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WHITHER OIL PRICES: THE EVIDENCE FROM THEORY

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Abstract

This paper suggests a likely course of oil prices over the next several years on the basis of theoretical models of the world oil market calibrated to pre-1973 levels of prices, production, and reserves. The current (1986) competitive environment, with price in the $10-$16 per barrel range and increasing very gradually, should prevail until the early 1990s. At that time excess supply and excess capacity in the industry will all but disappear, making a jump to the OPEC cartel's joint wealth-maximizing price of about $25-$30 per barrel likely.

WHITHER OIL PRICES: THE EVIDENCE FROM THEORY*

I. Introduction

In 1979-80 the price of crude oil in the world market roughly doubled--from (approximately) $15 per barrel to $30. This jump, the second within a decade, led many people to believe that the price would continue to rise rapidly with no apparent limit. Talk of oil at $50 per barrel (even $100 per barrel) in the very near future was not uncommon. As a colleague of mine in the Energy and Resources Group at the University of California, Berkeley, put it, OPEC appeared to be breaking "up," i.e., unable to prevent the price of oil from going up rather than down. Oil prices did, in fact, rise a bit more to around $35 per barrel in 1981.

Instead of continuing to rise, much less rise rapidly, however, prices started to fall even in nominal terms in 1982. By the second of half of 1985, they had fallen to about $26-$28 per barrel. In early 1986, the price of crude oil in the world market dropped sharply to $10 per barrel and has fluctuated in a range of $10-$15 per barrel since--occasionally dipping below $10. Accompanying the drop has been talk of a "free fall," presumably a continued fall in price with no apparent limit. The Vice President of the United States was dispatched on a mission to Saudi Arabia, the dominant producer within OPEC, to see what might be done about "firming up" oil prices. That was during the spring. As I write (in late summer 1986) OPEC has just announced that, as of September 1, it will cut back production from its current level of over 18 million barrels per day to about 16-1/2 million barrels. Spot crude prices have jumped in response to the upper end of the range--about $15 per barrel.

What does it all mean? What happened to the $100 per barrel oil, or even the $50 per barrel oil, of five years ago? And what happened to the free fall--below $10 per barrel--of last spring? I believe it is possible to make sense of these developments or, more precisely, to bound the possibilities by studying the implications of alternative generic economic models of the world oil market. That is, if oil is priced in a competitive environment, a model of the time path of the price (calibrated to pre-OPEC or at least pre-1973 levels of prices, production, and reserves) yields a relatively narrow range of projections of current and future prices. If, on the other hand, the price of oil is determined by a wealth-maximizing cartel (OPEC) in the presence of a "competitive fringe" (Mexico, Great Britain, China, etc.), a different but, again, relatively narrow range of projected prices is generated. Thus, we can explain current prices--and make educated guesses about future ones--based on what we believe about the prospect that OPEC will function successfully as a cartel.

There are still other, alternative explanations of oil-price movements. Given the intimate relationship in the standard model (developed in the text below) between exhaustible resource prices and discount rates, how much can we explain by movements in these rates as opposed to a shift from one market regime to another? Also, can all of the observed price instability be accounted for by changes in market structure or discount rates? A very simple model of the formation of price expectations can shed some light on this question.

In the remainder of this paper, I present a discussion of the several models mentioned thus far with special reference to their implications for near- to medium-term future oil prices. I also offer some judgments about the relevance of each, ending with a conclusion about likely outcomes. The point of this exercise is that anticipations of future oil prices are crucially important to the evaluation of a wide variety of energy options. A conservation investment (for example, in designing and building a fuel-efficient automobile) may look good if oil prices are expected to range upward from \$25 per barrel over the life of the investment but not for prices under \$15 per barrel. On the government level, subsidies for research into alternative energy sources, like solar and fusion, will appear more or less compelling depending on what one believes about the evolution of oil prices, and so on.

