Oil Resource Wealth of the Middle East

M.A. ADELMAN

Resource exhaustion has had little, if any, impact on oil costs and prices. Oil production costs have exhibited a falling long run trend, and the cost to produce oil in the Middle East is much lower than elsewhere. Having defended very high prices in the early 1980s, the Middle East producers experienced a sharp reduction in their sales. To improve their ability to manage the oil market and control prices, the producers must expand their market share. This presupposes a period of prices that are even lower than in the late 1980s. This the Middle East producers seem unwilling to accept.

L'épuisement des ressources n'a influé que dans une faible mesure — voire aucunement — sur le coût et le prix du pétrole. Les coûts de production du pétrole affichent une tendance baissière à long terme, et ces coûts sont beaucoup plus faibles au Moyen-Orient qu'ailleurs. Lorsque les producteurs de cette région ont cherché à pratiquer des prix très élevés au début des années 80, ils ont subi une forte chute de leurs ventes. Pour accroître leur capacité de gérer le marché du pétrole et de contrôler les prix, les producteurs doivent augmenter leur part du marché. Cela suppose une période pendant laquelle les prix seraient plus bas encore qu'ils ne l'étaient à la fin des années 80, situation que les producteurs du Moyen-Orient ne semblent pas disposés à accepter.

Introduction

Purpose

I propose to examine the economics of the Middle East oil industry. This will require me at some points to touch on the Organization of the Petroleum Exporting Countries (OPEC), and on the actions of Middle East governments when there is a direct and strong connection with the oil market. The overlap with Griffin (1992) and Mabro (1992) in this volume will, I think, contribute to a deeper vision.

Inexhaustible Resources

The first step in understanding oil economics is to get rid of the idea of "finite limited resources." Minerals are inexhaustible. Oil, gas, coal, copper, etc., will never be depleted. Investment in exploration and development constantly replaces in-ground inventories, known as "proved reserves," as they are extracted and used up. If the cost goes so high that nobody will pay a price sufficient to justify new investment, the inventory is not replaced. The industry disappears. What's left in the ground is unknown, probably unknowable, but above all unimportant.

"Finite resources" is an empty slogan; only

Morris Adelman is Professor Emeritus of Economics at the Massachusetts Institute of Technology. This essay summarizes various papers by the author, published or in working paper form, written in the course of a project on the world oil market since 1970, under the auspices of the National Science Foundation, grant #SES-8412791, and of the MIT Center for Energy Policy Research. Copies are available on request to the Center, in Cambridge, Mass. 02139, US. But all statements commit only the author, and do not necessarily reflect the views of any other person or group.

marginal cost matters — what we must pay to add reserves to inventory.

"Ultimate Recovery"

We occasionally see estimates of "ultimate recovery," or how much will be produced before the industry shuts down. These are not estimates of what is in the ground. They are forecasts of what it will pay to produce. They are made, unfortunately, without explicitly considering costs and prices. Take one of the most carefully done and most defensible. At end-1984, Middle East proved reserves stood at 398 billion barrels (*Oil & Gas Journal*, 'World Wide Oil,'[1] 1984). The US Geological Survey estimated as of end-1984 a 5% probability that there were as many as 199 billion barrels remaining to be discovered and developed (Masters *et al*, 1987). By end-1989, the gross increase in proved reserves was 289 billion barrels (*OGJ*-WWO, 1989). So an event with very low probability over many years actually occured in less than five.

A former Exxon chief geologist once remarked that these estimates were really *ordinal* — they showed which areas were most promising — but not how much was in each area. When a chief officer in BP Exploration says that what can be added in the Soviet Union exceeds what can be added around the Persian Gulf (Harding, 1991), his opinion is important even if his numbers are not.

Inventory Turnover 1960-1990

Table 1 shows the constant turnover of inventories since 1960. Throughout the 30 years, official wisdom has been that the non-Middle East oil areas would soon "empty out their reserves." The forecasters are a long impressive list, with practically no dissenters. They are still faithful to the assumption of "limited finite resources." In fact, non-Middle East countries did "empty out their reserves." Every single decade, they used up half their reserves — and replaced them with more. Anyone who thinks matters will be different in this or the next decade must first explain why these predictions went so badly wrong in previous decades.

Table 1: Production & Reserves Added, Middle East & World, 1960-1990 (billions of barrels)*

	1960	1961-70	1971-80	1981-90
Middle East				
Gross reserve-additions	—	194	92	351
Cumulative production	—	33	74	50
Proved reserves at end	183	344	362	663
Rest of World*				
Gross reserve-additions	—	159	127	168
Cumulative production	—	71	97	112
Proved reserves at end	89	177	207	263

* Excluding former Communist bloc
Source: *Oil & Gas Journal*, 'World Wide Oil,' annual supplement.

The 1980-1990 decade was one of declining, then crashing, oil prices. But reserve-additions increased, for reasons to be explored later.

Old Fields Grow

In 1944, the Middle East had been explored and developed for about 40 years. (The first great discovery had been in 1908.) A special mission had estimated its reserves as 15 billion proved, 6 billion probable. Over the next 30 years, those same fields, omitting later discoveries, produced 42 billion barrels and had 75 billion in "remaining reserves." We do not have publicly available data for the next 15 years.

From 1944 to the late 1960s there was a modest discovery effort which yielded enormous additional fields. Then discovery slacked off. The huge increases in the Middle East over the last 20 years have been almost completely the result of development, not exploration. Statistics on Middle East oil production are getting steadily worse, so no statement can be precise. But it is plain that Middle East discoveries since 1970 have added very little to reserves because it was easier and cheaper to keep expanding the old fields, and revising the estimates as one learned more by drilling and producing more. Look at the four largest producers, the total number of

1/ Hereinafter referred to as *OGJ*-WWO.

operating fields in 1990, and (in parentheses) the number of those discovered after 1969: Iran 13 (0); Iraq 19 (6); Kuwait 8 (0); Saudi Arabia 14 (0) (*OGJ*-WWO, 1990). Even in Iraq, we cannot tell whether the new fields made a substantial contribution.

There are many undeveloped Middle East fields. In Saudi Arabia, about 55 "commercial" oil fields have been discovered, 40 left undeveloped. We do not know, and may never know, what they can produce. But in the past two years, seven fields have been found outside the old concession area. They contain unknown amounts of light low-sulfur crude oil, and they are being developed (Saudi Aramco, 1990). The premium on the new high-quality oils is such that it would be worth shutting in old field production even if the cost were zero.

