ECONOMIC THEORY AND THE PRICE OF OIL

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Abstract

The purpose of this article is to discuss several factors that influence the present and future price of oil. It also extends and brings up to date some of the arguments in my new energy economics textbook (2007). Emphasis is placed on the new demand (especially from Asia), a shortage of oil in the crust of the earth (given present and future demand), and perhaps most interesting from a purely theoretical point of view, the diversifying 'out of oil' by key producers in OPEC. Short run pricing is also considered, there are some comments on futures markets, and I complete the discussion by claiming in the article's conclusion that the real price of oil has not *decreased.*

Key Words: *Futures contracts, diversification, natural decline, real price, stock-flow*.

Introduction

On the second of January, 2008, at approximately the same time that I was skimming an offbeat article by Christopher Helman with the title 'Really, really cheap oil', (*Forbes*, October 2, 2006), the price of oil on the New York Mercantile Exchange (NYMEX) touched one hundred dollars per barrel (=$100/b) for the first time in modern history. Almost immediately it declined by a small amount, however the statement had been made: a fundamentally different oil era was now in the offing, and this disturbing state-of-affairs appeared unresponsive to the bogus wisdom of a self-appointed denial lobby with barely a minimal comprehension of energy economics.

Virtually everything in Mr Helman's composition is wrong: it is a masterpiece of false impressions. "New" oil may be "coming from everywhere", but it is not sufficient to change supply and demand realities on world markets, and the same is true of "new" technology. His work contains a half-baked attempt to discount the growing energy demand of China, while Saudi Arabia is bizarrely pictured as reducing its production in order to make room for non-OPEC output. The resources of the Caspian and offshore Africa are overestimated, and there is a drastic mistake in the estimated spare capacity of the global oil production system: it is *at least* three million barrels per day (= 3mb/d) less than the 5 mb/d that that one of Helman's gurus believed would prevail at this time. Financial speculation (in the oil futures market) is provided a totally undeserved importance, and in addition may be theoretically incorrect. These and similar allegations have been examined in detail in my new energy economics textbook (2007), where I attempt to outline in non-technical language the departure from mainstream economic logic that still characterizes much of the commentary on petroleum markets.

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It is generally believed that the main explanatory factor for the 59% oil price rise in 2007 was the escalation in Chinese (and Indian) demand, which can only be supplied by greater imports. For instance, China now has about 30 million vehicles, but there are estimates that by the year 2020, this figure may reach 120 million. However even if it doesn't, the difference will be more than covered by the increased sales of cars, vans and trucks in India. Readers should also be aware of the growing oil consumption in leading exporters, of which Russia is an excellent example – although CNN recently called attention to a similar demand originating in the Middle East, where the largest fraction of OPEC oil is produced.

Among other things, the present contribution will attempt to make it clear that the actual and potential oil supply cannot possibly expand at a fast enough rate to satisfy future global demand without continued price increases, and perhaps sooner rather than later there could be a traumatic piece of bad news in the form of a peaking of the global oil supply, regardless of price dynamics. Note the expression "continued price increases", where "continued" should be interpreted as 'continued from a starting price somewhere in the vicinity of $90/b'. As a result, an unhealthy freight of ill-tidings could be featured on the oil price scene well before global production turns down.

'Really, really bad news' though would appear if the annual *growth* in demand again reached and continued for a few years at about 3 mb/d, which happened during a 12 month period in 2003-2004. The hypothesis that I have circulated of late is that the only way for the decision makers to accept this prospect without the risk of overdosing on aspirin is to make sure that a portion of this kind of growth is 'satisfied' with some brand of non-conventional energy, or its 'end-use' equivalent (By end-use *equivalent* I mean that some of the increased growth in conventional oil demand that is intended for refining into motor fuel is replaced by e.g. ethanol, bio-diesel or electricity).

Albert Einstein once remarked that even children were capable of understanding important physical concepts. If this is true, then we can certainly hope that they help their parents to understand the key idea in the book '*Hubbert's Peak'* by Kenneth Deffeyes (2003). (In l962, M. King Hubbert delivered a report to the National Academy of Sciences in which he said that U.S. oil production would peak between 1966 and 1971.). In more melodramatic terms, Deffeyes' work is about a peak in the output of what George Monbiot called "the resource on which our lives are built". It's about being faced with the possibility that the *global* oil production in some year in the very near future will, unexpectedly, only be marginally larger – if that – than production in the previous year, and when this dilemma reaches the media and is carefully analysed, the international macroeconomy and financial markets could react in a manner analogous to crowd behaviour in your favourite vampire movie when the *sold-out* signs are posted in the windows of garlic shops.

There are two very simple things that everyone who reads this paper should try to understand perfectly. The first is how easy it was for Dr. Hubbert to arrive at such a provocative conclusion, although the consensus opinion in the U.S. was that there would be an oil glut for the remainder of the 20th century, and probably most of the 21st. The second is that we are dealing with economics and not geology. It may sound like geology, but actually the correct approach features the same kind of reasoning highlighted in your favourite intermediate economics textbook. In the U.S. – and probably in most parts of the world – production did not turn down because of a shortage of reserves, but because it was 'sub-optimal' from an inter-temporal profit maximization point of view for producers to boost output.

Hubbert probably began his research by perusing what had happened and was happening in oil fields or oil provinces around the world. What he saw was small and large oil fields with (roughly) bell-shaped production curves, and which in one way or another could be aggregated into a very large bell-shaped or approximately bell-shaped curve for an entire region. Having done that he considered how best to mathematically represent these bell-like curves, and the answer of course was with hyperbolic or normal or logistic equations, or perhaps something slightly more exotic. Then, after looking at a plot of cumulative production in the lower '48 (of the U.S.) he applied the kind of statistical theory that I once taught at the International Graduate School of the University of Stockholm. The elementary kind that anyone with an interest in the subject can easily grasp.

Here I am reminded of what Professor Richard Bellman said about the first problem he was assigned at Las Alamos when he was working with the Manhattan Project: *it was about as difficult as the exercises that he and his friends amused themselves with in the mathematics club at his New York secondary school.*! The point is though that (Sergeant) Bellman was working his magic for people like Dr Robert Oppenheimer, who were open-minded in comparison to the drowsy scrutinizers of Hubbert's geometry who often show up at energy economics conferences with what in the US Army were once called 'attitude problems', and who sometimes give insipid lectures polluted by a blend of arrogance and error.