II. Models of the World Oil Market

A. The Competitive Model

Let us look first at pricing in a competitive environment, both because this seems to be approximately where we are today and because it is a useful benchmark. According to the received theory, a price-taking firm producing an exhaustible resource like oil will choose a time path of extraction to maximize the present value of its profits subject to the constraint imposed by the finite stock of the resource. In symbols, the firm wishes to maximize

(1) $$\sum_{t=0}^{T} [p_t y_t - c(y_t, X_t)] (1 + r)^{-t}$$

subject to

(2) $$\sum_{t=0}^{T} y_t = \bar{X}_0 - \bar{X}_T$$

where p_t = the price of the resource in period t; y_t = output; $c(y_t, X_t)$ = the cost of production as a function of output and the remaining stock, X_t, in period t; and r = the discount rate. $\overline{X}_0$ is the known stock in the initial period, and $\overline{X}_T$ is the stock at the end of the firm's time horizon--the terminal period T. We might simply assume that $X_T = 0$; i.e., the firm will ultimately exhaust the stock.[1]

The constraint, equation (2), can be rewritten to provide additional information about the evolution of the resource stock. Since output in any period is just the difference in amounts in the stock at the beginning and end of the period, we have

$$(3) \qquad y_t = X_t - X_{t+1} \qquad t = 0 \text{ to } t = T - 1.$$

Necessary conditions for a maximum of (1), subject to (3), are

$$(4) \qquad \left(p_t - \frac{\partial c}{\partial y_t}\right)(1 + r)^{-t} - \mu_t = 0 \qquad t = 0 \text{ to } t = T - 1$$

and

$$(5) \qquad -\frac{\partial c}{\partial X_t}(1 + r)^{-t} + \mu_t - \mu_{t-1} = 0 \qquad t = 1 \text{ to } t = T - 1$$

where μ_t is the Lagrange multiplier attached to the constraint $y_t = X_t - X_{t+1}$.

Equation (4) states that, along an optimal (wealth-maximizing) path, the price of the resource, p_t, is just equal to the marginal cost of extraction, $\partial c/\partial y_t$, plus the term $\mu_t(1 + r)^t$. This latter term is interpreted as the undiscounted resource royalty since, as is customary, the multiplier μ_t is interpreted as the royalty: the value, in terms of the discounted objective function, equation (1), of a unit of the resource in the stock.

Equation (5) describes the behavior of the royalty over time. Let us write $\lambda_t = \mu_t(1 + r)^t$. Then equation (5) becomes

(6) $$- \frac{\partial c}{\partial X_t}(1 + r)^{-t} + \lambda_t(1 + r)^{-t} - \lambda_{t-1}(1 + r)^{-t+1}$$

or, following some manipulation,

(7) $$\lambda_t - \lambda_{t-1} = r\,\lambda_{t-1} + \frac{\partial c}{\partial X_t}\,.$$

This condition is made easier to interpret by distinguishing two special cases more familiar in the literature. For the first, suppose that the size of the remaining stock has no effect on the cost of extraction. (This is plausible for much current oil production, especially from Persian Gulf fields.) Then the last term on the right-hand side of equation (7) vanishes; and we have the result that the (undiscounted) royalty, λ, grows at a rate equal to the rate of discount, r.

A still more familiar result is obtained if the cost of extraction is negligible relative to the price of the resource--a more extreme case but, again, perhaps appropriate to Persian Gulf production. Then, the price is just equal to the royalty and grows at rate r. This is the famous r-percent rule, or Hotelling rule, named for Harold Hotelling who first derived it.[2]

In the more general case, however, we have price rising in a more complicated fashion with the royalty component rising as in equation (7) and the marginal cost component changing as a result of changes in output and the remaining stock.

