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Crude Oil Price Fluctuations and Saudi Arabian Behaviour

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**CRUDE OIL PRICE FLUCTUATIONS
AND SAUDI ARABIAN BEHAVIOUR**

by

Roberto A. De Santis

October 2000

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CRUDE OIL PRICE FLUCTUATIONS AND SAUDI ARABIAN BEHAVIOUR*

Abstract:

This study seeks to explain why crude oil prices fluctuate, the main cause being the quota regime, which characterises the OPEC agreements. Given that the Saudi oil supply is inelastic in the short term, a shock in the oil market is accommodated by an immediate price change. In contrast, a dominant firm behaviour in the long term causes an output change, which is accompanied by a smaller price change. This explains why oil prices overshoot. The results of a general equilibrium model applied to Saudi Arabia support this analysis. They also indicate that Saudi Arabia does not have any incentive in altering the crude oil market equilibrium with either positive or negative supply shocks; and that its behaviour is asymmetric in the presence of world demand shocks, having an incentive (disincentive) in intervening if a negative (positive) demand shock hits the crude oil market. A second set of simulations is designed to understand what might be a correct OECD policy to lower prices. A tax cut would worsen the situation, whereas policies which can increase the price elasticity of demand seem to be very effective.

* I have benefited from discussions with Christiane Kasten, Bodo Steiner and Manfred Wiebelt. All errors are my responsibility.

Keywords: Crude oil prices, OPEC countries, export quota, computable general equilibrium

JEL classification: D58, F13, Q40

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1. Introduction

The oil crisis, circa 2000, is not a supply-side phenomenon. That is because the oil market is nothing like a normal market. In a normal market, the marginal producer, the one who provides the last bit of supply, is the high-cost producer. If prices rise a lot, that producer can finally make a profit and he starts to increase supply. That supply meets rising demand and helps to hold down prices. In oil, however, that situation is turned on its head. The marginal suppliers in that market are the gulf states, principally Saudi Arabia and Kuwait. They are also the lowest-cost producers, and the ones with reserves that will last for decades. The high-cost producers, including many wells in this country, are pumping all out and will not add production anytime soon no matter how high the price goes. What would lead the Saudis to start pumping enough oil to lower prices? In a word, fear. If they feared that a worldwide recession was imminent and knew that would cause demand to plummet, they might act. There is no such fear now. But the other fear is a longer-range one. A trend away from oil would be a scary phenomenon to the oil-rich Saudis, and they would hate to see a renewal of the 1970's trends toward better fuel economy and alternative energy sources. The real mistake in Washington came in the years after the last oil crisis, when oil prices were weak and Americans lost interest in energy conservation. Higher gas taxes and less loophole-laden fuel-economy rules would have helped avert the current problem. So now oil prices are high, and they are likely to remain above \$25 a barrel until growth slows significantly in an important region of the world -- or until the Saudis grow worried that this country will again get serious about energy conservation and research into alternative energy sources. It's the demand that counts.

New York Times, June 23, 2000

Is there an economic rationale behind Saudi Arabia or OPEC (Organization of the Petroleum Exporting Countries) behaviour? Is Saudi Arabia or OPEC behaving as an oligopolist? These are key questions that are often discussed in the public debate whenever oil prices fall below \$15/barrel or rise above \$25/barrel. The optimal oligopolistic price rule of basic microeconomics tells us that the price mark-up is a function of the marginal cost, the price elasticity of demand and the industry market share. These three variables are sluggish in the

short term. Hence, the crude oil price fluctuation in the short term is unlikely to be explained by an oligopoly theory. Crude oil is also an exhaustible resource and, therefore, it is often argued that the price dynamic is affected by scarcity issues, which have always been discussed in the literature in the last two decades (Stiglitz, 1976; Neumayer, 2000, for a survey). However, every year there is a new discovery or a technological improvement, which has permitted the proven reserves to increase rather than decline in several regions, especially OPEC, Asia and Latin America. In fact, the world proven crude oil reserves in 1998 were 60% and 5% larger than that in 1980 and 1990, respectively (OPEC, 1999).¹ Regarding output and trade, the amounts of world crude oil production and exports did not change much during the 1970's and the 1990's. World crude oil production has always been around 60 thousand barrel per day, 50 per cent of which is internationally traded. The OPEC share of world crude oil production declined from 50 per cent in the 1970's to 40 per cent in the 1990's. As a result, the OPEC share of world crude oil exports declined from 80 to 60 per cent in the last thirty years (OPEC, 1999). Similarly, technical improvements have markedly reduced the marginal cost to produce one unit of crude oil (Alazard and Champlon, 1999); whereas after the 1985 shock, the price elasticity demand for crude oil has become less elastic for OECD countries, which are the major

¹ In September 1999 for instance, Iran seems to have discovered a giant onshore oil field, containing perhaps 26 billion barrels of oil (The Economist, September 25th - October 1st, 1999).

consuming countries (Haas, et al., 1998). In summary, the fall of OPEC market share, the lower marginal cost, and the greater reserves all suggest that crude oil prices should have declined over time; whilst the lower elasticity of demand (in absolute value) implies a rise in crude oil prices. Nevertheless, these variables are sticky; whereas the monthly data indicate a large price fluctuation in the short term, which cannot be explained by an oligopoly theory.

The econometric evidence rejects both the hypotheses that the oil market is driven by a competitive behaviour and that OPEC is a pure cartel (Griffin, 1985; Jones, 1990; Alhajji and Huettner, 2000),² in line with Adelman's argument (Adelman, 1978 and 1993), who believes that the unstable OPEC cartel oscillates between the dominant firm model and the pure cartel.³ However, it is important

² Griffin (1985) and Jones (1990) tested the behaviour of OPEC countries in two different periods: in the 1970's, which were characterised by rising prices (Griffin, 1985), and in the 1980's, which were characterised by falling prices (Jones, 1990). They found that, among the different variants of the general cartel model, the Griffin's 'partial market sharing' hypothesis is the best one. The 'partial market sharing' model allows individual cartel members to respond less than proportionately to changes in their fellow members' aggregate production, while placing no restrictions on their responsiveness to prices. Namely, Griffin and Jones find that OPEC behaves as a quasi-cartel. The alternative hypotheses are: (i) 'constant market sharing' model, which implies that all OPEC members share equiproportionally the changes in output, regardless of the price; (ii) 'market sharing' model, which implies that OPEC members do not share equiproportionally the changes in output, regardless of the price; (iii) competitive model. Griffin also tests for the target revenue hypothesis and the property right model based on the theory of exhaustible resources. Both hypothesis were rejected. In addition, Jones and Griffin found that the major non-OPEC countries continue to behave much more in accordance with the competitive hypothesis than with any of the cartel variants.

³ Cremer and Salehi-Isfahani (1989) propose an alternative approach to explain crude oil price fluctuations. They argue that OPEC countries are characterised by a backward bending supply curve model. If the demand curve for crude oil is relatively inelastic, there can exist two stable equilibrium, which can explain the pre-1973 era (low prices) and the oil crisis era (high prices). However, their model is based upon the strong assumption that the crude oil market is perfectly competitive, an hypothesis rejected by the econometric evidence.

to point out that several authors argue in favour of a key role played by Saudi Arabia as a dominant producer (Griffin and Teece, 1982; Mabro, 1991), an hypothesis which is also supported by recent econometric evidence (Alhajji and Huettner, 2000).⁴ It is well known that the price elasticity of demand perceived by a dominant firm is endogenous, depending upon the responses to shocks of world demand and the rest of the world (RoW) supply. Hence, the price set by a dominant firm can fluctuate to a great extent. However, the dominant firm model alone cannot explain the overshooting effect of the crude oil prices, which seems to characterise this commodity market. I argue that two different behaviours are needed in the short and long term to better understand the crude oil price dynamics. I claim that the large fluctuation of the crude oil prices in the short term is due to the quota regime, which characterises the OPEC agreements. Given that the Saudi oil supply is inelastic in the short term, a large shock in the oil market is accommodated by an immediate and large price change. In contrast, Saudi Arabia acts as a dominant firm in the world oil market in the long term. A dominant firm behaviour leads to output changes, which are accompanied by lower prices changes. This explains why oil prices are not only extremely variable in the short term, but also able to recover and stabilise in the long term. In fact, only after numerous meetings among the OPEC members, is a new

⁴ Al-Yousef (1998) and Alhajji and Huettner (2000) provide an overview of several oil market models developed in the last twenty years explaining the behaviour of OPEC and the specific role of Saudi Arabia.

aggregate output level agreed, which maximises the OPEC profits and stabilises the prices.

