A brief economic explanation of Peak Oil

For a number of years there has been an arid debate between economists and geologists about Peak Oil. The geologists maintain that Peak Oil (maximal production) is a geological imperative imposed because reserves are finite even if their exact magnitude is not, and cannot be, known.

In contrast many economists maintain prices will resolve any sustained supply shortfalls by providing incentives to develop more expensive sources or substitutes. The more sanguine economists do concede that the adaptation may be slow, uncomfortable and economically disruptive.

The reality, I believe, is that both groups have part of the answer but that Peak Oil is, in fact, a complex but largely an economically driven phenomenon that is caused because the point is reached when: **The cost of incremental supply exceeds the price economies can pay without destroying growth at a given point in time.** While hard to definitively prove, there is considerable circumstantial evidence that there is an oil price economies cannot afford without severe negative impacts.

The current failure of most western economies to achieve anything more than minimal growth this year (2011) is most likely because oil prices are already at levels that severely inhibit growth. Indeed, research by energy consultants Douglas-Westwood concludes that oil price spikes of the magnitude seen this year correlate one-for-one with recessions.

The corollary is that if oil prices fall back to and sustain levels that do not inhibit growth, then economic growth will resume, with both recoveries and downturns lagging oil price changes by 1-6 months.

Looking at conventional cost curves shows incremental development costs range from $45/b (Saudi) to $90/b (Canadian Tar sands and Venezuelan Orinoco heavy oil) with most of the incremental deepwater sources in the $70-80/b range. Simplistically the historic production cost curve goes, in increasing cost order: Middle East onshore, other Opec onshore, non-Opec onshore, Opec and non-Opec deepwater, Canadian tar sands/Venezuelan heavy oils. Incremental costs broadly follow the same order.

It should be noted there are wide divergences in estimates of oil development costs depending on what is included and the treatment of financial costs, profits and overheads. Those used here are estimates of the prices needed to justify a new, large development.

For most Opec producers oil and gas revenues are their principal source of income and government revenues. There is much literature to show that when oil prices rise producer government expenditures rise and absorb most if not all of the gain very quickly.

The so-called 'Arab Spring' has added a further twist to this process. Governments in a number of Opec countries and some non-Opec producers have dramatically boosted government expenditures to reduce the risk of social upheaval leading to their being overthrown. Increased military and security expenditures feature alongside greater hand-outs and benefits to the population.

Saudi Arabia dramatically illustrates this phenomenon. On the latest budget projections Saudi needs an oil price of $90-100/b for its revenues and expenditures to balance and if it is not to run deficits and consume financial reserves. It is likely that many, if not all of the other, Opec members have revenue/expenditure breakeven oil prices comparable to those of the Saudis.

This means that, whatever the public statements, most Opec members now require oil prices around $100/barrel to balance their books and will seek to secure higher prices by restraining supply if necessary. However, under sufficient economic pressure oil prices would fall with severe impacts on Opec budgets.

As Saudi Arabia is the only oil producer with significant reported spare capacity, its policies effectively set the world selling price for oil. All other suppliers are effectively price-takers and will sell at the highest price available to them. Producers other than Saudi Arabia have the negative power to drive prices higher by reducing production but there are few, if any, prepared to forgo current income in the hope of greater income at a later date.

As a consequence the Effective Incremental Oil Supply Curve (EIOSC) is, in reality, surprisingly flat and lying somewhere in the $80-$110 range. For the immediate future this is the most likely range for oil prices. A recession has the potential to drive prices down to the $40-60 range but this is likely to be relatively short-lived as reviving economic activity, triggered by the lower oil price, would then drive oil prices higher again.

An escalation of oil development costs is happening now and will continue, because the world's endowment of 'easy' oil production is past. As of 1Q 2011 the IHS/CERA Upstream Capital Costs Index had risen to 218 from the 2009 low of 200 and is now on trend to pass the 3Q2008 peak of 230. Increasing producer government expenditures in both Opec and non-Opec countries also mean that the EIOSC will tend to rise.

The rise is actually being driven by the depletion of the low-cost, easily exploitable oil and its replacement (for the moment) by less accessible and higher-cost oil. The chances of any significant and sustained price fall, barring a major global depression, look remote.