In her recent textbook (2004), Professor Carol A. Dahl reproduced an expression of the type that Dr Hubbert used to estimate the date of the output peak for the lower '48 (of the U.S.), although a more thorough discussion based on the same equation can be found in Moroney and Berg (1999). For the purposes of the present exposition this can be written as $Q = R/[1 + \beta e^{-\alpha t}]$, where Q is cumulative production, R is the conjectured *ultimate* amount of the resource, and α and β are the parameters that Dr Hubbert estimated. This equation is logistic, and once we have the above parameters, it is a simple matter to obtain the inflection point, which for a bell-like curve corresponds to the peak. Equally as important, assuming that the parameters are correct or approximately correct, a simple mathematical operation will indicate that a 1% increase in R will result in a less than 1% increase in the time to the peak. Thus we have one source of an often-heard warning that even if large oil fields are discovered, they will not contribute greatly to keeping the wolf away from the door.

I can agree with the oil optimists that Dr. Hubbert might have been lucky to calculate that 1971 would be the latest year in which the peak for the lower '48 would arrive. Actually it came toward the end of 1970. As it happens though, that is mostly irrelevant, given that some influential observers genuinely believed that a peak for the U.S. would never take place (and apparently there are still some ladies and gentlemen who say that a global peak is out of the question, despite the regional peaks experienced in every part of the world). They believed, to paraphrase Deffeyes, that to obtain virtually any amount of oil, all that was necessary was to stand next to a well with a bucket and a handful of dollars, and with the help of the instantaneous technological masterpieces that are always at the beck-and-call of men of good will, Mother Nature would deliver the goods.

Justin Fox once pointed out in *Fortune* (September, 2002) that to keep oil prices from harming our economy, we need high oil prices." This was a correct judgement at that time, but it no longer applies.

Now we need lower oil prices. One of the ways not to obtain these is to listen to Nobel Laureates like Professor Gary Becker, who attempted to explain to the readers of *Business Week* (March 17, 2003) why the war in Iraq had *nothing* to do with oil, and in addition "Middle Eastern nations are far less important to world oil production than they were immediately after the formation of OPEC." This might have been true if, as Stanislaw and Yergin (2003) believed, OPEC was willing to produce 45% of world oil by 2005 (instead of the realized 33%), because 45% would have left the importing countries with a 'reserve' in one form or another, part of which would have been a larger capacity that OPEC might not have wanted to see idle. Moreover, had it been idle, it could have provided the 5 mb/d spare capacity referred to above by Helman.

Natural Decline: an Algebraic Comment

General Douglas MacArthur once said that his favourite song was 'Old soldiers never die, they only fade away.' The same can be said about old oil fields. The three largest fields are indeed still very large, but all of them are fading away, and perhaps at an alarming rate. (These three fields are Ghawar in Saudi Arabia, Cantarell in Mexico, which though in rapid decline is still the second largest producing field, and Burgan in Kuwait, which is second in reserves, but where claims a few years ago about the exact amount of proved reserves were aggressively questioned by outsiders.)

The fundamental theme of this paper, and for that matter my work for the last decade, is that oil is scarce. *It is scarce given the demand that is going to be made for it in the not too distant future*! To fully understand the unpleasantness that oil consumers now face, or will soon face, it behoves readers of this contribution to obtain some insight into what is known as natural decline, because there is now a constant reference to 'decline' (i.e. natural decline) in the daily and weekly press. Unfortunately, some mathematics must be employed at this point in the exposition, and readers who prefer not to be bothered by this type of presentation are advised to proceed to the next section, which is completely free of symbols, but just below, prior to the mathematics, are a few statements about natural decline that should be comprehensible to all readers.

Among other things, I want to eventually put together a semi-formal exercise of the kind I employed in my lectures on oil and gas in Stockholm and Milan (Italy). What I am aiming for is to say something meaningful about investment as well as production. The point is to work toward an implicit function of the type $\psi(q_1, q_2, \ldots, q_T ; I_1, I_2, \ldots, I_T) = 0$, where the 'q's are production, and the 'I's are investment, but I will refrain in this paper from doing a great deal more than mentioning my intentions.

Several years ago Mr Lee Raymond – the former CEO of Exxon-Mobile – gave an interview in which he emphasized the importance of the natural decline rate of oil deposits. Rather than turning to the technical literature, I consulted GOOGLE, where I found several useful examples by Matthew Simmons. He cites an oil field in which individual wells are declining at a rate of 18%/year, while the output of the field is only declining at 10%/y. What is happening is that if the inputs being used are held constant, then instead of the production of a well remaining constant, or nearly constant, it declines by 18% on the average. This is where 'natural decline' comes into the picture, and one way it can be described is in terms of the loss in capacity that would occur in a given structure/asset if no remedial or offsetting action is taken.

The 10% decline of the field (instead of 18%) can thus be explained by the fact that inputs are not constant. In other words, remedial action takes place in the form of drilling new wells and/or taking steps to increase the output of existing wells (via, e.g., injecting water or carbon dioxide or the use of 'surfactants' to increase viscosity). These procedures can be labelled investment, and roughly have the same significance as the investment required to produce, process and transport in one manner or another the output of an oil field.

It might be useful to add that according to information at my disposal, decline rates for Iran may be as high as 8%/y onshore and 13%/y offshore, while for Saudi Arabia the figure is ostensibly 2-4%. (Determining the suitability of these estimates however will be left to the readers.) Accordingly, if Saudi Arabia's decline rate averages 3%/y, then – via investment of one type or another – gross capacity must be increased every year by several hundred thousand barrels per day in order to maintain an output of 9-10 million barrels/day (mb/d). A problem here is that the deposits of that country are old, and investments required to maintain output could become very costly because of damage sustained by fields due to (among other things) production processes which involve the extensive use of water. As a result, given the expected future demand for (and priceof) oil, Saudi oil field managers may have concluded that optimal behaviour on their part takes the form of minimizing the expansion of output.

At this point I require as a background a simple model that I employed in the first lecture that I gave on oil, which was at the Australian National University in Canberra, in what now seems like several centuries ago. This model will then be extended somewhat to take into consideration the natural decline rate.

First of all we need to understand the fallacy in a statement such as "With all the reserves in place now, we have a 40 year supply of oil even if we do not find another drop." This statement originates with observing that the global reserve-production (R/q) ratio is 40, however the important issue is not the R/q ratio, but when production in a field, region, or for that matter the entire oil producing world turns down. As should be obvious from a consideration of the example below, present reserves should last hundreds or even thousands of years, however once the production peak has been reached, the number of years that oil 'lasts' is of minimal interest.