In order to distinguish between the short and long run effects of shocks on the crude oil market, I have constructed a Computable General Equilibrium (CGE) model for Saudi Arabia, which is able to quantify the size of price and output changes due to demand and supply shocks in the oil market under both the quota regime and the dominant firm model. One of the features of the CGE methodology is that it allows one to compute welfare measures, without relying on simple approximation from the partial equilibrium analysis. Generally, the welfare implications of economic policies are estimated to be small. However, OPEC countries, in particular the Arab members, depend heavily upon oil export revenues. As a result, a shock in the crude oil world market can affect these economies extraordinarily. The results of the simulations are very interesting because they can capture some of the stylised facts of the crude oil markets occurred in the last 15 years: the effects of the negative demand shock in 1998 due to the financial crises in East Asia; the effects of the positive demand shock in 2000 due to the severe winter in the US and the subsequent low inventories; the effects of the negative supply shock in 1987 when several OPEC countries decided to reduce output to sustain higher crude oil prices, after the disruption of the cartel in 1986. In addition, the results indicate that Saudi behaviour is

asymmetric having an incentive in intervening if a negative demand shock hits the crude oil market, and a disincentive if a positive shock occurs.⁵ By contrast, an exogenous change of Saudi exports always causes welfare losses, which implies that Saudi Arabia would be always reluctant to modify the equilibrium conditions in the crude oil market. The same model has been used to understand which policy to introduce in order to cool down high crude oil prices. Since supply shocks are ineffective, only OECD countries can help ease situations with hiking up prices. The temptation of OECD policymakers to lower taxes on crude oil, in order to satisfy the request of their discontented citizens, would be a great mistake because an additional positive demand shock would exacerbate the situation. Whilst, it seems that only an increase in the crude oil price elasticity of demand can reduce prices effectively, this implies that the development of alternative energy sources, which are close substitutes for crude oil, are desirable.

The study also consists of a further five sections. Section 2 discusses some of the stylised facts concerning the oil market and OPEC behaviour. Section 3 defines the algebraic specification of the model. Section 4 describes the benchmark data set. Section 5 explores the effects of the policy simulations, and the final section provides some conclusions.

⁵ The econometric literature has focused upon the asymmetric effects on the demand side (i.e. Gately, 1992 and 1993; Haas *et al.* (1998); and Renou-Maissant, 1999) neglecting the possible asymmetric response on the supply side.

2. A personal view of stylised facts

2.1. Saudi Arabia behaviour in the short term

The crude oil market is characterised by the fluctuations of the prices, because Saudi Arabia does not play the role of the swing producer in the short term. Figure 1 describes the short term effects of supply and demand shocks in the world crude oil market. E_{SA}^s denotes the Saudi short term vertical export supply curve, E_{SA}^d the Saudi perceived export demand curve, E^d the less elastic downward sloping world demand curve and E_R^s the RoW supply curve. The intersection point between E_{SA}^s and E_{SA}^d gives the initial equilibrium $e(p^*, E^*, E_R^*, E_{SA}^*)$. During the last fifteen years, five main strong shocks have hit the oil market. In 1986, Saudi Arabia refused to act as the swing producer by cutting its production when the world demand fell due to the world economic recession of the early 1980s and the more efficient energy policies adopted by OECD countries. The decision by Saudi Arabia to rise oil production caused the fall of the crude oil prices to less than \$10/barrel. Basically, the E_{SA}^s schedule shifted to the right, the prices fell, the RoW supplied less crude oil and a new equilibrium was reached at point $a(p^a, E^a, E_R^a, E_{SA}^a)$. The second shock in 1990 was due to the uncertainty associated with the Iraq-Kuwait war. The expectations that oil supply could severely decline raised oil prices to high levels. This

equilibrium can be represented by point $b(p^b, E^b, E_R^b, E_{SA}^b)$. The price increase in 1996 was due to low inventories. But oil prices soon set below \$20/barrel as inventory levels regained their general levels. In 1998, the oil market was hit by the economic crisis in Asia. The inability of OPEC members to agree production cuts caused the oil prices to fall below \$10/barrel. In terms of Figure 1, this negative demand shock shifted the world demand curve downwards. Given the supply of Saudi Arabia, the negative production shock was absorbed entirely by the RoW. A new equilibrium was reached at point $c(p^c, E^c, E_R^c, E_{SA}^*)$. Only in the autumn of 1999, a new agreement among OPEC countries and the non-OPEC Mexico, and substantial production cuts, especially by Saudi Arabia, allowed the oil prices to regain their ‘normal’ level. However, the commitment by the oil producing countries to stick with the production quotas agreed in the autumn of 1999 caused a large increase in crude oil prices at the beginning of 2000, as the demand for oil raised due to the severe winter in the US. In terms of Figure 1, the negative supply shock in 1999 shifted the Saudi supply curve to the left (let us say from ‘e’ to ‘b’). Whereas the positive demand shock shifted the world demand curve upwardly. These combined effects raised prices and the crude oil supply of the RoW markedly. A new equilibrium has been reached at point $d(p^d, E^d, E_R^d, E_{SA}^d)$. Thus, it is evident that the binding oil production quota is one of the main causes of the oil price volatility in the short term.

2.2. Saudi Arabia behaviour in the long term

The facts suggest that, after a shock, the OPEC members have always been able to find a credible agreement in the long term, which allowed them to behave as a stable cartel. The fact that oil prices frequently oscillate between \$15 and \$25 per barrel is an indication of the collusive behaviour of OPEC in the long term. The eighties were much more unstable than the nineties. In fact, during the period January 1980 and December 1989, the monthly arithmetic mean and standard deviation of the OPEC crude oil FOB costs were respectively 24.2 and 8.3 US dollars per barrel. In contrast, during the monthly period January 1990 and June 1999, these statistical measures reduced to 15.8 and 3.7, respectively. Notably, only if Saudi Arabia acts a swing supplier, is the cartel able to produce the collusive output. The battle for market shares has always caused problems within OPEC. During the 1980s, Iraq, Iran, the United Arab Emirates and Nigeria have all increased their market share at Saudi Arabia's expense, thus destabilising the cartel. In particular, Iraq exceeded the quota limit by 25 per cent during the three year period 1984-86, just before the collapse of the oil cartel in 1986. Only with the punishment of Iraq by the United Nations, due to the invasion of Kuwait in 1990, has the oil market gained the stability required. In fact, the large contraction of Iraq oil production allowed the other OPEC members to expand

their oil production ceiling allocations towards their full capacity level. This positive shock for the OPEC members has stabilised the cartel. OPEC crude oil exports increased slightly, and Brent oil tended to average \$17-18/barrel, which is what producers (countries and companies) and consumers, mainly the governments of OECD countries, accepted as a ‘normal’ price. Thus, except for the 1990 (Iraq-Kuwait war), the 1998 (Asia financial turmoil), and the 2000 (severe US winter and low inventories), the last decade has been notably stable with oil prices ranging between \$15 and \$20 per barrel.

