<td>34.000</td>
<td>30.112</td>
<td>+03.88</td>
</tr>
<tr>
<td>Jun. 80</td>
<td>28.000</td>
<td>35.416</td>
<td>-07.416</td>
<td>Mar. 82</td>
<td>29.000</td>
<td>28.470</td>
<td>+05.30</td>
</tr>
</tbody>
</table>

Source: OPEC Secretariat
When OPEC met in Abu Dhabi in December 1978, an agreement was reached for the first time on a strategy of gradually increasing the price with quarterly adjustments throughout 1979 that would have resulted in $14.55/B price for Arabian Light by the year's end. If this had been carried out, the price would have increased gradually at the rate of inflation. However, the spot price witnessed a sharp increase as the effect of the first production cuts by Iran began to be felt.

Saudi Arabia's oil exports for the whole year of 1978 averaged 7.71 MMBD. It registered an all-time record of 10.4 MMBD in December 1978. Since Iran's production fell to almost zero in January 1979 Saudi Arabia decided to raise the self imposed production ceiling on Aramco by 1 million BD from the 8.5 MMBD to 9.5 MMBD on a temporary basis applicable for the first quarter of 1979.

Table 3.5: Saudi Arabia Crude Oil Production for from October 1978 to February 1982

<table>
<thead>
<tr>
<th>Month</th>
<th>production</th>
<th>Month</th>
<th>production</th>
<th>Month</th>
<th>production</th>
<th>Month</th>
<th>prod</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct. 78</td>
<td>9323.2</td>
<td>Oct. 79</td>
<td>9726.5</td>
<td>Oct. 80</td>
<td>10533.3</td>
<td>Oct. 81</td>
<td>9684.7</td>
</tr>
<tr>
<td>Nov. 78</td>
<td>10272.7</td>
<td>Nov 79</td>
<td>9803.5</td>
<td>Nov. 80</td>
<td>10333.9</td>
<td>Nov. 81</td>
<td>8621.1</td>
</tr>
<tr>
<td>Dec. 78</td>
<td>10409.9</td>
<td>Dec. 79</td>
<td>9783.9</td>
<td>Dec. 80</td>
<td>10229.1</td>
<td>Dec. 81</td>
<td>8661.5</td>
</tr>
<tr>
<td>Jan. 79</td>
<td>9799.4</td>
<td>Jan. 80</td>
<td>9739.9</td>
<td>Jan. 81</td>
<td>10255.3</td>
<td>Jan. 82</td>
<td>8668.4</td>
</tr>
<tr>
<td>Feb. 79</td>
<td>9781.0</td>
<td>Feb. 80</td>
<td>9763.3</td>
<td>Feb. 81</td>
<td>10164.7</td>
<td>Feb. 82</td>
<td>8708.6</td>
</tr>
<tr>
<td>Mar. 79</td>
<td>9779.0</td>
<td>Mar. 80</td>
<td>9781.0</td>
<td>Mar. 81</td>
<td>9931.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apr. 79</td>
<td>8766.6</td>
<td>Apr. 80</td>
<td>9738.9</td>
<td>Apr. 81</td>
<td>10192.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May 79</td>
<td>8766.6</td>
<td>May 80</td>
<td>9737.6</td>
<td>May 81</td>
<td>10157.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>June 79</td>
<td>8802.7</td>
<td>Jun. 80</td>
<td>9750.5</td>
<td>Jun. 81</td>
<td>10165.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jul. 79</td>
<td>9796.5</td>
<td>Jul. 80</td>
<td>9739.6</td>
<td>Jul. 81</td>
<td>10251.1</td>
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<td>Aug. 80</td>
<td>9738.8</td>
<td>Aug. 81</td>
<td>10446.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sept. 79</td>
<td>9778.1</td>
<td>Sept. 80</td>
<td>9709.1</td>
<td>Sept. 81</td>
<td>9164.6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: OPEC Secretariat

In mid-March 1979 Saudi Arabia announced that production was immediately being reduced to a ceiling of 8.5 MMBD for the second quarter. This required Aramco to cut below 8.5 MMBD in order to reach the quarterly average. As a consequence the
cancellation of some contracts was necessary, which drove customers for Saudi oil, to turn to the spot market. Between January and February 1979, spot prices of Arabian Light rose from about $17.5/B to over $23/B. In early April, Saudi Arabia announced that production would continue at 8.5 MMBD for the second quarter of 1979, but the spot prices climbed to reach $29/B in May and $35/B in June. Uncertainty concerning Iran's plans for future production led consumers to try to stockpile oil, setting off speculative price increases on the spot market. In April-June, Arabian Light spot prices increased from $21/B to $35/B and in September - November from $35/B to $41/B. Peaking in November 1979, the Arabian Light spot price was a full $17/B above its official price.

This period is marked by the following events; from November 1978 to January 1979 the increase of Saudi production; and from 21 January 1979 to 9 April 1979, the increase of the ceiling of Saudi production from 8.5 MMBD to 9.5 MMBD; from April 10, 1979 to 4 July 1979, the decline of Saudi production to the previous 8.5 MMBD, the Iraq/Iran war in October 1980; and finally, the increase of the official OPEC price to $34/B in November 1981, until March 1982, when OPEC started production programming. Table 3.4 gives Saudi crude production for the corresponding months.

The Iranian oil disruption and the first increase in Saudi Arabian oil production up to the maximum capacity in December 1978, was followed by a production cut on 20 January 1979, after the announcement to increase the production ceiling for the quarter to an average of 9.5 MMBD, and the announcement in March 1979, to go back to the ceiling of 8.5 MMBD. This led to an increase in the spot prices and different explanations of the Saudis' action.
Some critics maintained that the Saudis actively sought higher prices. According to this view, if Saudi Arabia wanted to keep the lid on prices, it could have maintained its production at 9.5 MMBD which would have maintained the pressure on the upper-tier price producers. The cutback by Saudi Arabia was understood to have kept the market tight and let the pricing initiative remain with OPEC members (PIW 4.16/1979).

Adelman (1982) also held the view that Saudi Arabia favoured higher prices regardless of its pronouncements. He noted that

"governments, like stockholders, are always in pursuit of more money for many purposes some of which they do not know themselves. However, the more money they have the better, whatever they want to buy, whether it be investment, consumption, influence, armaments or anything else" (Adelman(1982).

Saudi Arabia at that time was criticised by the other members of OPEC and by the new regime in Iran for 'over producing'. In an attempt to win back some Arab friends, gain the support of the new regime in Iran and defend itself as serving both its national interest and the interest of OPEC members, at a time when Arabs were very unhappy with the direction of American politics, Saudi Arabia cut its oil production. Quandt (1982) emphasised this political dimension to Saudi Arabia's production decisions during that period.

Another political reason for the production cut in the first quarter of 1979 was attributed to the Kingdom's dissatisfaction with US policies in the Middle East at that time, resulting in the Camp-David accords and Egyptian - Israeli peace treaty which was
opposed by the other Arab governments including Saudi Arabia. Furthermore, the
American reaction to the Saudi cut in January was so severe that the US press ran articles
criticising Saudi Arabia. Relations between the two countries seemed to have deteriorated
during the period to the point that Saudi Arabia asked the US ambassador to leave Riyadh.

Golub (1985) reasoned that the change in Saudi’s oil policy resulted from changes
in its relations with the USA. He stated that: “Although relations between the US and
Saudi Arabia first developed strains in late 1978, it was not until 1979 that these strains
reached crisis proportions in the United States.” During the interviews in the course of
this thesis, Yamani related the change to Arab countries’ pressure on Saudi Arabia to
lower production. Nazer related it to the constraint in production capacity and was
supported by Seymour who thought that technical problems in the oil fields following the
high production levels in late 1978 had caused some technical difficulties which prompted
the production cut in the first quarter of 1979.

To evaluate the different hypotheses we need to look at factors affecting Saudi
Arabia’s production policy in the light of the underlying supply/demand situation
prevailing at the time namely:

1- The size of the reduction in Iranian supply.
2- The maximum capacity of Saudi production.
3- The Production capacity of other producing countries.
4- The level of demand.

Before November 1978, the average monthly Iranian output ranged between 5.3
MMBD and 6 MMBD. However, in November it had declined to 3,494 thousand BD
and continued to decline to its lowest level of 404,000 BD in January 1979 before rising slightly to 758,000 BD in February 1980. During the period between October 1978 and March 1979 the production of Saudi Arabia increased from 7.4 MMBD in September 1978 to 9.3 MMBD in October, and 10.2 and 10.4 MMBD in November and December 1978 respectively. Saudi production continued at this level in the first quarter of 1979 reaching an average of 9.8 MMBD, when Iranian production averaged 1.13 MMBD only in that quarter (Table 3.6).

**Figure 3.3: Crude Oil Production for Saudi Arabia, Iran, and Iraq June 1978 to February 1981. Thousands Barrel per Day**

![Crude Oil Production Chart](chart.png)

Iranian production climbed to more than 4 MMBD between April and June 1979, an increase of 3 MMBD over the 1st quarter period, thus diminishing the reason for increasing Saudi outputs (see Figure, 3.3). Total OPEC production increased from 29.2 MMBD in the first quarter 31.1 MMBD in the second quarter of 1979, in spite of the decline in Saudi
Arabia's production from 9.8 MMBD in the first quarter to 8.8 MMBD in the second quarter of 1979. (see Table, 3.6)

**Table 3.6 The Monthly Production for Saudi Arabia, OPEC Members, Supply of non-OPEC and World Consumption**

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Iran</th>
<th>Saudi Arabia</th>
<th>OPEC 11 Members</th>
<th>OPEC 13 members</th>
<th>Non-OPEC Supply</th>
<th>World Supply</th>
<th>World excluding CPE consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978</td>
<td>Q3</td>
<td>5.886</td>
<td>7.651</td>
<td>16.889</td>
<td>30.426</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Oct.</td>
<td>5.490</td>
<td>9.278</td>
<td>17.660</td>
<td>31.934</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Nov.</td>
<td>3.494</td>
<td>10.251</td>
<td>18.030</td>
<td>31.775</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Dec.</td>
<td>2.371</td>
<td>10.403</td>
<td>16.766</td>
<td>30.663</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Q4</td>
<td>3.785</td>
<td>9.977</td>
<td>17.695</td>
<td>31.457</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Avg.</td>
<td>1978</td>
<td>5.197</td>
<td>8.300</td>
<td>16.390</td>
<td>29.887</td>
<td>*</td>
<td>-</td>
<td>50.775</td>
</tr>
<tr>
<td></td>
<td>Feb.</td>
<td>7.58</td>
<td>9.777</td>
<td>18.517</td>
<td>29.025</td>
<td>17.468</td>
<td>46.520</td>
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<tr>
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<td>Mar.</td>
<td>2.220</td>
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<td>30.269</td>
<td>17.374</td>
<td>47.643</td>
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<tr>
<td></td>
<td>Q1</td>
<td>1.127</td>
<td>9.780</td>
<td>18.319</td>
<td>29.226</td>
<td>17.355</td>
<td>46.581</td>
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<tr>
<td></td>
<td>Apr.</td>
<td>4.134</td>
<td>8.791</td>
<td>18.256</td>
<td>31.181</td>
<td>17.594</td>
<td>48.774</td>
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<tr>
<td></td>
<td>May.</td>
<td>4.107</td>
<td>8.781</td>
<td>18.173</td>
<td>31.061</td>
<td>17.657</td>
<td>48.718</td>
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<tr>
<td></td>
<td>Jun.</td>
<td>3.936</td>
<td>8.779</td>
<td>18.311</td>
<td>31.026</td>
<td>17.713</td>
<td>48.739</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q2</td>
<td>4.059</td>
<td>8.784</td>
<td>18.246</td>
<td>31.089</td>
<td>17.655</td>
<td>48.744</td>
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<tr>
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<td>Jul.</td>
<td>3.766</td>
<td>9.773</td>
<td>18.285</td>
<td>31.824</td>
<td>17.824</td>
<td>49.706</td>
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<tr>
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<td>Aug.</td>
<td>3.741</td>
<td>9.771</td>
<td>17.893</td>
<td>31.405</td>
<td>17.851</td>
<td>49.256</td>
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</tr>
<tr>
<td></td>
<td>Sep.</td>
<td>4.009</td>
<td>9.772</td>
<td>17.772</td>
<td>31.553</td>
<td>17.718</td>
<td>49.271</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q3</td>
<td>3.839</td>
<td>9.772</td>
<td>17.983</td>
<td>31.594</td>
<td>17.817</td>
<td>49.411</td>
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</tr>
<tr>
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<td>Oct.</td>
<td>3.800</td>
<td>9.721</td>
<td>17.897</td>
<td>31.418</td>
<td>17.857</td>
<td>49.275</td>
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</tr>
<tr>
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<td>Nov.</td>
<td>3.300</td>
<td>9.798</td>
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<td>31.270</td>
<td>18.013</td>
<td>49.282</td>
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<td>Dec.</td>
<td>3.100</td>
<td>9.778</td>
<td>18.186</td>
<td>31.064</td>
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<td>49.149</td>
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<td>Q4</td>
<td>3.400</td>
<td>9.765</td>
<td>18.085</td>
<td>31.250</td>
<td>17.985</td>
<td>49.235</td>
<td></td>
</tr>
</tbody>
</table>

Source: Petroleum Intelligence Weekly, (PIW) different issues.

The above showed that Saudi Arabia acted as the world’s residual supplier or Swing producer. The fact that Iran’s crude oil is light, increased the burden on Saudi Arabia since most of its production is light while other Gulf OPEC members excess
capacity was more oriented towards heavier crudes which did not match the refinery configurations in the major industrialised countries.

We can show the interrelation between the Saudi Arabian and Iranian exports, under the impact of Saudi Arabia's decision at the beginning 1978 to limit exports of Arabian Light to 65% of its exports for the year 1978. In the following months the Iranian Light had been on the increase, both in absolute and relative terms. In June 1978 the production of Saudi Arabian Light had fallen from 5824 thousands BD (76.56% of production) in May to 4322 thousands BD (59.27% of production). Exports of Iranian Light on the other hand climbed from 1910 thousands BD (47.28%) of total exports) to 2255 thousands BD (54.18%) of total exports in the second quarter.

Figure 3.4: Oil Monthly Average Official Prices and Spot Prices S/B (Arabian Light 34)
Ademan’s view that Saudi Arabia favoured high prices seemed to be at odds with its attempts to hold down the official price throughout the rest of 1979 and 1980. If Saudi Arabia was seeking higher prices the opportunity would have been greatest in October 1978 during the oil workers’ strikes in Iran. A small cut in production would have lead to an increase in prices. However Saudi Arabia took the opposite step, it raised production to more than 10 MMBD.

Saudi Arabia had raised the ceiling on Aramco crude oil production by 1 million BD from the regular 8.5 MMBD to 9.5 MMBD on a temporary basis applicable for the first quarter of 1979. The decision was taken on 19 January, when production had been running at around 10.4 MMBD in the first 19 days the month. This prompted Aramco to cut production sharply after the announcement concerning the new ceiling.

The period 1979-80 was also marked by the increasing role of the spot market resulting in another multi-tier price system whereby spot prices were running ahead of official prices (Table 3.5). Saudi Arabia called for lower oil prices, and kept the official prices ranging from $26 -34 /B for the period 1980-81 while spot prices rose in some months to the level of $40/B causing a gap of $17/B between the official price of Arab Light and the spot prices (Figure 3.4). The official explanation given by Crown Prince Fahad in an interview to the New York Times was that Saudi Arabia did not want “to exploit the situation, that we want to lessen the sharpness of the oil crisis. ....... The companies that do the marketing should be accountable to their respective governments for the very high profits they make. If these companies had bought at a certain limited price and sold at a certain reasonable profit, the energy crisis would not have blown up.”

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Saudi Arabian official prices lagged well behind those of all other OPEC and non-OPEC producers. Saudi Arabia appeared to have been a price follower throughout the two years of price increases, with much smaller price rises than others up to April 1981. The reason for this was that OPEC members acted no differently than the non-OPEC producers (with the sole exception of Saudi Arabia) increasing prices irrespective of OPEC decisions thus undermining the monopoly power, its control and its cohesion. The manner in which official prices followed spot prices varied from country to country. At one extreme OPEC member country Ecuador followed spot movements quite closely. At the other extreme, Saudi Arabia lagged behind when all other official price rises throughout the period and its
official prices bore little or no relationship to movement in the spot price throughout 1979-1980 (see Figure 3.5).

During the period "multi-tiered" pricing appeared within OPEC, with Saudi Arabia keeping Arabian Light price increases to a minimum, and the rest of OPEC applying a much higher "Marker Price" to set their differentials. This happened despite frequent attempts by Saudi Arabia to achieve price unity for example in November 1979 when it increased the official price by $6 from $18/B to $24/B (Appendix 3) in order to close the existing price gap and also in January 1980 when Saudi Arabia again tried to close the gap with its own $2/B increases in June 1980. These attempts served only to induce further price increases by the rest of the OPEC countries. Saudi Arabia proved that even its main objectives of keeping moderate oil prices and a good relationship with OPEC members, were contradictory.

Figure 3.6: Supply and Demand for Oil and the Influence of Supply Interruption.
Nonetheless, some OPEC members did stick closely to the pricing pattern of Saudi Arabia. Indonesia and Venezuela increased official prices only slightly faster than Saudi Arabia in 1979 and remained stable thereafter. The motives of Saudi Arabia and this group of relative “moderates” can be explained by their attempts to keep the oil market stable and their reluctance to take full advantage of the increase in prices created by the spot market and the more aggressive producers. During the period producers within OPEC decided individually on both their output and prices, which was far from constituting a cartel in the economic sense of the word.

Although Saudi Arabia tried to lower world oil prices, through increasing its production levels, this attempt to enforce its price decision as in the “dominant-firm hypothesis” was not very successful and led Saudi Arabia to follow the market and increase its official price. As shown in Figure 3.6, the effect on price of movement in the Saudi supply curve was counted backward by a movement by demand due to speculative motives. The same market situations that appeared during November 1978- April, 1979 and characterised the interruption of Iranian crude were repeated in the September 1980 period at the beginning of the Iran/Iraq war. During the first period, Saudi Arabia filled 2.2 MMBD of the interrupted Iranian supplies of 4.7 MMBD under official prices lower than spot market prices. The monthly difference between the two price sets averaged $5/B (Table 3.5 p. 46). During the second period, the supply interruption from Iraq and Iran amounted to 3.4 MMBD. Saudi Arabia filled only 0.82 MMBD of that at official prices much lower than spot market prices. The monthly price difference between the two sets amounted to $7.587/B.
Theoretically it was impossible for a fixed price regime to survive amidst the proliferation of spot transactions. This was evident in the fourth quarter of 1978 and the first quarter of 1979. The seasonal demand surge coupled with the supply interruption caused spot prices in all markets to run ahead of official prices.

The period which characterised the first production surge by Saudi Arabia to fill the Iranian export shortfall during the Iranian revolution was followed by a production decline to allow for a resumption of Iranian exports. In the period after the Iran-Iraq war, Saudi Arabia maintained its production at around 10 MMBD throughout 1980 into the fourth quarter of 1980, despite the fact that world demand for OPEC oil had declined. Saudi Arabia maintained its average production of 10.4 MMBD in the fourth quarter of 1981 despite a decline in world demand of 1.8 thousand BD and a decline in overall OPEC production of 2.1 MMBD.21

Askari (1991) and Quandt (1982) explained that the rationale behind Saudi Arabia’s policy of increasing its output to the maximum sustainable capacity of nearly 10 MMBD from 1979 to 1981, thereby preventing even further prices rises, was due to a combination of political and economic factors. Economically, Saudi Arabia tried to keep a moderate oil price that would be in its best longrun interests because it would keep the oil market healthy and intact.

Roberts (1984) explained that the Saudi policy of maintaining a very high output despite weakening demand, and thereby causing production cuts in the rest of OPEC, was aimed at bringing the rest of OPEC down to around its official marker price. He added that
"It was an attempt by Saudi Arabia to reassert its position in the organisation and indeed in the whole oil market" (Roberts, 1984).

At the official level then, the Oil Minister justified the continuation of high output as being essential to bring down the oil price to the level favoured by Saudi Arabia. Saudi Arabia acted as the market leader to bring the rest of the system down to its level. It was aided by a general weakening of the market. The Saudi policies of 1981 fit well into the pure "dominant producer" leadership model. By virtue of its position as the largest supplier, it was able to enforce its chosen price regime on the rest of the system. The agreement for the $34/B marker in 1981 showed the desire of Saudi Arabia for a unification of OPEC pricing. Here it succeeded in unifying at higher levels, unlike in the previous two years when its desire to unify the price at lower levels was not successful.

The existence of excess capacity in some OPEC countries, meant that a price reduction by Saudi Arabia would be matched by like behaviour on the part of others. The inelastic demand for OPEC oil meant that price reduction would lead to lower revenues for all members. Saudi Arabia realised this dilemma when it decided to defend the price. The problem was that the agreed unified marker price was too high to defend, and this necessitated price volume trade off in the coming years.

3.3 Fixing Ceilings, Quotas and Prices: March 1982- August 1985

The period 1982-85 was characterised by a great excess of supply. The slack market in 1981 turned, in 1982, to a glutted one confronting all producers with tough choices. In one year only, OPEC's share had dropped from 40% in 1981 to 35% in 1982 while Saudi
Arabia’s share in OPEC had dropped by almost 10 percentage points from 44% to 34.6% in 1982 (Table 3.7).

Table 3.7: Crude Oil Production by Saudi Arabia, Total OPEC and World Oil 1981-1985 (Thousand Barrel per Day)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Saudi Arabia</td>
<td>9808.0</td>
<td>6483.0</td>
<td>4539.4</td>
<td>4079.1</td>
<td>3175.0</td>
</tr>
<tr>
<td>OPEC</td>
<td>22387.6</td>
<td>18759.5</td>
<td>16754.8</td>
<td>16091.1</td>
<td>15184.9</td>
</tr>
<tr>
<td>Saudi % OPEC</td>
<td>43.80</td>
<td>34.55</td>
<td>27.09</td>
<td>25.35</td>
<td>20.90</td>
</tr>
<tr>
<td>Total world</td>
<td>56049.1</td>
<td>53491.6</td>
<td>52572.1</td>
<td>51885</td>
<td>52937.8</td>
</tr>
<tr>
<td>Non-OPEC</td>
<td>33661.5</td>
<td>34732.1</td>
<td>35997.3</td>
<td>37095.8</td>
<td>37752.9</td>
</tr>
<tr>
<td>Non-OPEC%</td>
<td>60.1%</td>
<td>64.9%</td>
<td>68.1%</td>
<td>69.7%</td>
<td>71.3%</td>
</tr>
<tr>
<td>OPEC % World</td>
<td>39.9%</td>
<td>35.1%</td>
<td>31.9%</td>
<td>30.3%</td>
<td>28.7%</td>
</tr>
</tbody>
</table>

Source: OPEC secretariat.

Table 3.8: Indicators of Petroleum Use in the OECD Countries.

<table>
<thead>
<tr>
<th>Year</th>
<th>Consumption (MMBD)</th>
<th>Imports (MMBD)</th>
<th>Oil share in Consumption of Energy</th>
<th>Intensity use Energy</th>
<th>Petroleum</th>
<th>Change in seasonal demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>1974-1979</td>
<td>40.3</td>
<td>27.6</td>
<td>51</td>
<td>0.53</td>
<td>0.27</td>
<td>4.0</td>
</tr>
<tr>
<td>1980</td>
<td>38.6</td>
<td>23.5</td>
<td>48</td>
<td>0.50</td>
<td>0.24</td>
<td>3.6</td>
</tr>
<tr>
<td>1981</td>
<td>36.4</td>
<td>23.5</td>
<td>48</td>
<td>0.48</td>
<td>0.22</td>
<td>2.7</td>
</tr>
<tr>
<td>1982</td>
<td>34.6</td>
<td>17.8</td>
<td>45</td>
<td>0.47</td>
<td>0.21</td>
<td>2.8</td>
</tr>
<tr>
<td>1983</td>
<td>33.8</td>
<td>16.7</td>
<td>44</td>
<td>0.46</td>
<td>0.20</td>
<td>0.8</td>
</tr>
<tr>
<td>1984</td>
<td>34.3</td>
<td>17.1</td>
<td>43</td>
<td>0.45</td>
<td>0.20</td>
<td>1.8</td>
</tr>
<tr>
<td>1985</td>
<td>34.0</td>
<td>15.6</td>
<td>42</td>
<td>0.44</td>
<td>0.19</td>
<td>1.7</td>
</tr>
<tr>
<td>1986</td>
<td>34.4</td>
<td>16.1</td>
<td>43</td>
<td>0.43</td>
<td>0.19</td>
<td>0.7</td>
</tr>
</tbody>
</table>


The reduced demand for oil resulted from both a decline in oil share in world energy consumption and from a reduction in overall energy intensities (see Table 3.8). Increasing non-OPEC production (see Table 3.7) and continuing excess capacity in OPEC caused slackness in the market which put spot prices under pressure and forced subsequent reductions in official prices (see Table 3.9).
Faced with a glutted market and continued pressure on the price of the marker, OPEC decided in March 1983 to lower the price of the marker from $34/B to $29/B and to adopt for the first time a ceiling and quotas in what came to be known as the London Agreement (see Appendix 5). The signing of the agreement spelled out explicitly a role for Saudi Arabia which came to characterise the market and Saudi Arabia as a swing producer.

The agreement stated that the conference decided to

"allocate quotas for member countries and no specific quota had been allocated for Saudi Arabia which would act as the swing producer supplying the balancing volumes to meet market requirement within the overall ceiling." (OPEC Resolutions 1996)

<table>
<thead>
<tr>
<th>Month</th>
<th>Official Price</th>
<th>Spot price</th>
<th>Month</th>
<th>Official Price</th>
<th>Spot price</th>
<th>Month</th>
<th>Official Price</th>
<th>Spot price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan.84</td>
<td>29.00</td>
<td>28.630</td>
<td>Jan.85</td>
<td>28.00</td>
<td>27.860</td>
<td>Jan.84</td>
<td>29.00</td>
<td>28.487</td>
</tr>
<tr>
<td>Feb.00</td>
<td>29.00</td>
<td>28.487</td>
<td>Feb.00</td>
<td>28.00</td>
<td>27.737</td>
<td>Feb.00</td>
<td>29.00</td>
<td>28.400</td>
</tr>
<tr>
<td>Mar.83</td>
<td>29.00</td>
<td>28.200</td>
<td>Mar.85</td>
<td>29.00</td>
<td>28.487</td>
<td>Mar.83</td>
<td>28.00</td>
<td>27.737</td>
</tr>
<tr>
<td>Apr.00</td>
<td>29.00</td>
<td>28.737</td>
<td>Apr.00</td>
<td>29.00</td>
<td>28.837</td>
<td>Apr.00</td>
<td>29.00</td>
<td>28.837</td>
</tr>
<tr>
<td>May.00</td>
<td>29.00</td>
<td>28.590</td>
<td>May.00</td>
<td>29.00</td>
<td>28.400</td>
<td>May.00</td>
<td>29.00</td>
<td>28.400</td>
</tr>
<tr>
<td>Jun.00</td>
<td>29.00</td>
<td>28.837</td>
<td>Jun.00</td>
<td>29.00</td>
<td>28.037</td>
<td>Jun.00</td>
<td>29.00</td>
<td>28.037</td>
</tr>
<tr>
<td>Jul.00</td>
<td>29.00</td>
<td>28.975</td>
<td>Jul.00</td>
<td>29.00</td>
<td>27.420</td>
<td>Jul.00</td>
<td>29.00</td>
<td>27.420</td>
</tr>
<tr>
<td>Aug.00</td>
<td>29.00</td>
<td>28.910</td>
<td>Aug.00</td>
<td>29.00</td>
<td>27.762</td>
<td>Aug.00</td>
<td>29.00</td>
<td>27.762</td>
</tr>
<tr>
<td>Sep.00</td>
<td>29.00</td>
<td>28.650</td>
<td>Sep.00</td>
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<td>27.837</td>
<td>Sep.00</td>
<td>29.00</td>
<td>27.837</td>
</tr>
<tr>
<td>Oct.00</td>
<td>29.00</td>
<td>28.575</td>
<td>Oct.00</td>
<td>29.00</td>
<td>27.760</td>
<td>Oct.00</td>
<td>29.00</td>
<td>27.760</td>
</tr>
<tr>
<td>Nov.00</td>
<td>29.00</td>
<td>28.290</td>
<td>Nov.00</td>
<td>29.00</td>
<td>27.825</td>
<td>Nov.00</td>
<td>29.00</td>
<td>27.825</td>
</tr>
<tr>
<td>Dec.00</td>
<td>29.00</td>
<td>28.262</td>
<td>Dec.00</td>
<td>29.00</td>
<td>27.662</td>
<td>Dec.00</td>
<td>29.00</td>
<td>27.662</td>
</tr>
</tbody>
</table>

Source: OPEC Secretariat

During the years 1979-1981 non-OPEC production was increasing as well. North Sea production increased by 600,000 BD in 1979 and continued to rise thereafter. The loss of output from Iran and then from Iran and Iraq during the period 1979-1981 was offset by the increases from OPEC, and principally from Saudi Arabia. It was also offset by the
increase from non-OPEC producers which amounted to 2.5 MMBD. Table 3.10 shows the net addition to supply from OPEC and key non-OPEC countries.

After the demand downturn of 1982 OPEC production decreased by 3,390 MMBD from 1981, while non-OPEC increased by 1.025 MMBD and continued into 1983 and subsequent years.

Figure 3.7: OPEC and Non-OPEC Crude Oil Production 1965-1995.

The period 1981-1985 could be characterised as follows:

1. Declining demand due to slowdown in economic activity, conservation and substitution effects fuelled by higher official prices.

2. Increasing output from non-OPEC producers (see Figure 3.7) because of the high prices, favourable fiscal regime outside OPEC, increasing investment expenditure for exploration and development of the major oil companies. Nationalisation of some of the oil companies and participation agreements in OPEC countries, led the companies to look for oil in different non-OPEC
regions such as North Sea and Mexico23 (see Table 3.10), which led to the increase in non-OPEC supply.

3. Stock-building for the Strategic Petroleum Resources (SPR) in the USA, and precautionary stock-building following the Iran crisis and the outbreak of the Iran-Iraq war.

Pressure on the official price structure of OPEC because of the discounts and the different price arrangements by other members as well as non-OPEC countries.

OPEC had accepted the role of the residual supplier, with Saudi Arabia playing the Swing producer role. As described by Yamani,

"There is no doubt that the Kingdom carried the burden of maintaining prices and production levels. If supply exceeds demand prices fall, and if demand exceeds supply they rise. The Kingdom therefore plays the pivotal or "Swing" role in balancing supply and demand in order to achieve the right price in the world market."24

The London agreement,25 which was intended to balance the market, set the stage for more market instability in the next few years. Although the official price was lowered to $29/B, this reduction was not sufficient to arrest demand decline and the substitution effect. For example, on the BTU basis, the price of coal was still half the price of fuel oil even after the marker crude oil price reduction. Second, the output ceiling of 17.5 MMBD was higher than needed to clear the market. Further, after the agreement on a production ceiling for OPEC individual quotas for each member country and an adherence to the official price, many members began to pursue a policy of cutting prices to enable them to market as much oil as they could produce. Some of these countries granted discounts openly and boldly. Other countries were selling crude with other oil products in a package
deal and giving a discount on products, or manipulating taxes and royalties in order to end up with a lower price per barrel. Then there was the common method of refining crude and selling it in the form of products at any price, consequently flooding the oil market and putting downward pressure on prices. In addition, there are other countries, like Algeria, which linked the price of their gas to the price of oil. Thus a reduction in the price of oil would lead to a fall in the price of gas in which case these countries will suffer. There is also the problem of more fundamental structural change in the oil industry, with more and more oil being sold on a spot or spot related price basis.

Table 3.10: Crude Production from OPEC and non-OPEC sources (Thousand Barrel per Day)

<table>
<thead>
<tr>
<th>Year</th>
<th>OPEC</th>
<th>Mexico</th>
<th>UK</th>
<th>Norway</th>
<th>US</th>
<th>Canada</th>
<th>Total Non-OPEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973</td>
<td>18740</td>
<td>325</td>
<td>10</td>
<td>35</td>
<td>10945</td>
<td>2115</td>
<td>18740</td>
</tr>
<tr>
<td>1974</td>
<td>18440</td>
<td>655</td>
<td>10</td>
<td>35</td>
<td>10460</td>
<td>1995</td>
<td>18440</td>
</tr>
<tr>
<td>1975</td>
<td>18505</td>
<td>805</td>
<td>35</td>
<td>195</td>
<td>10010</td>
<td>1735</td>
<td>18505</td>
</tr>
<tr>
<td>1976</td>
<td>18965</td>
<td>895</td>
<td>250</td>
<td>290</td>
<td>9735</td>
<td>1600</td>
<td>18965</td>
</tr>
<tr>
<td>1977</td>
<td>20120</td>
<td>1085</td>
<td>790</td>
<td>285</td>
<td>9865</td>
<td>1610</td>
<td>20120</td>
</tr>
<tr>
<td>1978</td>
<td>21600</td>
<td>1325</td>
<td>1115</td>
<td>360</td>
<td>10275</td>
<td>1595</td>
<td>21600</td>
</tr>
<tr>
<td>1979</td>
<td>31430</td>
<td>1605</td>
<td>1605</td>
<td>400</td>
<td>10135</td>
<td>1835</td>
<td>22795</td>
</tr>
<tr>
<td>1980</td>
<td>27430</td>
<td>2160</td>
<td>1660</td>
<td>515</td>
<td>10170</td>
<td>1765</td>
<td>23385</td>
</tr>
<tr>
<td>1981</td>
<td>23305</td>
<td>2555</td>
<td>1850</td>
<td>495</td>
<td>10180</td>
<td>1610</td>
<td>23960</td>
</tr>
<tr>
<td>1982</td>
<td>19915</td>
<td>3000</td>
<td>2145</td>
<td>520</td>
<td>10200</td>
<td>1590</td>
<td>25045</td>
</tr>
<tr>
<td>1983</td>
<td>18095</td>
<td>2930</td>
<td>2400</td>
<td>645</td>
<td>10245</td>
<td>1660</td>
<td>26070</td>
</tr>
<tr>
<td>1984</td>
<td>17755</td>
<td>2940</td>
<td>2625</td>
<td>735</td>
<td>10510</td>
<td>1775</td>
<td>27545</td>
</tr>
<tr>
<td>1985</td>
<td>16895</td>
<td>2910</td>
<td>2670</td>
<td>815</td>
<td>10580</td>
<td>1810</td>
<td>28510</td>
</tr>
<tr>
<td>1986</td>
<td>19680</td>
<td>2760</td>
<td>2665</td>
<td>905</td>
<td>10230</td>
<td>1805</td>
<td>28445</td>
</tr>
</tbody>
</table>


The excess capacity and low spot prices during the period placed downward pressure on official prices. There was the incentive for an individual producer to attempt to undercut official prices in order to maintain a larger share of the market and hence create the potential for maintaining his production despite the contraction of OPEC production. The individual producer could then pass the production cuts to other members.
Although Saudi Arabia accepted a quota in the next OPEC meeting in 1983 it continued to play the swing producer role, changing its production according to demand. Its output reached a level of 2.2 MMBD in August 1985. The reasons that Saudi Arabia played that role appear to be as follows; first, there was its long standing position of rejecting production programming. When it was first suggested by Venezuela, in the early years of OPEC, Saudi Arabia opposed it and continued its opposition until 1982. Saudi Arabia wanted the flexibility to change its production up or down according to its national interest without any constraint on its production. Second, Saudi Arabia had exercised a swing producer role before, in 1975 and 1979 to 1981, and had found it rewarding, leading at times to stable prices.

