What can the oil futures curve tell us about the outlook for oil prices?

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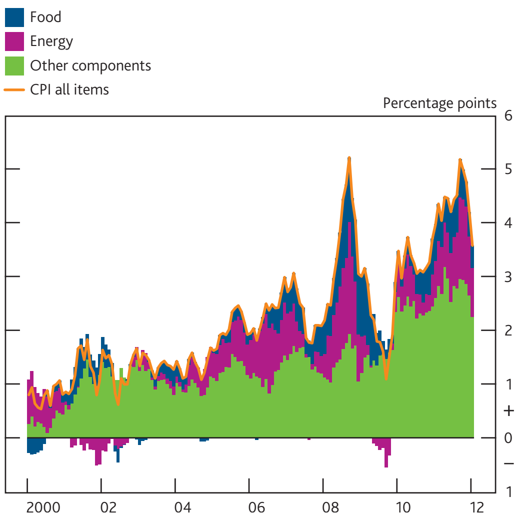
Large movements in the oil price have had significant effects on UK CPI inflation over the past few years. In order to produce an inflation forecast, it is necessary to assume a path for oil and other commodity prices. The Monetary Policy Committee assumes that oil prices follow the path given by market futures prices when deciding their central projections for CPI inflation and GDP growth. This article considers arguments for and against using the futures curve as an assumed path and describes some of the other indicators used by the Committee in assessing the outlook for oil prices.

Introduction

Large swings in the prices of raw materials have had significant effects on UK inflation in recent years. **Chart 1** shows that energy and food prices have been a key driver of changes in UK consumer price inflation since around 2004, reflecting large gyrations in the prices of commodities.(2)

Chart 1 Contributions of food and energy to UK CPI inflation



In order to produce a forecast for GDP growth and inflation, it is necessary for the Monetary Policy Committee (MPC) to make assumptions about a number of variables that feed into that forecast. The paths assumed for commodity prices in the *Inflation Report* central projections for growth and inflation are those implied by market futures curves. This article examines the case for using oil futures curves as the forecasting assumption for oil prices and compares its predictive power with other forecasting measures. It does that by looking at oil price movements over the past decade or so. It does not focus on the most recent movements in oil prices, or the current profile of the futures curve.

Generally, there are compelling reasons why a futures curve might *not* be an ideal forecasting assumption. Commodity futures prices cannot be directly interpreted as financial market participants' expectations of future spot prices. And, empirically, futures prices have not been reliable predictors of subsequent commodity price movements in the past.

But alternative oil price assumptions do not appear to offer consistently better predictions than the futures curve assumption. Moreover, the futures curve assumption has a number of advantages over alternative measures. Changes in the slope of the futures curve can reflect changes in the direction of the expected path of spot prices, and the futures curve offers a simple and transparent assumption for commodity prices which can help the MPC to communicate clearly and precisely the assumption underpinning its *Inflation Report* central projection.

This article is organised as follows. The first section sets out what information is contained in oil spot and futures prices and how it should be interpreted. The second section compares the predictive power of oil futures prices with other simple forecasting measures and rules of thumb. The third section discusses some reasons why none of the measures

(1) The authors would like to thank Shiv Chowla and Kate Stratford for their help in producing this article.
(2) Note that contributions to UK CPI from food and energy prices in **Chart 1** will include other input costs (such as processing and packaging of food products) in addition to changes in commodity prices. On the other hand, the prices of other raw materials — industrial metals, for example — contribute to the green swathe. Moreover, the *indirect* effects of changes in commodity prices on prices of other goods and services in the CPI basket (for example, via production costs) will also be picked up in the green swathe.

perform well in predicting oil price movements. It also sets out how the MPC considers the outlook for commodity prices over the forecast horizon both in terms of its central projection and the risks around that projection. And the fourth concludes.

What information is contained in the oil futures curve?

This section sets out the theoretical relationship between oil spot and futures prices. As for any risky financial asset, the oil futures price cannot be interpreted as a direct measure of market expectations of spot prices. But because oil is a physical good as well as a financial asset, the slope of the oil futures curve may contain some information about the expected path of spot prices.

Spot and futures prices

The 'spot price' of an asset is the price of buying or selling the asset today. The 'futures price' of an asset is the price of entering into a contract today to buy or sell the asset on some agreed future date. The set of prices for all future dates is then called the 'futures curve'.