The Saudi behaviour in the long term can be explained by Figure 2. MR denotes the Saudi marginal revenue curve for oil exports and c the cost to produce one barrel of crude oil. The optimal price-output combination is given by the point $e(p^*, E^*, E_R^*, E_{SA}^*)$. The high oil prices of the 1970s led the non-OPEC countries (particularly Mexico, the United Kingdom and Norway) to increase exploration and production. In addition, most of the OECD countries improved the efficient use of crude oil (see Figure 3). The net results of these changes were a large negative effect on export demand of crude oil produced by OPEC in the early eighties. This negative demand shock shifted both the demands and the marginal revenue curve downwards, negatively affecting both prices and output. A new equilibrium in Figure 2 would be represented by point $f(p^f, E^f, E_R^f, E_{SA}^f)$. After 1986, both OPEC oil production and prices started to

increase, due now to a positive demand shock. In fact, after the recession period of the early 1980s, the OECD market economies were expanding. However, oil production declined in the US, remained constant in Mexico and slightly increased in Norway and the United Kingdom. Thus, the increased demand for oil was satisfied by an increase in OPEC production bringing the equilibrium to the initial point e . The 1990's can be considered as a period of a relatively stability due to Iraq discipline plus the fact that OECD stabilised its demand.⁶

What about the new decade? Will the equilibrium crude oil prices move towards \$25-30/barrel? If the demand shock of the year 2000 is a permanent shock, then oil prices will increase. Figure 2 shows that a positive permanent demand shock would bring the equilibrium to the point $g(p^s, E^s, E_R^s, E_{SA}^s)$. The size of the long run price increase will depend upon the magnitude of the demand shock.

Figure 1 and Figure 2 clearly indicate that the impact of oil shocks on prices is larger in the short term, whereas the impact on output is larger in the long term. Hence, any shock in the crude oil market seems to be accompanied by a transitional dynamics, where prices generally overshoot in the short term, whereas output moves steadily towards the long term equilibrium.

⁶ Note that the ratio between the crude oil imports from the OPEC and the gross domestic product (GDP) of the main OECD countries presented a constant trend in the 1990's (Figure 3).

3. A CGE model for Saudi Arabia

The model presented in this study is a static multi-sector CGE model, where Saudi Arabia is either constrained by an export quota or plays the role of the dominant firm in the world oil market. This model is characterised by crude oil being an homogenous good, and the remaining international tradable commodities being subject to intra-industry trade. The world demand schedule for crude oil is downward sloping; the non-Saudi oil supply is upward sloping and the demand perceived by Saudi Arabia is determined residually. The differentiated tradable goods are assumed to have an export demand curve and an import supply curve both perfectly elastic. In other words, the country is assumed to be a price taker of international goods (with the exception of crude oil), though domestic prices are endogenously determined. The tradable differentiated goods and the nontradable services are produced under perfect competition and constant returns to scale. By contrast, crude oil is either exported under the optimal rule of a dominant firm or subject to a quota. Crude oil is also sold domestically as a production input to local industries. However, the domestic and the export markets are treated as segmented markets in order to shield domestic demand decisions from crude oil price fluctuations. The entire profits made by producing crude oil are collected by the government to finance its own expenditure.

To simplify the presentation, the specification of the model is divided into four components: production technology and factors of production, treatment of traded goods and foreign sector closure, government revenues and expenditure, household revenues and consumption. Note that I use the index j to represent the non-crude oil sector and i to represent all economic activities.

3.1. Technology and factors of production

The production function has a two stage nested CES structure. At the first stage, I assume a Leontief function among primary factors of production and intermediate inputs, which are in turn assumed to be net complements. At the second stage, the value added is a CES combination of labour and capital. The demand for factor inputs is derived by solving the two-stage dual problem, such that the factor returns equal their marginal revenue product. Labour and capital are fully employed and perfectly mobile.

3.2. Treatment of traded goods and foreign sector closure

3.2.1. Crude oil

Saudi crude oil production is run by the government, which sells in both the domestic market and the foreign market. As pointed out by Gürer and Ban (2000), the governments of OPEC countries intervene extensively in the setting of domestic oil product prices, by keeping fixed oil product prices for a certain period of time. Here, I assume that the domestic price of crude oil is exogenously given.

With regard to the crude oil to be exported, I consider two alternative cases in order to capture the stylised facts discussed in the previous section. I assume that Saudi oil exports, E_{SA} , are subject to a binding quota in the short term

$$(1a) \quad E_{SA} \leq \bar{E}_{SA},$$

whereas the long term optimal amount is determined by solving the standard problem faced by a dominant firm, that is

$$(1b) \quad p = \frac{c}{1 - 1/\eta}, \quad \eta > 1,$$

where p denotes the crude oil price, η the absolute value of the price demand elasticity perceived by Saudi Arabia and c the user cost to produce one barrel of crude oil, which is endogenously determined by solving the two-stage dual problem discussed in section 3.1.

With regard to the demand for crude oil, for simplicity I assume that the world demand function, E_W , is isoelastic.⁷ Hence,

$$(2) \quad E_W = \Theta(p + t)^{-\beta}, \quad \beta > 0,$$

where Θ is a parameter describing preferences, β the absolute value of the price elasticity of world demand and t the world specific tax rate on crude oil.

According to the dominant firm model, Saudi Arabia sets the price, the rest of the world supplies oil up to the condition where the price is equal to marginal cost, and Saudi Arabia supplies the remaining amount to satisfy world demand. Hence, the supply of the RoW, E_R , is upward sloping and the Saudi export demand is derived residually to match the equilibrium condition in the world market:

$$(3) \quad E_R = \Omega p^\delta, \quad \delta > 0,$$

$$(4) \quad E_W = E_R + E_{SA},$$

where Ω is a parameter describing foreign technology and δ the price elasticity of RoW supply for crude oil. Given the equilibrium condition (4), the price elasticity of demand perceived by Saudi Arabia can be endogenously determined as follows:

$$(5) \quad \eta = \beta \frac{E_W}{E_{SA}} + \delta \frac{E_R}{E_{SA}}.$$

⁷ It is important to stress that an econometric study by Hogan (1992) rejects linear demand models for crude oil in the OECD countries in favour of constant elasticity formulations.

3.2.2. *The nontradable goods*

The demand for the vector of nontradable goods is determined by the sum of the representative household's demand, the intermediate demand, exogenous investment and exogenous government spending. The vector supply of nontradable goods is given by the two stage production function. The market equilibrium determines the vector of domestic prices endogenously.

3.2.3. *The tradable differentiated goods*

On the demand side, a two stage nested separable CES function is employed. Thus, it is assumed that buyers first decide between composite commodities, then decide between domestically produced goods and imports, according to the Armington specification, which states that goods competing in the same market are imperfect substitutes. As far as the supply of imports is concerned, the *small country* assumption is postulated.

On the supply side, in order to avoid specialisation in production, the vector of domestic and export supply functions is derived by maximising total sale revenues subject to the production possibility frontier, which is defined by a constant elasticity of transformation (CET) function. The *small country* assumption implies the vector of export demand functions to be infinitely elastic.

Hence, export production is totally absorbed by foreign trade partners at world prices.

The solution of these two problems results in the vector of domestic demand functions, the vector of import demand functions, the vector of domestic supply functions and the vector of export supply functions, which determine the vector of domestic prices, domestic output, imports and exports.

3.2.4. Foreign sector closure

The current account deficit, B , is exogenously specified. Thus, the equilibrium in the balance of payments is

$$(6) \quad pE_{SA} + \sum_j \bar{p}_i^e E_j + \bar{B} = \sum_j \bar{p}_j^m M_j,$$

where \bar{p}_j^e denotes the vector of the world prices of exports E_j , and \bar{p}_j^m the vector of the world prices of imports M_j .

3.3. Government revenues and expenditure

The government finances its expenditure with lump-sum taxes on the consumer, T , and, most importantly, with profits especially gained from exporting crude oil.