Third, there was the Saudi notion that the decline in demand was temporary and the quota system would not be needed. In an interview following the London Agreement, the Saudi Oil Minister predicted that the ceiling of 17.5 MMBD would be gradually raised, because demand would rise. He also predicted that if demand revived, it would be OPEC production that would increase and not the benchmark price. The Saudi Minister summed up his views of the future in 1984:

"If we look to the future I feel confident that oil consumption will begin to increase, particularly after 1987. If we succeed, as I think we will, in preventing price increases within OPEC and in keeping prices frozen until the end of 1986, we will see an increase in consumption on a scale which will satisfy all the producers, both OPEC and non-OPEC"

This prediction did not come true, and so the swing producer role continued until August 1985. In his interview with the author he blamed other OPEC members for the failure of this role played by Saudi Arabia, because of cheating and over production by
some members of OPEC. As it was expressed by the Saudi Minister at that time "Saudi Arabia honoured its commitment to OPEC."³⁰

The fourth reason for the Saudi adoption of a swing producer role was the apparent pressure it was under from other members of OPEC notably Algeria, Iran, Libya, and Iraq.³¹ The Ministers of those countries united in opposition to Saudi policy at the meetings of OPEC, since then Saudi Arabia was the only country able to sustain declining revenues. According to unofficial sources, Yamani gave in to these pressures and took the proposal back to the Saudi government arguing that the demand would cover any loss and that it was best for Saudi Arabia to play the swing producer role in order to have more influence in the oil market. Minister Nazer said during the interview with the author that Saudi Arabia did not suffer in the first two years because it used its financial surpluses to cover the budget deficit. However, when demand for its oil continued to decline, as well as revenues, Saudi Arabia had to abandon the swing producer role.

3.4 Free Pricing and Production: September 1985-December 1986

Faced with a declining share, which reached its lowest level in August 1985 at 2.2 MMBD compared with a quota of 4.3 MMBD, Saudi Arabia started sending signals to the other members of OPEC, and to the market, that it could not continue playing the role of swing producer forever. Saudi Arabia was trying not to allow prices to go down by advocating non-OPEC co-operation, as this was believed to be the only way to prevent the collapse of oil prices. UK government officials had clearly stated that they did not wish to restrict production. A spokesman for Britain's Ministry of Energy then said that Britain
would not reduce oil production to ease pressure on prices. In Mexico, the official response had been a price cut and a more market oriented pricing system.


<table>
<thead>
<tr>
<th>Year</th>
<th>Actual Expenditure</th>
<th>Actual Revenue</th>
<th>Budget Actual Deficit</th>
<th>Current Account Deficit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>283.00</td>
<td>368.00</td>
<td>-84.70</td>
<td>-142.24</td>
</tr>
<tr>
<td>1982</td>
<td>244.90</td>
<td>246.20</td>
<td>-1.30</td>
<td>-139.12</td>
</tr>
<tr>
<td>1983</td>
<td>230.20</td>
<td>206.40</td>
<td>+23.80</td>
<td>-25.95</td>
</tr>
<tr>
<td>1984</td>
<td>216.40</td>
<td>171.50</td>
<td>+44.96</td>
<td>58.22</td>
</tr>
<tr>
<td>1985</td>
<td>184.00</td>
<td>133.60</td>
<td>+50.40</td>
<td>46.85</td>
</tr>
<tr>
<td>1986</td>
<td>137.40</td>
<td>76.50</td>
<td>+60.90</td>
<td>43.68</td>
</tr>
</tbody>
</table>

Source: Saudi Arabian Monetary Agency (SAMA).

During the period 1982-1985 Saudi Arabia’s fiscal budget was registering an average deficit of 35.7 billion Riyal annually. During the period drew down on its official reserves to finance the growing budgetary and current account deficits. This added to the pressure to abandon the swing producer role.

According to Ian Seymour, the decision to abandon the swing producer role was taken at the upper echelons of the government. But the pronouncements of the Saudi Oil Minister from the beginning of 1985 show a change of tone, Yamani announced at the Oxford Energy Seminar (August 1986), that Saudi Arabia would no longer continue to play the swing producer role. Although Yamani initiated this role and kept it, he also brought in the mechanism of netback pricing in order to abandon the swing role.

The idea of regaining market share through market-related pricing or abandoning the official prices was not a novel Saudi intervention. Most producers were resorting to some form of market-related pricing. The initial application of netback pricing starting in September 1985 helped regain Saudi Arabia’s share without market collapse. But after
other producers perceived the Saudi move as a price war, they resorted to netback pricing, which caused prices to deteriorate.

Table 3.12: Crude Oil Prices for Arabian Light 34 for the Year 1986

<table>
<thead>
<tr>
<th>Months</th>
<th>Spot Price Arab Light 34° S/B</th>
<th>Saudi Production Thousand Barrel per Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep.1985</td>
<td>27.587</td>
<td>2485.8</td>
</tr>
<tr>
<td>Oct.</td>
<td>27.850</td>
<td>3660.7</td>
</tr>
<tr>
<td>Nov.</td>
<td>27.937</td>
<td>3985.4</td>
</tr>
<tr>
<td>Dec.</td>
<td>27.870</td>
<td>4276.1</td>
</tr>
<tr>
<td>Jan.1986</td>
<td>27.450</td>
<td>3760.0</td>
</tr>
<tr>
<td>Feb.</td>
<td>15.875</td>
<td>4715.0</td>
</tr>
<tr>
<td>Mar.</td>
<td>13.125</td>
<td>4115.0</td>
</tr>
<tr>
<td>Apr.</td>
<td>11.300</td>
<td>4720.0</td>
</tr>
<tr>
<td>May.</td>
<td>12.625</td>
<td>4360.0</td>
</tr>
<tr>
<td>Jun.</td>
<td>10.750</td>
<td>5250.0</td>
</tr>
<tr>
<td>Jul.</td>
<td>8.500</td>
<td>5812.5</td>
</tr>
<tr>
<td>Aug.</td>
<td>13.112</td>
<td>6236.3</td>
</tr>
<tr>
<td>Sep.</td>
<td>13.700</td>
<td>4271.8</td>
</tr>
<tr>
<td>Oct.</td>
<td>14.000</td>
<td>4193.2</td>
</tr>
<tr>
<td>Nov.</td>
<td>13.812</td>
<td>4312.8</td>
</tr>
<tr>
<td>Dec.</td>
<td>15.600</td>
<td>4350.6</td>
</tr>
</tbody>
</table>


The first half of 1986 witnessed prices declining and OPEC and Saudi Arabia production rising (Table 3.12). During the period, one could say that OPEC did not operate as a cartel because there was no official price and no production quotas. Effectively there was no market leader, neither OPEC nor Saudi Arabia were willing to step in and change the course of events. It is true that the period witnessed a series of OPEC meetings but they all failed to come up with concrete results.33

Throughout the first eight months of 1986, Saudi Arabia and other members of OPEC pursued a strategy of increasing market share by continuing to use netback pricing and increasing production over the quota level. By July, OPEC production was running over 19.5 MMBD and every member country's output was in excess of quota levels. (see Table 3.13).
Table 3.13: Estimates of OPEC Crude Production Changes December 1985 and July 1986
(Thousand Barrel per Day)

<table>
<thead>
<tr>
<th>Country</th>
<th>Production December 1985 with free for all policy.</th>
<th>Production July 1986</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algeria</td>
<td>688.2</td>
<td>690.7</td>
<td>+02.5</td>
</tr>
<tr>
<td>Gabon</td>
<td>181.9</td>
<td>165.4</td>
<td>-016.5</td>
</tr>
<tr>
<td>Indonesia</td>
<td>1204.0</td>
<td>1320.0</td>
<td>+116.0</td>
</tr>
<tr>
<td>Iran</td>
<td>2176.0</td>
<td>2208.0</td>
<td>+032.0</td>
</tr>
<tr>
<td>Iraq</td>
<td>1777.0</td>
<td>1982.0</td>
<td>+205.0</td>
</tr>
<tr>
<td>Kuwait</td>
<td>986.0</td>
<td>1652.5</td>
<td>+666.5</td>
</tr>
<tr>
<td>Libya</td>
<td>1300.0</td>
<td>1150.0</td>
<td>-150.0</td>
</tr>
<tr>
<td>Nigeria</td>
<td>1620.0</td>
<td>1577.5</td>
<td>-042.5</td>
</tr>
<tr>
<td>Qatar</td>
<td>335.0</td>
<td>400.0</td>
<td>+065.0</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>4276.1</td>
<td>5812.5</td>
<td>+236.0</td>
</tr>
<tr>
<td>U.A.E</td>
<td>1225.0</td>
<td>1497.5</td>
<td>+272.5</td>
</tr>
<tr>
<td>Venezuela</td>
<td>1569.0</td>
<td>1794.5</td>
<td>+225.5</td>
</tr>
<tr>
<td>Total</td>
<td>17338.2</td>
<td>20250.1</td>
<td></td>
</tr>
</tbody>
</table>

Source: OPEC secretariat.
Change in Production of (Iran+Iraq+Kuwait+Qatar+U.A.E+Venezuela) = 1477/8068 = 0.183
Change in production of other members of OPEC (OPEC-Saudi Arabia) = 1270.5/13062.1 = 0.097.
Change in Saudi Production = 236/4276.1 = 0.055

In August 1986, in the OPEC ministerial meeting in Geneva, it was agreed that all
the member countries, with the exception of Iraq, were bound by quotas identical to those
decided upon in October 1984. This decision was welcomed by non-OPEC producers and
Mexico and others offered to cut their oil production. With Saudi Arabia’s production in
July averaging 5.812 MMBD it had to take steps to reduce output, which was achieved in
September/1986 (see Appendix 6).

The political pressure on Saudi Arabia and OPEC was mounted by various
producers. The decline in revenues by all producers led to economic, political and social
crises in many countries. It was not clear where the situation was leading. With prices in
mid 1986 below $10, some analysts started looking at what the floor of prices might be in
a free market atmosphere like the one prevailing at the time. In November 1986 when
Zaki Yamani who had been Oil Minister for 24 years, was replaced by Hisham. Nazer
who attended an OPEC meeting on 20 December 1986 which resulted in an agreement to use production cuts to reach the objective oil price of $18/B and set the stage for a return to OPEC's former system of fixed pricing. OPEC members agreed to eliminate all the prevailing netback and other market-related pricing arrangements with effect from 1 February 1987 (see Appendix 3 for details of the agreement). The basic features of the agreement were:

1-Abandoning Arab Light as the marker and devising a basket of crudes.

2-Return to fixed prices.

3-Return to the old quota system prior to the price war.

The OPEC agreement of December 1986 involved the following: Firstly, a production ceiling of 15.8 MMBD for each of the first and second quarters of 1987, rising to 16.6 MMBD in the third quarter and 18.3 MMBD in the fourth quarter, making a yearly average of 16.632 MMBD. Secondly, the agreement provided for the return, as from 1 January 1987, to a fixed price system at $18/B. This was based on the single average values of the basket of seven crudes calculated on the basis of the 1987 official price for each individual crude. These were; Saudi Arabian Light at $17.25/B; UAE's Dubai at $17.42/B; Nigerian Bonny Light $18.92/B; Algerian Saharan Blend $18.87/B; Indonesian Minas $17.56/B; Venezuelan Tia Juana Light $17.62/B; and Mexican Isthmus $18.07/B. The purpose of using a basket of crude was to try to avoid the drawbacks of the previous fixed price system, under which the use of a single marker crude - Arabian Light- tended to put undue swing production pressure on Saudi Arabia.

However, despite the reaffirmation of confidence in the OPEC price and production agreement, the market did not respond. The spot price of North Sea Brent crude in
February 1987, declined from $18.400/B to $17.262/B which was lower than required to enable the OPEC fixed-price structure to operate in full security. On the supply side OPEC production in February was running over 1 MMBD higher than the official ceiling, and by August it was at 19.7 MMBD, around 3 MMBD over the official ceiling. Between January and June 1987 Saudi Arabia was virtually the only country adhering to the official price structure and quota level. It insisted that its customers be left at the set official prices while other producers were resorting to market-related prices. Saudi Arabia had an unenviable choice between two options: either to hold on to official prices (when they had been virtually abandoned everywhere else) and let its export volume swing downwards, almost certainly to a quite unacceptable extent; or to maintain its export volume by protecting its customers from incurring losses on the lifting of Saudi crude as market prices fell below official levels. This forced Saudi Arabia to abandon its role as the protector of the official price structure and resort to formula pricing from June 1987 onwards. With the Saudi adoption of formula pricing and the continued quota system of OPEC, the market and OPEC had entered into a period characterised by volume fixing and flexible prices which still prevails today. This is contrasted with the fixed volume and price period of 1982-1985 and the short free-for-all episode of 1986.

From June until the end of the year market-related prices were the norm, official prices in the basket were just a reference point, as explained by Ian Seymour after the OPEC meeting in December 1987:

“No doubt official prices will remain on the books playing a useful role as guideposts to where target prices ought to be. But they are unlikely either to retain or recapture their role as the linchpin of the system- the automatic prices for crude oil sales by OPEC suppliers under term contracts”336
One of the issues often discussed is the role of the US government in influencing Saudi Arabia's oil decisions. The events of 1986 and the return to the quota system in December 1986 are seen to be a consequence of pressure put on Saudi Arabia by then vice president George Bush during his visit to the country in 1986. It is said that the Vice-president urged Saudi Arabia to take steps to bring order back to the market. As a result of my interviews with Saudi policy observers and Petroleum Ministers I reached the following conclusion:

1. There is no clear evidence of US influence in Saudi Arabia's oil decisions. Everything is written about Vice President Bush's visit falls within media speculation, he made a statement about the oil market but nothing to the effect of calling upon Saudi Arabia to change policy.

2. The domestic situation in the USA rendered impossible any indication by the US government of price preferences. There is no consensus in the USA as to an acceptable oil price, the oil-producing states prefer high oil prices, while the consuming sectors prefer lower prices.

3. Events have proven that the market is too complex for a single act by one producer to change it and maintain it on one track.

4. The assumption of co-operation between USA/Saudi Arabia in the oil market lacks any material evidence. Throughout the history of the oil market one can trace Saudi behaviour to its underlying position as a dominant producer. So, when it favoured stable prices in the seventies, filled the production gap of Iran and Iraq in 1979-1981
and when it played the swing producer role, there was an economic rationale for all its actions.

3.5 Volume Fixing, Flexible Pricing: January 1987-Present

Since mid 1987 the oil market has remained in a state of general directional confusion between adjusting the crude output of OPEC to balance the market seasonally on one hand and price gyration and changes in the crude price pegs on the other.

Throughout the period, as has been the case since the beginning of the quota system, quota violation has continued unabated, with Saudi Arabia appealing to member countries, in OPEC conference or through official pronouncements to abide by their commitment. At times, the political leadership exemplified by King Fahad has appealed to heads of states to ensure compliance with quotas. Saudi Arabia has insisted since 1987 that balancing the market is not the responsibility of Saudi Arabia but of all producers, whether OPEC or non-OPEC. The Saudi Minister of Petroleum was OPEC’s envoy to the Soviet Union and Mexico in 1987 to urge their cooperation in balancing the market through volume restraint. The contacts culminated in a ministerial meeting between OPEC and six major non-OPEC countries in April 1988 which resulted in an offer from the latter to cut oil exports by 5% to support the market, provided that the OPEC producers would commit themselves to similar proportional responses. This offer was refused by Saudi Arabia on the grounds that OPEC had already made output sacrifices to accommodate non-OPEC production and that a reduction of 5% for non-OPEC was too little. Mr. Nazer in 1997 stated that
"The Kingdom does not feel itself responsible for correcting the mistakes of others by cutting its production".

Table 3.14: Crude Oil Production for Saudi Arabia from January 1988 to July 1990. (Thousands Barrel per Day)

<table>
<thead>
<tr>
<th>Month</th>
<th>Production</th>
<th>R. Basket Price</th>
<th>Month</th>
<th>Production</th>
<th>R. Basket Price</th>
<th>Month</th>
<th>R. Basket Price</th>
<th>Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. 88</td>
<td>5620.2</td>
<td>16.008</td>
<td>Jan. 89</td>
<td>5010.0</td>
<td>15.919</td>
<td>Jan. 90</td>
<td>19.975</td>
<td>5620.2</td>
</tr>
<tr>
<td>Feb. 5463.5</td>
<td>15.661</td>
<td>Feb. 4545.0</td>
<td>16.170</td>
<td>Feb. 19.031</td>
<td>5463.5</td>
<td>Mar. 5853.5</td>
<td>15.405</td>
<td>5853.5</td>
</tr>
<tr>
<td>Mar. 5860.8</td>
<td>15.848</td>
<td>Mar. 4495.5</td>
<td>17.549</td>
<td>Mar. 15.624</td>
<td>5860.8</td>
<td>Apr. 5167.3</td>
<td>14.715</td>
<td>5167.3</td>
</tr>
<tr>
<td>Apr. 5568.1</td>
<td>14.353</td>
<td>Apr. 4949.1</td>
<td>17.788</td>
<td>Apr. 14.031</td>
<td>5568.1</td>
<td>May. 5509.5</td>
<td>14.004</td>
<td>5509.5</td>
</tr>
<tr>
<td>May. 5277.5</td>
<td>12.651</td>
<td>May. 5365.2</td>
<td>16.832</td>
<td>May. 15.405</td>
<td>5277.5</td>
<td>Jun. 6646.9</td>
<td>12.004</td>
<td>6646.9</td>
</tr>
<tr>
<td>Jun. 5983.8</td>
<td>11.518</td>
<td>Jun. 5501.6</td>
<td>17.606</td>
<td>Jun. 15.624</td>
<td>5983.8</td>
<td>Jul. 6793.8</td>
<td>14.100</td>
<td>6793.8</td>
</tr>
</tbody>
</table>

Source: OPEC Secretariat.

The year, 1988-1989 witnessed rampant quota violations and disputes among OPEC members characterised by:

1. Quota violations mainly from Kuwait, UAE and Nigeria.

2. Dispute over the definition of quota and the definition and volumes of condensates to be excluded from the quota.

3. Accommodating Iraq into the quota system from which it had been excluded throughout its long war with Iran. Eventually the quotas of Iraq and Iran were equalised at 3.14 MMBD in November 1988.

The period 1987-1990 also witnessed continued growth in OPEC production because of the reversal of the declining demand trend of 1982-1985 and a decline in non-OPEC production (mainly from USSR) which enabled OPEC to realign quotas and increase the ceiling more than three times, from 15 MMBD in January 1987 to 22.49 MMBD in August.

**Figure 3.8:** Saudi and Other Members of OPEC oil Production and Quotas (Thousands Barrel per Day) from 1982-1994

During the period between 1987 and 1989, Saudi Arabia was accused by some OPEC members of producing more than its quota. In an interview with the Oil Daily on 18 September 1989, Nazer commented on Saudi production policy regarding quota adherence:

"Our policy is to abide by our OPEC quota and we expect other countries to do the same. There is no point in having these agreements unless we stick to them. Some of those countries which are overproducing believe that others who abide by their quota believe that their claim to higher output is equally valid. We have reminded our OPEC colleagues that for some years our minimum quota should be no less than 6 MMBD. However
in the interests of cooperation and market stability, we have been willing to abide by any increases in the ceiling which should be on a pro-rata basis." 38

The invasion of Kuwait led to a disruption of exports of 4.00 MMBD from Iraq and Kuwait. To fill the supply gap an intense debate evolved in the consuming and producing countries. In the IEA countries, the issues of utilising emergency stocks, like the US Strategy Petroleum Reserve (SPR), or the sharing of emergency stocks in times of such crises were debated. The consensus was that there were enough commercial stocks and excess capacities in the system to fill the supply gap and there was no need to use strategic stocks. Furthermore, the military situation improved with the dispatching of multinational forces under US leadership to defend Saudi Arabia, and specifically the oil fields and oil supply routes from the Arabian Gulf. Gradually, the widening supply gap was eased.

In OPEC, the debate was about whether the organisation should interfere to fill the supply gap. Two opposing views came out of OPEC's extraordinary Ministerial meeting at the end of August 1990. The first was the Saudi view, supported by its Gulf allies, Kuwait, UAE, and Qatar, that it was the responsibility of OPEC to balance the market and fill the shortfall in Kuwaiti and Iraqi exports resulting from the invasion. Saudi Arabia contended that such responsibility is enshrined in OPEC statutes in Article 2c which states that:

"Due regard shall be given at all times to the interests of the producing nations and to the necessity of securing a steady income to the producing countries, an efficient economic and regular supply of petroleum to consuming nations, and a fair return on their capital to those investing in the petroleum industry."

Since some member countries had the capacities to fill the disruption of exports from the two members, it was argued that they should be allowed within the OPEC system to do
so. Saudi Arabia suggested termination of the quota system until the end of the Kuwait crisis. The second view, shared mainly by Algeria (which was then presiding over the conference) as well as Libya and Iran advocated a wait and see approach to allow the price to reach the OPEC target set just before the invasion at $21/B. They argued that the consuming nations should use their strategic stocks to balance the market, a notion rejected at the time by the IEA secretariat.

The split within OPEC was mainly between the members with excess capacity - Saudi Arabia, UAE, Venezuela and to a lesser extent Nigeria- and the other members who were already producing at full capacity prior to the crisis of Kuwait invasion, and who therefore stood to gain nothing from the volume increase. In the end, it was Saudi Arabia’s unequivocal and apparent threat that it was willing to exercise its market power with or without OPEC consent, that led OPEC to effectively terminate the quota system.

The wording of the press release coming out of the conference on 29 August 1990 did not state this outright, but stated only that OPEC would subsequently increase production according to need in order to reinstate market stability and regular supply of oil. It called upon the IEA to execute its oil sharing agreement by using the available stocks.

**Table 3.15: The Production Profile during the Crisis (July 1990- December 1990)**

<table>
<thead>
<tr>
<th></th>
<th>Iraq</th>
<th>Kuwait</th>
<th>Saudi Arabia</th>
<th>UAE</th>
<th>Venezuela</th>
<th>OPEC Basket</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quota/Ceiling</td>
<td>3140</td>
<td>1500</td>
<td>5380</td>
<td>1500</td>
<td>1945</td>
<td>22491</td>
</tr>
<tr>
<td>August</td>
<td>890</td>
<td>181</td>
<td>5701</td>
<td>1610</td>
<td>2040</td>
<td>19246</td>
</tr>
<tr>
<td>Sep</td>
<td>470</td>
<td>161</td>
<td>7511</td>
<td>2183</td>
<td>2250</td>
<td>21793</td>
</tr>
<tr>
<td>Oct.</td>
<td>440</td>
<td>160</td>
<td>7783</td>
<td>2264</td>
<td>2267</td>
<td>21887</td>
</tr>
<tr>
<td>Nov.</td>
<td>437</td>
<td>170</td>
<td>8197</td>
<td>2305</td>
<td>2312</td>
<td>22629</td>
</tr>
<tr>
<td>Sep-Dec</td>
<td>448</td>
<td>165</td>
<td>7988</td>
<td>2281</td>
<td>2291</td>
<td>22346</td>
</tr>
<tr>
<td>Difference between December and Quota</td>
<td>-</td>
<td>-</td>
<td>2608</td>
<td>781</td>
<td>346</td>
<td>145</td>
</tr>
</tbody>
</table>

Source: OPEC Secretariat.
The termination of the quota system led to an increase in the production of Saudi Arabia, UAE and Venezuela, which altogether filled during the period September - December 1990 about 3.2 MMBD of the interrupted 4.4 MMBD of Iraq and Kuwait exports.

It is clear that the disruption of these exports did not result in a big decline in OPEC’s production. Actually the September to December production was only 145,000 BD short of OPEC’s ceiling, which partly explains the relatively small increase in prices during this crisis compared with the consequences of supply disruptions and price jumps during the Iranian revolution and the Iran/Iraq war.

The period 1991-1993 was transitional in terms of quota allocation. It was also a period characterised by growing demand for OPEC oil due to higher world demand especially from Asia and a declining production from the former USSR. The extra demands for OPEC oil were met by increasing volumes from Kuwait after the gradual resumption of its production and exports following liberation in February 1991. Saudi Arabia and the other members did not have to adjust their quotas downward much due to the growing demand for OPEC oil. The only time Saudi Arabia acted, along with UAE, as swing producer was in September 1993 when they had foregone an increase in their quota while all other members did, thus reducing their relative share in the OPEC ceiling.

Looking at the actual OPEC production performance during the period 1994-1997 it can be seen that OPEC had kept on rolling over its ceiling of quotas with Saudi Arabia’s
quota at 8.00 MMBD since September 1993. However, during this period OPEC actual production continued to rise irrespective of the ceiling, with Venezuela accounting for the largest quota violation. Actual Saudi production had been kept at 8.00 MMBD since November 1994 despite an increase in OPEC production of 19.409 MMBD. Some suggested that such behaviour on the part of Saudi Arabia was a de facto return to the swing producer role since it now has an excess crude oil capacity of 2.00 MMBD (towards the end of 1997) and therefore has room to increase its share but has foregone that option.

Saudi Arabia never responded to such assumptions which indicated that it was satisfied with its volume and with the prevailing prices. Prices improved in 1996 and 1997 which helped increase the government revenues. It seems that Saudi Arabia did not seek to maintain its share since it was receiving what it considered to be adequate revenues. Up until 1997 with every country in OPEC producing at maximum capacity except for Saudi Arabia (and to a lesser extent Kuwait and UAE) it seemed that the burden of balancing the market had again fallen on Saudi Arabia. However in December 1997, it insisted in the OPEC ministerial meeting for a certain increase by 2.5 MMBD to account for an actual production by OPEC in excess of the ceiling by such amount and to make OPEC ceiling more credible. The conference ended in a major ceiling and quota increase with Saudi Arabia 1998 quota at 8260 MMBD.

During this period, as in the other periods discussed earlier, Saudi production capacity was used as the market anchor. Prices remained at the levels of $18-22 throughout the period because of market perception that Saudi Arabia was not willing to use its excess capacity to regain its share. All suggestions that it would step in and
discretion quota violations, such as those by Venezuela, by flooding the market did not seem to be valid. Nazer maintained in the interview with the author that, this 2 MMBD gives Saudi Arabia an advantage over other producers, in the world oil market.

3.6 Conclusion

Even though the political and economic environment changes with time, the main objectives of Saudi Arabia's oil policy tends to be consistent. We can conclude that there are three dominant facts:

1. The high reserve-high production- and low cost of production.
2. The high dependence of the Saudi economy on revenues derived from oil exports.
3. Its role in the oil market where prices ad production have to follow the logic of market forces.

Saudi Arabia’s vast oil reserves, equivalent to 26% of the world’s total have facilitated the build up of sizeable production capacity, reaching 10.3 MMBD by the end of 1997. Being the largest exporter during the last 20 years, Saudi Arabia has been keen to maintain supplies to consumers at such high rates even in crises, for example, the Iranian production cut in 1978 and 1979, the Iranian and Iraqi production interruption during the first Gulf war and the Kuwait- Iraq export interruption during the second Gulf war of 1990-91. Saudi Arabia has thus contributed to the availability of energy supplies in the world helping to stabilise the market and the world economy.

Saudi oil policy seeks to maintain oil as a viable long-term source of energy. This comes from the long life expectancy of its oil reserves. Consequently Saudi Arabia has
used its high production capacity to be able to influence the oil market to maintain stable oil prices. It seeks to optimise the long-term value of its reserves, protect its share of the market and keep oil prices stable to enhance the role of oil in energy demand and its share in the market. At the same time, Saudi Arabia's policy is affected by market forces. The decline in output and prices during the eighties (resulting from overproduction by other members of OPEC and increase of non-OPEC supply) is evidence of market influence on Saudi oil production. However, Saudi Arabia has a monopoly power that influences the outcome of the oil market because the world knows that it has several million barrels of spare capacity that could be used to protect the country's long- and short-run interest.
Notes

1 The OECD countries.
2 There was an informal discussion over allocating output outside one of OPEC's meeting in Geneva, early 1978. (Yamani (1996)
3 According to Yamani, he went to the meeting with a proposal to raise the price to $7/B while other members insisted on a higher level of prices and pressured the Saudi Minister to go along with the majority. (interview, Dec. 12, 1996)
4 The auction was not taken for two reasons: first OPEC agreed to freeze oil prices. Second some members of OPEC (such as Algeria) requested Saudi Arabia not to do it (Ian Seymour interview, 24 Mar. 1997)
5 A drop from an average of 8479.7 MMBD in 1974 to an average of 7075.4 MMBD in 1975. (Source: OPEC secretariat)
8 Total world oil consumption declined from 2711.3 tonnes (55.0 MMBD) in 1974 to 2680.8 tonnes (54.5 MMBD) in 1975. Of which OECD was 1886.7 in 1974 and 1821.9 in 1975 (a decline of 1.1% of total world and 3% of OECD). Source BP.
9 MEES 28 February 1975.
10 For the upper tier crude, the marker was supposed to be priced at $ 12.79/B. For the lower tier crude the marker perceived price was $ 12.09/B (MEES 3 January 1977).
15 Source: Saudi Ministry of Petroleum and Mineral Resources.
16 PIW 4 April 1979
17 In 1975 and 1976 Arabian Light accounted for around 80% of total Aramco output and for 72% in 1977. (MEES 3 July 1978)
18 MEES 4 September 1978.
20 September. Total production of Iran (1100) + Iraq (2900) = 4,000 MMBD which declined to 600 in Oct. Saudi output (3.400) increased from 9709.1 in Sep to 10533.3 in October an increase of 824.2.
21 Source BP.
23 The North Sea and Mexico have increased by 20% from 1980 to 1985. (see Table 3.10)
24 Interview 1996
See Appendix 5.

West German weekly magazine Stern published on 7 July, (MEES 18 July 1983)
(MEES 15/August/1983).

(MEES 19/March/1984).

Yamanie’s Interview 12 December 1996.

According to Ian Seymour 1997) when discussing decreasing Saudi output, the Algerian Minister said that Saudi Arabia had to bear the burden of OPEC on its own, Seymour said this was the attitude of other Oil Minister towards Saudi Arabia.

Washington Post 15 January 1985)

See Appendix 3.

(MEES 18 August 1986).


MEES 21/28 December 1987.

No quota assigned for the period of 4th quarter 1991 to February 92 and for the 4th quarter of 1992 to February 1993. (see Appendix 6)


January. 1994 OPEC production - January. 1997 OPEC production = 26945.3-25004.4=1940.9 Thousands Barrel per Day.
Source OPEC Secretariat

Nazer interview 14 February 1997.
CHAPTER 4

ECONOMIC MODELS OF OPEC BEHAVIOUR

AND THE ROLE OF SAUDI ARABIA

4.1 Introduction

With the rise of the oil prices in 1973, numerous theoretical and empirical studies were undertaken to analyse the structure of the world oil market and the role of OPEC. Most of these models analyse the oil market concentrating on OPEC as a whole and analysing the Saudi role within the organisation.

With Saudi Arabia holding the highest world proven reserves, and a large share in world production and exports, different studies have reviewed the relevant models of OPEC behaviour and analysed Saudi Arabia's role separately. Griffin and Teece (1982) provided a collection of papers on OPEC and world oil where they divided the models of OPEC into two distinct areas. The first are the wealth maximising models that include monopolistic and competitive behaviour and the second are non-wealth maximising models. Griffin and Teece provided an interpretation of OPEC as the dominant producer with Saudi Arabia as the swing producer who absorbs the fluctuations in supply and demand. Cremer and Isfahani (1991) also provided a survey with different classifications of models on OPEC behaviour. Mabro (1991) reviewed relevant works related to the pricing of oil. He divided such works according to four lines of research. The first line dealt with the exhaustible resource theory, while the second analysed OPEC behaviour in relation to how far OPEC pricing was from
competitive behaviour. The third dealt with the game theory, while the fourth type of studies applied econometric tests.

All these previous studies have suggested ways of explaining the behaviour of OPEC as a group. The specific role of Saudi Arabia in the market and within OPEC has received attention from some authors. Since we are interested in analysing the behaviour of Saudi Arabia only, it is important to provide a unifying framework which can facilitate the comparison and testing of competing behaviours.

**Table 4.1: The Models of OPEC Behaviour.**

<table>
<thead>
<tr>
<th>Models Type</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Models that do not recognise Saudi Arabia’s role</td>
<td>Monolithic cartel</td>
</tr>
<tr>
<td></td>
<td>Competitive Model</td>
</tr>
<tr>
<td>Models that address Saudi Arabia’s role</td>
<td>Two block cartel</td>
</tr>
<tr>
<td></td>
<td>Geroski, Ulph and Ulph</td>
</tr>
<tr>
<td></td>
<td>Swing Producer</td>
</tr>
<tr>
<td>Other theories of OPEC behaviour in the oil market</td>
<td>Property Right</td>
</tr>
<tr>
<td></td>
<td>Fiscal Constraint Models</td>
</tr>
<tr>
<td></td>
<td>Target Capacity Utilisation</td>
</tr>
<tr>
<td>Econometric Studies</td>
<td>Griffin (1985)</td>
</tr>
<tr>
<td></td>
<td>Dahl and Yeel (1991)</td>
</tr>
<tr>
<td></td>
<td>Griffin and Neilson (1994)</td>
</tr>
<tr>
<td></td>
<td>Al-Turki (1994)</td>
</tr>
<tr>
<td></td>
<td>A-Yousef (1994)</td>
</tr>
<tr>
<td></td>
<td>Gulen (1996)</td>
</tr>
<tr>
<td></td>
<td>Doran(1982)</td>
</tr>
<tr>
<td></td>
<td>Moran(1982)</td>
</tr>
<tr>
<td></td>
<td>Golub(1985)</td>
</tr>
</tbody>
</table>

In this chapter we will divide, the models of OPEC's behaviour into four sets. The first set of models does not address the role of Saudi Arabia, such as the monolithic cartel models and
the competitive models. The second set examines the role of Saudi Arabia in the oil market such as the different group cartels, and the swing producer model. Then we will discuss other theories of OPEC behaviour that may apply to Saudi Arabia, namely the target capacity utilisation model, the fiscal constraint model and the property right model. This will be followed by a political interpretation of Saudi Arabia’s behaviour in the world oil market. The previous empirical tests such as Griffin (1985) Dahl and Yucel (1991) Griffin and Neilson (1994), Al-Turki (1994), Al-Yousef (1994), and Gulen (1996) will be reviewed in the world oil market. These models will be evaluated under the institutional evidence already discussed in chapter 3. Since Saudi Arabia is a major producer of oil it might use its production and pricing policies to achieve certain objectives. These objectives will be discussed in the light of each model and compared with the expected oil policy according to that model in order to identify those which are supported by the institutional evidence.

4.2 Models that do not Recognise Saudi Arabia’s Role

There are several studies that have analysed OPEC as a group with no emphasis on Saudi Arabia’s role. Most of these studies appeared right immediately the first price shock in the early seventies. Those models are grouped into two, the monolithic cartel model such as Gilbert (1978) Pindyck (1978) and Salant (1976) and the competitive model MacAvoy (1979).

4.2.1. The Monolithic Cartel

In these models OPEC is described as a unified group which sets prices for crude oil with no competition among its members. The "competitive fringe" or the price takers are the
non-OPEC suppliers. The competitive fringe will increase their production to equalise their short-term marginal cost with the price set by OPEC, which sets crude oil prices by taking into account non-OPEC supplies and costs. The demand for OPEC oil is the difference between the total world oil demand and non-OPEC supplies at different levels of OPEC prices. Thus, OPEC is viewed as the residual supplier.

In equilibrium, the price for both OPEC and the competitive fringe is equal. When OPEC sets the price, the competitor takes it as given, and produces the output which maximises its profit. When acting as the residual supplier OPEC's output will be equal to:

\[ Q_{P}^{OPEC} = Q_{P}^W - Q_{P}^{NO} \]  

where \( Q_{P}^{OPEC} \) is the OPEC supply, \( Q_{P}^W \) is world oil demand and \( Q_{P}^{NO} \) is the competitive fringe’s supply (non-OPEC suppliers).

