A MODERN SURVEY OF WORLD OIL: REALITIES AND DELUSIONS

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Contents

UNESCO – EOLSS SAMPLE CHAPTERS

Summary

This is a modern and up-to-date survey of the world oil market. Its purpose is to introduce readers to some of the economic and political forces that determine the price of oil, which means clarifying much of the oil production economics that is only alluded to in conventional economics textbooks, as well as most energy economics presentations. For instance, conventional textbooks almost always fail to stress (or for that matter to mention) the stock-flow models that are essential for understanding short-run oil pricing, as well as the pricing of many other commodities. Long-term pricing is also discussed, pointing out the importance of long term (flow) supply and (flow) demand trends in theory, and also in the present global oil market. Of late, the place of speculation in determining the oil price has been a source of considerable debate in both the academic and popular press, and the contention in this chapter is that the role of speculation in the oil market is badly understood, and that over the past few years the key elements in oil pricing are flow demand outracing flow supply, as well as the increased sophistication of OPEC strategy.

1. Introduction

This long survey examines several important aspects of the world oil market. It also brings up to date some of the materials on oil in the author’s two energy economics textbooks [1, 2], as well as a few later publications. A major of this chapter is directed toward all categories of readers, in that the author wants to present – on a non-technical level where possible – some economic logic that is useful for contemplating recent and future trends in the availability of oil, and thus its price. Unfortunately, in most academic economics courses, these items are usually ignored in favor of simplified presentations such as the late Harold Hotelling's model of exhaustible resources [3]. Hotelling's model is a construction that was openly cursed by several members of the OPEC directorate when, after the dramatic run-up in oil prices following the first and second oil price 'shocks' (in 1973 and l980), those prices unexpectedly ceased to perform the way OPEC executives thought was appropriate. The author can also mention that Hotelling was a brilliant economist, and he considers his paper on exhaustible resources an unlucky digression.

The word "modern" also requires some explanation. In this chapter, and hopefully elsewhere, it means relevant, knowledgeable, today, and the opposite of unscientific or inapplicable. At the present time seminar rooms and the blogosphere are filled with tiresome variations on trivial or archaic energy themes, and while a few of these deserve our attention, many of them should be ignored. Worst of all are those that – intentionally or otherwise – mislead decision makers about the likelihood or seriousness of a protracted energy shortage.

In the penultimate section of this chapter the author examines several financial aspects of the oil market – to include the influence of speculation on the oil price. This is a topic that is often overlooked in academic energy economics publications, despite its constant appearance in the popular and business press. The author has been careful to use as little mathematics as possible in this exposition, remembering that Nobel Prize winners in physics like Albert Einstein and Enrico Fermi never hesitated to insist that scientific discussions should make every attempt to avoid becoming encumbered with superfluous mathematics. As a result, readers who stumble across unwelcome symbols in what follows should simply proceed to the next expanse of pure text. The author sincerely hopes however that all readers will carefully examine Figure 1 (and the short explanation accompanying it), which is much less complicated than might initially appear.

Here it can be mentioned that it was largely due to the over-employment of inconsequential mathematics – particularly in the learned journals – that it took so long for mainstream energy economics to attain the status it deserves. Among other things, this has resulted in a failure to recognize that if there is an insufficiency of energy in the industrial world for even a limited period, injurious economic and political consequences could result, particularly if at the same time there are pronounced macroeconomic instabilities. In particular, many countries/regions are increasingly vulnerable to shortages of e.g. oil and electric generating capacity.

2. The Bottom Line in the Peaking Dispute

"The production of energy is the moving force of world economic progress." - Vladimir Putin

UNESCO – EOLSS SAMPLE CHAPTERS

Michael Rothman, formerly chief energy strategist at the investment bank Merrill Lynch, puts it as follows: "the prosperity of the world hinges on oil", by which he means the price of oil. A great deal of attention was paid to this point of view in the author's course on oil and gas economics at the Asian Institute of Technology (Bangkok), and he made it clear that students who preferred a passing to a failing grade would have to learn some of its details perfectly.