The expenditure is represented by an exogenous consumption of goods and services in real terms, \bar{G}_j . Thus, the consumption decisions of the government are not affected by price changes. The budget balance is given by the following expression:

$$(7) \quad (\bar{q} - c)D + (p - c)E_{SA} + T = \sum_j q_j \bar{G}_j,$$

where \bar{q} is the exogenous domestic price of crude oil and D its output, and q_j the price vector of final goods. Clearly, the endogenous lump-sum taxes guarantee that the budget balance is always in equilibrium.

3.4. Household revenues and consumption

The source of private income originates from wage payments and returns to capital. However, the representative consumer pays lump-sum taxes to the government. Thus, the net income, I , is

$$(8) \quad I = w\bar{L} + r\bar{K} - T,$$

where w and r denote the wage rate and the capital rent, respectively; and L and K the total endowment of labour and capital, respectively.

Since the model is static, the consumer utility function is defined only over goods and services. Because of lack of data regarding the income elasticity and the elasticity of substitution among commodities, consumer preferences have been described simply by the Cobb-Douglas utility function. The consumer behaviour is therefore represented by the following Marshallian demand functions:

$$(9) \quad C_j = \alpha_j \frac{I}{q_j}, \quad \sum_j \alpha_j = 1,$$

where α_j denotes the constant household budget shares.

4. Benchmark and calibration

The theoretical model outlined above requires a benchmark data set to calibrate unknown parameters, such that the observed value of endogenous variables

constitutes an equilibrium of the numerical model. The lack of published official statistics by Arab countries is known. In fact, information about some statistical data is often regarded as highly confidential by these countries. Thus, I rely upon the 1990 social accounting matrix (SAM) for Saudi Arabia (Haji, 1993). Table 1 reports the data, which have been used to calibrate the model. The activities and commodities are disaggregated into 9 different types. The SAM for Saudi Arabia shows that mining, which is basically crude oil and natural gas, comprises 85.4 per cent of total exports. The export revenues are used to purchase manufacturing and agricultural imports. Crude oil and gas are also used as inputs in production, especially to manufacture petroleum refining products. Regarding private consumption, Saudi consumers spend much of their income in manufacturing goods (40.1% of consumer spending), services (19.5%), and wholesale and retail trade activities (18.7%). It is assumed that pure profits are generated only by the crude oil sector, and are equal to 40 per cent of oil export revenues to capture the fact that the marginal cost to produce one barrel of oil should include also the security cost.⁸ The Armington elasticity values for agriculture and manufacturing are high to capture the fact that Saudi Arabia is relatively small. The constant elasticity of transformation is set equal to 1.5 for all

⁸ As pointed out by Alhajji and Huettner (2000), the cost to produce one barrel of oil is generally computed to be small, because security costs to protect oil reserves and plants are not included in the production costs. They argue, for example, that the current military costs for Saudi Arabia to secure its oil wealth amount to 40% of oil revenues. It is believed that higher prices increase the perceived threat and, therefore, military expenditures.

tradable differentiated goods. This elasticity is small to capture the fact that little of the non-oil output is export-oriented. The share of Saudi exports in the world oil trade markets were on average 19.5% between 1990 and 1998 (OPEC, 1999). This information allows one to calibrate the world demand and the RoW supply of crude oil. The world price elasticity of demand and the RoW supply elasticity for crude oil have been estimated by Alhajji and Huettner (2000) for the dominant firm model, which is consistent with Saudi Arabia's behaviour: $\beta = 0.49$ and $\delta = 0.212$. The perceived price elasticity of demand is endogenously calibrated such that (5) is also consistent: η is equal to 2.86, which is in the range suggested by Alhajji and Huettner (2000). With regard to the world tax rate on crude oil, OPEC (1999) reports the composite barrel and its components in major consuming countries from 1994 to 1998. The average tax rate among the OECD countries for the entire five year period was 2.17 times the crude CIF price.

5. Numerical simulations

5.1. The economic impact of demand and supply shocks in the crude oil market

The first aim of the policy simulations is to examine the impact on price and output of both demand and supply shocks on the crude oil market under the two alternative market regimes: export quota and the dominant firm model. An

important empirical question is the comparison of the size of the oil price and output change in the short and long terms, as I discussed qualitatively in Figures 1 and 2. The second aim of the simulations is to measure the consequent impact on profits and welfare, because this would permit one to understand better the dimension of the problem faced by oil exporting countries, when the oil market is hit by a dramatic change. The simulation regarding the negative (positive) demand shock consists of reducing the parameter Θ in (2) such that, in the short term, the crude oil prices declines (increases) by 44.4 (66.6) per cent from \$18/barrel to \$10 (30)/barrel to simulate the year 1998 (2000) situation. The simulation regarding the negative supply shock consists of decreasing crude oil exports by 26% in order to simulate the 1987's event, when the crude oil exports of Saudi Arabia were reduced from 3,265,800 barrels per day in 1986 to 2,416,500 barrels per day in 1987 (OPEC, 1999), in order to increase the average prices from the low levels of the year 1986.⁹ The simulation regarding the positive supply shock consists of selling additional output in the world markets such that, in the short term, the crude oil prices decline by 16.6 per cent from an hypothetical 30 to \$25/barrel, which is what OECD and OPEC countries would like to achieve in the next months to cool down the overheated world oil market.

⁹ The average crude oil FOB costs was equal to 12.52 US \$ per barrel in the year 1986. This price increased to 16.38 US \$ in the subsequent year (EIA, 1999).

Table 2 reports the key results. With regard to the effects of the negative demand shock, the foreign crude oil price contracts by 44.4% under the quota regime, whilst it declines by 32.3% under the dominant firm model. As I have already argued in Figure 1, the demand shock is fully absorbed by a price change under quota. Conversely, the optimal price-output allocation under the dominant firm model seems to result in a decline in price and in a large output contraction. The fall in price is anyhow big, because the price elasticity of demand perceived by Saudi Arabia almost doubles. Saudi crude oil exports decline by 59.2% in the long term, whereas the world demand and the RoW supply decline by 17.8% and 7.9%, respectively. The cut in price and exports obviously has a negative impact on Saudi trade volume and profits. In particular, profits decline by 77.9% under the quota regime and 21.8% under the dominant firm model. The negative impact on welfare, however, is disturbing. CGE modellers are used to dealing with 1-2% welfare changes when policy scenarios are carried out. In this case, the welfare losses are equal to 35.3% of the consumer income under the dominant firm model, and 37.7% under the quota system, because oil export revenues comprise a large share of GDP.¹⁰ In fact, the value of petroleum exports and GDP at current market prices of Saudi Arabia respectively declined by 35.9% and 7.9% in 1998 compared with the previous year. Needless to say that the simulation well

¹⁰ The ratio between the value of petroleum exports and GDP at US dollars current prices in Saudi Arabia averaged 34.5% between 1990 and 1998.

captures the size of the shock. As GDP falls, the returns to capital and labour decline, bringing about large welfare losses. This implies that firstly, the difficulties of OPEC members originating from dramatic negative changes in the oil market are considerable; and secondly, Saudi Arabia has a real incentive to cut production to reduce enormously profits losses. If, by contrast, the crude oil market is favoured by a positive demand shock, such that world prices of crude oil rise by 66.6% as occurred in 2000, then the opposite economic implications would result. Profits, trade volume and welfare would rise markedly. In particular, Saudi Arabia would not have any incentive to expand production to meet new foreign demand patterns because the price increase would decline from 66% to 47.3% and, as result, positive profits by trading in the world markets (174.9%) and welfare gains (39.5%) would be smaller compared to the effects in the short term.