In equilibrium, the futures price of any purely financial asset must equal its current spot price, adjusted for the interest that could be earned by investing an amount equal to the spot price in a risk-free asset over the contract period. If this were not the case, investors could 'arbitrage' between the two prices to earn a risk-free profit: they could borrow money, buy the asset today at the spot price and agree to sell it in the future at a price that would yield a risk-free profit.

For example, if the spot price of a share (that is, a purely financial asset) in a particular company was £100 and the risk-free interest rate was 5% per year then, ignoring dividend payments, the price of a futures contract to buy (or sell) the share in one year's time would have to cost £105. If instead the futures price was, say, £110, then investors could borrow £100 and buy a share at the spot price, then sell a futures contract for £110; the £10 difference between the spot and futures prices would more than cover the £5 interest payments on the loan, leaving the investors with a £5 risk-free profit. A similar argument would hold if the futures price was below £105. Such an arbitrage opportunity would be unlikely to last for long. In this example, prices would adjust in response to arbitrage until the futures price was exactly 5% higher than the spot price.

The presence of this 'no-arbitrage' relationship implies that futures prices should not move independently of spot prices, except when the risk-free interest rate changes. So the spot and futures prices of purely financial assets should both reflect the same information about current and expected future market conditions.

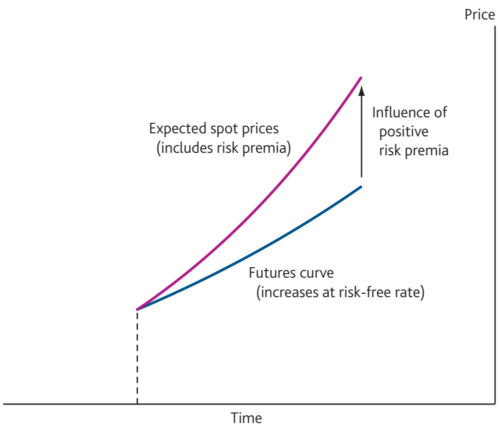
It is tempting, then, to think that the futures price equals investors' expectation of what the spot price will be at the contract expiry date. This would be true (for purely financial assets) if the path of spot prices were known with certainty. In general, however, the futures price of an asset is not the same as its expected future spot price. The difference between them can be explained in terms of a 'risk premium'. Furthermore, the fact that commodities such as oil are physical assets leads to deviations in the futures curve from the no-arbitrage condition due to the 'net convenience yield'. The rest of this section explains how these factors affect the shape of the futures curve and the path of expected spot prices.

The risk premium

Investors dislike uncertainty about future income and require additional compensation for holding assets that have uncertain pay-offs, that is, risky assets. That additional compensation — the difference between the expected return on a risky asset (the rate at which its spot price is expected to increase *on average*) and the risk-free interest rate — is called the 'risk premium'. Oil, for example, is a risky asset — its future price is uncertain — and so its expected return will differ from the risk-free rate.

When risk premia are positive, the spot price is expected to increase faster, on average, than the risk-free rate, and so the expected path of spot prices will lie above the futures curve, as shown in **Chart 2**. Similarly, when risk premia are negative then the expected path of spot prices will lie below the futures curve. In general, investors prefer assets which pay off more in situations when their overall income is likely to be low — that is, they prefer assets that are *negatively* correlated with income — as they can insure against low income by investing in those assets. But, investors expect the spot price of many risky assets one year ahead to be *positively* correlated with their income — for example, because periods of strong economic growth are typically associated both with higher asset prices and higher incomes.

Chart 2 The influence of risk premia on expected spot prices



Returning to the example given earlier, future share prices are not known with certainty and may be expected to be positively correlated with future income. This will affect spot and futures prices today. For example, if the share price is more likely to be below £105 than above in situations when investors' overall income is low, then they would be less willing to hold the share as an investment and would only be prepared to buy the share today at a spot price *below* £100 — for instance, £98. Due to the no-arbitrage relationship set out in the previous section, they would then only be prepared to pay roughly £103 for a futures contract: 5% more than today's spot price of £98.

The uncertainty around the expected future spot price would therefore have two consequences. First, with a spot price today of £98 and an expected future spot price of £105, an investor who bought the share could expect returns of roughly 7% on average, rather than the returns of 5% available on a risk-free investment. So they would earn a positive risk premium of roughly 2 percentage points on average, compensating them for the risk that the share price might turn out lower than expected at particularly inconvenient times. And second, the existence of this risk premium means that today's futures price of £103 would no longer equal next year's expected spot price of £105.

