

Assessing the risk to inflation from inflation expectations

By Gareth Anderson and Becky Maule of the Bank's Monetary Assessment and Strategy Division.⁽¹⁾

- Well-anchored inflation expectations play an important role in the achievement of the Monetary Policy Committee's (MPC's) 2% inflation target.
- At the moment, available measures are consistent with inflation expectations remaining well anchored to the MPC's target.
- Empirical work suggests that unexplained 'shocks' to households' expectations may have had a significant impact on inflation over the past.

Overview

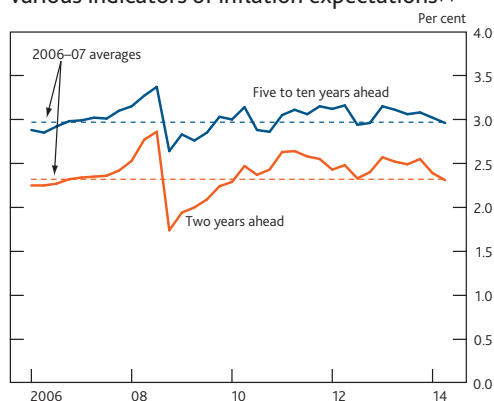
People's expectations about future inflation play an important role in determining the current rate of inflation: when people believe that inflation will be low and stable, they set wages and prices in a way that is consistent with those beliefs. Given that, the Monetary Policy Committee (MPC) monitors indicators of inflation expectations and they are a crucial factor in policy decisions.

There is a wide range of external indicators that the MPC draws on to assess whether inflation expectations remain well anchored, and there are a number of metrics that can be used to shed light on the risks around inflation expectations. Given that indicators of inflation expectations are numerous, and can move in different ways, it is helpful to provide an overview of the information they contain. This article introduces two methods to do that. One is based on a 'heat map' which uses statistical tests to analyse how unusual the latest outturns for various indicators are. Another relies on constructing summary measures of the various indicators of the levels of inflation expectations. These measures extract the overall signal from all the indicators of inflation expectations at each horizon.

Based on the latest data, the heat map and the summary measures are both consistent with inflation expectations remaining well anchored at all horizons. For example, the summary measures for expectations both two and five to ten years ahead are close to their pre-crisis levels, when inflation was close to the target, on average (see **summary chart**). And they have varied relatively little over the past few years. Across a wider set of metrics, most indicators also remain consistent with expectations being anchored.

The article also assesses the impact of the expectations of different economic agents — such as households and professional forecasters — on the actual rate of inflation. The analysis presented suggests that shocks to households' inflation expectations can have a significant impact on inflation. Inflation is estimated to increase by around 0.7 percentage points at the one-year horizon in response to a 1 percentage point shock to households' inflation expectations. In contrast, the empirical work suggests that shocks to professional forecasters' inflation expectations generally do not have a significant impact on inflation. But the analysis presented in this article is consistent with professional forecasters' expectations providing information to households on which to base their expectations, via reports in the media, for example.

Summary chart Summary measures of the levels of various indicators of inflation expectations^(a)



Sources: Bank of England, Barclays Capital, Bloomberg, CBI (all rights reserved), Citigroup, GfK NOP, HM Treasury, ONS, YouGov and Bank calculations.

(a) Data are non seasonally adjusted. For more information on how these measures are constructed, see Annex 2 on page 160.

(1) The authors would like to thank Nicola Worrow for her help in producing this article.

The Bank's monetary policy objective is to deliver price stability — defined by the Government's inflation target of 2%, as measured by the consumer prices index (CPI) — and, subject to that, to support the Government's economic objectives including those for growth and employment. Well-anchored inflation expectations are an important part of the monetary policy framework. People's expectations about future inflation play an important role in determining the current rate of inflation: when people believe that inflation will be low and stable, they set wages and prices in a way that is consistent with those beliefs.

There is a wide range of external indicators that the Monetary Policy Committee (MPC) draws on to assess whether inflation expectations remain well anchored. An article in the 2013 Q2 *Quarterly Bulletin* concluded that most of those indicators were consistent with inflation expectations remaining anchored to the target.⁽¹⁾ The article noted, however, that there continued to be a risk that expectations could become less well anchored while inflation was above the target. At the time of publication, CPI inflation had been above 2% for around three and a half years.

Over the past year, inflation has fallen, and is currently a little below the target. While the outlook is uncertain, the MPC's latest forecasts contained in the May 2014 *Inflation Report* project that, in the central view, inflation is likely to remain close to 2% over the next few years. This article discusses how indicators of inflation expectations have evolved over the past year, and the impact of those expectations on inflation. The first section discusses recent movements in inflation expectations, and assesses the extent to which they remain anchored by monetary policy. The second section analyses the impact that different measures of inflation expectations have on inflation, and the channels through which those effects might occur. The final section concludes.

Assessing the extent to which expectations remain anchored

The MPC is able to meet its objective more easily when inflation expectations are anchored by the monetary policy framework. Inflation expectations are considered to be anchored if deviations of inflation from the target are expected to be transitory, so that people have a reasonable degree of confidence that inflation will return to the target in the medium term and remain there. In that case, companies and households are likely to set prices and wages in a way that will help to limit the extent to which any deviation in inflation persists. Conversely, if inflation expectations were to become less well anchored, deviations of inflation from the target might trigger changes in price-setting and wage-setting behaviour that could make those deviations more persistent and more costly to reverse.

If inflation expectations were to become less well anchored, that might become apparent in indicators of expectations at both short and longer-term horizons. Shorter-term inflation expectations might become less well anchored if people believe that the MPC has become more tolerant of deviations of inflation from the target, even if they expect inflation to return to the target eventually. And longer-term inflation expectations might become less well anchored if people doubt the determination of the MPC to return inflation to the target in the long run.

The MPC has three main metrics for monitoring the risks to inflation expectations: the level of inflation expectations; uncertainty about future inflation; and the sensitivity of longer-term expectations to economic news. And the MPC monitors a broad range of indicators of these metrics, including measures from surveys of households and companies, forecasts by professional economists and indicators based on financial market instruments.⁽²⁾ This section reviews the latest data to assess whether expectations appear to be well anchored.