According to Gilbert (1978) OPEC as a dominant cartel is a Stackelberg leader, the price maker, and the other producers are the price takers. OPEC is described as a dominant producer which maximises its profit by choosing an optimal production path taking into consideration the reaction of the fringe to its policies.

The competitive fringe takes prices as given and maximises its profit given the cartel's production path. The demand for the competitor depends on total world demand minus the demand facing the cartel. The production of the cartel is known by the fringe, the inverse demand function is \( P = f(Q_{t}^{NO}, Q_{t}^{OPEC}) \) and the cost function for both the fringe and the cartel production \( C = C(Q_t, S_t) \) where \( S_t \) is the remaining reserve.
The cartel, acting as a Stackelberg leader, chooses an extraction path that maximises profits taking into account the response of the competitive fringe and given that total extraction will not exceed total reserve. The response of the competitive fringe depends on the cost of extraction.

Pindyck (1978) used an intertemporal model where the demand facing OPEC is $Q^{OPEC} = Q^W - Q^{NO}$ and the $Q_t^{OPEC} = f(P_t, Q_{t-1}^{NO})$. The objective is to derive the price $P_t$ that would maximise the sum of the discounted profits of the cartel taking into account the rate of depletion, reserve level, and production cost.

$$\text{Max}_{P_t} = \sum_{t=1}^{T} \frac{1}{(1+r)^t} \left[ P_t - \frac{m}{R_t} \right] Q_t^{OPEC}$$

where $r$ is the cartel's rate of discount and $m/R_t$ is the average production costs that go to infinity as the resource is exhausted.

Salant (1976) assumed that the oil market is dominated by an OPEC cartel that takes the sales path of the fringe as given and maximises its joint discounted profits. Here the cartel takes account only of the response of consumers to its policies and does not account for the response of the fringe (Nash Cournot behaviour).

Salant analysed the market structures consisting of the competitive firms on the one hand and on the other the producers forming a collusive cartel which dominates the oil market. The price path of a competitive market rises at the rate of interest until the initial stock of all firms is exhausted. The cartel will continue to sell after the competitors stop
selling at prices following the monopolistic path where the rate of increase in price is less than the interest rate on other assets until it reaches the backstop price.

According to this model, OPEC is a unified cohesive group that maximises its profits without any competition among its members. It is the residual supplier who sets the price. The competitive fringe is the non-OPEC supplier (price taker) with limited production capacity. The power of OPEC would depend on the elasticity of demand facing it, the elasticity of non-OPEC supply and the relative share of OPEC in world supply. In such models world demand depends on the real price (\(P\)) and economic activity (\(A\)) while non-OPEC production depends on real price (\(P\)) and exogenous supply variables (\(Z\)).

\[
Q^{OPEC} = Q^W_P - Q^{NO}_P, \quad 4.3
\]

Accordingly, OPEC supply as a unified group would be a function of the real price of oil, economic activity and non-OPEC supply:

\[
Q^{OPEC} = f(P, A, Q^{NO}) \quad 4.4
\]

Saudi Arabia’s production is a percentage of total OPEC production \(Q^{SA} = aQ^O\) since \(Q^{OPEC} = Q^{oo} + Q^{SA}\). where \(Q^{oo}\) is the production of other members. Thus, to test if Saudi Arabia is a member of a monolithic cartel

\[
Q^{SA} = f(Q^{oo}, P) \quad 4.5
\]

According to this model, Saudi Arabia is a member of a unified group, which means it will be acting in full co-operation with the other members of OPEC. According to the model, since Saudi Arabia and the other Gulf producers have the lowest production cost, full co-operation means that the production in the early period should be from those with the higher costs. However, there are sufficient significant differences in the OPEC members’ oil
Throughout the seventies and into the mid eighties when prices were set by OPEC, Saudi Arabia insisted that OPEC should follow a policy of price moderation. When the industrialised countries started to show signs of economic recovery after the first oil price increase in 1974 and the demand for oil was increasing, some OPEC members demanded an increase in the price level. However, Saudi Arabia argued that such an increase was inappropriate and thus was able to block any price increase until December of 1976. During the 48th OPEC conference in Doha, Qatar in December 1976, Saudi Arabia and UAE agreed to increase their prices by only 5% while other members insisted on a price increase of 10%. This resulted in the famous two tier price system which continued until the next conference (July 1977) when Saudi Arabia and the UAE agreed to increase their price by another 5% while the other members froze theirs. Another incidence of divergence between Saudi Arabia and other members was during the Iran crisis in 1978-1979, when it increased its production at official prices which were lower than spot prices in order to prevent further increases in oil prices. This was criticised by other members of OPEC who set their prices in line with that of the spot market.

During 1979/1981 Saudi Arabia tried to bridge the gap between its official price and that of other members by increasing the price of its Arabian Light crude. The other members responded by increasing their prices further. At one time the price of Iranian Light was $30/B compared to $24/B for Arabian Light, a similar product. But between 1983 and 1985 Saudi Arabia's Arabian Light 34° (the official price) was $28/29/B while spot prices in the
market were declining to a lower level, due to lower demand and increasing excess capacity in OPEC and world-wide crude oil production. Thus, even with the effort of Saudi Arabia, spot prices differ than the official prices of OPEC.

When OPEC abandoned the fixed official price structure in 1987 and chose quota allocation alone as a means to control the market, differences continued among its members concerning the appropriate quota for each member, the observance of the quotas and the choice of the ceiling. Saudi Arabia and other GCC members argued for a higher ceiling for OPEC in order to stimulate demand and advocated quota distribution along oil related criteria such as reserves, historical production and sustainable capacity.

During the seventies and until the mid eighties, the monolithic cartel model did not apply to OPEC owing to the disagreements over appropriate oil prices in most of its meetings. After 1986, disagreements over ceilings, quotas and cheating by other members as well as the decline of the monopolistic power of OPEC were all so evident that Saudi Arabia was not acting as a member of Monolithic group.

4.2.2 The Competitive Model

According to this model the market is the main determinant of oil price changes. The increase in demand and the decline in world oil discoveries during the 1960 and early 1970s, might have increased depletion and user costs causing the price of oil to rise. MacAvoy (1982) explained the changes in oil prices by focusing on supply and demand rather than cartel behaviour. Price increases were attributed primarily to supply disruptions. MacAvoy explained the price increase in 1973 as a result of speculative increases in demand because of
the supply cutback. The rise of prices in 1979 and 1980 was brought about by a decline in production due to the Iranian revolution and the Iraq-Iran War. On the other hand, most of the cutbacks imposed by OPEC have had limited effects. MacAvoy found that demand and reserve conditions were more important in influencing the oil price increase. Thus, oil supply ($S_t$) is a function of price ($P_t$), Reserves ($R_t$) and supply of the past period ($S_{t-1}$).

$$S_t = f(P_t, R_t, S_{t-1})$$  

Demand is a function of prices $P_t$, income $Y_t$ and past period demand $D_{t-1}$

$$D_t = g(P_t, Y_t, D_{t-1})$$

MacAvoy simulated the equilibrium prices under a number of assumptions using actual reserves, income, and some stipulated elasticities. His finding was that OPEC should not take credit for the cutback of supply, but only for restraining the supply expansion response in member countries. MacAvoy in his simulation model realised the significant role of Saudi Arabia in that if there is a substantial change in Saudi production it will have an effect on oil prices, since it has a very low production/reserve ratio, that gave Saudi Arabia the ability to change the level of output according to its objective.

Under the assumption of a competitive market, OPEC will not have any monopoly power. Thus, a competitive exhaustible resource producer will set its price to its marginal cost plus its user cost. It follows that Saudi Arabia would act as a competitive producer whose price is influenced by market forces and changes in its output will not have any effect on the price level.

According to this model, the changes in oil prices are explained by focusing on supply and demand rather than cartel behaviour. MacAvoy (1982) explained that the price
increase in 1973 was a result of speculative increases in demand because of the supply cutback. The rise of prices in 1979 and 1980, was brought about by a decline in production as a result of the Iranian revolution and the Iraq-Iran war. In all major events the market generally determined the price.

Table 4.2: Demand for Crude Oil, 1974-1979 (MMBD)

<table>
<thead>
<tr>
<th>Year</th>
<th>World Demand</th>
<th>OPEC</th>
<th>Change in OPEC production</th>
<th>Saudi Arabia</th>
<th>Change in Saudi Arabia production</th>
<th>Non-OPEC</th>
<th>Change in non-OPEC</th>
<th>Oil Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1974</td>
<td>45.8</td>
<td>30.6</td>
<td>-8.5</td>
<td>8.5</td>
<td>18.4</td>
<td>11.58</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1975</td>
<td>44.6</td>
<td>27.0</td>
<td>-3.6</td>
<td>7.1</td>
<td>-1.4</td>
<td>18.5</td>
<td>+0.1</td>
<td>11.54</td>
</tr>
<tr>
<td>1976</td>
<td>47.4</td>
<td>30.6</td>
<td>+4.6</td>
<td>8.6</td>
<td>+1.5</td>
<td>18.9</td>
<td>+0.4</td>
<td>11.51</td>
</tr>
<tr>
<td>1977</td>
<td>48.9</td>
<td>31.1</td>
<td>+0.7</td>
<td>9.2</td>
<td>+0.8</td>
<td>20.1</td>
<td>+0.2</td>
<td>12.40</td>
</tr>
<tr>
<td>1978</td>
<td>50.3</td>
<td>29.6</td>
<td>-1.5</td>
<td>8.3</td>
<td>-0.9</td>
<td>21.6</td>
<td>+1.5</td>
<td>12.70</td>
</tr>
<tr>
<td>1979</td>
<td>50.9</td>
<td>30.7</td>
<td>+1.1</td>
<td>9.5</td>
<td>+1.2</td>
<td>22.8</td>
<td>+1.2</td>
<td>17.28</td>
</tr>
</tbody>
</table>

Source: BP statistics.

According to this model, members of OPEC, including Saudi Arabia, take the oil price as given, assuming that changes in each member's output will not have any effect on the price level. The oil prices are determined by the fundamentals of supply and demand. Therefore an increase or a decrease in Saudi output would have no effect on the oil prices.

However, a close look at the market raises doubts about the competitive models. After WWII when the oil market was dominated by the majors, prices ranged between $1.75 and $1.80/B (source: BP), increased during the 1956 Suez war to $2.08/B and eventually returned to $1.90/B in 1959. Prices remained at this level until 1971 when they rose to $2.18/B. The stability of these prices, which remained steady in spite of the increase in oil demand during the sixties, is an indication of the monopolistic power of the majors. However, between 1973 and 1978 OPEC had power over oil prices. OPEC and Saudi
Arabia’s shares in the market were high enough to enable them to have some influence in oil prices on 1973-1978 (see section 3.2.) when oil prices were fixed by OPEC.

Between 1974 and 1978 world demand for oil was fluctuating; it declined in 1975 by 1.2 MMBD, while the demand for OPEC and Saudi crude declined by 3.6 and 1.4 MMBD respectively in 1975. This, as discussed above, resulted from the decline in demand caused by the recession at that time and the increase in non-OPEC supply. However, oil prices were stable with an average of $11.58/B due to the inelasticity of the supply curve, even with fluctuating demand prices should have more fluctuation in the short-run. In 1978, although the world demand for oil increased, the demand for OPEC and Saudi Arabian oil declined. However, the price for oil stayed at $12.7/B and the requirements from OPEC and Saudi Arabia declined in response to the higher official prices.

The competitive model would necessitate (in the short-run) a decline in prices as a result of decreasing demand during some of the period 1979-1981. However despite that, spot prices were running higher than official prices (see Table 4.3 and Figure 3.2, Figure 3.4)). The competitive model explains this spot price behaviour as being due to supply uncertainty resulting from political events and the scramble of consumers which bid prices up. But during the following period from 1982-1985, by sticking to official prices and lowering its production to defend such prices, Saudi Arabia kept spot prices ranging closer to the official. Had Saudi Arabia abandoned volume control and followed the spot market, prices might have deteriorated to much lower level. The experience of 1986 testifies to this. When Saudi Arabia chose the competitive solution, prices dropped to less than $10/B following the introduction of netback pricing and the beginning of market-related prices.
When OPEC, under the leadership of Saudi Arabia, decided to cut back its production and reinstate the quota system, prices went back to $17/B. Therefore, the only time the market was competitive, was in 1985/86 when OPEC production was a free for all and when Saudi Arabia produced at closer to full capacity.

Table 4.3: Demand for Crude Oil. (MMBD) 1979-1982.

<table>
<thead>
<tr>
<th>Year</th>
<th>World demand</th>
<th>OPEC production</th>
<th>Saudi Arabia production</th>
<th>Official prices $/B</th>
<th>Spot prices $/B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1979</td>
<td>64.1</td>
<td>30.7</td>
<td>9.5</td>
<td>17.28</td>
<td>30.02</td>
</tr>
<tr>
<td>1980</td>
<td>61.5</td>
<td>26.7</td>
<td>9.9</td>
<td>28.68</td>
<td>35.94</td>
</tr>
<tr>
<td>1981</td>
<td>59.9</td>
<td>22.4</td>
<td>9.8</td>
<td>32.50</td>
<td>34.26</td>
</tr>
<tr>
<td>1982</td>
<td>58.3</td>
<td>18.8</td>
<td>6.5</td>
<td>34.00</td>
<td>31.75</td>
</tr>
</tbody>
</table>

Source: BP statistics.

Another argument against the competitive model is that, marginal revenue was higher than marginal cost through the period. Whilst the marginal cost of barrel of crude oil was less than $1/B, the price never fell below $8/B which indicate that MR>MC. However, one might say this is due to the nature of oil as an exhaustible resource (see Fisher, 1981 among others) since the marginal cost of a barrel of oil includes the user cost MC= MR-User Cost, where user cost depends on the discount rate of the producer. However, with a free-for-all policy dominating the oil market in 1986, the price did not reach the marginal cost (for example the lowest price for API 34°, was $8/B in August, 1986).

This history indicates that Saudi Arabia has influenced the oil market since 1974 through different means, including insisting on moderate price increases, and using its output capabilities to influence the market outcome. The Doha 1976 price split, the utilisation of excess capacity in the 1978-1980 period to fill the shortfall of Iraqi and
Iranian disruptions, the output response in the second Gulf crisis and the production restraint throughout the period 1987-1997 are all examples of the extent of the influence that Saudi Arabia has exercised in the world oil market.

4.3. Models that Address Saudi Arabia’s Role

On 16 October 1973, OPEC Gulf producers decided to set the price unilaterally from $3.011/B to $5.119/B. When that was followed in December 1973 by another unilateral increase to $11.621/B by all OPEC members (Seymour, 1980), the description of OPEC as a cartel was introduced to the literature. An important aspect of OPEC relates to the role, the objective and the policies of Saudi Arabia. Given the size of its proven reserves and large share in world oil production and exports, the importance of the Saudi role was discussed in several studies in the early seventies. Mabro (1975) indicated that “OPEC is Saudi Arabia” while several studies of OPEC have treated Saudi Arabia separately and pointed to its importance as a cartel member. (for example Stevens, 1982).

OPEC has been described as a cartel able to raise prices through co-operation in reducing the quantity of the commodity supplied, causing prices to exceed the marginal cost. These models assume that the oil market is dominated by cartel whose members co-operate in order to maximise their joint profits. Producers in this model take into consideration the responses to their policies of both consumers and non-cartel producers. Where other models are used, there are several variants: the two-block cartel, the dominant producer model with Saudi Arabia as a swing producer and the market-sharing cartel.
through the use of the Nash solution and depends on the negotiated agreement between the two groups. If the share is fixed, OPEC will choose that of the monopolistic price. The model suggests that spender countries would produce first because of the high discount rate, while the savers will produce last.

In this model Saudi Arabia is a member of the saver group which means that would cooperate with Kuwait, UAE, Qatar, Libya and Iraq in order to maximise the group profit. To be a member of the saver group Saudi Arabia has to have a limited domestic absorptive capacity, large surplus and hence, low discount rate. The model suggests the use of Nash bargaining between the two groups and the spender group should produce first which means that Saudi Arabia and other members of the saver group should wait until the resources run out before they produce, Hnyilicza and Pindyck assumed that a fixed share of total production and bargaining between the two groups should relate to the overall production of OPEC. Thus, according to this model Saudi Arabia would have a certain percentage of agreed production, which should be low enough to allow the spenders to produce enough to maximise their profit. Saudi Arabia should also be in full co-operation with the saver group.

In respect of pricing and production decisions from Libya, and Iraq (Doha’s two tier prices and 1979/81 price increase where Saudi Arabia was joined only by the UAE) and differs in respect of pricing, to all other members of OPEC. Its production at certain periods was at full capacity while others were charging prices as high as the market would permit. Furthermore, from the history of the dispute between Saudi Arabia and some members of the saver group, most notably Libya and Iraq, full co-operation between members was unlikely. However, between 1983 and 1985, Saudi Arabia co-
operated with the other members and this led to a decline in its oil production and revenue. Thus ultimately in 1985, it abandoned its position as the swing producer.

Model of Geroski, Ulph and Ulph (1987): OPEC is described as a cartel where the behaviour of producers varies over time in response to previous data and the co-operation of other producers. It also varies according to the producer willingness to allow others to cheat, and the weight they put on long-run and short-run profits, which depends on their financial needs.

\[ q_{it}^* = \alpha_{i0} + \sum_{j=1}^{n} \alpha_{ij} p_{jt} + \sum_{k=1}^{m} \beta_{ik} Y_{kt} \]  

where \( p_{jt} \) are the prices of OPEC producers, and \( Y_{kt} \) are exogenous variables such as income, temperature and seasonal variables. By placing certain restrictions, the long-run demand (\( q_{i}^* \)) for OPEC members' production using the distributed lag model is given by

\[ q_{it} = \gamma_{i0} q_{it}^* + \sum_{L=1}^{L} \gamma_{iL} q_{i,t-L} + D_t \]

where \( D_t \) are supply interruption dummies, \( q_{it} \) and \( q_{i,t-1} \) the short-run demand and the production of the last period respectively.

With the above two equations and, with \( C_i \) being the unit costs of production which are assumed to be constant the \( i^{th} \) producers long-run and short-run profits are

\[ \Pi_i^S = (P_i - C_i) q_{i}^* , \quad \Pi_i^L = (P_i - C_i) q_i \]

Thus, the objective function where the producers follow a Nash equilibrium is to maximise \( V(P) \) and is given by
\[ V_t(P_t) = \delta \prod_{i=1}^{L} (P_t) + (1 - \delta_i) \prod_{i}^{S} (P_t) + \theta \sum_{j=1}^{L} \prod_{i}^{P_t} \]  

where \( P_t = (P_{1t}, \ldots, P_{nt}) \) is the vector of prices. The equation reflects the varying conduct of the producer \( i \), where \( \delta \) is the weight the \( i \) producer puts on long-run profit and \( (1-\delta) \) is the weight it puts on other short-run-profits, \( \theta \) the value of which reflects the degree of co-operation. It is the weight producer I attaches to the long-run profits of other producer. If \( \theta = 0 \) it indicates non-co-operative equilibrium which depends on the \( i \) producer's excess capacity, while the coefficient \( \delta \) depends on the financial needs of producers. The need for short-term profits would lower the value of \( \delta \), raising the non-co-operative behaviour.

By dividing the ten major OPEC producers into four groups, (fringe, high absorbers, low absorbers and Saudi Arabia) and using quarterly data for the period 1966-1981, Geroski et. al, estimated the model in two stages. First, by estimating the demand parameters and then by imposing these parameters on the first order conditions to maximise profits, they concluded that the member countries' conduct varies over time.

Al-Roomy (1987) extended the model of Geroski, Ulph and Ulph by trying to model the complete world oil market. He studied the interaction between OPEC and major non-OPEC producers, using monthly data for the period 1974-84. Al-Roomy grouped producers of oil into four groups; Saudi Arabia, the Gulf, African producers, and the fringe. He also used \( \theta \) as the only source of variation in the behaviour of each country's financial needs. While Geroski et. al. assumed cost as constant, Al-Roomy took into account various estimates of production costs. By using monthly data, he tested the model and concluded that price movements cannot be explained solely by conventional supply and demand features.
In the Geroski, Ulph and Ulph model and the Al-Roomy model, in addition to the same criticism that was discussed above for the division of OPEC producers into four groups (fringe, high absorbers (African producers), low absorbers (Gulf producers) and Saudi Arabia), the GUU model used events of the market to build the model. The problem with this approach is that models should explain the changes in the market, while GUU use the events to implement the model.

4.3.2 The Dominant Producer Model with Saudi Arabia as Swing Producer

OPEC as a monolithic cartel is capable of setting the price that maximises its discounted profits. In the long-run, if the price was high enough to provide a positive economic profit to the fringe competitors, oil would be discovered elsewhere and alternative energy forms would be developed. According to Seymour (1990) the higher price levels increased the pace of oil development in established fields, such as the North Sea, encouraged discoveries of new fields, and made the high cost fields more profitable. Under these conditions, the demand for OPEC oil would decline. Therefore, in order to maintain the monopolistic price, the output of the cartel must be restricted through the allocation of output quotas among its members. Some models attribute the cartel's stability to some members acting as swing producers in order to keep OPEC's output at a certain level. The swing producer role was borne by the producer with large revenues and limited absorptive capacity.

Griffin and Teece (1982) described Saudi Arabia as the swing producer or the balance wheel absorbing demand and supply fluctuations in order to maintain the monopoly price. They stated that the monopoly price and the stability of OPEC depends more on how much
Saudi Arabia’s share satisfies its objective, than on the cartel’s cohesion. According to this model, Saudi Arabia would choose the price path when maximises its wealth over time taking into account the reaction of the fringe.

Adelman (1982) described OPEC as a loosely co-operating oligopoly-cartel or a residual-firm monopolist, that lets everybody else maximise profits individually by choosing their own production levels while the cartel raises prices by restricting output. OPEC chooses its own production, to maintain the cartel price and Saudi Arabia acts as the swing producer. Adelman gave an example of output restriction in 1975, when Saudi Arabia reduced its production from an average of 8479.7 Thousands Barrel per Day in 1974 to an average of 7075.4 Thousands Barrel per Day in 1975 in order to maintain the price of oil at the monopolistic level.

Mabro (1975, 1986, 1988, 1991) like Adelman, but from a different perspective, draws attention to the important role of Saudi Arabia in OPEC. He applied the dominant producer theory to the oil market and noted that OPEC is a cartel with Saudi Arabia acting as a Stackelberg price leader. In the seventies, OPEC determined the price of Arabian Light as a reference, and the members of OPEC then set the price of their oil, selling as much as they wanted, while Saudi Arabia was able to maintain its role as the residual supplier because of its relatively lower absorptive capacity. However, the expansion of non-OPEC supply in the eighties caused the demand for OPEC oil to decline, and when this demand was less than the aggregate volume which could be produced, excess capacity increased, causing difficulties in maintaining prices. According to Mabro, OPEC’s ability to survive was more apparent in the
eighties (when demand for its oil was shrinking and the organisation started allocating output under a quota system in 1982) than in the seventies.

In explaining the causes of the 1986 oil price collapse, Al-Moneef (1987), saw it as a result of Saudi Arabia abandoning the swing producer role when it became less rewarding. This was as a result of the structural changes in world oil demand and non-OPEC supply, reducing OPEC’s market share and that of Saudi Arabia, thus undermining the effectiveness of the residual role of OPEC and the swing role of Saudi Arabia. Cremer and Salehi-Isfahni (1991) in their review of world oil market models, analysed the role of Saudi Arabia as the dominant firm. Saudi Arabia has significant market power in the short-run, but in the long-run the influence of Saudi production is small because world demand and supply of the fringe is more elastic.

Askari (1991) reviewed Saudi Arabia’s oil policy in a different period when as a major player of OPEC between 1973 and 1978, it supported the organisation, but, at the same time was reluctant to see the price of oil rise high enough to cause any damage to the world economy. During the period 1978-1981 Saudi Arabia increased its output to the maximum sustainable capacity to prevent price increases as a result of economic and political factors, to avoid further shocks to the world economy and to keep low prices for its long-term interest. From 1982-1985 Saudi Arabia continued to act as a swing producer to maintain OPEC price levels producing below its capacity for four years. By 1985, a long and costly period of production cutbacks resulted in the need for short-term revenue.
4.4 Other Models of OPEC Behaviour

In this section we will explore alternative approaches to explain the behaviour of OPEC members, paying particular attention to Saudi Arabia. Such models fall within these categories: the property rights model, the fiscal constraint model and the target utilisation model.

4.4.1 Property Rights Model

This model involves the effects of the transfer of ownership from international oil companies to the governments of the oil-exporting countries. The high discount rate employed by companies which led them to excessive production, was transformed through the change in property rights to lower rates by the governments who favoured lower production to account for exhaustibility.

Johany (1978, 1980), adopted the property rights model to explain the oil price increase of 1973-74. Johany argued that the sharp increase in the market price of oil that followed the October 1973 Arab Israeli War, was not because OPEC had become an effective cartel capable of reducing output to raise prices. Rather, it was the result of a shift towards price setting by the oil producers instead of through negotiations with the oil companies, as had been the practice before October 1973. The role of the oil companies was reduced essentially to that of contractors, and because OPEC countries have a lower discount rate than the companies' effective discount rate, their oil output since 1973 has been lower than what it would have been if the companies were still the owners of crude, which would have led to higher oil prices.
**Table 4.4: The Average Percentage Change for Saudi Oil Production from 1969-1996**

<table>
<thead>
<tr>
<th>Year</th>
<th>Production</th>
<th>%change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1969</td>
<td>3216.2</td>
<td></td>
</tr>
<tr>
<td>1970</td>
<td>3799.1</td>
<td>18.1</td>
</tr>
<tr>
<td>1971</td>
<td>4768.9</td>
<td>25.5</td>
</tr>
<tr>
<td>1972</td>
<td>6016.3</td>
<td>26.2</td>
</tr>
<tr>
<td>1973</td>
<td>7596.2</td>
<td>26.3</td>
</tr>
<tr>
<td>1974</td>
<td>8479.7</td>
<td>11.6</td>
</tr>
<tr>
<td><strong>Aver 1969-1974</strong></td>
<td><strong>=22%</strong></td>
<td></td>
</tr>
<tr>
<td>1975</td>
<td>7075.4</td>
<td>-0.17</td>
</tr>
<tr>
<td>1976</td>
<td>8577.2</td>
<td>+0.175</td>
</tr>
<tr>
<td>1977</td>
<td>9199.9</td>
<td>+0.07</td>
</tr>
<tr>
<td>1978</td>
<td>8301.1</td>
<td>-0.10</td>
</tr>
<tr>
<td>1979</td>
<td>9532.6</td>
<td>+0.15</td>
</tr>
<tr>
<td>1980</td>
<td>9900.5</td>
<td>+0.04</td>
</tr>
<tr>
<td><strong>aver.1974-1980</strong></td>
<td><strong>=+09.7%</strong></td>
<td></td>
</tr>
<tr>
<td>1981</td>
<td>9808.0</td>
<td>-0.34</td>
</tr>
<tr>
<td>1982</td>
<td>6483.0</td>
<td>-0.30</td>
</tr>
<tr>
<td>1983</td>
<td>4539.4</td>
<td>-0.30</td>
</tr>
<tr>
<td>1984</td>
<td>4079.1</td>
<td>-0.10</td>
</tr>
<tr>
<td>1985</td>
<td>3175.0</td>
<td>-0.22</td>
</tr>
<tr>
<td><strong>Ave. 1981-1985=+25.2%</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1986</td>
<td>4784.2</td>
<td>+0.51</td>
</tr>
<tr>
<td>1987</td>
<td>3975.2</td>
<td>+0.28</td>
</tr>
<tr>
<td>1988</td>
<td>5083.5</td>
<td>-0.003</td>
</tr>
<tr>
<td>1989</td>
<td>5064.5</td>
<td>+0.27</td>
</tr>
<tr>
<td>1990</td>
<td>6412.5</td>
<td>-0.27</td>
</tr>
<tr>
<td>1991</td>
<td>8117.8</td>
<td>+0.03</td>
</tr>
<tr>
<td>1992</td>
<td>8331.7</td>
<td>+0.03</td>
</tr>
<tr>
<td>1993</td>
<td>8047.7</td>
<td>-0.03</td>
</tr>
<tr>
<td>1994</td>
<td>8049.0</td>
<td>-0.00</td>
</tr>
<tr>
<td>1995</td>
<td>8000.0</td>
<td>-0.01</td>
</tr>
<tr>
<td>1996</td>
<td>8000.0</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>ave.1988-1996=+00.1%</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: OPEC Statistical Bulletin

The property rights model assumes that when the ownership of oil companies transferred from the company to the government of the producing countries, the discount rate dropped because the time horizon for the concessionaires is limited as compared with an oil producing government. For Saudi Arabia, the changes in ownership started with the participation agreement signed in 1972 and its influence on the production of the oil
company in the following year. By 1980,\(^4\) Aramco was totally owned by the government. The gradual transfer of ownership between 1972 and 1981 and its effect on Saudi Arabia’s production and pricing of oil should be analysed to see if the changes in rate of production had any relation to the percentage of government equity.

In this model, Saudi Arabia has a lower discount rate, since it has a longer horizon for production. Accordingly, production would fall, thereby driving up the world price. Production of Saudi Arabia and its rate of change in output level between 1969 and 1996 are shown in Table 4.4.

The table shows that production increased by an average of 22% annually during the 1969-1973 period. During the period of government control (1975-1980), the rate of change of Saudi Arabian output averaged 9%. The swing producer period (1981-1985) production changes averaged at a rate of -25.2%. While the period of flexible price volume control of 1988-1996 averaged a rate of production change of 0.1%.

The rate of change in production between 1969 and 1974, could be explained by the desire of Saudi Arabia for nationalisation,\(^5\) and the change in power of decisions over production in 1974 from the company to the government. From 1981 to 1985 the rate of change in production become negative. From 1988 to 1996 it averaged 0.1%. Thus, this approach explains one event, the changes in the rate of production between 1969 to 1974, when the four owners of Aramco had a short horizon in controlling oil production in Saudi Arabia\(^6\). However, it has little relevance to later history.
Moreover, while the theory partly explains the price increase in 1973, it does not explain the decline in prices during the eighties. According to the theory, following the 1979/80 price rise (due to a short-run of supply constraints) it would return to its initial level and then gradually increase. However, in real terms the price of oil fell lower in real terms than it had done in the sixties.

4.4.2 Target Capacity-Utilisation Model (TCU):

There are two assumptions on which the target capacity-utilization models are based: First, OPEC is the residual supplier of the world oil market; Second, OPEC prices are influenced by the gap between its current capacity utilization and some target level of capacity-utilisation.

The TCU model relates the production of OPEC to the rate of capacity-utilisation, which is measured as the production level divided by the production capacity level. Those who have tested the model previously found that prices would increase dramatically at high capacity-utilisation and decrease slowly at low rates of utilization.

According to this view, OPEC attempts to maintain capacity-utilisation near a target level. If capacity-utilization rises above the target then high demand stimulates OPEC price increases. The price increase will subsequently lower demand and reduce capacity-utilization down to the target. If capacity-utilization falls below the target, then OPEC uses price reductions to stimulate demand and increase utilization, until the target is reached. The target-capacity pricing model was used for OPEC by the US Department of Energy's Energy Information Administration (DOEEIA) where they used regression analysis.
between annual percentage changes in real prices and OPEC capacity utilization to forecast the price of oil.

To evaluate the ability of a target-capacity rule to satisfy OPEC's objective, Steven Suranovic (1993), defined capacity-utilisation, CU, as

$$CU_t = \frac{S^{\text{opec}}}{\text{MAXCAP}_t}$$  \hspace{1cm} 4.15

where $S^{\text{opec}}$ is OPEC supply at time $t$ and MAXCAP$_t$ is OPEC maximum sustainable capacity given exogenously. The relationship between the rate of change of the world oil price and capacity is given by:

$$\frac{P_t - P_{t-1}}{P_{t-1}} = a + \frac{b}{1 - CU_t}$$  \hspace{1cm} 4.16

Stephen Powel (1990) used the historical behaviour of the world oil market by plotting the annual percentage change in price and capacity utilization. He concluded that there is a relationship between the high capacity utilization and price increases, and low capacity utilization and price decreases, but he was critical of its continued use for forecasting after 1985.

Powel (1990) and Porter (1992) have been critical of the TCU because the deteriorating empirical basis of the statistical relationship after 1985 diminished its predictive value. Gately (1995) criticised the TCU model because of the shift of Saudi Arabia and other OPEC producers towards production ceilings and quotas. To apply this mode to Saudi Arabia we need to find out if there is a relationship between annual percentage changes in prices and Saudi Arabia's capacity utilisation, and the price.
In this model, Saudi Arabia should attempt to maintain capacity utilization near a target level (TCU), which was assumed by the model to be around 80%. Investigating the CU for Saudi Arabia, by dividing the total Saudi output by maximum sustainable production capacity, CU ranged from a high of 0.92 in 1980 to a low of 0.34 in 1985 averaging 0.70 over the period (Table 4.5).(see Figure 4.1).

Table 4:5 Crude Oil Production and Capacity of Production for Saudi Arabia (1976-1993)

<table>
<thead>
<tr>
<th>Year</th>
<th>Capacity</th>
<th>Production</th>
<th>CU</th>
<th>Price</th>
<th>Year</th>
<th>Capacity</th>
<th>Production</th>
<th>CU</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976</td>
<td>10790</td>
<td>8577.2</td>
<td>0.79</td>
<td>11.51</td>
<td>1987</td>
<td>8800</td>
<td>3975.2</td>
<td>0.45</td>
<td>17.73</td>
</tr>
<tr>
<td>1977</td>
<td>11840</td>
<td>9199.9</td>
<td>0.78</td>
<td>12.40</td>
<td>1988</td>
<td>7750</td>
<td>5083.5</td>
<td>0.58</td>
<td>14.24</td>
</tr>
<tr>
<td>1978</td>
<td>11840</td>
<td>8301.1</td>
<td>0.70</td>
<td>12.70</td>
<td>1989</td>
<td>7250</td>
<td>5064.5</td>
<td>0.69</td>
<td>17.31</td>
</tr>
<tr>
<td>1979</td>
<td>11840</td>
<td>9532.6</td>
<td>0.92</td>
<td>17.28</td>
<td>1990</td>
<td>7750</td>
<td>6412.5</td>
<td>0.82</td>
<td>22.26</td>
</tr>
<tr>
<td>1980</td>
<td>10800</td>
<td>9900.5</td>
<td>0.92</td>
<td>28.67</td>
<td>1991</td>
<td>9150</td>
<td>8117.8</td>
<td>0.88</td>
<td>18.62</td>
</tr>
<tr>
<td>1981</td>
<td>11300</td>
<td>9808.0</td>
<td>0.87</td>
<td>32.50</td>
<td>1992</td>
<td>8675</td>
<td>8331.7</td>
<td>0.91</td>
<td>18.44</td>
</tr>
<tr>
<td>1982</td>
<td>11700</td>
<td>6483.0</td>
<td>0.55</td>
<td>32.38</td>
<td>1993</td>
<td>9000</td>
<td>8047.7</td>
<td>0.89</td>
<td>16.33</td>
</tr>
<tr>
<td>1983</td>
<td>11300</td>
<td>4539.4</td>
<td>0.40</td>
<td>29.04</td>
<td>1994</td>
<td>9500</td>
<td>8049.0</td>
<td>0.85</td>
<td>15.53</td>
</tr>
<tr>
<td>1984</td>
<td>11300</td>
<td>4079.0</td>
<td>0.36</td>
<td>28.20</td>
<td>1995</td>
<td>10000</td>
<td>8000.0</td>
<td>0.80</td>
<td>17.18</td>
</tr>
<tr>
<td>1985</td>
<td>9300</td>
<td>3175.0</td>
<td>0.34</td>
<td>27.01</td>
<td>1996</td>
<td>10000</td>
<td>8000.0</td>
<td>0.80</td>
<td>19.81</td>
</tr>
<tr>
<td>1986</td>
<td>8800</td>
<td>4784.2</td>
<td>0.54</td>
<td>13.53</td>
<td>1997</td>
<td>10300</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: OPEC Secretariat.

