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We are in 1987.

Oil Prices: Can We Predict Where They Are Going?

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Introduction

Earlier explorations of how to predict oil prices led, in 1978, to my being named project director of a contract between USC and the OPEC Secretariat in Vienna to develop a world energy' model. OPEC wanted a tool to help devise rational oil production and pricing policies. Late in 1981, we installed the model on OPEC's computers in Vienna. It is unknown how effectively OPEC was able to use the model, but it did foretell the shape of recent events in world oil markets. In Jan. 1981, we gave our sponsors the results of a study of what would happen if OPEC raised its production rate back to 20 million barrels per day, a study they requested after their production rate fell to around 18 million B/D. The model predicted that if OPEC's rate were raised as proposed, oil price would fall $20/bbl within a year. Although not spot on, the prediction is certainly indicative of what was to come. (For this study all price elasticities were arbitrarily increased by 10 percent from their base levels, the medians of estimates reported in the literature. In hindsight, this adjustment was conservative. The past decade's price-induced, reduced growth rate in energy consumption, so-called conservation, corresponds to even larger values of price elasticity.) There is no indication that OPEC paid attention to this or other model predictions: they were still whistling their favorite high-price tune when the market forced their first official price cut late in 1982.

I first give some rules of thumb that experience suggests may help to understand the evolution of oil prices. The intent is not to prophesize future oil price. Rather, we want to consider how to decide on the credibility of an oil price forecast (yours or another's). Answers to a series of questions re oil price dynamics are advanced. This interrogatory is meant to broaden one's perspective on what makes the oil market tick. We also examine how individuals have responded in the past to signals from the marketplace. This examination calls to attention the impact of emotions in reaching an economic decision. In the oil patch expectations about highly uncertain outcomes, both economic (mostly prices and taxes) and physical, exert a major influence on investment decisions. Being aware of how emotions can slant these expectations is a key consideration for a decision maker.

Discussion & Questions

As background the first question asked is, "What is the consensus, if any, of recently published predictions of future oil prices?" Sorting through recent issues of Petroleum Intelligence Weekly, Oil and Gas Journal, et.al., one finds these major theses:

1. Oil price will be higher in five years than it is today and after that will increase at a little above inflation rate through the end of the century — If a consensus exists, this is it.
2. The odds that oil price will repeat 86's plunge are very small. The risk of a price below $15/bbl for more than a short period is law enough to allow major investments that are profitable at this price to be undertaken comfortably. The odds are improving that the current $18/bbl price will be close to the minimum experienced in this century. --Based upon the bottoming out of corporate expenditures, these hypotheses seem to represent beliefs held by most oil-company decision makers.

3. If oil price falls to the low teens and stays there *for* a considerable time, demand will rise, supply will fall, and the price shocks of the 70s will recur. This "deja vue" theme recognizes that history could repeat itself, although the possibility is thought to be small.

4. After factoring out inflation, oil price is likely to remain within the past 8-month's range of $12-20/bbl for the near and intermediate term. After the turn of the century, technology will push energy prices downward. — This thesis was recently advanced by the most insightful public forecaster, Arlon Tussing[1]. Similarly, Arco's Middleton[2] stated that an internal staff review of historical oil prices pointed to the likelihood that real oil price would not vary greatly.

5. Oil prices will soon drop to less than $10/bbl or jump to unprecedented heights. --- One of these could occur it the producing countries in the Gulf were struck by a catastrophe. The first result would require a mental affliction that brought on economic insanity, whereas the second could result if some event reduced drastically the flow of oil to market for an extended period

6. The lowered oil price for the last one and one- half years has caused demand to rise and supply to fall, making nudging oil price gradually upwards feasible. --- Rather than a forecast, this theme is the unrealistic, albeit understandable, wish of some OPEC producers

IMPACT OF EXPECTATIONS

First, "How have oil price forecasts affected past level of investment in the oil patch?" The answer is, "Chaotically!" Currently, US domestic oil and oil services industries are coming out of a deep depression. But, considering oil patch investment in the 11 years starting on 1/1/74, proverbial reports of the Dutch tulip craze and Britain's South Sea bubble come to mind. Investors outside the industry were propelled by "greed beyond the bounds of avarice"[3] to simply throw money at the oil patch. (Nearly 100 banks, including one of the nation's major financial institutions, were forced to reorganize by loans on such investments that soured.) Operators combined this exogenous cash flow with their own increased cash flow, and went on a truly remarkable spending spree. As shown below, active number of rigs, the most sensitive indicator of the industry's investment level, reached an all time high of 4530 in 1981, a level 5½ times that of only 10 years before (and 5½ times that of 4 years later).

