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The New Economics of Oil

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Introduction

The oil market has been at the centre of economic news over much of the past year: what should we make of the US shale revolution; how will the rebalancing of the Chinese economy affect demand; and most obviously, what are the implications of the dramatic fall in oil prices over the past year or so? The implications of these developments are far reaching. For policymakers, responding to their impact on the prospects for demand and inflation; for financial markets, involved in the trading and financing of oil flows; and most fundamentally of all, for businesses and families across the world that rely on oil to fuel their everyday businesses and lives.

As economists, when faced with questions about the oil market and oil prices, a natural instinct is to revert to the key principles and beliefs that we think underpin the operation of the oil market. In particular, much of the thinking has been based around four core principles:

Oil is an exhaustible resource: it will eventually run out. As such, as it becomes increasingly scarce, the price of oil is likely to increase over time relative to the prices of other (inexhaustible) goods and services. The classic reference here is obviously Hotelling[1], which treats oil resources as akin to a financial asset, such that (in the simplest case) the relative price of oil increases in line with the real interest rate.

Oil demand and supply curves are steep: i.e. they are very price inelastic: demand because there are relatively few substitutes for oil, especially in the short run; and supply because once an oil company has invested huge sums of money in building an operating platform and the oil is flowing, the supply from that operation is not sensitive to fluctuations in the price. A producer doesn't turn the tap off just because the oil price falls.

Oil flows from east to west: most obviously, oil is produced in the Middle East and flows to Europe and America. The counterpart is that money flows in the opposite direction, leading to well-known issues associated with petrocurrencies and petrodollars.

OPEC stabilises the oil market: for example, in 2008/9 with the global economy in deep recession, and oil prices plunging from $145 to $35, OPEC cut production by nearly 3 million barrels per day (mb/d) helping to stabilise prices. Similarly, OPEC raised production sharply in 2004 when global demand suddenly surged.

The individual toolkits that we each reach for when trying to make sense of the oil market will all be slightly different, with different elements and different emphases. But for many of us something like these four basic principles feature in them. If that is the case, we may need to think again. The oil market has changed very significantly over the last 10 or 15 years. The principles and beliefs that served us well in the past are no longer as useful for analysing the oil market. We need an updated set of principles reflecting the New Economics of Oil.

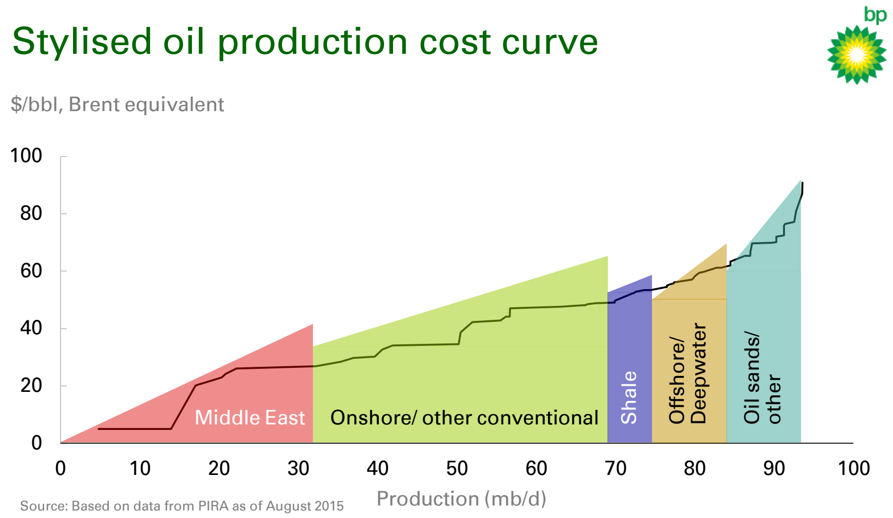
Two changes in particular have had a profound impact on the economics of the oil market. The most significant change stems from the US shale revolution. The rapid growth of on-shore oil production in the US, typically using hydraulic fracturing (or fracking) techniques to extract oil from shale and other types of so-called tight rocks. From a near standing start in 2010, US shale oil production has increased to around 4.5 mb/d today. Cost structures vary greatly across different regions and different plays, but most estimates suggest that the majority of US shale oil lies somewhere broadly in the middle of the