Now let us see how the theory can be combined with empirical information on demand, supply, and reserves to yield a set of oil price predictions. We know, from equation (7) or a specialized version, the shape of the price path. To determine actual price levels, though, we need some initial or terminal conditions. One possibility is to require that the initial price be such that, given reserves, demand for the resource goes to zero at about the same time reserves are exhausted. Also, we need to be more explicit about demand--and supply. Thus, we specify demand and supply functions for the world oil market such that the price p_t represents at any time the market-clearing equilibrium that equates quantity demanded and quantity supplied and is taken by the competitive producers. In keeping with our discussion of the effect of the remaining resource stock--or of cumulative production--on current costs, supply can be specified in such a way that it shifts to the left (marginal costs rise) with increases in cumulative production.

This is essentially the approach taken by Pindyck (1978) who parameterizes demand and supply functions on the basis of reserve, production, and elasticity estimates as of about 1974 and simulates a competitive equilibrium price trajectory very comparable to one derived from our equation (7).

Results, slightly adapted, are given in Table 1. The prices in column 2 are in 1974 dollars and so need to be adjusted to match up with nominal prices in 1984 and 1989. This is done in column 3, yielding projections that range from a low of $7.79 per barrel in 1984 (at a 10 percent rate of discount) to $12.55 per barrel in 1989. At a 5 percent rate of discount, prices move from $14.59 in 1984 to a high of $18.62 in 1989. Recall also that observed prices in the years just prior to 1974 were in the $2.00-$3.00 per barrel range or right in the middle of the simulated $1.55-$4.62 for 1974. This suggests that the discount rates are reasonable and that the model's simulations are reproducing observed prices in a reliable fashion.

TABLE 1

Oil Prices in a Competitive Environment

Year	Price 1974 dollars	Current price	Discount rate percent
1974	4.62	4.62	5
1984	7.53	14.59[a]	5
1986	8.35	16.21[a]	5
1989	9.60	18.62[a]	5
1974	1.55	1.55	10
1984	4.02	7.79[a]	10
1986	5.00	9.69[a]	10
1989	6.47	12.55[a]	10

[a]These figures are computed by adjusting upward the figures in the 1974 dollars column to reflect movements in the U. S. producer price index.

Source: Adapted from Pindyck (1978), Table 1.

We may state with some confidence, therefore, that:

1. As of 1984, oil prices in a competitive world market would have been (to the nearest dollar) in the range of $8-$15 per barrel.

2. As of 1989, they would move to $13-$19 per barrel.

3. As of today (1986), they ought to lie between $10 and $16 per barrel. Notice that this coincides almost exactly with the range of fluctuations over this past year. We shall have more to say about these results presently. First, we consider the range of price outcomes corresponding to a representative cartel model.

B. The Cartel Model

A number of models of the OPEC cartel have been developed in recent years. For ease in comparing results with those just derived for a competitive industry, let us work with Pindyck's model.[3] I have chosen this model also because it seems to capture key features of both OPEC behavior and world oil demand.

Recall that, in the competitive case, we specified a single demand and a single supply. To model the world oil market with an effective cartel, we simply split demand and supply--dividing them between OPEC and the "competitive fringe" producers. Thus (following Pindyck), we distinguish total demand for oil, which is just the same as demand in the competitive case, and "net demand" for OPEC oil where net demand is a residual--the difference between total demand and competitive fringe supply. Fringe supply is formally identical to the earlier competitive supply function, though calibrated to just the fringe producers. The cartel's objective is to pick a price path to maximize the present value of its profits. In symbols, the cartel wishes to maximize

$$\sum_{t=0}^{T} \left(p_t - \frac{k}{X_t}\right) D_t (1 + r)^{-t} \tag{8}$$

where D_t equals net demand and k/X_t equals average production cost. The parameter k is chosen such that k/X_0 is equated to the initial period's average cost. Since average cost becomes infinite as the remaining stock, X_t, approaches zero, the stock constraint need not be separately specified. Notice also in this formulation that average (and marginal) costs are constant as a function of output in a given period.

So the cartel picks a price which (along with income) determines total demand and competitive fringe supply. These, in turn, determine the residual net demand, D_t, in equation (8). Results, again slightly adapted, are given in Table 2.