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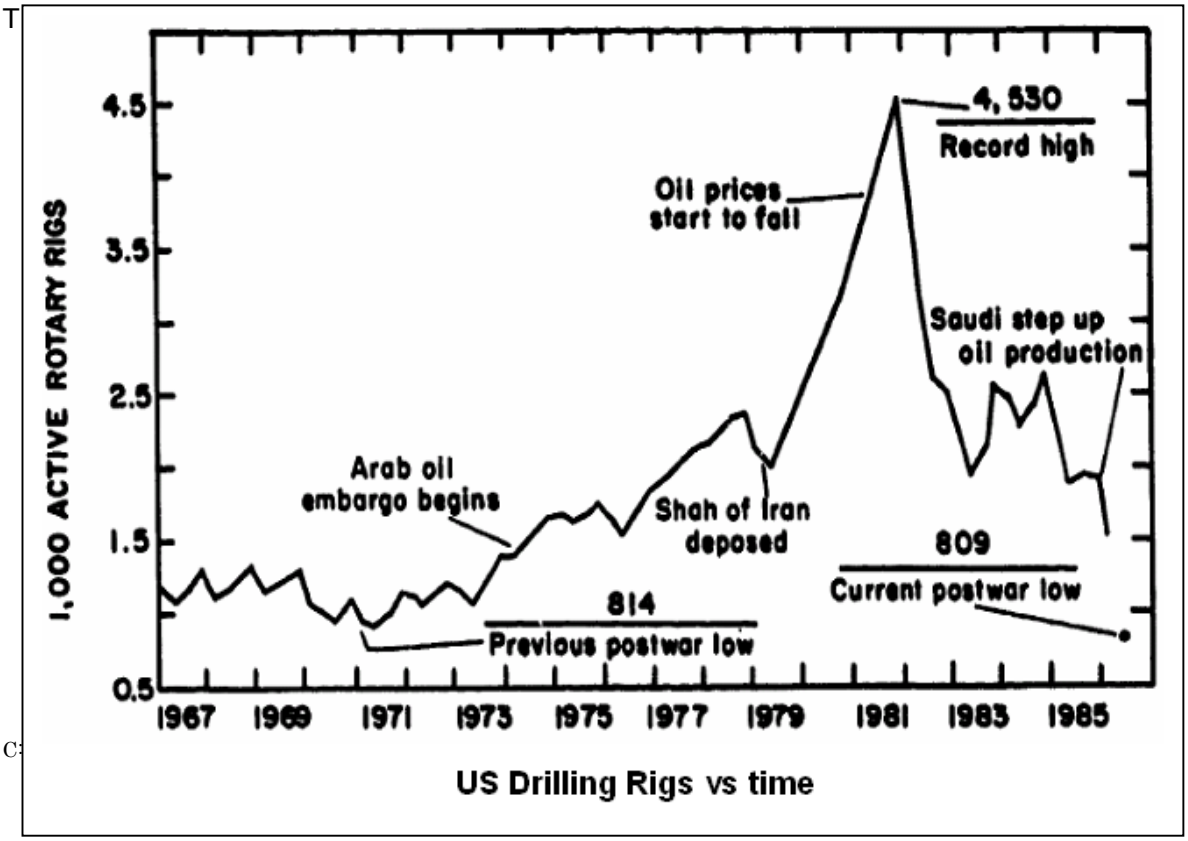

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US Drilling Rigs vs time

FIRST RULE OF THUMB

"*Be extremely skeptical of a price forecast of any commodity, product or commercial service that exceeds the rate of inflation for more than a brief period of time.*" A rising real price (over and above inflation) will educe added supply. For crude oil witness the 22% increase in non-OPEC production from '80-'85. This 4.3 MMB/D [(4)] addition to world oil supply exceeded the corresponding 5-year drop in oil consumption. Together, more supply and less demand drove OPEC's production rate down to a level that their swing producer, Saudi Arabia, found to be unacceptably low.

