What can be said about the rise and fall in oil prices?

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The price of oil rose steadily between the middle of 2003 and the end of 2007, rose further and more rapidly until mid-2008 and fell sharply until the end of that year. Commentators agree that a significant part of the increase in the oil price over that period was due to rapid demand growth from emerging markets, but there are substantial differences of view about the relative importance of other factors, and limited work thus far in explaining the large fall in oil prices in the second half of 2008. The purpose of this article is to analyse the main explanations for the rise and fall in oil prices in the five years until the end of 2008. It argues that shocks to oil demand and supply, coupled with the institutional factors of the oil market, are qualitatively consistent with the direction of price movements, although the magnitude of the rise and subsequent fall during 2008 is more difficult to justify. The available empirical evidence suggests that financial flows into oil markets have not been an important factor over the period as a whole. Nonetheless, one cannot rule out the possibility that some part of the sharp rise and fall in the oil price in 2008 might have had some of the characteristics of an asset price bubble.

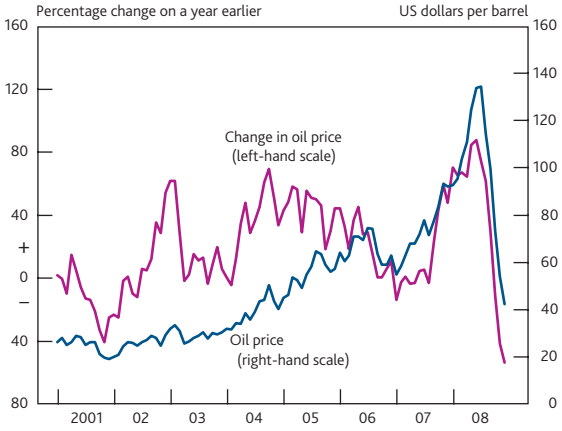
Introduction

The past six years have seen unprecedented swings in the price of oil. 'Dated Brent' crude oil prices rose steadily between the middle of 2003 and the end of 2007, before the pace of increase picked up sharply in the first half of 2008 (**Chart 1**). By July 2008, prices had risen by more than 50% in nominal terms over a six-month period, but they then collapsed, ending 2008 no higher than they had been at the end of 2004.

There has been no shortage of interest in, and explanations for, the remarkable rise and fall in oil prices. Most commentators agree that part of the increase over the five years to the start of 2008 was due to rapid demand growth from fast-growing emerging economies.(2) But there are substantial differences of opinion about the relative importance of other factors, with some stressing shocks to fundamentals and others focusing more on the role of speculative activity and asset price bubbles.

The purpose of this article is to analyse the main explanations that have been put forward. It discusses explanations that stress demand and supply shocks with those that emphasise the role of speculative activity in the oil market and considers whether conclusions reached about the 2003–07 period also hold for 2008. Although the underlying factors considered here are also relevant in analysing the behaviour of oil prices in 2009,(3) the focus of this analysis is the five-year period up until the end of 2008.

Chart 1 Dated Brent oil price(a)



Sources: Bloomberg and Bank calculations.

(a) Monthly averages.

The paper is organised as follows. The next section reviews the predictions of economic theory about the prices of exhaustible commodities, such as oil. The article then considers whether

(1) The authors would like to thank Dan Nixon for his help in producing this article.
(2) See Chapter II of the IMF April 2006 *World Economic Outlook*.
(3) In the first eight months of 2009 prices increased by around 75%.

shocks to demand and supply are consistent with the behaviour of oil prices since 2003 and follows with an assessment of the role of asset price bubbles and speculative flows. The final section concludes.

Economic theory and oil price dynamics

Oil has two key characteristics that differentiate it from other goods. First, it can be stored away. Second, it is exhaustible. Both of these characteristics have important implications for oil price dynamics.

Storability

The seminal paper on the effect of storability on commodity price behaviour is Working (1949). Market participants can purchase a futures contract which promises to deliver one barrel of oil in the following period. Alternatively, they can buy a barrel of oil in the spot market in the current period, and exploit its storability by holding it as inventory. They will then incur the costs of storage and forego the interest from not saving the money in a bank. The benefit they get in return is a 'convenience yield', which is the flow of services gained by holding the oil rather than a futures contract. There is always a risk that a futures contract will not be able to deliver the physical oil when needed. Large users of oil prefer to hold it rather than a promise of it in the future (oil refineries cannot produce petrol using financial contracts). This means that the futures price of oil for delivery one period ahead can be written as:

$$f_t = s_t(1+i_t) + sc_t - cy_t \qquad (1)$$

where f_t is the futures price, s_t is the spot price, sc_t is the storage cost, cy_t is the convenience yield and i_t is the one-period rate of interest.

It follows that the level of inventories market participants hold in the oil market will in part reflect the exploitation of all profitable deviations between futures prices and spot prices by drawing down or building up inventory. At the same time, the level of oil inventories will also reflect 'fundamentals' as market participants will respond to shocks to the net balance of oil demand and supply by changing their inventories. For example, in response to a positive but temporary demand shock oil refineries might draw down their inventories, which in turn will smooth the spot price response to the shock. By contrast, a permanent demand shock would lead them to increase their desired level of inventories, and hence the spot price and the futures price will rise.

Exhaustibility

The seminal paper on the impact of exhaustibility on oil price dynamics is Hotelling (1931). Hotelling's main insight was that for a planned path of oil extraction to be optimal, producers must be indifferent between selling an additional barrel of oil in one period and investing the proceeds at the prevailing market rate of interest or waiting and extracting the barrel in the following period. Otherwise producers would benefit from moving resource extraction between periods. It follows that the price of the exhaustible resource net of marginal extraction costs ('net price') should be expected to increase at the rate of interest between one period and the next. This condition is known as Hotelling's rule, and it produces a path for the expected net oil price (Hotelling's path). This path will be consistent with an expected path for future demand. A different path for future expected demand will produce different paths for net prices (still increasing at the rate of interest but from a different level).