The levels of inflation expectations

Tables A and B show indicators of inflation expectations at shorter and longer-term horizons. Interpreting whether the levels of the series shown in these tables are consistent with expectations remaining well anchored around the MPC's target can be difficult. This is because some measures are not direct indicators of expectations for CPI inflation — the MPC's target variable. For example, measures derived from financial instruments reference RPI inflation, and the surveys of households ask about general price movements, not a specific price index (see Annex 1 for details of the questions asked). One way to try and assess whether indicators of expectations are consistent with well-anchored CPI inflation is to compare the series' current levels with their historical averages — particularly averages taken over a time when CPI inflation averaged close to the MPC's 2% target.

There is an additional complication in assessing the implications of expectations data at shorter horizons because, although the inflation target applies at all times, the MPC's remit recognises that the actual inflation rate will occasionally move away from 2% as a result of disturbances to the economy. So, even if inflation expectations remain anchored, shorter-term indicators are likely to move in response to economic shocks that are projected to push inflation away from the target temporarily. One way to assess whether differences between the levels of indicators and their past averages reflect economic shocks is to compare them to the MPC's forecast for inflation, which captures the Committee's judgement about how various economic developments have affected the outlook for inflation.

(1) See Maule and Pugh (2013).

(2) The available measures are described in more detail in Annex 1.

Table A Indicators of shorter-term inflation expectations^(a)

Per cent

| | Start of data | Whole-sample average | Averages to 2007 ^(b) | Averages since 2008 ^(c) | 2013 | | | | 2014 | |
|--|---------------|----------------------|---------------------------------|------------------------------------|------|-----|-----|-----|------|-------------------|
| | | | | | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 ^(d) |
| One year ahead expectations: | | | | | | | | | | |
| Surveys of households^(e) | | | | | | | | | | |
| Bank/GfK NOP | Dec. 1999 | 2.8 | 2.3 | 3.3 | 3.6 | 3.6 | 3.2 | 3.6 | 2.8 | 2.6 |
| Barclays Basix | Dec. 1986 | 3.6 | 3.8 | 3.1 | 3.1 | 2.6 | 2.8 | 2.8 | 2.3 | 2.4 |
| YouGov/Citigroup | Nov. 2005 | 2.7 | 2.5 | 2.7 | 2.8 | 2.5 | 2.6 | 2.8 | 2.2 | 2.0 |
| Survey of companies | | | | | | | | | | |
| CBI ^(f) | June 2008 | 2.0 | n.a. | 2.0 | 1.4 | 0.9 | 1.2 | 1.0 | 1.4 | n.a. |
| Surveys of professional forecasters | | | | | | | | | | |
| Bank | Feb. 2006 | 2.0 | 1.9 | 2.1 | 2.2 | 2.5 | 2.5 | 2.4 | 2.1 | 2.0 |
| HM Treasury ^(g) | Feb. 2004 | 2.1 | 2.0 | 2.1 | 2.2 | 2.3 | 2.3 | 2.4 | 2.0 | 1.9 |
| Measures derived from financial instruments^(h) | | | | | | | | | | |
| Swaps | Oct. 2004 | 2.7 | 2.6 | 2.7 | 3.2 | 3.0 | 2.9 | 3.0 | 2.8 | 2.9 |
| MPC Inflation Report forecast⁽ⁱ⁾ | Feb. 2004 | 2.0 | 1.9 | 2.1 | 3.0 | 2.6 | 2.5 | 2.1 | 1.8 | 1.7 |
| Two year ahead expectations: | | | | | | | | | | |
| Surveys of households^(e) | | | | | | | | | | |
| Bank/GfK NOP | Mar. 2009 | 2.9 | n.a. | 2.9 | 3.4 | 3.3 | 3.0 | 3.4 | 2.8 | 2.5 |
| Barclays Basix | Dec. 1986 | 3.9 | 4.1 | 3.4 | 3.5 | 2.8 | 3.1 | 3.2 | 2.7 | 2.8 |
| Surveys of professional forecasters | | | | | | | | | | |
| Bank | Feb. 2006 | 2.0 | 2.0 | 2.0 | 2.2 | 2.3 | 2.2 | 2.2 | 2.2 | 2.0 |
| HM Treasury ^(g) | Feb. 2004 | 2.0 | 2.1 | 2.0 | 2.2 | 2.2 | 2.2 | 2.2 | 2.1 | 2.0 |
| Measures derived from financial instruments^(h) | | | | | | | | | | |
| Swaps | Oct. 2004 | 2.8 | 2.8 | 2.8 | 3.1 | 3.0 | 3.0 | 3.0 | 3.0 | 3.1 |
| MPC Inflation Report forecast⁽ⁱ⁾ | Feb. 2004 | 1.8 | 2.0 | 1.6 | 2.3 | 2.0 | 2.0 | 1.9 | 1.9 | 1.9 |
| Memo: | | | | | | | | | | |
| CPI inflation | Jan. 1997 | 2.1 | 1.6 | 3.1 | 2.8 | 2.7 | 2.7 | 2.1 | 1.7 | 1.8 |

Sources: Bank of England, Barclays Capital, Bloomberg, CBI (all rights reserved), Citigroup, GfK NOP, HM Treasury, ONS, YouGov and Bank calculations.

(a) Data are non seasonally adjusted.

(b) Averages run from the start of the series to 2007 Q4.

(c) Averages run from 2008 Q1 (or the start of the series if later) to the latest data.

(d) YouGov/Citigroup data point is an average of April and May 2014. Financial markets data are the averages from 1 April 2014 to 20 May 2014. CPI inflation data point is April 2014.

(e) The household surveys ask about expected changes in prices but do not reference a specific price index, and the measures are based on the median estimated price change.

(f) Mean estimated price change for the distribution sector. Companies are asked about the expected percentage price change over the coming twelve months in the markets in which they compete.