To be in accord with the "real price" rule, what should you do when presented with an oil price forecast? Determine its average escalation rate and subtract the projected inflation rate to determine the escalation rate in real (constant) dollars. If the real rate differs significantly from zero in either direction, treat the oil price forecast with caution. Since inflation rate cannot be forecast with certainty (but with greater certainty than oil price), using a range of values for this pivotal judgment rate gives a solider picture of the forecast's credibility

ENERGY PRICE COMPETITION

Next. we consider two interrelated questions: "How does price of crude oil affect the price of other fuels with which it competes?"; and "How is crude oil price determined?" Consider the first question. Because it is the only universal fuel, crude oil currently occupies an axial position in energy markets. All energy requirements can be readily generated from crude oil and it can be transported relatively easily and inexpensively over long distances. Each competitive fuel must carve out a sales volume that oil could fill. In some cases the competitor is unquestionably cheaper, e.g., geothermal steam, hydropower from an existing dam or coal to generate electricity. In other instances research objectives, regulatory bodies and government policies may exert overriding influenoe, such as with solar heating and power generation using energy from nuclear fission, geothermal brines or winds. In a few instances price competition is keen, e.g. in recent years the market split between natural gas and crude oil has been primarily determined by the price of a Btu of energy used to boil water in industrial and electrical generating plants.

The competitive pressure of other fuels notwithstanding, we observed above that crude oil's major market competitor currently is crude supplied by another producer. Thus, the primary determinant of crude oil price right now seems to be the marginal coat of the last barrel squeezed out of the ground in the US. The thousands and thousands of marginal producers shut in since 1/1/86 testify to the effectiveness of this competition. This discussion of competition throws directly in front of us the fundamental question in world energy markets today; "What is the equilibrium price of crude oil?" We return to this question later. For now let us examine how price of crude is determined.

The Fixing of Crude Oil Prices

Experience since 1973 clearly demonstrates that at any given instant the primary determinant of crude oil price is the volume of crude oil offered for sale. Small percentage changes in volume cause large percentage changes in price. For example, at the beginning of 1987 OPEC and a few cooperating producers reduced the volume of oil sold by

about 2 million B/D, a little over 4% of Free World consumption. The resulting price change was about 50%, from 12 to 18 $/bbl.

This behavior illustrates the general principle of oil price determination operational for the past 70 years the rate selected by the world's major producer establishes oil price. Saudi Arabia now occupies this central position because its tremendous reserves and spare capacity allow it to raise or lower the volume of oil going into world markets by an amount sufficient to achieve a targeted price. The Texas Railroad Commission and its ally, the Interstate Oil Compact Commission, occupied this position from the 30s to the early 60's. Toward the end of this period, the US became a net oil importer. However, US import restrictions maintained the power of the domestic regulatory bodies to control domestic crude price. Outside the US, the international oil companies controlled production to establish world price at a level below the domestic price.

The 1960s were years of transition. US consumption rose, US production fell, and, thus, imports increased. Finally, US import restrictions were abandoned. European and Japanese imports also rose rapidly. Producing countries exercised their sovereign power to gain control of their own production operations. As these changes unraveled the existing warp and woof, it was only a question of time until the new price leaders grasped the scepter of power. This crisis occurred in October 1973. to the long term benefit of the world.

SECOND RULE OF THUMB

The above discussion makes clear our 2nd of thumb: "*Examine carefully the motivations, actions and words of the price leader*." Previously, this was called "Yamani watching." Now King Faud and his new oil minister, Nazir, are the principal players. Apparently, King Faud is targeting a price of $18/bbl. My speculation is that the balance of political and market pressures he feels make him want to hold the price there for a while.

Events occurring between June 1985 and January 1986 demonstrate the efficacy of our 2nd rule. In June to maintain OPEC's official price of $27/bbl, in a continuation of a downward trend from a peak rate of 10 MMB/D in 1980, Saudi Arabia found it necessary to lower its production rate below 3 MMB/D. If this trend continued, an end to Saudi Arabia's pivotal price setting position was approaching. Ergo, the price must be too high. Not surprisingly, Yamani said the Saudi production level was unsatisfactory. He rectified the problem with a remarkable tripartite orchestration:

(1) Obtained agreement at a ministerial meeting that OPEC should defend market share rather than price,

(2) Introduced netback contracts (crude price equals product sales price less oil company's profit margin) guaranteeing the purchaser a reasonable profit and allowing Sandi Arabia to immediately find buyers for all of the crude that it wanted to sell ,

(3) Covered his campaign to deliberately drive price down with a smokescreen -- blamed North Sea producers for undermining OPEC's official price, even though shutting in one-half of North Sea production would have brought only short term relief to a market being swamped by growing volumes of supply.

From June, 1985 onward "Yamani watching" clearly signaled the forthcoming price drop – at the beginning of August Yamani announced that Arabia would increase its crude exports. The price upheaval of 1986 was not the "collapse of OPEC" as many editorialized, but rather was the logical unfolding of Yamani's plan to bring oil price down to a sustainable level. In support of this thesis, recall that on two previous occasions Saudi Arabia

acted to keep price down, maintaining price of Arab light below the official OPEC price in 1979-81 and substantially raising production rate during the Iranian revolutionary crisis.