Risk premia are unobservable and vary over time.(1) This is one reason why forecasting spot prices is difficult. At turning points in the economic cycle, for example, expectations of demand are especially uncertain and therefore especially sensitive to news from data outturns, and so risk premia may be larger and more volatile than usual.(2)

The net convenience yield

Commodities, unlike other financial assets, are physical, storable and exhaustible.(3) This makes the relationship between their spot and futures prices a little more complicated than it is for purely financial assets. Most obviously, holding physical commodities such as oil for future consumption imposes storage costs. But in addition, physical ownership gives the holder an extra benefit known as a 'convenience yield':(4) it allows businesses to respond to unexpected shocks to demand for their goods without the risk of paying a premium for delivery at short notice.

The level of the convenience yield and the cost of storage both affect the slope of the futures curve, moving it away from the slope implied by the no-arbitrage relationship described above. An increase in the convenience yield or a decrease in storage costs makes holding physical oil more attractive relative to holding a futures contract. So the price investors are willing to pay for physical oil increases relative to the futures price, making the futures curve less upward sloping. Unfortunately since neither the convenience yield nor the cost of storage is easily observable, there is no way of telling which of the two is responsible for changes in the slope of the futures curve. But the 'net convenience yield', defined as the convenience yield minus storage costs, can be measured as the deviation from the no-arbitrage relationship.(5)

A stylised example of how this can affect the oil futures curve is shown in **Chart 3**. The blue line shows an oil futures curve where the net convenience yield is zero so that spot and futures prices are simply linked by the no-arbitrage relationship, as in **Chart 2**.(6) The green line shows an oil futures curve with a positive net convenience yield where, for the purposes of illustration, the two curves start from the same spot price. Relative to that spot price, the positive net convenience yield in the green curve means that investors are not willing to pay as much for futures contracts as the no-arbitrage relationship would suggest. This results in a less upward-sloping futures curve.

Chart 3 The influence of the net convenience yield on the oil futures curve

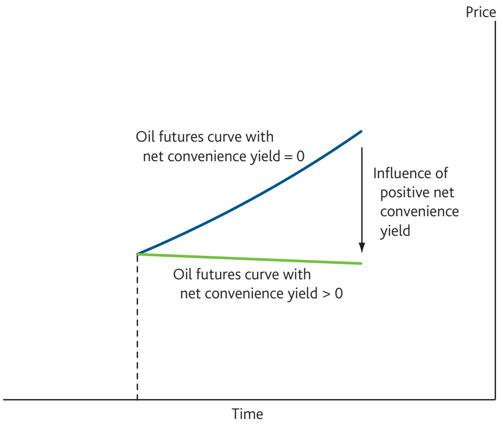
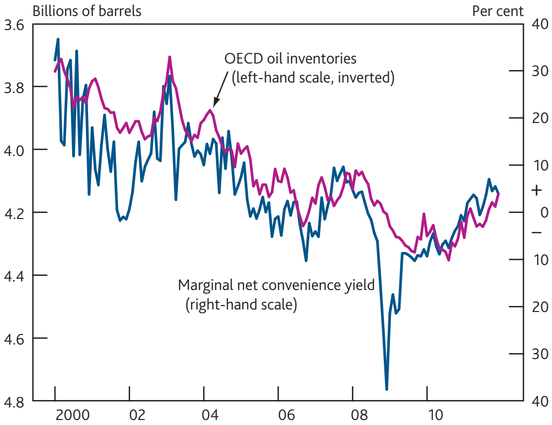


Chart 4 shows that the net convenience yield is typically high when oil inventories are low. Intuitively, when inventories are low, inventory holders have less capacity to smooth through unexpected shocks before they run out of oil altogether. So the marginal benefit from holding an additional barrel of oil will be relatively high. At the same time, when inventories are

(1) For a more detailed discussion of how risk premia behave over time, see Cochrane (2011).
(2) Over the near term, at least, prospects for world oil supply are less sensitive to economic conditions — they are determined by past investment and technological progress in the oil extraction sector.
(3) Minerals and fossil fuels, including crude oil, natural gas and industrial metals are all considered exhaustible. Other raw materials such as agricultural commodities and livestock are not exhaustible but remain in fixed physical supply over the short to medium term.
(4) Some financial assets can also provide benefits to their holders, and can therefore also have convenience yields: for instance, equity holders in a company have voting rights at the company's meetings.
(5) The one-year net convenience yield is calculated as the interest rate minus the log of the ratio of the one-year futures price to the spot price, annualised to give a rate in per cent. The nominal US one-year government spot interest rate is used in place of the risk-free rate.
(6) That is, the convenience yield (which pushes up on spot prices relative to futures prices) exactly offsets storage costs (which push up on futures prices relative to spot prices).