The model fails both to explain the rationale behind choosing a particular capacity utilisation rate, and to project the best capacity that could be maintained over a long period of time. However data show that when capacity is high for a period, the next period would have higher oil prices. For example, the highest CU was in 1980, the following period (1982) showed the highest spot prices, and in 1985 when CU as low as 34% the average oil price for (1986) went down to $13.53/B. This concept was used to predict oil prices in the period before 1987 by the US Department of Energy’s Information Administration (DOEIA). But this could be applied only before 1987.
4.4.3 The Fiscal Constraint Model

In the model espoused by Ezzati (1976,1978) and Cremer and Salehi-Isfahani (1980), OPEC member countries are developing nations, some with limited absorptive capacity. It is expected that when oil revenues become large in comparison to the country's needs, output levels would be restricted to decrease the oil revenue and force it to come in line with the country's needs. However, others such as Adelman (1993) found that with low oil prices and given countries' financial needs some members of OPEC tried to increase their production level to cover their economic needs.

In the late seventies the absorptive capacity of members of OPEC was discussed in a model by Ezzati (1976,1978) which used an analysis of OPEC in an intertemporal cartel framework and allowed for differences in the economic infrastructures of OPEC member countries and their ability to absorb oil. The model was constructed mainly to assess the "stability" of the cartel by comparing the production of the members of OPEC at certain
prices, with demand for these countries' oil. This is obtained by estimating the total demand for OPEC allocated to individual members based on their relative shares in 1975. OPEC as a residual supplier can maintain future stability by eliminating the difference between the forecasted demand and the desired supply of OPEC oil. At each given price, the model determines how much crude oil production is required by each OPEC member country to satisfy its economic needs, which is relative to its absorptive capacity for investment, and is estimated as a function of oil revenues. The model determined the optimal pattern of oil production for nine members of OPEC (including Saudi Arabia), and an evaluation of price and production strategies in relation to Saudi absorptive capacities during the period 1960-72. Ezzati used the result to predict the stability of OPEC up to 1982, and concluded that there is a significant relationship between oil production and absorptive capacity of the OPEC members including Saudi Arabia.

Following Ezzati, Cremer and Salehi-Isfahani (1980), argued that oil revenue needs depended on the economic ability of the producing country to absorb investment. Rather than analysing OPEC as a cartel like Ezzati, their analysis of the oil market was in a competitive framework showing that the supply curve of oil is backward bending. Production would decline in response to rising oil prices and would increase in response to lower oil prices, in order to equate oil revenues with investment needs, creating what is known as a “backward bending supply curve.” According to this model, OPEC members have no incentive to increase production when the price is high and vice versa. Thus oil revenues are determined by internal investment needs which are constrained by the economy's ability to absorb targeted investment. If \( I_t^* \) represents investment needs, and \( q_a \) is
the production of an OPEC member, then according to the model, $I_{it}^*$ should be equal to the target revenue.

$$P_t q_{it} = I_{it}^*$$  \hspace{1cm} 4.17

Investment needs and oil prices are exogenous to the producer, so the quantity produced takes the form:

$$\ln q_{it} = \alpha_i + \gamma_i P_t + \gamma_{i2} \ln I_{it}^* + \varepsilon_{iy}$$  \hspace{1cm} 4.18

Increase in investment needs would result in an increase in production; but for a given price coefficient, $\gamma$, it would be negative.

Adelman (1993) argued that the objective of OPEC members is to maximise their revenue. He said that OPEC is a cartel whose members cooperate to set the price that covers their revenue needs. OPEC uses its monopolistic power to gain the high revenue needed by member governments. Accordingly, Saudi Arabia co-operates with other members of OPEC to raise its revenue by restricting output either by using the dominant firm model or by co-operation with other members in determining output.

Linderoth (1992), using data covering public revenues and expenditure plus the balance of payments, tested the target revenue theory and concluded that Saudi Arabia was on the backward sloping part of the supply curve only for a very short time after the first and second oil shocks.

Evaluating the actual performance of Saudi Arabia in the market, we can say that it differs from other OPEC members in that it has a huge reserve, and can influence the price more than countries with a small reserve and little spare capacity. Such countries will sell
their oil at any price while Saudi Arabia is interested in maximizing the value of its oil revenue.

Table 4.6: Saudi Arabia's GDP in Saudi Rial 1974-1996

<table>
<thead>
<tr>
<th>Year</th>
<th>GDP real (Billion Saudi Ryal)</th>
<th>GDP nominal (Billion Saudi Ryal)</th>
<th>Current Account Billion Saudi Ryal</th>
<th>Oil Price $/B</th>
<th>Saudi Arabia production Thousands B/D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1974</td>
<td>31.7</td>
<td>139.60</td>
<td>81990.00</td>
<td>11.58</td>
<td>8479.7</td>
</tr>
<tr>
<td>1975</td>
<td>34.7</td>
<td>164.50</td>
<td>50336.00</td>
<td>11.54</td>
<td>7075.4</td>
</tr>
<tr>
<td>1976</td>
<td>39.7</td>
<td>205.10</td>
<td>50414.00</td>
<td>11.51</td>
<td>8577.2</td>
</tr>
<tr>
<td>1977</td>
<td>42.0</td>
<td>225.40</td>
<td>41971.00</td>
<td>12.40</td>
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</tr>
<tr>
<td>1978</td>
<td>44.8</td>
<td>249.50</td>
<td>-7528.00</td>
<td>12.70</td>
<td>8301.1</td>
</tr>
<tr>
<td>1979</td>
<td>49.4</td>
<td>385.80</td>
<td>40416.00</td>
<td>17.28</td>
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</tr>
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<td>520.60</td>
<td>142240.00</td>
<td>28.67</td>
<td>9900.5</td>
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<td>54.2</td>
<td>524.70</td>
<td>139123.00</td>
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<td>415.20</td>
<td>25955.00</td>
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</tr>
<tr>
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<td>-58216.00</td>
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</tr>
<tr>
<td>1984</td>
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<td>-64845.00</td>
<td>28.20</td>
<td>4079.1</td>
</tr>
<tr>
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<td>-46855.00</td>
<td>27.01</td>
<td>3175.0</td>
</tr>
<tr>
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<td>271.10</td>
<td>-43680.00</td>
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</tr>
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<td>275.50</td>
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</tr>
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<td>1992</td>
<td>62.3</td>
<td>461.40</td>
<td>-66437.00</td>
<td>18.44</td>
<td>8531.7</td>
</tr>
<tr>
<td>1993</td>
<td>59.5</td>
<td>443.90</td>
<td>-64668.00</td>
<td>16.33</td>
<td>8047.7</td>
</tr>
<tr>
<td>1994</td>
<td>61.5</td>
<td>150.00</td>
<td>-30940.00</td>
<td>15.53</td>
<td>8049.0</td>
</tr>
<tr>
<td>1995</td>
<td>63.8</td>
<td>469.40</td>
<td>-19900.00</td>
<td>17.18</td>
<td>8000.0</td>
</tr>
<tr>
<td>1996</td>
<td>67.0</td>
<td>509.80</td>
<td>700.00</td>
<td>19.81</td>
<td>8000.0</td>
</tr>
</tbody>
</table>

Source: OPEC secretariat and IMF.

In 1979, 1980, and 1981 Saudi Arabian oil revenue reached a high level (see Table 4.6), and the excess revenue was invested abroad. In other years (1983-1986), it produced less than needed for financial requirements and suffered budget deficits. Saudi Arabia did not cut its production but increased it to 10 MMBD in 1980. The problem was that the financial absorptive capacity hypothesis did not come up when production declined in 1982 and revenues declined below the financial absorptive capacity requirement. In the case of Saudi
Arabia, its national development strategy required heavy expenditure, which led to rapidly increasing domestic investment opportunities, thereby raising the absorptive capacity of the economy and its revenue requirements.

Furthermore, in dealing with its surplus funds during the period 1973-1981 Saudi Arabia invested part of it through the Saudi Arabian Monetary Agency (SAMA) which placed part of this surplus in US treasury bills and notes and other financial markets. Thus financial absorptive capacity did not deter countries from producing at higher prices and accumulating funds. In addition, this contradicts the model’s assumption that the oil-exporting countries would have no efficient foreign investment opportunities (Bergendahl 1984).

Saudi Arabia cut its production twice (while the oil prices were high). The first cut in 1975 was caused by the decline in oil consumption in the industrial world as a result of economic recession (see section 3.2.1). The second cut was in April 1979, and various the reasons discussed in section 3.2.2. However, Saudi Arabia increased oil production to 10 MMBD a few months later. It lowered its production again in 1982 and 1983 owing to the low demand for OPEC crude.

Following the collapse of oil prices in 1986, Saudi Arabia increased its production in order to increase its revenue. This caused its GDP to expand from 271 billion Riyals in 1986 to 455 billion Riyals in 1994. Hence, there was no evidence to support the target revenue model for Saudi Arabia.
4.5 Econometric Testing

Econometric testing for the competitive model was done by Griffin (1985), using the following equation to test a competitive model of OPEC behaviour:

\[ \ln q_{it} = \alpha_{it} + \gamma_{it} \ln P_t + \varepsilon_{it} \]  

4.19

The result of the competitive model for Saudi Arabia is that the positive coefficient (\(\gamma > 0\)) on price is rejected, concluding that price (exogenously determined) influences the decision of production for Saudi Arabia. But Griffin's study used OLS with no consideration of dynamics.

Griffin (1985) tested the model using the following equation, where under the property right model production will be influenced by the percentage of government controlled production:

\[ \ln q = \alpha + \delta G + \varepsilon \]  

4.20

\(G\) is the percentage of production controlled by the government in the producing country, with \(\delta < 0\). Griffin used annual data for the period 1971 to 1981, and the result was not significant for Saudi Arabia. Griffin also tested the target revenue model using the following equation

\[ \ln q_{it} = \alpha_i + \gamma_{it} \ln P_t + \gamma_{i2} \ln I^*_{it} + \varepsilon_{ij} \]  

4.21

where \(I^*\) is the target investment. Griffin tested a restricted variant for the value \(\gamma_{i2}=1, \gamma_{it} = 1\), which was rejected by ten members, including Saudi Arabia, for whom investment data is available. On the other hand, with the partially restricted variant \(\gamma_{i2}<0, \gamma_{it}>0\) it was
difficult to reject the hypothesis despite the lack of evidence to support the theory even with the use of trended investment series.

Griffin used quarterly data for price and production for the period 1973.1 to 1983.3 in order to test different models of OPEC behaviour separately. The cartel model was tested using the following equation:

$$\ln q_{it} = \beta_{i0} + \beta_{i1} \ln Q_{it}^{O} + \beta_{i2} \ln P_t + \epsilon_{it}$$

where $q_{it}$ is the production of the $i^{th}$ member, $Q_{it}$ is the production of OPEC minus the $i^{th}$ member's production and $p$ is the price. Using the OLS, Griffin concluded that the production of Saudi Arabia varies with the production of others, indicating the dominant firm models with Saudi Arabia acting as the market leader which varies production inversely to the competitive output including the rest of OPEC.

The study of Griffin was criticised for using improper econometric tests. Al-Turki (1994), described the study as an example of the misuse of the statistical model when faced with the problem of autocorrelation. He attempted to overcome the shortcomings of Griffin's study by re-examine the model in the presence of autocorrelation. Al-Turki suggested the presence of autocorrelation as a result of misspecified dynamics, so he specified an unrestricted dynamic model and tested for the optimal number of lags. Then he reduced the general unrestricted dynamic model by imposing restrictions and testing for these restrictions. The final model was of the form:

$$\ln q_{it} = \alpha + \beta_1 \ln Q_{it}^{O} + \beta_2 \ln P_t + \ln q_{t-1} + \epsilon_{it}$$

Al-Turki used quarterly data for the period 1971 to 1987 and by applying the OLS procedure, he provided more accurate estimates to evaluate the behaviour of OPEC countries
in the world oil market. His results supported the hypothesis that described Saudi Arabia behaviour along the lines of the partial market-sharing model.

The market-sharing model implies that OPEC is a cartel and that Saudi Arabia is a member of a cartel who is assigned a quota of production. So there must be a relationship between the production of Saudi Arabia and the other members of OPEC, in which case we can test the model using the equation suggested by Griffin with the use of data for different periods of the study and more advanced econometric procedures.

Salehi-Isfahani (1987), criticised the study for the use of misspecified regression equations, at least for the target revenue model. He questioned Griffin's interpretation of his results where he concluded that any increase in price would be met with a decrease in production (restricted variant). Salehi-Isfahani suggested the use of the expected price variable rather than actual ones. Using the same model and data and allowing for expectations with a lagged price, Isfahani's results supported the target-revenue model. Salehi-Isfahani used a dynamic model of member countries of OPEC with high absorptive capacities, and with development plans depending on oil revenues, to test for the oligopolistic model of the oil market. The numerical results supported the hypothesis that there may be some economic reasons to restrict oil output when prices rise to a certain level. He described such reasons as low absorptive capacity, imperfect capital markets and diminishing marginal utility of consumption.

Cremer and Salehi-Isfahani (1991), criticised Griffin's study for lack of dynamic considerations made apparent by the presence of acute serial correlation. They suggested
including the long term expected price variable which would solve the problem of the acute serial correlation.

Dahl and Yucel (1991) tested two variants of the target revenue model, the strict and the weaker one for OPEC members using data for Saudi Arabia from 1971-87. The hypotheses of both variants were strongly rejected, but Dahl and Yucel suggested including the investment in the general market model to be tested for members of OPEC. Dahl and Yucel tested the swing producer model using output co-ordination between members of OPEC and the total production of OPEC, rejecting the hypothesis of co-ordination and concluding that Saudi Arabia’s production doesn’t have any relationship with the production of others. Dahl and Yucel used quarterly data for Saudi Arabia from 1971 to 1987.

Econometric testing for the swing producer model was undertaken by Griffin and Neilson (1994), focusing on the strategies used by OPEC to generate cartel profits over the period 1983-90. The result supported the hypothesis that OPEC adopted a swing producer strategy from 1983-85. But when Saudi Arabia’s profit fell below the level of Cournot profits in the summer of 1985, it abandoned the role of swing producer, driving the prices to the Cournot level. According to Griffin and Neilson, Saudi Arabia appears to have adopted a tit-for-tat strategy designed to punish excessive cheating by other OPEC members.

For testing the swing producer model Griffin and Neilson used the following:

\[ Q_{SA}^{pA} = Q_{W}^{pA} - Q_{NO}^{pA} - Q_{OO}^{pA} \]

where \( P \) denotes the price specified by OPEC. \( Q_{W} \) denotes world demand for oil at price \( P \), \( Q_{NO} \) denotes the supply of non-OPEC countries, and \( Q_{OO} \) denotes the output of other OPEC
countries. Fluctuations in Saudi Arabia’s output (ε_{SA}) should be positively related to
demand shocks (ε_{W}) and negatively correlated with non-OPEC and other OPEC supply
shocks (ε_{NO}, ε^{∞}) as follows:

\[ ε^{SA} = ε^{W} - ε^{NO} - ε^{∞} \quad 4.25 \]

Assuming that world demand is constant, the strategy used by Saudi Arabia is to behave like
a swing producer as long as other productions are below level Q^*. If other production levels
exceed Q^*, then the Saudis produce according to the Cournot best-response function for the
remainder of the game using the following:

\[ Q^{SA} - Q_{quota}^{SA} = γ(Q^{∞} - Q_{quota}^{∞}) \quad 4.26 \]

On account of the lack of monthly data, instead of the above test Griffin and Neilson
adopted an indirect test which utilises available price data. Accordingly, under the swing
producer, the price should fluctuate around the Saudi marker price causing the price to remain
stationary, while under fit-for-tat it should differ structurally. Therefore the following
general equation was used:

\[ P_t - P_{t-1} = α + βT + (γ - 1)P_{t-1} + δ(P_{t-1} - P_{t-2}) + ε_t \quad 4.27 \]

to test the hypothesis of random walk (β=0 and γ=1) using data for the swing producer from
May 1983 through August 1985 and the tit-for-tat period from October 1985 through March
1990.

Even with the rejection of the hypothesis of random walk, Griffin and Neilson still
believe that the equation is consistent with the swing producer model. They tested the
structural change for the two periods and the equality of the two variance of prices, and
found that the prices exhibited much greater variation and differed structurally in the two
periods.
Griffin and Neilson tested tit-for-tat. They used equation testing for the punishment of cheating by Saudi Arabia to other members. So they added a non-linear punishment for cheaters:

\[
Q^{SA} - Q^{SA}_{\text{quota}} = \gamma_0 + \gamma_1(Q^{oo} - Q^{oo}_{\text{quota}}) + \gamma_2(Q^{oo} - Q^{oo}_{\text{quota}})^2
\]

The test shows that Saudi Arabia does not appear to react to low levels of cheating and may absorb some minor cutbacks, but high levels of cheating evoke a forceful response.


Al-Yousef (1994) used quarterly data from 1973:3-1993:3 to test the market sharing model for all members of OPEC by using cointegration analysis and Johansen procedures. It was found that members of OPEC differ in their behaviour. Saudi Arabia behaviour was described as expanding market share since its production changed by more than was proportionate to the production of other members of OPEC. It also had a negative relationship with the price, which indicated that Saudi Arabia’s production had some effect on the price of oil.
Gulen (1996) tested the cartel hypothesis for OPEC applying the same relationship used by other tests. The relation between member’s production and total OPEC production is:

\[ Q_{it} = \alpha_i Q_t \]

Where \( Q_{it} \) is the \( i^{th} \) member’s production and \( Q_t \) is the total OPEC production at time \( t \), and \( \alpha \) is the production share of the \( i^{th} \) members of the cartel. Using Engle and Granger’s (1987) two-step cointegration tests, between individual member production and total OPEC production, and testing for different periods of the study using monthly data ((1965:1-1993:2) full sample and 1965:1-1973:9 (before the oil shock), 1974:2-1993:2 (after the first oil shock) and 1982:1-1993:2 (the output rationing era)) Gulen concluded that there was no-coordination between Saudi Arabia’s output and that of the rest of OPEC. Gulen used Granger’s causality test to see if there was a significant relationship between the production of OPEC and the oil price. He also replaced the production of OPEC by Saudi Arabian production and reached the same conclusion that there was no causal relation between OPEC or Saudi Arabia’s output and the price of oil in either direction.

4.6. Political Interpretation of Saudi Arabia’s Behaviour

The above attempts have tried to explain the behaviour of OPEC members by economic factors. In this section we to review the studies that tried to explain oil policy by suggesting alternative political decision rules.
Saudi Arabia’s political and strategic importance has grown dramatically with the increased reliance on Saudi oil by consuming countries. In the “Report to the Congress of the United States explaining critical factors affecting Saudi Arabia’s oil decisions” political and security factors, such as the peaceful resolution of the Middle East conflict and the security of the country, were discussed.

Stevens (1992) considered Saudi Arabia as the price setter in OPEC and the objective of its pricing policy is crucial in understanding OPEC’s behaviour. He discussed reasons for Saudi Arabia’s policy in pursuing moderately low prices: The first is to keep a higher value on its huge reserve; second, is the influence of the U.S.A on its oil policy. Stevens rejected this explanation on the grounds that being an oil producer itself, the low oil prices would increase US dependence on imported oil. Stevens also discussed the possibility of Saudi Arabia aiming for higher oil prices, accommodate the other Arab oil-exporting countries, and to cover its budget needs.

Doran (1977), recognised the different political reasons why members of OPEC would adopt certain pricing strategies. For members with large petroleum reserves, the long-term strategy is to increase oil prices slowly to minimise the chance of the innovation of new energy sources and the processing of new discoveries, and to reduce substitution possibilities.

Moran (1982) concentrated on Saudi Arabia as the largest member of OPEC and explained the country’s actions as a result of political factors more than a result of optimising an economic model. Saudi Arabia has exercised price leadership within the cartel to stabilise or moderate oil prices to achieve its political objectives. Moran stated that “No economic
calculation alone, such as the strength and weakness of oil markets or the state of world economy, can account for Saudi Arabia’s use of its petroleum base to shape the course of OPEC’s price path. Insofar as Saudi Arabia has exercised price leadership within the cartel, the decision to do so required a deeper dimension of policy-making which sprang from Saudi political priorities.”

Quandt (1982). explained that long-term Saudi interests may dictate a comparatively moderate pricing strategy, but uncertainties combined with a cautious Saudi style of decision making, prevented the Kingdom from consistently following such a long-term approach. In some circumstances, political pressure from within the Arab world or from the OPEC members can influence Saudi oil decisions for the short term.

Golub (1985) explained the pattern of Saudi Arabia’s behaviour in crises and during what he calls routine periods. Saudi Arabia oil policy appears to be determined by forces unrelated to long-term economic concerns but more related to political factors. However, during routine periods, the profit motive is worthy of attention.

4.7. Conclusion

Saudi Arabia has a vital role in meeting world petroleum needs because of its huge oil reserves and productive capacity and the flexibility to increase or decrease oil production. Its decisions on oil production and prices have been an important factor in providing the world oil supplies. From the previous survey of the literature and evaluation of the models, we can conclude that the two models that would best describe the behaviour of Saudi Arabia are the
swing producer model and the market-sharing model which will be discussed in chapter 5.

This is to be followed by the testing of the model applicable to Saudi Arabia’s behaviour.
NOTES

1 Most cartel models utilised the theory of exhaustible resources, where for an owner of such a resource, the optimal path of extraction depends on the market structure and the elasticity of demand. For a competitive market, the price rises with the rate of interest. For a monopolist, the rate of increase in prices would be less than the relevant rate of return indicating that the monopolist is more conservative than a competitive supplier of an exhaustible resource (see Hoteling (1931) and Dasqupta and Heal (1979).

2 48th OPEC Conference held in Doha, Qatar, from 15 to the 17 December 1976.

3 The costs of producing oil are not just the extraction costs. Marginal cost include the opportunity cost of selling the oil today instead of tomorrow, taking into account the depletable nature of a non-renewable resource.

4 The difference between the legal ownership and the realistic ownership.

5 After the announcement of the Saudi Minister in the American University under the title “Participation Versus Nationalisation”.

6 See the section on participation in chapter 3.
CHAPTER 5

THE SWING PRODUCER AND MARKET-SHARING MODELS

5.1 Introduction

The importance of Saudi Arabia as a large producer of oil cannot be ignored and Adelman (1982) Mabro (1975, 1991) Stevens (1982)(1992) have drawn attention to its role. In my discussion with Stevens (1996), he stated his views that Saudi Arabia was acting as a swing producer for the period 1975-1986, when it changed its output in order to influence the price of oil. Mabro applied the dominant producer theory to the oil market with Saudi Arabia acting as the Stackelberg price leader. In the seventies, OPEC determined the price of Arabian Light as a reference and the members of OPEC set the price of their oil, selling as much as they wanted, while Saudi Arabia was able to maintain its role as the residual supplier because of its lower absorptive capacity. However, the expansion of non-OPEC supply in the eighties caused the demand for OPEC oil to decline, and when the demand became less than the aggregate volume which could be produced excess capacity increased, causing difficulties in maintaining prices. In 1982 the organisation started allocating output under a quota system.

Cremer and Salehi-Isfahni (1991) in their review of world oil market models, analysed the role of Saudi Arabia as the dominant firm. Saudi Arabia has significant market power in the short run but in the long run, the influence of its production is small because the world demand and supply of the fringe are more elastic. The elasticity of demand facing Saudi Arabia should be very small to bring about a significant effect. This depends on its share of
the market and the elasticity of world demand and the supply of the competitive fringe (world - Saudi Arabia). Saudi’s share of the world oil market ranged from a high of 17.5% in 1981 to a low of 6% in 1985 and its share of OPEC from a high of 44.2% in 1980 to a low of 20.9% in 1985.

A review of Saudi Arabia’s oil policy in different periods indicates that, as a major player of OPEC between 1973 and 1978 Saudi Arabia supported the organisation, but, nonetheless did not want the price of oil to rise high enough to cause any damage to the world oil market. During the period 1978-1981 Saudi Arabia increased its output to the maximum sustainable capacity, to prevent any price increase as a result of economic and political factors and to avoid further shocks to the world oil market. It was in its own interest in the long run to keep prices stable. From 1982-1985 Saudi Arabia continued to act as a Swing producer to maintain OPEC price levels, producing below its capacity for four years. By 1985, after a long and costly period of production cutbacks, resulting in the need for short-term revenue, Saudi Arabia abandoned the swing producer position and requested other producers (OPEC or non-OPEC) to co-operate with it.

However, following the price collapse in 1986, the oil market has changed from what it was during the time of administered prices (1973-1985) to the time of market-related prices (1987-present). This is the result of many major structural changes in the world oil market. We can summarise such changes as follows: first, oil’s share in the world energy mix declined from 55% in 1974 to 41% in 1995.¹ The relationship between economic growth and oil/energy use weakened and in 1982-1985 the relation was even negative on the demand side, as a result of either efficiency gains or energy consumption
regulation. Today, the industrialised world uses 40% less oil to generate the same unit of real GNP that they produced two decades ago.²

On the supply side major changes were underway as well. While OPEC’s production constituted more than 54% of the world oil supply in 1973, it decreased to 30% in 1986 and recovered to 41% in 1994. The share of the world’s oil production supplied by Saudi Arabia, the largest producer of oil, reached a high of more than 17% in 1981 to decline to 6% in 1986 and accounted for an average of 13.5% in 1996. Production from new areas such as Alaska, the North Sea and new formations in Latin America and Africa increased the non-OPEC supply dramatically, from 25 MMBD in January 1974 to 35.9 MMBD in January 1995.³

Financial development, world wide telecommunications and technological advancement since the early eighties have overtaken the oil market. Today, the paper oil market, whether forward, futures, options or derivatives, along with its speculative aspects, influences the oil market as much as oil companies or OPEC conferences.

Saudi Arabia as an oil producer has been facing the challenge of responding to world oil market realities. It has done this since 1987 by making oil prices market oriented, using formula prices with a factor adjustable to the prices of other leading oil indicators. It is trying to follow a market share model where the objective of its policy is to maintain a market share. Thus since 1987 Saudi Arabia has acted as a large producer who is concerned with output. According to Lambertini (1996) the demand function can affect firms’ ability to collude. The cartel stability can continue only if they act as quantity
setters rather than price setters. According to Lambertini (1996), "As the number of firms tends to infinity, Cournot behaviour is preferable to Bertrand behaviour in order to stabilise collusion".

We can say that during the first period Saudi Arabia followed a swing producer strategy, adjusting output so as to stabilise price. After 1986, it abandoned the role of swing producer and adopted instead a role of market sharing producer.

5.2 The Swing Producer Model (1975-1986)

As we have shown, Saudi Arabia can adjust its production to changes in world oil demand, non-OPEC production and other OPEC members' production. The fringe members would adjust their market share according to their marginal costs; including the user cost while Saudi Arabia's market share would fall when the demand for OPEC decreased and would rise with increasing demand. Assuming that Saudi Arabia is the residual supplier:

\[ Q_t^{SA} = Q_t^{W} - (Q_t^{NO} + Q_t^{OO}) \] 5.1

where \( Q^W \) is world demand, \( Q^{NO} \) is the non-OPEC supply and \( Q^{OO} \) is other members of production. Saudi Arabia can be considered in the swing producer model as the price maker in the oil market, and other members of OPEC and non-OPEC suppliers, the competitive fringe. Being the residual supplier, Saudi Arabia is the Stackelberg leader that maximises its profit by choosing an optimal production path, taking into consideration the reaction of the fringe to its policies, the competitive fringe takes prices as given.
Saudi Arabian objectives of a stable oil price are:

1. To keep oil competitive over the long term since Saudi Arabia has a high reserve/output ratio.

2. To keep its share in the market as a low cost producer.

3. To maintain the initiative in OPEC pricing decisions and assert its power in the market.

Saudi Arabian policies to achieve these objectives are:

1. Resisting attempts by other producers to raise the price, 1975, 1977, 1979 and beyond.

2. Selling at official set prices and using volume control to ascertain such periods.


4. Maintaining its market share at reasonable levels despite an increase in non-OPEC production (1994-1997).

This model seems to fit the behaviour of Saudi Arabia at various times in the history of the oil market. During 1975-1982 it varied its production to achieve its price objectives and to fill the gap of supply shortfalls resulting from the Iranian revolution and the Iran-Iraq war. Between 1982 and 1985 Saudi Arabia officially undertook the swing producer role when it agreed with the OPEC quota system to vary its production in order to balance the market. Although that role was only one episode and Saudi Arabia did not take a quota, it continued swinging its production in 1975, 1978, 1979 and 1981. In the 1987-1997 period, Saudi Arabia abandoned the Swing producer role and insisted on protecting its market share (AbdelAziz Al-Saud 1997). Some believe, like the former Saudi Minister of Petroleum, that
it is still performing the swing producer role. During my interview in December 1996 with ex-
Petroleum Minister, Zaki Yamani, he told me that he believed Saudi Arabia to be a swing
producer by definition. He said that not only did it exercise the swing role in the 1982-1985
period but even prior to that, and continues until today. The 1975 downward production
And today, he said, Saudi Arabia swings its production by keeping it constant while others
in OPEC increase theirs.

Saudi Arabia objects to any increase in oil price, explained Yamani, because “Oil
prices should not be raised in a way which would reduce demand for oil and as a
consequence weaken the OPEC position.” This agrees with the idea that Saudi Arabia was
trying to keep the oil prices stable.

Therefore, Saudi Arabia can be described during the period 1975-1986 as a member of
a cartel that exercised its power by assigning a price and producing the quantity necessary to
maintain that price so as to satisfy its objective of keeping the oil price at a stable level.
 Accordingly it can also be described as a price leader who sets the price which others take as
given. The price leadership model is solved as follows: Saudi Arabia $Q^{SA}$ is a price leader
with other OPEC members $Q^{OPEC}$ and the non-OPEC supplier constituting the competitive
fringe $Q^{No}$. The oil market is assumed to be composed of Saudi Arabia as a price-setting
leader and a competitive fringe which is composed of the other members of OPEC and non-
OPEC producers.
Price leadership behaviour is illustrated in Figure 5.1, where the demand curve $D^T$ represents the total demand curve for crude oil and the supply curve $S^W$ represents the supply decisions of all the fringe suppliers. Using these two curves, the demand curve $D^{SA}$ that Saudi Arabia faces is derived as follows. For a price of $P_1$ or above, the leader would sell nothing since the competitive fringe would be willing to supply all that is demanded. For a price below $P_2$ the leader (Saudi Arabia) has the market to itself since the fringe is not willing to supply anything. Between $P_2$ and $P_1$ the curve $D^{SA}$ is constructed by subtracting what the fringe will supply from the total market demand. Thus, the leader gets that portion of demand not taken by the fringe firms. (Pindyck et al 1998)

In this study, to test for the Swing producer Model the relation between Saudi production and the production of other OPEC members was used to maintain the price level. When the difference between the official price ($P^{SA}$) and the market price ($P^M$) increased Saudi Arabia would increase or decrease its production to lower the gap between
the official oil price in either direction. Therefore, if the production of others increased Saudi Arabia's production would decrease and the converse was usually true.

However, the main objective for swinging its production was to influence the OPEC official price of oil which was used by Saudi Arabia to sell its oil while other members of OPEC were more influenced by spot oil prices (see chapter 3). Saudi Arabia increased its production to stabilise the price of oil at times when there was a shortage resulting in an increase in price. It would increase its output to offset the influence of the shortage of oil supply, as happened during the Iranian revolution and the Iran/Iraq war. However when there was pressure on the price of oil to decline to a level that would affect the Saudi economy, Saudi Arabia tried to keep higher oil prices by decreasing its output level. Such was the case in the early eighties. Therefore, the difference between spot oil prices $P^M$ and the official OPEC oil prices $P^{SA}$ (Saudi selling prices), should be included in the equation for the period 1975-1985.

For that period Saudi Arabia was concerned about price stability. Since OPEC used a price setting strategy, and Saudi Arabia followed that price (the price of the marker Arabian Light API 34°). Saudi Arabia did not just defend that price, it manipulated its production in order to minimise the difference between the official price $P^{SA}$ and the market price $P^M$. However, it was not concerned about the absolute value, it was concerned about the propionate difference, since it increased its production in 1977 to upset the 10% price increase by OPEC while Saudi Arabia agreed only to 5% (then equal to 5 cents/B difference). In 1981, Saudi Arabia increased its production to the same amount to minimise the difference between $P^M$ and $P^{SA}$ that was equal to $17/B$. 
For the period 1975-1986, the objective function of Saudi Arabia in the world oil market was to minimise the difference between the spot price $P^M$ and the official price of OPEC or Saudi Arabia (the price of the Marker API $34^\circ$) $P^{SA}$. Thus, the objective function

$$\left(\frac{P_t^{SA}}{P_t^M}\right) = 1 \quad \text{keeping the difference between both prices equal to zero}$$

This function is under several constraints

1- The production capacity of (C) Saudi Arabia which is $2.2 \text{ MMBD} \leq C \leq 10.5 \text{ MMBD}$

2- The OPEC supply should constitute at least 40% of the market for Saudi Arabia to work as swing producer.

3- Oil share from consumption should be at least 50% of total world energy.

If the demand is high for OPEC oil $\left(\frac{P_t^{SA}}{P_t^M}\right) < 1$ Saudi Arabia would increase its output.

If demand is low for OPEC oil $\left(\frac{P_t^{SA}}{P_t^M}\right) > 1$ Saudi Arabia would decrease its output.

Using the notation $P_t^{SM} = \left(\frac{P_t^{SA}}{P_t^M}\right)$ the function will be

$$Q_t^{SA} = f_1(P_t^{SM}) \quad \text{5.2}$$

However, Saudi Arabia is a member of OPEC, so its production is also a proportion of total OPEC production.

$$Q_t^{SA} = f_2(Q_t^{OPEC})$$
\[ Q_{t}^{OPEC} = (Q_{t}^{OO} + Q_{t}^{SA}) \]

Thus, by substituting the values of Saudi and OPEC production and combining with equation 5.2, we can arrive at the following equation

\[ Q_{t}^{SA} = f(Q_{t}^{OO}, P_{t}^{SM}) \]  

5.3

It is reasonable to assume that \( Q^{SA} \) is a function of the price level as well as other factors (using the above models) such as the size of the reserve and the extraction cost. However, according to other oil market theories, Saudi Arabia's production output was also influenced by factors such as the level of its financial needs. In the absence of reliable data on the extraction cost and reserves, one is forced to disregard their effects. Therefore, we can say that Saudi output is a function of production of other countries and of the ratio of official and spot oil prices.