THIRD RULE OF THUMB

Clearly, listening to an expert gives us needed guidance. However, our 3rd rule of thumb cautions us not to accept the predictions of would-be oracles too readily. "*Be very cautious in selecting an expert to 1isten to!*" If in 1984 you had listened to Arlon Tussling, you would have been well served; to paraphrase, he said. "It is not a question of whether oil price will fall below $20/B, but when!" Not surprisingly, some companies are paying handsome stipends to learn what he says now.

Now for some less helpful prognostications

- In the Energy Information Administration's 1985 Annual Energy Outlook"[5] we find the following: "Energy markets over the next 10 years are likely to be more stable than those of the 1970's. Following the wild fluctuations in energy prices ---- that occurred then, some basic long-term trends ….are expected to reappear and continue through 1995."
- At Western Oil and Gas Association's annual meeting in Los Angeles in December 1985, the featured luncheon speaker, an energy "expert" from Georgetown Univ., predicted that OPEC producers would soon raise oil price substantially! He spent 30 minutes presenting evidence he thought supported his case. (I am relieved to report that at the podium after the talk, I told him I believed him to be absolutely wrong, but I was too timorous to shout the warning for all to hear.)

QUANTIFYING DEMAND AND SUPPLY CHANGES

Let us examine in more detail how demand and supply for crude oil change over time. Demand response is conventionally represented by:

$$\ln\left(Q_t\right) = \left(1-\lambda\right)*\left(A_o + \varepsilon_I \ln\left(I_t\right) + \varepsilon_p \ln\left(p_t\right)\right) + \lambda \ln\left(Q_{t-1}\right) \quad (1)$$

(For a demonstration of how the parameters in Eq(1) are determined from historical data, see Dougherty and Al Blehed[6] and Al Blehed[7].) The lag parameter, λ, is a positive fraction, typically around 0.9. Since the length of time required for demand to adjust to a change in income or price is approximately 1/(1-λ), the value of λ is a critical indicator of the dynamic response of energy markets. Price elasticity, $\acute{\varepsilon}_p$, is the percent change in demand resulting from a percent change in price, viz:

$$\varepsilon_p = \left[\left(Q_t - Q_{t-1}\right)/Q_t\right] / \left[\left(p_t - p_{t-1}\right)/p_t\right] \quad (2)$$

A corresponding expression relates income elasticity, $\acute{\varepsilon}_I$. to demand and income changes.

Since they represent the one-year response, $\acute{\varepsilon}_p$ and $\acute{\varepsilon}_I$. are called short-run elastioities. Their values are relatively small. For example, the demand response cited above gives $\acute{\varepsilon}_p$ = 0.04/0.5 = 0.08. The long-run price elasticity, which represents the cumulative response over a long time, is equal to $\acute{\varepsilon}_p$ / (1-λ). Thus, an order of magnitude estimation tells us that were oil price to be maintained at $12/B rather than $18/B from now to, say, 1995, oil demand would be an undesirable 80% higher with the lower price. (This calculation assumes that the demand response to a downward price move is the exact inverse of that to an

upward move. Some energy economists now hypothesize that a "ratchet effect" will prevent such reversibility.) Since 1973 long- run income elasticity has dropped by about one-third, from 1.0 to 0.67; conservation has allowed healthy economic output growth to continue with a substantially reduced growth rate in energy demand.

The supply response to price changes also unfolds slowly over time. For example, the 4.5 MMB/D increase in non-0PEC production rate from '80 to '85 consisted of increases of 655, 1000, 970, 1285 and 590 MMB/D, respectively. If the decline in capacity of existing production is taken into account, these supply increases are somewhat larger.

Rather than being available only from an econometric estimate, as is the case for demand, the supply lag can be determined from a consideration of the economic, physical and regulatory actions required to find reserves and put this on production. The supply lag may vary from 1-15 years depending on the geography and position within the exploration-production cycle.

What do demand and supply parameters tell us about the future course of oil prices? First, their values are not zero. Lest you think that obviousness renders this statement trivial, let me cite a striking supply example. In the second half of the 1960s, when Federal controls fixed the price of natural gas in interstate trade - about 25 ¢ /MCF - on some winter days businesses and schools in the Northeastern US closed because enough natural gas to heat the place' was not to be had. Our industry pleaded for an increase in price to make development of the needed additional capacity economically feasible. However, the prevailing opinion among the economists advising the policy makers in Washington, DC was that an increase in price would not educe new reserves and capacity, and would, therefore, simply rip off consumers to the benefit of gas producers. Fortunately, the uncontrolled intrastate market proved these mavens wrong. There, gas price rose to $1.80/MCF, and plentiful supplies became available. To preserve national harmony and promote the nation's commerce, Congress passed the Natural Gas Production Act -- which unified US gas markets by extending Federal controls to all domestic gas sales and allowed price of new gas to rise.