[1] Hotelling, H. 1931. The economics of exhaustible resources. *Journal of Political Economy*, 39, pp. 137–175.

aggregate cost curve (Figure 1). Although US shale oil accounts for less than 5% of the global oil market, the rapid growth in US shale oil was the key factor driving the collapse in oil prices last year: US oil production on its own increased by almost twice the expansion in global oil demand. Moreover, the different production techniques and financing structures found in the US shale industry have the potential to have a lasting impact on global oil market dynamics.

The second major change is occurring more slowly and arises from the increasing concerns about carbon emissions and climate change. Such concerns are, of course, nothing new. But increasing prominence is being given to them, in China and the US as well as Europe, and momentum for increased action is growing – particularly this year as the Paris talks approach. If that sense of urgency translates into policies this could have significant implications for the long-run demand for all fossil fuels.

Figure 1



New Economics of Oil

To consider what this might mean, let's revisit the four basic principles outlined above and see how they are affected by recent developments.

Revisiting Principle 1: Oil is an exhaustible resource

The first, most basic, principle was that oil is an exhaustible resource. In its simplest form, Hotelling does not allow for the possibility of new discoveries of oil or for uncertainty as to how much can be extracted from a particular reservoir. The total stock of recoverable oil resources is assumed to be known and the main focus is on the optimal pace at which these resources should be exhausted.

But in practice, estimates of recoverable oil resources are increasing all the time, as new discoveries are made and technology and understanding improves. And, importantly, they are increasing far more quickly than existing reserves are consumed. In very rough terms, over the past 35 years, the world has consumed around 1 trillion barrels of oil. Over that same period, proved reserves of oil have increased by more than 1 trillion barrels. Put differently, for every barrel of oil consumed, another two have been added. Total proved reserves of oil – reserves of oil which, with reasonable certainty, can be economically recovered from known reservoirs – are almost two-and-a-half times greater today than in 1980.

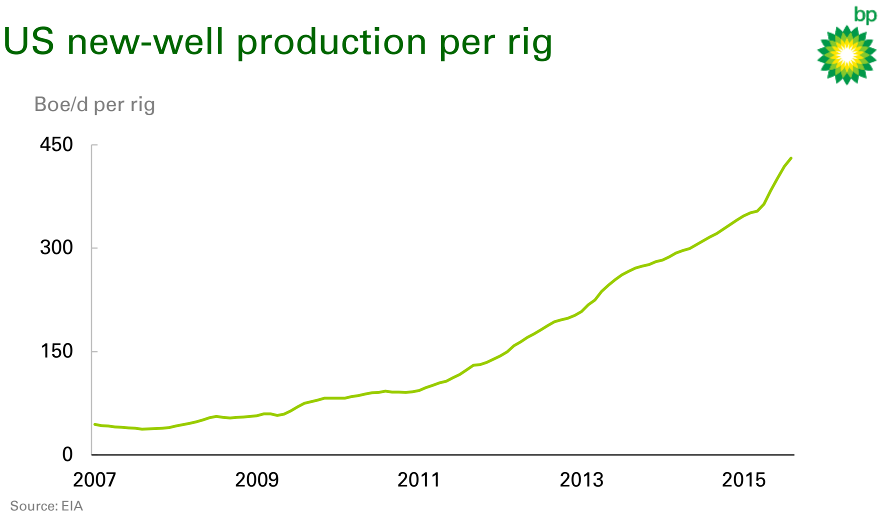
Increases in available oil resources are nothing new. But what has changed in recent years is the growing recognition that concerns about carbon emissions and climate change mean that it is increasingly unlikely that the world's reserves of oil will ever be exhausted. Existing reserves of fossil fuels – i.e. oil, gas and coal – if used in their entirety would generate somewhere in excess of 2.8 trillion tonnes of CO_2, well in excess of the 1 trillion tonnes or so the scientific community consider is consistent with limiting the rise in global mean temperatures to no more than 2 degrees Centigrade.[2] And this takes no account of the new discoveries which are being made all the time or of the vast resources of fossil fuels not yet booked as reserves.