5.3 Market-Sharing Model (1987-1996)

Since 1987 and in the absence of a binding agreement to restrict output, Saudi Arabia and other members of OPEC have been involved in a repeated game between quantity-setting producers, with Saudi Arabia acting as a Stackelberg leader and others as followers. Assuming market demand is linear and costs are constant, Stackelberg's model can be analysed diagrammatically using isoprofit curves (Figure 5.2). Given the demand curve \( D^{SA} \) the leader can construct its marginal revenue curve (\( MR' \)) and then refer to its own marginal cost curve (\( MC \)) to determine the profit-maximising output level, \( Q^{SA} \). Market price will be the given \( P^{M} \), at that price the competitive fringe will produce \( Q^{OPEC} - Q^{SA} \) and total industry output will be \( Q^{T} = (Q^{OO} + Q^{SM} + Q^{SA}) \). Saudi Arabia has the largest production capacity and the highest proven reserves.
Here, the isoprofit lines for Saudi Arabia indicate the combinations of output levels that yield constant profits. Saudi Arabia wants to operate at the point on the other producers' reaction curve where it has the output that yields the largest possible profits. In 1982, OPEC adopted output rationing, but did not abandon price fixing. However by 1987, Saudi Arabia had led the other members of OPEC to determine output without specifying a fixed price. According to Minister Hisham Nazer (1997) within OPEC Saudi Arabia assigns a quantity of production and other members of OPEC take it as given. This suggests that Saudi Arabia acts as Stackelberg leader. The model is actually a two-stage model in which Saudi Arabia gets to move first, before other producers can choose their own optimal level of output. Given Saudi Arabia's output, the rest of the OPEC producers want to maximise their profit, $[\text{Price}(Q_{SA} + Q_{OPEC}) Q_{OPEC} - \text{Cost}]$. According to the Stackelberg leadership model, Saudi Arabia wants to determine its level of output in anticipation of the response of the other members.
The objective function of Saudi Arabia the period 1987-1996, with price no longer set up by OPEC, and given the factors discussed above is to determine the output level that maximises its revenue. Therefore, the equation for testing for the period 1987-1996 is as follows:

\[ Q_{t\text{SA}} = j(Q_{t\text{OO}}, P_t^M) \]  

5.4

This model was tested by Griffin (1985), Dahl and Yucel (1991), Al-Turki (1994), Al-Yousef (1994), Griffin and Neilson (1994), and Gulen (1996) (See chapter 4 section 4.4). Both models will be tested using monthly data. The properties of the time series used will be tested and the econometric procedures which fit in with such properties will be applied. Price and production data will be discussed in the next chapter and econometric theoretical procedures in chapter 7. The results of the econometric tests will be explained in chapter 8.
NOTES

1 OECD Economic Outlook and Energy Policies Program of IEA Countries.

2 OECD Economic Outlook and Energy Policies Program of IEA Countries.

3 Source: OPEC secretariat.

4 In 1994 the proven oil reserve for Saudi Arabia was 261374 (million Barrels) and the total world was 1042991. Hence Saudi Arabia's proven reserve constitutes more than 25%. Source OPEC Bulletin.
6.1. Introduction

In chapter 5, we specified the two models to be tested, which include four variables: Saudi Arabia’s production $Q^{SA}$, production of others $Q^{OO}$, $P^{SM}$ which is equal to $(P^{SA}/P^{M})$, where $P^{SA}$ is the Saudi’s selling price and $P^{M}$ the market price of oil:

The Swing Producer Model

$$Q^{SM}_t = f(Q^{OO}_t, P^{SM}_t)$$  \[6.1\]

The Market-Sharing Model

$$Q^{SM}_t = J(Q^{OO}_t, P^{M}_t)$$  \[6.2\]

Equation 6.1 describes the swing producer model which will be tested for the period 1974-1986. And the second equation 6.2. will be used to test the market-sharing model for the period 1987-1996. In this chapter, we will investigate the time series to be utilised in testing the two models.

There have been fundamental changes in the structure of the world oil market, which are reflected in the oil price volatility. Consequently, to adopt one price series would be impossible and a price that takes these changes into account must be found. While Saudi Arabia at times used the OPEC official price, which is the marker (Arabian
Light API 34°), at other times it used netback pricing. In the later period at the study, right up to the present, Saudi Arabia, has used formula pricing when it has had to rely on other oil trading markers such as Dubai, WTI and Brent. Consequently, issues and concepts related to the price of oil need to be discussed before a time series to be included in the model can be constructed.

There are two important issues to be considered in the selection of crude oil price series. First, crude oil is classified into various types and qualities on the basis of its specific gravity. Consequently, there are as many prices as there are types of crude. Associated with this is the fact that there are different price series according to quantity, location and length of contract for each type of crude oil.

In section 6.2 we introduce the different categories of crude. Then, in section 6.3, we introduce different concepts of oil prices such as posted prices, Government Selling prices (GSP), spot prices, netback pricing and the OPEC reference basket. In section 6.4 we discuss the time series to be used to reflect the production data for Saudi Arabia and the production of others.

6.2. The Categories of Crude

Crude oil is categorised into light, medium, and heavy and precisely graded on a specific gravity scale devised by the American Petroleum Institute (API). Crudes rated at 40° and above are very light and those below 22° very heavy.
The Saudi crudes consist of Arab Extra Light Berri 39° API, Arabian Light 34° API, Arab Medium 31° API, Arab Heavy 27° API and most recently, Arab Super Light 41° API. Consequently, there are five price quotes for Saudi oil.

Apart from differences in gravity, an important determinant of the relative worth of different crudes is their sulfur content, a chemical which is costly to remove during the refining process. A crude containing a negligible amount of sulfur is termed very sweet; crude with a sulfur content exceeding 1% by weight is termed sour.

6.3 Structure of Prices

There have been fundamental changes in the structure of the world oil market which are reflected in prices. There is the posted price which was used by the oil companies 1950 up to the mid seventies, the Government Selling Prices, the spot price, formula prices, which were initially a replacement for the GSP, then there is the recent development in trading instruments including forward, and future prices.2

6.3.1 Posted Prices

These are the prices, posted by the producers of crude, at which they are prepared to sell. This system, introduced by exporting companies in the early 1950s, was initially the companies’ fob selling prices for cargo supplied to “arm’s-length” customers. After 1960, the posted price was used only as a tax reference, it was not an actual market price, because the integrated system of the oil market allowed very little oil to be traded, since
most of the oil was within the integrated structure of each company. The price of the oil that was traded could be higher or lower than the posted price.

With the subsequent extension of government control over production, official government selling prices (GSP) became the focal point of the OPEC pricing system after 1973, while postings (derived from official selling prices) continued to be used as reference value to a proportion of exports.

6.3.2 GSP Government Selling Prices

GSP, the official fob export prices, were formally adopted as a basis for OPEC prices from October 1973, and the price of Arabian Light API 34° was used as the OPEC marker, or the official price of Saudi Arabia. However, other types of OPEC crude had their official prices which were related to the marker by differentials set by OPEC.

6.3.3 Spot Prices

The disruption of Iran’s oil production in 1978-1979 increased the role of the spot market. Increased uncertainty kept the spot oil market in turmoil. Arabian Light API 34°, which was selling at around $15/B at the beginning of 1979, reached $30/B by midyear and nearly $40/B by the end of the year (Table 6.1). The period 1978-1981 was marked by the growing role of the spot market, resulting in a two-tier price system where spot prices were running ahead of official prices. Saudi Arabia continued to use the official price of OPEC.
6.3.4 Spot-GSP Relation

The difficulty of maintaining viable official pricing systems increased considerably from 1982 onwards, with increasing competition from non-OPEC oil supplies and the decline of demand. Saudi Arabia held on to the official price of OPEC. At the end of 1983, the non-OPEC supply showed an increase and this caused uncertainty as to whether OPEC could hold on to the official price. Other non-OPEC producers such as Norway decided to use spot prices as a basis for their prices. The importance of spot prices has increased to reflect the market price of oil.

Table 6.1: Official and Spot Oil Prices of Arabian Light

<table>
<thead>
<tr>
<th>Year</th>
<th>Average Official Price*</th>
<th>Average Spot</th>
<th>The Difference between the Official and the Spot Prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>1974</td>
<td>10.77</td>
<td>10.98</td>
<td>-0.21</td>
</tr>
<tr>
<td>1975</td>
<td>10.73</td>
<td>10.43</td>
<td>+0.30</td>
</tr>
<tr>
<td>1976</td>
<td>11.51</td>
<td>11.63</td>
<td>-0.12</td>
</tr>
<tr>
<td>1977</td>
<td>12.40</td>
<td>12.57</td>
<td>-0.17</td>
</tr>
<tr>
<td>1978</td>
<td>12.70</td>
<td>12.91</td>
<td>-0.21</td>
</tr>
<tr>
<td>1979</td>
<td>17.28</td>
<td>29.19</td>
<td>-11.91</td>
</tr>
<tr>
<td>1980</td>
<td>28.67</td>
<td>36.01</td>
<td>-7.34</td>
</tr>
<tr>
<td>1981</td>
<td>32.50</td>
<td>34.17</td>
<td>-1.67</td>
</tr>
<tr>
<td>1982</td>
<td>33.77</td>
<td>31.76</td>
<td>+2.01</td>
</tr>
<tr>
<td>1983</td>
<td>29.04</td>
<td>28.92</td>
<td>+0.12</td>
</tr>
<tr>
<td>1984</td>
<td>28.20</td>
<td>27.70</td>
<td>+0.50</td>
</tr>
<tr>
<td>1985</td>
<td>28.00</td>
<td>27.04</td>
<td>+0.96</td>
</tr>
</tbody>
</table>

*Average Official Prices of the Arabian Light (FOB, Ras Tanura).
Source: OPEC Secretariat.

It cannot be said that the official prices of the marker for this period were representative of the market price. Therefore the spot price of Arabian Light will be used for this period to represent the market price while for Saudi Arabia, which maintained selling at the official OPEC price, the marker will represent the selling price for Saudi crude until July 1985, when the swing producer role was abandoned and netback pricing came with use.
6.3.5 Netback Pricing

By July 1985, Saudi Arabia had started selling on a netback basis. Other members followed suit and prices declined to a low of $8/B in August 1986. The process of obtaining the netback value for crude, consists of taking a price back from one basis to another after deducting refining and transportation expenses. For example, the value of the products refined from crude is netted back through the supply chain by deducting the importing refiners, agreed profit margins, as well as agreed allowances for the costs of shipping and refining. Therefore, the value of netback depends on the type of crude used, the type of refining process, and the location of the refinery. (Mabro 1987, p5)

In 1985, Saudi Arabia used netback pricing where they netted back prices from product markets (in Rotterdam in NW Europe) to the point of loading in Ras Tanura. This was obtained by the following procedure:

(a) computation of the product prices from the crude.
(b) deduction of the cost of refining and refining profit.
(c) deduction of the cost of transportation to the refinery.
(d) the value remaining is the netback price for the crude.

The construction of netback price series required information on four elements; the spot product prices in a particular market; the refinery yields in that market; the running costs per barrel for the refinery and the transport and insurance costs between the refinery and the export point of the crude under consideration. Because of these requirements and the absence of any official agency, there are a multiplicity of estimates.
6.3.6 OPEC Reference Basket Price

After the oil price collapse of 1986, OPEC decided to set the price of a basket of “Seven OPEC internationally traded crudes” at $18/B, supported by an OPEC production ceiling of 16.6 MMBD and distributed into production quotas. The basket is a tool to obtain the average export price of OPEC representative crude. The initial intention was to fix the price to a basket rather than a marker, but the system did not survive long with Saudi Arabia being the only country selling at the official prices until mid 1987.

The return of the old system with prices at a lower level did not survive long and by mid 1987, Saudi Arabia and members of OPEC had reverted to market related prices, where the prices of their crude were tied to a formula linking them to the prices of spot traded crudes such as Brent, ANS and Dubai.

6.3.7 Market-Related Formula Prices

The development of forward and futures markets led to important changes in oil pricing (see appendices 7 and 8). Oil exporters moved to market-related pricing through the use of price formula, a method of determining a crude price by relating it to the spot or forward price of other crude used as a reference (Horsnell et al 1993). This method was used first by Mexico in 1986. In 1987, OPEC and other producers applied this method by establishing a differential to account for quality together with a freight differential and an adjustment factor. The adjustment factors change from time to time with market conditions (Roeber, 1993).
Saudi Arabia's Pricing Formula: Saudi Arabia started using a pricing formula, in October 1987, for Arabian Light, and in December 1987 for other crudes. This formula was used for crude export to the USA, and in late 1988 to Europe and the Far East. ANS was used as the reference crude for the USA, and Brent for Europe, Oman and Dubai (and later Dubai only for the Far East). The crude price in the formula used "adjustment factor" to account for quality and "freight differential." For example, Arabian Light formulas for January 1998 for ex-Aramco partners (Exxon, Mobil, Texaco and Chevron) for deliveries to the USA, Europe and Far East-on an FOB Saudi Arabia basis, are as follows ($/B):

Table 6.2: Arabian Light Formulas for January 1998 for ex-Aramco Partners for Deliveries to the USA, Europe and Far East-on an FOB Saudi Arabia Basis.

<table>
<thead>
<tr>
<th></th>
<th>Adjustment factor</th>
<th>Freight Adjustment $/ long tonne</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>-3.15</td>
<td>7.36</td>
</tr>
<tr>
<td>Europe</td>
<td>-1.55</td>
<td>$7.39</td>
</tr>
<tr>
<td>Far East</td>
<td>+0.10</td>
<td>None</td>
</tr>
</tbody>
</table>

Source MEES 40.49 December 1997.

The adjustment factor reflects the difference in the Gross Product Worth (GPW) between the export and the reference, the difference in the freight rate of moving the reference (e.g. Sullom Voe (for Brent) to Rotterdam and moving the export from Ras Tanura to the oil consuming region. (This has been set at a fixed level of $7.36 per long ton for the USA and $7.39 per long ton to Europe since 1990; Hartshorn, 1993). The use of market-related formula pricing enables exporters to set their prices close to those of their competitors in the place where the crude oil is refined.

This period is also marked by the increasing importance of trading instruments where financial trading instruments such as forward, and future contracts are used (see
Appendix 7). Arabian Light is related by formula to other crudes. However since we are dealing with Saudi oil production, we will be using Arabian Light 34°, the most traded oil in the world and constituting more than 60% of the Saudi production. Since Saudi Arabia has used formula pricing from 1978, so Arabian Light could reflect the market prices. Therefore this is the reference crude that has been chosen for the price time series used for analysis.

6.4 The Data

As was mentioned in chapter 5, the two models which will be tested, the swing producer and the market-sharing require price data. Since there is different price data available depending on the time period under consideration, one would have to choose the most appropriate data set. And after the institution of the quota system, many production data become available which also require the most accurate to be chosen.

6.4.1 Oil Prices Data

The first time series is the Saudi selling price. Saudi Arabia used the OPEC reference price for its crude during the period from 1974 to July 1985 and we will be using the OPEC official price of the Marker (Arabian Light 34°) as the Saudi price $P^S$, throughout the period, while for market price, we will use the Arabian Light spot prices, which started to be reported in March 1976, the data when we start.

For the period August 1985 to December 1986, Saudi Arabia used the netback price. The netback price of Arabian Light will be obtained from. The international Crude Oil
and Product Prices. For the period January 1987 to July 1987 Saudi Arabia reverted to the official selling price, so we will be using the official selling price of Arabian Light. Starting from August 1987, when the price are pegged to Brent (Europe), WTI (North America) and Dubai/Oman for the Far East. The simple average price of Arabian Light 34° derived from these formulas will be used from Platts assessment. The source of the price data is the OPEC Secretariat.

Table: 6.3 Crude Oil Prices Data For the Swing Producer Model

<table>
<thead>
<tr>
<th>Period</th>
<th>Saudi Arabia Selling Oil Price ((\text{P}^\text{SA}))</th>
<th>Market Oil Price ((\text{P}^\text{M}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aug.1985-Dec 1986.</td>
<td>Crude oil netback values Basis NW Europe/ARA port of Shipment</td>
<td>Crude oil netback values Basis NW Europe/ARA port of Shipment</td>
</tr>
</tbody>
</table>

Figure 6.1: Saudi Selling and Market Oil Price (1976.3-1994.12)
For the period 1974-1985, the Arabian Light spot price was the market price used.

For the period August 1985 to June 1987 Saudi Arabia was using netback pricing, so there was no difference between the selling price and the market price.

Table 6.4: Crude Oil Production Data.

<table>
<thead>
<tr>
<th>Period</th>
<th>Production Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>March 1982-Dec. 1996</td>
<td>Average of the six agencies that report oil production data</td>
</tr>
</tbody>
</table>

Figure 6.2: Saudi Arabia's Crude Oil Production as Reported by OPEC and the Six Agencies

![Figure 6.2: Saudi Arabia's Crude Oil Production as Reported by OPEC and the Six Agencies](image)
6.4.2 Production Data

For this, there is the problem of using different production series when the reporting of production differs from one source to another (see Figure 6.2). Thus, for the period 1975-March 1982, with OPEC members reporting to OPEC on the production with no concern over quotas, direct communication to OPEC can be relied on. In the period from March 1982, the use of quotas led to different methods of reporting by OPEC members. This was as because some countries were exceeding their quotas by manipulating the production/domestic consumption system to report lower numbers. In recent years the OPEC secretariat and the ministerial meetings relied more on production data from six sources (PIW, Petroleum Argus Reuters, Platt’s Oilgram Price Report, IEA, CGES), taking a simple average of the estimation of those sources of OPEC members actual production. We will rely on this data for that period.

Figure 6.3: Saudi Arabia and Other Members of OPEC's Monthly Oil Production (Thousands Barrel per Day).
Notes

1 Other pricing instruments such as formulas and forward and future prices, and the different price markets are discussed in appendices (7 and 8).

2 See appendix 7 and 8 for trading instruments and markets of crudes.

3 In OPEC conference/December 1974, the Arabian Light API 34° has chosen to be the marker of OPEC crudes, where it was used for setting the price of OPEC crudes. As it continued until December of 1986 when OPEC reference basket prices were chosen instead.

4 After transportation to a refinery, either by direct pipeline or by tanker, crude petroleum undergoes its downstream transformation into a wide variety of Hydrocarbon products which are separated into light, middle, and heavy cuts. After further processing these fractions yield petroleum gases, gasoline, naphtha, gas oil (diesel fuel and higher grade heating fuel), kerosene and heavy fuel oils.

5 The price relationship between crude and its products depends on the technical characteristics of the crude feedstocks, the configuration of the individual refinery and geographical and seasonal differences between the markets it is supplying.

6 The seven crudes in OPEC reference basket are the Algerian Sahara 44, the Indonesian Minas 33, Nigerian Bonny Light 30, the Saudi Arabian Light 34, UAE’s Dubai 32, Venezuela T.J 32, and isthmus 32.

CHAPTER 7

THE ECONOMETRIC METHODOLOGY

7.1 Introduction

The standard classical methods of estimating are based on the assumption that the means and variance are constant and independent of time. However, applications of the unit root tests have shown that these assumptions are not valid in many economic time series (see Nelson and Plosser 1982). Variables whose means or variances change over time are known as non-stationary. When classical estimation methods, such as the ordinary least squares (OLS), are used to estimate relationships with non-stationary variables, misleading inferences, known as "spurious regression" are obtained. These are a result of computing statistics in the regression model using means and variance of the unit root variables that change over time, and failing to converge to their true values as the sample size increases. Furthermore, the use of the conventional tests gives a biased view and leads to a rejection of the null hypothesis with no relationship between the dependent and the independent variables (Granger and Newbold 1974).

7.2 Stationary and Non-Stationary Time Series

Many time series can be characterised as non-stationary, which can be described by the following models:
First, \( y = \alpha + \beta t + u_t \) is an example of a non-stationary process where \((\alpha + \beta t)\) is a deterministic trend and \(u_t\) is stationary. \(y_t\) is said to be trend stationary, that is, stationary around a trend, i.e. its deviation from the deterministic trend is stationary.

Second, \( y_t = \beta + \rho y_{t-1} + u_t \) has a non-zero intercept: if \( \rho = 1 \) it gives a random walk process with drift. Or \( y_t = \rho y_{t-1} + u_t \), if \( \rho = 1 \) gives a random walk without drift. If \( \rho = 1 \), \( y_t \) will follow a stochastic trend in that it will drift upwards or downwards depending on the sign of \( \beta \). This can be stationary by taking the first difference, and \( y_t \) is referred to as a difference stationary.

The two models differ because the first detrending one will produce a variable that is stationary (TS), and it is called “a trend stationary” model, while the second model will not. It will achieve stationarity through differencing so it is called “a difference stationary” model (DS), Harvey (1990) and (Davidson and MacKinnon (1993).

Trends in the data lead to spurious relationships (see, Newbold and Davis (1978) and Granger and Newbold (1986)) where the statistical inference (based on t- and F-tests) leads to a rejection of the null hypothesis of no-relationship, and gives support to the economic theory. Thus, there is a chance of falsely concluding that a relationship exists between two unrelated non-stationary series. Moreover, the use of differenced variables will avoid the problem of spurious regression. It will also remove any long-run information. (see, Davidson, Hendry, Srb, and Yoo. DHSY 1978).
Unit Roots and Stationarity: Starting with a very simple data generating process (DGP), suppose that a variable $y_t$ is generated by the following (first-order auto-regressive) process:

$$ y_t = \rho y_{t-1} + u_t \quad \left| \rho \right| < 1 \quad 7.1 $$

or

$$(1 - \rho L)y_t = u_t$$

$u_t$ is a white noise error process (mean is zero $E(u) = 0$) and constant variance $E(u^2) = \sigma^2$. $L$ is the lag operator such that $L y_t = y_{t-1}$ while $L^2 y_t = y_{t-2}$. Formatting a characteristic equation (i.e., $(1-\rho z) = 0$); if the roots of this equation are all greater than unity then $y$ is stationary. In equation $7.1$ there is only one root ($z = 1/\rho$) thus stationarity requires $|\rho|$ which is less than one. If $\rho = 1$ then $y$ will be non-stationary. A stationary series tends to return to its mean value and fluctuate around it with a finite variance, while a non-stationary series has different means and its variance increases with sample size. Thus, stationarity requires that $|\rho| < 1$.

This simple time series model can be extended to let $y$ depend on past values. To extend $7.1$ is to let $y$ depend on past values up to a length of, say, $k$.

$$ y_t = \rho y_{t-1} + \rho_2 y_{t-2} + \ldots + \rho_k y_{t-k} + u_t \quad 7.2 $$

or

$$ A(L)y_t = u_t $$

where $A(L)$ is the polynomial lag operator:

$$ 1 - \rho_1 L - \rho_2 L^2 - \ldots - \rho_k L^k \quad 7.3 $$

7.3 is described as the $k^{th}$ order auto-regressive (AR) model. An alternative way of capturing the dependence of $y_t$ on its past is by a moving average model. The first order moving average (MA) process is defined by
$y_t = u_t + \theta u_{t-1}$ \hspace{1cm} |$\theta$| < 1 \hspace{1cm} 7.4

or a model with past values up to lag length of q:

$$y_t = u_t + \theta_1 u_{t-1} + \ldots + \theta_q u_{t-q}$$

or $$y_t = B(L)u_t$$

Where $B(L)$ is the polynomial lag operator $1 - \theta_1 L - \theta_2 L^2 - \ldots - \theta_q L^q$

By combining the two models what is known as the auto-regressive-moving average (ARMA) process is obtained:

$$y_t = \rho y_{t-1} + \rho_2 y_{t-2} + \ldots + \rho_k y_{t-k} + u_t + \theta u_{t-1} + \ldots + \theta_q u_{t-q}$$ \hspace{1cm} 7.5

This represents the most flexible class of models for univariate time series which can be extended to multivariate time series. If $y$ is a vector of observation, it may be modelled on its own past by a multivariate, or vector, ARIMA process (Box and Jenkins 1976; also Box, Jenkins and Reinsel 1994).

$$y_t = \Phi y_{t-1} + \Phi_2 y_{t-2} + \ldots + \Phi_k y_{t-k} + u_t + \Theta u_{t-1} + \ldots + \Theta_q u_{t-q}$$ \hspace{1cm} 7.6

The parameters are now contained within the square matrices, $\Phi_1, \Phi_2, \ldots, \Theta_1, \ldots, \Theta_q$ while $u_t$ is a vector of random disturbances.

A pure auto-regressive process $y_t = \Phi y_{t-1} + \Phi_2 y_{t-2} + \ldots + \Phi_k y_{t-k} + u_t$ is the easiest model to handle. It is usually known as a vector auto-regressive, and abbreviated as VAR.

Before any regression analysis can be performed, it is essential to transform the non-stationary time series into a stationary one through differencing. However, the problem with differencing the data is that the long-run information is lost, that is, the long-run relationship cannot be recovered from an estimated model. Hendry and Mizon
(1978) and DHSY (1978), formalising the similar work of Sargan (1964), viewed the auto-correlation residual as providing valuable information about the behaviour of the dependent variable. This led to the development of the co-integration concept and the ECM model.

7.3 Testing for Unit Roots and Stationarity

Several tests were suggested to test the null hypothesis that a series does contain a unit root as against the alternative of stationarity, the Dickey-Fuller (DF) approach, the Sargan-Bhargava (1983) CRDW-test, based on usual Durbin- Watson statistic, and a non-parametric test which is based on Philip (1987), Philip and Perron (1988).

Prior to the above tests, examinations of stationarity were done through the estimation of the auto-correlation function (ACF) following the work of Box and Jenkins (1976). If the ACF dies off and reaches zero quickly, it means the series is stationary. The problem with this approach is that it is highly subjective and not based on formal testing.

The most popular tests for unit root will be reviewed here; the formal test of Dickey Fuller (DF) and ADF for the presence of unit roots and the Philip and Perron Z-test, when structural break is present in the time series.

7.3.1 The Dickey Fuller Test

The simplest form of the DF test is to estimate

\[ y_t = \rho y_{t-1} + u_t \quad \text{or} \quad \Delta y_t = (\rho - 1) y_{t-1} + u_t \]

with \( u_t \) a white noise.
If $p=1$ or $(p-1)=0$, $y_t$ is stationary and we can apply standard statistical procedures to estimate and test the hypothesis involved in regression containing stationary variables. If $p=1$, $(p<1)$, $\delta<0$, $y_t$ is said to have a unit root and is non-stationary. The distribution of the t-test statistic is not the standard t-distribution, rather it is skewed to the left. Critical values of the DF test were estimated via a Monte Carlo study by Dickey and tabulated in Fuller (1996, p. 641) and Mackinnon (1991).

If $u_t$ does not have the usual assumption (e.g. autocorrelated), Dickey and Fuller (1979) suggested adding lagged dependent variable values to ensure that the error term is white noise. In this case, the equation to be estimated becomes:

$$\Delta y_t = \delta_0 + \delta_1 y_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta y_{t-i} + u_t$$  \(7.7\)

This version of the test is called the Augmented Dickey-Fuller test (ADF). The ADF has the same distribution as the DF test. The null and alternatives are the same as before, that is, $H_0: \delta=0$ verses $H_A: \delta < 0$

Several extensions and modifications have been proposed to the ADF test. For example, Dickey and Fuller (1979, 1981) provided an empirical distribution when a random variable has deterministic and/or stochastic trends (Harvey, 1990, Harris, 1995) where the test equation becomes

$$\Delta y_t = \delta_0 + \delta_1 y_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta y_{t-i} + u_t$$  \(7.8\)

It is also important to select the appropriate lag-length; too few lags may result in over rejecting the null when it is true, while too many lags may reduce the power of the test. Banerjee et al.(1993) favour a general parameterisation, instead of using a few lags which
implies some remaining autocorrelation. It has been suggested that model selection procedures be used, that is, tested to see if the additional lag is significant in them. However, the increase of $R^2$ was shown, in Harr"{i}e (1992) to be unsatisfactory, and instead it was suggested that the formula suggested by Schwert (1989) be used, which is consistent with Banerjee et al (1993).

7.3.2 Structural Change and Unit Roots

The other means of obtaining unit root test statistics is to use the non-parametric unit root tests of Phillips (1987) and Phillips and Perron (1988). They argued that the wide spread of evidence of unit roots in the univariate representation of time series may be due to the presence of important structural changes in the trend function; see Perron (1989) (1994). Perron argued that if there is a break in the deterministic trend $\delta$, then unit root tests will lead to the misleading conclusion that there is a unit root, when in fact there is not. Phillips and Perron argued that the presence of structural changes might affect the result of the unit root test. Following the approach of Dickey and Fuller (1979) and extended by Said and Dickey (1984), using simple autoregressions that are appropriately augmented with trend and dummy components which take into account the break in the series, Perron (1989) derived a conditional test, with a given known break point. This assumption of known break data (treating it as an exogenous event) raised the problem of pre-testing regarding the choice of break date. After Perron several methods have been developed for endogenising the choice of a break point into the testing procedures. (See Zivot and Andrews (1992) Banerjee et al (1993), Perron and Vogelsang (1992). For more reviews of other tests see Maddala and Kim (1996)). However, in practice, there is a lot of prior methodology available for use. For instance, major events during the testing period such as
war or supply interruptions occur during the time of the study. Therefore, the Phillips and Perron test will be used to test for stationarity in addition to Dickey and Fuller Tests.

7.4. Cointegration

The economic interpretation of cointegration is that if two (or more) series are linked to form an equilibrium relationship in the long-run, then even though the series themselves may contain a stochastic trend (i.e. be non-stationary) they will nevertheless move closely together over time and the difference between them will be stable (i.e. stationary) (Harris 1995). This means that their relationship is a long-run equilibrium which in an economic system converges over time, and the disturbance can be interpreted as the dis-equilibrium error or the deviation from the long-run path.

7.4.1 Order of Integration

If a series must be differenced \(d\) times before it becomes stationary, then it contains \(d\) unit roots and is said to be integrated of order \(d\), denoted \(I(d)\). If two time series \(y_t\) and \(x_t\), which are both \(I(d)\) the difference between them \((y_t - \beta x_t)\) is varying randomly around some fixed level, with a fixed variance. For example, if two series say are both \(I(1)\), the difference between them might be stable around a fixed mean. The implication would be that the series are drifting upward roughly at the same rate. Two series that satisfy this requirement are said to be cointegrated. It can be defined such that time series \(x\) and \(y\) are said to be cointegrated in the order of \(d, b\) and there exists a vector such that

\[
\beta x \sim I(d-b), \ b > 0.
\]
Thus if a set of I(d) variables yields a linear combination that has a lower order of integration (d-b < d) for b > 0, then the vector $[1, -\beta]$ is the cointegrated vector.

### 7.4.2 Error Correction Mechanism (ECM)

We can distinguish the long-run relationship between $y_t$ and $x_t$, that is the manner in which the two variables drift upward together, from short-run dynamics that is the relationship between the deviations of $y_t$ from its long-run trend and the deviation of $x_t$ from its long-run trend. (see Engle and Granger 1987)).

Engle and Granger (1987) showed in their Granger representation theorem, that, if two time series $x$ and $y$ are cointegrated, the short-term disequilibrium relationship between them can always be expressed in the error correction form:

$$\Delta y_t = \text{lagged}(\Delta y_t, \Delta x_t) - \lambda u_{t-1} + \varepsilon_t \quad 0 < \lambda < 1$$

where $u_t$ is the disequilibrium error or the extent of departure from the long-run relationship, and $\lambda$ is a short-run adjustment parameter.

To show an ECM we can use a very simple dynamic model (with lags $p=q-1$) of short-run adjustment:

$$y_t = \gamma_0 + \gamma_1 x + \gamma_2 x_{t-1} + \alpha y_{t-1} + u_t \quad 7.9$$

where $u_t$ is a white noise residual, $\sim IN(0,\sigma^2)$. In the solution suggested by Engle and Granger (1987), it is shown that if $y_t$ and $x_t$ are cointegrated CI(1.1), then there must exist an ECM where instead of using the first difference, which might lead to the removal of information on the long-run from the model, adopting the error-correction (ECM)
formation of the dynamic model, rearranging and reparameterising the short-run equation would give:

\[ \Delta y_{t-1} = \gamma_0 + \gamma_1 \Delta x_t - \lambda (y_{t-1} - \beta_1 x_{t-1}) + \epsilon_t \]

By defining a new parameter \( \beta_i = (\gamma_1 + \gamma_2)/\alpha \) and \( \beta_0 = \gamma_0/\lambda \) as a second parameter.

\[ \Delta y_t = \gamma_1 \Delta x_{t-1} - \lambda (y_{t-1} - \beta_0 - \beta_1 x_{t-1}) + \epsilon_t \]

This differs from the long-run relationship model where it includes the term in parentheses which indicates the disequilibrium error from period t-1.

Assuming that \( x_t \) and \( y_t \) are cointegrated the ECM model incorporates both the short-run and long-run effects, where the term \([y_{t-1} - \beta_0 - \beta_1 x_{t-1}]\) measures the distance the system is away from the equilibrium, and the coefficient \([\gamma\)] is an estimate of information on the speed of adjustments, that is, how the variable \( y \) changes in response to disequilibrium. (see Engle and Granger, (1978), Banerjee, al. (1993) and Hendry (1995). This allows for any previous disequilibrium in the levels of \( x \) and \( y \) where the value of \( y \) is in fact being corrected for any previous disequilibrium or error. The parameter \( \beta_1 \) is the long-run elasticity of \( y \) with respect to \( x \). While \( \gamma_1 \) appears in the short-run as disequilibrium (equation 7.5) relationships, it clearly reflects the immediate response of \( y \) to a change in \( x \). It is therefore the short-run elasticity. Another advantage of the ECM is that all the terms in the model are stationary so standard regression techniques are valid. And a further advantage is that an ECM representation of disequilibrium relationship will always reduce problems of multicollinearity. According to Banerjee et al. (1993) the correlation between any two variables in an ECM are virtually zero (see Thomas (1997) p. 388) for more detailed explanation of the advantage of the ECM.
The ECM can be applied to a more complicated dynamic process, where additional lag-length \( p \) and or \( q \) is added, the ECM will be generalized as:

\[
a(L)\Delta y_t = B(l)\Delta x_t - (1-\mu)[\gamma_{-p} - \beta_0 - \beta_1 x_{t-p}] + u_t
\]

7.10

where \( A(L) \), \( B(L) \) is the polynomial lag operators

\[
A(L) = 1 - \alpha_1 L + \alpha_2 L^2 + ... + \alpha_p L^p
\]

\[
B(L) = 1 - \gamma_1 L + \gamma_2 L^2 + ... + \gamma_p L^p
\]

and \( \mu = (\alpha_1 + \alpha_2 + ... + \alpha_p) \).

The ECM can be specified in multivariate form, allowing for a set of cointegration vectors. This will be discussed later in this chapter.

7.4.3 Cointegration and Granger-Causality

The cointegration technique, by Engle and Granger (1987), Hendry (1986) and Granger (1986), made a significant contribution towards testing Granger-Causality. According to this technique, if two variables are cointegrated, the finding of no-causality in either direction (one of the possibilities with the standard Granger (1969) and Sims (1972) tests) is ruled out. As long as the two variables have a common trend, causality (in Granger sense, not in the structural sense) must exist in at least one direction, either unidirectional or bi-directional (Granger, 1986 1988).

However, although cointegration does indicate the presence or absence of Granger-Causality, it does not indicate the direction of causality between variables. This direction of the Granger Causality can be detected through the vector error correction model (VECM) derived from the long-run cointegrating vectors (See Masih et al (1996). The Granger Causality (or endogeneity of the dependent variables) can be evidenced either
through the statistical significance of the t-test of the lagged error-correction term(s), or the F-test applied to the joint significance of the sum of the lags of such explanatory variables. The non-significance of both, the t-test as well as the F-test, in the VECM indicates econometric exogeneity of the dependent variable (Masih et al (1996)

7.5 Seasonality

When observations are available on a monthly or quarterly basis, some allowance must be made for seasonal effects, since variables might exhibit strong seasonal patterns which account for a major part of the total variation in the data and which are therefore important in modelling time series.

7.5.1 Definition of Seasonality

The concept of seasonal time series depends on a definition of seasonality. This definition may vary according to the various approaches to modelling seasonality (Hylleberg 1992), see also Hylleberg 1986). The simplest definition of seasonality is the deterministic seasonal dummy definition,

\[ y_t = \sum_{s=1}^{S} \alpha_s d_t^s + \varepsilon_t \quad 7.11 \]

where \( d \) is the dummy for season \( s \), \( \alpha \) is the mean value of \( x \), in season \( s \), \( S \) is the number of seasons (4 for quarterly and 12 for monthly data) \( \varepsilon \) is a stationary stochastic process. This definition of seasonality is that, although part of the seasonal fluctuations can be approximately deterministic because of, say, calendar and weather effects, some part of the seasonal fluctuations may be caused by the behaviour of economic agents (Stochastic).
The second definition of seasonality involves the presence of seasonal unit roots. The most common specification is

\[ y_t = y_{t-12} + \varepsilon_t \quad 7.12 \]

If economic time series are characterised by seasonal unit roots, then estimation of models such as \( y_t = \sum_{s=1}^r \alpha_s d_t^s + \varepsilon_t \) provides spurious results.