Apart from the higher current range, two interesting differences from the competitive industry results stand out. First, price jumps immediately in the initial year of the simulation and dramatically to $13-$14 per barrel. This is a consequence of an assumption not yet discussed: that there are adjustment lags in demand and competitive fringe supply. The lag assumption is, in fact, a key distinguishing feature of Pindyck's model and one that seems persuasive. Put differently, we are simply assuming that demand and supply responses to a price change are inelastic in the short run and become progressively more elastic over time. The point of the result is that a cartel can take advantage of the inelastic initial responses by its competitors and its consumers to charge a high price. Contrast this with the previous situation in which individual cartel members cannot (by definition) collude to bring about this result, however much they might wish to do so.

TABLE 2

Oil Prices Under the Cartel

Year	Price 1974 dollars	Current price	Discount rate percent
1974	13.24	13.24	5
1984	10.84	21.03[a]	5
1986	11.30	21.83[a]	5
1989	11.98	23.24[a]	5
1974	14.08	14.08	10
1984	11.28	21.88[a]	10
1986	11.78	22.84[a]	10
1989	12.51	24.27[a]	10

[a]These figures are computed by adjusting upward the figures in the 1974 dollars column to reflect movements in the U. S. producer price index.

Source: Adapted from Pindyck (1978), Table 1.

A second difference, interesting perhaps mainly for technical reasons, is that the unadjusted prices in column 2 of the table do not follow a monotonically increasing path. Instead, they decline gradually over the first five years of the simulation to prevent further erosion of the cartel's market share and then begin the conventional pattern of steady increases (shown here to 1989).

Turning now to projections for the current period and the near future, we see, from column 3 of the table, that prices, in current dollars, are in the $21-$22 per barrel range for 1984 and increase to $23-$24 per barrel in 1989. As of this year (1986), they should be about $22-$23 per barrel. Of course, this is a good deal higher than anything in the range observed for the year which, as we have noted, coincides almost exactly with the projected competitive outcomes. But notice that it is fairly close to the price as of late 1985--about $26 per barrel--the last that can reasonably be taken to reflect an effective cartel decision.

III. Instability Around the Edges: The Role of Price Expectations

Although both competitive and cartel models appear to yield projections close to observed prices for the periods to which they can be assumed to apply, they do not fully capture the volatility of price movements since 1973. In particular, each dramatic change has been (at least temporarily) amplified. For example (as noted earlier), the $30 per barrel of 1980 became $35 per barrel in 1981 and, in fact, moved even higher on spot markets before falling back to levels consistent with model projections. I believe there is an explanation for this "instability around the edges," and it lies in the formation of price expectations.

The source of the difficulty here is that a complete set of futures markets does not exist. Accordingly, the future price of oil, as we have seen a key influence on current production decisions, is an expected price--not a market price. Where does the expected price come from? Let me suggest an extremely simple model that generates the observed amplification of departures from a smooth price trajectory.

In keeping with the spirit of simplification, I assume no significant production costs so that in (competitive) equilibrium

$$p^e_{t+1} - p_t = r\, p_t \qquad \text{[from equation (7)]}$$

(9) or

$$p^e_{t+1} = p_t(1 + r)$$

where p^e_{t+1} equals the expected price in period $t + 1$.

Now suppose p_t is suddenly increased as a result of an unanticipated shock to the system--an OPEC production cut, for example. What happens to p^e_{t+1}? Define the elasticity of expectations, ε, as the percentage change in p^e_{t+1} relative to the percentage change in p_t. If $\varepsilon = 1$, clearly p^e_{t+1} is increased by just enough to maintain the equilibrium relationship in equation (9). If, however, $\varepsilon > 1$, the relationship is upset and a series of increases is triggered in both p^e_{t+1} and p_t.