Similarly, in Kuwait there was drilling for gas for local power generation in the 1970s, but they found "only oil" — fields estimated at 26 billion barrels, for starters, and some cheap enough to be worth developing soon (*World Oil* 'International Outlook,' 1982-1985). But like other good ideas, Kuwait found it easier to postpone it.

The oil industry discovers fields, and then develops reserves in those fields. The United States (excluding Alaska) is the extreme example of the very old oil province. In 1930, its "remaining recoverable reserves" were just over 13 billion barrels. In the next 59 years, the area produced not 13 but about 130 billion barrels, and had nearly 20 billion left. There were very few large discoveries, but many small ones, and there was great expansion of old fields, which never seem to die. The Kern River field in California was found in 1899. In 1942, its "remaining reserves" were 50 million barrels. Over the next 49 years, it produced not 50 but 900 million, and had about 700 million left as "remaining reserves." This is not typical, but it shows how old fields can grow.

The same thing happens everywhere, but it is much bigger in the Middle East because the oil deposits are so much bigger.

The constant talk of "finding reserves" is wrong in itself and is also linked to the idea that there are typically very long lead times between the start of investment and the start of production. This is not true. The French refer to exploration as *recherche*, i.e., research, and that is exactly right: the quest for the new idea or for the new field or region. These are infrequent big events. The great bulk of all reserves added in any year are in existing operating fields.

A well takes two weeks to drill in the US, two months in the Middle East; but even adding the time needed to join to a gathering system, that is not very long. We have seen Saudi Arabia, credited with 7 million barrels of capacity, go to nine in the space of several months. Of course that was under unusual conditions — and at unusual expense — but it is nothing like years or decades.

How much could the Middle East produce? Production this year is around 15 million barrels daily, or 5.5 billion barrels per year. Let us assume it increases by 5% per year, which far exceeds any forecast I know. Then the existing inventory would last 82 years. In the interim, existing fields would expand, and there would be new discoveries. We are looking at something well over a century. Clearly there is an enormous resource here, far more than anywhere else in the world. The real question is, again, cost.

Why Don't Costs and Prices Increase?

Once we get rid of the false questions about how much oil there is and how long it will last, we can face up to the real question, and it is worth everything we can give it.

Costs and Prices Should Rise...

In any state of knowledge, the biggest fields are found first, simply because they are big. This would happen even by chance, if the searchers were blindfolded and throwing darts at a board. Deliberate search strengthens the tendency.

Once found, the best oil is used first, because it is most profitable for private owners, and most rewarding for society, to produce wealth earlier, so it can be reinvested.

For these two reasons, if we assume rational economic conduct, the marginal cost of developing oil will rise over time: more and more invest-

ment must be put into the ground for every additional unit added to reserves, or for every additional unit of capacity. To reach this conclusion, we need no theory of "limited resources." The rising cost will bring up the market price. In the long run, it will look like a rising tide: advance and retreat, but always reaching higher.

But They Don't

But this logical conclusion is killed by the facts. The long run tendency of every mineral price is downward or, at most, sideways. Oil after 1970 is a glaring exception which needs special explanation. A special story had better be a good one.

Every mineral is subject to an endless tug-of-war, diminishing returns against increasing knowledge. There is progress in science and technology in general; even more important is cumulative knowledge of local geology, which grows steadily with more drilling and production. These two factors often interact.

Watch Cost Over Time

So far, knowledge has won everywhere. It need not keep winning forever. We must look at each mineral individually. Instead of the vain question about how much is left, we need to ask: are the investment requirements creeping or leaping up? So far, knowledge is pretty scanty, and the basic sources of information are getting leaner not richer, but we must do the best we can with what we have.

Figure 1 shows a series of crude supply curves. In order to get numbers comparable for 30 years, it is necessary to have a very simple definition of cost and to make various simplifying assumptions. But better data would not change the end result. During 1955-1975, capacity increased enormously, but with no increase in unit investment requirements. During 1975-1985, there was very little change in capacity since there was little increase in demand.

The line labeled "1985 (5% of reserves)" is based on the assumption that increasing output out of a given reserve raises investment by the square of the additional capacity. For example, doubling output multiplies investment needs by a factor of four, so that investment or cost per unit doubles. For most of the Middle East countries, the assumed increase in intensity is very large. To go from the neighborhood of 1 or 2% to 5% means to increase cost by a factor of 2.5 to 5 times. Even so, it is obvious that a big increase in cost would still leave it very low.

Again we can use the history of the oldest oil province, the US, as a case study. Development cost per unit declined somewhat, then was steady during 1955-1972, then fluctuated wildly. I think it is substantially higher than 19 years ago, but have not been able to partition the increase between the frenzied boom of the 1970s and the longer-run effects of depletion. After the era of big discoveries ended around 1929 (the East Texas Field), the average size of new fields fell steeply, yet costs and reserves-added per year were stable for at least 40 years thereafter. I think this is a model for the rest of the world.

The average in-ground market value per barrel of oil and gas reserves should in theory vary between equality with development cost and twice that amount, and it is usually in that range. Unlike cost, the value is forward-looking. If costs were expected to increase in the future, then the value of reserves already put into inventory would also increase, and this should be reflected back into the current price of reserves. But the value is flat in the United States during 1947-1972 (Adelman DeSilva & Koehn, 1991).

Recent Investment Requirements in Five Areas

Table 2 shows investment requirements per daily barrel in four areas of the real world, and in Never-Never Lands, some "places" which do not exist. They are pieced together from various sources, as indicated. The US and offshore North Sea were around $10,000 per daily barrel[2] in 1985-1987, and probably not very different today, since many costs have declined since then.

Libya is surprisingly high, which confirms our method, since it checks with what is known to

2/ Dollar amounts in this paper are in US currency.