There are many caveats and qualifications to this type of simple calculation. Most importantly, not all fossil fuels are alike: coal is the highest-carbon fuel and burning current reserves of coal would account for 60% of those emissions. It follows that coal is likely to be more affected by future climate policies than either oil or gas. Moreover, emerging technologies, such as Carbon Capture and Storage (CCS), mean that we may be able to find new ways of using fossil fuels for power generation which significantly reduce Greenhouse Gas emissions. But even so, the pace at which estimates of recoverable oil resources are increasing, together with growing concerns about the environment, means that it seems unlikely that all of the world's oil will be consumed.

How might this change our understanding of the oil market? Importantly, it suggests that there is no longer a strong reason to expect the relative price of oil to increase over time. As with other goods and services, the price of oil will depend on movements in demand and supply. From the supply side, it might still be natural to assume that the relative price of oil will increase over time as it becomes increasingly difficult (and costly) to extract. The most easily accessible oil is extracted first, forcing energy companies to dig deeper and deeper in increasingly difficult environments.

But this increasing difficulty needs to be set against technological progress. The oil industry, as with any other successful industry, is continually innovating and implementing new techniques and processes. The poster child for these advancements in recent years has been the US shale industry. The use of increasingly sophisticated drilling techniques and huge improvements in cost efficiencies has allowed previously uneconomic resources of oil to be recovered. Productivity gains within the US shale industry in recent years have been mind-boggling. Productivity growth, as measured by initial production per rig, averaged over 30% per year between 2007 and 2014 (Figure 2).

Figure 2



[2] IPCC 2013, *Fifth Assessment Report, Summary for Policymakers*

The recognition that oil resources are probably never likely to be exhausted puts greater focus on future productivity trends when assessing the long-term outlook for oil prices. The possible implications of the US shale revolution are particularly fascinating in this regard.

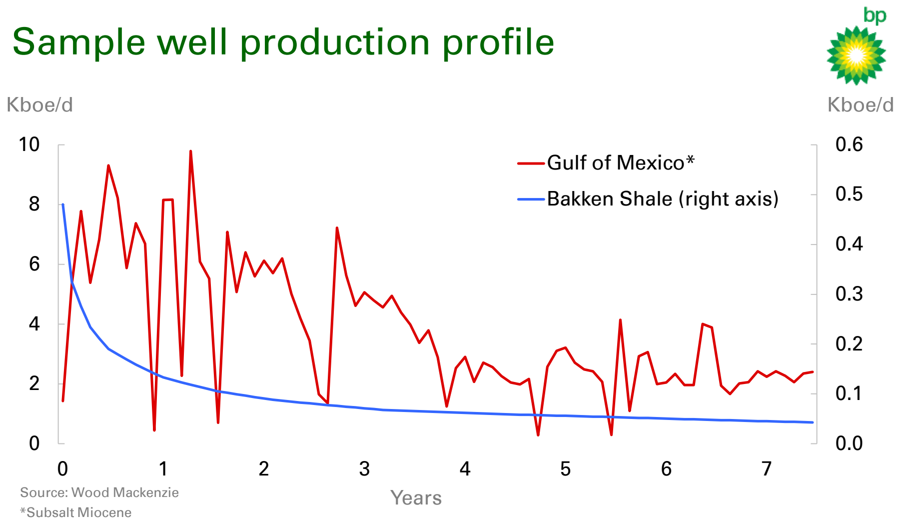
The key point here is that the nature of fracking is far more akin to a standardised, repeated, manufacturing-like process, rather than the one-off, large-scale engineering projects that characterise many conventional oil projects. The same rigs are used to drill multiple wells using the same processes in similar locations. And, as with many repeated manufacturing processes, fracking is generating strong productivity gains. The strength of manufacturing productivity has led to a trend decline in the prices of goods relative to services. A fascinating question raised by fracking – and its manufacturing-type characteristics – is whether it will have the same impact on the relative price of oil. A key issue here is whether these types of repeated, standardised processes can be applied outside of the US and to more conventional types of production. Can the discipline of lean manufacturing be applied to conventional oil operations?