To see this, let p_t increase by 100 k percent so that $p'_t = p_t(1 + k)$ where the ' superscript indicates a newly increased price. If $\varepsilon = 1$, $p^{e'}_{t+1} = p_t(1 + r)(1 + k) = p'_t(1 + r)$--precisely the equilibrium condition. Now suppose $\varepsilon > 1$, specifically that the percent change in p^e_{t+1} is 100 ℓ where $\ell > k$. Then, $p^{e'}_{t+1} = p_t(1 + r)(1 + \ell) > p'_t(1 + r)$. Since the expected future price has increased by more than the current price, a change in current production plans is called for; less is produced. This brings about further increase in the current price which, in turn, leads to a further (disproportionate) increase in the expected future price and so on. Thus, an initial shock to the system--the increase in the current price--is amplified. It is easily verified that the same process works in reverse. Given an elasticity of expectations greater than unity, an unanticipated drop in the current price (a result, say, of a failure of cartel discipline to hold the line on production) will trigger further drops.

Is there any limit? Will prices rise indefinitely as some feared in 1981? Will they go into a free fall as some (the same?) feared in early 1986? The answers given by the evidence are "yes," "no," and "no." Clearly, something in the system prevents an explosive cycle of increases or decreases. In our simple model, all that is needed is that the elasticity of expectations eventually falls to, or below, unity. This is not an unreasonable requirement. Resource owners might be assumed to hold expectations of future prices rooted in their knowledge of developments in the technology for producing the resource and the likely demand for it. Although there will still be uncertainty, bounds on future price might be set, at least.

This informal analysis is supported by some results from the much more abstract theory of temporary general equilibrium, in particular by one of the conditions for the existence of a temporary general equilibrium. Suppose that future prices (for all commodities) are not known and agents must form expectations and act on them in making decisions about current consumption and production exactly as we have assumed for exhaustible resources. Current or spot markets can clear but, because individual expectations about the future need not coincide, markets will reopen and must clear again and so on. One condition for the existence of a sequence of spot-market equilibria (temporary equilibria) is that each individual's expected future price lies within a closed bounded interval (Grandmont, 1977). But this is essentially what we are talking about in the resource case. Knowledge of demand and cost developments is likely to set bounds on expected future price.

IV. An Alternative Explanation: Discount Rate Movements

Any attempt to explain oil price movements on the basis of discount rate movements runs up against a fundamental question: Which discount rates? In the absense of perfect capital markets, there will be many different individual discount rates. Indeed, even with such markets, observed interest rates will vary with the degree of risk attached to interest-bearing assets.

But it is precisely this variation that provides an alternative explanation of the oil price jump in 1973-74. Prior to 1973, the oil reserves in the OPEC countries (and elsewhere) were held largely by private oil companies. The oil companies, so the argument goes, employed relatively high discount rates in making their production decisions for two reasons--one general and one specific. The general reason is that private discount rates are allegedly higher than social discount rates. Specifically, the risk facing private oil producers during the late 1960s and early 1970s was greatly increased by the threat of expropriation. When the expropriation in fact occurred (largely coincident with the price increase of 1973-74), ownership was transfered to the producing countries with their relatively low discount rates. Low discount rates make future production of an exhaustible resource like oil more attractive. Given reserves, this must mean lower current production which, given a downward-sloping demand, means higher current prices. In this scenario no cartel (indeed, no change in market structure) is needed to explain the price increase.

So far, so good. But a difficulty with this explanation of oil price movements is that it can be used only once or, more precisely, only when the pattern of ownership of oil reserves changes dramatically as it did in 1973-74. Discount rates might change for other reasons, however. Something like this appears to have happened in the early 1980s. Although we have no direct evidence on the discount rates used by OPEC oil producers, we do know that interest rates and bond yields moved well above historic levels in the United States and elsewhere. Figures for a broad aggregate of U. S. corporate bond yields, in both nominal and real terms, are given in Table 3. Real yields are well below 5 percent until 1981 and increase sharply to about 9 percent in 1982-1984. Again, it is not clear that these are the relevant rates for OPEC producers. Yet, their movements, at least, are in line with those of other conceivable indicators of the opportunity cost of capital to the producers. To the extent that the producers' discount rates, in turn, reflect movements in the cost of capital (in a perfect capital market, they would coincide), relevant discount rates increased in the early 1980s. By the same reasoning that suggested a sudden drop in discount rates would lead to a jump in oil prices, a sharp increase in rates should lead to a fall in oil prices. This is exactly what happened.