The third definition of seasonality is stationary, stochastic seasonality

\[ y_t = \rho y_{t-s} + \varepsilon_t \quad |\rho| < 1 \quad 7.13 \]

\[ y_t = \varepsilon_t + \theta \varepsilon_{t-s} \]

where \( s \) is the number of seasons. These series are not seasonal in the sense of seasonal dummy process because their means do not differ across seasons (Miron1994)

### 7.5.2 Test for Seasonality

A test for seasonality can be obtained by plotting the time series to see if there are any seasonal fluctuations, in order to obtain the amount of seasonal variation. Franses1996a, 1996b suggested the method used by Miron (1994) as a tentative approach to the test of seasonality. This method amounts to the regression of the first order difference variables on 12 seasonal dummies for monthly data.

\[ \Delta_1 y_t = \delta_1 D_{1t} + \delta_{12} D_{2t} + \delta_3 D_{3t} + \ldots + \delta_{121} D_{12t} + u_t \]

where \( u \) is some error process. By using \( R^2 \) for the regression and the estimate of the coefficient \( \delta \), and by assuming the filter \( \Delta_1 \) is sufficient to remove the trend from the time series, and that the seasonal dummies are sufficient to describe seasonality, the estimated \( R^2 \) value tentatively indicates the amount of variation in \( y \) accounted for by seasonality.
There exist many arguments for expecting a varying and changing seasonal component, but the important question is concerned with the degree of variation. A parsimonious model which depicts a constant deterministic seasonal pattern may be depicted as a model with unit roots, i.e. a model which allows for integration at seasonal frequencies.

Box and Jenkins (1970) used differencing to remove seasonal components, such as, using the fourth difference transformation, \( y_{4t} = (1-L^4)y_t \), to remove the seasonal components from the quarterly data, or the twelfth difference \( y_{12t} = (1-L^{12})y_t \), where \( L \) is the lag operator. This differencing is in addition to the first difference, \( 1-L \) in the stationary process phase of the procedure.

When the seasonal component of a time series is deterministic i.e. very regular, the transformation will be regular too, but in case of varying and changing seasonal patterns the transformation will show some variation. This variation in seasonal patterns is an indication of the existence of unit roots, which indicates the need for a test of the existence of such unit roots.

stochastic seasonality process generated by, \( y_t = \phi_s y_{t-s} + u_t \). Such a process may exhibit a seasonal pattern which changes over time. If we start with seasonal difference

\[
\Delta_s y_t = \sum_{i=1}^{k} \theta_i \Delta_s y_{t-i} + u_t \quad 7.14
\]

use the OLS estimates of \( \theta_1, \theta_2, \ldots, \theta_k \) to construct the variable \( z \) from \( y_t, y_{t-1}, y_{t-k} \), as

\[
z_t = y_t - \sum_{i=1}^{k} \hat{\theta}_i y_{t-i} \quad 7.15
\]

and substitute the lagged value of \( z \) into the regression equation

\[
\Delta_s y_t = \delta z_{t-s} + \sum_{i=1}^{k} \delta_i \Delta_s y_{t-i} + \varepsilon_t \quad 7.16
\]

then, based on the t-statistic for the OLS estimate the parameter is \( \delta \). The critical values for the test are given in Dickey, Hasza and Fuller (1984). If the estimate of \( \delta \) is significantly negative, the null hypothesis of the existence of seasonally integrated process may be rejected. If the null hypothesis is not rejected, it is usual to consider the order of non seasonal integration.

Hylleberg, Engle, Granger and Yoo (1990), hereafter termed the HEGY test developed procedures for determining whether a series is characterised by deterministic, seasonal or unit roots at seasonal frequencies (see also Banerjee et al (1993)). This can be expressed by using the lag operator \( L y_t = y_{tl} \) and \( L^j y_t = y_{t} \) where a seasonal difference may be written as \( (1-L) y \). The HEGY tests for quarterly data use the representation:

\[
\Delta_4 y_t = \sum_{i=1}^{4} \alpha_i D_{i} + \sum_{i=1}^{4} \beta_i Y_{i,t-l} + \sum_{i=1}^{k} \phi_i \Delta_4 y_{t-i} + \varepsilon_t \quad 7.17
\]
where $k$ is the number of lagged terms included, $D_a$ is the seasonal dummy variables, and the $Y$ variables are constructed from the series on $y$ as: $Y_{4t} = (1-L^4)x_t$, where $L$ is the lag operator. The lag polynomial $1-L$ can be written as

$$(1-L)(1+L)(1+L^2) = (1-L)(1+L)(1-iL)(1+iL),$$

where $i^2 = -1$.

To test the null hypothesis of $I(1,1)$, that is if the series is stationary after the first period of differencing, against the alternative $I(1,0)$ and $I(0,1)$. If $\beta_1 < 0$ and $\beta_2 = 0$, this implies accepting the alternative hypothesis $I(0,1)$; while if $\beta_2 < 0$ and $\beta_1 = 0$ then accept $I(1,0)$ the critical values of these tests are provided in Hylleberg et al (1990). Beaulieu and Miron (1993) review HEGY to derive its mechanics and the asymptotic distribution of its statistics in the case of monthly data rather than quarterly data. Critical values are published in Hylleberg et al (1990) (for quarterly data), Beaulieu et al (1993) for monthly data and Franses et al (1997) for monthly and quarterly data.

According to Miron (1994) there are many ways one can model seasonal patterns as evolving through time without resorting to the seasonal unit roots hypothesis. His results indicate that the seasonal pattern is best described by seasonal dummies. Hatanka (1996) doubted the modelling of seasonal variation by unit roots because the deviations of seasonal fluctuations from the deterministic periodicity are bounded at any time, and the complex unit roots are inappropriate to model the deviations (see Hatanka 1996 p. 15). Therefore, if there is a seasonality in the time series, there is no need to model unit roots seasonality, and we can use seasonal dummies to model the seasonal effect where the seasonal dummy coefficient can account for the variation resulting from seasonal factors.
7.6 Testing for Cointegration

There are many tests for cointegration, such as the two-step method, introduced by Engle-Granger (1987) which used least squares estimation. Engle and Yoo (1987) discuss a cointegration test with more than two variables, and Stock and Watson (1988) present tests for multiple cointegrating vectors. Johansen (1988, 1991, 1996) and Johansen and Juselius (1992) developed a maximum likelihood approach to estimate and test for multiple cointegrating vectors.

In estimating the cointegrating vector, the two most widely used methods are the Engle and Granger two step estimator and the Johansen (1988, 1991, 1996) and Johansen and Juselius (1992) maximum likelihood estimator.

7.6.1 The Engle and Granger Two-Step Procedures (EG)

With the long-run relationship \( y_t = \beta x_t + u_t \), the cointegration regression is estimated by OLS. The residual can be used to test for cointegration. To do this we test the null hypothesis of \( \delta = 1 \) in the following equation

\[
u_t = \delta u_{t-1} + \zeta_t\]

where \( \zeta \) is white noise.

If \( x_t \) and \( y_t \) are cointegrated, it implies \( u \) should be \( I(0) \). EG used the ADF test using critical values that were published by Engle and Granger (1987). If the ADF test indicates stationarity of the OLS residuals \( u \), which means that cointegration of \( y \) and \( x \) of order \( (1,1) \) with the cointegrating vector \([1, -\beta]\) can be positively accepted, we can estimate the short-run model with an error correction mechanism:

\[
\Delta y_t = \delta \Delta x_t + \lambda (Y - \hat{\beta} X)_{t-1} + \nu_t.
\]

The test is popular because of its simplicity since it depends on estimating the static model.
by OLS and then performing unit root tests on the residuals from the equation before estimating the short-run ECM itself, using the estimates of disequilibrium \((u_t)\) to obtain information on the speed of adjustments to equilibrium.

However, the EG test can be criticised; First, because it doesn’t estimate the long-run relationship. Second, it is possible to have a mixture of different order series when there are three or more series in the model. As Pegan and Wickens (1989) point out, if \(y\sim I(1), x\sim I(2)\) and \(z\sim I(2)\) then we can find a cointegrating relationship between \(x\) and \(z\) such that \(v_t = x_t - \lambda z_t \sim (1)\), and then \(v\) can be potentially cointegrated with \(y\) to obtain \(w_t = (y_t - \xi v_t) \sim I(0)\). Thus, if there are \(n>2\) variables in the model, there can be more than one cointegrating vector, it is possible for up to \(n-1\) linearly independent cointegrating vectors to exist, and this has implications for testing and estimating cointegrating relationships.

7.6.2 Cointegration in Multivariate Systems

When extending the analysis of cointegration to more than two variables, several procedures have been suggested to estimate and test the multivariate cointegrating model. A recent survey and/or comparison of these procedures can be found in, Perman, (1991), the Oxford Bulletin of Economics and Statistics (August, 1991) Dolado el al (1990), Campbell and Perron (1991), Gonzalo (1994), Holden and Perman (1994) and Hargreaves, (1994). Where it is based on Monte Carlo evidence, it has been found that the maximum likelihood procedures of estimating the multivariate cointegration widely use Johansen (1988,1991,1996) and Johansen and Juselius (1992)) which are the most powerful among the alternative procedures.
7.6.3 The Johansen Approach:

If the single equation ECM is extended to a multivariate framework by defining a vector \( z = [y_1, y_2, x_1]' \) and allowing all three variables (\( n=3 \)) in \( z \) to be potentially endogenous, and model \( z \) is an unrestricted vector autoregression (VAR) involving up to \( k-l \) lags of \( z \) then:

\[
z_t = A_1z_{t-1} + \ldots + A_kz_{t-k} + u_t \quad u \sim \mathcal{N}(0, \Sigma)
\]

This can be reformulated into a vector error-correction (VECM) form:

\[
\Delta z_t = \Gamma_1 \Delta z_{t-1} + \ldots + \Gamma_{k-1} \Delta z_{t-k+1} + \Pi z_{t-k} + u_t
\]

\[
\Gamma_i = -(I - A_1 - \ldots - A_i) (i = 1, \ldots, k-1), \\
\Pi = -(I - A_1 - \ldots - A_k)
\]

This method of specifying the system contains information on both the short and the long-run adjustment to changes in \( z \), where the \( \Pi \) matrix contains information on the long-run relationships; \( \Pi = \alpha \beta' \) where \( \alpha \) represents the speed of adjustment to disequilibrium, while \( \beta \) is a matrix of long-run coefficients. The term \( \beta' z \) embodied in \( \Pi z_t \) represents \( (n-1) \) cointegrating relationships in the multivariate model, which ensures that the \( z \) converges to their long-run steady state solution.

Johansen (1988, 1991, 1996) and Johansen and Juselius (1992) focused their attention on the \( \Pi \) matrix and, in particular, on its rank. Three situations now arise related to the rank of \( \Pi \). Firstly, if \( \Pi \) has a full rank equal to \( n \), then it can be shown that \( z \) must be stationary. If the rank of \( \Pi \) is zero, then \( \Pi \) is a null matrix and there is no cointegration. If the rank of \( \Pi \) is equal to \( r<n \) then \( \Pi \) can be written as the product of two matrices, \( \alpha \) and \( \beta \), i.e. \( \Pi = \alpha \beta' \) where the cointegrating space is defined by \( \beta \) and the adjustment factors are
defined by \( \alpha \). To illustrate, if we set the lag length in the above equation to \( k=2 \) and write out the model as follows:

\[
\begin{bmatrix}
\Delta y_{1t} \\
\Delta y_{2t} \\
\Delta x_t
\end{bmatrix} = \Gamma \begin{bmatrix}
\Delta y_{1t-1} \\
\Delta y_{2t-1} \\
\Delta x_{t-1}
\end{bmatrix} + \begin{bmatrix}
\alpha_{11} \alpha_{12} \\
\alpha_{21} \alpha_{22} \\
\alpha_{31} \alpha_{32}
\end{bmatrix} \begin{bmatrix}
\beta_{11} \beta_{12} \beta_{31} \\
\beta_{21} \beta_{22} \beta_{32}
\end{bmatrix} \begin{bmatrix}
y_{1t-1} \\
y_{2t-1} \\
x_{t-1}
\end{bmatrix} + \begin{bmatrix}
u_1 \\
u_2 \\
u_3
\end{bmatrix}
\]

Matrix \( \beta \) is the long-run relationships coefficients. It is the co-integrating matrix which has the property that although \( z_t \) is \( I(1) \), \( \beta'z_t \) is \( I(0) \); that is, \( \beta'z_t \) is stationary. The columns of \( \beta \) are co-integrating vectors. In a VAR model with \( n \) variables, there can be at most \( n-1 \) co-integrating vectors. Note that when \( r<n \) it is a multivariate generalisation of the Engle and Granger (1987) two step procedures discussed above, and the term \( \beta'z_{t-1} \) is equivalent to \( (y_{t-1} - \beta x_{t-1}) \) except that it contains up to \( (n-1) \) vectors in multivariate.

The Johansen procedures provide techniques for determining the number of co-integrating vectors, \( r \); estimating all possible co-integrating vectors, \( \beta \); and a set of error correction coefficients, \( \alpha \).

The basic steps to apply the Johansen procedures are:

1. Test the order of integration of each variable that enters the multivariate model, using the Augmented Dickey Fuller Test with a constant and time trend.
2. Test if the model includes seasonal dummies as explained above.
3. Test for dummy variable to take account of short-run shocks to the system, such as policy interventions.
4. Specify if the model includes intercept and time trend, and test for it by restricting the intercept in the long-run model to account for the unit measurement of the variables in
173.

z. (See Hansen and Juselius, 1994 for detailed description of the methods). If there is some long-run linear growth which the model cannot account for, to test for it, the value of the time trend coefficient should be restricted to being equal to zero and the cointegration space should include time as a trend-stationary variable to take account of unknown exogenous growth.

5. VAR specification: lag length determination. In determining the lag length, it is important to avoid too many lags which allow the presence of many parameters. One should also set the appropriate lag length of the VAR model in order to ensure Gaussian error terms in the VECM. The lag length determination can be classified into two criteria (Lutkepohl 1993, p.125), one is to choose the p that minimize some criterion function of p, this can be done through Akaike information proposed by Akaike (1973) and Schwarz information criterion proposed in Schwarz (1987). Another way is to use the general to specific method where we start with large lag length, by using the likelihood ratio statistic, check the residuals to test that the coefficient to the largest lag is zero (see Hatanaka 1996 p. 229). This can be done by plotting the autocorrelation and cross-correlation functions for the individual residual series to see if there are any residual autocorrelations and look at the summary test statistics for autocorrelation.

6. Testing for the number of cointegrating vectors. This is done by testing for reduced rank, finding the presence of \( r \leq (n-1) \) cointegrating vectors in \( \beta \), which means finding the number of \( r \) linearly independent columns in \( \Pi \). The Johansen approach uses a reduced rank regression which provides \( n \) eigenvalues \( \lambda_1 > \lambda_2 > \ldots > \lambda_n \) and their corresponding eigenvectors. Thus to test the null hypothesis that there are at most \( r \)
cointegration vectors (and thus \(n-r\) unit roots) amounts to: \(H_0: \lambda_i = 0 \quad i=r+1,...,n\)

where only the first \(r\) eigenvalues are non-zero. Using the likelihood ratio test (the trace statistic):

\[
\lambda_{\text{trace}} = -2 \log(Q) = -T \sum_{i=r+1}^{n} \log(1 - \hat{\lambda}_i) \quad r=0,1,2...,n-2,n-1
\]

where \(Q=\) restricted likelihood divided by unrestricted maximized likelihood. Another test of the significance of the largest \(\lambda\), is the so-called maximal eigenvalue or \((\lambda\)-max-statistic):

\[
\lambda_{\text{max}} = -T \log(1 - \hat{\lambda}_{r+1}) \quad r=0,1,2...,n-2,n-1..\]

Critical values are those used in Microfit 4. For more discussion of these critical values see Pesaran (1997).

7. Estimates and inference for the parameters of the cointegrating vectors. First impose restrictions to test the hypothesis concerning the cointegrating space of the vectors. Having determined how many cointegration vectors there are, it is now necessary to consider whether these are unique and consequently whether they tell us anything about the structural economic relationships underlying the long-run model. This can be done by placing restrictions motivated by economic arguments (e.g. that some of the \(\beta_{ij}\) are zero or that homogeneity restrictions are needed such as \(\beta_{ij} = \beta_{ij}\)) and then testing whether the columns of \(\beta\) are identified by using the LR test, which is based on the \(\chi^2\) distribution with \((r \times (n-s))\) degrees of freedom.

8. Estimates and inference for the adjustment coefficients. The term in non-zero columns of \(a_{11}\) represents the speed at which the dependent variable \(\Delta y_{11}\) in the first equation of the VECM, adjusts towards the single long-run relationship.
while $\alpha_{21}$ represents the speed at which $\Delta y_{2t}$ adjusts and $\alpha_{21}$ shows how fast $\Delta x_t$ responds to the disequilibrium changes represented by the cointegration vector. If $\alpha_{21}=0$ it means that $x_t$ is a weakly exogenous variable and not included in the short-run but included in the long-run.

7.7 Conclusion

Many economic time series appear to be integrated of order one. When regressing the levels of such series and using the standard econometric procedures, this would lead to spurious relationships. The classical approach in dealing with integrated variables, especially in the time series literature, has been to difference them as many times as needed to make them stationary. The problem with this approach is that differencing leads to the loss of information about the long-run relationship. A second approach to estimating the cointegrating vector is the use of EG procedures. However, there are drawbacks with this approach including the problem of an inability to validly estimate the long-run relationships between the variables when there are more than two, and the inefficiency in estimating a single equation.

There has been a good deal of empirical work done involving cointegration tests and the estimation of models for cointegration variables in dealing with multivariate systems (see Culter et al. 1997) and Lin et al 1997). Cointegration analysis in the form which has been used until now do not take account of what the theory may predict concerning short-run dynamics, on the grounds that theory is concerned with long-run behavior only (see
Pesaran 1997). To investigate the short-run effects we can model them within an unrestricted VAR framework. With the structure and the dynamics of the oil market, the behaviour of participants could be modelled through ECM to predict the short-run behaviour which might then be used to predict the theory.

For testing the long-run cointegrating relations, the Johansen estimation method based on the error correction representation of the vector auto-regressive (VAR) model will be used as suggested by Johansen (1988, 1991, 1996) and Johansen and Juselius (1992) to estimate the equilibrium relationship between the relevant variables.
CHAPTER 8

EMPIRICAL ANALYSIS

8.1 Introduction

In this chapter, a description of the data used in the study is presented followed by the results of the empirical estimations and tests. In section 3 tests of unit roots are presented. Section 4 gives empirical evidence from the Johansen procedure of cointegration. Section 5 shows the results of testing alternative market-sharing models and the relevancy of price in production decisions.

8.2 Variables of the Study

The variables of the study are Saudi’s monthly crude oil production $Q^{SA}$, other OPEC members’ production $Q^{OO}$, the Saudi selling price $P^{SA}$, and the market oil price $P^{M}$.

The period of the study witnessed changes in the world oil market in terms of oil supply interruptions as well as structural changes which have affected the production profiles (chapter 4). The oil market can be divided into different sub-periods with dummy variables used to indicate sub-periods along the lines discussed in chapter 4. We divide the data into two periods:

- $D_1 = 1$ for 1978.11 - 1982.02, 1990.8 - 1991.2
The dummy variables are designed to account for the upset of unexpected political events on the oil market. The Iranian revolution occurred in October of 1978. The Iranian oil supply interruption was followed by a substantial increase in spot oil prices. Also, the start of the Iraq/Iran War in October 1980 caused a sharp increase in oil spot prices. By March 1982, the influence of such events was diminished. In August 1990, Kuwait was invaded by Iraq leading to the Gulf war in January 1991 which continued until the end of February 1991.

8.3 Descriptive Statistics

Tables 8.1 and 8.2 show descriptive statistics of Saudi oil production, production of other members of OPEC and market oil prices, Table 8.1, covers the period from 1976.3 to 1986.12 and Table 8.2 covers the period 1987.1 to 1997.5.

**Table 8.1: Descriptive Statistics for the Variables of the Study for the Period 1976.3 to 1986.12**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saudi production</td>
<td>7259.30</td>
<td>2421.5</td>
<td>2340.0</td>
<td>10533.3</td>
</tr>
<tr>
<td>Other members</td>
<td>16147.0</td>
<td>4435.1</td>
<td>10408.7</td>
<td>24978.3</td>
</tr>
<tr>
<td>Nominal Saudi Selling Price</td>
<td>22.73</td>
<td>08.76</td>
<td>08.99</td>
<td>34.00</td>
</tr>
<tr>
<td>Nominal Market Price</td>
<td>24.44</td>
<td>09.53</td>
<td>08.99</td>
<td>41.31</td>
</tr>
<tr>
<td>Difference</td>
<td>-01.71</td>
<td>04.86</td>
<td>-20.00</td>
<td>-5.53</td>
</tr>
</tbody>
</table>

**Table 8.2: Descriptive Statistics for the Variables of the Study for the period 1987.1 to 1997.5**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saudi production</td>
<td>7032.3</td>
<td>1626.0</td>
<td>3277.50</td>
<td>8664.2</td>
</tr>
<tr>
<td>Other members of OPEC</td>
<td>15943.93</td>
<td>1648.36</td>
<td>11327.50</td>
<td>19014.50</td>
</tr>
<tr>
<td>Price</td>
<td>17.36</td>
<td>3.63</td>
<td>11.92</td>
<td>34.56</td>
</tr>
</tbody>
</table>
8.4 Testing the Properties of the Time Series

The three time series to be considered here are: the log of the monthly crude oil production for Saudi Arabia $Q^{SA}$, log of the production for other members of OPEC $Q^{OO}$, and log of the market price $P^{M}$, observed from 1974-1997.

Table 8.3: Estimation Results from the Regression $\Delta y_t = \delta_1 D_{1t} + \delta_2 D_{2t} + \delta_3 D_{3t} + \delta_4 D_{4t} + \delta_5 D_{5t} + \delta_6 D_{6t} + \delta_7 D_{7t} + \delta_8 D_{8t} + \delta_9 D_{9t} + \delta_{10} D_{10t} + \delta_{11} D_{11t} + \delta_{12} D_{12t}$ where $D_{st}$ ($s=1,2,3,12$) are Seasonal Dummies.

<table>
<thead>
<tr>
<th></th>
<th>Sample</th>
<th>$R^2$</th>
<th>$\delta_1$</th>
<th>$\delta_2$</th>
<th>$\delta_3$</th>
<th>$\delta_4$</th>
<th>$\delta_5$</th>
<th>$\delta_6$</th>
<th>$\delta_7$</th>
<th>$\delta_8$</th>
<th>$\delta_9$</th>
<th>$\delta_{10}$</th>
<th>$\delta_{11}$</th>
<th>$\delta_{12}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\ln Q^{SA}$</td>
<td>76-97</td>
<td>0.13</td>
<td>-.07</td>
<td>.01</td>
<td>-.04</td>
<td>.01</td>
<td>.03</td>
<td>.03</td>
<td>.01</td>
<td>.01</td>
<td>.04</td>
<td>.01</td>
<td>.01</td>
<td>.01</td>
</tr>
<tr>
<td></td>
<td>76-86</td>
<td>0.16</td>
<td>-.06</td>
<td>.01</td>
<td>-.04</td>
<td>.00</td>
<td>.05</td>
<td>.04</td>
<td>.03</td>
<td>.03</td>
<td>.00</td>
<td>.05</td>
<td>.01</td>
<td>-.00</td>
</tr>
<tr>
<td></td>
<td>87-97</td>
<td>0.18</td>
<td>-.06</td>
<td>.00</td>
<td>-.02</td>
<td>.01</td>
<td>.00</td>
<td>.01</td>
<td>.01</td>
<td>.02</td>
<td>.03</td>
<td>.02</td>
<td>.01</td>
<td>.02</td>
</tr>
<tr>
<td>$\ln Q^{OO}$</td>
<td>76-97</td>
<td>0.11</td>
<td>-.05</td>
<td>.01</td>
<td>.00</td>
<td>.01</td>
<td>.01</td>
<td>.00</td>
<td>.01</td>
<td>.01</td>
<td>.01</td>
<td>.01</td>
<td>.01</td>
<td>.00</td>
</tr>
<tr>
<td></td>
<td>76-86</td>
<td>0.19</td>
<td>-.07</td>
<td>.01</td>
<td>.00</td>
<td>.01</td>
<td>.01</td>
<td>.01</td>
<td>.00</td>
<td>.02</td>
<td>.01</td>
<td>.01</td>
<td>.01</td>
<td>.00</td>
</tr>
<tr>
<td></td>
<td>87-97</td>
<td>0.06</td>
<td>-.02</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
<td>.01</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>$\ln P^{M}$</td>
<td>76-97</td>
<td>0.06</td>
<td>-.01</td>
<td>.01</td>
<td>-.03</td>
<td>.01</td>
<td>-.02</td>
<td>-.00</td>
<td>.03</td>
<td>.01</td>
<td>.02</td>
<td>.01</td>
<td>.02</td>
<td>-.02</td>
</tr>
<tr>
<td></td>
<td>76-86</td>
<td>0.08</td>
<td>-.02</td>
<td>.01</td>
<td>-.02</td>
<td>.00</td>
<td>-.02</td>
<td>.00</td>
<td>.02</td>
<td>.01</td>
<td>.02</td>
<td>.02</td>
<td>.02</td>
<td>-.02</td>
</tr>
<tr>
<td></td>
<td>87-97</td>
<td>0.07</td>
<td>.00</td>
<td>.00</td>
<td>-.03</td>
<td>.00</td>
<td>.01</td>
<td>.00</td>
<td>.02</td>
<td>.02</td>
<td>.02</td>
<td>.01</td>
<td>.02</td>
<td>-.04</td>
</tr>
</tbody>
</table>

To obtain a first and tentative impression of the amount of seasonal variation, Franses (1996) suggested the use of the approach advocated in Miron (1994). The method amounts to the regression of the first order difference variables on the 12 seasonal dummies

$$\Delta y_t = \delta_1 D_{1t} + \delta_2 D_{2t} + \delta_3 D_{3t} + \delta_4 D_{4t} + \delta_5 D_{5t} + \delta_6 D_{6t} + \delta_7 D_{7t} + \delta_8 D_{8t} + \delta_9 D_{9t} + \delta_{10} D_{10t} + \delta_{11} D_{11t} + \delta_{12} D_{12t} + u_t$$  

where $u_t$ is some error process. By using $R^2$ for the regression and the estimate of the coefficient $\delta_t$, assuming the filter $\Delta_t$ is sufficient to remove the stochastic trend from the time series, and that the seasonal dummies are sufficient to describe seasonality. These assumptions may be debatable (see e.g., Hylleberg et al 1993), therefore I follow the suggestion of Franses (1996,b) concerning the use of a tentative model framework that can
give some indication of the amount of seasonal variation in a monthly time series. Franses used $R^2$ and divided the sample to sub-samples and compared the estimates of the coefficients $\delta$.

The estimated $R^2$ value tentatively indicates the amount of variation in time series accounted for by seasonality (see Table 8.3). For the three time series, $R^2$ ranges from 6% to about 19% which indicates that the seasonality effect is too small. Further tentative observations from the results for the coefficients $\delta_i$, show that $\delta_i$ seems constant over time. So we conclude that the time series does not have any deterministic seasonality.

The rejection of the presence of deterministic seasonal effect does not mean there is no presence of non-stationary stochastic seasonality due to seasonal unit roots. It is the ‘non-stationary’ due to seasonal unit roots that raises the most troubling statistical issues. So we first proceed with a test for the presence of seasonal unit root. In order to test hypotheses about various unit roots, one estimates equation 8.1 with additional lags of $y_{12}$ lags to whiten the errors.

\[
\Delta_{12}y_t = \sum_{i=1}^{12} \alpha_i D_i + \sum_{i=1}^{12} \beta_i y_{i,t-1} + \sum_{i=1}^{k} \varphi_i \Delta_{12}y_{t-1} + \varepsilon_t
\]

The equation is estimated by OLS. For a 5% significant level, the critical value for monthly data, provided in Beaulieu and Miron (1993). For a time series with 240 observations, the critical values are for $\pi_1$ is equal to -2.76, $\pi_2$ is equal to -2.76, and for odd coefficients is equal to -3.25 and even coefficients is equal to -1.85. The hypothesis
tested is $\varphi=0$, ($\varphi$ consists of the coefficients $\pi_1, \pi_2, \pi_3, \pi_4, \pi_5, \pi_6, \pi_7, \pi_8, \pi_9, \pi_{10}, \pi_{11}$ and, $\pi_{12}$). (see Table, 8.4)

**Table 8.4**: Results of Tests for Seasonal Unit Roots in Monthly Time Series (1976.3-1997.5) for the log of the Variables $Q^S, Q^O, P^M$

<table>
<thead>
<tr>
<th>Variables</th>
<th>$\pi_1$</th>
<th>$\pi_2$</th>
<th>$\pi_3$</th>
<th>$\pi_4$</th>
<th>$\pi_5$</th>
<th>$\pi_6$</th>
<th>$\pi_7$</th>
<th>$\pi_8$</th>
<th>$\pi_9$</th>
<th>$\pi_{10}$</th>
<th>$\pi_{11}$</th>
<th>$\pi_{12}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\ln Q^S$</td>
<td>-5.3</td>
<td>-5.6</td>
<td>-1.0</td>
<td>-2.4</td>
<td>-3.1</td>
<td>1.99</td>
<td>0.14</td>
<td>-2.6</td>
<td>-5.2</td>
<td>-2.5</td>
<td>3.6</td>
<td>1.8</td>
</tr>
<tr>
<td>$\ln Q^O$</td>
<td>4.7</td>
<td>-5.0</td>
<td>-1.7</td>
<td>1.69</td>
<td>3.4</td>
<td>0.70</td>
<td>-7.4</td>
<td>-9.4</td>
<td>-2.83</td>
<td>5.9</td>
<td>2.2</td>
<td>-7.4</td>
</tr>
<tr>
<td>$\ln P^M$</td>
<td>0.7</td>
<td>4.26</td>
<td>2.97</td>
<td>-0.46</td>
<td>0.01</td>
<td>4.72</td>
<td>1.59</td>
<td>-8.9</td>
<td>-1.35</td>
<td>9.33</td>
<td>2.7</td>
<td>-4.0</td>
</tr>
</tbody>
</table>

With F-statistic for the three time series $F(23,226)= 109.37$ for $Q^S$, $F(23,202)= 85.59$ for $Q^O$ and $F(23,198) = 189.77$ for $P^M$. Since the null is two dimensional, the F-statistics for the joint null for the coefficient for $(\pi_5, \pi_6)$ $(\pi_7, \pi_8)$ $(\pi_9, \pi_{10})$ and $(\pi_{11}, \pi_{12})$ are computed and reported in Table 8.5 which provide strong evidence against seasonal unit roots. The 5% critical value for the F-test (with intercept, seasonal dummies and no trends) is 6.25.

**Table 8.5**: Results of Tests for Seasonal Unit Roots in Monthly Time Series (1976.3-1997.5) for the log of the Variables $Q^S, Q^O, P^M$ Using the F-statistic for the Joint Null for the Coefficients.

<table>
<thead>
<tr>
<th>Variables</th>
<th>$F$ for $\pi_5\pi_{16}$</th>
<th>$F$ for $\pi_7, \pi_{12}$</th>
<th>$F$ for $\pi_9, \pi_{10}$</th>
<th>$F$ for $\pi_{11}, \pi_{12}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\ln Q^S$</td>
<td>7.61</td>
<td>33.80</td>
<td>13.8</td>
<td>9.01</td>
</tr>
<tr>
<td>$\ln Q^O$</td>
<td>6.04</td>
<td>78.40</td>
<td>18.54</td>
<td>30.85</td>
</tr>
<tr>
<td>$\ln P^M$</td>
<td>9.41</td>
<td>46.26</td>
<td>48.85</td>
<td>8.80</td>
</tr>
</tbody>
</table>

Table 8.4 and 8.5 present the results, applying HEGY (1990) test procedures, for the Saudi crude oil production, production of other members of OPEC and the market price of oil. The definition of each series is given in appendix 10. The estimation equations include a constant, seasonal dummies and lags of the dependent variable. We allow for seasonal dummies in all tests, because the loss of power that results from inclusion when unnecessary is significant compared to the bias that results from their omission when necessary (Franses 1996a). The value of the coefficients and the F-test statistic are reported in Tables 8.4 and
8.5. Lag length is determined using a test for serial correlation of residuals which is reported in Table 8.6.

**Table 8.6: Test for Serial Correlation of Residuals.**

<table>
<thead>
<tr>
<th>Variables</th>
<th>LR $\chi^2$(1) [p-value]</th>
<th>F statistic [p-value]</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\ln Q^SA$</td>
<td>0.6263 [.429]</td>
<td>$F_{1,325} = 0.565 [.453]$</td>
</tr>
<tr>
<td>$\ln Q^{SO}$</td>
<td>0.617 [.432]</td>
<td>$F_{1,197} = 0.549 [.459]$</td>
</tr>
<tr>
<td>$\ln P^M$</td>
<td>1.004 [.316]</td>
<td>$F_{1,197} = 0.895 [.345]$</td>
</tr>
</tbody>
</table>

We generally reject seasonal unit roots at the 5% level at all seasonal frequencies using the t-test Table (8.4) and compare its value with critical value reported by Beaulieu and Miron (1993). We reject the null hypothesis of zero for most of the coefficients $\pi_1, \pi_2, \pi_3, \pi_4, \pi_5, \pi_6, \pi_7, \pi_8, \pi_9, \pi_{10}, \pi_{11}, \pi_{12}$ and we reject the joint null for the coefficients $(\pi_5, \pi_6)$ $(\pi_7, \pi_8), (\pi_9, \pi_{10})$ and $(\pi_{11}, \pi_{12})$. The data on Saudi production rejects unit roots less often than those for other members of OPEC, where for $Q^SA$, they fail to reject zero coefficients for $\pi_3, \pi_4, \pi_6, \pi_7$. While for $Q^{SO}$ we fail to reject for only one coefficient $\pi_6$. For $P^M$ we fail to reject zero coefficients for $\pi_1, \pi_4, \pi_7, \pi_9$. However, they were all rejected by the joint hypothesis test.

To summarise, for most series we reject unit roots, and there is no series for which we fail to reject unit roots for at least eight of the frequencies. The strongest evidence for seasonal units is in Saudi production, and price, but even in this case we reject more often than not at the 5% level. Generally we reject the hypothesis of unit roots for the three time series and we proceed accepting the hypothesis of no seasonality effect.
8.5 Tests for Stationarity and Unit Root

In this section, the time series properties of data used in the study will be examined. The Augmented Dickey-Fuller (ADF) tests and Phillips-Perron Test (PP) will be applied to the time series employed in the study: $Q_s^A, Q_o^O$, $P^M$ and $P^M_t$. Unit root tests with trend and without time trend using equations (7.8) and (7.9) from chapter 7 are applied. All test equations include a constant. The Akaike information Criterion, Schwarz Baysian Criterion, and Hannan-Quinn Criterion are used to determine the log order for the ADF test to guarantee white noise for the disturbance of the equations.