The issue here is simple. The OPEC countries – who may produce about 40 percent of world oil (while possessing more than 50 percent of confirmed *reserves*) – are now absolutely and irrevocably in position to play the major role in the determination of the oil price. As Rothman pointed out, *after the world oil price escalated to the vicinity of $150/b* (in the summer of 2008), *for the first time since the Second World War there was no meaningful supply response by producers outside OPEC.* Although he did not elaborate on the reason for this unprecedented dilemma, it is easy to infer: at the present time the non-OPEC oil supply is in the process of peaking – although some observers feel that this dramatic but largely unnoticed development is no longer an unresolved process but a historical fact.

What about the future of the global oil supply? This is a highly contentious matter, and the author approaces it as follows: everything you need to know about the likelihood of global peaking can be deduced in the course of a casual examination of the peaking of oil production in the United States. As far as the author is concerned, anyone who spends an hour or so reviewing what happened to the U.S. oil supply during and after its peaking in l970, should realize that a global peak is inevitable, and regardless of when it actually takes place, it should be accepted that it might arrive sooner rather than later. At the same time he feels it necessary to assert that given the oil price increases that may take place after the present global macroeconomic difficulties are mitigated, the peaking of oil output should be a far less captivating topic than at the present time. If the oil price touches its previous summit, while at the same time indications are that it will continue to rise, the macroeconomic 'fall-out' would leave little time or gusto for theorizing about local or global production issues.

Output in the 'lower' 48 states of the U.S. peaked at the end of l970 at a value of about 9.5 million barrels per day (= 9.5 mb/d) – which is approximately the present output of both Saudi Arabia and Russia, the largest producers of oil in the world. When that peaking took place there was still an enormous amount of oil onshore or directly offshore the United States. Production then slowly dropped to 7.5 mb/d, but when the giant Prudhoe Bay field in Alaska came on line, it resulted in the output in the entire U.S. (i.e. 50 states) turning up. Unfortunately however, the previous peak was never regained. Instead, total U.S. production stopped well short of 9.5 mb/d, and once again began to decline. Today U.S. output is approximately 5.7 mb/d, and there is only one way for it to go, which is down.

Now take a good look at the production curves for the 50 largest oil fields in the world. What this will reveal is that a majority of these fields have unambiguously turned down (i.e. peaked) or their output is on a 'plateau'. This being the case, ask yourself how is it possible for anyone to sincerely believe that a global peak will not take place. Readers should also note the word "sincerely". What it means is that there are people who know

UNESCO – EOLSS SAMPLE CHAPTERS

better than the author does that a global peak will arrive, but have excellent reasons – of a career and/or financial nature – for claiming the opposite.

One of these persons is the director of global oil and gas research at an influential consulting firm, who employed the picturesque word "garbage" to describe the work of peak-oil believers. If you encounter him some fine day, tell him that the output of the U.S. has peaked, as has oil in the UK and Norwegian North Sea. Given the opportunity you can also mention that what was the second largest field in the world just a few years ago – the Cantarell field in Mexico – has peaked and is declining at a startling rate. Moreover, the last time the author looked, an influential publication – the *Oil and Gas journal* – claimed that Middle Eastern oil could start peaking in a decade.

The author usually cites two key reasons for the decline of the Cantarell and other fields. One of course is production, which is the straightforward removal of reserves; while the other is called *natural depletion* (*or natural decline*). This is a falling off of the productive capacity of a field or reservoir that supplements the decrease in reserves due to conventional production, although it needs to be appreciated that present production as well as the *rate* of present production influences natural depletion. In economic theory this process has a certain similarity to 'depreciation by evaporation', in that this decline reduces the value of the asset.