(g) Data are taken from the quarterly surveys of medium-term forecasts, which, for CPI inflation, start in February 2004. Before that date, the surveys asked about RPIX inflation.

(h) Financial market measures are RPI inflation at various horizons implied by swaps.

(i) Data are the MPC's modal projections for CPI inflation. CPI inflation projections have been published since February 2004; before that date, the MPC projected RPIX inflation, the Bank's previous target measure of inflation.

In contrast, longer-term inflation expectations would not be expected to move in response to transitory economic shocks if they are anchored; they would be expected to remain relatively stable at levels consistent with the inflation target. For example, announced increases in household energy bills might be expected to raise inflation — and therefore inflation expectations — in the near term. But if expectations are well anchored, they should not be affected further ahead: at that point, the price rises will have dropped out of the annual inflation calculation.

Overall, indicators of shorter-term inflation expectations appear to be well anchored. In general, the current levels of one year ahead inflation expectations measures are close to, or somewhat below, their historical averages (Table A). This is consistent with the MPC's central projection for inflation in the

May 2014 *Inflation Report* at the one-year horizon, which was also a little below historical averages and the inflation target — reflecting judgements about economic developments. Over the past year, some measures of expectations one year ahead have fallen quite sharply, as has the MPC's projection at that horizon. Two years ahead, indicators of financial markets' and professional forecasters' expectations — and the MPC's central projection — are close to their historical averages, although households' expectations are a little below theirs.

All indicators of longer-term expectations are currently relatively close to historical averages (Table B), consistent with inflation expectations remaining anchored. Measures of households' inflation expectations have not been particularly stable over the past year though — most increased towards the end of 2013, before falling back sharply in early 2014.

Table B Indicators of longer-term inflation expectations^(a)

| Per cent | Time horizon | Start of data | Whole-sample average | Averages to 2007 ^(b) | Averages since 2008 ^(c) | 2013 | | | | 2014 | |
|--|--------------|---------------|----------------------|---------------------------------|------------------------------------|------|-----|-----|-----|------|-------------------|
| | | | | | | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 ^(d) |
| Surveys of households^(e) | | | | | | | | | | | |
| Bank/GfK NOP | 5 years | Mar. 2009 | 3.3 | n.a. | 3.3 | 3.6 | 3.6 | 3.5 | 3.7 | 3.2 | 2.9 |
| Barclays Basix | 5 years | Sep. 2008 | 3.8 | n.a. | 3.8 | 3.6 | 3.5 | 4.0 | 3.9 | 3.6 | 3.7 |
| YouGov/Citigroup | 5–10 years | Nov. 2005 | 3.4 | 3.5 | 3.4 | 3.5 | 3.3 | 3.3 | 3.7 | 3.0 | 3.0 |
| Surveys of professional forecasters | | | | | | | | | | | |
| Bank | 3 years | Feb. 2006 | 2.0 | 1.9 | 2.0 | 2.2 | 2.2 | 2.2 | 2.2 | 2.1 | 2.1 |
| HM Treasury ^(f) | 4 years | Feb. 2006 | 2.1 | 2.1 | 2.2 | 2.4 | 2.2 | 2.2 | 2.1 | 2.2 | 2.1 |
| Measures derived from financial instruments^(g) | | | | | | | | | | | |
| Swaps | 5–10 years | Oct. 2004 | 3.3 | 3.0 | 3.5 | 3.4 | 3.5 | 3.5 | 3.5 | 3.4 | 3.4 |
| Memo: | | | | | | | | | | | |
| CPI inflation | | Jan. 1997 | 2.1 | 1.6 | 3.1 | 2.8 | 2.7 | 2.7 | 2.1 | 1.7 | 1.8 |

Sources: Bank of England, Barclays Capital, Bloomberg, Citigroup, GfK NOP, HM Treasury, ONS, YouGov and Bank calculations.

- (a) Data are non seasonally adjusted.
- (b) Averages run from the start of the series to 2007 Q4.
- (c) Averages run from 2008 Q1 (or the start of the series if later) to the latest data.
- (d) YouGov/Citigroup data point is an average of April and May 2014. Financial markets data are the averages from 1 April 2014 to 20 May 2014. CPI inflation data point is April 2014.
- (e) The household surveys ask about expected changes in prices but do not reference a specific price index, and the measures are based on the median estimated price change.
- (f) Data are taken from the quarterly surveys of medium-term forecasts, which, for CPI inflation, start in February 2004. Before that date, the surveys asked about RPIX inflation.
- (g) Five-year, five-year forward RPI inflation implied by swaps.

Given that the various indicators of the levels of inflation expectations often move in different ways, it can be helpful to use summary measures to assess the general message, abstracting from the ‘noise’ in individual series. Summary measures of inflation expectations at a number of horizons are shown in **Chart 1**. Annex 2 on page 160 of this article discusses how these measures have been constructed.

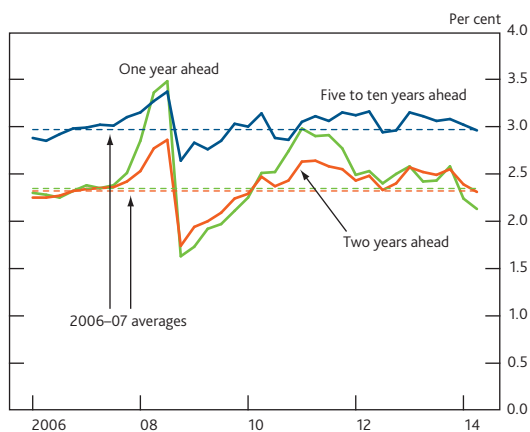
The summary measures suggest that inflation expectations are well anchored at all horizons. The one year ahead measure is a little below its pre-crisis average, but that is consistent with the MPC’s central projection at that horizon, and so probably reflects economic developments (**Chart 1**). At the five to

ten-year horizon, the summary measures are close to pre-crisis levels, and have varied relatively little over the past few years.

