Economic Models of OPEC Behaviour and the Role of Saudi Arabia

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June 1998

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. We are interested in analysing the role of Saudi Arabia in these models. In order to understand how OPEC model explain the Saudi role, we need to review all the models that explained OPEC behaviour and try to find how much they explain the role of Saudi Arabia on the period from the 1973 increase in oil prices to the time of the study.

Table 1: The Models of OPEC Behaviour.

Models Type	Model
Models that do not recognise Saudi Arabia's role	Monolithic cartel Competitive Model
Models that address Saudi Arabia's role	Two block cartel Geroski, Ulph and Ulph Swing Producer
Other theories of OPEC behaviour in the oil market	Property Right Fiscal Constraint Models Target Capacity Utilisation
Econometric Studies	Griffin (1985) Dahl and Yucel (1991) Griffin and Neilson (1994) Al-Turki (1994)

	Al-Yousef (1994) Gulen (1996)
Political Interpretation of Saudi Arabia's behaviour.	Stevens (1982,1992) Doran(1982) Moran(1982) Golub(1985)

In this paper we will divide, the models of OPEC [1] 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.

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).

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:

$$Q_P^{OPEC} = Q_P^W - Q_P^{NO} \qquad 1$$

where Q^{OPEC} is the OPEC supply, Q^{w} is world oil demand and Q^{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.

$$Max^{w}_{p_t} = \sum_{t=1}^{T} \frac{1}{(1+r)^t}[P_t - \frac{m}{R_t}]Q_t^{OPEC} \qquad 2$$

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).

$$Q^{OPEC} = Q^{W}_{P,A} - Q^{NO}_{P,Z} \qquad 3$$

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

$$Q^{OPEC} = f(P, A, Q^{NO}) \qquad 4$$

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

$$Q^{SA} = f(Q^{oo}, P) \qquad 5$$

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 policies and their economic and political objectives to warrant full co-operation between them.

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[2] 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 34^0 (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.

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_{it}) is a function of price (P_t), Reserves (R_{it}) and supply of the past period ($S_{i(t-1)}$).

$$S_{it} = f(P_t, R_{it}, S_{i(t-1)}) \qquad 6$$

Demand is a function of prices P_t , income Y_{jt} and past period demand $D_{j(t-1)}$

$$D_{jt} = g(P_t, Y_{jt}, D_{j(t-1)}) \qquad 7$$

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.

Table 2: Demand for Crude Oil. 1974-1979 (MMBD)

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

Source: BP statistics.

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.

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 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. 3 and Figure 2, Figure 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 3: Demand for Crude Oil. (MMBD) 1979-1982.

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

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[3] (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 34^0, 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.

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.

3.1 OPEC as a Cartel with Different Groups

Since there are differences among OPEC members with respect to production and pricing policies, OPEC can be divided into different groups according to their financial needs, absorptive capacities, costs of extraction, and the size of reserve.

Two-Block Cartel: *Hnyilicza and Pindyck (1976)* considered OPEC as a two-part cartel where members are divided into two groups according to their immediate financial needs. The "*savers"* group consists of *Saudi Arabia*, Kuwait, UAE, Qatar, Libya, and Iraq, and the *"spenders*" group consists of all other members. Because of the limited domestic absorptive capacity of the first group, they would have a low discount rate and the spenders have a high discount rate. The objective function for the saver group is to maximise:

$$\text{Max}_{p_t} W_1 = \sum_{t=1}^{T} \frac{1}{(1+r_1)}[P_t - \frac{m_1}{R_1}]Q_t^1 \qquad 8$$

while the objective function for the spenders group is

$$\text{Max}_{p_t} W_2 = \sum_{t=1}^{T} \frac{1}{(1+r_2)}[P_t - \frac{m_2}{R_2}]Q_t^2 \qquad 9$$

the discount rate of the first group being smaller than the discount rate of the second group $r_1 < r_2$. The output level for each group is determined by a division of total cartel production, $Q_t^1 = \beta_t Q_t$, here β_t is the share of the savers in the total OPEC production and the second group's output $Q_t^2 = (1-\beta_t) Q_t$ where $0 \leq \beta_t \leq 1$. The depletion of reserve levels for each group is equal to $R_t = R_{t-1} - Q_t$

For OPEC, the weighted sum of the two objectives is as follows

$$\text{Max}W = \alpha W_1 + (1-\alpha)W_2 \qquad 10$$

Using the above equations, Hnyilicza and Pindyck, solving the optimisation solution for the two groups, showed that the optimal price trajectory is quite different from that in the monopolistic solution. The price path would depend on the value which is determined 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 co-operate 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.

$$q_{it}^{*} = \alpha_{io} + \sum_{j=1}^{n} \alpha_{ij} P_{jt} + \sum_{k=1}^{m} \beta_{ik} Y_{kt} \qquad 11$$