Table 8.7: Tests for Stationarity for the Time Series for the Period 1976:3-1986:12

<table>
<thead>
<tr>
<th>Variable (lag order)</th>
<th>Without Trend</th>
<th>Variable (lag order)</th>
<th>With Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>$95%$ critical values</td>
<td>-2.87 PP(1)</td>
<td>-2.87 ADF</td>
<td>-3.45 PP</td>
</tr>
<tr>
<td>$\ln Q_s^A(1)$</td>
<td>-1.32</td>
<td>-1.40</td>
<td>$\ln Q_s^A(2)$</td>
</tr>
<tr>
<td>$\ln Q_o^O(1)$</td>
<td>-1.31</td>
<td>-1.77</td>
<td>$\ln Q_o^O(1)$</td>
</tr>
<tr>
<td>$\ln P^M(1)$</td>
<td>-0.23</td>
<td>-0.45</td>
<td>$\ln P^M(1)$</td>
</tr>
<tr>
<td>$\ln(P^M_t)^0(0)$</td>
<td>-1.85</td>
<td>-1.92</td>
<td>$\ln(P^M_t)^0(0)$</td>
</tr>
</tbody>
</table>

Table 8.8: Test for Stationarity for the Time Series for the Period 1987:1-1995.8

<table>
<thead>
<tr>
<th>Variable (lag order)</th>
<th>Without Trend</th>
<th>Variable (lag order)</th>
<th>With Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>$95%$ critical values</td>
<td>-2.87 PP</td>
<td>-2.87 ADF</td>
<td>-3.43 PP</td>
</tr>
<tr>
<td>$\ln Q_s^A(3)$</td>
<td>-2.16</td>
<td>-1.10</td>
<td>$\ln Q_s^A(3)$</td>
</tr>
<tr>
<td>$\ln Q_o^O(0)$</td>
<td>-2.87</td>
<td>-2.54</td>
<td>$\ln Q_o^O(0)$</td>
</tr>
<tr>
<td>$\ln P^M(2)$</td>
<td>-2.99</td>
<td>-3.08</td>
<td>$\ln P^M(1)$</td>
</tr>
</tbody>
</table>

8.5.1 The Dickey Fuller Test

The test statistic suggested by Dickey Fuller (1979) is used to test the null hypothesis of the presence of unit root (non-stationarity) for all the relevant variables. The results of the ADF tests are reported in Tables 8.7 and 8.8 along with their 95% critical values which are taken from Fuller (1976). It follows that the null hypothesis of a unit root, for Saudi Arabia’s
production and for the level of oil production of others, cannot be rejected for both periods.

It also can not be rejected for the Saudi Price, market price and the difference of prices for the first period. However for the crude oil price $P_M(1987-1995.8)$ the price time series is stationary and we reject the null hypothesis of unit root. Almost all test statistics were higher than the critical value, where the critical value is -2.87 without a time trend and -3.43 with a time trend. Therefore, it is concluded that all time series included in the study are non-stationary in levels except price of oil (1987-1995.8).

8.5.2 Phillips-Perron Test

When time series contain one or more time breaks, and a break consists of one or more changes in the level and or in the slope of the trend function, Phillips-Perron suggested that it might influence the test of stationarity. By taking this into account the PP test is used in testing for the presence of unit roots in levels of all variables included in the study and the results are reported in Tables 8.7 and 8.8. It follows that the null hypothesis of a unit root cannot be rejected for the level of production for Saudi Arabia, the production of other countries, and the real price at the 5% significant level, which confirms the ADF results of the test.

Table 8.9: Test for the Degree of Integration 1976:3-1986.12:

<table>
<thead>
<tr>
<th>Variable (lag order)</th>
<th>Without Trend</th>
<th>With Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>95% critical values</td>
<td>Variable (lag order)</td>
</tr>
<tr>
<td></td>
<td>-2.89 PP</td>
<td>-2.89 ADF</td>
</tr>
<tr>
<td>$\Delta \ln Q_A(0)$</td>
<td>-11.69</td>
<td>-11.00</td>
</tr>
<tr>
<td>$\Delta \ln O_M(0)$</td>
<td>-10.60</td>
<td>-9.20</td>
</tr>
<tr>
<td>$\Delta \ln P_M(1)$</td>
<td>-9.30</td>
<td>-6.24</td>
</tr>
<tr>
<td>$\Delta \ln P'(1)$</td>
<td>-8.40</td>
<td>-7.71</td>
</tr>
<tr>
<td>$\Delta \ln (P^M)(2)$</td>
<td>-11.35</td>
<td>-4.65</td>
</tr>
<tr>
<td>Variable (lag order)</td>
<td>Without Trend</td>
<td>With Trend</td>
</tr>
<tr>
<td>---------------------</td>
<td>---------------</td>
<td>------------</td>
</tr>
<tr>
<td>95% critical values</td>
<td>-2.89 PP</td>
<td>-3.43 PP(1)</td>
</tr>
<tr>
<td>ΔlnQsA(2)</td>
<td>-10.68</td>
<td>-10.78</td>
</tr>
<tr>
<td>ΔlnQ°°(0)</td>
<td>-12.14</td>
<td>-12.20</td>
</tr>
<tr>
<td>ΔlnPm(1)</td>
<td>-08.07</td>
<td>-08.06</td>
</tr>
</tbody>
</table>

8.5.3 Test for Degree of Integration

Variables to be included in the VAR model should all be integrated of the same order. Since the degree of integration is the number of times the variable is differentiated to induce stationarity, the ADF and PP tests are used, to test for stationarity of the first difference:

\[ \Delta^2 X_t = \delta_0 + \delta_1 T + \delta_2 \Delta X_t + \sum_{i=1}^{p} \gamma_i \Delta^2 X_{t-i} + \varepsilon_t \]  

Where \( \Delta^2 X_{t+1} = \Delta X_t - \Delta X_{t-1} \)

Both ADF and PP tests are used for comparing the computed statistics given in Table 8.9 and 8.10. The critical values used are from Dickey and Fuller (1981) and Fuller (1976). The tests firmly reject the null hypothesis of a unit root in the first difference of the time series.

Therefore, it is concluded that the time series included in the two periods are integrated of order one Saudi oil production \( ln QsA-I(1) \), production of others \( lnQ°°-I(1) \), and the ratio of prices \( ln(P^SM)-I(1) \). The crude oil price series for the period 1987-1995.8 is integrated of order 0, \( P^M-I(0) \) and is stationary in level. So we can proceed to do the cointegration tests.
8.6 The Multivariate Cointegration Model

Having specified the variables included in the model, the next step is to explain how the equation should be estimated and tested. The focus of attention is on a single equation, but we cannot ignore the concept of exogeneity. In a VAR system all variables are treated as endogenous. Which leads to the use of the p-dimensional vector auto-regressive model with Gaussian errors

\[ X_t = \Gamma_1 X_{t-1} + \ldots + \Gamma_k X_{t-k} + \delta D_t + \varepsilon_t \]  

8.4

The variables included in the model are Saudi oil production, production of other members of OPEC and price difference, all expressed in logarithm \([\ln Q^S, \ln Q^0, \ln(P^{SM})]\). To get the real crude oil prices, the Saudi selling price and the market price are divided by the indices of exchange rate and inflation based January 1972 (source DSD/Statistics Section).

The form of (8.4) will be better understood if we express it as a three equation model, with maximum lag of \(p=2\) periods. The equations take the form

\[
\begin{align*}
\ln Q^S &= \gamma_{11} \ln Q^S_{t-1} + \gamma_{12} \ln Q^O_{t-1} + \gamma_{13} \ln(p^{SM}\r_t)_{t-1} + \delta_{11} \ln Q^S_{t-2} + \delta_{12} \ln Q^O_{t-2} + \delta_{13} \ln(p^{SM}\r_t)_{t-2} + \varepsilon_{1t} \\
\ln Q^O &= \gamma_{21} \ln Q^S_{t-1} + \gamma_{22} \ln Q^O_{t-1} + \gamma_{23} \ln(p^{SM}\r_t)_{t-1} + \delta_{21} \ln Q^S_{t-2} + \delta_{22} \ln Q^O_{t-2} + \delta_{23} \ln(p^{SM}\r_t)_{t-2} + \varepsilon_{2t}
\end{align*}
\]

\[
\ln(p^{SM}\r_t) = \gamma_{31} \ln Q^S_{t-1} + \gamma_{32} \ln Q^O_{t-1} + \gamma_{33} \ln(p^{SM}\r_t)_{t-1} + \delta_{31} \ln Q^S_{t-2} + \delta_{32} \ln Q^O_{t-2} + \delta_{33} \ln(p^{SM}\r_t)_{t-2} + \varepsilon_{3t}
\]

In equation (8.4) the vectors \(X\) and \(\varepsilon\) are given by

\[
X = \begin{pmatrix} \ln Q^S_t \\ \ln Q^O_t \\ \ln(p^{SM}\r_t) \end{pmatrix}, \quad \varepsilon_t = \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{pmatrix}
\]  

8.5
We notice in (8.5) each variable in the VAR model depends on all other variables, with exactly the same lags structure applied to each variable; in all equations no current values for any variables appear on the right-hand side of any equation. In fact a VAR can be regarded as the reduced form of a structural model in which no variables are exogenous.

Since the model has more than two variables, it may feature as part of several equilibrium relationships governing the joint evolution of the variables. It is possible for up to (n-1) linearly independent cointegrating vectors to exist. We can assume that there is only one cointegrating vector. In fact when there are more it leads to inefficiency in the sense that we can only obtain a linear combination of these vectors when estimating a single equation model. However, the drawback of estimating only one equation extends beyond its ability to validly estimate the long-run relationships between the variables, even if there is only one cointegration relationship, estimating a single equation is potentially inefficient. It is useful to extend the single equation to a multivariate framework by defining a vector \( X = [\ln Q^S, \ln Q^O, \ln (P^{SM})] \) and allowing all three variables to be potentially endogenous.

For testing the cointegrating relations the Johansen estimation method based on the error correction representation of the vector auto-regressive (VAR) model is used, as suggested by Johansen (1988,1989), and Johansen and Juselius (1990,1992) to estimate the equilibrium relationship between the relevant variables. The model is reformulated in the error-correction form,

\[
\Delta X_t = \sum_{t=1}^{k-1} \Gamma_k \Delta X_{t-k} + \Pi X_{t-k} + \mu + \delta_t T + \gamma_t D_t + \epsilon_t
\]

8.6
Where $X$ represents the vector of $\ln Q^A, \ln Q^O, \ln P^S$, and $\Delta X_t$ represent the vector of first differences of the three variables $\Delta \ln Q^A, \Delta \ln Q^O, \Delta \ln P^S$. If $\Pi$ is less than a full rank it can be written as $\Pi = \alpha \beta'$ where $\beta'$ represents the coefficients of the cointegrating vector which describes the long-run relationship that links together the three variables, and $\alpha$ represents the adjustment to the deviation from the long run path which is interpreted as the error correction mechanism.

The hypothesis of cointegration is formulated as a reduced rank of the matrix $\Pi$-matrix

$$H_A(r): \Pi = \alpha \beta'$$

This hypothesis implies that $\Delta X_t$ is stationary, $X$ is not stationary, but $\beta'X$ is stationary (see Johansen 1991). The error correction formulation includes both difference and levels in the same model allowing us to investigate both short-run and long-run effects in the data.

**Rank Determination:** That is the number of cointegrating relations. There are two statistics for testing the hypothesis that the cointegrating rank is at most $(r< k)$, using the likelihood test for Trace Statistic. The likelihood ratio statistic for the null hypothesis of at most $r$ cointegrating vectors,

$$-2 \ln(Q) = -T \sum_{j=1}^{n} (1 - \hat{\lambda}_j)$$

and the Maximal -eigenvalue of $\lambda$ - max Statistic as follow

$$-2 \ln(Q) = -T(1 - \hat{\lambda}_{r+1})$$

The null hypothesis in the LR tests is that $\hat{\lambda}_{r+1} = \lambda_{r+1} = \lambda_p = 0$. The LR ($N-r$) do not follow $\chi^2$ distribution. Johansen 1989 applies some results of Brownian motion theory and gives the critical values for the distribution of LR($N-r$). The third test is the eigenvalue of the
Companion matrix. By investigating the roots of the companion matrix, where we get the roots describing the dynamic properties of the process. To test the null hypothesis that there are at most $r$ cointegrating vectors:

$$H_0: \lambda_i = 0 \quad i = 1, 2$$

where we use the test for $\lambda_1 = \lambda_2 = \lambda_3 = 0$ when the hypothesis is accepted one has the number of unit-roots and thereby the number of cointegrating vectors.

Testing for unique cointegration vectors: Restriction on $\beta$-vector: Following the determination of the number of cointegrating vectors and establishment of the existence of a long-run relationship between the variables, it is necessary to impose restrictions motivated by the economic theory to obtain unique vectors lying within the space, then test whether the columns $\beta$ are identified. This identification is achieved by placing linear restrictions on the parameters of the cointegrating vector, $\beta$ coefficient, by Johansen (1992, 1994) and 1995).

This can be tested by using the likelihood ratio (LR) test

$$LR = T \sum_{i=1}^{r} \ln \left( \frac{1-\lambda_i^*}{1-\lambda_i} \right)$$

where $\lambda_i^*$ are the eigenvalues produced by the restricted vector, and $\lambda_i$ are the corresponding eigenvalues for the unrestricted estimate. The $L$ statistics follow an asymptotic chi-square distribution with degrees of freedom equal to $r(n-s)$ where $n$ is the number of variables and $s$ is the number of restrictions and $r$ is the number of vectors.
8.7 Testing the Swing Producer Model for the Period 1976-1986

The following equation would represent the cointegrating vector which describes the long-run relationship linking together the three variables.

\[
\ln Q^{SM} = \beta_2 \ln Q^{OO} + \beta_3 \ln P^{SM} + \epsilon_t \tag{8.10}
\]

To describe the Saudi Arabian production policy for the period 1976:3 to 1986:12, we test the swing producer model by imposing the following restrictions:

For a swing producer role \( \beta_3 \neq 0 \), which means the difference between the Saudi price and the market price has an influence on the Saudi output decision. When the ratio \( P^{SM} \) between \( P^{SA} \) and \( P^{M} \) decrease (\( P^{SA} < P^{M} \)) Saudi Arabia would increase its production to lower \( P^{M} \). When the ratio \( P^{SM} \) increases (\( P^{SA} > P^{M} \)) Saudi Arabia would decrease its production to increase \( P^{M} \). \( \beta_3 \neq 0 \) for the model. that is Saudi Arabia has a relationship with the production of other members of OPEC, to prove that we have a cartel behaviour with Saudi Arabia acting as the swing producer.

Specification of the cointegrating VAR Model: To choose the optimal lag length we tested down from the general 12 lags system. The Schwarz Baysian criterion (SBC) and the Akaike information criterion is (AIC) suggesting a different order of VAR. We can choose 2 as the order of the VAR (see appendix 11).
We use the Log-Likelihood ratio statistic for testing zero restrictions of the coefficients of a subset of deterministic/exogenous variables; for the intercept LR test of restriction $\chi^2 = 5.7365 \ [0.125]$, for the deterministic trend $\chi^2 = 0.962 \ [0.810]$, and for the dummy representing the structural change $\chi^2 = 15.11 \ [0.002]$. Therefore, the model for the period 1976-1986 has no intercept, no trend, but has a dummy variable.

The results of the Johansen-Juselius cointegration tests are presented in Table 8.11. The trace test, the trace statistic and the eigenvalue (maximum) test indicates also the existence of one relationship, suggesting that there exist one co-integrating relationship.

\[
\ln Q_t^{SA} = \beta_2 \ln Q_t^{GO} + \beta_3 \ln (P_t^{SM}) + \varepsilon_t
\]

We use the LR test of deletion of deterministic variables in the VAR, is used to test for the presence of intercept $\mu$, the result is the LR test of restrictions $\chi^2(3) = 3.9281 \ [0.269]$. Thus we reject the zero coefficients of the variables, which indicates no presence of intercept.

Table 8.11. Cointegration with no Intercepts or Trends in the VAR. Cointegration LR test based on Maximal Eigenvalue and LR Test based on Trace of the Stochastic Matrix. Period 1976:3-1986:12, lags=2

<table>
<thead>
<tr>
<th>Eigenvalue</th>
<th>L=Max</th>
<th>Trace</th>
<th>$H_0=r$</th>
<th>$H_\lambda=P-r$</th>
<th>Critical Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>90% L-Max</td>
</tr>
<tr>
<td>.24656</td>
<td>36.22</td>
<td>49.05</td>
<td>0</td>
<td>1</td>
<td>19.02</td>
</tr>
<tr>
<td>.088795</td>
<td>11.60</td>
<td>12.83</td>
<td>1</td>
<td>2</td>
<td>13.98</td>
</tr>
<tr>
<td>.00959</td>
<td>1.22</td>
<td>1.22</td>
<td>2</td>
<td>3</td>
<td>6.50</td>
</tr>
<tr>
<td>.0000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 8.11 shows Johansen likelihood ratio statistics for determining the number of cointegrating vectors $r$, using the maximal eigenvalue test ($\lambda$-max test) and the trace test, starting with the null hypothesis of zero cointegrating vector $r=0$, followed by tests for $r\leq1$, and $r\leq2$. The $\lambda$-max test shows that the hypothesis of zero cointegrating vectors is rejected at the 90% and 95% critical value (The source of critical values is Pesaran & Pesaran...
The results of the trace test confirm the conclusion that there is one cointegrating relationship with respect to the three variables. While the model selection criteria (Table 8.12) only SBC select one relationship.

Table 8.12  Cointegration with no Intercepts and no Trends in the VAR. Choice of the Number of Cointegrating Relations using Model Selection Criteria.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Maximised LL</th>
<th>AIC</th>
<th>SBC</th>
<th>HQC</th>
</tr>
</thead>
<tbody>
<tr>
<td>r=0</td>
<td>152.55</td>
<td>140.55</td>
<td>116.16</td>
<td>128.86</td>
</tr>
<tr>
<td>r=1</td>
<td>170.66</td>
<td>152.66</td>
<td>122.14</td>
<td>139.08</td>
</tr>
<tr>
<td>r=2</td>
<td>176.47</td>
<td>154.47</td>
<td>120.67</td>
<td>140.14</td>
</tr>
<tr>
<td>r=3</td>
<td>177.08</td>
<td>153.08</td>
<td>118.88</td>
<td>139.17</td>
</tr>
</tbody>
</table>

Since we accept the existence of the relationship amongst the three variables, we proceed to the next step of the Johansen procedures, which is the estimation of the normalised cointegrating vector.

\[
\ln Q_{t}^{SA} = \beta_2 \ln Q_{t}^{OO} + \beta_3 \ln(P_{t}^{SM}) + \epsilon_t
\]

\[
\ln Q_{t}^{SA} = -1.44 \ln Q_{t}^{OO} - 0.87 \ln(P_{t}^{SM}) + \epsilon_t 
\]

The equation 8.11 shows the results from the Johansen ML estimation for the estimates of \([1, \beta_2, \beta_3]\) which were obtained by normalising the corresponding elements by the coefficient \(\beta_1\) of \(Q_{t}^{SA}\) for the cointegrating vector. \(\beta_3\) close to 1 which means that any change in the ratio of the two prices would be met by 0.87 change in production of Saudi Arabia (elasticity of supply is less than one). We test for \(\beta_3=0\), the \(\chi^2(1) = 23.477[.000]\). We reject the null hypothesis of no relationship between the ratio of prices and the production of Saudi Arabia. We test for \(\beta_2=0\), the \(\chi^2(1) = 32.92[.000]\). We can reject the null hypothesis of no relationship between the production of others and the production of Saudi Arabia.
It is concluded that there is a relationship between Q^{SA} and Q^{oo} and \( \frac{P^{SA}}{P^{M}} \) and we say that the swing producer model is applicable to Saudi Arabia for the period (1976-1986) it is concluded that the production of Saudi Arabia has a relation with the difference in price and with the supply of others. These results indicate that Saudi Arabia was trying to keep the price of oil stable and close to the official price either by increasing production when the market price was high in order to lower prices, or by decreasing production when the market price was low.

The estimated coefficients of errors for \( \ln Q^{SA} \), \( \alpha_1=0.009, \alpha_2=.001, \alpha_3=.001 \), which represents the adjustment to the deviation from the long-run path. The values are too small, suggesting that it would take a long time for the equation to return to its equilibrium once it had been shocked.

8.8 Test the Market-sharing Model for the Period 1987-1996

For the second period 1987:1 to 1995.8 we test for the existence of the relationship between the production of Saudi Arabia and the production of the others and the price of oil using the following equation.

\[
\ln Q^{SA} = -\gamma_2 \ln Q^{oo} + \gamma_3 \ln P^M + \epsilon_t \quad 8.12
\]

where \( P^M \) is the price of Arabian Light 34° API for the period 1987.1-1995.8.

\( \gamma_2 \) differs according to the type of market share we are investigating; Partial market share means that \( 0 < \gamma_2 < 1 \) and negative, and \( \gamma_3 \neq 0 \). Constant market share \( \gamma_2 = -1 \) and negative, and \( \gamma_3 = 0 \). With \( P^M \sim I(0) \), we will be testing for the constant market share.
Specification of the cointegrating VAR Model: To choose the optimal lag length we tested down from the general 12 lags system. The Schwarz Baysian criterion (SBC) suggests a VAR of order 1, the Akaike information criterion is (AIC) of order 2. We can choose 1 as the order of the VAR (see appendix 11).

We use the Log-Likelihood ratio statistic for testing zero restrictions of the coefficients of a subset of deterministic/ exogenous variables; for the intercept LR test of restriction $\chi^2=8.93 [0.012]$, for the deterministic trend $\chi^2=9.85 [0.007]$, and for the dummy representing the structural change $\chi^2=24.54[.000]$. Therefore, the model for the period 1987:1-1995:8 cannot reject the presence of intercept, time trend and a dummy variable.

Table 8.13 shows the Johansen likelihood ratio statistics for determining the number of cointegrating vectors r, using the maximal eigenvalue test ($\lambda$-max test) and the trace test, Table 8.14 shows the number of cointegration relations using model selection criteria (AIC, SBC and HQC). With the three variables $Q_{sA}$ and $Q_{oO}$. However, with $P_m$ $\sim$I(0) as a stationary variable the cointegrating vector includes the Saudi production and other members production. Both the maximum eigenvalue and the trace static suggest $r=1$. The hypothesis that $r=0$ is rejected against $r=1$, but the hypothesis that $r=1$ cannot be rejected against $r=2$.

**Table 8.13 Cointegration with Unrestricted Intercept and Unestricted Trend in the VAR. Cointegration LR test based on Maximal Eigenvalue and LR test based on Trace of the Stochastic Matrix. Period 1987:1-1995:8 lags=1**

<table>
<thead>
<tr>
<th>Eigenvalue</th>
<th>L=Max</th>
<th>Trace</th>
<th>$H_0=r$</th>
<th>$H_0=P-r$</th>
<th>90% L-Max</th>
<th>90%Trace</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.12771</td>
<td>17.72</td>
<td>25.60</td>
<td>0</td>
<td>1</td>
<td>16.28</td>
<td>21.23</td>
</tr>
<tr>
<td>0.03942</td>
<td>7.88</td>
<td>7.88</td>
<td>1</td>
<td>2</td>
<td>9.75</td>
<td>9.75</td>
</tr>
</tbody>
</table>
Table 8.14 Cointegration with Unrestricted intercept and Unrestricted Tend in the VAR. Choice of the Number of Cointegrating Relations using Model Selection Criteria

<table>
<thead>
<tr>
<th>Rank</th>
<th>Maximised LL</th>
<th>AIC</th>
<th>SBC</th>
<th>HQC</th>
</tr>
</thead>
<tbody>
<tr>
<td>r=0</td>
<td>349.03</td>
<td>341.03</td>
<td>330.45</td>
<td>336.75</td>
</tr>
<tr>
<td>r=1</td>
<td>357.89</td>
<td>346.89</td>
<td>332.35</td>
<td>341.00</td>
</tr>
<tr>
<td>r=2</td>
<td>361.83</td>
<td>349.83</td>
<td>333.97</td>
<td>343.41</td>
</tr>
</tbody>
</table>

Since we accept the existence of the relationship amongst the two variables, with the price is stationary we proceed to the next step of the Johansen procedures which is the estimation of the normalised cointegrating vector.

\[
\ln Q_{t}^{SA} = \mu_t + \gamma_2 \ln Q_{t}^{OO} + \varepsilon_t
\]

\[
\ln Q_{t}^{sa} = -.726 \ln Q_{t}^{oo} + \varepsilon_t
\]

The equation shows the results from the Johansen ML estimation for the estimates of \([\gamma_2]\) which were obtained by normalising the corresponding elements by the coefficient \(\gamma_1\) of \(Q^{SA}\) for the cointegrating vector. For the production of other members the sign is negative which means that an increase in supply of others means a decrease in the Saudi production.

To explain the model we test for hypothesis \(\gamma_2 = 1\) belongs to the space spanned by the cointegrating vector \([-1, 1]\). This means that any change in the production of others would be met by a change in Saudi production with elasticity one \(\chi^2 (1)=.144[0.704]\) which indicates that with stationary market prices, the elasticity of Saudi supply in respect to the production of others is one.
The estimated coefficients of errors for \( \ln Q^S \), \( \alpha_1 = 0.004 \), \( \alpha_2 = 0.0009 \). Which represent the adjustment to the deviation from the long-run path. The values are too small suggesting that it would take a long time for the equation to return to its equilibrium once it has been shocked.

8.9 Conclusion

By dividing the sample into two periods 1976-1986 and 1987-1995, we can test both models for the swing producer role for the first period and for the market-sharing role for the second period. We can say that the swing producer is applicable to Saudi Arabia where the Kingdom changed its production in order to keep stable oil prices. So it increased its production when demand was high for OPEC oil (e.g. 1978.8-1981.8) and decreased its production when the demand was low (1983.3-1985.8). For the second period (1987-1995) where prices of oil became market related with the number of producers in the world oil market increased, Saudi Arabia acted as a market-sharing producer who was concerned with maintaining its share in the oil market.
Figure 8.1. Saudi Arabia Crude oil production 1976.03-1996.09
CHAPTER 9

CONCLUSION

This dissertation sought to analyse Saudi Arabian oil policy in the world oil market. Its prices and production decisions in the 1970s and eighties were analysed. Certain important developments in the market the two-tier price system, the Iranian revolution, the Iran-Iraq war and the Iraqi invasion of Kuwait and the responses of Saudi Arabia to these crisis and events were discussed.

The analysis points to a clear desire by Saudi Arabia in the past to exercise its market power and influence the price at levels acceptable to its wealth maximising objective being a high reserve holder, and a large exporter with high production capacity. Throughout the survey of events and approaches it is clear that Saudi Arabia behaved from the perspective of dominant producer. Having 26% of world reserves and being the largest producer gave it a longer time horizon, thus it was in a position to pursue stable prices and maintain a high market share. This behaviour was traced through three different market systems: A fixed price regime with official prices as the medium to influence the market from 1975-1982, the fixed price-volume from 1982-1985, and in recent years a regime of volume fixing, flexible pricing using market-related prices.

The behaviour of Saudi Arabia throughout the period of the study was analysed relying on published data and interviews with key decision makers in Saudi
Arabia (including the three successive Oil Ministers and advisors in the Ministry who witnessed events in the three periods). These interviews were supplemented by interviews with outside observers in the oil business and media who covered the oil market, in order to compare their reflections to those of the Saudi Arabia perspective.

This study surveyed and evaluated the different models of oil market behaviour and their relevance to Saudi Arabia to gather the evidence from the decision makers. Of all the models that attempt to explain OPEC’s behaviour, the two most pertinent for the role of Saudi Arabia are the swing producer and the market-sharing model.

The dissertation then went on to test these two models using appropriate price and production data after discussing the rationale for the use of particular data in chapter 6.

Based on recent developments in econometric analysis, this study has analysed the behaviour of Saudi Arabia using procedures which examine the properties of time series within the context of cointegrating recent analysis. Johansen (1988, 1992) was used for the swing producer model, and the market sharing model.

The study finds that Saudi Arabian oil policy followed the role of swing producer for the period 1976-1986. Post 1986 until 1996 its oil policy has followed a market-sharing model.
Limitations of the Study:

Some of the limitations associated with this study were:

1-The lack of relative studies in the literature about decision making in Saudi Arabia.

2-Although the people I interviewed about the behaviour of Saudi Arabia in the different time periods were forthcoming and gave me great insights, some were nevertheless value judgements involved while I needed to be as objective assessment as possible.

3-Lack of some data on the oil market and its. Such as financial absorptive capacity for Saudi Arabia precluded me from testing the revenue constrained model.

Future Research Possibilities:

A- The effect of financial needs on the oil policy. Financial needs have influenced the outcome of the decision-making process, and high or low revenues had effected the size of production. Thus in order to test this hypothesis we need to include an indicator for the financial absorptive capacity of Saudi Arabia. This has been discussed, but not tested empirically. To be able to do such testing would give more insight about Saudi policy.

B- An analysis of price collapse, concentrating on the netback pricing mechanism and how much it influenced the price decline in 1986.

C- As discussed in the section on the swing producer role, it would be advisable to test the role of information in oil decision-making.

D- The effect of communication technological changes and the development of paper markets in world oil prices.
E- Since 1987, there has been a large development in the downstream industry in Saudi Arabia, and expansion of the foreign downstream. A study of these developments will be useful for understanding the oil industry in the Kingdom.

F- Aramco has passed through three stages: first, controlling the downstream and upstream oil industry in the Kingdom, second, control of the downstream only; third, the stage of Saudi Aramco. Investigating such developments is important to understand the role of oil companies in the oil market.
APPENDICES
APPENDIX (1)

The Saudi Ministers of Petroleum and Mineral Resources

The Ministers of Petroleum and Mineral Resources have contributed to the oil policy. Each of them has been a powerful advocate in taking the oil decisions of Saudi Arabia, starting with Abdullah Al-Tariki who was the first Minister (1960-1962), Ahmad Zaki Yamani (1962-1986), Hisham Nazer (1986-1995) and to Ali Naimi (1995-present).


Al-Tariki was appointed as a director of Oil and Mining in 1953, and became the first Oil Minister in December 16 1960. He was one of the two founders of OPEC along with Perez Alfonzo, where his objective was to obtain the government’s right to control oil from the “majors”. He believed in “Arab Oil for Arabs”. Al-Tariki was replaced as minister by Zaki Yamani in March 1962. He then worked as an oil Consultant for some of the Arab producing countries, such as UAE and Libya. and died on 31 September 1997 in Egypt.


Yamani had a Masters Degree in Comparative Jurisprudence from New York University in 1955 and a Second Masters Degree from Harvard Law School, Mass in 1956. He was appointed legal advisor to the Council of Ministers under Crown Prince Faisal, became a Minister of State in 1959 and Minister of Petroleum and Mineral Resources in 1962. He led the successful negotiation between OPEC and the oil companies in the early seventies which led to the signing of very significant agreements such as Tehran, Tripoli, Geneva I, Geneva II. He was in charge of negotiating the Saudi government take-over of the Aramco oil concession. He masterminded the introduction of OPEC’ s first regulation and quota programme in 1983. In all these oil policy decisions he always had to make sure that he had the full endorsement and backing of the highest authorities in the Kingdom and follow the direction of the King and the Council of Ministers.2


Nazer was appointed as an acting Minister, and later as Minister. He had experience in oil matters when he joined the Directorate General of Petroleum and Minerals in 1958. In 1960 he was appointed Director General of the Ministry, and then served as Deputy Minister of Petroleum and Mineral Resources from 1962-1968. He was the President of the Planning Organisation (1968-1975) and from 1975 he was Minister of Planning. He was a member of the Supreme Petroleum Council. His relationship with OPEC differ from that of Yamani, who used more negotiations with OPEC members while Nazer followed a policy of take it or leave it, wherein the Saudi decision was formulated in the

2 Ian Seymour interview (1997)
Kingdom and taken to the OPEC conference. Nazer believed that other members of OPEC tried to use Saudi Arabia to their own benefits with no consideration for the interest of the Kingdom. Like Yamani he also had to have the full endorsement and backing of the King to be able to conduct the oil decisions.

Ali Naimi: August 1995- present
Naimi was appointed as Aramco President in 1984 and President and Chief Executive Officer in 1988. He has spent all his working life with Aramco.

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1 Nazer interview 1997.
APPENDIX (2)

The Structure of OPEC

The Organisation of the Petroleum Exporting Countries (OPEC) was founded in September 1960, as a direct response to the challenge posed by the multinational oil companies, which unilaterally reduced the posted prices of crude oil in February 1959 and again in August 1960. OPEC started with five founding members (Iran, Iraq, Kuwait, Saudi Arabia and Venezuela). But it expanded to 13 members, with the entry of Algeria (1968), Ecuador (1975), Gabon (1975), Indonesia, Libya (1967), Nigeria, Qatar, United Arab Emirates. In 1992, Ecuador withdrew from OPEC and in 1995 Gabon followed suit, leaving the membership at 11.

Saudi Arabia is one of the founder members and since the 1970s it has become the focal point of the organisation due to its market weight, having the largest share of world reserves and being the biggest producer within OPEC. Saudi Arabia had been a major contributor to the major decisions of OPEC.

The principal aim of the Organisation was clearly stated in paragraph (4) of Resolution I, article 2, adopted by the founding members at their conference in Baghdad. It stated that its objectives were:

"the unification of petroleum policies for the member countries and the determination of the best means for safeguarding the interests of Member countries individually and collectively,... ensuring the stabilisation of prices in international oil markets...the interests of the producing nations and to the necessity of securing a steady income to the producing countries; an efficient, economic and regular supply of petroleum to consuming nations; and a fair return on their capital to those investing in the petroleum industry".

These objectives, in general terms, seem to be still valid in spite of the major changes in the pattern of relationships between producers, consumers and companies.

The structure of the organisation consists of the conference, the Board of Governors and the Secretariat.

The Conference: The conference is the supreme authority of the Organisation. It consists of delegations representing the member countries. A delegation is usually led by a high-level official, generally the Minister of Petroleum or the equivalent. The function of the conference as enumerated in the Statute is as follows:

"Formulation of general policy of the organisation and determination of the appropriate ways and means of its implementation; decision on application for OPEC membership; directing the Board of Governors to submit reports or make recommendations on any matter of interest to the organisation."
Decisions on the budget of the organisation as submitted to it by the Board of Governors; approval of any amendments to the Statute; appointment of the Chairman of the board of governors, the Alternate Chairman the appointment of the Secretary General of the organisations and the Deputy Secretary General and the Auditor. In addition, all matters not expressly assigned to other organs fall within the competence of the Conference.

b) The Board of Governors: The Board of Governors manages the affairs of the Organisation. It is composed of a representative from each member country, called the governors. The Board of Governors meet twice a year and its functions, as set by the Statute, include: Direction of the management of the affairs of the organisation and the implementation of decisions of the conference; consideration of, and decisions upon any reports submitted by the secretary general for making recommendations to the conference on the organisation; drawing up the budget and submitting it to the conference for approval; nomination of the auditor for one year; consideration of the statement of account and the Auditor’s report and submission to the conference for approval.

c) The Secretariat: The secretariat carries out the executive functions of the Organisation under the direction of the Board of Governors.

d) The Economic Commission Board: The Economic Commission Board is a specialised organ, established in accordance with Article 41 of the Statute which gives the conference the right to establish specialised organs to assist in resolving certain problems of particular importance. The functions of the Board include the establishment of the necessary contracts with private and public bodies, the oil industry in particular; collection of data and information; examination of the position of oil prices on a permanent basis; the study of other economic factors affecting petroleum prices; submitting to member countries monthly price reports; formulating and submitting to the conference its findings and recommendations on prices.
APPENDIX (3)

Major OPEC Decisions

Chronology

1st, September 10-14, 1960, Baghdad: The first OPEC Conference, A statement of Policy and Objectives was adopted and Membership requirement established.

5th, December 24-31, 1963, Riyadh. Establishment of a three-member OPEC negotiation committee (Iran Iraq and Saudi Arabia) with oil companies on royalty payments and marketing expenses.