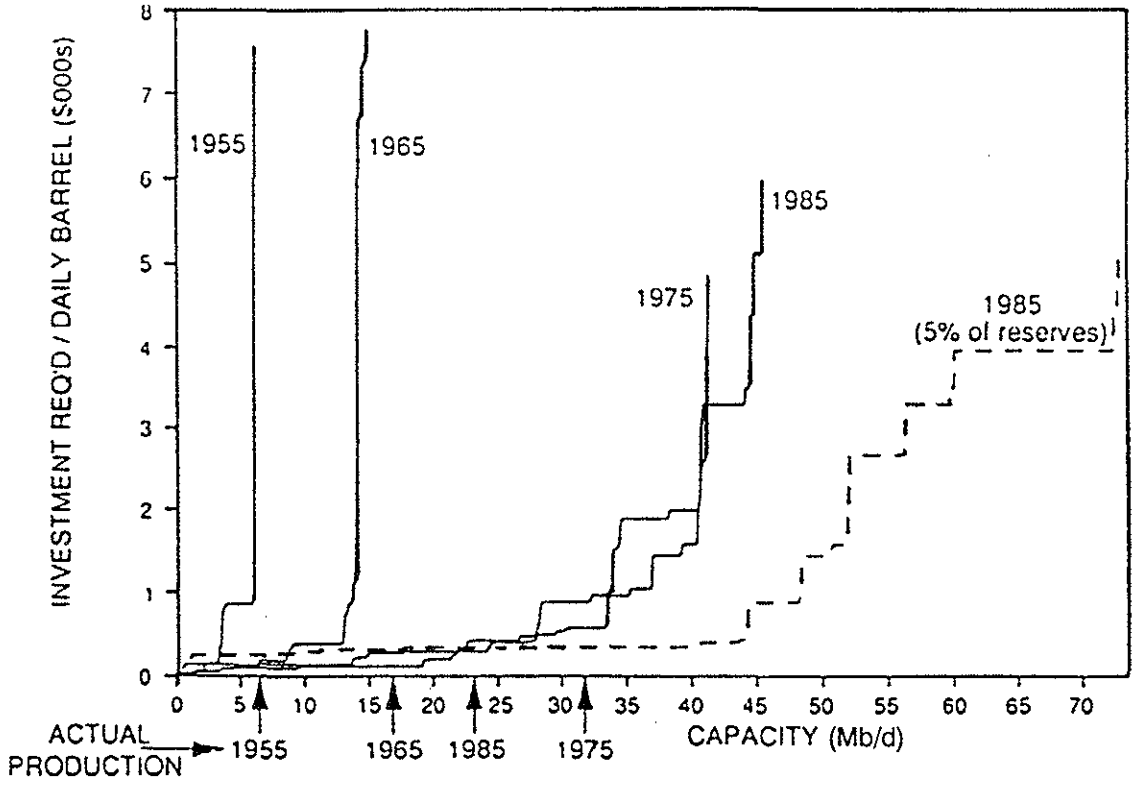

Figure 1: Non-Communist World supply curve (excluding N. America and W. Europe).

have happened during that time.[3]

As for the $12,000 average for OPEC — mostly Middle East — we are not told how it was dreamed up. The kindest thing to say about it is to say nothing, and to disregard the unspoken threat: without higher prices or grants of capital, there will be oil shortages.[4]

The Capital Crunch

In the Middle East, Table 2 shows that production capital expenditures have been a tiny part of their revenues. Expansion would require several times as much — still a very small share. Yet they do find it difficult to raise the money because of public ownership. Oil investment must get in line with all other claimants for government money. Everybody tries to be a free rider, expecting the benefits of oil investment while some-

3/ In 1985, many American and other foreign technicians left the country. In 1985, 38% of the wells drilling in Libya were suspended at end-year, a proportion many times the average. In all three years, there was an abnormally high percentage of dry holes. The large offshore Bourri field had been expected on stream in 1987 and to reach 150 thousand barrels daily (tbd) by 1990 (*World Oil* 'International Outlook', 86:78). By mid-1987, there were reported delays in the $2 billion project (*World Oil* 'International Outlook,' 87:81). *Oil & Gas Journal* 'World Wide Oil,' 90:89, reports only 24 wells and only 4.3 tbd average output in 1988. *International Petroleum Encyclopedia*, 90:298, reports the same 24 wells, and only 7.3 tbd output. Our number has captured a fiasco.

4/ A rough rule of thumb: the minimum supply price is 1/1000 of the needed investment per daily barrel. Assume that variable cost is 5% of the investment, that output declines by 10% per year, and that the needed gross return is 21%. Then multiplying the investment by .36/365 is to divide by 1000. Hence Middle East oil cannot pay at less than $12 per barrel, and non-OPEC oil cannot pay at less than $70. Comment would be superfluous.

Table 2: Investment Per Daily Barrel in Five Areas

Item	Amount
1. United Kingdom 1990	
Oil Development Investment (M$)[a]	4525
Production (Mb)[b]	708
Net reserve additions (Mb)	193
Gross reserve additions (Mb)	901
Production/reserves	0.171
Investment/barrel in ground ($)	5.01
$/daily barrel[c]	10682
2. US 1989	
Oil Development Investment (M$)	5838
Production (Mb)	2586
Net reserve additions (Mb)	-324
Gross reserve additions (Mb)	2262
Production/reserves	0.098
Investment/barrel in ground ($)	2.58
$/daily barrel	9613
3. Venezuela 1988	
Capital expenditures: Oil (M$)[d]	605
Gas (M$)	190
Infrastructure (M$)	304
Oil, adjusted (M$)	836
Gross added capacity (Mb/d)	0.522
Investment/daily barrel ($)	1602

4. Middle East & Africa 1985-1987[e]	Abu Dhabi	Iran	Iraq	Kuwait	Saudi Arabia	Libya	Nigeria	Sub-Total
Oil Revenues ($bil.)	28	29	30	22	70	21	28	228
Oil & Gas Outlays (do.)	0.543	0.676	0.713	0.217	0.266	0.749	0.374	3.538
Outlays/Revenues (%)	1.9	2.3	2.4	1.0	0.4	3.6	1.3	1.6
Outlays/oil completion ($mil.)	2.42	na	na	2.62	2.46	14.13	3.74	—
1978 Production/oil well (bd)	5626	13048	13162	3475	11523	1937	1357	—
Investment ($1000/bd)	0.429	na	na	0.754	0.214	7.296	2.759	—

5. Never-Never Lands

- Secretary-General of OPEC says it "must develop an additional 15 million b/d capacity in five years to meet demand. Cost is estimated at $12,000 per daily barrel of capacity (*World Oil*, 1991)."

- Former Head of Energy Economics Analysis at International Energy Agency, writing in *OECD Observer*, No.135, July 1985: "The daily capital cost of new production outside of OPEC [was] $70,000 in 1982."

- The Department of Energy (US DOE, 1991), Tables 51 and 52, estimates that 23 large oil companies invested $36,800 per daily barrel of new capacity in 1987-1989. (In Canada, it was $59,300!)