Revisiting Principle 2: Oil demand and supply curves are steep

The limited responsiveness of conventional oil supply to price movements stems from the significant time lag between investment decisions and production. It can often take several years or more from the decision to invest in a particular field before it starts to produce oil, and once the oil is flowing, it will often last for many years.

Shale oil (and fracking) completely changes all that, in two important respects. First, the nature of the operation in which the same rigs and the same processes are used to drill many wells in similar locations means the time between a decision to drill a new well and oil being produced can be measured in weeks rather than years. Second, the life of a shale oil well tends to be far shorter than that for a conventional well: its decline rate is far steeper. Figure 3 compares production data taken from a typical US shale well, in this case in the Bakken in North Dakota, with that from a Deepwater well in the Gulf of Mexico (GOM). Daily production from the shale well declined by around 75% in its first year of production – a really steep rate of decline. The corresponding rate of decline for the GOM well was far slower.

Figure 3



These two characteristics – short production lags and high decline rates – mean there is a far closer correspondence between investment and production of shale oil. Investment decisions impact production far more quickly. And production levels fall off far more quickly unless investment in maintained.

An important consequence of these characteristics is that the short-run responsiveness of shale oil to price changes will be far greater than that for conventional oil. As prices fall, investment and drilling activity will decline and production will soon follow. But as prices recover, investment and production can be increased relatively quickly. The US shale revolution has, in effect, introduced a kink in the (short-run) oil supply curve, which should act to dampen price volatility. As prices fall, the supply of shale oil will decline, mitigating the fall in oil prices. Likewise, as prices recover, shale oil will increase, limiting any spike in oil prices. Shale oil acts as a form of shock absorber for the global oil market.

It is important to be clear exactly why shale oil is likely to play this role. The short lead-time between investment decisions and production means output can adjust relatively quickly. Equally important, the very high rates of decline of shale wells mean that operating costs in the shale industry – i.e. the variable cost associated with producing a barrel of oil – are a relatively high ratio of total costs. The high decline rates mean, in effect, that shale operations have relatively low fixed costs. This high ratio of variable costs to total costs increases the short-run responsiveness of shale oil.

In contrast, more conventional operations tend to have a significant fixed investment component, for example, in the form of operating platforms, pipelines etc. These sunk costs mean that the variable cost of producing an extra barrel of oil is materially lower than the total (all in) cost, dampening the responsiveness of conventional supply in the short run.

To be clear: shale oil is the marginal source of supply only in a temporal sense. The majority of shale oil lies somewhere in the middle of the cost curve. As such, further out, as other types of production have time to adjust and oil companies have to take account of the cost of investing in new drilling rigs and operating platforms, the burden of adjustment is likely to shift gradually away from shale oil towards other forms of production, further up the cost curve.