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_{it}) for OPEC members' production using the distributed lag model is given by

$$q_{it} = \gamma_{io} q_{it}^{*} + \sum_{L=1}^{L} \gamma_{il} q_{jt-l} + D_t \qquad 12$$

where D_t are supply interruption dummies, q_{it} and q_{it-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

$$\prod_i^S = (P_l - C_i)q_i \,, \qquad \prod_i^L = (P_l - C_i)q_i^* \qquad 13$$

Thus, the objective function where the producers follow a Nash equilibrium is to maximise V(P) and is given by

$$V_t(P_t) = \delta_i \prod_i^L (P_t) + (1-\delta_i)\prod_i^S (P_t) + \theta \sum_{j=1} \prod_j^L (P_t) \qquad 14$$

where $\mathbf{P}_t = (P_{1t} \,..P_{nt})$, is the vector of prices. The equation reflects the varying conduct of the producer i, where δ is the weight the i producer puts on long-run profit and $(1\text{-}\delta)_i$ is the weight it puts on other short-run-profits, θ 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 θ=0 it indicates non-co-operative equilibrium which depends on the i producer's excess capacity, while the coefficient δ depends on the financial needs of producers. The need for short-term profits would lower the value of δ, 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 θ 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 edition 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.

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 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.

4.1 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.

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.

Table 4: **The Average Percentage Change for Saudi Oil Production from 1969-1996**

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

Source: OPEC Statistical Bulletin

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.

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.

4.2 Target Capacity -Utilisation Model (TCU)

There are two assumptions on which the target capacity-utilisation 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 utilisation 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 utilisation.

According to this view, OPEC attempts to maintain capacity-utilisation near a target level. If capacity-utilisation rises above the target then high demand stimulates OPEC price increases. The price increase will subsequently lower demand and reduce capacity-utilisation down to the target. If capacity-utilisation falls below the target, then OPEC uses price reductions to stimulate demand and increase utilisation, 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 utilisation 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_t as

$$CU_t = \frac{S_t^{opec}}{MAXCAP_t} \qquad 15$$

where S^{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:

$$\frac{P_t - P_{-1}}{P_{\ 1}} = a + \frac{b}{1 - CU} \qquad 16$$

Stephen Powel (1990) used the historical behaviour of the world oil market by plotting the annual percentage change in price and capacity utilisation. He concluded that there is a relationship between the high capacity utilisation and price increases, and low capacity utilisation 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 utilisation 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 5).(see Figure 1).

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 (DOEEIA). But this could be applied only before 1987.

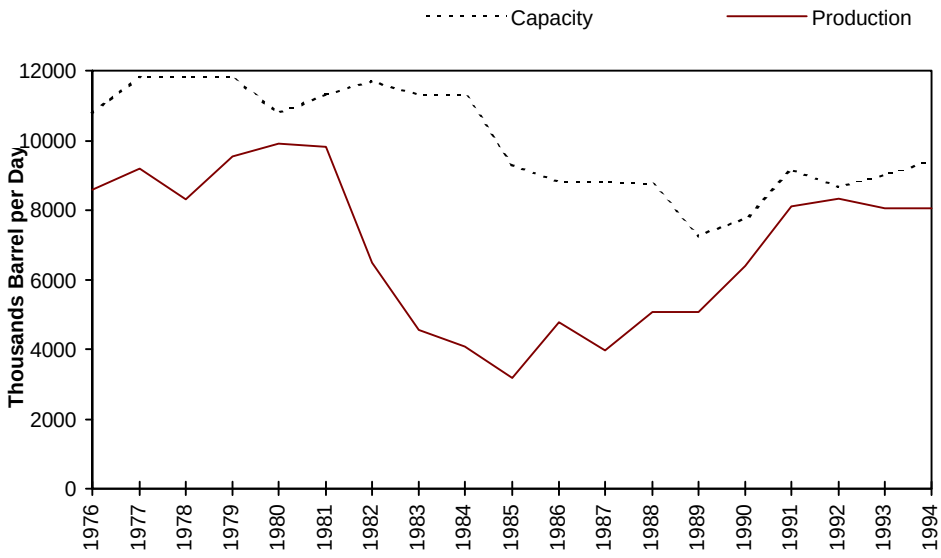
Table 5

Arabia (1976-1993)

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

Source: OPEC Secretariat.

Figure 1 Saudi Arabia's Crude Oil Production and Sustainable Oil Production Capacity (1976-1994)



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.

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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_{it}* represents investment needs, and q_{it} is the production of an OPEC member, then according to the model, I^*_{it} should be equal to the target revenue.

$$P_t q_{it} = I^*_{it} \qquad 17$$

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

$$\ln q_{it} = \alpha_i + \gamma_{i1} \ln P_t + \gamma_{i2} \ln I^*_{it} + \varepsilon_{iy} \qquad 18$$

Increase in investment needs would result in an increase in production; but for a given price coefficient, γ, 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 co-operate 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 maximising the value of its oil revenue.