Incremental non-Opec supply in the period 2011-2016 in increasing order of costs comes from biofuels (various sources), shale oils (US now, China later), NGLs (various sources), Brazil (deepwater), US (offshore), Canada (tar sands), and with smaller gains from the generally lower cost Colombia (onshore) and Kazakhstan (onshore and offshore).

For Opec incremental supply in 2011-2016 may come from their current spare capacity, predominantly held by Saudi Arabia, or from new capacity. Only three Opec members have realistic plans to expand net capacity. The largest increment comes from Iraq, with rather smaller increments from Angola and the UAE. [Even major projects such as Saudi Arabia's Manifa field development 2013/15 only offset depletion and do not add net capacity]

The Table below attempts to show the size and likely cost of these incremental supplies.

The main oil and NGLs production gains anticipated for 2011-2016 and their likely development costs.

Country	Production gain (million b/d)	Incremental oil Cost ($/barrel)	Comment
Non-Opec			
Canada	1.0-1.2	70-90	Tar sands
Brazil	0.9-1.1	60-80	All deepwater
NGLs	0.5-0.7	50-80	Various sources
US offshore	0.2-0.3	70-80	
US shale oil	1.2-1.5*	50-70	Bakken et al
Colombia	0.2-0.4	40-60	
Kazakhstan Offshore	0.1-0.2	70-80	Multiple delays
Kazakhstan onshore	0.1-0.2	50-70	Delays
Other non- Opec	0.2-0.3	40-70	Mostly Africa
Opec			
Iraq	1.1-1.3	40-60	Security concerns
Angola	0.6-0.8	70-80	deepwater
UAE	0.4-0.5	50-70	redevelopments
Opec NGLs	1.4-1.6	40-60	
Other Opec	0.5-1.0	40-80	Rises & declines

*Bank of America/Merrill Lynch

Thus the geologists are right that the depletion of low cost oil will produce Peak Oil but it will not be caused by a shortage of oil resources.

The economists are right that there is no shortage of oil resources or oil substitutes but have so far failed to recognise that there is an oil price which cannot be afforded and this constraint will create and define an economic Peak Oil to be differentiated from a geological Peak Oil.

Ideally we need to identify a price curve to show the point economic growth is constrained to the point of vanishing but we are confronted with a paucity of data. We believe that $147/b in mid 2008 helped trigger the 'Great Recession' but the global economy was weakening from late 2007. We know that the run up in prices to around $120/b in 2Q 2011 brought growth to a near halt in a number of western economies and notably in Europe. But in this case the economies had not really recovered from the 'Great Recession'. Douglas-Westwood analysis also shows that in mature economies, such as the US, there is a significant economic impact at over $90/barrel. In contrast China can probably sustain oil prices in the $100-110 range.

We also know that the low oil prices of late 2008/early 2009 helped stimulate both an economic recovery but also a rapid recovery in oil demand. In 2010 oil consumption rose by 3.1% globally according to the *BP statistical Review of World Energy June 2011*, the fastest growth in oil demand seen since 2004. Various studies have shown a close correlation between sharp oil price rises and US economic recessions with only the dotcom recession of 2001/02 proving the exception that had no oil price component. Indeed a study by University of California-San Diego economist James Hamilton, links oil price spikes to 10 of the last 11 recessions.

The US shows the pattern of rising oil prices slowing economic growth most clearly, probably because oil products taxation is low, which means that changes in the price of oil feed almost linearly into the economy. As might be expected the effect becomes more damped in European economies which levy high rates of tax on oil products in general and on gasoline and diesel in particular.

Oil producing countries subsidising fuel use can apparently be virtually immune in terms of the impact on economic growth in the short run, although the impact ultimately shows up as spiralling government expenditures as well as lavish and inefficient use of fuel. Venezuela and much of the Middle East are notable examples.

In consumer countries with fuel subsidies, price support programmes are often accompanied by price caps. In the face of rapid oil price increases either national budgets are hit or fuel shortages appear as has been the case in both Iran and Pakistan among others.

According to the IEA's *World Energy Outlook 2010* the largest government subsidies to oil consumption, in 2009, as a percentage of the price and in descending order were: Iran (since reduced), Saudi Arabia, India, Egypt, Venezuela, Indonesia, Iraq, China and Algeria.

But all these countries are ultimately hostage to Chinese demand. By itself, China represents about half of demand growth for most commodities in a typical year. The growth of the Middle Eastern economies and commodity suppliers like Brazil, various African countries, as well as Australia and Canada are largely derivative of China's growth. If China's demand were zero, Brazil's mining and oil sectors would be weak, and with them, the Brazilian economy as a whole.