FOURTH RULE OF THUMB

Our 4th rule of thumb recognizes the timeframe to modify the energy domain; "*The lagged response of energy demands and supplies to price changes causes short-run elasticities to be much smaller than long- run elasticities.*" As a rule, short-run elasticities are around 0.1. Long-run elasticities are 5-10 times the short-run values, but 5-10 years are required for the total response to occur. Hence, the full effect of the 1973 price shock has taken place, residual effects of the 1979 price shook are still surfacing, while the impact of the 1986 drop is just getting underway. To be an accurate projector of energy markets, one must patiently watch to see if anticipated movements are evolving and alertly adjust expectations as market signals warrant. Two additional factors, changes in crude and product inventory and shifts in exchange rates, muddy the water, making insight more difficult.

FIFTH RULE OF THUMB

Let us now consider our 5th (and last) rule of thumb: "*Production comes from reserves, cash flow from production and tomorrow's reserves from today's cash flows. To forecast the effect of an oil price change, you must circle the loop.*" A vital question raised by this rule is, "Will tomorrow's reserves be enough?" The answer echoes the nagging question

confronting all operators who want to stay in the oil business over the long haul; "Are we replacing our reserves?" If over time cumulative volume of reserves added is less than cumulative production, we are gradually going out of business. Worldwide, between 1975-85 reported reserves held steady at close to 700 billion barrels. Of these 400 are in Middle Eastern countries abutting the Gulf, 220 in other Free World countries and 80 in the Communist area. During this period US and Canadian reserves also stayed nearly constant, at 35.5 and 7.5 MMMB, respectively, but dropped by about 10% in 1986. Since the '86 price collapse caused number of operating rigs to drop by about two-thirds -- to less than 1000 -- further drops in US reserves are coming.

Usefulness of the Reserve / Production Ratio

Although reserves measure ultimate producing potential, the reserve to production ratio, R/P, is a much better indicator of the likely direction of oil price over the next 3-5 years. R/P, reserves divided by current annual production rate, [B / (B/yr)] is the number of years required to deplete those reserves if production capacity did not decline. For the world currently R/P = 34. We do not face a near-term shortage of crude oil unless some catastrophic events prevent production from flowing to market. Because the bulk of the world's reserves are concentrated in the Middle East, the possibility of such a disruption is a serious concern. For the countries surrounding the Gulf R/P = 100 at year-end '85, for the US R/P = 9, for Western Europe R/P = 18, for Japan R/P = 0. Dividing by consumption rather than production, RIP for the US and Western Europe is 6.5 and 6, respectively. Thus, the need to worry about possible discontinuities in supply will continue indefinitely.

What sets the value of R/P? The investment in producing wells and equipment fix an oil reserve's R/P. Stripped to the core, these economic evaluations are targeted to maximize discounted profit and to assure that a minimum rate of return is realized on the last investment increment. In the US and Western Europe oil produced can be sold immediately, so the limiting factor is cost per unit of production. The large proportion of onshore production, with lower development cost, allows smaller reserves per well in the US than can be afforded in the North Sea, the source of over 90% of Western Europe's production.

In contrast, in the Middle East, where the unit cost to the producer is much smaller, the factor constraining development investment is the volume of production that can be sold. Profitability of any production sold at, or even considerably below, current prices is very high. Hence, the optimal strategy is to install sufficient excess producing capacity to allow capturing even short- term sales opportunities.

Useful as R/P is as a quasi-quantitative indicator of a region's capability to produce, its reciprocal is a more precise measure of longevity. The decline rate, D (fraction/year), is approximately equal to l / (R/P). Thus, existing US production should decline by approximately 11%/yr and to fall to one- half of its current level (8.3 MMB/D) by 1993. In 1986, US production rate fell by only 8% (700 MB/D). This slower decline rate occurred because nearly 36,000 new wells were completed in the US in 1986.