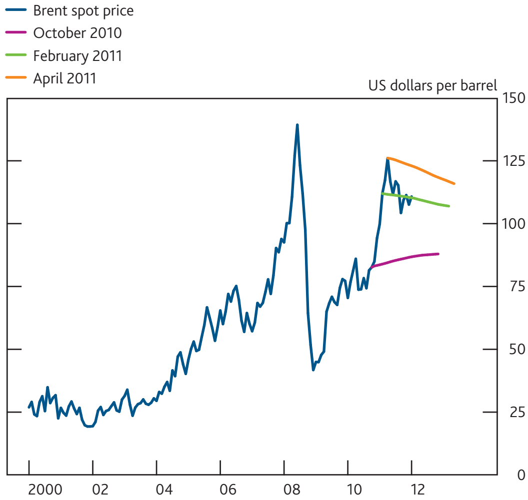
Chart 4 The net convenience yield and OECD oil inventories(a)(b)



Sources: Bloomberg, International Energy Agency and Bank calculations.

(a) Inventories refers to combined government and industry holdings of crude oil, natural gas liquids, feedstocks and other oil products.
(b) The net convenience yield is calculated as the interest rate minus the log of the ratio of the one-year futures price to the spot price, annualised to give a rate in per cent.

Chart 5 Oil futures curves in 2010–11(a)



Sources: Bloomberg and Bank calculations.

(a) End-of-month futures prices are used throughout this article.

low, the volume of available storage space is high, which may bear down on the cost of storage.(1)

This link between inventories and the net convenience yield means that changes in the slope of the futures curve can be used to make inferences about changes in the direction of the expected path of spot prices. For example, suppose that a negative supply shock occurs which is expected to be temporary. This boosts the oil spot price, although this boost is tempered by businesses running down their inventories of oil. That inventory drawdown in turn leads to an increase in the net convenience yield, resulting in a futures curve that is less upward sloping. But what about expected spot prices? At *short* maturities, these will also increase, reflecting reduced supply in the near term. But since the shock is expected to be temporary, expected spot prices at longer maturities will be largely unaffected, and so the expected path of spot prices, too, will become less upward sloping. So the observed change in the slope of the futures curve can act as a signal of the change in the slope of the path of expected spot prices.

Applying this to the real world, **Chart 5** shows the evolution of oil spot prices and futures curves towards the end of 2010 and the first half of 2011. Shifts in the slope of the futures curve during this period can be given meaningful economic interpretations. In October 2010, the oil futures curve was unusually upward sloping. This is likely to have reflected historically high levels of oil inventories (**Chart 4**) following the global recession, which pushed down on the spot price relative to the futures price.

By February 2011, stronger-than-expected indicators of world oil demand led to expectations of a permanent tightening in the oil market. That led to higher prices across the futures curve, but boosted spot prices more than futures prices as large inventory stockpiles were run down increasing the net convenience yield. And, following tensions in the Middle East and North Africa, concerns about disruptions to oil supply also started to be factored into oil prices, with the futures curve becoming downward sloping. By April 2011, these tensions had led to still higher spot prices but also a downward-sloping futures curve. Market participants were willing to pay more for physical oil than for futures contracts, indicating that at least some of the supply disruptions were expected to be temporary. In this instance, oil spot prices did fall back in subsequent months. Of course, there could be other explanations for these price movements, but the direction they moved in is consistent with observed changes in the slope of the futures curve.

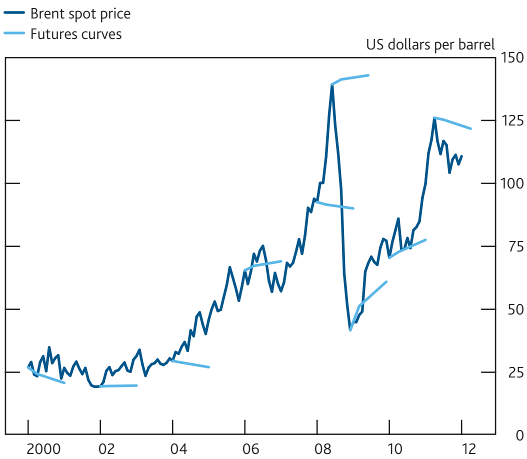
There are reasons why the theory set out above may not hold perfectly in practice for all commodities. In particular, the physical nature of commodities may pose limits on the degree to which investors can incorporate information about expected future demand and supply into current spot and futures prices. For example, many agricultural commodities cannot be stored indefinitely, placing limits on the time period over which investors can arbitrage between prices. This means that the no-arbitrage relationship between spot and future prices will only hold over a finite horizon.(2)

