An Outlook on the Supply of Oil

*By Ferdinand E. Banks**

Summary

This article argues that we are now in the run-up to the last phase of the (conventional) oil cycle, which means that in a few decades, conventional oil will be recognized as being on - or nearly on - its last legs as the most prominent (and valuable) hydrocarbon resource. A certain amount of attention is paid to the concept known as the "length-of-life of global oil reserves", because in numerical terms this reduces to 45-50 years; this is essentially meaningless from a geological point of view. (It is also meaningless from an economic point of view given the distribution of oil reserves). Instead, more emphasis needs to be placed on the reserve-production ratio. There is also a brief discussion of the oil futures market. This market is invaluable where risk management is concerned, but it seems to be true that it is not as well understood as it should be. (This is one of the reasons why it is possible to spread so much misinformation on the place of futures in the new deregulated gas and electricity markets.) The claim here is that the long-term derivatives market is (and will likely remain) the swaps market, although it may be true that exchange traded futures and options can be combined with swaps or similar price protection schemes in order to form more comprehensive and flexible derivatives.

Introduction

Although it is estimated that 500 million years were required to create the stock of (conventional) oil that we began consuming in large amounts about 1860, the present age of oil will soon be approaching its last phase. Expectations are that by 2060 there will still be sufficient oil in the crust of the earth to fuel the lamps of China and California, although most likely there will not be enough to keep your Cadillac in the fast lane.

What about unconventional oil? Recently, in *Nature* (1997), Professor Henrik Houthakker (of Harvard University) expressed a poignant belief that technical progress will soon make up for increasing natural scarcities by developing acceptable substitutes, and/or lowering the extraction/exploration costs of new reserves. There is no point in shouting to the high heavens that he almost certainly is wrong, or for that matter elaborating on the futile experiments with, for example, tar sands and oil shale that took place after the first two oil price shocks. Instead, I prefer to say that while some - and possibly a great deal - of unconventional oil will eventually be available, it is unnecessarily reckless to believe, on the basis of evidence available at the present time, that it will be adequate from a quantitative point of view.

The consumption of crude oil at the present time is about 70 million barrels per day (70 mbbl/d), and increasing at 1.5 to 2 percent per year (1.5-2%/y). As will be emphasized below, the challenge posed by producing an amount of new oil equal to roughly 1.4 mbbl/d every year from a declining reserve base (and/or from unconventional resources) may turn out to be too much for the firms and governments managing the global oil industry -- unless, of course, they can count on being compensated for their efforts by some very healthy price increases.

If we turn to mainstream economic theory, the price alluded to above should rise to a level where an industrial substitute for the natural product can be produced in an amount sufficient to replace the natural product. No further speculation on this matter will take place in this paper because I do not want to encourage another wave of esoteric theories and manipulations based on the pseudo-scientific Hotelling model/hypothesis. Instead, as I have also done in my forthcoming textbook, I argue that economists - to include myself - must take a back seat to geologists and certain corporate players where consideration of the oil supply is concerned. Put another way, this aspect of energy economics is becoming too important to be left to economists.

One more topic can be broached here. At the present time much enthusiasm seems to be directed toward the possible replacement of conventional fuel (i.e. petrol/gasoline) in existing or a new generation of vehicles. According to Joanna Walters in a recent issue of *The Sunday Observer*, "tomorrow's world of vehicles that run on alternative power is around the corner". Suddenly I find myself thinking of the Tommy Dorsey orchestras rendition of the popular tune from World War II, *It Seems To Me I've Heard That Song Before*. It is definitely true that a new generation of vehicles is going to be necessary, and we can expect to see them on the highways and parked outside the better discos in the not too distant future, but whether a sufficient number of them are "right around the corner" remains to be seen. I doubt, however, whether they are going to appear *en masse* for a long time yet, and also whether (natural) gas is going to play the part in this transposition that Ms. Walters (and others) believe that it will play, because, like oil, there is less (conventional) natural gas in known deposits than many persons have deluded themselves into thinking, especially when the growth in world population and the escalating demand for electricity is brought into the picture.