With regard to the impact at sectoral level, when the demand shock is negative, despite the contraction in domestic demand, output does not decline in each sector for two main reasons: firstly, the lower factor returns permit industries to produce at lower marginal costs and sell in the domestic market at the expense of the substitute agricultural and manufacturing imported goods (price effect); secondly, although import volume declines, exports sales of non-crude oil activities will expand to keep the balance of payment in equilibrium

(trade balance effect). In particular, domestic production of manufacturing expands by 9.9%. Since this sector uses crude oil as an important production input, due to the Leontief specification, crude oil output can increase in the short term. Due to the expansion of these two sectors, which are relatively more capital intensive, plus the contraction of the labour intensive services, the ratio between capital rent and the wage rate rises by 10.2%. However, under the dominant firm model, crude oil exports decline bringing about an output contraction of 22.5%. Resources are then shifted to agriculture and manufacturing, which can expand by 20.8% and 35.1%, respectively. If, by contrast, the crude oil market is favoured by a positive demand shock, then the opposite economic implications would result also at sectoral level. The positive demand shock has an inflationary effect, which causes the factor prices and, as a result, domestic prices to increase. Agriculture and manufacturing, which are the only importable goods, would contract, whereas the relatively labour intensive sectors would expand, bringing down the ratio between the capital rent and the wage rate.

With regard to the negative supply shock, the immediate effect of a 26% reduction in Saudi exports is a rise in price by only 8%. In addition, when adjustments take place in the long term, exports reduce by 12.6%, whereas prices increase by only 3.8%. This is because the Saudi marginal revenue curve is slightly affected by the supply shock. The fall in exports are offset by a rise in

RoW sales to satisfy world demand. Note that despite a rise in profits, the policy generates welfare losses in both the short and long term. The monthly data indicate that crude oil prices (i.e. OPEC countries average crude oil FOB costs) from less than \$10/barrel in July 1986 increased to \$17.35 in July 1987 and landed to \$14.5 at the end of the year, with an average price equal to \$12.52 and \$16.38/barrel in 1986 and 1987, respectively (EIA, 1999). The simulation is able to capture the overshooting effect of the price, but is unable to reproduce the size of the impact, which implies that other variables such as the agreement among OPEC members and agent expectations might have influenced the actual results.

The opposite economic implications would occur in the presence of a positive supply shock. The immediate effect of a 64% increase in exports is a price fall by 16.6%. However, the price would decline by only 5.8% in the long term. The positive supply shock has a large negative effect on profits and welfare under both regimes due to a negative terms of trade effect. This implies that Saudi Arabia will avoid an output expansion, which is welfare reducing. It is also important to stress that the OPEC statement in July 2000 (OPEC, 2000a) to increase OPEC [Saudi] production by 500,000 [162,000] barrel per day (that is, 2% from 25,400,000 [8,253,000] barrel per day), which was not translated into actual new production, followed by the statement in September 2000 (OPEC, 2000b) to increase production by 800,000 [259,200] barrel per day (that is, 3.1%

from 25,400,000 [8,253,000] barrel per day), seems to be too small to reduce oil prices sufficiently. In fact, the numerical simulation suggests that an output expansion of 43.3% (namely 3,573,549 barrel per day) is required for crude oil prices to decline from 30 to \$25/ barrel. With regard to the impact on sectoral output, the expansion (contraction) of crude oil pushes the capital rent up (down) relative to the wage rate. As a result, the capital intensive sectors, such as agriculture and manufacturing, contract (expand).

It is important to emphasise that any supply shock brings about a welfare loss. This implies that Saudi Arabia will avoid any intervention, which might dismantle an equilibrium in the crude oil market. In particular, an increase in production might be disruptive in the long term. This might explain why OPEC members are very careful in setting production quota increases to lower the crude oil prices.

5.2. The economic impact of a the 2000 oil demand shock and OECD intervention

What if the demand shock of the year 2000 is a permanent shock and the long term equilibrium price is indeed \$30/barrel? How will Saudi Arabia be affected? What policy is left to the OECD countries to make sure that the price pressure can be eased? In order to answer these questions, I have increased the parameter

Θ in (2) such that, under the dominant firm model, the crude oil prices increase by 66.6 per cent from \$18/barrel to \$30/barrel so as to simulate the year 2000 situation as a long term equilibrium. The first column of Table 3 reports the results. Can OECD countries introduce a policy, which leads to an equilibrium with lower prices? In this model, the only variables which OECD countries can influence are the price elasticity of demand and the specific tax rate on crude oil. Recent econometric evidence (Haas, et. al, 1998) suggests that the absolute value of the price elasticity of demand for crude oil during the period 1970-95 was half that during the period 1970-85 for several OECD countries. Assume that OECD members introduce policies, which are able to increase the price elasticity of demand to the levels recorded in the hot period when crude oil prices were hiking. Then, the answer to the above question is affirmative. As it can be seen from the second column of Table 3, if the crude oil price elasticity of demand doubles, the crude oil price can fall back to \$11.8/barrel with Saudi production declining by 31.3%. Thus, it is desirable to diversify the energy sources which are close substitutes for crude oil so as to reduce the pressure on oil production processes when demand shocks occur. If, however, policymakers of OECD countries accept to reduce the tax rate on crude oil to ease the protests of local citizens, then the crude oil prices would further increase, because lower taxation is an additional positive demand shock. In fact, if the tax rate is reduced by 30%,

the crude oil price would reach \$35.7/barrel. Needless to say that Saudi Arabia would enjoy large profits and welfare gains, which explains why OPEC members ask OECD countries to cut their extremely high tax rates.¹¹ Note that the results obtained in columns 1 and 3 seem to be unfeasible, given the capacity constraints of Saudi Arabia, because a raise in export sales by 55.7% and 66.3% would be required. It is also very interesting to note the negative impact on Saudi agriculture and manufacturing, which would decline markedly, due to the Dutch disease phenomenon. However, the underlying assumption of the scenarios so far discussed is that Saudi capital is perfectly mobile among sectors. However, it might be the case that the capital stock is sector specific due to the nature of the industry or to the imperfections of the capital markets. How would the results change under this alternative hypothesis? The last three columns of Table 3 report the scenarios of the last three simulations under the assumption that the capital stock is sector specific. The results are similar for the key variables, whereas the impact is clearly far smaller at sectoral level. It is important to emphasise that Saudi crude oil production remains constant to demand shocks,

¹¹ Note that in September 2000, when crude oil prices reached \$35/barrel, OPEC (2000c) made the following announcement: 'The Organization is not to blame for the high prices of petroleum products, such as gasoline and heating oil, in the consuming countries. The responsibility for such high prices lies fairly and squarely on the shoulders of those governments that see fit to impose exorbitant levels of taxation on petroleum products. In the European Union, for example, only about 16% of the revenue from a barrel of refined oil goes to oil exporters, about 16% to refiners and marketers, whilst the government take averages 68%!.... Having now taken effective action to successfully bring crude oil prices down, OPEC awaits a reciprocal response from the governments of consuming nations to help alleviate the burden of high pump prices to their citizens.'

because the share of capital required to produce one barrel of oil is huge relative to the labour and the other intermediate inputs.¹² The results of the simulations are indeed feasible. The scenarios presented in Table 3 suggest that only an increase in the price elasticity of demand can counteract a situation with long term price hikes.

6. Conclusions

This study seeks to explain why crude oil prices fluctuate. I show that the short-term export quota combined with the long-term dominant firm model played by Saudi Arabia well explain several stylised facts of the crude oil market, most importantly, the overshooting effect on prices and the steady change in output. I use a CGE model for Saudi Arabia to quantify numerically the impact of crude oil demand and supply shocks on prices, output, profits and welfare. The results support the view that any shock in the oil market has an overshooting effect on oil prices. Profits of oil producing countries and companies are clearly affected both in the short and long term and, most importantly, the impact on Saudi welfare is extremely large compared to the results known in the CGE literature.

¹² Total pure profits are negative in the presence of positive demand shocks, because the capital rent in the crude oils sector surges. It increases by 75.7% in the scenario labelled ‘positive oil demand shock’ and by 119.2% in the scenario labelled ‘positive oil demand shock plus tax cuts’. Since domestic prices are exogenously given, then the results would suggest an implicit high subsidy to domestic producers. However, since the capital rent is paid to the government, gross profits are still positive.