When mention is made of Mexico, attention is often called to two ostensibly very large exploratory successes in the Western Hemisphere. One of these is in the deeper part of the Gulf of Mexico, and the other is in deep water off the Brazilian coast. Researchers and lecturers can easily be located who for one reason or another would like to convince their audiences that these 'strikes' will succeed in returning the oil price to a level which they picture as justified by 'fundamentals' – i.e. supply and demand. The opinion here is that this optimism should be heavily discounted. Accordingly, it would be a good thing for all of us on the buy side of the petroleum market if our political leadership did not make the mistake of accepting erroneous forecasts and theories in which the availability of oil is overplayed for political and commercial reasons.

The Russian oil output is probably close to peaking, and in any event the director of one of the largest Russian firms says that his country will never produce more than 10 mb/d. This is a nice round number (that may be slightly wrong), but it happens to be one-tenth of the amount (= 100 mb/d) that the present CEO of *Total* (the French oil major) – Christophe de Margerie – says is the absolute maximum for global oil production. If this is not sufficient, consider the following. The *discovery* of what we think of as conventional oil peaked in l965. In the early l980s the annual *consumption* of oil became larger than the annual discovery, and at the present time only about 1 barrel of (conventional or near-conventional) oil is discovered for every 3 consumed. According to a British Petroleum (BP) document, of 54 producing nations only 14 still show increasing production. 30 are past peak output, while output *rates* are declining in 10. To claim, as a few observers still do, that all of this bad news does not imply an eventual global peaking, is the same as implying that the (oil) whole is less than the sum of the parts, which is a myth that no intelligent observer would rush to accept if they realized what they were saying or thinking.

UNESCO – EOLSS SAMPLE CHAPTERS

Before continuing the author would like to suggest that serious readers examine an important article of Professor Douglas Reynolds [4], in which he presents and explains a simplified version of the "Hubbert Curve". In a series of papers that began about l962, or earlier, M. King Hubbert paved the way for instant fame when, employing a statistical analysis based on the logistic distribution, he correctly predicted that oil production in the 'lower 48' of the United States would peak before 1971. As far as the author can tell, the 'lower 48' peak arrived in the closing months of 1970.

There have been a steady stream of discussions about this phenomenon, some of which are completely without a scientific basis, but the conclusion of Reynolds tells the entire story: "Using the U.S. and Russia as examples, it is easy to see the Hubbert curve pattern that any given region will follow during the course of oil exploration, no matter what type of economic system is in place. What happens in one region will also happen in another. What happened to the U.S. (i.e. a Hubbert-type increase and subsequent decline in oil production) happened to Russia. What happened to Russia and the U.S. will happen to the entire world. It is only a matter of time. However, all indications are that that time is now."

The author prefers the word 'exploitation' to "exploration" in the above; and when Reynolds published his article the author found it difficult to accept his belief that "all indications are that that time is now", but as it happens he was very correct. In the latter years of the 20th century the oil price almost descended to $10/b, which meant that the price of a barrel of oil was about on the same level as the price of a barrel of coca-cola, while at the beginning of the 21st century the physical investments of major oil companies were purported to be justified if the oil price reached and maintained a level in the low twenties. As for the OPEC directors, in their public pronouncements they often spoke of a "desirable" price range between $22/b and $28/b, although mention of the latter price often gave the impression that it belonged in a fantasy rather than the real world. But regardless of what the oil price was at that time, or what observers thought it would be, it began a sustainable escalation (rather than a 'spike') in 2003, and it moved in such a manner that by the middle of 2008 some of the leading energy professionals in the world were talking about a price of $200/b before the end of 2010. Only the bad macroeconomic news that began in late 2008 checked the oil price rise.