Table 6: Saudi Arabia's GDP in Saudi Riyal 1974-1996

Year	GDP real (Billion Saudi Riyal)	GDP nominal (Billion Saudi Riyal	Current Account Billion Saudi Riyal	Oil Price $/B	Saudi Arabia production Thousands B/D
1974	31.7	139.60	81990.00	11.58	8479.7
1975	34.7	164.50	50336.00	11.54	7075.4
1976	39.7	205.10	50414.00	11.51	8577.2
1977	42.0	225.40	41971.00	12.40	9199.9
1978	44.8	249.50	-7528.00	12.70	8301.1
1979	**49.4**	**385.80**	**40416.00**	17.28	9532.6
1980	**53.3**	**520.60**	**142240.00**	**28.67**	**9900.5**
1981	**54.2**	**524.70**	**139123.00**	**32.50**	**9808.0**
1982	**48.3**	**415.20**	**25955.00**	**32.38**	6483.0
1983	48.3	372.00	-58216.00	29.04	4539.4
1984	47.2	351.40	-64845.00	28.20	4079.1
1985	45.3	313.90	-46855.00	27.01	3175.0
1986	47.8	271.10	-43680.00	13.53	4784.2
1987	47.2	275.50	-36604.00	17.73	3975.2
1988	50.7	285.10	-27492.00	14.24	5083.5
1989	50.8	310.80	-35776.00	17.31	5064.5
1990	56.2	392.00	-15555.00	22.26	6412.5
1991	61.0	442.00	-103502.00	18.62	8117.8
1992	62.3	461.40	-66437.00	18.44	8331.7
1993	59.5	443.90	-64668.00	16.33	8047.7
1994	61.5	150.00	-30940.00	15.53	8049.0
1995	63.8	469.40	-19900.00	17.18	8000.0
1996	67.0	509.80	700.00	19.81	8000.0

Source: OPEC secretariat and IMF.

In 1979, 1980, and 1981 Saudi Arabian oil revenue reached a high level (see Table 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. The second cut was in April 1979, and various political reason. 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.

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 :

$$\ln q_{it} = \alpha_{it} + \gamma_{it} \ln P_t + \varepsilon_{it} \qquad 19$$

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:

$$\ln q = \alpha + \delta G + \varepsilon \qquad 20$$

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

$$\ln q_{it} = \alpha_i + \gamma_{i1} \ln P_t + \gamma_{i2} \ln I^*_{it} + \varepsilon_{iy} \qquad 21$$

where I* is the target investment. Griffin tested a restricted variant for the value $\gamma_{i2}=1$, $\gamma_{i1} =- 1$, which was rejected by ten members, including Saudi Arabia, for whom investment data is available. On the other hand with the partially restricted variant $\gamma_{i2}<0$ $\gamma_{i1}>0$ 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:

$$\ln q_{it} = \beta_{io} + \beta_{i1} \ln Q^{OO}_{it} + \beta_{i2} \ln P_t + \varepsilon_{it} \qquad 22$$

where q_{it} is the production of the i^{th} member, Q_{it} is the production of OPEC minus the i 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:

$$\ln q_{it} = \alpha + \beta \ln Q_{it}^{OO} + \beta \ln P_t + \ln q_{t-1} + \varepsilon_{it} \qquad 23$$

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:

$$Q^{SA}_{pA} = Q^{W}_{pA} - Q^{NO}_{pA} - Q^{OO}_{pA} \qquad 24$$

where P^A 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^{OO}) as follows:

$$\varepsilon^{SA} = \varepsilon^{W} - \varepsilon^{NO} - \varepsilon^{OO} \qquad 25$$

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:

$$Q^{SA} - Q^{SA}_{quota} = \gamma(Q^{OO} - Q^{OO}_{quota}) \qquad 26$$

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 tit-for-tat it should differ structurally. Therefore the following general equation was used:

$$P_t - P_{t-1} = \alpha + \beta T + (\gamma - 1)P_{t-1} + \delta(P_{t-1} - P_{t-2}) + e_t \qquad 27$$

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:

$$Q^{SA} - Q^{SA}_{quota} = \gamma_0 + \gamma_1(Q^{OO} - Q^{OO}_{quota}) + \gamma_2(Q^{OO} - Q^{OO}_{quota})^2 \qquad 28$$

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.

Gulen (1996) used monthly data for the thirteen OPEC members from 1965 to 1993. Using cointegration and causality tests for four different periods, 1965:1-1993:2 (full sample), 1965:1-1973:9 and 1974:2-1993:2 and 1981:1-1993:2, he compares the performance of OPEC before and after the first oil shock of 1973-74 to see whether the organisation has been successful in co-ordinating output among its members since adopting the quota system in 1982. Gulen concluded that there was co-ordination among the members during the output rationing era.

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:

$$Q_{it} = \alpha_t Q_t$$

Where Q_{it} is the i^{th} member's production and Q_t is the total OPEC production at time t, and α 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-co-ordination 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.

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 on 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.

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.

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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 Hotelling (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] Because of the agreement of participation between the Saudi government and Aramco four owners Company .