This implies that, if a negative demand shock hits the crude oil market, the difficulties experienced by Saudi Arabia are serious and considerable. Therefore, Saudi Arabia has an incentive to cut production to sustain higher prices. By contrast, if a positive demand shock hits the market, then the large gains do not encourage Saudi Arabia to expand production. This asymmetric behaviour on the supply side is an interesting result, which should be studied more in depth. With regard to the supply shocks, the simulations indicate that the effects on crude oil prices are small, because the rest of the world partly offsets the Saudi supply shock in the short term, whereas the Saudi marginal revenues curve is slightly affected in the long term. Nevertheless, any supply shock has an adverse effect on Saudi welfare, which suggests that Saudi Arabia would avoid any intervention, which might dismantle an equilibrium in the crude oil market.

The same model has been used to understand which policy to introduce in order to cool down high crude oil prices. Since supply shocks are ineffective, only OECD countries can help ease the present situation. The temptation of OECD policymakers to lower taxes on crude oil, in order to satisfy the request of discontented OECD citizens, would be a great mistake because an additional positive demand shock would exacerbate the present situation. It seems that only an increase in the crude oil price elasticity of demand can reduce prices, which implies that the development of alternative energy sources, which are close

substitutes to crude oil, are desirable. Note that this long term investment policy strategy can hit Saudi Arabia and surely the other OPEC members and oil supply companies markedly. This implies that if the commitment is credible, prices might even decline once the announcement is made.

REFERENCES

- Adelman, M. A. (1978), Constraints on the World Oil Monopoly Price, *Resource and Energy*, Vol. 1, pp. 3-19.
- Adelman, M.A. (1993), Modelling World Oil Supply, *The Energy Journal*, Vol. 14, pp. 1-32.
- Alazard, N. and Champlon, D. (1999), The Technical and Scientific Progress in Exploration-Production: Impact on Reserves and Costs, *International Journal of Global Energy Issue*, Vol. 10, pp. 70-82.
- Alhajji, A.F. and Huettner, D. (2000), OPEC and World Crude Oil Markets from 1973 to 1994: Cartel, Oligopoly or Competitive?, *The Energy Journal*, Vol. 21, pp. 31-60.
- Al-Yousef, N.A. (1998), Economic Models of OPEC Behaviour and the Role of Saudi Arabia, University of Surrey, *Surrey Energy Economics Discussion Paper Series*, No. 94.
- Cremer, J. and Salehi-Isfahani, D. (1989), The Rise and Fall on Oil Prices: A Competitive View, *Jannales D'Economie et de Statistique*, Vol. 20, pp. 427-454.
- Energy Information Administration – EIA (1999), *Monthly Energy Review*, August, U.S. Department of Energy, Washington, DC.
- Gately, D. (1992), Imperfect Price-Reversibility of US Gasoline Demand: Asymmetric Responses to Price Increases and Declines, *The Energy Journal*, Vol. 13, pp. 179-207.
- Gately, D. (1993), The Imperfect Price-Reversibility of World Oil Demand, *The Energy Journal*, Vol. 14, pp. 163-182.
- Gürer, N. and Ban, J. (2000), The Economic Cost of Low Domestic Product Prices in OPEC Member Countries, *OPEC Review*, Vol. 24, pp. 143-164.
- Griffin, J.M. and Teece, D.J. (1982), *OPEC Behaviour and World Oil Prices*, London, George Allen & Unwin.
- Griffin, J.M. (1985), OPEC Behaviour: A Test of Alternative Hypothesis, *American Economic Review*, Vol. 75, pp. 954-963.

- Haas, R., Zöchling, J. and Schipper, L. (1998), The Relevance of Asymmetry Issues for Residential Oil and Natural Gas Demand: Evidence from Selected OECD Countries, 1970-95, *OPEC Review*, Vol. 22, pp. 113-145.
- Haji, J.A. (1993), The Construction of the Social Accounting Matrix (SAM) for Saudi Arabia, *Margin*, Vol. 25, pp. 293-305.
- Hogan, W.W. (1992), OECD Oil Demand Dynamics: Trends and Asymmetries, *The Energy Journal*, Vol. 13, pp. 125-157.
- Jones, C.T. (1990), OPEC Behaviour under Falling Prices: Implications for Cartel Stability, *The Energy Journal*, Vol. 11, pp. 117-129.
- Mabro, R. (1991), OPEC and the Price of Oil, *The Energy Journal*, Vol. 13, pp. 1-17.
- Neumayer, E. (2000), Scarce or Abundant? The Economics of Natural Resource Availability, *Journal of Economic Survey*, Vol. 14, pp. 307-336.
- OECD (1999), *Statistical Compendium CD-ROM*, Paris.
- OPEC (1999), *Annual Statistical Bulletin 1998*, Vienna.
- OPEC (2000a), *OPEC Secretariat Issues Statement on Production*, Press release No. 7.
- OPEC (2000b), *OPEC Secretariat Issues Statement on Production*, Press release No. 10.
- OPEC (2000c), *OPEC Secretariat Issues Statement on Production*, Press release No. 11.
- Renou-Maissant, P. (1999), Interfuel Competition in the Industrial Sector of Seven OECD Countries, *Energy Policy*, Vol. 27, pp. 99-110.
- Stiglitz, J.E. (1976), Monopoly and the Rate of Extraction of Exhaustible Resources, *American Economic Review*, Vol. 66, pp. 655-666.

Table 1: A benchmark data set for Saudi Arabia, 1990 (millions US \$ and shares of total values)

	Total	Agriculture	Crude oil	Manufacturing	Electricity-Gas	Construction	Trade	Transport	Finance	Services
Imports	30289.2	0.1087	0.0000	0.8913	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Exports	25078.8	0.0014	0.8544	0.0081	0.0000	0.0000	0.0091	0.0792	0.0073	0.0406
Labour	11247.3	0.0227	0.0205	0.1054	0.0059	0.2453	0.0733	0.0744	0.0459	0.4067
Capital	66080.5	0.0257	0.2930	0.2690	0.0081	0.1454	0.0974	0.0955	0.0422	0.0237
Profits	8571.0	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Public spending	22081.3	0.0141	0.0000	0.4685	0.0138	0.0148	0.1214	0.0559	0.0479	0.2636
Private spending	30569.1	0.0819	0.0000	0.4006	0.0162	0.0102	0.1866	0.0666	0.0426	0.1952
Investment	38458.8	0.0093	0.0641	0.2449	0.0036	0.5413	0.0055	0.0454	0.0079	0.0780
Agriculture	2563.1	0.1326	0.0000	0.0256	0.0000	0.0000	0.0813	0.0019	0.0000	0.0000
Crude oil	5508.2	0.0000	0.1104	0.6902	0.0000	0.1991	0.0001	0.0000	0.0000	0.0001
Manufacturing	17977.9	0.0099	0.0053	0.0133	0.0224	0.4551	0.0179	0.0496	0.0032	0.4233
Electricity-Gas	230.8	0.0152	0.0823	0.0256	0.0217	0.1989	0.1599	0.0251	0.0199	0.4515
Construction	1446.5	0.0000	0.2236	0.0268	0.0845	0.0204	0.0583	0.0425	0.0253	0.5186
Trade	432.5	0.0153	0.0102	0.0113	0.0312	0.4162	0.0395	0.0395	0.0079	0.4289
Transport	1561.3	0.0009	0.0669	0.0253	0.0118	0.0922	0.2242	0.1377	0.0175	0.4234
Finance	896.9	0.0000	0.0084	0.0196	0.0003	0.1570	0.2007	0.0347	0.2262	0.3531
Services	2555.9	0.0000	0.0279	0.0067	0.0028	0.2816	0.3112	0.0722	0.0434	0.2542
Labour/Capital ratio	0,1702	0,1506	0,0119	0,0667	0,1251	0,2872	0,1280	0,1325	0,1852	2,9207
Labour/Capital intensity	1.0000	0,8846	0,0699	0,3917	0,7348	1,6874	0,7519	0,7786	1,0881	17,1598
Elasticities:										
Labour/Capital		0.24	0.20	1.26	1.26	1.40	1.68	1.68	1.26	1.26
Armington		4.40	-	5.60	-	-	-	-	-	-
CET		1.50	-	1.50	-	-	1.50	1.50	1.50	1.50

Source: Author' data elaboration from Haji (1993).