The empirical applicability of Hotelling's rule has often been limited. One reason for this is that it applies to the price net of costs rather than the actual price paid in the market. And each expected path for the net price can be consistent with a variety of expected paths for actual prices, depending on what is expected to happen to marginal extraction costs. Second, shocks to demand and supply will cause the expected net price to move between different Hotelling paths over time. It follows that in order to analyse oil price movements in the post-2003 period, it is necessary to identify the demand and supply shocks that may have moved prices on to different Hotelling paths.

Shocks to demand and supply

This section considers whether unexpected changes in demand and supply can explain the fluctuations in oil prices between 2003 and 2008. In doing so, the analysis relies on official estimates of demand and supply and their revisions by the US Energy Information Administration (EIA) and the International Energy Agency (IEA) over a two-year horizon. In interpreting this analysis, it is useful to bear in mind that although the EIA and IEA estimates are widely monitored by market participants, they are not necessarily the market's view. Moreover, prices today will be affected by the market's view about the balance between demand and supply well beyond two years.

This article attempts to assess whether the direction of price movements was in accordance with the news about net demand. But it does not attempt to measure the scale of the effects of news on net demand on the oil price. To do so one would need to estimate a model of oil prices that performs well in terms of out-of-sample forecasting and, crucially, allows for the identification of demand and supply shocks. Given the relatively poor forecasting success of existing efforts (see the box on page 217), this article does not seek to estimate such a model.

Modelling oil prices — a brief review of the literature

The vast literature on modelling oil prices can be broadly grouped into two classes. The first includes futures prices and often interest rates, storage costs and measures of the convenience yield as explanatory variables so as to capture arbitrage opportunities between spot and futures markets. Some authors (eg Longo, Manera, Markandya and Scarpa (2007) and Zeng and Swanson (1998)) have found that forecasts from such models outperform those from simple time-series benchmarks, such as autoregressive or random walk models. But these results are far from unanimous and, in any case, spot and futures prices are jointly determined by current and expected demand and supply. As such, it is difficult to identify demand and supply shocks in these models.

The second class of models estimates oil prices as a function of oil market fundamentals. Such models can be set up as a vector autoregression (VAR) (eg Kilian (2008)), but typically tend to be single reduced-form equations, and explain oil prices in terms of proxies for demand, supply and extraction costs. But oil prices respond to both current and prospective demand and supply. And this implies two minimum requirements for such models to identify demand and supply shocks. First, they must include forward-looking explanatory variables. And second, explanatory variables should be that component of changes in fundamentals that comes as news to the market. That is, given that oil prices behave like asset prices, it is not strong demand growth, but stronger-than-expected demand growth that should push prices up. Data constraints, especially at higher frequencies, make it difficult to estimate such models.

Given these limitations, perhaps it is unsurprising that even when models of this type compare favourably to time-series benchmarks in terms of estimation, they do not have a similar advantage when it comes to forecasting (Dées, Gasteuil, Kaufmann and Mann (2008) and Longo *et al* (2007)). Longo *et al* (2007) find that forecasting power is greatly improved if financial variables such as futures prices are also included to form 'mixed models'. But, as explained above, the inclusion of financial variables limits the usefulness of a model for judging whether price changes have been consistent with fundamentals. And, in any case, it is not possible to attribute price movements to demand or supply news, when unexpected changes are not isolated in the estimation process. An alternative method used to explain price movements is to combine estimates of the price and income elasticities of oil demand and the price elasticity of supply with actual growth rates in income and oil market fundamentals to back out an implied path for prices. But the ability of such models to capture year-on-year variation in prices is poor (eg OECD (2008)). Again, this is likely to be related to the omission of expectations of future supply and demand, which also means that such models fail to identify demand and supply shocks. For this reason, there is no attempt to invert the model of oil demand (described in the box on page 218) in a similar way.

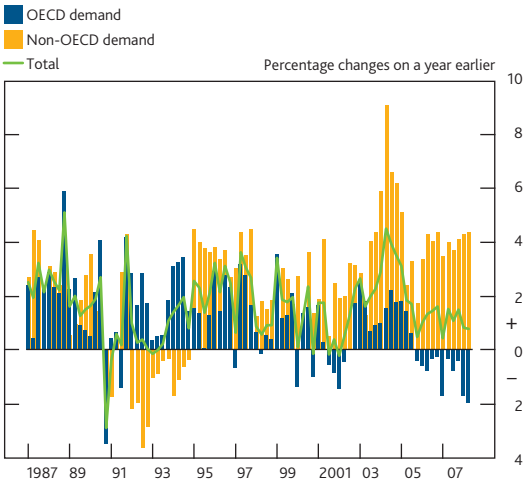
Oil demand

Over 2003–07 growth in final demand for oil averaged 2.0% per year (**Chart 2**), 0.8 percentage points faster than during the preceding five years, and 1.2 percentage points faster than its average since 1980. And around 90% of demand growth during this period came from non-OECD economies. Indeed, OECD demand has been falling year on year since the end of 2005.

A significant proportion of this increase in oil demand was unexpected. Between 2002 and 2005, the six month ahead forecast of oil demand from the IEA was on average 2% lower than the eventual outturn (**Chart 3**), and the same was true for other reputable forecasters. Moreover, more than two thirds can be accounted for by underestimation of the strength of demand from non-OECD Asia and the Middle East.

One reason for this underestimation was errors in expectations of income growth. The IMF forecasts of GDP growth in non-OECD Asia, for example, were repeatedly revised upwards over 2003–05: calendar-year growth turned out on average 1.6 percentage points stronger than anticipated a year earlier. And oil demand in these regions seems to be particularly sensitive to income growth. Income elasticities of demand[1] for non-OECD countries are at least double those for OECD countries. These estimates, which are outlined in the box on page 218, suggest that, between 2002 and 2007, income growth in non-OECD countries generated 5.2 million barrels

Chart 2 Final oil demand



Source: International Energy Agency *Oil Market Report*, January 2009.