3. Remembering the Oil Price Future

One of the high points of 2007 course of the author on oil and gas economics in Bangkok, was a long discussion of the predictions of the future oil price sponsored by the International Energy Agency (IEA), and about the same time the United States Energy Intelligence Agency (EIA). In both cases it was forecast (at that time) that oil production in 2030 would be 121 mb/d, which implies that no output peak had occurred. It was a simple matter for the author to convince his students that this forecast was absurd, because assuming linearity the author demonstrated that among other things it implied that Saudi Arabia would produce about 20 mb/d of oil. Since memories tend to be short when the subject is oil, the author should perhaps mention that a Saudi production of 20 mb/d was the goal of the foreign oil companies operating in Saudi Arabia before the nationalization of their properties, and which – according to some

U.S. government documents – was an economic destination that was unconditionally rejected by the government of that country.

35 years ago the king of Saudi Arabia informed anyone who was willing to listen that his country has no intention at all of ever producing that much oil. The reason he gave – which made all the sense in the world – was that the largest part of the oil under his control would be needed by future generations of Saudis. In a book on oil that the author wrote many years ago [5], he said that Saudi Arabia would never produce more than 12mb/ day of oil, however a few years ago the Saudi oil minister promised oil importers in general, and the U.S. in particular, that his country intended to raise the output of oil to 15 mb/d, and output could easily be kept at that level for 50 years.

The author certainly found no reason to dispute this claim in his publications and lectures, because he understood that these assurances were not intended for him. They were and still are directed at the great number of energy professionals and researchers who in one sense or another are selling bogus assertions to influential persons and institutions, who in turn are in position to use spurious pronouncements about present and future oil supplies to increase profits and/or career prospects.

It is also easy to identify the establishments that are especially interested in the circulation of myths of the above nature? First on the author's list are several of the larger oil companies in North America and Europe, because if voters came to accept with all their hearts and minds that the oil price would not only touch $147/b again, but continue up, then many of them might stop buying vehicles that used traditional means of propulsion, and instead would elect governments capable of protecting their mobility by subsidizing or giving tax incentives to alternative transportation technologies. In a country like the United States, about 75 percent of oil is used to produce transportation fuels, while most of the remainder goes into petrochemicals. The author therefore believes it can be argued that while oil firms can collect many billions of dollars if a reduction in the demand for transportation fuels caused them to place more weight on supplying petrochemical firms with inputs, this could not possibly replace the monetary gains that would come their way if they are able to greatly extend their present oil production and refining activities.

One of the most important topics treated in this chapter and the author's textbooks has to do with the power of OPEC, but first the author wants to examine something that has not been taken up in an optimal manner by energy researchers. The author is thinking of the economics and mathematics associated with the decision by M. King Hubbert to employ the logistic distribution in the empirical work that enabled him to predict the l970 peaking of U.S. oil production.

Hubbert's thinking must have gone as follows. The more oil (*reserves*) in a particular plot of earth, i.e. a *deposit*, the easier they are to extract. After a while though oil becomes more difficult to lift, which might be due to a decline in *deposit pressure*, which in turn might be influenced by an increase in *natural depreciation.* Eventually a natural production limit is reached or approached that is set by the amount of the resource (i.e. oil) in the deposit. In the mathematics below, the resource ceiling will be

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called R^*. This is the estimated quantity (in barrels) of reserves in a particular deposit, region or globally, depending upon the object of the exercise.

It does not take much of a background in mathematical economics to suggest that what we have thus far 'might' be presented by the simple equation $dR/dt = \lambda\left(R^* - R\right)$, where R is reserves extracted, and dR/dt is the change in reserves *being* extracted per unit of time, as the available deposit goes toward exhaustion. As for λ, this is a constant, and in the derivation below it is modified to take the form of the initial depreciation rate of reserves. dR/dt is clearly the production from the deposit, or q units per time period, but this can be overlooked at present because while the above equation might be interesting in an unsophisticated context, it does not lead to the 'bell-like' (= 'normal-like') curve that we associate with production from a typical oil deposit over a long time period. The beauty of the logistic equation is being able to justify its use on the basis of economics, and not just its ability to generate a recognizable piece of geometry.