Uncertainty about inflation

Individuals’ uncertainty about future inflation may increase if they become less sure that the MPC will respond to shocks that would push inflation away from the target persistently. Alternatively, an increase in people’s uncertainty about inflation could also result from a change in view about the size or persistence of shocks that might affect the economy in the future. For example, the uncertainty around the MPC’s inflation projections has increased since the financial crisis. In that case, while the decisions of households and firms might be affected,⁽¹⁾ it would not necessarily signal that inflation expectations have become less well anchored by monetary policy.

Chart 1 Summary measures of the levels of inflation expectations^(a)



Sources: Bank of England, Barclays Capital, Bloomberg, CBI (all rights reserved), Citigroup, GfK NOP, HM Treasury, ONS, YouGov and Bank calculations.

- (a) Data are non seasonally adjusted. For more information on how these measures are constructed, see Annex 2 on page 160.

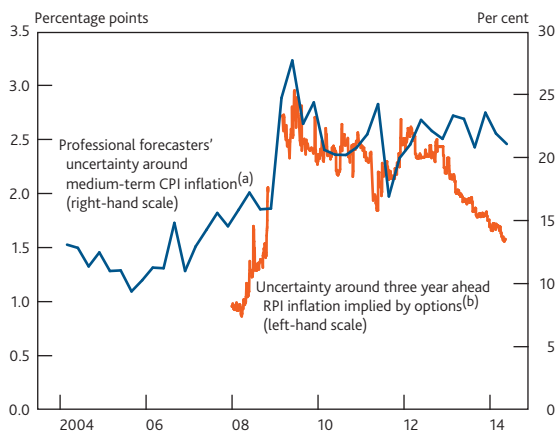
The Bank’s survey of external forecasters (SEF) provides one indicator of the amount of uncertainty over the level of future inflation. It provides information about how wide or narrow the distribution of professional forecasters’ expectations is, given the probabilities they attach to various outcomes for future inflation. Alternatively, options prices can be used to estimate the weight that market participants attach to different future inflation outcomes.⁽²⁾

Over the past year, neither measure suggests that inflation uncertainty has increased. The uncertainty around

- (1) See Haddow *et al* (2013) for a discussion of how uncertainty matters for economic activity.
- (2) See Smith (2012) for a detailed discussion of how implied probability density functions for UK RPI inflation can be calculated from inflation options.

professional forecasters' expectations has been relatively stable, while the implied volatility from inflation options prices suggests that uncertainty has declined somewhat (Chart 2). Both measures remain elevated relative to the period preceding the financial crisis, however.

Chart 2 Uncertainty around three year ahead inflation for professional forecasters and financial market participants



Sources: Bank of England, Bloomberg and Bank calculations.

- (a) Professional forecasters' uncertainty is calculated as the average probability that inflation will be more than 1 percentage point away from the target, calculated from the probability distributions for inflation reported by forecasters responding to the Bank's survey. Forecasters' reported probability distributions for CPI inflation two years ahead between February 2004 and February 2006, and for CPI inflation three years ahead from May 2006 onwards.
- (b) Standard deviation of the probability distribution of annual RPI inflation outturns three years ahead implied by options. It is not possible to construct a full set of probability distributions for some days due to technical reasons.

Responses to a survey of households also suggest that uncertainty about the future rate of inflation has not increased over the past year. The Bank/GfK NOP survey asks respondents how confident they are about inflation being within 1 percentage point of the target in two to three years' time. In 2014, just under 40% of households reported that they were very or fairly confident that inflation would be close to the target, slightly higher than the proportion giving these responses in 2013.

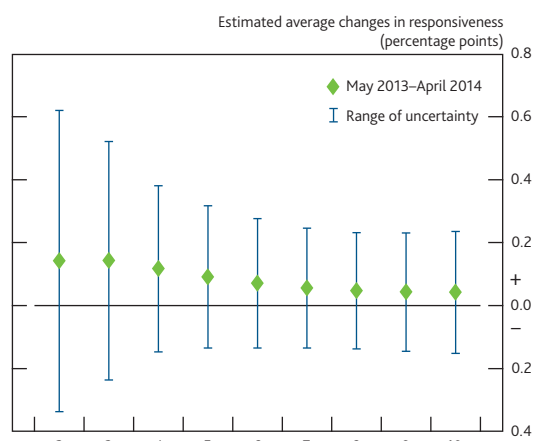
The responsiveness of longer-term inflation expectations

As discussed above, unexpected economic news might be expected to result in changes to individuals' inflation expectations in the near term, but not to those at longer horizons. If longer-term inflation expectations become more responsive to news, it could indicate that people have begun to expect deviations of inflation from the target to be more persistent, or have begun to attach less weight to the MPC bringing inflation back to the target in the long run.⁽¹⁾

One source of news that might be expected to affect near-term inflation expectations is a 'surprise' in the outturn for CPI inflation. For example, if inflation is unexpectedly high, individuals might revise up their forecast for inflation in the short term. But longer-term expectations should not move in response to such news if they remain well anchored.

Market participants' sensitivity to the news in inflation outturns can be estimated by observing movements in financial market measures of inflation expectations on the day CPI inflation data are published, and comparing those movements to the difference between the inflation outturn and the market median expectation for the data before its release. Over 2004–07, on average, market measures of expected inflation did not respond significantly to CPI news at horizons greater than one year ahead. The green diamonds in Chart 3 show the change in the responsiveness over the past year relative to that period. For example, the green diamond at the five-year horizon shows the estimate of how much more responsive five year ahead inflation expectations have been to CPI news over the past year than they were during 2004–07. And the bar shows a measure of the uncertainty around that central estimate.

Chart 3 Change in responsiveness of instantaneous forward inflation rates to CPI news relative to pre-crisis^(a)



Sources: Bloomberg, ONS and Bank calculations.

- (a) The diamonds show the estimated slope coefficients for the change in responsiveness of instantaneous forward inflation rates (derived from inflation swaps) to news in the CPI release over the past twelve months relative to the pre-crisis period (2004–07). The bars cover two standard errors either side of the estimated slope coefficients.