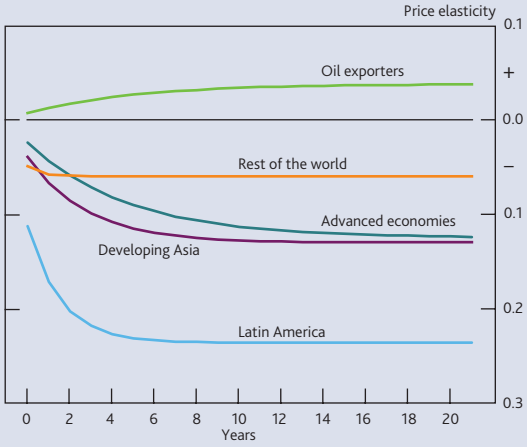
(1) Income elasticity of demand measures the responsiveness of demand, in this case the demand for oil, to a change in income. Similarly, price elasticity of demand measures the reaction of demand to a change in price.

Income and price elasticities of oil demand

This box summarises estimates of income and price elasticities of oil demand, from both external sources and a new model estimated at the Bank. The income elasticity of oil demand measures the responsiveness of oil demand to changes in income and the price elasticity of oil demand measures how changes in the oil price affects oil demand. Available external estimates tend to report two data points for oil demand elasticities — the 'short run' and the 'long run' — but rarely the full time path of the demand response. The approach presented here — a dynamic panel method — allows for a progressive build-up of effects over time. The model is estimated for over 100 countries divided into five regions (advanced economies, developing Asia, oil-exporter countries, Latin America and rest of the world) over 1984–2004. Oil consumption per capita is regressed against one lag of itself, current GDP per capita and the real price of oil (instead of the preferred, but not widely available, domestic fuel price). All variables are included in logs, and income per capita is expressed in dollars using market rates.

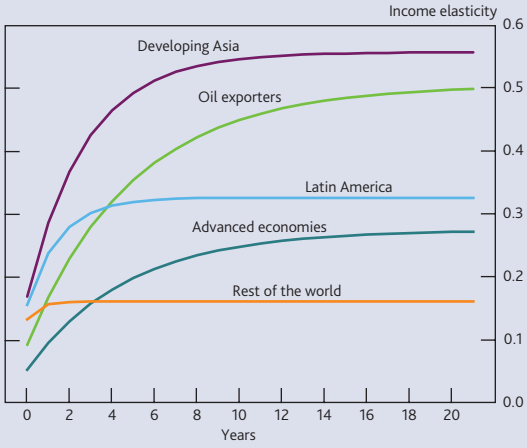
The results are shown in **Charts A** and **B**. Long-run elasticities are higher (by between two and five times depending on the region) than short-run elasticities, and income elasticities are bigger than price elasticities (at least double, and for some regions substantially more). These results are broadly in line with external estimates (**Tables 1** and **2**). Oil demand in less-developed countries tends to respond much more strongly to rising income relative to the advanced economies (**Chart B**): developing Asia and oil exporters' long-run income elasticity is double the income elasticity of advanced countries. As shown in **Chart A**, the price elasticity for oil exporters is positive; this may reflect the fact that an increase in crude oil prices translates into higher export revenues, in turn boosting demand, although this result is not statistically significant. In practice, the sensitivity of oil demand to changes in the international price of crude oil may be unstable, because price changes in the international oil market are not always immediately passed through to domestic retail prices — for which comprehensive data are unfortunately not available.

Chart A Estimated price elasticity of oil demand



Source: Bank calculations.

Chart B Estimated income elasticity of oil demand



Source: Bank calculations.

Table 1 IEA price and income elasticity of oil demand

	Advanced economies	Developing Asia	Oil exporters	Latin America	Rest of the world
Price elasticity					
Short run	-0.02	-0.03	0.05	-0.03	-0.03
Long run	-0.12	-0.11	-0.25	-0.21	-0.28
Income elasticity					
Short run	0.04	0.14	0.08	0.09	0.09
Long run	0.22	0.49	0.39	0.73	0.94

Note: Based on annual data from 1979 to 2005.

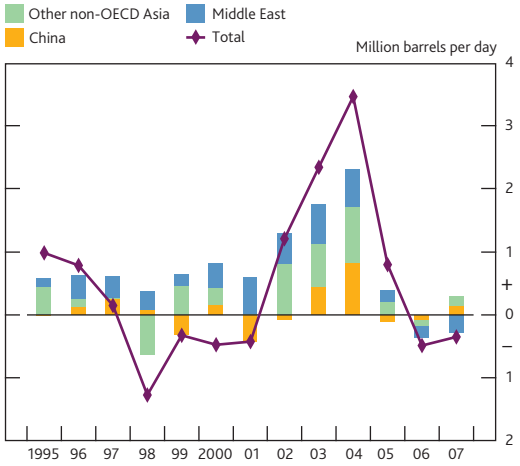
Source: IEA *World Energy Outlook*, 2006.

Table 2 Bank price and income elasticity of oil demand

	Advanced economies	Developing Asia	Oil exporters	Latin America	Rest of the world
Price elasticity					
Short run	-0.02	-0.04	0.01	-0.11	-0.05
Long run	-0.12	-0.13	0.04	-0.24	-0.06
Income elasticity					
Short run	0.05	0.17	0.09	0.16	0.13
Long run	0.27	0.56	0.50	0.33	0.16

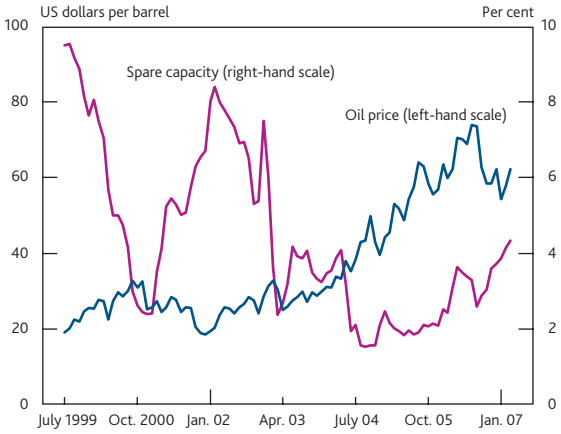
Source: Bank calculations.