Agriculture: Agriculture, Livestock and Fishing; Crude Oil: Mining, quarrying and fuel, Manufacturing: Manufacturing industry, Electricity-Gas: Electricity, Gas and Water; Construction: Construction; Trade: Wholesale and Retail Trade, Hotels and Restaurants; Transport: Transport Storage and Communication; Finance: Finance, Insurance, and Banking; Services: Services.

Table 2: The economic impact of demand and supply shocks in the crude oil market

	<i>Negative oil demand</i>		<i>Positive oil demand</i>		<i>Negative oil supply</i>		<i>Positive oil supply shock</i>	
	<i>shock</i>		<i>shock</i>		<i>shock</i>			
	<i>Export quota</i>	<i>Dominant firm</i>	<i>Export quota</i>	<i>Dominant firm</i>	<i>Export quota</i>	<i>Dominant firm</i>	<i>Export quota</i>	<i>Dominant firm</i>
World price of crude oil	- 0.444	- 0.323	+ 0.660	+ 0.473	+ 0.080	+ 0.038	- 0.166	- 0.058
World oil demand	- 0.095	- 0.178	+ 0.092	+ 0.157	- 0.037	- 0.018	+ 0.093	+ 0.030
Non-Saudi oil supply	- 0.117	- 0.079	+ 0.113	+ 0.086	+ 0.016	+ 0.008	- 0.038	- 0.013
Saudi oil exports	+ 0.000	- 0.592	+ 0.000	+ 0.458	- 0.260	- 0.126	+ 0.640	+ 0.208
<i>Economic implications for Saudi Arabia</i>								
Welfare	- 0.377	- 0.353	+ 0.437	+ 0.395	- 0.041	- 0.016	- 0.085	- 0.339
Total Profits	- 0.779	- 0.218	+ 1.340	+ 1.096	+ 0.129	+ 0.075	- 0.728	- 0.031
Export Profits	- 1.315	- 0.867	+ 1.970	+ 1.749	+ 0.039	+ 0.041	- 0.844	- 0.366
Trade volume	- 0.339	- 0.522	+ 0.501	+ 0.851	- 0.144	- 0.066	+ 0.256	+ 0.073
GDP at factor costs	- 0.168	- 0.192	+ 0.259	+ 0.396	- 0.036	- 0.015	+ 0.046	+ 0.083
Perceived price elasticity	- 0.100	+ 1.079	+ 0.097	- 0.219	- 0.023	- 0.128	+ 0.059	+ 0.208
Marginal cost	- 0.086	- 0.178	+ 0.120	+ 0.303	- 0.054	- 0.025	+ 0.138	+ 0.113
Capital rent	- 0.088	- 0.184	+ 0.123	+ 0.314	- 0.056	- 0.026	+ 0.145	+ 0.120
Wage rate	- 0.172	- 0.216	+ 0.230	+ 0.343	- 0.046	- 0.021	+ 0.054	- 0.050
Capital rent / Wage rate	+ 0.102	+ 0.042	- 0.087	- 0.021	- 0.010	- 0.006	+ 0.086	+ 0.179
Agriculture	- 0.038	+ 0.208	- 0.068	- 0.389	+ 0.106	+ 0.051	- 0.305	- 0.375
Crude oil	+ 0.102	- 0.225	- 0.024	+ 0.411	- 0.131	- 0.064	+ 0.433	+ 0.578
Manufacturing	+ 0.099	+ 0.351	- 0.185	- 0.520	+ 0.129	+ 0.061	- 0.326	- 0.331
Electricity-Gas	- 0.177	- 0.165	+ 0.199	+ 0.163	- 0.018	- 0.006	- 0.046	- 0.164
Construction	- 0.010	- 0.013	+ 0.012	+ 0.015	- 0.003	- 0.001	+ 0.002	- 0.004
Trade	- 0.227	- 0.194	+ 0.239	+ 0.159	- 0.013	- 0.004	- 0.084	- 0.235
Transport	- 0.086	+ 0.016	+ 0.088	+ 0.005	+ 0.021	+ 0.010	- 0.094	- 0.171
Finance	- 0.154	- 0.119	+ 0.158	+ 0.094	- 0.005	- 0.000	- 0.068	- 0.173
Services	- 0.134	- 0.118	+ 0.148	+ 0.125	- 0.012	- 0.004	- 0.037	- 0.130

Table 3: The economic impact of a the 2000 oil demand shock and OECD intervention (The dominant firm model)

	<i>Capital mobility</i>			<i>Capital sector-specific</i>		
	<i>Positive oil demand shock (1)</i>	<i>(1) plus price elasticity increase</i>	<i>(1) plus tax cuts</i>	<i>Positive oil demand shock (2)</i>	<i>(2) plus price elasticity increase</i>	<i>(2) plus tax cuts</i>
World price of crude oil	+ 0.666	- 0.344	+ 0.985	+ 0.666	- 0.555	+ 1.044
Gross price of crude oil	+ 0.210	- 0.108	+ 0.391	+ 0.210	- 0.175	+ 0.414
World oil demand	+ 0.200	- 0.163	+ 0.254	+ 0.093	- 0.176	+ 0.134
Non-Saudi oil supply	+ 0.114	- 0.085	+ 0.156	+ 0.114	- 0.158	+ 0.164
Saudi oil exports	+ 0.557	- 0.485	+ 0.663	+ 0.006	- 0.254	+ 0.009
<i>Economic implications for Saudi Arabia</i>						
Welfare	+ 0.556	- 0.245	+ 0.863	+ 0.415	- 0.540	+ 0.614
Total Profits	+ 1.468	- 0.475	+ 1.988	- 0.084	+ 0.099	- 0.142
Export Profits	+ 2.429	- 0.882	+ 3.465	+ 0.535	- 0.828	+ 0.821
Trade volume	+ 1.186	- 0.472	+ 1.719	+ 0.472	- 0.432	+ 0.752
GDP at factor costs	+ 0.556	- 0.205	+ 0.867	+ 0.498	- 0.325	+ 0.819
Perceived price elasticity	- 0.244	+ 1.873	- 0.261	+ 0.092	+ 0.929	+ 0.131
Marginal cost	+ 0.445	- 0.168	+ 0.696	+ 0.724	- 0.467	+ 1.142
Capital rent	+ 0.462	- 0.174	+ 0.723	+ 0.535	- 0.360	+ 0.752
Wage rate	+ 0.514	- 0.179	+ 0.856	+ 0.725	- 0.447	+ 1.235
Capital rent / Wage rate	- 0.034	+ 0.006	- 0.072	- 0.111	+ 0.157	- 0.162
Agriculture	- 0.518	+ 0.271	- 0.674	- 0.018	+ 0.012	- 0.029
Crude oil	+ 0.521	- 0.313	+ 0.596	+ 0.000	- 0.000	- 0.000
Manufacturing	- 0.667	+ 0.371	- 0.821	- 0.036	+ 0.045	- 0.052
Electricity-Gas	+ 0.222	- 0.113	+ 0.327	+ 0.039	- 0.158	+ 0.047
Construction	+ 0.021	- 0.011	+ 0.028	+ 0.007	- 0.014	+ 0.009
Trade	+ 0.209	- 0.122	+ 0.300	+ 0.013	- 0.064	+ 0.013
Transport	+ 0.014	+ 0.050	+ 0.041	+ 0.033	+ 0.068	- 0.042
Finance	+ 0.124	- 0.069	+ 0.180	+ 0.001	- 0.014	- 0.001
Services	+ 0.172	- 0.078	+ 0.256	+ 0.095	- 0.169	+ 0.127