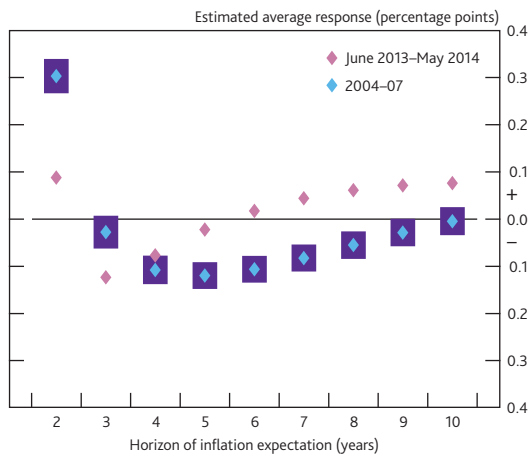
Over the past twelve months, inflation expectations appear to have been a little more responsive to news in the CPI release than they were during 2004–07, although the size of the changes is very small relative to the uncertainty surrounding the estimates, as indicated by the bars showing statistical significance.

An alternative approach of assessing whether the responsiveness of longer-term expectations has increased is to estimate the sensitivity of measures of expected inflation at longer horizons to changes in one year ahead expectations. One year ahead expectations might well be reassessed if there is news, but expectations at longer horizons should not change much in response to economic developments if they are well anchored.

(1) For more on this topic, see Gürkaynak, Levin and Swanson (2006).

For market measures of inflation expectations, movements in two year ahead inflation expectations were correlated with those one year ahead during 2004–07, but beyond that horizon, inflation expectations tended to change little (Chart 4). Over the past year, inflation expectations six to ten years ahead have tended to move in a similar direction to one year ahead expectations, unlike during 2004–07. But these movements are small — less than 0.1 percentage points in response to a 1 percentage point increase in one year ahead expectations. And the correlation between changes in market measures of shorter-term and longer-term expectations could also reflect other factors, for example variations in liquidity in the markets for short and long-maturity instruments.

Chart 4 Estimated changes in instantaneous forward inflation rates derived from swaps in response to a 1 percentage point increase in one year ahead inflation expectations^(a)



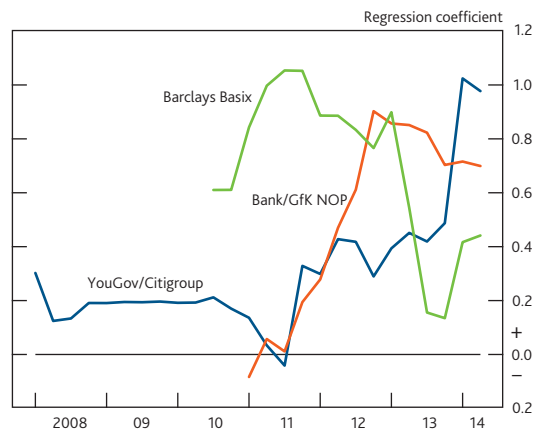
Sources: Bloomberg and Bank calculations.

(a) The average changes are estimated using the slope coefficients from regressions of daily changes in instantaneous inflation forward rates at each horizon on the daily change in the one year ahead instantaneous forward rate. The instantaneous forward rates are derived from inflation swaps. Data start in October 2004. Data for May 2014 are based on daily data from 1 May to 20 May 2014. The bars cover two standard errors either side of the estimated slope coefficients for the 2004–07 period.

Some longer-term household measures of inflation expectations appear to have become more sensitive to shorter-term indicators over the past few years. Chart 5 shows the coefficient estimates from rolling regressions of changes in longer-term household inflation expectations on one year ahead expectations. For the Citigroup measure in particular, the sensitivity has increased recently, although the sample period is short. And the same pattern is less evident for the Basix measure of households' expectations. Differences between the sensitivities of the measures might, in general, reflect differences in the questions asked in the various surveys.

Assessing whether inflation expectations are sensitive to inflation outturns might also provide evidence about how well anchored inflation expectations are. Chart 6 shows the estimated coefficients from rolling regressions of five to ten

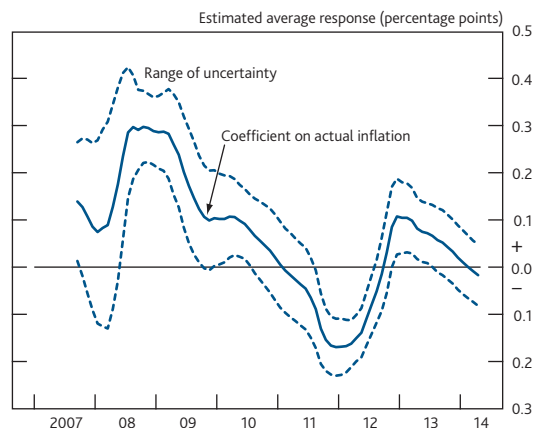
Chart 5 Two-year rolling estimates of changes in longer-term household inflation expectations in response to a 1 percentage point increase in one year ahead expectations^(a)



Sources: Bank of England, Barclays Capital, Citigroup, GfK NOP, YouGov and Bank calculations.

(a) The lines show the estimated slope coefficients from two-year rolling regressions of quarterly changes in five or five to ten-year inflation expectations from each survey on the equivalent change in the one year ahead measure. YouGov/Citigroup data point for 2014 Q2 is based on an average of data for April and May 2014.

Chart 6 Three-year rolling estimates of the responsiveness of five to ten year ahead inflation expectations to inflation outturns^(a)



Sources: Bloomberg and Bank calculations.

(a) Data from September 2007 to April 2014. The solid line shows estimated slope coefficients from three-year rolling regressions of monthly-average five to ten-year forward RPI inflation rates (derived from swaps) on CPI inflation. The dashed lines cover two standard error bands either side of the estimated slope coefficients.

year ahead inflation expectations derived from financial markets on CPI inflation outturns. If longer-term inflation expectations were well anchored, one would expect them not to be sensitive to the level of actual inflation, and so the estimated coefficient to be zero. The estimated coefficients have varied over the past, but the most recent estimates are close to zero, suggesting that longer-term inflation expectations have not been related to inflation outturns.