Chart 3 Six month ahead oil demand forecast errors(a)



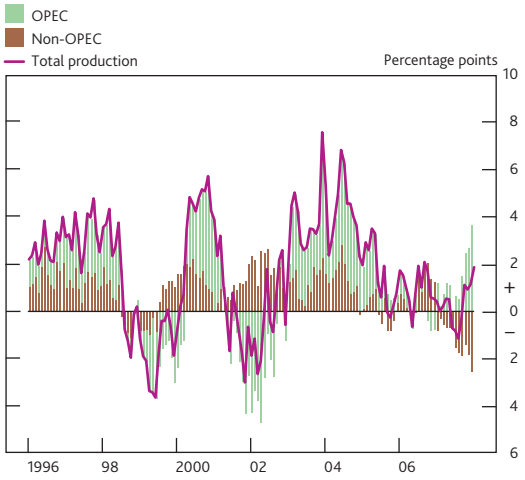
(a) Difference between oil demand outturns and forecasts made six months before the start of that year, where possible. For the period 1996–2001, some forecasts are four or five months ahead only.

Chart 4 OPEC spare capacity as percentage of total oil demand



Sources: Bloomberg, Energy Information Administration and Bank calculations.

Chart 5 Annual crude oil production growth



Source: International Energy Agency *Oil Market Report*, January 2009.

per day (mbd) of additional oil demand, while income growth added only 1.8mbd in developed economies.

Estimates of price elasticities of demand, also outlined in the box on page 218, suggest that the rising price of oil should have limited demand increases by more than was seen in the data. Two reasons can explain the muted response of demand to rising oil prices. First, the extensive use of oil price subsidies in non-OECD countries has dampened substitution effects, keeping oil demand higher than it otherwise would have been.(1) Second, the fact that the transportation sector represents a higher share of oil consumption in advanced economies today than it has over the period when price elasticities were estimated, might have limited the effect of increasing prices on demand.(2) The ability to substitute oil for other fuels is both more limited and more gradual in the transport sector than in any other oil-consuming sector.(3)

Oil supply

As documented above, growth in final demand for oil picked up during 2003 and 2004. This initial increase in demand was largely met by increases in OPEC production. In early 2002, OPEC had spare capacity equivalent to around 8% of global oil demand (**Chart 4**) and was therefore in a position to increase output with relatively little delay. And, indeed, between the end of 2002 and mid-2005, OPEC increased quotas by 6.3mbd (29%).

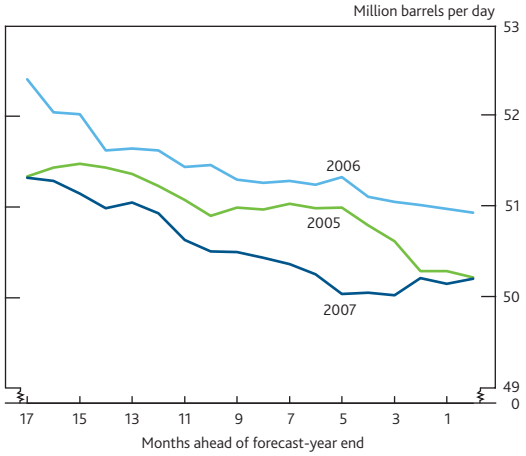
Since 2005, however, total annual oil production growth averaged less than 1%, down from 3.3% over the preceding two and a half years (**Chart 5**). Indeed, by mid-2005 OPEC had little remaining spare capacity, with only 1.5mbd available to it. Also, non-OPEC production actually declined in 2007 by 2%.

This lower non-OPEC production growth appears to have been largely unexpected, with the international agencies revising down their forecasts for production year after year. In its predictions for 2005–07, the IEA, for example, revised down its forecast for annual non-OPEC oil production by an average of 2.4% between its first published forecast and the final outturn (**Chart 6**).

The response of production to rising oil prices was surprisingly muted. It is possible to point to a number of reasons why. The 1990s and early 2000s were years of relatively low returns on capacity investment in the oil industry and, because prices were expected to stay low, there was little prospect of returns increasing. This led to a decade of low investment and a

(1) A recent study by the IMF (2008b) suggests that one quarter of low and middle-income countries failed to pass through even one half of the price increase in gasoline, diesel and kerosene to domestic consumers between end-2003 and end-2007.
(2) For example, the share of the transportation sector in total oil consumption in the United States has increased from 56% in 1980 to 63% in the mid-1980s and to 70% in the late 2000s.
(3) Cabinet Office (2008) also highlight the increasing share of transport fuels as one reason why oil demand had been so slow to respond to increases in crude oil prices.

Chart 6 Evolution of IEA non-OPEC oil production forecasts for particular years[a]



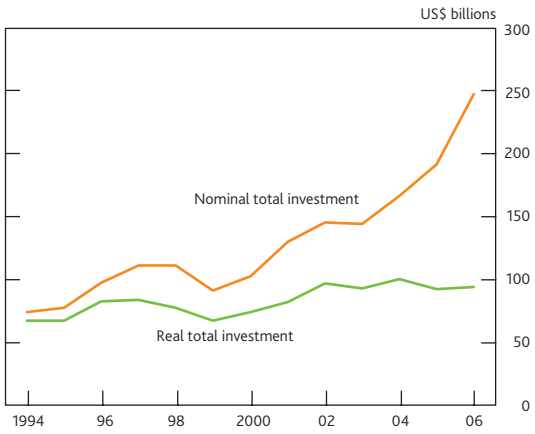
Source: International Energy Agency *Oil Market Report*, several years.