Consideration of Saudis Arabia's R/P reveals the motivation for its oil policies. Saudia Arabia is officially credited with 170 billion barrels of reserves, but 200 billion is a more realistic estimate. At the current quota rate of 4.133 MMB/D, R/P = 132 giving a decline rate of 0.7%/yr. At 1985's midyear rate of 3 MMB/D, R/P = 200 years. Suppose you were selling 1985 vintage stock from a pantry containing 200 years supply at your current rate. You know the pantry's contents will not spoil, but given the current pace of technological change, what odds will you give that in 2150 your great-great-great grandchildren will still be able to sell the stuff? By then, some new energy form, such as that used by extraterrestrials to power their UFOs, may well be the dominant source of energy. Wouldn't you undertake to bring the price down to a level that would stop cur-

rent replacement of your product by conventional competitors? Wouldn't you target a price intended to give you the level of income you could live with now and assure a healthy sales rate for the foreseeable future? In light of these questions, the actions taken and policies pursued by Saudia Arabia and its cooperating Gulf neighbors over the past two years seem well crafted to serve both their short and long-term interest.

They Need the Money

To this point, we have not focused on the importance to the producing countries of income from crude oil exports. This lack of emphasis is consistent with that frequently given in our newspapers and business and trade publications; we naturally tend to concentrate on our view of the situation rather than theirs. From their view, income from oil exports is the fundamental consideration. In most OPEC countries, crude oil sales make up the large majority of national income. Without this revenue, the society as it currently exists could not be maintained. Ergo, the national welfare of these countries, as well as the personal well-being of those enjoying the fruits of governing, depends upon maintaining this income level.

This requirement overrides political and religious considerations, no matter how strong. Do you think Iran is willing to sell us oil because the mullahs like us? Why was the Arab oil embargo - imposed in October 1973 to punish the US and The Netherlands for supporting the Israelis - discontinued in February 1974 with no visible change in the political situation in the Middle East, but after oil price had jumped fourfold? The OPEC oil exporters require their sales to the West. Even if the country is radically disposed, as Libya seems to be, its oil must find a Western market. The Russians won't buy it; they, too, are exporting to the West to raise hard currency, and the volume that can be bartered with Eastern Europe is only slop off the top of the full oil bucket that must be sold. The sales propensity of OPEC and other producing countries must be carefully weighed in deciding what we need to do to assure adequate future oil supplies. Obviously, the more countries we can assist in positioning themselves to produce and export oil, the better off we are.

Level of income also has a strong bearing on the likelihood that OPEC countries will cooperate to maintain the current price. In the summer of '86 Saudi Arabia and Kuwait opened the valves and drove the price to as low as $8/bbl. In Fall '86 the OPEC ministers decided to cut production by about 1.5 million barrels/day. As a result, price stabilized in '87 at $18/bbl, and OPEC's total income went up by about $100 million/day. This demonstration of the painful consequences of non-cooperation should assist governments of OPEC countries in resisting the temptation to try to slip extra oil into the marketplace.

Industry Cash Flow

Turning now to the third leg of the oil supply loop, the flow of cash into drilling; "How is the level of this flow determined?" In 1986 the industry's wellhead revenues from oil and gas dropped to $71 billion, down greatly from 1985. However, this drop did not alone cause average number of drilling rigs to fall by nearly 60%. A useful measure of industry outlook is obtained by dividing a year's expenditure on drilling by the annual wellhead revenue. When prospects look good, this ‘plowback ratio’ expands. At the beginning of the decade plowback peaked at over 30%, fell gradually through 1985 and then plunged to just over 10% in 1986. Optimists are now projecting that plowback will climb back above 15% this year. Thus, we see that plowback is a sensitive measure of how potential investors gauge the future profitability of drilling in the US. Corporate investors are displaying pessimism about future US prospects both by cutting oil patch investment budgets and by raising the percentage spent outside the US. Most investors outside the industry have registered

their disenchantment by not investing in the oil patch at all; at the peak over $20 billion/yr was obtained from outside investors, over 10 times the amount currently being raised.

THE EQUILIBRIUM OIL PRICE

Consider the question, "What is the equilibrium price of crude oil?" Our glimpse of oil-patch investor's behavior hints at the correct answer. The "equilibrium" price is not a hard and fast number; rather it is an expected price trajectory over time. The higher is projected inflation rate, the higher this path. Some suggest that in real terms the oil price required to keep supply and demand in balance has changed little in this century. Others argue that we are using up the cheaper oil (certainly this is true in the US) so that real price must increase gradually to allow exploiting more expensive reserves. The fact that the world's oil supply comes from a very large number of individual wells located in reservoirs with widely divergent per barrel production costs adds complexity. In the final analysis, then, "equilibrium" oil price is a conceptual range, whose upper and lower limits can be defined, but whose precise value is unknowable. Recent history tells us that in today's dollars. $27/bbl is above the world's equilibrium price, even though this value is not far above the heart of the range required to maintain US production rate. Likewise, we can confidently assert that at $15/bbl. growing demand would sop up slowly falling surplus producing capacity in a few years, leading to an inevitable price rise. Even after considerable study, we can only speculate where within this range, the equilibrium core lies. The consensus seems to be that the core's center is a little above the current nominal price of $18/bbl.