This is not to say that the R/q ratio should be ignored, but a statement such as the above (about a 40 year availability) is scientifically meaningless. In looking at a deposit or field the important thing is that if the R/q ratio falls below a certain level – probably somewhere between 10 and 15 – then the deposit is being 'damaged' in the same manner that sucking too hard on a straw will damage an ice-cream soda. This particular R/q ratio can be designated the *critical* R/q ratio, or θ^*, and for simplicity I always take it as 10 – although Flower (1978) prefers the higher figure (for reasons spelled out with some simple algebra in my previous textbook). The damage will be manifested by a reduction in the total amount of oil that can ultimately be removed from the deposit.

Now for the important point. *When the R/q (= θ) ratio reaches the critical value, the critical value will determine production in the sense that production should adjust in such a way as to hold the critical value approximately constant.* (S*hould* and not *will*, because there might be valid economic reasons for hastening depletion. Moreover this is a theoretical point in economics rather than physics, and so from time to time it may be possible to see large exceptions.)

An example is useful here. Assume that we have a field with 225 units (= R) of oil reserves, and we desire to lift 15 units per year, and our critical R/q ratio (θ^*) is 10. Using the logic expressed in the previous paragraph, it is obvious that we can have an output of 15 units/year for five years. During this period the R/q ratio falls from 14 (at the end of the first year) to 10 at the end of the fifth year, while reserves fall to 150 units. After that, however, if we continue to remove q = 15 units/year, we are violating our constraint: the R/q ratio will fall under ten. For instance, if we removed 15 more units (q = 15), then reserves would fall to 135, and R/q decreases to 135/15 = 9.

To keep this ratio at 10 (= θ^*), production in the sixth year should not be larger than 13.64. (Thus R/q = (150 – 13.64)/13.64 = 10.) Continuing, in the seventh year production cannot be larger than 12.4. Readers should be able to get these results by simple trial and error, however this exercise may be generalized to show that $10 \leq R_t/q_t \leq (R_{t-1} - q_t)/q_t$. In turn this expression may be solved to give $q_t \leq R_{t-1}/11$ (or, more generally, $q_t \leq R_{t-1}/1+ \theta^*$). As explained in my new textbook, this operation is merely another way of saying that in any (e.g.) year, the percentage of reserves extracted should be less than or equal to 10%.

The above is an important example, and after making sure that they understand it perfectly, readers should confirm that there is a large amount of oil in the ground when output turned down. Moreover, when we look at the production profiles of *actual* major oil or gas regions like the United States, what we see is that when peaking takes place (and production sooner or later begins to decline), there is still a huge amount of the resource in the ground, and in addition – if economic considerations are ignored – much of this is immediately extractable. The interpretation here is as follows: *the peak is explained by economics and not geology*. *More is not extracted – and the peak delayed – because in the interests of profit maximization, the optimal behaviour is to extract it later!* As explained in Banks (2004, 2000), geology essentially functions as a constraint. This is a crucial point that everyone reading this note should make every effort to understand.

But something is missing here, and that something is the natural decline rate. In the above example, sufficient investment was made to obtain an output of 15 units/year. But what would happen if the natural decline rate was 20%, and the intention was to keep output at this level? Then next year more investment would be necessary in e.g. new wells or increasing the output in existing wells. And the year after that: still more investment would have to take place. The decline rate being used here is probably excessive, however it makes the arithmetic simple. I have also kept the decline rate constant, however it is very likely that this rate is influenced by the extraction program. In addition, although in the example below I am operating exclusively on production, this business of holding production constant almost certainly causes stresses on reserves. I don't treat this however, because the International Energy Agency (IEA) has claimed that globally, due to natural decline, 3.2 mb/d of new reserves must be found just to maintain output. Like most of the IEA's Sunday-Supplement wisdom or expertise, this assertion poses more questions than it answers.

At the same time I want to make it clear once more that when the asset under discussion is an oil deposit rather than a conventional capital good, it is still possible to think in terms of what in economic theory is called "depreciation by evaporation". What this means in the present example is that the asset is subject to a force of 'mortality' that will be taken as constant, and equal to 'Θ'. If A is the constant annual revenue generated by the asset, or perhaps the size of an annuity derived from non-constant revenues, we can write for the value of the deposit:

$$V = A \int_{t}^{t+T} e^{-(\Theta + r)(\tau - t)} d\tau = \frac{A}{\theta + r}[1 - e^{-(\Theta + r)T}] \qquad (1)$$

Equation (1) could serve as a useful starting point for examining this topic if many readers were not allergic to integrals, because it indicates that the presence of natural decline (Θ) reduces the value of the deposit; but even if they were madly in love with the calculus, the presentation below is more suitable because the importance of investment is made explicit.

As noted, to keep things simple I will take a constant decline rate of 20%. As in the previous example I elect to hold production at 15 units/year, however the initial reserves are increased from 225 units to 'something' much larger. The reason why I do not specify the size of this 'something' is that I am not concerned in this section with e.g. peaking. I simply want to clarify the significance of the natural decline rate, and its influence on investment. If readers want details, they can examine my new textbook. Now we have:

YEAR 1: 15 (I_1)

YEAR 2: 0.8 x 15 0.2 x 15 (I_2)

YEAR 3: 0.8^2 x 15 0.8 x (0.2 x 15) 0.2 x 15 (I_3)

YEAR 4: 0.8^3 x 15 0.8^2 x (0.2 x 15) 0.8 x (0.2 x 15) 0.2 x 15 (I_4)

YEAR 5: 0.8^4 x 15 $0\text{-}8^3$ x (0.2 x 15) 0.8^2 x $(0.2 \text{ x } 15)^2$ 0.8 x (0.2 x 15) 0.2 x 15 (I_5)

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YEAR T: 0.8^{T-1} x 15 ……………………………………… 0.2 x 15 (I_{T})

If we look at this tableau what we see is that in YEAR 1 an investment of I_1 was made to obtain 15 units of output. Because of natural depletion, in YEAR 2 additional investment of I_2 was necessary to obtain an additional output of 0.2 x 15 – i.e. the decline rate times 15 – in order to keep the total output at 15 [= (0.8 x 15) + (0.2 x 15)].

Mathematical induction could be useful here if the logic behind this scheme was not so simple. Let's take the decline rate as $(1 - \Theta)$, which in the example means 0.20, which in turn means that $\Theta = 0.80$. Now let's see what we have for YEAR 4 in symbolic terms: $15(1 - \Theta)[1 + \Theta + \Theta^2 + \Theta^3]$. The expression is the large parenthesis can be simplified to $[(1 - \Theta^4)/(1 - \Theta)]$, and so in YEAR 4 we have $15(1 - \Theta^4) + 15\Theta^4 = 15$.