Here, however, we come to another difficulty with the theory. By how much should prices have fallen? Since we do not know the producers' discount rates, it is hard to answer the question. Still, we might make some qualitative statements. Even in the absence of any change in discount rates, we

TABLE 3

Real Rate of Return, Corporate Bonds

Year	Nominal rate (Corporate, Moody's)	Inflation (GNP deflator)	Real rate
1973	7.80	5.80	2.00
1974	9.03	8.80	0.23
1975	9.57	9.30	0.27
1976	9.01	5.20	3.81
1977	8.43	5.80	2.63
1978	9.07	7.40	1.67
1979	10.12	8.60	1.52
1980	12.75	9.20	3.55
1981	15.06	9.60	5.46
1982	14.94	6.00	8.94
1983	12.78	3.80	8.98
1984	13.49	3.80	9.69

Source: Statistical Abstract of the United States, 1978 and 1986.

should have expected oil prices to fall back to the pre-1979 level as the market adjusted to the reduction in Iranian production that triggered the increase. With the very substantial rise in real interest rates, prices should have fallen still further. Yet, we observe that until early 1986 price was still in the $26-$28 per barrel range (i.e., still somewhat above the pre-1979 level, even adjusted for inflation). On the other hand, price has since then fallen dramatically to well below the earlier level--in fact, all the way to where it was (adjusted for inflation and the indicated royalty increase) before the first jump of 1973-74. But the ownership of the resource has changed. The current price would seem to imply that the producing countries are employing the same discount rate as the companies once did; perhaps they are. According to this explanation of oil price movements, they have followed changes in the relevant discount rates in an essentially competitive market environment despite the surface manifestations of cartel activity.

This is an intriguing possibility but, in my judgment, the discount rate explanation of oil price movements, though not demonstrably false, is at best too qualitative to yield useful projections. Finally, there remains a problem of timing. Why did the price jump immediately following the alleged fall in the relevant discount rate in 1973-74 but then take five years to fall in response to the sharp rise in the rate in 1981? It seems more plausible that the observed price changes occurred in response to changes in market structure that, in any case, yield relatively precise quantitative projections consistent with the observed changes. In attempting to predict future prices, then, let us focus on the prospects for OPEC while, at the same time, acknowledging that substantial shifts in factors affecting the relevant discount rate can have an impact--the direction of which can be determined.

V. Oil Prices in the Near to Medium Future and Implications for Energy Choices

Let us quickly review the "evidence from theory" on oil prices over the next several years--say to the early 1990s. If the world market is more or less competitive, then price this year (1986) should be in the range of $10-$16 per barrel with the spread accounted for by a plausible range of assumptions about the discount rates used by OPEC and other producers. If the market remains competitive and there are no exogenous shocks, such as wars or major discoveries, price can be expected to increase modestly in real terms. The annual percentage increase will be at a rate below the rate of discount.

Suppose, instead, the cartel is able to restrict production to the level consistent with joint wealth maximization. Then we would expect a price this year in the range of $22-$23 per barrel, increasing very gradually (the cartel, like the monopolist in depletion theory, exhibits a flatter price path than the competitive industry).