There is one other interesting point to note when considering the supply of shale oil. Although its production characteristics should dampen price volatility, the financial characteristics of the independent producers operating in US shale may introduce an additional source of volatility. Conventional oil supply is dominated by large national oil companies and, to a lesser extent, large international oil companies. These companies are very big, with global footprints, producing huge quantities of oil every day. They have relatively low levels of gearing, significant cash reserves, and an operating model which, in most times, ensures that the cash generated by the business is more than sufficient to cover capital expenditures. In contrast, the financial structures of even the largest independent producers operating within the US shale are far less robust. The scale of activity is considerably smaller. Typical gearing levels are far higher. And, importantly, the vast majority of independent producers have negative cash flows; that is, they don't generate sufficient cash from their operations to fund future investments. As such, they are dependent on a continual supply of external finance in order to invest and produce.

In macroeconomic context, US shale has introduced a credit channel to the oil market. And it is well known from the misery of the financial crisis how destabilising credit and banking flows can be in transmitting and amplifying shocks. Until now, the financial resources of the national oil companies and the large supermajors mean that the oil market has been largely insulated from the vagaries of the banking system. But the small, heavily-indebted, independent producers that characterise the shale industry change all that.

It seems quite likely that the scale of funding that enabled the US shale revolution to expand at the pace it did over the past 4 or 5 years would not have been available had global interest rates not been close to zero, with central banks using large-scale quantitative easing to encourage investors to invest in riskier forms of assets. Likewise, with the balance sheets of many shale producers now severely weakened by low oil prices, a key factor determining the supply of shale oil over the next few will be the willingness of banks and creditors to continue to fund these businesses, especially as global interest rates begin to rise.

The emergence of US shale oil has altered the nature of global oil supply. The production characteristics of shale oil should increase the price responsiveness of supply, dampening price volatility. But the greater exposure of shale producers to the financial system means the oil market is more exposed to financial shocks.

Revisiting Principle 3: Oil flows from East to West

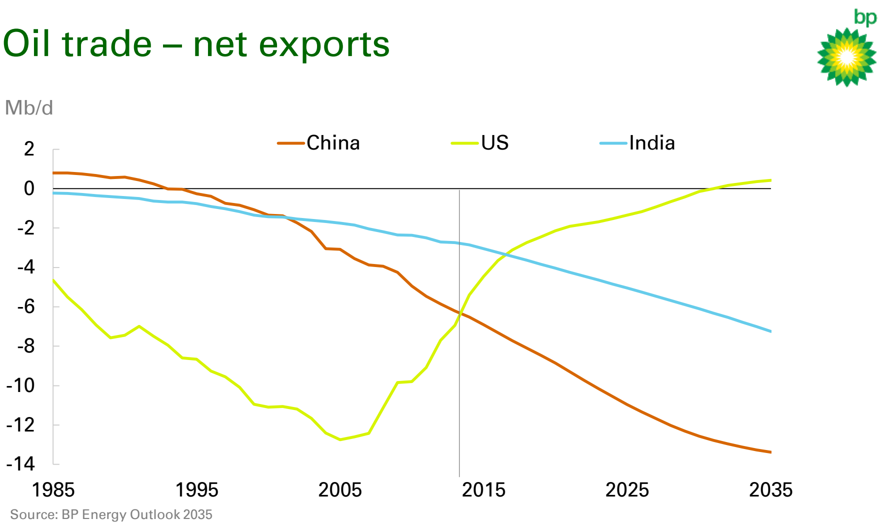
This traditional pattern of trade is also changing, reflecting developments in both the west and the east. In terms of the west, two developments are important. First, the demand for oil in the west is falling. Oil consumption in the US and Europe peaked about 10 years ago and has been on a downward trend ever since. This largely reflects the improving efficiency of motor vehicles, with fuel economy of new cars in the US, measured in terms of miles per gallon, around 20% higher than 10 years ago. And if anything, tightening regulation and improving technology mean that the pace of efficiency gains is likely to quicken over the next 20 years. In BP's Energy Outlook 2035, which looks at energy trends over the next 20 years or so, the EU's consumption of oil in 2035 is projected to be back down to levels last seen in the late 60s, even though EU GDP would have almost quadrupled over the same period.