(a) IEA forecasts have been adjusted so as to not be distorted by countries leaving or joining OPEC within a particular year.

depletion of much spare capacity. Moreover, the subsequent need for investment meant that any supply response to increased demand would be constrained by the industry's lengthy lags from investment to production.

That is not to say that investment did not take place: between 2003 and 2006, nominal capital expenditure in oil exploration increased by 70% (**Chart 7**).(1) But a large proportion of this investment went towards covering escalating industry costs.(2) As **Chart 7** shows, when nominal investment expenditure is deflated by an appropriate sectoral cost index, it shows that real investment increased by relatively little. And much of that gross investment is likely to have been absorbed by the need to maintain production in existing fields rather than adding new capacity. The IEA (2008) projects that half of global energy investment over the next 25 years will be devoted to maintaining the current level of supply capacity.

Chart 7 Total investment of oil companies[a]



Source: IMF.

(a) Real investment is nominal capital investment in exploration deflated by the US oil cost producer price index (weighted average of oil and gas wells drilling services, operational support services, and oil and gas fields' machinery and equipment indices).

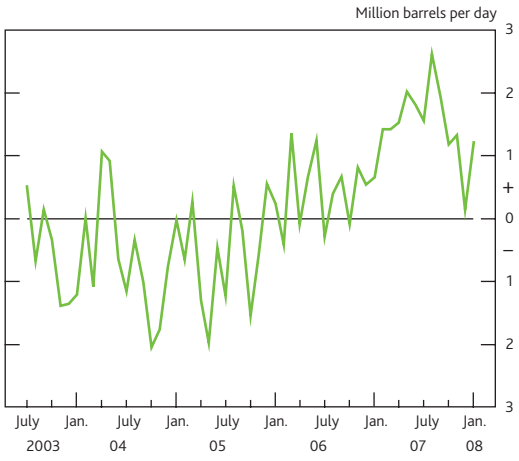
Marginal costs per barrel are typically much lower for OPEC than non-OPEC, but restrictions on, and disincentives against investment by foreign oil companies in OPEC countries, coupled with geopolitical instability, have prevented net marginal returns from being equalised globally. This has resulted in less efficient levels of production.

To sum up, until 2005, what increase there was in the growth rate of total oil production was accounted for by OPEC running down much of its existing spare capacity. Thereafter, total oil production growth did not keep pace with the rise in total demand, with non-OPEC production outturns repeatedly surprising on the downside.

Oil market balance

Bringing demand and supply factors together paints a picture of increasing tightness in the crude oil market from the second half of 2003 onwards. The market moved from a position in which demand could only be met by depleting OPEC spare capacity, to one in which there was excess demand (**Chart 8**). This picture is starker if OPEC production is stripped out, making it clear that supply growth was maintained by using up existing capacity rather than expanding that capacity — with an unambiguous increase in market tightness over the whole period (**Chart 9**).

Chart 8 Oil market tightness



Notes: Consumption has been seasonally adjusted. Market tightness is defined as total consumption (excluding stocks) minus non-OPEC production and OPEC production.

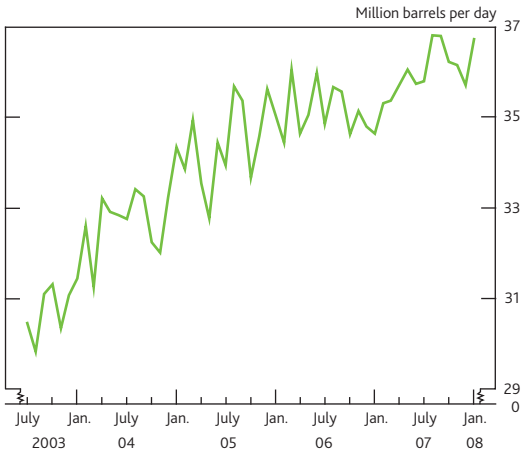
Sources: Energy Information Administration and Bank calculations.

Moreover, the extent of this tightness was unexpected, with adverse surprises about both demand and supply. **Chart 10** plots how the implied expectation of oil market balance in each of the years from 2003 to 2007 evolved over time. A

(1) Defined as total investment by 53 national and international oil companies, IMF (2008a).

(2) Production costs increased as higher demand for offshore drilling met with a limited supply of deep-water rigs; higher prices for metals and other raw materials also put pressure on costs — indeed *The Economist* metals index, a measure of metals prices, more than tripled over 2003–07. And a limited supply of graduates and an ageing workforce produced a shortage of trained engineers, procurement and construction managers.

Chart 9 Balance of consumption and non-OPEC production

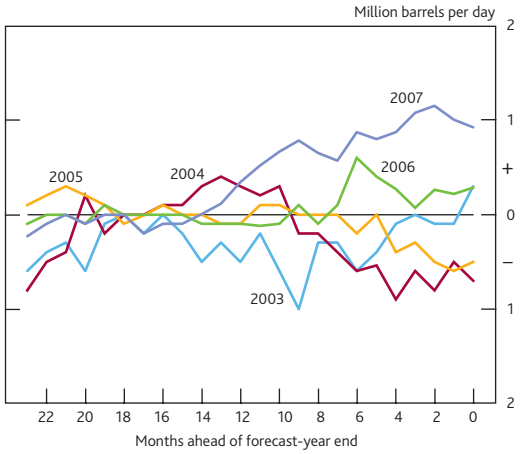


Note: Total consumption (excluding stocks, seasonally adjusted) minus non-OPEC production.

Sources: Energy Information Administration and Bank calculations.

rising profile indicates that the market turned out to be tighter than forecasters had been expecting. In the first three years, there was seemingly little news about increases in oil market tightness, though as discussed this was largely the result of OPEC raising quotas. But 2006 and 2007 did indeed turn out significantly tighter than forecasters had been anticipating previously.