The basic question is, what are the prospects for effective cartel action over this period? In recent months we have witnessed what has been termed an oil "glut," an excess of production over consumption variously estimated at from 2 million to 4 million barrels per day. As long as this persists, it is hard to imagine that OPEC will be in a position to raise the price dramatically. Moreover, the market is affected by a substantial "overhang" in the form of excess OPEC production capacity. In 1973, OPEC accounted for just under 31 million barrels per day--a level that was maintained through 1979.[4] Production over the first five months of 1986 averaged a little less than 18 million barrels per day. Of the implied excess capacity of 13 million barrels, about 4 million barrels represent lost output from Iran and perhaps as much as 1 million from Iraq. Even assuming production from these sources cannot readily be expanded, we are left with a market overhang of about 8 million barrels and a combined overhang and glut of 10-12 million barrels.

At the new lower price, however (which, as we have seen, is consistent with competitive market conditions), we can expect increases in demand and decreases in competitive fringe supply. Also, demand will increase with increases in the income of the consuming countries. In the very short run, the price elasticities are probably too small to matter--as OPEC discovered when it initially raised the price. In the longer run, the response may be sufficient to eliminate the overhang and glut, thereby tightening the market and improving prospects for the cartel.

Let us carry out a simple exercise to determine the plausibility of this scenario. Assume a price decrease of 50 percent from, say, $26 per barrel in late 1985 to $13 per barrel in early 1986, just in the middle of the projected--and observed--range for the year. Given estimates of short- and long-run demand price elasticities, income elasticity, and competitive fringe supply elasticity, how soon will the market tighten to about where it was just before the price jump of 1973-74?

A recent paper by Gately and Rappoport (1986) estimates lag structures of price elasticities for the United States over a 10-year period for alternative specifications of the lag. Results suggest that, over the first two to three years following a price change (a period we might identify as the short run), the elasticity of response will be in the neighborhood of 0.1 (over the full 10 years, it increases to between 0.3 and 0.4--still less than other long-run estimates of over 0.5, presumably because adjustment continues beyond 10 years). Other things equal, then, we can expect a change in demand of about 5 percent over the next two or three years. Assuming these numbers are about right for the total OECD response, average early 1986 consumption of about 36 million barrels per day will rise by just under 2 million barrels.

Income elasticity is estimated by Gately and Rappoport at between 0.7 and 0.8. Assuming a figure of 0.75 and income growth of 3 percent per year, demand will grow by 2.25 percent, or about 0.8 million barrels per day, per year. In two years then, demand will have increased by just over 1.5 million barrels and in three years by just under 2.5 million.

Competitive fringe supply elasticity is much less certain since most econometric studies of the world oil market, such as Gately and Rappoport, focus on demand. Pindyck suggests a short-run elasticity of a little over 0.1. If this is correct, the 50 percent price decrease implies a production decrease of a little over 5 percent. For competitive fringe production of about 23 million barrels per day (the average for the first five months of 1986), this translates to a decrease of something over a million barrels.

Summing up the short-run demand and supply responses to the price fall, we can predict an increase in demand of almost 4.5 million barrels per day over the next three years and a decrease in supply of, perhaps, 1 million barrels. Taken together, these responses are more than sufficient to eliminate the excess supply, though they have only a small impact on the overhang. On the basis of this exercise, we can say that market conditions do not favor an immediate attempt by OPEC to dramatically increase the price of oil. In two or three years, however, or by the end of the decade, the situation could be different. The glut, at least, would be gone so that, if cartel discipline could hold production at current levels well below capacity, a price increase might stick. Still, the remaining excess capacity would provide some incentive for price-cutting behavior by producers.

In the longer run, even the excess capacity will disappear as demand continues to increase and competitive fringe supply continues to decrease. How many years are we talking about? At the end of six years or, in other words, by about 1992, the accumulated price elasticity (from Gately and Rappoport) lies between 0.15 and 0.20. Using the larger figure which is just double the three-year response, I calculate an implied increase in demand of 4 million barrels per day. Assuming continued income growth in the major consuming countries of 3 percent per year and the same income elasticity of 0.75, income-induced growth in demand over a six-year period comes to a little over 5 million barrels per day. The combined demand response is, thus, about 9 million barrels which is just on the threshold of the 10-12 million barrels needed to eliminate excess supply and capacity. Adding in just the short-run competitive fringe supply decrease of over 1 million barrels calculated earlier, we come up with a total of over 10 million barrels. Then, by the end of the six years following the price fall of early 1986--or by about 1992--the world oil market is likely to be quite tight, just as it was before the price jump of 1973-74.