The second factor is the huge growth in the supply of energy in the west, particularly North America. Over the past 5 years, the US on its own has accounted for almost two-thirds of the increase in the global supplies of oil and natural gas. Added to that is the growth of Canadian oil sands. North America has become a major force amongst global energy suppliers.

The impact of these two factors has had a huge impact on the dependency of the US on energy imports. At its peak in 2005, the US imported more than 12 mb/d of oil; comfortably the world's largest importer of oil. The growth of shale oil has changed all that. US import demand has more than halved over the past 8 years, and the US was overtaken by China as the world's largest net oil importer in 2013. Looking ahead, we expect the US to become self-sufficient in energy by the early 2020s and in oil by the early 2030s (Figure 4). If anyone, 10 or even 5 years ago had suggested that the US would be self-sufficient in energy in their life time they would have been laughed at. The US shale revolution has changed all that.

In contrast, the fast growing economies of the Far East, particularly China and India, are becoming increasing dependent on imported energy. As their economies grow, and the prosperous middle-classes balloon, China and India are likely to account for around 60% of the global increase in oil demand over the next 20 years[3]. This increase in oil demand will far outstrip local supplies, such that by 2035, China looks set to import around three-quarters of the oil it consumes and India almost 90%.

Figure 4



[3] BP Energy Outlook 2035

This changing pattern of energy flows has a number of potentially important implications. The most obvious are for the sources of demand that are likely to drive energy markets over the coming years. The answer – as is the case for so many questions these days – is to look east.

Next are implications for financial flows: as energy increasingly flows from west to east, the funds to pay for that energy will travel in the opposite direction. This has potentially far-reaching implications for our understanding of financial risks and asset prices. The US current account deficit, along with China's current account surplus, was a key part of the so-called global imbalances that foreshadowed the global financial crisis. Energy imports were a big part of this imbalance, accounting for almost half of the US current account deficit of 6% in 2007. That energy deficiency has now reduced to around 1% of GDP, with the US set to move to energy self-sufficiency by the early 2020s. A key element in the global imbalances has completely changed. In a similar vein, this reduction in the US energy deficit is also likely to have contributed to the appreciation of the dollar in recent years. Much of the discussion of the dollar's appreciation has focussed on cyclical factors: the relative strength of US demand growth and its implications for the timing of interest rate hikes. But it is also important to recognise the important structural changes that have taken place as the US reliance on energy imports has been transformed.

As well as energy and financial implications, the changing pattern of energy flows also has potentially important geo-political implications. It is inconceivable that the reduced dependency of the US on oil imports won't affect its relationship with some of the key oil producers. Perhaps even more importantly, China's increasing reliance on energy imports to fuel its future growth – and the associated concerns this brings about energy security – is likely to have an increasing influence on China's foreign relations. Indeed, it seems likely that the creation of the Asian Infrastructure Investment Bank (AIIB) – and the associated "one belt, one road" policy which has been a centre piece of President Xi Jingping's first term – stems in no small measure from these energy security concerns.

Revisiting Principle 4: OPEC stabilises the oil market

Many commentators have interpreted recent developments as suggesting that the role of OPEC has changed. That OPEC has given up its role as swing producer to shale oil. Or that, rather than stabilising the market, OPEC has waged war on US shale.

In my view, these suggestions are problematic. Indeed, I would argue that the role of OPEC has not fundamentally changed relative to the past 20 or 30 years. Rather, the belief that OPEC would always stabilise the market was never correct.