Nothing has been said here about the size of the 'I's (which represent additional investment in e.g. wells for the purpose (in this example) of holding output at 15 units/year), but on the basis of the work of Simmons and others, it involves more than petty cash. (Something like this kind of program may be relevant for Saudi Arabia, where for the time being the intention seems to be to hold output in the 9-10 mb/d range.) Note also that if we had numerical values for the 'I's, we could do more with the implicit expression $\psi(q_1, q_2, \ldots, q_T ; I_1, I_2, \ldots, I_T) = 0$ that was given above. To begin, with T = 5, this expression would be $\psi(15, 15, 15, 15, 15 ; I_1, I_2, I_3, I_4, I_5) = 0$. Putting together an example with explicit 'I's which also said something about the depreciation of the deposit due to additional investment should be a comparatively simple matter algebraically, but it would involve a degree of arbitrariness relating to the decline of the deposit that I prefer to avoid for the time being.

Show Me The Money

The long-overdue increase in importance of academic energy economics is gratifying in many respects, but disturbing in others. Nobody can doubt its usefulness, given the place of energy in our daily lives, however all except the hopelessly naïve must be aware that economics is not a science in the usual sense. It is *like* a science, which makes it pleasant to teach and/or study, but there are probably many things that you want academic economics to tell you about the availability of energy that you are not going to find out no matter how hard you stare at the supply and demand curves that caused you such grief in Econ. 101. The reason is provided by Frederic Nietzsche, and it goes like this: "The future is as important for the present as the past".

As bad luck would have it, reading the future is an art that only a few lucky people can master. For example, despite having studied the global oil market for as long as I can remember, until recently I was almost as much a hostage to (forecasting) fortune as the often-quoted Dr Michael Lynch, who – according to Mr Helman – has apparently claimed that the oil price could "dip briefly into the 20s in 2008". The only way this 'dip' could materialize is for the main oil exporters to decide that less money is preferable to more, because according to Björn Lindahl (2007), a survey of oil analysts has predicted that the average price of oil in 2008 will be almost $75/b. Oil analysts have often been wrong in the past, but it would take extraordinarily bad luck for them to miss this time. Moreover, if the kind of swings in the oil price that took place in 2007 take place in 2008, then there could be many days when the $100/b 'benchmark' was exceeded.

A big issue at the present time is estimating how the oil situation in the Middle East will develop. At one time I was convinced that we would have to accept provisional answers to that question until we know more about the future ownership of Iraq's petroleum assets, and also how forthcoming changes in the Iraqi government could influence the structure and agenda of OPEC. I no longer believe that this is the case. The overriding fact that everyone reading this article should make it his or her business to comprehend is that the investments in new production capacity that the oil importing countries (and the International Energy Agency) want the Gulf producers to make, and which on various occasions these producers say that they will make, will in reality NOT be made. *Why should those countries choose to finance expensive investments when, if they don't, it is certain that the oil price will continue to rise*?

'Street smarts' of this nature do not appear to be adequately understood by many prestigious energy experts in e.g. the great world of journalism, however the articles and particularly the comments on the important site EnergyPulse (www.energypulse.net) reveal that it is a 'given' for almost all of the participants in that forum – the majority of whom are technicians or engineers. Instead of increased investment by Gulf oil producers, what we are going to witness is the adoption of an optimal development economics scenario, where profits from high oil prices will be used to promote diversification out of oil. Very likely, the higher the profits the more intensive the diversification. Can we justify this kind of behaviour with conventional economic theory? The answer is yes, because oil is a wasting asset, and if there is no danger of its price collapsing, then it probably makes sense to preserve it as long as possible. Thus, it can even happen that a fall in demand will be met by a fall in output. In addition, despite what you may or may not have heard, the value of oil in the ground will not suddenly decline due to the availability of e.g. alternate motor fuels. This is because in the absence of a 'Manhattan Project', that availability of alternative fuels will be limited over *at least* the next few decades. Furthermore, even after those decades are over and forgotten, oil will be invaluable as a petrochemical input. I noted this in my oil book (1980), and now, finally, it is taken for granted in OPEC councils.

This might be a good place for an aside on the word 'value'. Certain teachers of economics will try to assure you that price and value are identical, however as I mentioned *en passant* in my finance book (2001), in financial economics it is often necessary to distinguish between price and value. Price is what you pay to acquire an asset, while value is what the asset is really worth, and the price is called *fair* when it is equal to the value. Attempting to distinguish between price and value may sound odd to some readers, however what the 'efficient markets hypothesis' says is that there can be a difference and, more important, on average investors in the share markets cannot tell exactly what this difference is. This is one of the reasons why so many investors are now in possession of shares that should be dumped, where by investors I include the managers of the 800-1000 hedge funds that go out of business every year because they have made foolish wagers, and a similar number who will soon be gone.

As for determining value, the study of finance is heavily involved with constructing models that ostensibly will provide us with this information. The Black-Scholes-Merton option pricing formula – which the *Economist* (UK) incredibly labelled the most important relationship in economics – is an excellent example of this kind of thinking. (For those who are unfamiliar with this model, it is intended to identify the value of an asset; and in theory, if the price of the asset is different, arbitrage should enable somebody to make a great deal of money). Personally I regard many of these models as questionable approximations, although I am willing to entertain arguments that often – though not always – they are more useful than e.g. relying on *gut* feelings. Another example can be given here. Milton Friedman insisted in the l970s that the price of oil should be less than five dollars a barrel, because he accepted the loony idea that the quantity of proved and hypothetical oil reserves in the crust of the earth was so immense that that it had no *scarcity* value. Of course, somewhere in the background to this approach and acceptance was an unspoken belief that the owners of much of this oil were fools who could be tricked into parting with this invaluable commodity if they were exposed to the worthless advice of academic celebrities.

Until a few years ago I was occasionally involved in *ad-hoc* debates with persons sympathetic to the theories about oil (and other raw materials) prices that originated with the late Professor Julian Simon. People like Simon held the twisted belief that because the cost of producing a barrel of oil in the Middle East was a few dollars, or less, *all* oil was generally overpriced in world markets, and in reality a barrel of this commodity should sell for the price of a barrel of coca-cola, or perhaps less. What Simon and his cheering-section failed to realize was that if the oil producing countries in that part of the world coordinated their sales, and bided their time, then those very corrupt persons in certain exporting countries who were willing to sell a tank-car of oil for the price of a can of coca-cola would eventually shift to some other line of work or play, and the price of oil would ascend to a level commensurate to its value.