Inflation expectations 'heat map'

To help assess whether inflation expectations remain well anchored, summary 'heat maps' can be constructed. These

perform tests of statistical significance on the latest outturns for many of the indicators of inflation expectations in this section.

When a cell is coloured green, the indicator is unlikely to provide cause for concern. A green cell signals either that the indicator is close to a historical average, or for the shorter-term indicators, that it is close to the level that might be expected, given economic circumstances — with those summarised by the MPC's projections. To the extent that those averages provide a good proxy for what level the indicators might be expected to be at when inflation expectations are well anchored, a green cell suggests that the indicator is consistent with well-anchored expectations.

When cells are not green, the indicator might be signalling that there is a risk to inflation expectations. For the various indicators of the levels of inflation expectations, cells are coloured amber and red when measures are above their historical averages — with the darker colour showing those that are further away — and so might suggest that inflation expectations pose an upside risk to inflation. And those coloured light and dark blue signal the opposite. If the indicators of uncertainty and responsiveness increase relative to their historical averages, that might suggest that inflation expectations are becoming less well anchored, although not the direction of that risk. For those indicators, grey and black cells indicate where risks could be arising. White cells indicate where we do not have data.

Figure 1 Heat map for the levels of inflation expectations^(a)

| | Financial markets ^(b) | Professional forecasters ^(c) | | Households ^(d) | | | Companies ^(e) |
|--|----------------------------------|---|-------------|---------------------------|-----------|----------------|--------------------------|
| | Swaps | Bank SEF | HM Treasury | Bank/NOP | Citigroup | Barclays Basix | CBI |
| Short-term expectations (one year) | | | | | | | |
| – relative to MPC's forecast ^(f) | | | | | | | |
| Medium-term expectations (two year) | | | | | | | |
| – relative to MPC's forecast ^(f) | | | | | | | |
| Medium-term expectations (three year) | | | | | | | |
| – relative to whole-sample average | | | | | | | |
| – relative to post-crisis average ^(g) | | | | | | | |
| – relative to pre-crisis average ^(h) | | | | | | | |
| – relative to MPC's forecast ^(f) | | | | | | | |
| Longer-term expectations compared to series average | | | | | | | |
| – relative to whole-sample average | | | | | | | |
| – relative to post-crisis average ^(g) | | | | | | | |
| – relative to pre-crisis average ^(h) | | | | | | | |

Key: ■ π^e more than 2 standard deviations (SD) higher ■ π^e more than 1 SD higher ■ π^e less than 1 SD away ■ π^e more than 1 SD lower ■ π^e more than 2 SD lower

Figure 2 Heat map for uncertainty and the responsiveness of inflation expectations^(a)

| | Financial markets ⁽ⁱ⁾ | Professional forecasters ^(j) | | Households | | | Companies |
|---|----------------------------------|---|-------------|------------|-----------|----------------|-----------|
| | Swaps | Bank SEF | HM Treasury | Bank/NOP | Citigroup | Barclays Basix | CBI |
| Inflation uncertainty relative to series average | | | | | | | |
| – relative to whole-sample average | | | | | | | |
| – relative to post-crisis average ^(g) | | | | | | | |
| – relative to pre-crisis average ^(h) | | | | | | | |
| Longer-term inflation expectations more responsive to: | | | | | | | |
| – shorter-term inflation expectations ^(k) | | | | | | | |
| – CPI news ^(k) | | | | | | | |
| – deviations of inflation from target ^(l) | | | | | | | |

Key: ■ Uncertainty/responsiveness considerably above average ■ Uncertainty/responsiveness above average ■ Uncertainty/responsiveness around or below average

Sources: Bank of England, Barclays Capital, Bloomberg, CBI (all rights reserved), Citigroup, GfK NOP, HM Treasury, ONS, YouGov and Bank calculations.

(a) Data are non seasonally adjusted. The latest data for the Bank and HM Treasury surveys of professional forecasters and the Bank/GfK NOP and Barclays Basix household surveys are for 2014 Q2. For the YouGov/Citigroup household survey, the data are for May 2014 and for the financial markets measure, the data are the averages for the 20 working days to 20 May 2014. For the CBI company survey measures, the latest data are for 2014 Q1.

(b) Financial market measures for each horizon are instantaneous RPI inflation one, two and three years ahead and five-year, five-year forward RPI inflation, derived from swaps.

(c) Taken from the Bank's survey of external forecasters and HM Treasury's medium-term *Forecasts for the UK economy: a comparison of independent forecasts*.

(d) The household surveys ask about expected changes in prices but do not reference a specific price index, and the measures are based on the median estimated price change.

(e) Mean estimated price change for the distribution sector. Companies are asked about the expected percentage price change over the coming twelve months in the markets in which they compete.

(f) Comparisons use the MPC's modal projections for CPI inflation at the relevant horizon.

(g) Post-crisis averages run from 2009 Q1 to 2013 Q2.

(h) Pre-crisis averages run from the start of the series to 2007 Q4.

(i) Inflation uncertainty is measured by the standard deviation of the probability distribution of annual RPI inflation outturns three years ahead implied by options. For the tests of whether longer-term inflation expectations have become more responsive to shorter-term inflation expectations and CPI news, instantaneous RPI inflation forward rates at horizons between one and ten years (derived from swaps) are used. For the test of whether longer-term inflation expectations have become more responsive to deviations of inflation from target, the monthly-average five to ten-year forward RPI inflation rate (derived from swaps) is used.

(j) Professional forecasters' uncertainty is calculated as the average probability that inflation will be more than 1 percentage point away from the target three years ahead, calculated from the probability distributions for inflation reported by forecasters responding to the Bank's survey.

(k) This tests whether inflation expectations are more responsive than during 2004–07.

(l) This tests whether inflation expectations are more responsive, relative to a null hypothesis of zero.