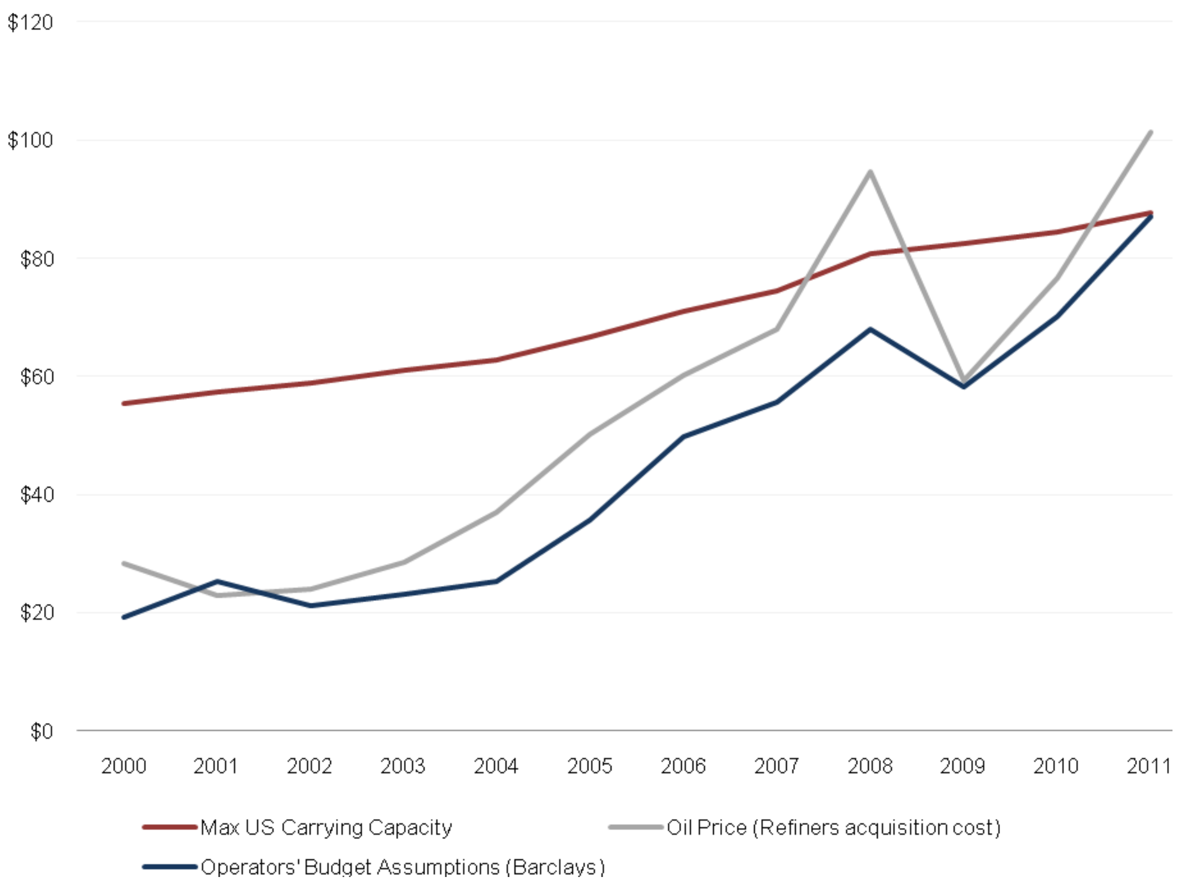
What price, then, can China bear? The historical record shows tremendous volatility, but in general, it would appear the country can afford to spend 6.3%-6.7% of its GDP on crude oil expenditures, or approximately $100-$110/barrel. When prices are above this level, both China's oil consumption and GDP growth tend to fall. This is a good bit higher than the $90/barrel estimated as the bearable price for the US and Europe.

Why is China's tolerance higher? Because the value of oil is higher there. For example it is fairly clear that the economic benefit of the first car in a family is much greater than that of the third. Similarly the productivity gain from the first truck in a commercial fleet is greater than that of the twentieth. This observation suggests that rapidly industrialising economies such as China and India have a higher marginal productivity from an incremental barrel of oil than in more developed economies.