In terms of mainstream economic theory, this value has no intrinsic relationship to the cost of production in the Middle East. Instead, in the textbooks that Professor Simon read or should have read, the price of all oil would be determined by the price paid for the marginal barrel supplied by the *highest* cost producer. Today the OPEC countries are the *lowest* cost producers, with an output of 27-28 mb/d as opposed to a total output of approximately 85 mb/d, which gives them a distinct quasi-monopoly power. By that I mean that control of the lower end of the aggregate supply curve for oil provides them with an opportunity to (figuratively) 'control' of the entire curve.

A few years ago there was a widely advertised belief that when the price of oil exceeded thirty or forty dollars per barrel, and there were indications that this price was sustainable, then a great deal of investment would take place for the purpose of bringing new supplies to the market – where in the minds of some experts "new supplies" would include oil found at the bottom of the deepest part of the Gulf of Mexico, or perhaps at a similar depth in 'Iceberg Alley', off the far northern cost of Canada. This kind of supposition implies that the cost of finding and developing new properties may increase by a very large amount, and according to the consultants Wood-McKenzie, oil companies need a price of $70/b in order to obtain the same profit that they would have realized two years ago with a price of $30/b.

This doesn't sound completely right to me, however it hardly makes any difference. It seems likely that firms will have no problem obtaining a sustainable price of at least $70/b for any and all oil that they succeed in lifting, but the *revenue* they obtain as a result of selling oil at this price will hardly be spectacular unless, possibly, they gain extensive access to exploration and production rights in the Middle East. Whether this will take place is dubious, because if they are acquainted with some of the jargon that the greatest singer of the twentieth century, Frank Sinatra, was prone to use, the managers of Middle East oil may have concluded that if you fall into the arms of the major oil firms of North America and Europe, it might be for "keepsville".

As reported on the Op-Ed page of the *New York Times* in 2005, the journalist John Tierney and the wife of Professor Simon bet the investment banker and former advisor to President Bush, Mr Matthew Simmons, $5000 that the price of oil would not reach the level predicted by Mr Simmons (which was $200/b) by 2010. While $5000 is hardly Saturday night walking-around money to Mr Simmons, I found the publicity accorded this strange wager an unwelcome distraction, given the real issue. Professor Simon obviously believed or was capable of believing that brainpower and technology could find oil that geologists said did not exist, and so according to this nutty logic an oil price that reached astronomical levels was at best a transient irritation, even though a series of spikes in the vicinity of $100/b might unleash the mother of all macroeconomic dislocations. Similarly, certain journalists in prominent business publications have chosen to tell their readers that oil price convulsions of any magnitude are no longer particularly relevant as an explanatory factor for economic downturns. To my way of thinking, if the TV audience and their political masters choose to believe this kind of foolishness, they deserve what they will get.

Oil Futures and Oil Inventories

In a lecture derived from my unpublished paper '*Some Analytical Aspects of the New Oil Market*', I provided students in my course on oil and gas economics at the Asian Institute of Technology (Bangkok) with a partial introduction to the use of oil futures. The decisive thing that needs to be appreciated where this topic is concerned is that it is much less complicated than often believed! I also attempt to clarify for my students in all the countries in which I have taught *derivatives* (i.e. futures, options and swaps), that the attractive salaries and bonuses that traders and analysts of various assets enjoy is due to their ability to learn a relatively small amount of basic doctrine perfectly, rather than squandering time and gusto on more abstract materials. (Derivatives are assets – such as 'paper oil' – whose value is derived from other assets!)

In virtually all of my lectures and publications I employ a stock-flow model of the oil market that I developed after reading a seminal article on copper by Professor Franklin Fisher of MIT. One of the most important purposes of my model is to make it clear that the flow models in your microeconomics textbooks are insufficient for comprehending short-run pricing in the oil market. Everyone who reads the *Financial Times* (UK) and watches CNN or Bloomberg should already realize this, and the U.S. energy minister /Samuel Bodman) recently attributed the rising oil price to inventories being under the five-year average. My model will be presented later, and normally there are several mathematical expressions associated with the discussion that I usually advise students to skip if they want; however there is one equation which I insist that all my students must be capable of duplicating and discussing whenever they are in my classroom, assuming that they prefer a passing to a failing grade. This is that the rate of change of oil prices is a function of the difference between desired (D) and actual (A) inventories, or $dp/dt = f(D - A)$, and when e.g. $D>A$ implies that p increases.

I will begin by saying a few things about the oil futures market, and if you want the rest of this story, and/or are curious about options and swaps, read the chapter called 'Energy and Money' in my new energy economics textbook. We can begin with a couple of terms: *physical oil* and *paper oil*. Physical oil is the oil that we have been talking about in previous sections – the black liquid that usually is put in barrels – while paper oil is the oil bought and sold on *futures markets*, which is stored in computers. The relation between these is not straightforward. Present consumption (and production) of physical oil is in the neighbourhood of 85 mb/d, while daily transactions on major futures exchange such as NYMEX in New York and the International Petroleum Exchange in London often total several hundred million barrels of (paper) oil. As with physical oil, each transaction on a futures market consists of a purchase and a sale of a certain number of contracts, where each futures contract represents 1000 barrels of paper oil. Under certain circumstances paper oil can be transformed into physical oil.

The oil futures markets operate as follows: against a background of speculators buying and selling futures contracts for the purpose of betting on the direction in which the price will move, an impersonal agency comes into existence which permits persons involved with physical oil to reduce (or 'hedge') price risk. As simple as all of this actually is, there are a great many misunderstandings about these markets.

Twenty years ago Senator Alan Cranston – who wanted to be elected president of the United States – assured his constituents that agricultural futures markets were responsible for high agricultural prices; and only several years ago the well known television commentator, Bill O'Reilly, informed his large public that "little guys in Las Vegas" were responsible for the sharp rise in gasoline prices. As it happens however, futures trading may have contributed to reducing gasoline prices by reducing the price risk faced by buyers and sellers of physical oil. Mr O'Reilly's belief that the agonies associated with high oil and gas prices originated on The Strip in Las Vegas, and had nothing to do with physical supply and demand, is exactly the opposite of the truth.

The success of a commodity futures market is dependent on the satisfaction of several well defined criteria. Perhaps the most important is that the physical item (e.g. oil), which is known as the *underlying*, is sold in an *auction market* – e.g. an exchange. This is a market characterized by the visibility (or transparency) of all prices, and where all transactions involving *bids* (buying) and *offers* (selling) are handled almost immediately. Also, prices should fluctuate in a random or non-systematic manner. Without these provisions speculators may not be attracted to the market, and without considerable speculation futures markets will be *illiquid*. This means that there could be delays in buying or selling, and very large transactions will result in the price moving. The major share markets furnish perhaps the best examples of highly liquid markets.