  We can test for the reasonableness of their estimates:

Annual depletion/decline rate	0.10	
After-tax return assumed	0.12	
Total rate of return:	0.22	
Investment assumed ($/bd)	36,800	10,000
Return per barrel ($)	22.18	5.79

The *lifting cost* is given by the DOE at $4.76 per barrel. Royalties and local taxes are assumed at 15% of the price. Effective income tax is assumed to be 20% of net income to allow for debt allowance and other offsets. We then have the following equation, where P = price needed for required return, L = lifting cost, N = net amount providing 22% gross return:

$P - .15P - L - .2(P - .15P - L) = N$. For a return per barrel of $22.18,
$.68P_1 - .8L = N_1$
$.68P_1 = \$22.18 + .8(4.76) = \$25.99$, and the resulting price is
$P_1 = \$38.22$. For a return per barrel of $5.79,
$.68P_2 - .8L = N_2$
$.68P_2 = \$5.79 + .8(4.76) = \$9.60$, for a price of
$P_2 = \$14.47$

The domestic "first purchase price" of crude oil during 1987-1989 averaged $14.61 (DOE Monthly). Thus an investment of $10,000 would have returned the 12% assumed. It is at least within the range of reasonableness. But an investment of $38,600 would require a price 2.6 times the average market price. Such estimates cannot be taken seriously.

Notes:
a/ £1 = US $1.785
b/ Tonne = 7.73 barrels
c/ ((Investment/barrel in ground) x 365) / (Production/reserves)
d/ 14.5 bolivars = US $1
e/ Allocated to countries by rig time. Total expenditures for oil/gas operations divided by oil well completions. Number drilled, and 1978 production (Iran 1977) per operating oil well.

Sources: UK Department of Energy (1990); American Petroleum Institute (1990); US Department of Energy (1989); Petroleos de Venezuela (1988); Chase Manhattan; *International Petroleum Encyclopedia*; *World Oil* 'International Outlook.'

---

body else carries the burden.

It is a great weakness of public ownership. In a market economy, expected profit creates private investment. If there is money to be made, money will be found. But in a government, one must build political coalitions to get a share of expenditures, and a national oil company is no exception. However, other reasons provide an even stronger explanation for the limited investment activity (see below).

It is all too easy to under-invest by under-maintenance. Hence also the usual lack of engineering and management expertise, both in individuals and in corporate bodies. They were expelled from Iran and Iraq. In Kuwait, they seemed superfluous, with vast low-cost oil fields in steady operation. The Saudi Arabs were much more sensible, and they had their reward in the early 1980s and now in the early 1990s.

Middle East capacity will keep growing during this decade. A real price crash, say to less than $10, would cause a mighty surge of investment there, because much higher output would be the only way to offset partially the lower prices. But setting that aside: even if we take the announcements of all the countries with a grain of salt, there is no doubt of the growth. They cannot live without the oil. Furthermore, they must bargain among themselves over quotas. They need bargaining power against each other, and excess capacity is the way to get it. Like all good things, it has a price.

Three Legends About Cost, Price, and Investment

Mineral and oil economics has long been saddled with myths, of which we note three which are live at the moment.

Low Variable Cost

Many industries, including oil, have current variable costs — labor, supplies, fuel and power, etc. — which are a small proportion of total cost. There is a rule of thumb that they run annually about 5% of capital cost. Producers, we are told, will keep operating so long as they can cover

these costs and a little more. Hence the price can be forced down to ruinously low levels. "This industry" (there are many such) cannot stand competition. The industry, or the government must restrain competition to prevent general ruin.

In fact, the variable cost is not relevant unless there is excess capacity in the system, and the amount supplied exceeds the amount demanded. Then the price tends to drop, and inflict losses. That is a market signal: get rid of the excess capital. Once capacity is trimmed, the problem disappears.

In fact, even under excess capacity, the price will not fall to variable cost (or more accurately, to operating marginal cost). A retailer will not sell off his shelf inventory for less than what it will cost to replace it. Nor will an oil producer deplete his reserve at a derisory price if he thinks demand will revive and more reserves will be needed later. We see this happening right now in natural gas production in the US. Unlike crude oil, cost has actually been declining, and prices have sunk also. A number of gas producers have shut in their wells because they expect better prices in the future. By rights this should end the legend about low variable cost as the distinctive curse of oil and gas production, but of course it will not.

Excess capacity in oil production was unusual and transient before 1974, except in the United States. There the cartel of the producing States caused a great deal of excess, as cartels usually do. Elsewhere, any excess that did appear — perhaps because much capacity had to be added all at once by a large new project — was promptly liquidated by constant growth and the constant decline of production in any given well.

Table 2 has shown the real problem in world oil, above all in the Middle East. Not variable cost but total cost is a small fraction of price. Hence strenuous efforts are needed to protect the price.

Cycles and Roller Coasters

This has recently become quite popular. The World Bank has more or less officially "bought" one version (*Petroleum Finance*, 1988). A price too low leads to under-investment, hence insufficient capacity. Production falls short of demand, raising the price, and inducing new investment. But it takes so long to install the new capacity that production lags, raising the price still higher. As new capacity begins to come on stream, it forces the price down. But the sorcerer's apprentice cannot turn off the flood. New capacity, initiated years before, keeps arriving.

The price becomes unsustainably low, because it will not provide an acceptable return on building new capacity. Construction dries up. In time, growing demand outruns capacity. The price rises, stimulating the building of new capacity, but the long lead times preclude new production until the price has soared to unsustainably high levels, and...here we go again.

For the sake of briefness, assume the theory to be correct — its limitations were exposed over 50 years ago. Overlook, too, the long lead times. Even so it has no relation with what actually happened.

During 1948-1973, the Middle East price, which became the world price, fell by over 60%, inflation-adjusted. Yet Middle East capacity and output increased by 600%. Moreover, far from any looming scarcity, the world was dominated by huge excess potential, though not actual excess capacity.

What little information we have shows that long-term contracts in the late 1960s were at prices below current spot prices. In 1969, when the spot price was $1.27 per barrel, the Shah of Iran offered the United States one million barrels daily for 10 years at $1. Middle East governments constantly pressured their concession companies to invest and produce more with them — and less with their neighbors. In 1970, an internal oil company document later made public by a US Senate committee said: "No known method of allocating the available growth is likely to simultaneously satisfy... Iraq, Iran, Kuwait and Saudi Arabia." In 1972, Iraq demanded that the Iraq Petroleum Company increase production, and expelled them from the country for their refusal; while Saudi Arabia and Venezuela each proposed that they have special entry into the US

market. All these are symptoms of a huge excess potential, which can quickly be translated into capacity. During 1973, the market was occasionally tight, but this was because of precautionary buying by those who rightly expected the price to be raised soon.