As with the theory of economic growth, what has to be done is to work with *rates* rather than the derivative. Using the same symbols as above, the expression that will be employed as the first step in the derivation of the logistic equation is given in (1):

$$\lambda' = \frac{1}{R}\frac{dR}{dt} = \lambda\left(\frac{R^* - R}{R^*}\right) \qquad (1)$$

Now for a key recognition. First of all, when $R \to 0$, then $\lambda' \to \lambda$, but when $R \to R^*$ – or the amount of the deposit that has been extracted is approximately equal to the amount available (R^*) – then $\lambda' \to 0$, because there is no more to extract. Clearly, as R increases, then λ' – the rate at which exhaustion is taking place – decreases. At this point it might be useful to recognize that λ' is also analogous to a growth rate: it is the rate at which the deposit is being depleted, and it declines as reserves are exhausted. Observe that instead of using ($R^* - R$) on the right hand side of (1), the author used $\left[\left(R^* - R\right)/R^*\right]$. This was necessary in order for the units on both sides of the equation to match. As noted, λ is analogous to a growth rate, and *ceteris paribus* can be taken as constant, but $\left[\left(R^* - R\right)/R^*\right] = \left[1 - \left(R/R^*\right)\right]$ is a 'damping factor' that is directly related to the limit put on production by the availability of the resource: it reduces λ'.

A problem with (1) is that it does not look like the logistic equations you see in your favorite mathematics book, and so it will have to be adjusted. Doing this is uncomplicated and involves no more than treating (1) as a differential equation. Then we get:

$$\frac{R^* dR}{R(R^* - R)} = \lambda dt \Rightarrow \int \frac{R^* dR}{R(R^* - R)} = \lambda t + \text{constant}(c) \qquad (2)$$

UNESCO – EOLSS SAMPLE CHAPTERS

Dealing with this apparently complicated integral is straightforward:

$$\frac{R^{*}dR}{R(R^{*}-R)}=\int\left(\frac{1}{R}+\frac{1}{R^{*}-R}\right)dR=\ln R-\ln(R^{*}-R)=-\ln\left(\frac{R^{*}-R}{R}\right)$$

Thus we get with this expression and (2):

$$\ln\frac{R^{*}-R}{R}=-\lambda t-c \quad (\text{or}) \quad \frac{R^{*}-R}{R}=e^{-\lambda t}e^{-c}=ae^{-\lambda t}$$

Observe that the constant e^{-c} is now written as a. From this we get the logistic equation:

$$R=\frac{R^{*}}{1+ae^{-\lambda t}} \qquad (3)$$

Since $dR/dt=q$, it is a simple matter to derive a Bell-like curve from (3), particularly when a few more manipulations yield the curve's inflection point, which is $R'=R^{*}/2$ and $t'=2\ln a$. This inflection point is the maximum for the Bell-like curve, and returning to the previous discussion, Hubbert's t' was 1970. A great deal of the subsequent discussion about applying Hubbert's work to the entire world had to do with the value of R^{*}. Persons who want to believe that there is plenty of oil in the crust of the earth, and so t' would not be soon, want R^{*} to be extremely large.

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Biographical Sketch

Ferdinand E. Banks performed his undergraduate studies at Illinois Institute of Technology and Roosevelt University (Chicago), graduating with honors. He has the MSc from Stockholm University and the PhD from Uppsala University. He is professor at Uppsala University, and has been visiting professor at 5 universities in Australia, 2 universities in France, The Czech University (Prague), Stockholm University, and has held energy economics professorships in Singapore, Hong Kong, and the Asian Institute of Technology (Bangkok). He has also been a lecturer in mathematical economics in Dakar (Senegal) and Lisbon (Portugal). He was an econometrician for UNCTAD in Geneva, Switzerland for 3 years, and fellow of the Reserve Bank of Australia when he was visiting professor of mathematical economics at the University of New South Wales (Sydney). He has been a consultant for the Hudson Institute in Paris. He has published 12 books, to include 2 energy economics textbooks, and more than 200 articles of various lengths.

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SAMPLE CHAPTERS