This in turn poses a terrifying question: Would this higher price tolerance mean developing economies could keep developed economies in growthless stagnation by paying oil prices that were just above those that bring developed economies to an economic halt?

The challenges are clear. Historically, the oil prices used by companies for project approval remained well below the carrying capacity of the US economy. For example in 2004 operators were approving projects assuming a $20 oil price, even though the US economy was theoretically capable of handling a price near $60. However, in its most recent survey, Barclays Capital indicates that operator's budget assumptions have risen to $87, literally the maximum carrying capacity of the US (and probably European) economies.

Thus, on current trends, the oil companies will be approving projects that deliver oil at prices literally unaffordable to the advanced economies.(Graph 1 below)



Graph 1 Oil Prices: Refiner's Acquisition Costs, Maximum US tolerance levels, and Operators Budget Assumptions for Project Approval.

Source: Barclays, IMF, EIA, Douglas-Westwood Analysis

Undoubtedly the reality would be less clear cut, as economic growth in emerging economies also stimulate activity. For example, China's rapid growth has created a huge pool of capital; thus the US saw a dual shock in 2008, caused by the low cost of capital, on the one hand, and the high price of oil, on the other. But emerging market growth should, as a practical matter, provide export markets and low-cost capital to assist the advanced economies to adapt to living within smaller energy budgets.

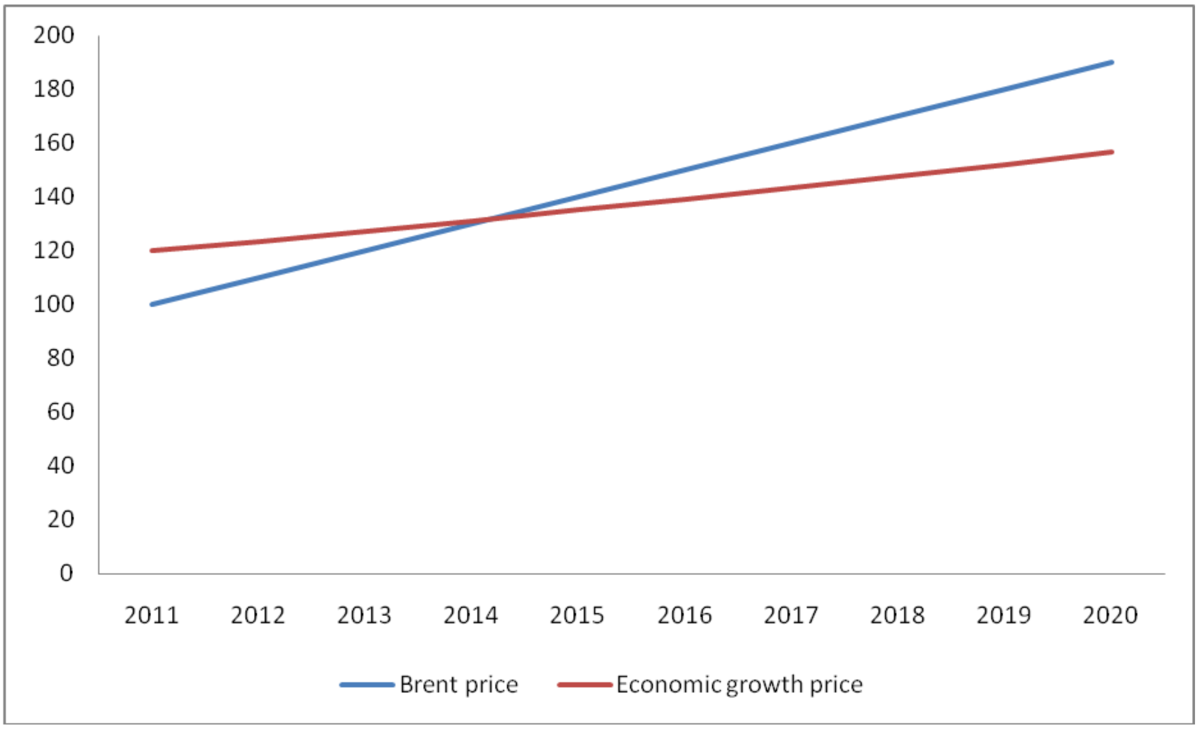
As adaptive responses come through in terms of more efficient vehicles, social and organisational changes such as more home working and the improving economics of energy alternatives, economies will become better able to cope with higher oil prices and suffer less economically.