The reason for excess potential is easily seen by looking at the all-time low price of $1.21 per barrel in 1970. Variable costs were about 5 cents. Thus the sale of one barrel daily provided $423 per year. [($1.21-.05) x 365 = $423] The investment needed in the Middle East was about $80. The "too low" price allowed a return of 500% per year.

So the roller coaster or cycle theory fares badly before the 1970s. In that decade, while high prices brought out new investment in the US and elsewhere, oil wells drilled in Saudi Arabia fell by two-thirds to 1980, when prices peaked (*World Oil* 'International Outlook'). The rollercoaster theory makes price the cause and drilling and reserve-additions the effect. But this is true only in a competitive industry. The Middle East producers played by the contrary monopoly rule: restrict investment to restrict output to maintain prices. Table 2 shows that at current "low" prices the rate of return on investment in Middle East oil is lush, to put it mildly. When it was even more lush, they drilled less.

Look now at the 1980s: a period of declining, and then collapsing, prices. Drilling in the US is down by about three-fourths; reserve-additions and production, by about one-fourth.

But elsewhere, outside OPEC and outside North America, oil wells drilled are quite a different story. Since the price peak of 1980-1981, they have doubled. And reserve-additions and production have continued obstinately to climb. Later we will look at the reasons.

The price declined for five years after 1980, then collapsed in 1986, with only a partial recovery. Four years later, in June 1990, after 10 years of decline, the price was near an all-time low since 1973. But worse was expected because the amount supplied **still** exceeded the amount demanded. Then the market turned around because Iraq became an Enforcer with a loaded pistol. But like many bandits hired to be "protectors," Iraq decided robbery was more profitable.

The "cycle" or "rollercoaster" is a story with no relation to what is happening in the real world: price control by restriction of output.

Multinational Companies Kept the Price Artificially Low

Again one can cite a semi-official World Bank study (Ahmad *et al*, 1989). Now, lower oil prices meant lower profits for these companies. Also, low prices put their concessions at risk in the producing countries, as witness Iraq. Moreover, in their home countries low oil prices brought them political trouble because they were allegedly ruining honest British coal miners, American oil producers, etc. Why would profit-seeking and trouble-avoiding oil companies try to keep prices down? The evidence would need to be pretty strong. We get none at all.

An Unbalanced World Industry

With this perspective, we can return to Table 2. Nobody is too surprised to see Middle East investment requirements or cost per unit only a minor fraction of the US or the North Sea, but one-fiftieth does seem a bit surprising. In a competitive market system, there should be a **convergence**. The low cost sources get exploited increasingly, raising cost; while the high cost sources dwindle, keeping only the best in operation, lowering cost.

In fact, there are two factors accounting for such discrepancies. One is Middle East geology: big reservoirs in big simple structures. But the other is a low percent of utilization. We remarked earlier that rational economic conduct was to exploit the better oil first. It is radically different in world oil.

The waiting period for the high cost US is seven years, and less for the North Sea. For the big Middle East areas it is an order of magnitude higher. This is usually considered proof of the long view of the Middle East producers: they do something, or refrain from doing something else, because their reserves will last so long. This is upside-down thinking. **Why** does an intelligent

Table 3: Reserve:Production Ratios 1989[1]

Area	Proved Reserves (b x 10^9)	R/P Ratio	Average Waiting Time (yrs)
Industry rule of thumb:		15.0	10.4
North America	42.4	10.4	7.2
Latin America[2,3]	99.2	40.3	27.9
Venezuela[2]	32.5	47.0	32.6
Mexico[3]	46.4	44.2	30.6
Western Europe	18.4	12.6	8.7
Norway	11.6	20.2	14.0
UK	3.8	5.5	3.8
USSR & Eastern Europe	58.4	13.1	9.1
Middle East	660.3	109.0	75.6
Africa	58.8	27.5	19.1
Asia & Australasia	46.8	20.2	14.0
World	1011.8	44.4	30.8

Notes:
1/ We assume what is true under ideal conditions, i.e., that the annual production decline rate is the reciprocal of the reserve: production ratio in column (2). Then the time it takes to bring up half the reserve can be shown to equal .69 times the reserve:production ratio. This is shown in column (3).
2/ Conventional oil only, omits Orinoco. See *Oil & Gas Journal*, 'World Wide Oil', 1987.
3/ Omits Chicontepec fields, not commercial.

Source: *Oil and Gas Journal*

asset-holder keep an asset in the ground so long instead of extracting and selling it off? We can see the effect by comparing two bits of data we happen to have.

A Newfound Barrel Worth $1.60 in the UK, 1 Cent in Saudi Arabia

In 1976, as part of the buyout of Arabian-American Oil Company (Aramco), newly-discovered oil was to be paid for at the rate of six cents per barrel, as produced. Aramco was producing at the rate of 2% of reserves. If a barrel of the new oil was produced at the same rate, that would mean a royalty series: 0.1200 cent (6 x.02) the first year, 0.1176 cents (6x.02x.98) the second year, and so on. The value of the series of payments for all eternity is:

$V = Pa/(a+i)$,

where *a* is the depletion/decline rate,

and *i* the discount rate. Taking *i* at 10%, the value of the barrel is:

$V = (.06x.02)/.12 = 1$ cent.

We might use a different discount rate, etc. but no adjustment would ever get us far from one penny per barrel. It measures the "resource rent" or "user cost" of a barrel of oil in Saudi Arabia, and also gives us an indication of what the Aramco companies (Exxon, Mobil, Texaco, and Chevron) thought it cost to find an additional barrel.[5]

By contrast, in the same year 1976, a North Sea block of newly found undeveloped oil, was sold at about $1.60 per barrel. Yet development/operating cost in the North Sea was far higher than in Saudi Arabia, where an undeveloped barrel ought to be worth much more, not 99.4% less. And it would be worth much more, **to an operator free to produce and sell the oil at the most profitable depletion rate.** But production in Saudi Arabia was, and is, constrained to a small fraction of that rate. To produce more would have wrecked the price structure. That made additional oil worth very little to its owners.