Based on the latest data, the inflation expectations heat maps suggest that inflation expectations remain sufficiently well anchored. The vast majority of cells are green; those that are not are relatively evenly split between signalling tentative upside and downside risks. The black cell indicates that financial market measures of longer-term inflation expectations have been more sensitive to movements in shorter-term expectations than they were during 2004–07. But, as noted above, the estimated average responsiveness has been small.

It is worth noting that these statistics, by themselves, do not say anything about the economic significance of the various measures of inflation expectations. In order to fully assess the implications of these indicators, it is important to consider the extent to which they have affected inflation in the past. This is discussed in the next section.

Assessing the impact of inflation expectations on inflation

Channels through which inflation expectations affect inflation

There is a wide range of data about the inflation expectations of different groups, such as companies, households, professional forecasters and financial market participants. The expectations of these different groups could affect inflation through a variety of mechanisms.

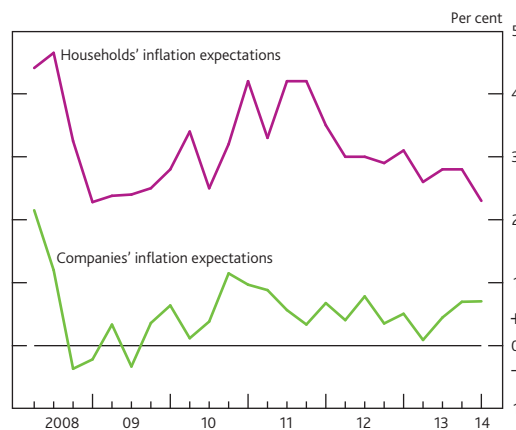
Companies' expectations have an important role in determining inflation since firms set wages and prices. If companies expect prices to rise in the future, they may increase the prices of the goods and services they produce and they may agree to pay higher wages (in order to maintain their employees' income in real terms, for instance). They might also choose to increase their investment if their inflation expectations increase and the nominal interest rate remains fixed, such that the real rate of interest they face falls. This would increase demand and put upward pressure on prices.

Data on the inflation expectations of UK companies are limited. The Confederation of British Industry (CBI) surveys companies in the distributive trades, manufacturing and services industries on their price expectations, but these surveys only began in mid-2008.

Some studies have suggested that households' inflation expectations can be used to infer companies' expectations. For example, Coibion and Gorodnichenko (2013) present evidence from the United States and New Zealand which suggests that households' inflation expectations provide a good proxy for companies' inflation expectations.

Plotting the data that are available on UK companies' inflation expectations — as measured by the CBI surveys — against households' inflation expectations at the same horizon shows that there is a positive correlation between the two indicators (Chart 7). The correlation coefficient between the two is 0.6. Households' inflation expectations have been persistently higher than those of companies, however. This might reflect the different questions that are asked in surveys of companies and households. Alternatively, each group may consider different measures of prices when responding: for example, companies might respond on the basis of their selling prices excluding duties and Value Added Tax (VAT), which households are likely to include in their responses.

Chart 7 Households' and companies' inflation expectations twelve months ahead^(a)



Sources: Barclays Capital and CBI (all rights reserved).

(a) Households' inflation expectations are based on the one year ahead Barclays Basix series. Companies' inflation expectations are from CBI surveys and reflect companies' expectations of prices twelve months ahead in their own industry. The series is based on data for the manufacturing, business/consumer services and distribution sectors, weighted using nominal shares in value added. Data are to 2014 Q1.

Households' expectations can also affect inflation directly. Expectations of higher future prices reduce households' expected future spending power, which might lead them to bargain for higher wages, raising the input costs of companies. Companies may in turn respond to these higher costs by raising prices so that profit margins are maintained. In addition, like companies, households expecting future inflation to be high may bring forward their spending.

Professional forecasters' inflation expectations might not affect economic decisions directly, but they might have an indirect effect if households or companies use them as a source of information for their own expectations. For instance, households may be exposed to professional forecasters' expectations through the media. This is discussed in the box on page 158).

Financial market measures of inflation expectations could be used in a similar way to professional forecasters' expectations. In addition, they might affect the exchange rate. If UK inflation is expected to be higher than inflation in other countries, the nominal exchange rate may depreciate so that

the real exchange rate remains constant. A lower nominal exchange rate might increase import prices and CPI inflation.⁽¹⁾

The impact of inflation expectations on inflation

One way of assessing the economic significance of recent movements in inflation expectations and the extent to which they affect inflation is to use a structural vector autoregression (SVAR) model. An SVAR is a way of analysing the underlying economic relationships between a number of variables. The inflation expectations SVAR estimated here includes seven variables: households' inflation expectations, professional forecasters' inflation expectations,⁽²⁾ CPI inflation, annual average earnings growth,⁽³⁾ annual GDP growth, Bank Rate and real oil price inflation. That set of variables allows us to analyse the relationships between measures of inflation expectations and actual inflation, while controlling for the impact of other factors that are also likely to be important in determining inflation and inflation expectations — the latter four variables.

In the structural model, each variable depends on lagged values of itself and contemporaneous and lagged values of the other variables, which means changes in one variable affect all the variables in the system. Under certain assumptions we can decompose movements in each variable into those that can be explained by developments in the variables in the model, and unexplained 'shocks'.⁽⁴⁾ At a given point in time, it can be shown that each variable depends on a combination of the contemporaneous and past shocks to all the variables in the model.