This short paper is intended for easy reading, with the topics taken up elaborated on further in my textbook. A possible exception is the brief section on derivatives, but these materials seem necessary due to the deluge of untruths about electricity derivatives that the more sensitive of us are being exposed to on a daily basis, as well as some chronic misunderstandings about oil derivatives. A major problem in the latter case is the lack of attention paid to oil swaps. For example, two-thirds of Metallgesellschaft's derivatives position was in swaps, although a great deal of effort seems to have gone into concealing this not very concealable fact.

First the Bad News

Marvin Davis, the Denver and Hollywood investor who seems to be right most of the time, puts it as follows: "You don't have to be a cockeyed genius to see this coming." The problem is, however, that when the subject is oil, seeing is not always believing.

Davis says that he is scouring the globe for oil, and he is being joined by assorted billionaires and multi-millionaires who have picked up the scent of a coming oil boom. The large and not so-large oil companies are also stepping up their

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exertions, looking for what they call *new plays*, but at the same time upgrading their technology in hope of pressing more oil from the properties under their control.

Often they receive help from their governments who, unlike the television audience, are familiar with the underlying supply and demand fundamentals, and want to avoid an energy crunch. Many members of the energy bureaucracy are fully aware of what escalating oil prices mean for such things as inflation and productivity, and political stability. They also realize that with every passing day the world becomes more dependent on Persian Gulf assets; and that population growth and galloping consumerism in the developing countries in general – and Asia in particular have brought about a ravenous appetite for private transportation and the motor fuel that goes with it. That appetite is not going to go away.

As to be expected, everyone does not share these concerns. Several of our most prominent academic energy economists find the above kind of talk alarmist, while the American Petroleum Institute seems to think that there will always be enough oil, arguing that existing deposits are constantly being augmented from underground sources and that, as one of their spokesmen put it, "With all the reserves in place now, we have a 50 year supply of oil even if we didn't find another drop." Unfortunately I cannot formulate a knowledgeable comment on the first of these claims, other than to say that it doesn't sound very useful in a world where (on the average) 70 mbbl/d of oil are bought. As for the second, it will be shown that it is considerably less than useful.

The curse of modern macroeconomics is its tendency to resort to algebraic overkill instead of observation and common sense. Similarly, we don't need the Hotelling hypothesis or option pricing theory to tell us what is going on in the great world of oil. A simple parameter, the reserve-production (R/Q) ratio is capable of telling us a large part of what we need to know about that subject. It works as follows.

If the R/Q ratio falls below 10 (or 9 or 11, depending on the deposit), then the deposit is being 'damaged' in the same manner that sucking too hard on a straw will damage an ice-cream soda. The damage will be manifested by a reduction in the total amount of oil that can eventually be removed from the deposit. This *minimum* R/Q ratio can be designated the critical R/Q ratio, and in my teaching I usually take it as 10.

Now for the important point. When the R/Q ratio reaches the critical value, this critical value will determine production, in the sense that production must adjust in such a way as to hold the critical value (approximately) constant. For example, assuming a critical R/Q ratio of 10, suppose that we have R = 150 units of oil reserves to start with, and we want to extract 10 units per year for as long as possible. The initial R/Q ratio is 15, and after 5 years it has fallen to the critical value of 10. (150/10, 140/10, 100/10). For R/Q to remain at 10, production (Q) in the next period will be 9.09. In the period following that it will be 8.26, and so on. (The formula that can be used here is production in period, t, is $Q(t) = R(t-1)/(1+\theta)$, where θ is the critical R/Q ratio, and R(t-1) are reserves in period t-1. This expression is derived in my textbook.

For what it is worth, the life of this deposit is not 150/10=15 periods. Instead, it approaches infinity. More relevant, when production turned down, two-thirds of the deposit (= 100 units) was still in the ground. In the real world however, on the average, the production from a deposit will turn down with about half the deposit still below the surface. (And, conceptually, nothing in the discussion above changes if the amount of reserves is growing relative to the annual production, unless this growth is very large – which is not the case for reserves outside the Middle East.) Thus, the contention above that we have, for example, 50 years of oil even if we do not find more is misleading. In fact, once we look at the global distribution of oil reserves we see that it is dangerously misleading, because most of these reserves are owned by countries without the slightest interest in making the fantasies of the American Petroleum Institute come true.