It is upside-down economics: the best oil is being held back to prop up prices, while the high-cost oil is being developed and produced. If the price collapsed to a competitive level, output would expand greatly in the Middle East even as it was sharply cut back elsewhere. Middle East cost would rise and other areas' cost would fall. Over the years they would converge. The value of oil in-ground would crash else-

5/ Of course Saudi Arabia was a monopsonist, the only possible buyer of newly-found oil. They could lower the price to the companies' bare cost of discovery, i.e., to an acceptable rate of return on the companies' investment. They also knew that the more they offered, the more the companies would find. But the value to them could not be much above the avoided cost of more intensive development, and this avoided cost was very low because the intensity of development was so low.

where, but would rise greatly in the Middle East. Private companies would be willing to pay down large sums of money for unrestricted production rights, as well as exploration rights.

Middle East governments are trying to find some way of giving out some concessions, without seeming to do so, and on terms companies will find attractive, after the expropriations of the 1970s. Algeria, which was once among the most doctrinaire anti-capitalist nations, has quietly welcomed the companies back. They can get away with this, because they are a small producer. Higher production from them will not affect the world price. The big Middle East producers have a much more difficult problem. At present, I think they would lose heavily if they produced to the limit and the price fell to a competitive level. But this need not always be so. If the price kept drifting down, and they had less to lose, they would need to do some reckoning.

There is an internal debate going on in Venezuela as the oil potential of the country is seen as several times greater than a decade ago; the same may happen in the Middle East, to an even greater degree.

Objectives of the Middle East Nations

Since about 1975, the Middle East nations have been full owner/managers of their oil fields. What difference does that make? Private companies try to maximize the present discounted value of the stream of expected revenues, i.e. to maximize wealth. They may not have any precise idea of where the maximum lies, but they keep trying to move toward it.

Government Objectives: "Revenue Requirements"

It is widely believed that these governments do not try to maximize wealth. One influential variant has been that governments aim only to meet "revenue requirements," because they prefer to keep the oil in the ground. In 1979, the US Central Intelligence Agency (CIA) warned of long-term supply shortages as demand outran the "production preferences" of the largest producers (US CIA, 1979, p.5).

This theory has the appeal of a horror movie. If governments restrict output to their current "revenue requirements," the price will rise, and with it their revenues. Then the target production level must be reduced again, raising prices still more, causing more production cutbacks... It hardly bears thinking of, and has indeed been a good thought-suppressant.

In the consuming countries, particularly the US, statesmen and their advisers cherish the non-maximizing theory because it makes them feel needed. They will establish "special relationships" with producers to obtain "access" to oil. The theory was tested and found wanting in the so-called "embargo" of 1973-1974. The US had a real "special relationship" with most of the Arab producers: their special target. But the "friendly" and "preferred" British and French apparently lost more supply than average, the "odiously neutral" Japanese did best, while the United States stayed in the middle. Some would draw a moral: it does not pay to be taken for granted. I think the simpler and better explanation would be: noise in the data. Nobody did any better than anyone else.

Secretary Kissinger, who had spent time and energy and political capital trying to end the "embargo," admitted years later that it was meaningless. So did Minister Yamani, who must have been amused by the caperings of American statesmen. An Abu Dhabi diplomat said undiplomatically that the "embargo" was "a lie we wanted you to believe."

The production cutback of October-December 1973 was real, and it made spot prices explode. It was done in the name of Palestinian rights, but it was cancelled after two months, with nothing done for the Palestinians, but with spot prices way up. So much for the political objectives.

Government Objectives: Maximum Wealth

The first objective of any state is to survive. Then it must decide among many other aims: cultivate its garden, or spread the true faith, or bash its neighbors, or anything else. But whatever the objectives, the more wealth it has the more it can accomplish. Hence in acquiring, each govern-

ment seeks maximum value from oil production. But they can do far more than private companies to attain it.

Governments are Unlimited in Pursuit of Wealth

Governments are a far closer fit to a wealth-maximizing model than any private companies could ever be. No private companies residing in a modern industrial state would dare to raise the price of a product as important as oil by a factor of 10 or more. They would harm interest groups far more numerous and powerful than themselves. In the United States, they would go to jail. Every other industrial country would have its own way of stepping on them.

But in a small exporting less-developed-country (LDC), there is no conflict between the oil industry and the rest of society. The benefits of a higher price all go to the local economy; the burden is all borne by foreigners. Hence the seller is free to seek all the traffic will bear. If there is a world recession following a price explosion, that is merely a detail in calculating demand elasticity and the wealth-maximizing price. Moreover, the recession weakens the price of manufactured imports. Hence a group of LDC governments can go much farther in raising the price than can a group of private companies.

Governments' Short Time Horizons, High Discount Rates

As compared with private companies, however, LDC governments have short time horizons and high discount rates.[6] Of course the official truth is just the contrary. The Middle East governments are said to be "low absorbers," who would prefer to produce less, and save the oil for future generations. They are said to produce more than they wish: to help the world economy, or to favor the consuming nations, or to show their solidarity with the West.

If this theory were true, these countries would run current account balances which were always positive, and increasing. Not wanting to import as much as they could, they would deposit the money abroad. But we need only look at the budgets and current account balances of Saudi Arabia. Their imports of goods and services rose even faster than their revenues. Their 1974 surplus turned into deficit within four years. The surplus of 1980-1981 was even bigger and turned into deficit in only two years. They have been in deficit ever since 1982 (Askari, 1990).

Temporary surpluses at least permitted them to accumulate about $160 billion in assets by 1981. But by 1985, if we exclude "loans" which will not be repaid, they were down to $50 billion (Askari, 1991). In the next four years, their cumulative current-account deficit was $38 billion. Saudi Arabia has very little left to show for the glorious 20 years.

The money went on unproductive uses, mostly weapons and subsidies, mostly for consumption (Askari, 1990; Askari, 1991; Barker, 1988). The oil percent of GNP grossly understates dependence on oil, which is higher than ever. "Non-oil" sectors exist to serve the oil sector, and the income recipients in it. Infrastructure is not productive in itself, it only makes productive investment possible. There is no income from money spent on weapons, subsidized industrial plants that become monuments in the desert, or agriculture depleting fossil water deposits at ever rising costs in order to raise and export wheat costing six to ten times the world price (Barker, 1988; Askari, 1991). Even if petrochemical plants made money, the amount is very small compared with oil.