However, adaptive responses, on the basis of the reactions after the first (1973) and second (1979) oil crises, are slow (taking 10-20 years) while oil prices have been faster moving going from $25 to $100 in the eight years between 2003 and 2011.

If adaptive responses were fast enough and large enough, oil prices might be broadly stable. They clearly are not.

There is a measure of adaptive response in the efficiency gain for oil in use. The adaptive response is to use oil more efficiently or to back out lower added-value uses of oil or to move to other fuels. Either way this shows up as improved efficiency in use (volume of oil per unit of GDP). For many years this has been running at around 2%/year (although some sources believe 1.2% to be a more accurate figure). The IEA now uses a figure of 3% suggesting they believe the process is speeding up.

Between 2003 and 2008 oil prices rose at $10/year. Post-recession this trend ($10/year) has re-established itself (See Graph 3). **Graph 2** (see below) plots an oil price rise of $10/year and a productivity gain of 3%/year (adaptive response). The graph shows the price increases, driven upwards by depletion, outrunning the adaptive responses that higher prices induce, to give a crossover in 2014. The crossover gives the timing of the economically determined Peak because an oil price is reached that is economically destructive and cannot be paid for any length of time.



Graph 2 Plots Brent oil prices rising at $10/year (blue line) and a price that allows economic growth growing at 3% year to reflect an increasing adaptive response (red line). The crossover point gives the economically determined Peak Oil when sustained growth becomes impossible.

This analysis now gives an alternative method of determining the likely timing of Peak Oil. The other method is to determine the net flows of incremental capacity (new capacity minus depletion) and to balance this against the most likely growth trajectory.

The dating of Peak Oil using this economic approach gives almost identical results to calculations based on net incremental supply (New capacity minus depletion) with both approaches showing 2014/2015 as the crunch point. This coincidence is not surprising as most of the remaining oil development projects are high cost (Deepwater, Tar sands, Arctic).

Oil prices are likely to spike in the run up to Peak Oil, whether this is reached because of geological constraints or affordability constraints. This will be economically destructive. It may have the effect of bringing the Peak forward as rapidly changing prices tend to inhibit appropriate investment, particularly if there is significant price volatility within the price trend. Some of the larger and financially stronger companies may be able to maintain investment through the cycle but the weaker ones will find this difficult.

The key adaptive response to high oil prices, at least initially, is fuel substitution. In the 1970s around 25% of all oil went for power generation as heavy fuel oil. Currently, oil in world electric power generation is 4% and falling, having been backed out by coal, gas and nuclear generation. Similarly the use of oil for space heating (gas oil/furnace oil) is in decline and largely displaced by gas although efficiency in use and improved insulation have played their part.

Gas to liquids (GTL), Coal to liquids (CTL), Biomass to liquids (BTL) and Enhanced Oil Recovery (EOR) all have the potential to increase oil liquids supply as does Algal oil. At the moment only GTL costs are economically robust and then only if there is a guaranteed supply of low-cost gas. According to the IEA currently the lowest cost of these potential incremental supplies is CO_2 EOR then GTL, other EOR, BTL and CTL.