Economics is an observational rather than an experimental science, and it occasionally happens that single events can tell us a great deal. I began watching the R/Q ratio in the United States when it was about 12, and nobody was more surprised than myself when it sailed past 10 without any pronounced effect on the aggregate flow of oil from that country's deposits. However when it was approaching 9, the inevitable happened in the form of one of the largest declines in oil output in modern American history. Furthermore, there will be no recovery from this situation – no genuine oil production cycle. Instead, according to the U.S. Energy Information Administration (EIA), in 10 years the United States should be importing 60 percent of its oil consumption, perhaps 10 mbbl/d, for an annual cash outflow of 100 billion dollars, if they are lucky.

At the present time I occasionally observe the R/Q ratio in the oil producing world outside OPEC. This is somewhere between 17 and 18, and slowly falling. In a decade it should be approaching the magic number, whatever that happens to be. Not only that, OPEC is also undergoing some important compositional changes. If we move to a 10-15 year horizon, then according to Leo Drollas, chief economist and deputy director of the Centre for Global Energy Studies (London), such OPEC stalwarts as Libya, Algeria, Nigeria, and Indonesia will be well past their prime where oil is concerned. I can also mention that the North Sea, which seems to figure so prominently in the ruminations of many energy professionals (although its total reserves are only 1.5 percent of the world total), will at best be a minor oil province at that stage of the game – or, as it might be better put, that stage of the run-up to the oil market end-game.

What all this means is that the Middle East, with 65 percent of the world's oil reserves, but just over a third of global production, will gradually assume an unambiguous leadership of the supply side of the world oil market. Earlier this year the associate director of the Cambridge Energy Research Associates in Paris, reacting to news of a higher oil output in the North Sea, said that "OPEC's fate is not in its own hands". The truth is, as Professor Milton Friedman found out almost two decades ago, OPEC's fate has been in its own hands since October, 1973, and never more so than at the present time. In the major OPEC oil producing countries both exploration and investment are down to minimal levels, with output pressing on (maximum) capacity, because the decision makers in those countries have come to understand that the lower the gap between output and capacity, the less the temptation – and need to sell oil for

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bargain basement prices.

This arrangement has led to what Paul Tempest, Director General of the World Petroleum Council (London), has called a "paradox": the great majority of investment spending on oil is taking place in high cost, relatively oil poor regions outside OPEC and/or the Middle East, and thus causing reserves in these regions to be depleted much faster than elsewhere. As Tempest makes clear, a consequence of this behavior is that even sophisticated observers are "dazzled by buoyant production growth among non-OPEC producers". These observations, and their significance, need to be understood by everyone who is seriously interested in how much we are going to have to pay for oil in ten or fifteen years.

More of the Same

As far as I can tell, those wealthy investors in the United States who plan to become wealthier via ownership of the right energy shares and properties, are looking more at demand than at supply. As the very successful Richard Rainwater expresses it: "Rising global demand paints a picture for me that doesn't have any other outcome. The price of oil is going to have to come up."

What he should have added was, it will keep 'coming up'. For example, given the present global oil consumption, and an average rate of increase of 1.5-2%/y, about 3 million extra barrels of oil per day will have to be found by midnight, December 31, 1999, when the New Year's eve parties start ringing in the next century. Turning to important periodicals such as *The OPEC Bulletin* and *Petromin*, we can get a great deal of information about ongoing and proposed undertakings in every corner of the world that will be of assistance in mustering that extra 3 mbbl/d. There doesn't seem to be anything exciting happening North of the Bay of Fundy, or within shouting distance of Tierra del Fuego, but we have been assured by various experts that "lessons learned in the North Sea, a hostile environment, are applied elsewhere."