Buying or selling paper oil is no different from buying shares. If you are a speculator and think that the price of physical oil will rise, then you telephone your broker and *open a position* by telling her to buy a certain number of contracts. *This is called going long*. If you think that the price of physical oil will decline, then you open a position by telling her to sell. *This is called going short.* The contracts in both cases involve a certain maturity (or expiry date), and assuming that you do not want to have anything to do with physical oil, then at some point before the maturity or expiry date you *close your position*. How is this done? If you opened by buying a certain amount of (paper) oil, you close by selling the same amount! If you opened by selling a certain amount of oil, you close by buying the same amount. All of this can take place from your rocking chair in front of the TV. (A certain amount of money called *margin* is involved in these transactions, but that will be discussed briefly later in this section.

What about gains or losses? If you went long and the price actually increased, then you make money. If the opening price was p' and the closing price was p", and you bought N barrels of oil, then your profit was (p" – p')N, minus the broker's fee. If you were wrong and the price actually decreased, then you lost money. If you opened by going short and the price actually fell, then you made money; but if the price increased, then you lost money. If you started out by going short, with the initial price p', and the price fell to p*, then if N barrels are involved, the gain is (p' – p*)N minus the broker's fee. At this point the reader should use some numbers to assure himself or herself that he or she really understands what is taking place. (Something else of great importance: the selling of paper oil in a futures market does *not* involve selling an asset that you possess, as in a share or physical market! You would simply inform your broker that you want to sell 2000 barrels of oil. You will *not* be asked, "WHERE IS YOUR OIL"?)

Next we can pay some attention to hedgers, who also buy and sell futures contracts, depending upon whether they want to guard against price rises or price declines. Consider, for example, someone who has contracted for 2000 barrels of oil (= 2 contracts) that are to be delivered in a month, but who is not allowed to pay for this oil in advance, and instead must pay the market (or 'spot') price of the oil at the time it is delivered. This buyer thus faces considerable price risk (i.e. '*exposure*') in that the price of oil might rise sharply. Airlines typically have to deal with this kind of complication where fuel is concerned.

Risk averse buyers in the situation above can 'lock in' the price at which they will receive their oil if they buy – at the time they contract for 2000 barrels of oil – two futures contracts, which provide 2000 barrels of paper oil. Later, about the time when the physical oil is being delivered, they close their futures position by making an *offsetting* sale of 2 contracts (= 2000 barrels). (Something that should be noted here is that a futures contract is also a *forward* contract, however delivery does not have to take place on a futures contract because of the possibility of an offsetting transaction before the maturity/expiry date. *Observe, before the expiry date*! On the other hand, forward contracts involve delivery, and normally, offsetting transactions cannot take place.)

The key point in the above procedure is that if the price of the physical oil increases, which is 'bad', so does the price of the paper oil, which is 'good'. This is how we get the 'locking in' effect. Similarly, if the price of the physical oil decreases, so does the price of the paper oil. Thus a loss or gain for physical oil is compensated for by a gain or loss on paper oil. There are reasons why full compensation cannot always be realized, and there is also the matter of a fee for the broker arranging the transaction, but viable oil futures markets have turned out to be very efficient and popular establishments for hedging price risk.

Sellers of oil are usually afraid of price declines, and so their hedging activity begins with selling paper oil – NOTE, paper and not physical oil, and so they do not need to store any barrels of physical oil in their kitchen and bedroom. If the price of physical oil declines, so does the price of paper oil, and so approximately what they lose on the physical market they gain on the paper market. I can refer readers to my new energy economics book for a more comprehensive discussion of the above, but there is an important matter that deserves attention immediately.

Assume that you believe that the oil price will rise, and to take advantage of this you go long in paper oil. Now suppose that the futures price declines instead of rises. What this means is that your futures contract loses value. When you open a position it is customary to pay a certain amount of *margin*, which is a security deposit. If the contract loses value (because the futures price goes the wrong way), you will immediately be asked by your broker to 'top up' your margin account. Take the example above, where you bought 2000 barrels of paper oil. Suppose that margin was 10% of the price, and the opening price was $90/b. The total value of the contract is $180,000, and so margin is $18,000, which you pay to your broker. Suppose that the futures price fell to $85/b. Your contract has now lost $10,000 (= 2000 x 5), which – via your broker and the futures exchange – is paid to the person who was the seller of the contract, (or the person(s) who bought it from the original seller). Your margin account has now decreased to $8000 (= 18,000 – 10,000). Accordingly, your broker might ask you to bring your margin account up to its original level ($18,000), and if you don't he closes your position.

There are some further aspects of this topic that will be taken up below, but the complete discussion – at an elementary level – is presented in my new energy economics book or my finance book. Accordingly, at this point, I can present my stock-flow market, which is in Figure 1.

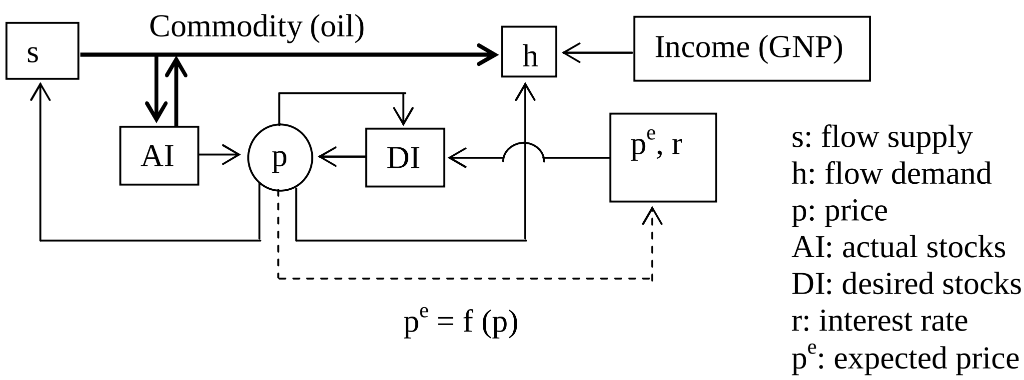

Figure 1

Readers should not make the mistake of thinking that this diagram possesses the same order of difficulty as the diagrams in their courses in electric circuit analysis. As noted, s and h are flows, whose units are the same as in your elementary economics textbook (e.g. b/y), while the AI and DI are stock components, and do not contain a time dimension. For instance, they might simply be barrels of oil.