(1) Pindyck (2001) thoroughly documents the relationship between oil spot prices, futures prices and inventory levels. Gorton, Hayashi and Rouwenhorst (2007) present a model in which commodity inventories are inversely related to the slope of the futures curve.
(2) Structural factors in commodity futures markets might also move futures prices away from their theoretical equilibrium levels. For example, market intelligence suggests that, in general, consumers of commodities such as oil hedge more than producers, since shareholders in oil-producing companies want exposure to changes in the oil price. See Campbell, Orskaug and Williams (2006).

Assessing the predictive power of the futures curve

Despite the theoretical link between the futures curve and expected spot prices, the futures curve has not been a very good guide to predicting future spot prices, failing to predict the upwards trend in prices between 2003 and 2008 as well as the collapse and recovery in oil prices since then (**Chart 6**). This section describes some of the academic literature on forecasting with futures curves, and presents empirical evidence on some alternative forecasting rules for the oil price.

Chart 6 The futures price as a forecast



Sources: Bloomberg and Bank calculations.

There is a wide range of academic literature on forecasting oil prices. A number of papers examine the forecasting performance of the futures curve, often comparing it to a random walk — the assumption that all changes in the oil spot price are unpredictable, so that the current spot price is the best possible forecast for the future spot price.

Alquist, Kilian and Vigfusson (2011) find that oil futures prices are generally no better at predicting spot prices than a random walk. At a twelve-month horizon they may marginally outperform a random walk, but this result is sensitive to the sample period and data frequency chosen. On the other hand, Chernenko, Schwarz and Wright (2004) conclude that the oil futures price predicts spot prices correctly on average; Wu and McCallum (2005) agree, but observe that the forecasting errors are large. Reichsfeld and Roache (2011) find that the oil futures price outperforms a random walk at the three-month horizon but is no better at longer horizons.

Overall, then, the results from the literature are mixed. But they do not strongly suggest that the futures curve is a much better predictor of spot prices than a random walk.

Testing the forecasting performance of the futures curve

In this subsection, the predictive power of oil futures curves is compared with three other simple forecasts and rules of thumb.

The three rules are all based on readily observable measures from financial markets and surveys:

- **A random walk.** The assumption that all changes in the oil spot price are unpredictable, so that the current spot price is the best possible forecast for the future spot price.

- **Consensus forecasts.** The arithmetic mean of a survey of professional economists' expectations for the oil price one year ahead, carried out by Consensus Economics.(1)

- **Hotelling's rule.** The simple theoretical model of oil production set out in Hotelling (1931) implies that oil prices increase in line with nominal interest rates.(2) Producers are indifferent between selling an additional barrel of oil today — investing the proceeds at the market interest rate — and waiting to extract the oil in the following period.(3)(4)

Table A summarises the forecasting performance of the futures curve, together with each of these methods at the one-year horizon, during the period January 2000 to January 2012.(5) Two measures of predictive power are shown. The first measure is the mean forecast error, which captures any systematic bias in the forecast. Unbiasedness is a desirable characteristic for a forecast, but that does not mean that the least biased forecast is necessarily the most useful: a forecast which is far too high half the time and far too low the rest of the time will be unbiased, but it will not be very helpful to policymakers. The second measure, the root mean squared error (RMSE), captures this kind of predictive weakness.

Table A Alternative forecasts for the oil price

	Futures curve	Random walk	Consensus	Hotelling's rule
Mean error	-8%	-6%	-12%	-4%
Root mean squared error	37%	38%	33%	39%
Diebold-Mariano statistic(a)	–	0.55	-0.78	0.76

Sources: Bloomberg, Consensus Economics and Bank calculations.