The power of OPEC to stabilise the market stems from its ability to vary supply inter-temporally: to increase or decrease supply from one period to another in response to shocks or fluctuations. As such, OPEC has considerable power to stabilise the market in response to *temporary* shocks, to either demand or supply. In terms of demand shocks, in 2008/9 at the height of the great recession, as oil prices plunged from $145 to $35, OPEC reduced supply by nearly 3 mb/d, stabilising the market and boosting prices. Similarly in 1999, as the Asian financial crisis was hitting demand, OPEC reduced supply in order to support market prices. And on the supply side, as the Arab Spring caused significant supply disruptions in several oil producers in the Middle-East and North Africa, other OPEC producers – most notably the main GCC states: Saudi Arabia, Kuwait and UAE – increased their supply to offset partially these disruptions.

The ability of OPEC to respond to temporary shocks in order to stabilise the market has not changed. OPEC still accounts for around 40% of crude oil production – close to its average over the past 40 years. Many of the key producers still have the ability to control directly their levels of production. And Saudi Arabia has the only significant margin of spare capacity. But OPEC has never had the ability to stabilise the market in response to structural shocks, at least not in a sustainable way. Suppose, just for a moment, that in 2008/9 there hadn't been a severe global recession, but instead a mass-produced electric car had been invented overnight and had replaced the existing car fleet. The impact on the oil market would have been similar in that the demand for oil would have contracted sharply and oil prices would have fallen.

But the ability of OPEC to do anything about it would have been very limited. It is true that OPEC could cut its production; but only at the expense of giving up its share of an already contracting market to higher-cost producers. And to maintain prices, it would have needed to give up progressive amounts of market share in subsequent years as the number of electric cars increased. This is not a sustainable response.

The key point is that, unlike the global recession where demand was expected to recover at some point in the future, my hypothetical example of a mass-produced electric car is a persistent shock. The economically sensible response to such persistent shocks is for OPEC to maintain its market share and let other higher-cost producers, less able to compete, bear the brunt of the demand contraction. We haven't yet seen the invention of the mass-produced electric car. But the emergence of US shale oil had a similar qualitative impact on the supply side.US shale, although more cyclical, is likely to be a persistent source of supply for many years to come. Much of current shale oil production is situated somewhere in the middle of the cost curve. And the rapid pace of productivity improvements means that its competitive position relative to other types of production is increasing all the time.

OPEC is no more able to wage war on US shale than it could on the electric car. And it hasn't. Last year, as oil prices plummeted, OPEC stated that it would maintain its production target of 30 mb/d and it did just that: producing an average of 30.1 mb/d in 2014. This doesn't mean that OPEC has ceded its role of swing producer to shale oil. To repeat: OPEC's ability to stabilise the market in response to short-lived, temporary shocks remains largely unaffected. The greater responsiveness of US shale means that cyclical movements in shale production should also help to stabilise the market. But OPEC's role remains dominant.

But when interpreting OPEC's likely response to a change in prices it is important to ask why are prices changing? Is it in response to a temporary shock or a more persistent factor? A global recession or the mass deployment of an electric car?

Conclusion

The emergence of shale oil, together with growing concerns about climate change and the environment, means that the beliefs that many of us have used in the past to analyse the oil market are out of date. We need a new toolkit, a new set of principles, to guide our analysis of the oil market. A new set of principles that reflect the New Economics of Oil. What this means in terms of formal models and frameworks still need to be worked out. But my instinct is that any new framework should include the following four principles:

Oil is not likely to be exhausted: As such, there shouldn't be a presumption that the relative price of oil will necessary increase over time. A key factor governing the future price of oil is whether the standardised, repeated, "manufacturing-like" processes characterising shale production, with the associated rapid gains in productivity, spread to other types of production.

The supply characteristics of shale oil are different to conventional oil: shale oil is more responsive to oil prices, which should act to dampen price volatility. But it is also more dependent on the banking and financial system, increasing the exposure of the oil market to financial shocks.

Oil is likely to flow increasing from west to east: with important implications for energy markets, financial markets, and geo-politics.

OPEC remains a central force in the oil market: but when analysing its ability to stabilise the market, it is important to consider the nature of the shock driving the change in oil prices and, in particular, whether it is a temporary or persistent factor.