At the beginning of this section I presented what I regard as an indispensable expression for discussing price movements. This was $dp/dt = f(D – A) \equiv f(DI – AI)$, where AI and DI have been shortened to A and D. What is essentially being said here is that if , for example, D > A, then price increases; and if supply and demand are a function of prices – i.e. $s = s(p)$ and $h = h(p)$ – then flow supply increases (because price increases), while flow demand decreases (also because price increases), and the difference between supply and demand, $(s – h)$, goes into increasing inventories. This is the explanation that I expect my students to be able to repeat verbatim (although dp/dt is often replaced by $\Delta p/\Delta t$, which economics students should recognize from their work on elasticities in their first course in economics). Readers who desire more can examine several of the papers mentioned in the references, where simple differential equations are formulated. Here I would like to emphasize that all of the equations in my papers and in the papers of other authors are arbitrary. The 'truth' is in Figure 1 and the equation at the beginning of this paragraph.

That brings us to a topic that is not stressed in those papers, but which ties in with the discussion of oil futures markets above. By way of an introduction though, let's note that if you decide to open a position (by going long or short) in futures contracts, it is also necessary to specify a maturity – i.e. 'running time' – for your contract. *You should also be aware that the price of paper barrels on contracts with different maturities do not have the same price!* Something that is very often forgotten by so-called experts in academia is that there is very little liquidity for long-term futures contracts, which influences their price. A scholar at Harvard recently assured his readers that all was well in the oil market because it was possible to hedge production and consumption for several years in the future with futures, although at that time three months was probably the optimal hedging period. (He also was unaware that the reserve-production ratio was an inadequate measure of oil availability.) Now let's look at Figure 2.

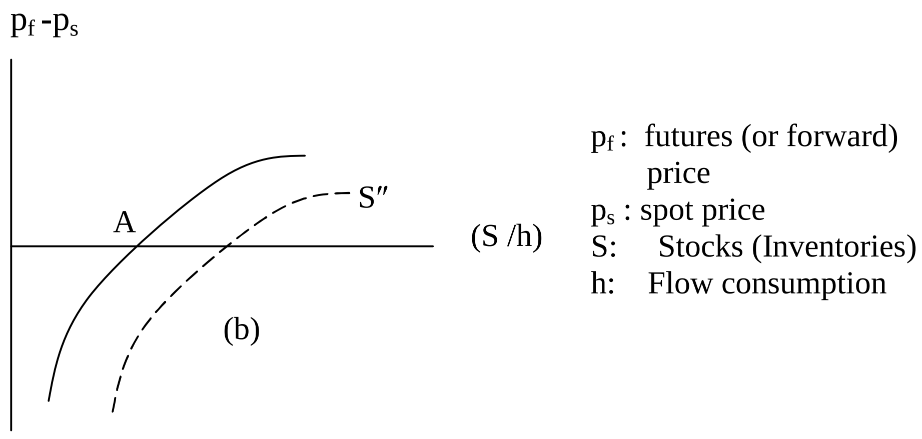

Figure 2

A normal arrangement in this matter of holding inventories, and perhaps hedging these with futures contracts, is that futures prices tend to increase with inventory holding (or inventory coverage, as it is sometimes called). This makes sense for several reasons, one of which is that inventory holders expect to be compensated for tying up cash in buying and storing oil instead of purchasing interest bearing financial assets (such as bank deposits or securities).

Figure 2 is special in that to the left of A, present prices are higher than futures (or forward) prices. This situation is called *backwardation*, and is caused by a comparatively low inventory coverage. The opposite situation, to the right of A, is called *contango*. As it happens, today oil markets are in backwardation, although over the past few years contango has been the rule. In going back a few decades though, it is clear that backwardation has been experienced much more often for oil than contango.

I do not want to make heavy weather of the present topic, but a slight rephrasing and extension of the above discussion might be useful. First, note that if producer or consumers' inventories are low, then each extra unit held in stock reduces the possibility that e.g. industrial operations will have to be scaled down because of the absence of a crucial input. Remember that both producers and purchasers of industrial raw materials are bound by contractual obligations to their customers, and so inventories must be held as long as uncertainty exists as to whether an essential input or promised output will be physically available during the period when it is required.

Moreover, even if the expected money yield from acquiring, storing and later selling a commodity does not cover such things as its storage cost, this negative aspect might be regarded as counterbalanced by a positive *marginal convenience yield*: when the size of inventories is small relative to the amount of the commodity being used as a current input in production processes, it could make economic sense to increase the size of inventories. An effective price system should function in such a way as to ration existing stocks among perhaps many demanders of inventories, and if stocks are generally judged to be too small, we get a departure from normality (i.e. contango) and instead find the spot price ending up at a premium to the futures price, or the price of futures contracts whose maturity dates are in the near future being higher than the price of contracts that expire later.

Perhaps the most immediate impact that variations in inventory levels have is in the *spreads* between the nearer futures contracts. Until comparatively recently, market actors apparently believed there to be a light surplus of oil on the market or coming to the market, which meant that 'A' in the diagram would be fairly far to the left. As it happened though, for various reasons this opinion changed, which is shown in Figure 2 by a shifting down of the curve. 'A' would then be located a considerable distance to the right, and the familiar backwardation that often characterizes the oil market would be intensified.

Final Statements and Conclusions

> *In 20 years I predict energy wars over oil and gas resources. By the time it becomes politically profitable to react to problems in the transport energy sector, it will be too late for significant development of alternatives and too politically risky not to fight over remaining supplies.*

Len Gould (in *EnergyPulse*, Jan. 8, 2008)

In one of the latest issues of *Business Week*, there is a long article on the adventures in Russia of one of the most prestigious oil-field services firms, Schlumberger, where this multinational giant (with French roots) is frequently engaged in many countries to carry out exceptionally difficult drilling. Schlumberger has experienced considerable success, and among other things they have a reputation for leaving the politics to others, and concentrating on outperforming competitors and potential competitors.

This does not mean, however, that the presence of this and similar firms with state-of-the-art technology at their disposal will make the impossible possible, by which I mean find and produce oil that does not exist. For instance, when the next issue of British Petroleum's Statistical Review appears in the middle of 2008, it is unlikely that a drastic upturn in Russian reserves will be registered. Instead, the thousands of wells that reputedly will be drilled by Schlumberger are necessary to prevent a steep decline in Russian output. This is an important observation, because Professor Gary Becker has advanced the opinion that we can find a portion of our energy salvation beneath the frozen tundra of Russia.