Alternative assumptions about elasticities and exogenous income growth are clearly possible and would lead to some difference in the predicted timing of the market tightening. But it seems evident that this is coming in what we might call the medium run--almost certainly by the early to middle 1990s.

An important caveat here is that I am assuming that the price of oil will be affected only by market forces. Yet, it is widely believed that the increase of 1979-80 was the result of the Iranian revolution which removed about 4 million barrels per day from the world market. Clearly, further exogenous shocks are possible, even likely. But it is hard to predict the direction of the resulting effects, much less the magnitude. Suppose the Iran-Iraq war comes to an end with the prewar production capacity in both countries more or less intact. Iran is currently producing about 2 million barrels per day--up from 1.5 million just after the revolution but still about 4 million below the prerevolutionary level of nearly 6 million barrels. Iraq is producing about 1.5 million barrels per day--down from a prewar average of about 2.5 million. An end to the war could then be accompanied by as much as 5 million barrels per day of extra production. So perhaps the economic scenario is too gloomy (from the point of view of the consuming countries). On the other hand, a wider war (affecting the major producers of the Persian Gulf) seems at least as likely as an end to the war. The point is that, although such noneconomic events may well have an important effect on price, even the direction of the effect is problematic. Probably the best we can do under the circumstances is to represent the economic forces underlying market price movements while, at the same time, acknowledging that the resulting predictions can be upset by noneconomic events.

The chief implication of the predicted tightening of the world oil market, in perhaps as little as two or three years and quite probably in five or six years, is that decisions having consequences for oil and other energy use beyond the next two or three years ought to assign a modest probability to a sharp increase in the price of oil (to approximately \$23-\$24 per barrel) by 1989 and a very substantial probability to an even larger increase (to about \$25 per barrel) by 1992.

Even this may be too modest. If the increase comes after six years of price-induced expansion of demand and contraction of fringe supply, it may well be optimal for OPEC to "overshoot" as in 1973-74. Specifically, this implies a jump to a price in the range of \$28-\$30 per barrel, with a gradual easing to the long run wealth-maximizing level of \$25.

The moral is that it still makes sense to worry about the energy-using characteristics of buildings, appliances, cars, and industrial processes when making a long-run or investment decision. A short-run decison involving the pattern of use of the existing capital stock, on the other hand, need not be much concerned about the expected price increase.

VI. Concluding Remarks

In this paper I have sought to put some bounds on the sometimes frantic speculation about the course of oil prices, drawing on theoretical models of oil price behavior under different market structures, and on empirical findings about demand and supply elasticities. Contrary to popular belief of five or six years ago, oil prices are not likely to move any time soon into regions beyond \$35 per barrel nor, contrary to popular belief of earlier this year, are they likely to "free fall" below \$10 per barrel.

Instead, the most probable outcome appears to be pattern of very modest increases above current levels of about \$15 per barrel over the next several years with a good likelihood of a jump to \$25-\$30 per barrel shortly after 1990. Further, price instability is indicated to the extent that expectations of future prices are responsive to movements in current prices.

These conclusions are based on theory, evidence, and some guesswork about the economic conditions underlying the formation of oil prices. Clearly, noneconomic events, such as war in the Persian Gulf, can upset the economic predictions.

Footnotes

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1. For a more detailed discussion, see Fisher (1981), pp. 23-36.

2. The classic article appeared in 1931 in the Journal of Political Economy.

3. Other notable contributions to the theory of resource cartels, generally with reference to OPEC, include those of Kalymon (1975), Schmalensee (1976), Salant (1976), Cremer and Weitzman (1976), and Gilbert (1978).

4. Figures on oil production are taken from the Monthly Energy Review for May, 1986.

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