The Middle East oil producers (Kuwait was once a partial exception) are monocultures, living on oil. In general, income from only one source is more risky, because the recipient cannot wait out fluctuations. But the revenue fluctuations of the Middle East are greater than for the oil industry generally. They are the swing producer group, who must bear the fluctuations in the whole world oil industry, which are proportionally much greater for them.

Moreover, these governments are despotic, and opposition works only by violence and con-

6/ The following paragraphs are a simple adaptation of the standard capital asset pricing model. For a fuller statement, see Adelman, 1986.

spiracy. Also, they are unruly to each other. The Middle East has long been a "dangerous neighborhood." For all these reasons, revenues must be discounted at a relatively high rate because their oil assets are risky assets. Their preferences, or their borrowing rates, have nothing to do with it.

All this financial stress has a feedback effect on oil policy. The producing nations, especially Saudi Arabia, have short horizons, and will take what they can get when they can get it.

Much attention has been paid to a financial stress which is mostly fiction. Some of the income of an oil-producing nation is said to be only consumption of its original non-reproducible asset. Even on that assumption, the fraction is negligible. (See Appendix.)

"The Future Leaves Them Cold. They Want Money Now."

Back in 1935, an oilman so reported to his company on his negotiations with Iraq and Qatar. That is still true. It is not regional "culture," nor being Muslims, or Arabs, etc; it is a rational response to difficult conditions.

Economic Aspects Of the Gulf War

In 1961, Iraq laid claim to Kuwait and mobilized its army on the border. The British flew in a brigade, 3000-5000 men, and that ended it. Thirty years later it took a force 100 times as great and far more heavily armed to expel the Iraqis from Kuwait, with terrible devastation on both sides.

The difference lay in the years of high oil prices. About $2.5 trillion poured into the Middle East, much of it spent on weapons. That does not make war "inevitable," only more likely.

High Oil Revenues: Means and Motive for War

Saddam Hussein has been an **investor** in search of high-risk high-return projects. Oil revenues provided the means. His neighbors' wealth was the motive.

The first venture, the 1980 attack on Iran, looked fairly safe because the revolution in Iran had disorganized the armed services there. The reward would have been great: the province of Khuzistan, which contains nearly all of Iranian oil production, most of it within 150 miles of the attacking point. Khuzistan is mostly populated by Arab-speakers. Perhaps that is why the Iraqi government recalled the battle of Qaddisiya in 637, when the Arabs had given "those insolent Persians" a beating; it was time for another. None can say whether these 1300-year-old hatreds are good for another 1300 years.

The first venture failed, despite a million dead, more wounded, many hundreds of thousands displaced, etc. But the next venture looked even more promising. In June 1990, oil at $13/b was overpriced, and OPEC members were overproducing. As the Kuwait Oil Minister said: "Those who could cheat, did. Those who could not, complained."

Kuwait was more candid about this, or perhaps only more nervous. In March 1989, Saudi Arabia had signed a nonaggression pact with Iraq, without the consent of the Gulf Cooperation Council, the confederation of Persian Gulf countries. When Kuwait privately asked Iraq for such a pact soon afterward, it was brusquely refused.

In mid-July 1990, Iraq became the Enforcer of prices and threatened violence to the overproducers. The Saudi government threatened that its "protection would not be extended to Kuwait in the face of Iraqi anger." Press reports frequently mentioned the cooperation of the Saudis and Iraqis with Iran. The world oil industry rejoiced because "discipline is guaranteed by a principal player which carries a loaded gun." Kuwait capitulated. Then on July 25, the American Ambassador told Saddam Hussein that the United States sympathized with his "need" for funds to keep a million under arms; that the United States welcomed a higher oil price, perhaps over $25; and it had no opinion on Iraq's border dispute with Kuwait.

Small wonder that the Enforcer thought: extortion is good, armed robbery even better. Kuwait was occupied in a day, and had it not been for outside interference, Saudi Arabia and the rest of the Gulf would soon have been swallowed up.

Nearly 200 years ago, earnest people saw the hand of God in famines and epidemics, which were allegedly needed to restrain the growth of population. One might equally see the political feedback of high oil prices upon the Middle East oil industry. In 1978, the combined capacity of Iraq, Iran, and Kuwait was about 13 million barrels daily. Today its capacity is less than half, and actual production much less. When high prices brought political upheaval to Iran, the Islamic Revolution had, by March 1979, dismissed all the foreign technicians and shot some of the native Iranians to encourage the others. Their efforts stabilized domestic production, but they could not continue the great gas-injection scheme which the old Consortium had planned. The government now wants to build it, but nobody knows when they will, if ever.

In the autumn of 1991, as this is being written, Iraq and Kuwait are at ground zero in oil exports. By the end of the year, Iraq will probably be in slow recovery, and Kuwait a little faster, but from a lower starting point than even 1990. Thus the huge potential of the region will remain locked up for some time, and its opening will be very slow as devastation is repaired and confidence slowly builds. Private operation — even if publicly owned — would bring up production swiftly, but I do not expect it. Not money but expertise, in management and engineering, will remain in short supply at the Persian Gulf. Saudi Arabia will for years keep the great comparative advantage which it owes to its own good judgment: harnessing the know-how of the multinational oil companies, while slowly building its own.

The Middle East and the Price of Oil

In the short run, the Middle East oil producers, or even Saudi Arabia on its own, could immediately and drastically raise the oil price. They did so in October 1973 and January and April 1979: cut or threaten to cut production, and (repeated in August 1990) be vague about when they will resume.

Again, and for the same reasons, there would immediately be a surge of **precautionary** demand for hoarding, not use. As spot prices rose, there would be super-added a wave of **speculative** demand, trying to save money by buying sooner rather than later — or to profit more directly on resale. As spot prices rose, the producing nations would "follow the market" and raise their official prices.

But as things stand, a permanent substantial price increase would do them more harm than good because the Middle East nations would be required to absorb nearly all of the reduction in demand which higher prices would generate. In the early 1990s, they produce about 40% of the world oil supply, excluding — as we must for a time continue to do — the output of the Soviet and Chinese blocs.

Suppose that a 50% price increase would reduce demand by 10%. (The implied long-run elasticity of demand is -.25, which is improbably low.) The rest of the world oil industry would benefit by the higher price, and discount only a little to sell as much as before. The Middle East producers and their allies, who would lose about one fourth of sales, would not gain much, and there would be a considerable risk of actual loss.