There is little or no good news in this paper for those of us on the buy side of the oil market. One of the reasons for this is the stunning failure of important observers to draw the correct conclusions about the structure and mechanics of the world oil market. In addition, in considering the actions and claims of certain oil companies who are involved with activities in places like the Gulf of Mexico and Caspian, some words of the billionaire Canadian investor Stephen Jarislowsky are highly applicable: "It's absolutely unbelievable what's going on. We're living in just about the most dishonest time in the history of man." He could have added that a large part of this dishonesty originates with so-called students of the oil markets in the universities and 'think tanks', who have decided that their best career move is to take advantage of the veneration of their devotees by abandoning the restraints imposed by history and conventional logic, and instead turn to mythical claims that the price system will relieve our oil anxieties.

A few provocative observations are in order at this time, beginning with one offered by Professor Michael Klare, editor of the important journal *Current History.* "If the oil from the Persian Gulf cannot be kept under U.S. control, our possibility to remain the dominating power in the world could be brought into question." A useful comment on this can be derived from the likely outcome of the present war in the Gulf, which is that it may no longer be possible to ensure that the oil in the Gulf can be kept under U.S. control. Of course, for what it is worth, it may still be possible to guarantee the stipulations of the Carter Doctrine from 1980: "Every attack by a foreign power to win control over the Persian Gulf will be interpreted as an attack on the vital interest of the United States. Such attacks will be repulsed employing all necessary means, to include military force."

One problem here though is an interpretation of the term "foreign power", which at the time that President Carter issued this warning almost certainly meant the Soviet Union. At present it could mean countries to which the oil belongs. I see no evidence that a peaking of the global oil supply will take place in the *very* near future, but if it did some doubt must be expressed as to whether the countries in e.g. the Persian Gulf would be encouraged/allowed to produce oil at the rate that they consider desirable. The energy wars to which Len Gould referred can only mean wars between some oil exporters and some oil importers, since even owners of a fleet of SUVs might hesitate to endorse nuclear war in order to enjoy the thrill of zooming down the Pacific Coast Highway (in California) with the throttle down all the way..

In another *Business Week* article (January 21, 2008), it was stated that six Gulf States control sovereign wealth fund assets of about \$1.7 trillion – or as much as all the hedge funds in the world. Since I consider the importance of hedge funds largely a myth, the deal-making referred to in that article belongs in a soap opera as much as it does in a serious business publication, and I have attempted to make this point whenever I get the opportunity. However, I am prepared to admit that something that cannot be disregarded is the ability of money generated in that part of the world to influence the price of oil by financing the diversification of Gulf States away from oil and into 'something else'. This is not the place however for me to elaborate on that observation, other than to say that the kind of economics that I have studied and taught informs me that (*ceteris paribus*) the greater the pace of diversification, the less will be the effort made to produce and export oil and gas. The decision makers in the oil (and gas) importing countries would do well to focus on this point.

One more item needs to be mentioned before closing this discussion. This concerns the real price of oil – which takes into consideration inflation (and perhaps also) exchange rates – as compared to the money (or 'nominal') price. The real price has to do with how much 'real goods' that a certain amount of money will buy. It is often claimed that although the money price of oil may have touched $100/b, the real price was much lower on that occasion.

The excellent Josh on the soap opera 'The West Wing' informed that program's faithful listeners that the highest real price since October 1973 (which was the date of the first oil price shock) was in l980-81, when a change in the political situation in Iran led to the nominal oil price spiking to $40/b. This might be correct if the base date for the calculation of the real price was 1973.

I prefer to believe that the base date for calculating the present real price should be in the middle of the l980s, or perhaps the middle of the l990s, after adjustments had been made to the earlier price shocks, and large industries – to include oil producing firms – as well as consumers, were making plans and investments to deal with a future in which there was talk in the corridors and restaurants of power that someday the oil price would stabilize at $28/b (which was OPEC's goal), or even in the low 20s, which oil firms said that they were using as a benchmark for their investment plans.

For the persons and firms who accepted those forecast prices as realistic, and who adjusted their investment and consumption to deal with these expectations, an oil price in the range that we have experienced in the last year or two is capable of bringing about real sacrifices. For instance, at the present time the economy of e.g. the U.S. is in the process of weakening, bringing perhaps serious job losses and/or lower standards to millions, while at the same time in the Gulf economies are strengthening, and a new Olympus is being constructed. This oil price has also had a major influence with share prices, and what we are experiencing now is the start of a cycle in which falling share prices will impact of GDP via the wealth effect, and this in turn will impact on shares. And so on and so forth. As they might say on Wall Street: no, Virginia, the real price of oil that ill-informed observers often discuss in those unread journals gathering dust in our academic libraries does not pertain to real people. Really.

References

Albouy, Michel (1986). Nouveau Instruments Financiers et Gestion du Couple Rentabilité Risque sur le Marché du Petrole. Stencil: Grenoble Université.

Allen, R.G.D. (1960). *Mathematical Economics*. New York: St Martin's Press.

Banks, Ferdinand E. (2008). 'Economic theory and OPEC'. *PetroMin.* (Forthcoming).

______. (2007). *The Political Economy of World Energy: An Introductory Textbook.* London and Singapore: World Scientific.

______. (2005). 'Logic and the Oil Future'. *Energy Sources.*

______. (2004a). 'A new world oil market'. *Geopolitics of Energy* (December).

______. (2004b). 'Beautiful and not so beautiful minds: an introductory essay on economic theory and the supply of oil'. *OPEC Review* (March).

______. (2001). '*Global Finance and Financial Markets'*. Singapore: World

Scientific.
______. (2000). *Energy Economics: A Modern Introduction*. Dordrecht and Boston: Kluwer Academic.
______. (1994). 'Oil stocks and oil prices'. *The OPEC Review* (Summer).
______. (1991). 'Paper oil, real oil, and the price of oil'. *Energy Policy* (July/August).
______. (1980). *The Political Economy of Oil*. Lexington and Toronto: D.C. Heath.
Dahl, Carol A. (2004). *International Energy Markets*. Tulsa Oklahoma: Pennwell.
Deffeyes, Kenneth S. (2003). *Hubbert's Peak*: *The Impending World Oil Crisis*. Princeton: Princeton University Press.
Flower, Andrew (1978) 'World oil production'. *Scientific American*. 283(3): 41-49.

Fox, Justin (2002). 'The truth about oil security'. *Fortune* (September).
Helman, Christopher (2006), 'Really, really cheap oil'. *Forbes* (October).
Lindahl, Björn (2007). 'Opec ökar inte produktionen'. *Svenska Dagbladet* (December).
Salameh, Mamdouh G. (2007)- 'Peak oil: myth or reality' *Dialogue* (of the USAAE).
Stanislaw, Joseph and Daniel Yergin (1993), 'Oil: Reopening the door.' *Foreign Affairs* (September-October).