In perusing the aforementioned lists of projects, I see new output coming on stream in hostile, friendly, and neutral settings. A hundred thousand barrels a day here, a hundred thousand there, maybe even an extra half-million or more, eventually, from Colombia. According to Lawrence Goldstein, president of the Petroleum Industry Research Foundation (New York), the increased demand for oil up to the year 2000 will largely be met by increased non-OPEC supplies. As for OPEC, they will find themselves "in a stagnant volume environment at best".

He might be correct. I expect the non-OPEC countries to squeeze out most of that extra 3 mbbl/d, even though the arithmetic looks a bit tricky, and one of Mr. Goldstein's predecessors at the Foundation clearly stated that OPEC had "turned the corner, and was moving back into the driver's seat." He is almost certainly not correct, however, in saying that in the 5 years after that, which will be distinguished by still another 6-7 mbbl/d being required, non-OPEC supplies will rise to the occasion. When the world wants those extra supplies, they will have to go to OPEC, and the longer they wait, the harder they will have to *work* their own deposits. As a result, the steeper the decline in non-OPEC production is going to be when it finally takes place: it is going to resemble the precipitous downturn experienced earlier in the United States. It does not need to be said, I hope, that when the oil importing countries find it necessary to approach OPEC for the greater part of the supplies that some mistakenly believes they can obtain elsewhere, they will have to have more than their hats in their hands.

Among the most prominent of these consumers will be the automobile and motorcycle owners of Asia. Philip Abelson, the former editor of *Science* magazine, recently said that these countries are going to require enormous amounts of motor fuel, and they will be able to export the labor intensive goods needed to buy this fuel, even if its price is rising. As a result, in order to keep this price – and the price of oil from which it is produced – from exploding upwards, Abelson calls for a concentrated research effort to find alternative fuels. Whether this effort will be put forth or not remains to be seen, but personally I cannot see it having much effect in the near future if it began tomorrow.

Many students of world oil demand have zeroed in on China as the country in which the future of the oil price will be determined. This makes sense, perhaps, but I suspect that more attention needs to be paid to Russia. If that country pulls itself out of the (macroeconomic) doldrums, which is not impossible, but is unable to put its oil production and distribution apparatus in order, then instead of a *research effort* to find new motor fuels, something on the scale of the Manhattan Project might be necessary. Eastern Europe is also going to be a very large demander of motor fuel (and petrochemicals), but unlike the Former Soviet Union, they do not have much to offer in the way of supply.

Casual watchers of the world oil scene are mostly concerned with the motoring habits of our friends in Shanghai, Kuala Lumpur, and Bombay, but little or nothing is mooted about the needs of farmers and others in, for example, rural Mexico, Thailand, and Botswana. I seem to remember giving a lecture once called *The Price and the Value of Oil*, in which I came to the conclusion that – despite what we teach in microeconomics – price may not always be an unequivocal measure of value. Clearly, a liter of oil in the tractor of one of those farmers is of more value than it is in my Volvo should I get a sudden urge to wheel into Stockholm in order to find out whether Madonna has cut a sensual new version of *Papa Don't Preach*, and the same thought applies to oil as an input into fertilizer. In addition, where energy resources are concerned, oil has a unique flexibility that makes it invaluable to those countries that are still far from the *Tiger* category. As Paul Hawken pointed out many years ago, developing nations can make virtually any sacrifice except drastically reducing their input of energy, while in the long run, not being able to economize on energy could make the industrial countries more vulnerable.

A Simple But Important Observation About Oil Futures Markets

As far as I was concerned, the two main topics at the 18th international meeting of the International Association for Energy Economics (IAEE), were electricity deregulation – which generally reduces to reregulation; and the oil futures markets in the wake of the widely advertised misfortunes of Metallgesellshaft (MG). Where the first of these topics is concerned, people like myself tried but failed to show that even hardened derivatives traders are running the risk of overdosing on aspirin because of gyrations on the (Scandina-

vian) electricity futures markets, and this continues to be true. By the same token, it was not revealed – as it should have been revealed – that the hedging of price risk via oil futures markets is not always a straight-forward exercise. Here I can refer once more to the paper by Professor Houthakker mentioned earlier, where it is claimed that obtaining adequate oil in a decade or two will not be much of a burden because long-range planning can be facilitated by futures (and options) markets. In my judgment, this contention is wrong, unless you think that what happened to MG cannot happen to other firms.