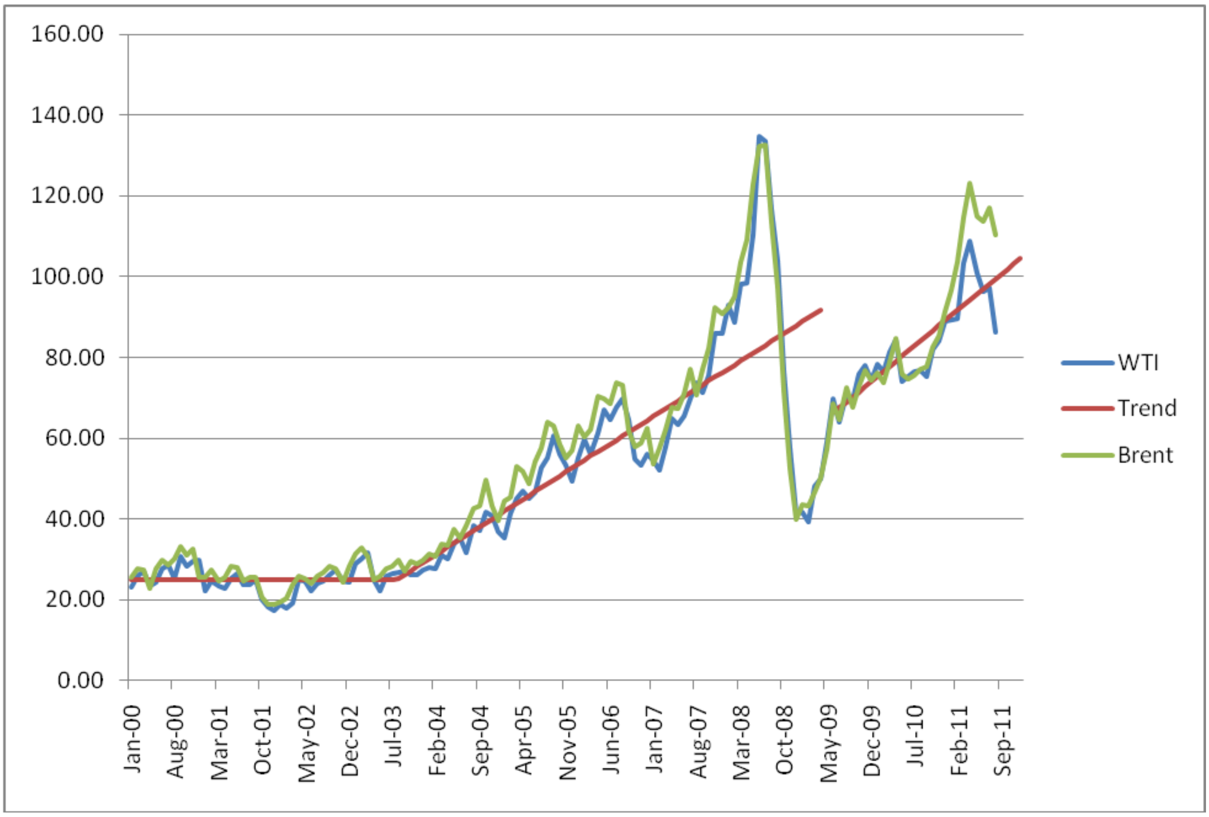
The new challenge is, that with 70-75% of oil going into the transport sector globally and 80-85% in the US how can or will this be substituted? The radical change – moving to electrical power – is not yet fully economic and is really only applicable to surface transport. Biofuels are being actively promoted but are really only fuel extenders. In addition the food or fuel challenge has not been fully resolved. The so-called second and third generation biofuels solve the food/fuel dilemma but are not yet economic. The use of natural gas for transport in places like Pakistan, India, Brazil, Iran and other emerging economies is becoming fairly widespread. However, in all economies, any transition takes significant time and investment.

In short the ability to substitute oil-derived transport fuels, other than in the longer term, is quite limited while transport demand is growing strongly, particularly in Asia, Africa and South America. In addition there is an existing global fleet of over 800 million vehicles that run on gasoline and diesel.

High added-value uses of oil such as solvents and lubricants will almost certainly withstand higher oil prices and efficiency in use will be driven by higher prices. Petrochemicals feedstock are another high added-value use but even here there has been a notable move from using petrochemical naphtha to the Natural Gas Liquids (NGLs) ethane, propane and butane.

In short the relatively straightforward substitution of heavy fuel oil and heating oils has already been mostly done while the hard task of substituting transport fuels has barely started.

All the indications are that adaptive responses have failed in terms of both size and speed to restrain the steady rise in oil prices seen after 2003. The only break in the steady oil price increase occurred as a result of the 2008 economic crisis and the subsequent 'Great Recession'.



Graph 3 Shows the development of oil prices and illustrates the $10/year trend (red line)

The conclusion appears to be that:

Unless and until adaptive responses are large and fast enough to constrain the upward trend of oil prices, the primary adaptive response will be periodic

economic crashes of a magnitude that depresses oil consumption and oil prices. These have the effect of shifting consumption from incumbent consumers—the advanced economies—to the new consumers in the developing economies.

This is exactly what happened in the last recession when between the start of the recession in January 2007 and its effective end in 1Q 2011 demand rose by 4.3 million b/d in the non-OECD area and fell by 4 million b/d in the OECD area.

Acknowledgement: I would like to thank Steve Kopits and Robert Hirsch for all their help and support and for valuable input to this article.