Figure 1: The world crude oil market in the short term

The model with an export quota

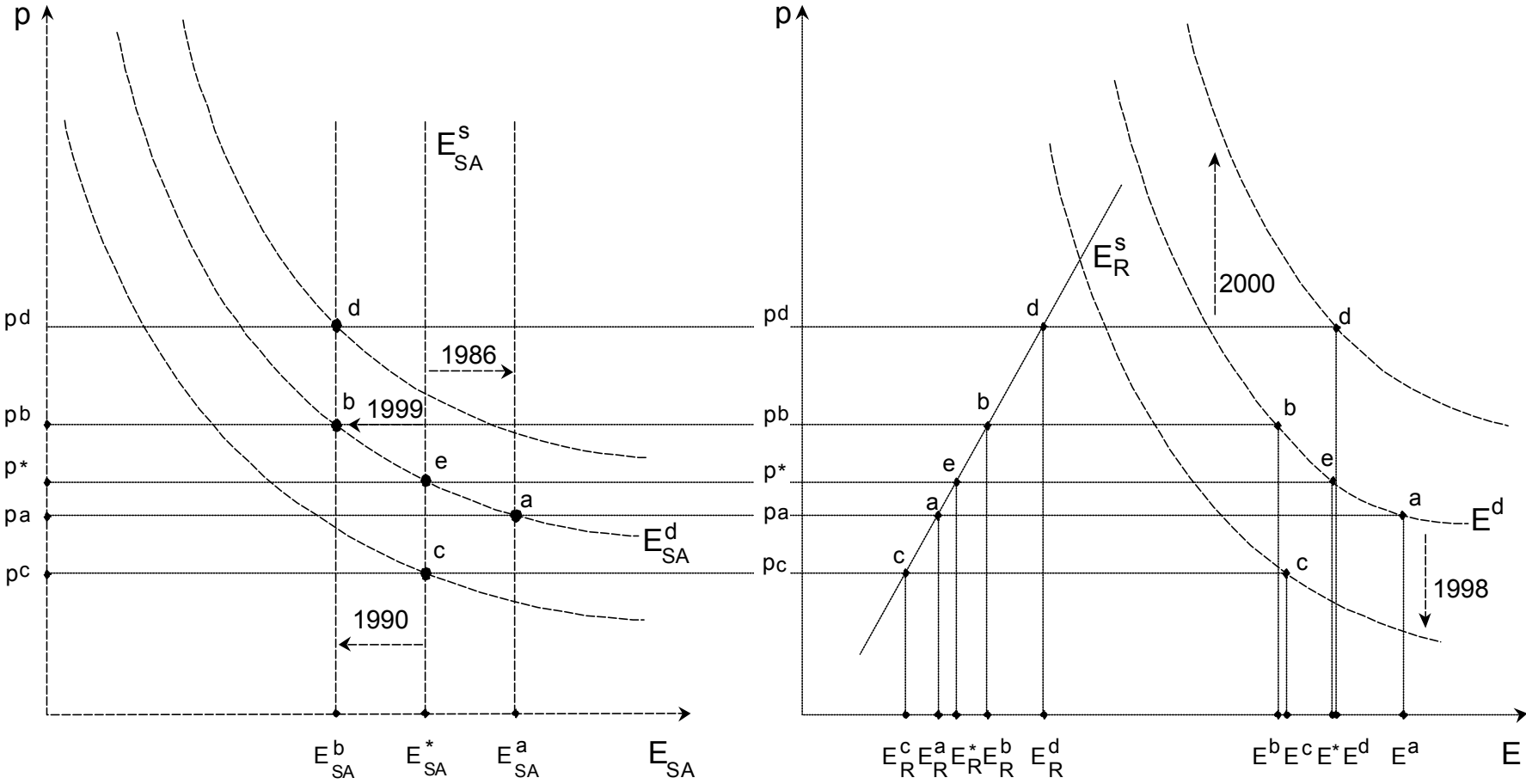


Figure 2: The world crude oil market in the long term
The dominant firm model

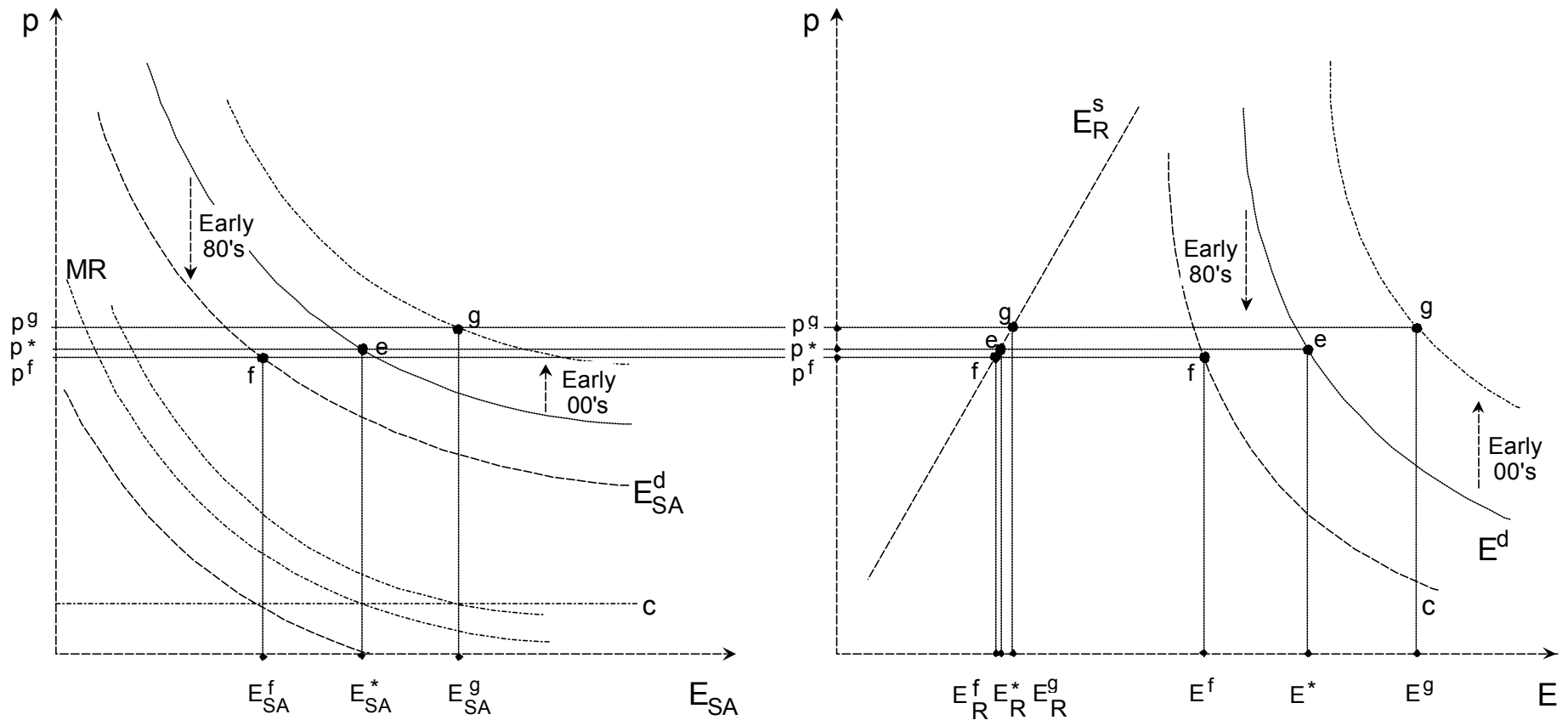


Figure 3: Share of OPEC's crude oil imports in OECD's GDP, 1974-1997

(Barrels per day / 1 million US \$ GDP at constant price)