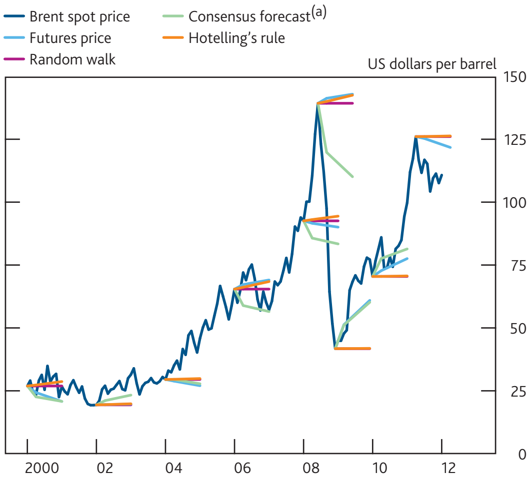
(a) The statistic compares the RMSE of the futures curve with each of the other measures. When the two RMSEs are equal, this statistic has a standard normal distribution in large samples. Here, the absolute value of the statistic is less than 1.96 in all three cases, implying that none of the RMSEs are significantly different from the futures curve at the 5% significance level (see Diebold and Mariano (1994)).

While futures prices have typically underpredicted oil prices over the past decade, alternative market-based measures have not performed consistently better. The futures price, random

(1) These forecasts are for the price of West Texas Intermediate (WTI) oil, while the MPC uses the Brent oil price. This is taken into account when considering the results. In addition, Consensus forecasts do not correspond precisely to the end-of-month data used throughout this article.
(2) Strictly, Hotelling's rule applies to the net oil price, that is, the oil price minus the cost of production. But marginal production costs, which vary considerably by oilfield project, are not easily observable — making forecasting using this rule difficult. The formulation used here implicitly assumes that production costs also increase in line with nominal interest rates.
(3) Again, the nominal US one-year government spot interest rate is used in place of the risk-free rate.
(4) An alternative way of motivating the same rule is to interpret it as assuming that risk premia are equal to zero.
(5) The table concentrates on this horizon because oil futures markets are much less liquid for longer-dated contracts, while Consensus energy forecasts for horizons longer than one year are only published on a quarterly basis.

walk and Consensus forecasts all underpredicted the actual spot price on average by between 4% and 12% (illustrated in **Chart 7**). The forecasts made using Hotelling's rule were, on average, the least biased. But this apparent accuracy masked considerable variation of forecasting performance within that period, with the RMSE comparable to that of the other forecasting methods. Statistical tests, reported in the third row of **Table A**, could not reject the hypothesis that the RMSE for the futures curve was the same as that for either the random walk, Consensus survey or Hotelling's rule forecasts: in other words, none of the other forecasts was significantly better than the futures curve.[1]

Chart 7 Alternative forecasts for the oil price



Sources: Bloomberg, Consensus Economics and Bank calculations.

(a) The Consensus forecast for April 2011 is omitted due to the size of the wedge between the price of Brent crude and WTI at this time (see footnote (1) on this page).

Of course, there are various extensions to these forecast measures that one might consider. Reeve and Vigfusson (2011), for example, consider a random walk with drift, which assumes that commodity prices continue on the path implied by their average growth rate over the previous twelve months. This approach could be consistent with the idea that commodity prices will continue to rise in line with world demand, say. But the authors find that this measure performs significantly worse than the futures curve. Interestingly, however, they do find that the futures curve outperforms a random walk when the slope of the futures curve is steep. Other authors find that augmenting the futures price with additional financial or real-world variables can improve its forecasting performance. Pagano and Pisani (2009), for instance, find that a measure of capacity utilisation in US manufacturing can explain part of the forecast error from using futures prices. There are, of course, various ways to model the oil market based on market fundamentals — this approach is discussed briefly in the following section.

Assessing the outlook for commodity prices

The previous section highlighted the poor track record of both oil futures prices and other simple forecasting rules in predicting changes in oil spot prices. In this section some reasons are put forward as to why this finding is not very surprising given the likely determinants of oil price movements over the past. The MPC's approach to considering the outlook for commodity prices over the forecast horizon is then discussed, including the futures curve assumption for the central projection.

Explaining why oil prices are hard to predict

The nature of oil as a financial asset means that the failure of futures prices and other measures to predict large swings in prices is not very surprising. As discussed earlier, oil spot and futures prices will always be tied by an arbitrage relationship, which, in practice, means that the futures curve has been relatively flat compared to the scale of price moves seen over the past few years. So what can explain these large swings in oil and other commodity prices?