Until the Middle East market share rises considerably above the current level, they are wedged into a corner, and their power to raise prices must be wielded cautiously, if at all, because it would do them harm. For reasons given earlier, I do not expect that market share to rise much soon. The non-OPEC countries will continue to expand reserves and output for years, especially when we take account, as we should, of the growing role of natural gas.

In the 1980s, as prices fell, oil wells drilled, production, and reserves increased in the non-OPEC world. The reason was that public and government opinion slowly awoke from dreams of ever-rising prices. In one dream, a national company could flourish, handing out jobs, contracts, and rewards for the faithful. Or if there were private companies, the dream was of ever-rising royalties and taxes. Now they realize they would receive larger tax revenues with lower taxes per barrel. All over the world, privatization and tax reform is going on. Oil companies are today "spoiled for choice," and investment

grows. Of course the greatest and most uncertain promise is in the former Soviet Union.

Each country has its own political/social dynamics. But what cannot be predicted of any one of them is a good prospect for all of them taken together: more oil reserves added, and more output. Hence it is doubtful that the Middle East proportion of the world market will drastically increase, and it is this proportion which governs the effect of higher prices on demand for its oil.

Perhaps this is mistaken, and perhaps there will actually be a substantial increase in Middle East market share. That would allow a higher price, and the producing nations will seize the opportunity. They will again trade off higher prices against lower sales. Either way, while Middle East oil will remain very important in the world market in the next century, dependence on the Middle East will not greatly increase, and may decrease.

References

Adelman, M.A. (1986) 'Oil Producing Countries' Discount Rates,' *Resources & Energy*, Vol.8, pp.309-29.

Adelman, M.A., Harindar De Silva, and Michael F. Koehn (1991) 'User Cost in Oil Production,' *Resources & Energy*, Vol.13.

Adelman, M.A. and M. Shahi (1989) 'Oil development - operating cost estimates 1955-85,' *Energy Economics*, 11:1.

Adelman, M.A., John C. Houghton, Gordon M. Kaufman, and Martin B. Zimmerman (1983), *Energy Resources in an Uncertain Future* (Cambridge, Mass.: Ballinger & Co.).

Ahmad, Yusuf J., Salah El Serafy, and Ernst Lutz (1989) *Environmental Accounting for Sustainable Development*, a UNEP-World Bank Symposium (Washington: World Bank).

American Petroleum Institute (1990) *American Petroleum Institute: Survey on Oil & Gas Expenditures.*

Askari, Hossein (1990) *Saudi Arabia:Oil and the Search for Economic Development* (Greenwich, Connecticut: JAI Press).

—(1991) 'Saudi Arabia's Oil Policy,' in Wilfrid L. Kohl (ed.) *After the Oil Price Collapse* (Baltimore: Johns Hopkins University Press).

Barker, P. (1988) 'Gulf States' Fiscal Policy Options to the 1990s,' in Economist Intelligence Unit, *Gulf States' Fiscal Policy Options to the 1990s.*

Griffin, J.M. (1992) 'OPEC and World Oil Prices: Is the Genie Back in the Bottle?,' *Energy Studies Review*, 4:1:27-39.

Harding, D.C (1991) BP Ltd., Chief Executive Europe, talk to Institute of Petroleum, April.

International Petroleum Encyclopedia.

International Petroleum Encyclopedia (1990) p.298.

Mabro, R. (1992) 'The Political Instability of the Middle East, and Its Impact on Oil Production and Trade,' *Energy Studies Review*, 4:1:45-50.

Masters, C.D. et al (1987) 'World Resources of Crude Oil, Natural Gas, etc.' in *Proceedings of the 12th World Petroleum Congress*, Vol.5, pp.3-33 (New York: Wiley).

OECD (1985) *OECD Observer*, No.135, July.

Oil & Gas Journal, weekly.

Oil & Gas Journal 'World Wide Oil,' annual supplement (various years).

Petroleos de Venezuela (1988) *Annual Report.*

Petroleum Economist, monthly.

The Petroleum Finance Company Ltd. (1988) *World Petroleum Markets: a Framework for Reliable Projections*, World Bank Technical Paper No.92 (Washington: The World Bank).

Saudi Aramco Oil Co. (1990) *Annual Report 1990.*

UK Department of Energy (1990) *Annual Report 1990.*

US Central Intelligence Agency (1979), *The World Oil Market in the Years Ahead*, August.

US Department of Energy (1989) *US Crude Oil, Natural Gas and Natural Gas Liquids Reserves: Annual Report.*

—(1991) *Performance Profiles of Major Energy Companies*, DOE/EIA-0206(89).

—*Monthly Energy Review*, monthly.

World Oil (1991) May 5.

—(1991a) 'International Outlook,' August.

—(1982-85) 'International Outlook,' various issues

Appendix: True or Permanent Net National Product in a Mineral-Producing Country

El Serafy (Ahmad *et al*, 1989) and (Askari, 1990) analyze the income of a country which exploits a limited mineral resource. We assume the limitation, and set out their theory, but change the nomenclature somewhat:

P = price
Q = annual output
R = reserves
T = R/Q = years to exhaustion
PQ = apparent annual income
Y^* = true or perpetual income

Then the present values of the stream PQ and the stream Y^*:

$$PV(PQ) = PQ\int_0^T e^{-it}dt = \frac{PQ}{i}(1-e^{-iT}) = \frac{Y^*}{i}, \text{ and}$$

$$\frac{Y^*}{PQ} = 1-e^{-iT}. \qquad [1]$$

Askari assumes also that the price increases at some annual rate g:

$$PV(PQ) = PQ\int_0^T e^{-(i-g)t}dt = \frac{Y^*}{i}, \text{ and}$$

$$\frac{Y^*}{PQ} = \frac{i}{i-g}(1-e^{-(i-g)T}). \qquad [2]$$

The 1990 T for Saudi Arabia was 105.3 years (it was much higher before the Persian Gulf war). As for i, El Serafy suggests 5 or 10%, Askari suggests 8%, which we use. Let g=3%, which is as high as was assumed in the delirium of the early 1980s.

Then by [1], $\frac{Y^*}{PQ} = .9998$

Or by [2], $\frac{Y^*}{PQ} = 1.592$

Thus the "true" or perpetual Saudi income is either indistinguishable from the nominal one, or it is half again as large.

If g=i, Equation [2] is indeterminate, 0/0. One can use L'Hospital's rule to make $Y^*/PQ = iT = 105.3 \times .08 = 8.424$. In general, if PQ will increase for many years, its present value exceeds a smaller constant perpetual flow.