16th, June 24-25, 1968, Vienna: Adopted the Declaratory Statement of Petroleum Policy in Member countries. The views on how to deal with the often tense relationship between the government and the oil companies operating in OPEC member countries revolved around two lines: The first favoured nationalisation of the companies, assets by the governments. This approach was favoured by the more radical members of the organisation such as Iraq, Algeria, Venezuela and, to a certain extent Iran. The other approach favoured by Saudi Arabia and its Gulf allies called for partnership between the governments and the companies through participation in all phases of the industry. After intense debate in the organisation, OPEC made an announcement in 1968 in the form of Declaratory Statement of Petroleum Policy. In it, member countries declared their intentions, and determination, to make strategic decisions at the upstream level, including participation in the ownership of oil companies. This new policy recommended that there should be; a direct role in the development of hydrocarbon resources; participation in the equity of existing concessions; and progressive and accelerated relinquishment of acreage of present contact areas. The declaration also stipulated a role for government in setting tax reference prices.

17th, November 9-10, 1968, Baghdad: Recommended that member countries should not grant what to companies whose home countries pursued policies tending to artificially depress petroleum prices on international markets.

21st, December 9-12, 1970, Caracas. The establishment of 55% as the minimum rate of taxation on the net income of oil companies.

February, 14, 1971. Tehran: The Tehran Agreement was signed between six member countries in the Gulf and 23 international oil companies whereby the posted price of Arabian Light was adjusted to $2.18/B. The agreement included a flat across-the-board increase of 33 cents/B in the posted prices, a flat increase of 5 cents annually in lieu of claims relating to adjustments in product prices, an increase
of 2.5 per cent annually for inflation, full expensing of royalties, elimination of the marketing allowance, an increase in the tax rate to 55 per cent, and the realignment of all posted prices in the Gulf, using the price of Arabian Light as a reference, taking into account a freight differential based on a rate of Worldscale 72. The Tripoli Agreement was signed among East Mediterranean OPEC producers.

January 20, 1972, Geneva. The Geneva I Agreement was reached between OPEC countries and the oil companies, supplemental to the 1971 Tehran Agreement, whereby oil revenues of member countries were increased by the provision of an immediate price adjustment in the Arabian Light posted prices of 8.49 per cent. The settlement also included provision for further adjustments in oil revenues between 1972 and 1975 based on an index measuring changes between the exchange rates of the dollar and nine other key currencies.

June 1, 1973, Geneva. Geneva II Agreement was reached with the international oil companies on adjustments to posted prices to take account of the world currency situation; it included an expanded basket of major currencies, from 9 to 11, with a new mechanism for a monthly measurement of change.

October 16, 1973 Kuwait: The Gulf Members announced an immediate increase in posted prices to $5.12 per barrel. It was the first move by member countries to exercise their sovereign right to determine the price of their natural resources. After this, OPEC set prices unilaterally for its oil.

December 22-23, 1973, Tehran: OPEC decided to set Government take at $7 a barrel for Maker Crude and, therefore, taking into account the Geneva II Agreement, the posted price for Maker Crude would become $11.651/B as of January, 1974.

37th, January 7-8, 1974: The Gulf Member countries decided to abandon the ratio of 1.4 to 1.0 between posted prices and market prices, in response to changes in the petroleum market conditions.

40th, June 15-17, 1974, Quito: OPEC decided to increase the rate of royalty by 2 per cent or alternatively to increase the government take by an equivalent amount.

41st September 12-13, 1974, Vienna: Decided to freeze posted prices for the fourth quarter of 1974, but to increase the total government take by 3.5 per cent, effective October 1, 1974 in order to compensate for inflation in the industrialised countries. The weighted average government take for Marker Crude would thus increase from $9.41 to $9.74 per barrel.
November, 10, 1974, Abu Dhabi: Three OPEC Gulf States, Saudi Arabia, United Arab Emirates and Qatar, decided to raise income tax and royalty rates on the equity crude lifted by the major oil companies to 85 per cent and 20 per cent respectively.

42<sup>nd</sup> December, 12-13, 1974 Vienna, OPEC decided to adopt a new pricing system based on the decision taken by the three Gulf States on November 10. As a result, the average government take was set at $10.12 per barrel for Marker Crude, effective from January 1, 1975 through to September 30, 1975.

March, 4-6, 1975, Algeria: Solemn Declaration, the Sovereigns and heads of state of member countries of the Organisation of the Petroleum Exporting Countries including late King Faisal of Saudi Arabia met in Algeria from March 4-6 1975. The meeting stressed that world peace and progress depended on mutual respect for the sovereignty and equality of all member nations of the international community. They confirmed that the exploitation of the oil resources in their countries must be based, first and foremost upon the best interests of their peoples and that oil, which is the major source of their income, constitutes a vital element in their development.

45<sup>th</sup> September 24-27, 1975, Vienna: OPEC decided to increase the price of Arabian Light, the Marker Crude, by only 10%, bringing it to $11.51 per barrel from October 1, 1975, and hold it at that level until June 30, 1976.

48<sup>th</sup>, December 15-17, 1976, Doha: Doha two tier price. OPEC decided with the exception of Saudi Arabia and the United Arab Emirates, to increase the price of Marker Crude by 10%, from $11.51 per barrel as of January 1, 1977.

49<sup>th</sup>, July 12-13, 1977, Stockholm: End of two tier pricing system. Saudi Arabia and the UAE adjusted their prices upwards by 5%.

50<sup>th</sup> December 20-21, 1977, Caracas: Price Freeze. The price of Arabian Light remained unchanged at $12.70/B.

3-7 May, 1978, Taif: Establishment of long-term strategy committee. Oil Ministers of OPEC invited by the government of Saudi Arabia to meet in Taif/ Saudi Arabia to take a strategic look at the future. It was decided it set up a “Strategy Committee” consisting of six member countries to carry out an exhaustive study for long-term strategic planning. This committee worked on a report that served as a basis for policy recommendations, and was forwarded to the November 1980 OPEC meeting. This helped in creating a new perspective to long-term strategic planning by OPEC.

52nd, December 16-17, 1978 Abu Dhabi. OPEC decided to adjust the price of oil by a 10%, average over the whole of 1979.

53rd, March 26-27, 1979: OPEC decided to bring forward the price adjustments of the fourth quarter of 1979 and apply it as of April 1, 1979. This adjustment set the marker crude at $14.546/B.

54th June 26-28, 1979 Geneva OPEC decided to adjust the Marker Crude price to $18/B to allow Member countries to add to the prices of their crude a maximum market premium of $2/B over and above their normal differential, if and when such a market premium was necessitated by market conditions; and that the maximum prices that could be charged by member countries were not to exceed $23.50.

55th December 17-20, 1979 Caracas. OPEC: each for himself on prices; Saudi Arabia up from 18 to 24. Seven members align on the Saudi Arabian Marker on $26/B, others up to $30/B.

56th, May 7-8, 1980. Taif. OPEC's Long-Term Strategy Committee proposal approved with reservations on report's proposed long-term formula. Also, OPEC recommended that the price of natural gas should be in line with the price of oil on a BTU basis.

57th, June 9-11, 1980. Algeria: OPEC decided to set the price level for a Marker Crude at a ceiling of $32/B. that the value differentials which would be added over and above this ceiling for the Marker Crude, to take account of quality and geographical locations, should not exceed $5/B; and that this price structure should apply as of July 1, 1980. The objective of the new price structure was to achieve an equilibrium between supply and demand to avoid further stockpiling, which was considered harmful to both producers and consumers. The conference reiterated OPEC member countries' determination to set gas prices in line with those of crude oil in order to achieve a coherent marketing policy for their hydrocarbons.

58th, September 17, 1980 Vienna: OPEC decided to fix the price of the Marker Crude (Arabian Light) at the level of $30/B and to freeze the other official prices of OPEC member countries' crude at that level.

59th, December 15-16, 1980 Bali. OPEC decided to fix the official price of the Marker Crude at the level of $32/B. that prices of OPEC may be set on the basis of an oil price ceiling for a demand Marker Crude of up to $36/B; and to set the maximum price for OPEC crudes at $41/B.
60th, May 25-26, 1981. Geneva: OPEC decided to maintain the deemed Marker Crude price at a ceiling of $36/B, with a maximum OPEC price of $41/B, until the end of the year. The majority of member countries decided to cut production by a minimum of the per cent effective from June 1, 1981.

61st October 29, 1981. Geneva: Set the Marker Crude at $34/B in order to adopt a unified pricing system for OPEC crudes with a view to creating the right conditions for stability in the market.

63rd March 19-20, Vienna: Production Programming and confirmed the price of the marker crude at $34/B. For the first time, OPEC decided to place a ceiling of 18 MMBD on OPEC aggregate production with the effect of April 1 1982. For quota distribution see Appendix 6

66th, December 19-20, Vienna: OPEC decided that production for the year 1983 should not exceed 18.5 MMBD.

67th, March./14, 1983. London: The London Agreement: was signed reducing oil prices to $29/B, and putting a ceiling of 17.5 MMBD on production Quotas were allocated to member countries but with no specific quota allocated to Saudi Arabia which was to act as the swing producer to supply the balancing volumes to meet market requirement within the over all ceiling. Thus a new era in Saudi Arabia’s role in OPEC was established. (see Appendix 5)

71st, October 29-31, 1984, Geneva: OPEC determined to defend the price structure of its Marker Crude at the level of $29/B and cut the production ceiling of OPEC to 16 MMBD.

80th December 11-20 , 1986 Geneva, OPEC decided to return promptly to a fixed pricing system at a level of $18/B for OPEC’s reference price. This price which is based on a basket of seven crudes, would come into force as of January 1, 1987. Total production should not exceed 15.8 MMBD.

82nd 9-14, March 1987 Vienna Production level of all member countries, with exception of Iraq, would be 15.06 MMBD during the first half of 1988. Reference price of the OPEC crude basket is $18.5 /B.

April, 26-27, 1988, Vienna - OPEC/non-OPEC Meeting. Seven non-OPEC independent producers (Angola, Colombia, Egypt, Malaysia, Mexico and Oman. With six members of OPEC (Algeria, Indonesia, Kuwait, Nigeria, Saudi Arabia and Venezuela).
84th, November 21-28, 1988, Vienna. Total OPEC production for the first half of 1989 should be set at a ceiling of 18.5 MMBD. Reference price of the OPEC crude basket is $18.5 /B.

85th, June 5-7, 1989. Vienna: Total OPEC production for the first half of 1989 should be set at a ceiling of 19.5 MMBD. Reference price of the OPEC crude basket is $18.5 /B.

86th, November 25-28, 1989. Vienna. Total OPEC production for the second half of 1990 should be set at a ceiling of 22 MMBD.

87th, July 26-27, 1990. Vienna. Total OPEC production for the first half of 1990 should be set at a ceiling of 22.449 MMBD. Reference price of the OPEC crude basket is $21 /B.

August 2, 1990. Invasion of Kuwait.

August 29, 1990, Vienna. Increased production in accordance with need.

March 11-12, 1991. Geneva: Total OPEC production for the second quarter of 1990 should be set at a ceiling of 22.3 MMBD. Reference price of the OPEC crude basket is $21 /B.

September 24-25, 1991. Geneva: Total OPEC production for the fourth quarter of 1991 should be set at a ceiling of 23.65 MMBD. Reference price of the OPEC crude basket is $21 /B.

November, 26-2, 1991. Geneva: Reaffirmed total OPEC production for the first half of 1991 should be set at a ceiling of 22.3 MMBD. Reference price of the OPEC crude basket is $21 /B.

February 12-15, 1992, Geneva: Saudi Arabia reduce its quota by 500,000 B/D.

September 16-17, 1992: Total OPEC production for the fourth quarter of 1992 should be set at a ceiling of 24.2 MMBD. Reference price of the OPEC crude basket is $21 /B.
November 25-27, 1992 Vienna. Down trend in oil price, with OPEC basket price falling from $18.80 from the first week of November. Total OPEC production for the first quarter of 1993 should be set at a ceiling of 24.582 MMBD.

February 13-16, 1993. Vienna. Overall OPEC production reduced, effective from March 1, 1993 should be set at a ceiling of 23.582 MMBD.

94th, September 25-29, 1993. Geneva: Oil prices deteriorated to such an extent that the OPEC basket price had fallen below $15.0/B. Set the overall OPEC production ceiling for the following six months, at 24.5 MMBD.

97th, November 22-25, 1994. Bali. Maintained the total production ceiling of 24.52 MMBD.

98th, June 20, 1995. Vienna. Maintained the total production ceiling of 24.52 MMBD.


100th, June 7, 1996. Vienna. Supply ceiling to be set until the end of 1996 at 25.033 MMBD to consider the deal of oil humanitarian needs (oil for food and medicine) between Iraq and the United Nations.
## APPENDIX (4)

### The Participants in the Decision Making Process in the Kingdom of Saudi Arabia*

<table>
<thead>
<tr>
<th>The Period</th>
<th>The King</th>
<th>Major Decisions</th>
<th>MINIPT</th>
<th>Minister</th>
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</thead>
<tbody>
<tr>
<td>1953-1963</td>
<td>King Saud</td>
<td>COM: 8 Ministers (1953)</td>
<td>Directorate of Oil and Mining Affairs (1953)</td>
<td>Al-Tariki</td>
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<td>Ministry of Petroleum and Minerals (December 21, 1960)</td>
<td>Al-Tariki</td>
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<td>COM: 14 ministers</td>
<td>Yamani</td>
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<td>1964-1975</td>
<td>King Faisal</td>
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<td>Establishment of SPR 1973</td>
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<td>Nov. 2, 1964</td>
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<tr>
<td>1975-1982</td>
<td>King Khaled</td>
<td>COM: 23 Ministers</td>
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<td>1982-present</td>
<td>King Fahad</td>
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<td>Jun. 13, 1982</td>
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<td>Saudi Aramco 1988</td>
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<td>Establishment of consultative Council 1992</td>
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<td>COM: 29 ministers</td>
<td>1st Naimi</td>
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</tbody>
</table>

APPENDIX (5)

The London Agreement

Resolution LXVII. 238

The conference,

Having assessed the prevailing condition in the oil markets and determined to bring the necessary stability into these markets

resolves
1. To set the official price of the Marker Crude, Arabia Light, 34 API, ex Ras Tanura, at US$ 29.00 per barrel.
2. To maintain the existing differentials among the various OPEC crudes at the same level as agreed upon at the 63rd (Extraordinary) Meeting of the Conference held in Vienna, Austria, in March, 1982, with the temporary exception that the differentials for the Nigerian crudes shall be US $ 1.00 over the price of the Marker Crude.
3. That Member countries will not reduce their official prices below the agreed OPEC level without previous approval from an OPEC conference.
4. That, when non-OPEC exporters take action jeopardising an OPEC agreement, OPEC shall convene a special session immediately to take remedial measures.
5. That, when market conditions allow it, price shall gradually be increased by increments of 50 cents per barrel until the Marker Crude price reaches a level of US$ 30.00 per barrel. In order to take a decision on the matter, an Extraordinary Meeting of the Conference shall then be convened.
3. That the ceiling for OPEC production shall be set at 17.5 million barrels per day for the remaining part of 1983.
4. That Member countries’ quota shall be allocated as follows:

<table>
<thead>
<tr>
<th>Country</th>
<th>Million b/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algeria</td>
<td>0.725</td>
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<tr>
<td>Ecuador</td>
<td>0.200</td>
</tr>
<tr>
<td>Gabon</td>
<td>0.150</td>
</tr>
<tr>
<td>Indonesia</td>
<td>0.300</td>
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<tr>
<td>Islamic Republic of Iran</td>
<td>2.400</td>
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<tr>
<td>Iraq</td>
<td>1.200</td>
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<tr>
<td>Kuwait</td>
<td>1.050</td>
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<tr>
<td>Socialist People Libyan Arab Jamahiriya</td>
<td>1.100</td>
</tr>
<tr>
<td>Nigeria</td>
<td>1.300</td>
</tr>
<tr>
<td>Qatar</td>
<td>0.300</td>
</tr>
<tr>
<td>United Arab Emirates</td>
<td>1.100</td>
</tr>
<tr>
<td>Venezuela</td>
<td>1.675*</td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
</tbody>
</table>

The national quotas are to be observed quarterly.

7. No quota is allocated to the Kingdom of Saudi Arabia which will act as the swing producer to supply the balancing quantities to meet market requirements.

8. That the Ministerial Monitoring Committee shall continue its work in order to ensure full compliance by Member countries with the set ceiling and quotas.

9. That the Ministerial Monitoring Committee shall include in its term of reference the following:

- Determine the factors that affect the level of demand for OPEC oil below or above the agreed upon production ceiling;
Following-up the production level of each Member Country in order exports, in order to anticipate possible changes in supply, demand and prices.

10. That Member countries shall:
   a) avoid giving discounts in any form whatsoever;
   b) refrain from dumping petroleum products into the world oil market at prices which would jeopardise the crude oil pricing levels.

11. That Member countries shall not sell crudes directly or indirectly on the spot market below the agreed upon OPEC price levels.

- (1.7 MMBD, including condenses)
### APPENDIX (6)

**OPEC Agreements 1000 B/D March 1982- December 1994**

<table>
<thead>
<tr>
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<td>Venezuela</td>
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OPEC Secretariat
APPENDIX (7)

Trading Instruments

Increased price volatility in the seventies and eighties and the existence of transportation and refining lags, provided incentives to establish different trading instruments, including spot, physical forward and future contracts. In the late eighties, other instruments, such as options on future contracts, swaps and warrants were introduced. These instruments were used for the purpose of hedging and speculation. Hedging is used to reduce the risk of losses when there is price variability in the cash market. Where this was a risk, speculators traded and took positions according to their price expectations.

**Forward and Future markets:** At any given point in time, there are different spot prices for a given crude variety depending on whether delivery is prompt or Forward. For a given crude, Brent for example, three spot prices may be quoted on one day. For example, the 10th of June 1994, prices, such as Brent at June, Brent at July and Brent at August could be quoted, which means there is one spot and two Forward. Forward differs from spot in that the delivery day is some time in the future at a price established at the time of transaction. Forwardness is measured as the number of days between the date at which the deal was made and the middle of the delivery month. Thus the forwardness for the August deal is 65 days, that is the sum of the remaining 20 days of June, 31 days of July and half of August, the delivery month. While for the July deal the forwardness is 35 days. Forward contracts are often used to hedge the risk of increasing the price for the buyer or lowering the price for the seller, in order to fix the revenue to the date of transaction. This means that during a time of crisis forwardness increases because hedgers try to lock prices as far ahead as they can.

**Future contracts:** The first successful attempt was the creation of future contracts for heating oil in New York Mercantile Exchange (NYMEX) in 1983. Meanwhile, contracts for other products and for crude, such as Brent at the International Petroleum Exchange (IPE) in London and the

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*Brent crude is a blend of light, sweet crude produced from the British sector of the North Sea field.*
WTI\(^1\) in New York Mercantile Exchange (NYMEX), had been introduced. Also Dubai\(^6\) crude had been traded on the Singapore International Monetary Exchange (SIME), though in relatively small volumes.

Future contracts are similar to forward in that the products are sold or bought for delivery at some time in the future, but differ in respect of the fact that while the forward contract is bilateral with no other parties concerned, futures are traded between agents on the exchange floor. It essentially represents two contracts: a sellers' contract and a buyer contract, each with the clearinghouse operated by the futures exchange.

The contracts traded in oil futures markets are commitment to deliver or accept standard quantities for a given crude oil or refined product at specified future times (or dates within periods).

Hartshorn (1993)p.207

Futures are contracts traded for speculation purposes not as a source of supply even though they are contracts offering delivery at a future point of time. All bargains are registered as to price and timing and are immediately communicated to all other participants in the market. These contracts are backed by a deposit and guaranteed by a clearing house. Before delivery becomes due for most future markets, the buyer or seller will usually reverse the commitment by reselling or repurchasing contracts. This is known as "paper crude" (in which physical delivery is formally possible but not the main objective of the deal), before it becomes "Wet crude" which is spot and forward, the main purpose of which is physical delivery.

Future contracts are governed by regulations and laws\(^7\) which differ from the less formal forward markets. These regulations might affect the size of contract that should be liquidated, and the design draft of the future contracts.

Options and derivatives: The option underlying the future contracts may be exercised at any time before it expires; a 'call' option gives its holder the right to buy the underlying future contracts,

\(^1\)Crude with similar characteristics to Brent produced from a number of fields throughout West Texas in the USA.
\(^6\) Medium crude produced in the UAE.
and a ‘put’ option, the right to sell. The option is a function of the strike price, if the underlying futures price is above a given option’s strike price, then the option is ‘in the money’ if it is a ‘call’ and ‘out’ of the money, if it is ‘put’.

Swaps: Swap is the CFD (Contract for Deliveries) market, which trades the difference between the Platt’s assessment for spot crude and the first month forward crude, and can be used to manage the risk arising from differential price moves between the spot and the forward market. This can be explained as follows a producer can arrange a swap for a given value over a given period at a price equal to an estimate of weighted average of market price over that period. At the end of that period the value of the swap is compared to the actual price and to the estimated one. If the actual price is higher, the producer pays the swaps provider the difference and if the price is lower than the estimate the provider pays the producer the difference. Consequently, the swap requires no physical exchange.

These sets of trading instruments apply to a small number of crudes, the most important being Brent, Dubai West Texas Intermediate (WTI), and Alaska North Slope (ANS.) These various crudes define each particular oil market by location and institutional characteristics of its own. These crudes are partially linked together but there is no perfect integration between them. Local and international forces influence some of the prices of these crudes.

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7 Regulation established through legislation imposed by government organisations such as The Commodity Futures Trading Commission (CFTC) In the United States.
APPENDIX (8)

Markets of Crudes

Historically, spot markets were few and were confined to specific locations such as Rotterdam, the south of Europe, Singapore, the US Gulf coast, and New York, where trade was conducted on products rather than crude oil, and used by the major companies. Spot markets have now become global, with many participants (refiners, middleman, producers and consumers). Published spot prices are a representative average calculated by specialist reporting services which monitor a cross-section of the open market.

Before the 1970s, spot trading was largely confined to refined products, as all international trade in crude oil consisted either of integrated transfers between upstream and downstream affiliates of multinational companies or sales under long-term supply contracts. In the late 1950s, when crude posting prices were discounted, the interest started in spot prices, using Netback by deducting estimated refining costs and crude shipping costs from the average prices paid by spot buyers for wholesale products in Rotterdam and certain other major refining centers.

In the 1970s, there was a development of spot trade in crude oil, which exposed OPEC’s official selling prices to direct comparison with open market price trends. In 1979, many companies were willing to pay premium prices for substantial volumes of spot crude following a disruption of long term contract trading. A consequent spot-led escalation of official prices continued in 1980, when the developments of 1979 prompted further changes in the pattern of trade.

North America. There are two major markets in the US; the US Gulf and NYMEX.

The US Gulf: The importance of the US A Gulf terminals is that the Saudi and other Middle East crudes are landed there. The Alaskan North Slope (ANS): This is not the most quoted crude in the American spot markets for oil and is only consumed in California. The importance of the ANS, as a price indicator is that it happens to be delivered to the same USA Gulf terminals as Saudi and other Middle East crudes; and it is closer to them in quality than WTI (Hartshorn, 1993).
NYMEX and the Market for WTI: NYMEX\(^4\) (The New York Mercantile Exchange) first entered into the energy market in 1978, but its success began in 1983. West Texas Intermediate (WTI) is the light sweet (40 API and sulphur content of 0.4 per cent) crude oil contract on the NYMEX (which is the dominant crude oil for price setting in the US domestic market). Future markets for crude have been established successfully since 1983. WTI, which is the spot frequently quoted in the US, is a crude that does not enter physically into the world trade at all (it is only available from a landlocked pipeline terminal in Oklahoma,) but has the most liquidity in the world because of the trading in the future markets contract (Hartshorn, 1993).

Brent Market: Until the mid. 1980s, the term “Brent Market” only referred to the spot of physical forward transactions involving this particular blend. Now the Brent market includes partial forward transaction, a futures contract traded in London on the floor of the International Petroleum Exchange (IPE), options on futures contracts, and swap deals. There are two types of transaction in the physical Brent blend market:

(a) **Dated Brent**: the trade in Brent for the current or delivery month, which refers to a spot transaction for a specific cargo that is either available at a specific loading place or already loaded in transit to some destination.

(b) **15 days Brent**: a specified cargo that will be made available by the seller to the buyer on an unspecified day of the relevant month (Horsnell and Mabro (1993). It is called the 15-day market because the contract assures the buyer of 15 days notice of the period when he must lift his cargo from the loading terminal at Sullom Voe in the North Sea. This can be divided into two major forms of 15-day Brent market; forward cargoes can either be traded as single cargoes with an absolute price agreed or use spread trading which involves the trading of the difference in price between Brent for delivery in different months. A less common form of spread trading is that of trading the differentials against another crude oil, which in the Brent market normally means trading against either Dubai or WTI.

\(^4\)NYMEX is currently one of the largest futures markets in the world in terms of the volume of contracts traded.
In 1988, IPE started successful trading in Brent futures contracts. The other trading instruments used are the IPE Brent Options and Swaps which started in 1989. What with all the trading on the Brent market, it became the price indicator available for the world crude oil trade. Although there is some trading in all the North Sea crudes the existence of a substantial forward paper market is confined at present to Brent Blend, because it is sold in a volume larger than any other crude in the North Sea. Though it consists of only 5% of world crude exports, it is considered that which is generally available at the most flexible price (Hartshorn, 1993).

**The Dubai Forward Markets:** Dubai crude is a medium 31 API and high sulphur crude oil. Since the United Arab Emirates allows equity production by oil companies, unlike other Gulf producers the Dubai market developed from 1984 to reach a peak in 1988 but has declined since. One quarter of the production of Dubai oil is normally sold in the forward market directly, the remainder is sold under term contracts to companies who may choose to sell them on the forward market.

The Dubai market started around 1984 with small numbers of deals which increased dramatically in 1985 because of the interest of Japanese trading companies in the Dubai market, followed by Wall Street refiners in mid 1987 and then by other western companies. By 1988 Iran, Iraq and Saudi Arabia used formula pricing linking sales of the Far East directly with Dubai market quotations. Also in 1988, deals on Brent - Dubai differentials were increasing. However, the total liquidity of the Dubai markets shows a decline since 1988 because of the Gulf crisis in 1990, as well as the rise of spread deals to over 90 per cent in 1991. The Dubai market is used for the pricing of oil exported to the East from the Arabian Gulf, but due to the limited number of participants coupled with the domination of western companies its importance is diminishing.

Brent is the only reference crude that is traded in a market which displays many of the essential economic characteristics required for eligibility. It is located in a large consuming region, and well linked through active arbitrage to WTI in the USA and Dubai in the Gulf.

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*Dubai is one of the Arab Emirates in the UAE which is one of the Gulf states and a member of OPEC.*
APPENDIX (9)

The VAR Model

To interpret the model, we use an example of three variables as has been indicated in chapter (5), with two lags and no deterministic components

If \( r = 1 \) \[ \Pi Z_{t-1} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \end{bmatrix} \begin{bmatrix} y_{t-1} \\ y_{2t-1} \\ x_{t-1} \end{bmatrix} \]

\[ = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \end{bmatrix} \begin{bmatrix} \beta_1 y_{t-1} + \beta_2 y_{2t-1} + \beta_3 x_{t-1} \end{bmatrix} \]

To normalise we multiply by \( 1/\beta_1 \) given the cointegration vector \( \begin{bmatrix} y_{t-1} + \frac{\beta_2}{\beta_1} y_{2t-1} + \frac{\beta_3}{\beta_1} x_{t-1} \end{bmatrix} \)

which describes the long-run relationship between the three variables.

If \( r = 2 \) \[ \Pi Z_{t-1} = \begin{bmatrix} \alpha_1 \alpha_{21} \\ \alpha_2 \alpha_{22} \\ \alpha_3 \alpha_{32} \end{bmatrix} \begin{bmatrix} \beta_{11} \beta_{21} \beta_{31} \\ \beta_{12} \beta_{22} \beta_{32} \\ x_{t-1} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ y_{2t-1} \\ x_{t-1} \end{bmatrix} \]

\[ = \begin{bmatrix} \alpha_1 \alpha_{21} \\ \alpha_2 \alpha_{22} \\ \alpha_3 \alpha_{32} \end{bmatrix} \begin{bmatrix} \beta_{11} y_{t-1} + \beta_{21} y_{2t-1} + \beta_{31} x_{t-1} \\ \beta_{12} y_{t-1} + \beta_{22} y_{2t-1} + \beta_{32} x_{t-1} \end{bmatrix} \]

To normalise we multiply by \( 1/\beta_{11} \) given the cointegration vector \( \begin{bmatrix} y_{t-1} + \frac{\beta_{21}}{\beta_{11}} y_{2t-1} + \frac{\beta_{31}}{\beta_{11}} x_{t-1} \end{bmatrix} \)

and the second cointegration vector is multiplied by \( 1/\beta_{12} \) \( \begin{bmatrix} y_{t-1} + \frac{\beta_{22}}{\beta_{12}} y_{2t-1} + \frac{\beta_{32}}{\beta_{12}} x_{t-1} \end{bmatrix} \) Both vectors

describe the long-run relationship between the three variables. To identify we use procedures to test the structural hypothesis about cointegration space.
APPENDIX (10)

Definition of the Polynomial used in Seasonality Testing

For seasonal integration in monthly data, the auxiliary regression is augmented by lagged values of the dependent. By defining the Polynomial:

\[ y_1 = (1+L+L^2+L^3+L^4+L^5+L^6+L^7+L^8+L^9+L_{10}+L_{11})X_t, \]

\[ y_2 = (1-L+L^3-L^4+L^6-L^7+L^8+L^9-L_{10}-L_{11})X_t, \]

\[ y_3 = -(L-L^3+L^7+L^8-L_{11})X_t, \]

\[ y_4 = -(L^2+L^4+L^5+L^9)X_t, \]

\[ y_5 = 1/2(1+L^2-L^4+L^6-L^7-2L^8-L^9+L_{10}+2L_{11})X_t; \]

\[ y_6 = 1/2(1-L^2+L^3-L^4+L^6-L^7+L^9-L_{10}-L_{11})X_t; \]

\[ y_7 = -(L^6-L^7-L^9+L_{11})X_t; \]

\[ y_8 = 1/2(1+L^2+L^3+L^4+L^6-L^7+L^9-L_{10}-L_{11})X_t; \]

\[ y_9 = 1/2((1+L^3+L^6+L^7-L^9+L_{11})X_t; \]

\[ y_{10} = 1/2(1+L^3+L^6+L^7+L^9-L_{10}-L_{11})X_t; \]

\[ y_{11} = 1/2((1+L^3+L^6+L^7-L^9-2L^8-L_{10}+2L_{11})X_t; \]

\[ y_{12} = -(1-L^3)X_t. \]
APPENDIX (11)

Selecting the Order of the VAR Model

1- Based on 118 observations from 1976.3 to 1986.12. Order of VAR = 12

List of variables include in the unrestricted VAR: ln $Q^S_A$, ln$Q^O_O$, ln$(P^S_A/P^M)$. with intercept.

<table>
<thead>
<tr>
<th>Order</th>
<th>LL</th>
<th>AIC</th>
<th>SBC</th>
<th>Adjusted LR test</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>231.92</td>
<td>120.92</td>
<td>-32.84</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>225.10</td>
<td>123.10</td>
<td>-18.20</td>
<td>$\chi^2(9)=9.36$, [.404]</td>
</tr>
<tr>
<td>10</td>
<td>220.44</td>
<td>127.44</td>
<td>-1.39</td>
<td>$\chi^2(18)=15.76$, [.609]</td>
</tr>
<tr>
<td>9</td>
<td>216.08</td>
<td>132.08</td>
<td>15.71</td>
<td>$\chi^2(27)=21.75$, [.750]</td>
</tr>
<tr>
<td>8</td>
<td>207.37</td>
<td>132.37</td>
<td>28.47</td>
<td>$\chi^2(36)=33.71$, [.578]</td>
</tr>
<tr>
<td>7</td>
<td>199.11</td>
<td>133.11</td>
<td>41.67</td>
<td>$\chi^2(45)=45.05$, [.470]</td>
</tr>
<tr>
<td>6</td>
<td>191.81</td>
<td>134.81</td>
<td>55.84</td>
<td>$\chi^2(54)=55.07$, [.434]</td>
</tr>
<tr>
<td>5</td>
<td>184.54</td>
<td>136.54</td>
<td>70.04</td>
<td>$\chi^2(63)=65.05$, [.405]</td>
</tr>
<tr>
<td>4</td>
<td>175.01</td>
<td>136.01</td>
<td>81.98</td>
<td>$\chi^2(72)=78.12$, [.290]</td>
</tr>
<tr>
<td>3</td>
<td>170.03</td>
<td>140.03</td>
<td>98.47</td>
<td>$\chi^2(81)=84.96$, [.360]</td>
</tr>
<tr>
<td>2</td>
<td>160.76</td>
<td>139.76</td>
<td>110.67</td>
<td>$\chi^2(90)=97.69$, [.272]</td>
</tr>
<tr>
<td>1</td>
<td>152.04</td>
<td>140.04</td>
<td>123.41</td>
<td>$\chi^2(99)=109.67$, [.218]</td>
</tr>
<tr>
<td>0</td>
<td>-548.19</td>
<td>-551.19</td>
<td>-555.34</td>
<td></td>
</tr>
</tbody>
</table>

2- Based on 104 observations from 1987:1 to 1986:12. Order of VAR = 12

List of variables include in the unrestricted VAR: ln $Q^S_A$, ln$Q^O_O$, and ln$(P^M)$ as a stationary variable, with intercept.

<table>
<thead>
<tr>
<th>Order</th>
<th>LL</th>
<th>AIC</th>
<th>SBC</th>
<th>Adjusted LR test</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>425.04</td>
<td>373.04</td>
<td>304.29</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>422.11</td>
<td>374.11</td>
<td>310.64</td>
<td>$\chi^2(4)=4.40$, [.354]</td>
</tr>
<tr>
<td>10</td>
<td>410.84</td>
<td>366.84</td>
<td>308.67</td>
<td>$\chi^2(8)=21.30$, [.006]</td>
</tr>
<tr>
<td>9</td>
<td>407.14</td>
<td>367.14</td>
<td>314.25</td>
<td>$\chi^2(12)=26.85$, [.008]</td>
</tr>
<tr>
<td>8</td>
<td>404.41</td>
<td>368.41</td>
<td>320.81</td>
<td>$\chi^2(16)=30.95$, [.014]</td>
</tr>
<tr>
<td>7</td>
<td>395.68</td>
<td>363.68</td>
<td>321.37</td>
<td>$\chi^2(20)=44.05$, [.001]</td>
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<tr>
<td>6</td>
<td>375.17</td>
<td>347.17</td>
<td>310.15</td>
<td>$\chi^2(24)=74.80$, [.000]</td>
</tr>
<tr>
<td>5</td>
<td>370.15</td>
<td>346.15</td>
<td>314.41</td>
<td>$\chi^2(28)=82.34$, [.000]</td>
</tr>
<tr>
<td>4</td>
<td>366.49</td>
<td>346.49</td>
<td>320.05</td>
<td>$\chi^2(32)=78.83$, [.000]</td>
</tr>
<tr>
<td>3</td>
<td>358.69</td>
<td>342.69</td>
<td>321.54</td>
<td>$\chi^2(36)=99.52$, [.000]</td>
</tr>
<tr>
<td>2</td>
<td>358.06</td>
<td>346.06</td>
<td>330.20</td>
<td>$\chi^2(40)=100.47$, [.000]</td>
</tr>
<tr>
<td>1</td>
<td>352.92</td>
<td>344.92</td>
<td>334.34</td>
<td>$\chi^2(44)=108.19$, [.000]</td>
</tr>
<tr>
<td>0</td>
<td>-125.97</td>
<td>-129.97</td>
<td>-135.26</td>
<td></td>
</tr>
</tbody>
</table>
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