Previous analysis has concluded that it is likely that much of the large swings in oil prices can, *ex post*, be explained by changes to oil market fundamentals. For example, Hamilton (2009) attributes the run-up to the 2007–08 spike in oil prices to a combination of strong demand confronting stagnating world production. Saporta, Trott and Tudela (2009) stress the importance of *unexpected* shocks to fundamentals — notably the strength of demand from emerging markets and a successive overestimation of non-OPEC oil supply — in explaining the steady upwards trend in oil prices between 2003 and 2007.[2] At the same time, the authors do not find empirical support for theories that point to the rapid increase in financial flows from speculators in the oil futures market as driving a wedge between spot prices and market fundamentals.

This view that shocks to fundamentals have been the main drivers of oil price changes might suggest using a model based on oil market fundamentals to generate forecasts for the oil price. Increasingly, this is being investigated in the academic literature. For example, Kilian and Murphy (2010) develop a structural vector autoregression (VAR) model of the oil market that includes measures for global oil production, economic activity, oil stocks and the real oil price. Baumeister and Kilian (2011) test the forecasting performance of this model and find that the mean square error is lower than for a random

(1) Since early 2011, WTI and Brent oil prices have diverged considerably. As mentioned in footnote (1) on page 43, Consensus forecasts are made for the WTI price. This could in principle explain their underprediction of the Brent price. But restricting the sample to the period before the two prices diverged does not improve their forecasting performance. And again, caution should be taken when assessing the predictive power of these forecasts at the peaks and troughs shown in **Chart 7**, since the forecasts may have been made before those peaks and troughs were reached.

(2) This view has implications for the interpretation of the empirical forecasting tests of the previous section. For example, the Hotelling path is *always* upward sloping (as nominal interest rates are positive) even though news on oil market fundamentals can contingently move in either direction. If we consider the subperiod of January 2000-July 2007, we find that the RMSE for the Hotelling path is considerably lower than for the other measures considered above. But if one believes that shocks to market fundamentals drove price changes over that period, then the Hotelling rule would appear to be broadly right but for the wrong reasons over that sample period.

walk over short horizons (one to three months ahead) over the period from January 1992 to June 2010. The model, however, performs less well over longer horizons (six to twelve months ahead).(1) Moreover, similarly to the simple forecasting rules discussed in the previous section, their fundamentals-based model is unable, for the most part, to predict the large swings in oil prices over the 2008–09 period.

More generally, forecasting oil prices using a fundamentals-based approach can be problematic for two reasons. First, there is the challenge of generating predictions for all the oil market-specific variables required to forecast oil prices.(2) And second, there is the communications challenge that this would present. This is discussed in greater detail below.

How the Monetary Policy Committee assesses the outlook for commodity prices

Despite the poor track record of oil futures prices in predicting large movements in spot prices, the MPC's central projections for growth and inflation are based on the futures curve for oil and other commodity prices. This is for three main reasons. First, as discussed in the previous section, there are no other simple measures that consistently outperform the futures curve in predicting future price movements.

Second, changes in the slope of the futures curve should, by signalling changes in the net convenience yield, reflect changes to the expected path of spot prices — at least in terms of the direction of this expected path. This consideration would be lost by assuming a random walk, say. As mentioned in the previous section, there is some evidence that the futures curve outperforms a random walk when the slope of the futures curve is steep, perhaps because the signal from the convenience curve is clearest in such situations.(3)

The third reason for assuming that commodity prices follow the path implied by futures curves is that it is easy to communicate a simple and transparent market-based measure as an underlying assumption in the central projections for GDP growth and inflation — an important consideration for the MPC when publishing the *Inflation Report*. In this respect, the futures curve is preferable to less transparent, model-based forecasts.

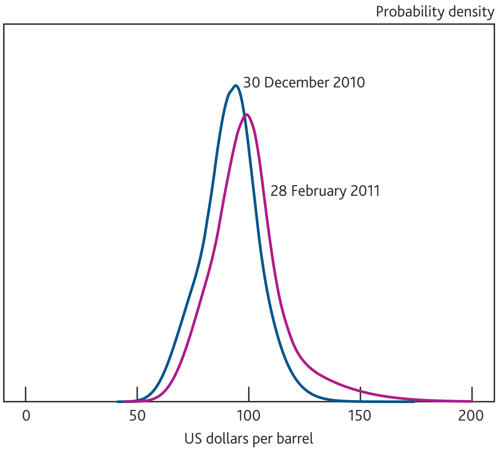
Nonetheless, in assuming that commodity prices follow paths implied by futures curves, the MPC remains mindful of a number of factors. As described earlier, oil futures prices are not generally equal to market expectations of spot prices. And due to practical limits to arbitrage they may not reflect all available information about future supply and demand. Moreover, as described above, there is an expanding academic literature on oil price forecasting with increasingly sophisticated techniques employed to refine those forecasts.