Chart 10 Revisions to market tightness forecast



Sources: Energy Information Administration and Bank calculations.

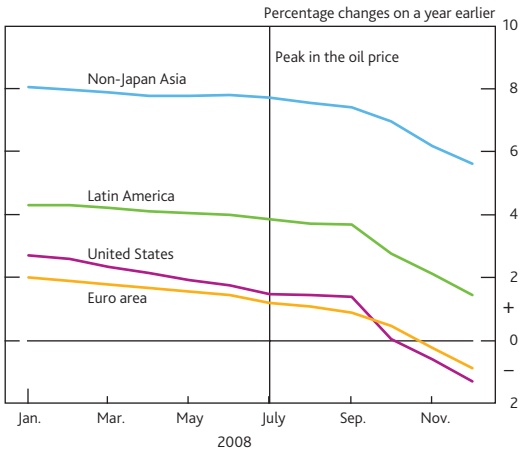
The analysis therefore suggests that shocks to oil demand growth, coupled with the surprisingly inelastic response of supply to higher prices, are directionally consistent with the increase in oil prices over 2003–07.

Demand and supply during 2008

Whereas oil prices increased steadily over 2003–07, 2008 was characterised by a particularly sharp rise in prices followed by an even sharper fall. The nominal price of dated Brent crude oil increased by 49% in the first half of 2008, reaching a peak above $145 per barrel in early July (**Chart 1**). But by the end of 2008 it had fallen back by about 70% to $42 per barrel, 57% down on its price at the beginning of 2008. Is it possible to identify news to current and prospective demand and supply that might be consistent with these remarkable movements in prices?

Consensus forecasts for GDP growth in the advanced economies in 2009 declined throughout 2008, and much more rapidly after the collapse of Lehman Brothers in September (**Chart 11**). However, for much of the year, expectations of growth in non-OECD countries held up well. Reflecting this, IEA and EIA forecasts for non-OECD oil demand over 2008–09 remained robust. This resilience in non-OECD consumption meant that overall IEA demand forecasts for 2008 were only 1.2% lower in June than they had been at the beginning of the year, despite a revision of -2.2% for the OECD.

Chart 11 Consensus forecasts for GDP growth in 2009



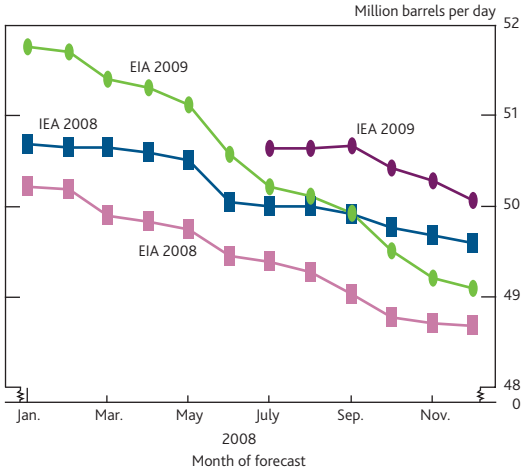
Sources: Bloomberg and Consensus Economics.

Over the second half of the year, however, prospects for income growth across the world, and in emerging markets in particular, deteriorated markedly. This led the IEA to lower its projections for global oil demand by 1.2% for 2008 and by 1.6% for 2009.

Taken together therefore, the news on demand is consistent with falling prices in the second half of 2008, but they do not provide much support for the rapid rise in prices in the first half of the year, nor do they explain why the fall in prices began in July.

On supply, as had been the case during much of 2006 and 2007, non-OPEC production continued to weaken during 2008 (ending the year 1% below where it started), and forecasts for non-OPEC supply continued to be revised down throughout the year (**Chart 12**). Moreover, once prices began to fall in mid-2008, OPEC took action to cut back on its production quite swiftly, with a cumulative cut in quotas of 13% of OPEC production or just under 6% of total world supply — the largest in the organisation's history.

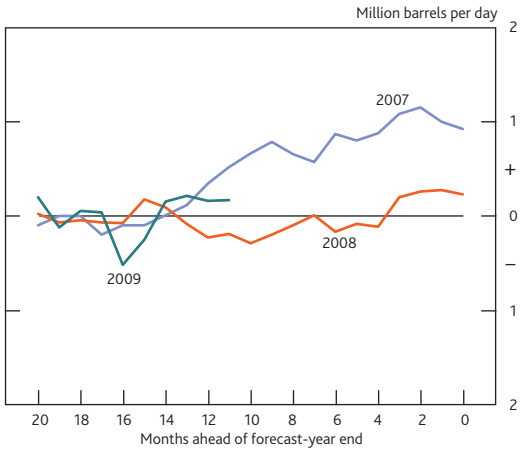
Chart 12 Non-OPEC supply forecasts made in 2008



Sources: Energy Information Administration and International Energy Agency.

So the downside news on supply continued to be material throughout 2008. But, once demand and supply expectations are brought together, it turns out that revisions to views on supply were of the same order of magnitude as revisions to demand (**Chart 13**). In other words, expectations about the oil market balance made in 2008 have not proven to be overly pessimistic.

Chart 13 Revisions to market tightness forecast



Sources: Energy Information Administration and Bank calculations.

Based on news about the balance of demand and supply in 2008, therefore, it seems that one can justify neither the rise in prices in the first half of 2008, nor the fall in prices in the second half.