Exactly what is the problem here? The main dilemma is that many students of commodity and financial derivatives are so busy trying to confect econometric masterpieces that they have completely disregarded the basic mechanics of futures trading. For example, I have always told my students that beyond 9 or 10 months, the derivatives market in most commodities generally narrows to the swaps market, with activity in futures and options being reduced to a comparatively low level. This has become common knowledge in New York and Chicago, and most likely London and Singapore; but at the Washington (i.e., 18th) meeting, we were grandly informed that futures contracts for crude oil now exist with maturities up to 7 years. When I asked one of the gentlemen active in this market if this were true, his reply was that if contracts of this maturity are what producers and consumers of oil naively desire, then *The Market* will make them available.

What he did not say, however, was that liquidity in such long duration 'paper' markets was almost non-existent, and if at some point late in those 7 years a transactor wanted to close a position, then he or she might have to accept a resounding loss. The advantages presented by copious liquidity (i.e., always being able to trade at or near the last quoted price) are why large traders, such as MG, elected to employ short-dated contracts, although 'rolling over' these contracts poses dangers of its own. (It might also be useful at this point to note that a protracted shortage of liquidity is the reason why options traded on the Oslo electricity exchange have occasionally been grotesquely overpriced, and why – as I predicted a year ago in my paper *Economic Theory and Electricity Futures Markets* – the Finnish electricity exchange, Elex, has fallen on very hard times).

Another interesting (but false) idea advanced (again) at the Washington meeting was that the major oil producing countries could hedge the greater part of their production on existing exchanges. The sad truth is that if producers were to take this kind of advice seriously, they would swamp the market – driving, for example, the price of paper oil well below that of physical oil, and thereby making it impossible, on average, to lock in the price of physical oil. This will be explained below.

As far as I know, there is no listed market for very long dated futures and options, i.e., with maturities of more than 18 months. Instead, these derivatives are traded by a few dealers, at a price which these dealers think will compensate them for the risks they are taking, which by extension means that entry and exit costs are unknown. Such is the wonderful world of *price discovery* in long term situations. By way of contrast, commodity swaps can (in theory) enable producers and consumers to avoid exposure to adverse price fluctuations by locking in prices for a comparatively long period. However, since a particular transactor might deem future price fluctuations favorable, many swaps involve fairly short maturities.

Of course, by *rolling* futures positions forward, it is theoretically possible to think in terms of any maturity. As MG found out, however, there are occasions when it is less risky to be exposed to an unknown oil price, then to become involved with a strategy where futures positions were concentrated (or *stacked*) in short-dated futures (and swaps) that had to be rolled forward monthly or bimonthly in order to maintain its hedge over a horizon that, reputedly, was a decade.

It is also a well known fact that under normal circumstances liquidity – as measured by open interest – builds up gradually over the life of a given futures contract, to collapse rather rapidly as the maturity date approaches; but on a very long dated futures, the opposite arrangement would not be unnatural.

Now for the main item of business. I was informed at the Cambridge (UK) meeting of the IAEE, early in the 1980s, that there was not enough liquidity on all the futures markets in this old world of ours, to perform the hedging that some persons insist should and could be performed on futures markets – where these *persons* are often associated with futures exchanges in one capacity or another. Why do they continue to make this mistake? A part of the answer is that they do not understand that where, for example, short hedging is taking place, the price being locked in is the futures (i.e., the *paper*) price, and not the spot (i.e., the *physical*) price. (Short hedging involves protecting against a price fall; long hedging against a price rise).

An example might be useful here. Suppose that at time, t, both the paper price (F) and the spot price (S) were 20, and at time T – the maturity date – the spot price falls to 10. Because (in theory, and for the most part in practice) at the maturity date spot and the futures prices converge, the loss on physicals is completely offset by the gain on futures: $-10 + 10 = 0$.