Due to these considerations, the MPC looks at a range of measures, in addition to the futures curve, when assessing the balance of risks to commodity prices over the forecast horizon. These risks are then reflected in the fan charts of the *Inflation Report* projections for growth and inflation. Analysis of commodity market fundamentals helps inform the MPC's view about possible outcomes for oil and other commodity prices. For example, fundamentals-based models of the oil market, as well as simple rules of thumb, are used to consider the range of plausible outcomes for oil prices under various scenarios for world demand, oil production, spare production capacity, and so on over the forecast period.

Financial markets also provide useful metrics for considering the range of plausible outcomes for oil prices at a given point in time. One such measure is the probability distribution for the oil price implied by option prices.(4) Changes in this distribution can be informative about changes in market perceptions of the risks around the oil price. But just like spot and futures prices, the implied probability distribution for oil prices will differ from market participants' beliefs about the actual probability distribution for the oil price.(5)

Chart 8 shows two implied probability distributions for the oil price three months ahead from late 2010 and early 2011. As

Chart 8 Option-implied distributions for the oil price three months ahead[(a)]



Sources: Bloomberg, Chicago Mercantile Exchange and Bank calculations.

(a) Calculated from options on WTI crude oil.

(1) Baumeister and Kilian (2011) also test a version of the VAR using Bayesian estimation techniques. For the specification with a lag order of 24 months, they find that the model does perform better than a random walk over all horizons out to twelve months. However, the model only reduces the RMSE at the twelve-month horizon by a relatively small amount (approximately 2.5%).
(2) In some models (such as structural VARs) this problem can be partly overcome by estimating the oil market as a system of equations that can generate forecasts for each variable in the system. Ideally, though, to forecast oil prices, one would need to form a view on the outlook for variables such as the amount of OPEC crude oil production and marginal production costs (for which data over the past is not readily available), both of which are hard to predict.
(3) See Reeve and Vigfusson (2011).
(4) These distributions are calculated using the non-parametric fitting technique described in Clews, Panigirtzoglou and Proudman (2000) and Bliss and Panigirtzoglou (2002).
(5) The prices paid for options will also reflect the distribution of risks perceived by market participants. The mean of the distribution, for instance, is not the expected spot price but the futures price.

discussed earlier, the futures curve became downward sloping during this period as geopolitical tensions increased in the Middle East and North Africa. At the same time, the implied weight on future oil prices above US$100 per barrel, and even above US$150 per barrel, also increased sharply, despite the oil spot price only rising to around US$110 per barrel. So the skewness of the implied distribution became more positive. On the other hand, the increase in the skewness was much larger at the three-month horizon than at the twelve-month horizon (**Chart 9**), suggesting that any possible shock to the oil supply was expected to be temporary.

Chart 9 Balance of risks to the oil price(a)(b)

Sources: Bloomberg, Chicago Mercantile Exchange and Bank calculations.

(a) Calculated from options on WTI crude oil.
(b) The balance of risks is measured by the skewness of the implied distribution of returns. No unit is shown on the y-axis because skewness is unitless.

Conclusion

There have been large movements in the oil price over the past few years, which have been a major contributor to UK CPI inflation. For their central projections for GDP growth and inflation published in the *Inflation Report*, the MPC assumes that oil prices follow the market futures curve profile.

There are problems associated with using the futures curve to forecast oil prices. The presence of risk premia in asset prices means that futures prices are not the same as expected spot prices. And they did not predict the large movements in oil spot prices observed over the past few years.

But it is not clear that any other simple forecasting rule consistently outperforms the futures curve assumption. Commodity futures curves offer a simple, transparent and market-based measure which helps the MPC communicate the assumptions underlying its forecasts for growth and inflation. Moreover changes in the *slope* of the futures curve can reflect changes to the *direction* of the expected path of spot prices.

When assessing the balance of risks to commodity prices over the forecast horizon, the MPC considers a range of measures. These risks are reflected in the fan charts for GDP growth and inflation. As explained in this article, the central projections for GDP growth and inflation in the *Inflation Report* use the futures curve profile, but this is one of many possible assumptions and the MPC will continue to monitor the validity of this assumption in the future.

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