A LOOK AHEAD

Before summing things up, we address one final question, "As energy markets evolve in the days ahead, what observations will help us gauge what is happening?" Two factors seem to warrant special consideration: level of excess oil producing capacity and oil's share of world energy markets. In a recent study of world oil demand at USC[6,7] we calibrated demand equations by matching history from 1970-85, and used these to project energy demand and oil market share through 2000. We will consider only the high and low of the three price trajectories used in making projections. Both assumed real price of oil to grow at 2%/yr from 1987 to 2000, from a 1987 price of 20 and 10 $/B, respectively. (The 2000 real price for the low trajectory is below the 1987 real price for the high trajectory.) Important results are tabulated in Tables 1, 2 and 3. Growth rate in total Free World energy demand comes out at 1.5 and 2.4%/yr, close to or slightly above the current consensus. The bulk of this growth occurs outside the industrialized regions. In contrast, oil share for the Free World is projected to fall for both the high and low trajectories from the 1985 level of 45% to 44% and 38%, respectively, in 2000. Only in the US for the (unlikely) low price trajectory is an increase (of about 4%) in oil share predicted.

Currently, PIW estimates OPEC's excess producing capacity is about 10 MMB/D. Relative to 1985 for the low price trajectory Free World oil demand increases by over 20 MMB/D by 2000 whereas for the high price trajectory the increase is only about 1 MMB/D. Even without accounting for decline in existing producing capacity or newly developed capacity, we can conclude that the actual price trajectory is likely to fall between our upper and lower bounds. OPEC is unlikely to be able to hold in place a price trajectory that perpetuates its present excess capacity for over a decade, as the high price profile would do. Looking at the other side of the coin, only an inveterate optimist would give credibility to a low price trajectory, which ab-

sorbs all the current excess capacity by the early 1990s, and which requires a net increase in capacity of 10 MMB/D between 1987-2000.

Summation

In closing we briefly touch on an important issue and make a final observation. While suffering through an unprecedented economic cataclysm, many are pleading with the Federal Government to relieve some of the distress by imposing an oil import fee. As those stalwarts of our industry who managed to stay afloat now look forward to touching bottom again, let us ask the question, "Do we want to do anything that will cause the Feds to poke around in our business any more than they already are?" A review of past events dictates an answer of "No!" Take as a given that consumers do not like to pay a high price for energy, whether it be to producers in another country, state or just another county. Give all consumers one vote and concentrate them in non-energy producing regions. The result is a voting bloc in Congress that sees its interest served by trimming fat, muscle, and bone off the country's energy producers. A list of their accomplishments is long. We touched on natural gas. The industry is still trying to rid itself of paying excise taxes on so-called windfall profits. The most egregious, however, is the two-tier oil price episode. (These regulations kindled the larcenous side of operators in the oil patch. Some exhibited great ingenuity -- inexpensively and clandestinely converting low to high tier oil.) Holding down domestic price to pamper consumers siphoned off revenue from domestic producers to subsidize foreign producers. Decreased revenue curtailed increases in US domestic crude supplies. US demand fell less than world price dictated and the inflated oil demand made worse the second energy crisis.

If an oil import fee were levied, any short term benefits are almost guaranteed to be more than offset by vindictive legislation intended to punish the public's best known "rip off" artists, us. Spend efforts on getting less regulation of our industry, not more, and pushing for restoration of more favorable tax regulations appropriate to maintaining the viability of our hard-pressed, but vital industry.

The World Energy Experiment

Finally, in closing let us reflect on what has happened in the energy field in the past 20 years. A casual observer might say, "Nothing much has changed. We're using a little more coal and nuclear and a few other odds and ends, but we are still totally dependent on imported oil and are beginning to need imports of natural gas." To this observation we reply, "Look again! In these two decades a live, worldwide energy experiment has been conducted and, all in all, the results are favorable."

At the start of the period, although nobody was worrying about energy because it was so cheap, things looked grim. Crude oil supplied approximately 50% of the world's energy. Oil's share was growing by 1% every 2 years. Crude oil consumption in the Free World was 37 MMB/D and was growing by 7.7%/yr. If this growth rate had continued, Free World consumption would now be an astounding 163 MMB/D! US growth rate was 5.3%/yr, which translates into '87 demand of 34 MMB/D. Can you conceive of our imports totaling 25-28 MMB/D? Industrial response to newly enacted environmental laws had pushed up the Btu/GNP multiplier, so that the income elasticity of demand, ε_I, exceeded 1.0. Some economic publications suggested that gasoline was not price elastic.