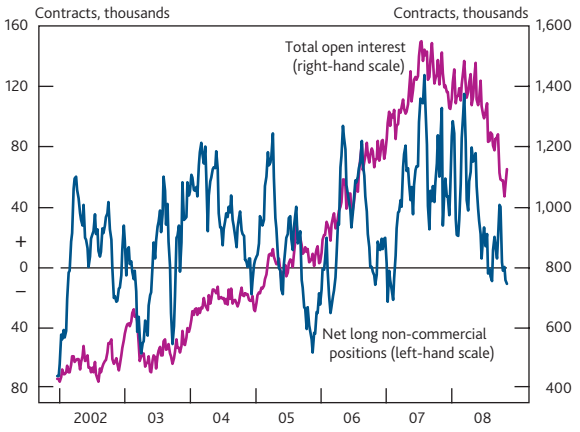
But one further observation is worth making. As in 2003–04, the rebalancing of demand and supply during 2008 was brought about by shifts in OPEC spare capacity. Indeed, spare capacity reached a record low during the spring of 2008, before rising again in the autumn as demand started to deteriorate. Market participants could have been concerned in the first half of the year about the ability of OPEC to act as a buffer against further upward pressure on prices. And they could have been sceptical in the second half of the year about OPEC's ability to enforce new quota levels. This could have contributed to the sharp rise in oil prices during the first half of 2008 and the rapid fall during the second half.

Speculative flows and asset price bubbles

The analysis so far suggests that it is difficult to be fully confident about whether the evolution of oil prices since the beginning of 2003 is entirely consistent with news about demand and supply. This section asks whether other factors could have played an important role.

Some commentators have suggested that the remarkable increase and fall in the oil price in 2008 was due to an asset price bubble which originated at the time that the mortgage price bubble burst in the United States (Caballero, Farhi and Gourinchas (2008)). Others have suggested that financial flows into the futures market from investors who do not use oil futures to hedge their consumption or production plans (so-called 'speculative' flows) have pushed prices above the level warranted by the current and projected balance of supply and demand (eg Masters (2008)). These commentators point to the dramatic increase in financial flows into the futures market since 2006 (see the evolution of non-commercial net long positions, a proxy of speculative financial flows, in **Chart 14**). If they are right, some part of the fall in oil prices since July last year may reflect an unwinding of this overvaluation. This section looks at how plausible such arguments are both theoretically and in light of the available data.

Chart 14 Financial flows



Sources: Bloomberg and Bank calculations.

Asset price bubbles

Broadly speaking, economists have identified two reasons for asset price bubble creation — 'irrational exuberance' and rational expectations of price movements not warranted by fundamentals that are shared widely and are fulfilled in equilibrium.

The proponents of the irrational exuberance argument (Shiller (2005, 2008)) describe asset price bubbles as the result of a simple feedback mechanism. In the first phase, asset prices start to rise, say due to a temporary demand or supply shock. The success of some market participants attracts public attention that fuels interest in the rest of the market (and not necessarily limited to financial investors). Less sophisticated investors enter the market and bid up prices, causing further enthusiasm based on the extrapolation of recent price movements far into the future. At some point, pessimism can take hold and cause the process to reverse. This theory depends on the assumption that a significant number of investors behave irrationally, an assumption that mainstream economic theory has tried to eschew in the past.

By contrast, rational bubble models do not require market participants to behave irrationally. One such model, with an application to the oil market, has recently been put forward by Caballero *et al* (2008). The authors argue that there has been a fundamental scarcity of investment assets across the globe — with only a few countries, such as the United States and the United Kingdom, having the ability to produce 'good assets', attracting large flows from countries with excess savings, such as China and the Middle East. They argue that these capital flows led to low real interest rates in asset-producing countries, accompanied by the development of an asset price bubble in non-storable assets such as US mortgage securities.

This bubble burst in August 2007 when unexpected losses on these assets revealed that they were riskier than investors had thought. In the first phase of the ensuing crisis, the bursting of this bubble exacerbated the global asset shortage and led investors to increase rapidly their demand for other sound and liquid financial instruments. The combination of low real interest rates and existing spot market tightness made oil a desirable destination for funds. And so, in essence, the argument is that the bubble relocated from the US mortgage market to the oil market. Eventually, when it became clear that the outlook for the world economy, and therefore oil market fundamentals, was much weaker than had been thought, the oil price bubble burst.

Although theoretically elegant, this account does not explain the timing of the asset price bubble expanding and then bursting. As **Chart 1** shows, there is no visible change in the rate of increase in oil prices in the immediate aftermath of the sub-prime shock in August 2007. Moreover, as discussed above, the point at which expectations about global economic prospects really began to deteriorate was in September 2008, whereas oil prices started falling in July.

Can 'speculative' flows move prices away from fundamentals?

Investors who trade in the futures markets for speculative purposes tend to avoid taking costly delivery of the physical commodity — they instead either settle their futures contracts for cash, or sell them before they expire. For example, between 2003 and May 2008 only around 2% of West Texas Intermediate oil futures contracts on the New York Mercantile Exchange resulted in physical delivery (Interagency Task Force on Commodity Markets (2008)). This means that speculative position-taking in the futures market can only impact spot oil prices significantly if it affects spot market participants' expectations of future spot prices. And if spot market participants are rational, this requires that financial flows are thought to contain new information on the prospective balance of demand and supply.

In practice, spot traders are not capable of distinguishing perfectly the proportion of financial flows originating from investors with new information about fundamentals from the proportion that comes from uninformed 'noise' traders (eg passive investors taking positions for portfolio allocation reasons or for liquidity purposes). So over short horizons — limited by the lags before publicly available information on demand and supply dispels this uncertainty — the activity of 'noise' traders can cause spot traders to update their beliefs regarding fundamentals. And it is therefore possible for them to cause spot prices to diverge, for a limited time, from the level warranted by prospective market tightness.(1) The August 2008 *Inflation Report*, for example, suggested that while purely speculative activity might have sometimes amplified oil price movements in the short term, sustained price changes had tended to reflect market fundamentals.

The best publicly available data on financial flows into and out of commodity markets are from the US Commodity Futures Trading Commission (CFTC). The data disaggregate positions by investor type. Specifically, investors are reported as 'commercial' if they are primarily involved in the market to hedge their main business activity, which typically involves the production or consumption of oil. Otherwise, they are 'non-commercial'.