But now suppose that country X decides to hedge its entire production. Assuming that X is a large producer, the dramatic increase in the supply of futures would then force down the price of these instruments, as per the analysis in my textbook. Suppose (unrealistically) that it instantaneously forced it down to 15. Then the gain on futures ($= 15 - 10 = 5$) would not offset the loss on physicals ($= 10 - 20 = -10$). This is what some observers claim went wrong with MG although I doubt whether it is this simple. In the numerical example here the market moved from neutral, with $S = F$ to backwardation (or inversion), with $F < S$. This is bad news for a short hedger.

But it would have been good news for MG, since they were hedging long. As bad luck would have it, however, MG's strategy of rolling its short term long positions forward ran into problems when the futures market went into a sustained contango (with $F > S$). Some question can also be raised as to whether a hedge ratio of unity (with the size of the position in futures equal to the size of the exposure) was wise, but that issue will be left to the experts to mull over, since it is not easy to get right.

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Conclusion

Almost 15 years ago I published a book on oil in which I got most things right; but after that I have generally been wrong about the trend price of oil. Since 1983, I have predicted that it must begin to climb. Instead, until recently, the real price slowly descended.

But, as they say, what goes around comes around. When the rest of the energy people claimed that the oil price had to go up, in the 1970s, I joined them, and stayed on long after they left the chorus line. Now they are joining me. Of course, the trend price will not go up tomorrow, and obviously it would be a good thing for all of us who are on the 'buy' side of the oil scene if it never went up, but the only way that I can see this happening is if the Middle East producing countries come to the conclusion that they prefer less money to more. Frankly, I would be extremely surprised if this took place.

"If we were smart," Richard Rainwater has said, "we would be encouraging OPEC nations to put lots of money in the ground, and would be signing the kinds of long term contracts so that enough oil would be coming on line in 1999, 2000, 2004. And we would be willing to pay higher prices today to guarantee us access to that oil." (This, incidentally, is not the kind of "planning" that Professor Houthakker, and certain others, have in mind.)

Readers of my forthcoming textbook will not have a difficult time finding a similar argument in several chapters; however, I find it hard to believe that a consensus of oil consumers are prepared to accept Mr. Rainwater's approach at face value. Instead, I am afraid that too many people are prepared – even anxious – to believe that new technologies and various financial incentives will enable us to find our oil salvation West of those fascinating Shetlands, beneath the Eiffel Tower or the Via Flaminia, or for that matter on the floor of the New York Mercantile Exchange.

Appendix

Where did Hotelling go wrong? Answer, he didn't; but he failed to complete his algebraic analysis: although he recognized the importance of capital, and mentioned it in a greatly ignored paragraph in his paper, he did not include it in his algebra.

For simplicity, let us consider a two period situation. V represents discounted profit, with ' referring to the first period, and " referring to the second period. p, q, and c represent price, quantity, and average unit cost for the appropriate period; while R is reserves, P the price of a unit of capital, K the amount of capital, and r the rate of interest. Assume constant returns to scale, and no depreciation. The usual Hotelling results can be obtained by operating (in the usual fashion) on a simple Lagrangian where capital costs are (unfortunately) ignored:

$$L = V'(p,q,c) + V''(p,q,c) + \lambda\,[R-(q'+q'')]$$

Here, λ is a multiplier, as are alpha and beta in the following expression, where the need to pay the rental charge each period for the (nondepreciable) production factor capital (K) is explicitly recognized. Our Lagrangian thus becomes:

$$L = V'(p,q,c) + V''(p,q,c) + \lambda[R-(q'+q'')] + \alpha(p'q'-c'q'-rPK) + \beta(p''q''-c''q''-rPK)$$

Now, if the usual operations are performed, we do *not* end up with the well known (but impotent) expression $\Delta p/p = r$, where p is the *net* price. This matter is further discussed in my textbook, but on an elementary level.

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