At the start of the 70's the US seemed to be heading into an energy abyss. Although not written into the Constitution, the right of Americans to cheap energy was a given that no prudent politician was about to challenge. It was left to an outside agency to resolve this

impasse, the Arab oil exporters, using the mechanism of a politically inspired oil embargo, brought about a fourfold increase in crude oil price. Although viewed at the time with general alarm by consumers everywhere, this action launched a transition to a stastable, long-term energy system. In response to the quadrupling of price, Free World oil consumption fell by 4.4%./yr in 1974-75, before turning up again. At the end of the '70s, oil price again jumped, this time by a factor of 2-3. In response, oil demand fell 7 MMB/D to 45 MMB/D, and is just now starting to work its way upward from that level.

In the main, the results of this massive experiment bode well for the US. We now know that if the price of oil is raised to $40/bbl, a price the world's consumers could certainly afford, oil supply will not be a constraining factor on the economic growth vitally needed to maintain our evermore-interdependent civilization. Since we can be certain that in the intermediate term, oil price cannot be maintained at $30/bbl for over 5 years without triggering a repeat of the price collapse of '86, we can anticipate that price is unlikely to reach that plateau any time soon. The results clearly demonstrate one discomfiting fact -- for the foreseeable future the backbone of our energy system must continue to be oil and gas flowing out of wellheads. No substantial alternate source of these hydrocarbons is available. The demise of the Great Plains coal gasification project and Unocal's economically disastrous shale venture memorialize the many alternate energy failures, while the Canadian tar sands production demonstrates the gargantuan effort (and unacceptable pollution effects) that would be required to mine even 5% of our current oil and gas requirements. I believe there is going to be a future need for petroleum engineers.

Bibliography

1. Tussing, A. Editorial Page, Wall Street Journal (May 1987).
2. Middleton. J.A., "The Political and Economical Context of the Oil Industry", presented at 1987 SPE Hydrocarbon Economics and Evaluation Symposium, Dallas (March 2 1987).
3. Expression a principal in a now defunct, go-go Hollywood underwriter used to titillate clients.
4. BP statistical review of world energy, 1981-86, British Petr. Co., London.
5. Annual Energy Outlook 1985, Energy Information Administration (1985)
6. Dougherty, E.L. & Al-Blehed, M.A.. "Free World Total Primary Energy Demand: An Econometric Approach", SPE 16920, Proc. 1987 SPE Hydrocarbon Economics and Evaluation Symposium, Dallas (March 1987)
7. Al-Blehed, M.A..[N]An Engineering-Economic Approach to Modeling Free World Total Energy Demand and Oil's Market Share", PhD thesis, Dept. of Petr. Eng., Univ. of Southern Calif. (June,1987)

TABLE 1				
Annual Growth Rates – Projected Total Energy Demand - %/yr (1986-2000)				
REGION	Actual – '85	Low Price	Base Case	High Price
US	− 0.2	1.6	1.0	0.7
WEUR	2.8	2.2	1.7	1.4
Japan	− 1.2	2.7	2.0	1.6
CAAN	3.3	2.4	2.1	1.8
ROFW	3.5	3.6	3.1	2.8
Free World	1.4	2.4	1.9	1.5

TABLE 2				
Annual Growth Rates – Projected Oil Share - %/yr (1986-2000)				
REGION	Actual – '85	Low Price	Base Case	High Price
US	− 0.2	0.7	0.4	0.1
WEUR	− 4.2	− 1.1	− 1.3	− 1.9
Japan	− 5.3	− 0.4	− 0.9	− 1.9
CAAN	− 3.8	0.1	− 0.6	− 1.5
ROFW	− 2.9	− 0.7	− 0.9	− 1.4
Free World	− 2.5	− 0.2	− 0.5	− 1.0

TABLE 3				
Annual Growth Rates – Projected Crude Oil Demand - %/yr (1986-2000)				
REGION	Actual – '85	Low Price	Base Case	High Price
US	− 0.5	2.3	1.5	0.8
WEUR	− 1.5	1.0	0.4	− 0.6
Japan	− 6.4	2.2	1.0	− 0.3
CAAN	− 0.6	2.5	1.5	0.2
ROFW	0.5	2.8	2.1	1.3
Free World	− 1.1	2.1	1.3	0.5

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