The net long non-commercial (NLNC) position can be used as a proxy measure of speculative financial flows (**Chart 14**). To assess whether these flows cause movements in oil prices, VARs are estimated that relate price changes in one-month, three-month and one-year futures contracts to changes in NLNC positions.(2) The model is estimated over two samples:

(1) There are a number of theoretical models in the market microstructure literature that demonstrate how imperfect information about the composition of aggregate order flow between 'informed' orders and 'uninformed' orders can cause temporary deviations of financial prices away from fundamentals (O'Hara (1995) and Lyons (2001)). Recent research has emphasised that the proportion of trades from investors trading on the basis of news on fundamentals (fundamentalists) in a market responds endogenously to the perceived misalignment of prices relative to their warranted levels (Redrado, Bastourre, Carrera and Ibarlucia (2008) and Reitz and Slopek (2008)). In these models, the confidence with which fundamentalists can predict the direction of future price movements is increasing in the extent of this misalignment, limiting further the extent through which deviations from warranted levels can persist.

(2) Details of the VARs are available upon request. The number of VAR lags is decided using information criteria. Alternative VARs are estimated as robustness checks using different sample lengths in addition to those reported in the main text.

2003–06 and 2006 to mid-November 2008, in order to investigate whether the importance of these flows changed over the period considered. In neither sample is there support for the hypothesis that financial flows occur before changes in prices, evidence — albeit limited — that financial flows do not cause prices to change. These results are entirely consistent with those of other studies including a report by the Interagency Task Force on Commodity Markets (2008) that used confidential CFTC data on investor positions that enable a more accurate identification of flows originating from 'speculators' and other investors than the publicly available data (IMF (2006) and Haigh, Hranaiova and Overdahl (2005)).(1)

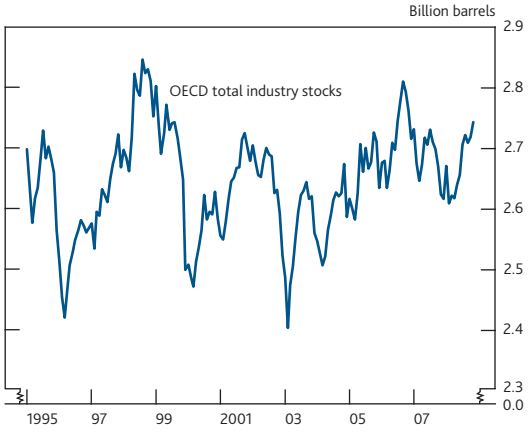
Cabinet Office (2008), while acknowledging that the impact of financial investors on futures commodity prices has been difficult to establish empirically, suggests that 'in the absence of large financial flows into and subsequently out of futures markets, it is possible that futures prices may not have risen and fallen as much as they did during 2008'. As supporting evidence, the authors appeal to the marginal costs of non-conventional sources of oil supply falling short of futures prices during the first half of 2008 and the difficulties of explaining the rise and fall in prices during 2008 by probable future demand and supply scenarios.

Speculative flows, asset price bubbles and inventories

A number of commentators have pointed out that any evidence of speculative flows driving oil prices should be reflected in inventory data (Krugman (2008) and Hamilton (2009)). The argument is based on Working's theory of storage summarised earlier in the article. In particular, if commercial traders interpreted large financial flows into the futures market as an indicator of future tightness, they would have an incentive to bring forward spot purchases — inventories would therefore need to build up. Equally, an inventory build-up is necessary for the argument in Caballero *et al* (2008) to hold, as speculators shift their demand from non-storable financial assets to storable oil.

Although data on inventories are not comprehensive, the available figures do not seem to support the claim that speculative flows have been driving up oil prices. OECD inventories did not increase substantially between late 2006 and 2008 (**Chart 15**). And data provided by the Joint Oil Data Initiative suggest that total inventories in 30 countries for which data are available fell by almost 7% over this period.(2) This, by itself, convinced some commentators that speculation could not have been a major driver behind the rise in oil prices (Krugman (2008)). Another possibility is that oil was kept in the ground by producers deliberately slowing the rate at which oil was extracted. However, OPEC spare capacity reached a trough in the first half of 2008, making it unlikely that they were building up inventories under the ground.

Chart 15 OECD crude oil stocks



Source: International Energy Agency monthly reports.

But as set out in the discussion of Working's model earlier, the level of inventories responds to a number of shocks. Speculative demand for oil as an asset class will tend to lead to an increase in inventories. By contrast, a shock to oil demand that is perceived to be temporary will lead consumers to draw down their inventory. It is at least conceivable, therefore, that observed inventory levels did not rise because the speculative demand for oil was being offset by physical investors adjusting their inventories in response to a positive shock to oil demand that they did not expect to last. That is, it is possible that speculative flows could have played a role in driving up oil prices but it did not show up in the observed inventory data.

Conclusion

This article has examined the potential key factors that have driven the sharp movements seen in oil prices over the past few years. It argues that demand shocks from fast-growing emerging markets coupled with subsidised prices and successive overestimation of non-OPEC supply are together consistent with the continued rise in the oil price between 2003 and 2007. The behaviour of prices in 2008 is more difficult to reconcile with news on the balance of demand and supply. At the same time, theories that suggest that the rapid increase in financial flows from speculators in the oil futures market during recent years led spot prices to diverge from fundamentals do not find empirical support. That said, neither this evidence nor evidence from inventories is sufficient to rule out completely the possibility that asset price bubble dynamics might have played a role.

(1) For example, the publicly available NLNC data would exclude flows from oil producers and consumers that trade in the futures markets for speculative purposes.
(2) The data are from www.jodidata.org. Their sample includes developing economies, but omits much of the Middle East and importantly China. The inventory data that do exist however do not support the argument that speculative behaviour was a major driver of oil prices.

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