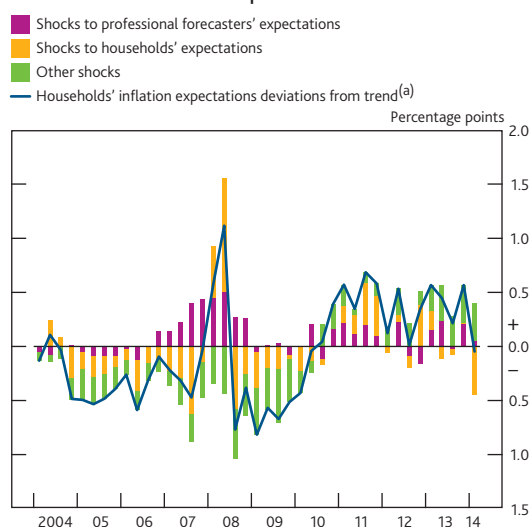
Using the SVAR, it is possible to decompose movements in CPI inflation into those that the model attributes to past or current shocks to inflation expectations and movements caused by past or current shocks to the other variables within the system. The extent to which inflation expectations shocks account for movements in CPI inflation away from its model-implied trend depends on both the frequency of the unexplained shocks to inflation expectations and how they affect all of the variables within the system.

Shocks to inflation expectations

Chart 8 shows the contributions of past and contemporaneous shocks to movements in households' inflation expectations away from trend. Over the past, a significant proportion of the movement in households' inflation expectations has been accounted for by shocks to professional forecasters' expectations and to the other variables in the model — the magenta and green bars in **Chart 8**.

In recent quarters, shocks to the other variables in the model have tended to push up households' inflation expectations, as shown by the positive green bars in **Chart 8**. Only a small proportion of the movements in households' inflation

Chart 8 Historical decomposition of movements in households' inflation expectations relative to trend



Sources: Bank of England, Barclays Capital, Bloomberg, GfK NOP, ONS and Bank calculations.

(a) Deviations in households' inflation expectations from the model-implied trend over the period 1998–2014 Q1.

expectations has been explained by shocks to professional forecasters' inflation expectations, as illustrated by the magenta bars. That is likely to reflect the fact that professional forecasters' expectations have been relatively stable around the inflation target (**Table A**). In general, though, there is evidence that households' inflation expectations do respond to shocks to professional forecasters' inflation expectations (see the box on page 158).

Over the past year, shocks to households' inflation expectations have exerted some downward pressure — as shown by the orange bars in **Chart 8**. The shocks to households' inflation expectations may reflect the influence of variables which are omitted from the model but which households' expectations respond to. For example, some of the shocks could reflect the impact of changes in VAT rates between 2008 and 2011 which are not captured by the model. They might also be driven by news about household utility prices or central bank communication that are not captured by the model.

(1) This channel is discussed in Maule and Pugh (2013).

(2) Companies' inflation expectations and expectations derived from financial markets are not included in the model, since these data are only available with a short backrun. Households' expectations are measured by the Barclays Basix survey of inflation expectations at the two-year horizon until 2009 Q4. From 2010 the Basix survey is spliced forward using changes in inflation expectations at the two-year horizon in the Bank/GfK NOP survey. The Bank/GfK NOP measure has been spliced to abstract from volatility in the Barclays Basix measure. Professional forecasters' inflation expectations are based on expectations of inflation at the two-year horizon reported in the Bank's quarterly survey of external forecasters. Prior to 2004, the expectations of professional forecasters have been adjusted downwards by 0.5 percentage points to account for the change in the inflation target in December 2003, from 2.5% on the RPIX measure of inflation to 2% on the CPI measure.

(3) The quarterly average of average weekly earnings is used. Prior to 2000, data are projected backwards using the average earnings index.

(4) The reduced-form SVAR is estimated at a quarterly frequency over the period 1998–2014 Q1 and includes two lags of all of the variables. The identification of households' and professional forecasters' inflation expectations shocks is based on a timing restriction. A Cholesky ordering is assumed in which professional forecasters' inflation expectations are ordered first and households' inflation expectations are ordered second. More detail on the SVAR model is provided in Harimohan (2012) and Maule and Pugh (2013).

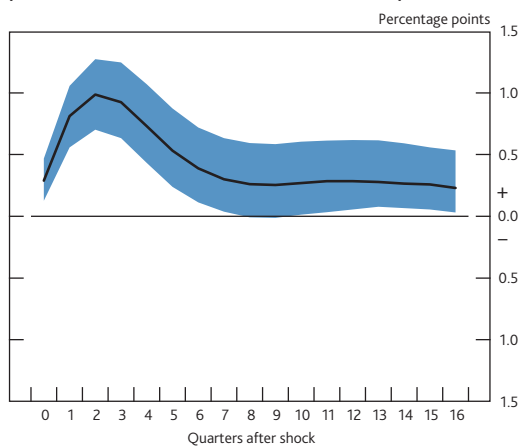
Alternatively, the shocks could reflect information which households have about the future values of the variables included in the model. The SVAR model implicitly assumes that households form their expectations based on the current and past values of variables in the model. But it might be the case that households use information about the future movements of variables within the model as an input to their inflation expectations. For example, households might revise their inflation expectations upwards if they receive information which suggests that oil price inflation is likely to be higher in the future.⁽¹⁾

The effect of inflation expectations on inflation

Using the SVAR, it is also possible to identify how a simulated 'shock' to one variable would impact on all of the variables within the system. An 'impulse response function' traces the response over time of a variable of interest, for example inflation, to a one-period shock to one of the variables in the system.

The results of the model suggest that shocks to households' inflation expectations do have an economically significant impact on inflation outcomes. **Chart 9** shows the impact on CPI inflation, over time, from a 1 percentage point shock to households' inflation expectations. The swathe illustrates the confidence bands around that impulse response. The SVAR suggests that an unexplained 1 percentage point increase in households' inflation expectations would typically increase CPI inflation by around 0.7 percentage points at the one-year horizon and would still be pushing up inflation by around 0.3 percentage points at the two-year horizon.⁽²⁾ This significant impact might reflect the role that households play in wage bargaining, or, as mentioned above, households' expectations might be serving as a proxy for companies' expectations.⁽³⁾ In contrast, the SVAR suggests that shocks to professional forecasters' inflation expectations generally do not have a significant impact on CPI inflation.

Chart 9 Impulse response of CPI inflation to a 1 percentage point shock to households' inflation expectations^(a)



Sources: Bank of England, Barclays Capital, Bloomberg, GfK NOP, ONS and Bank calculations.

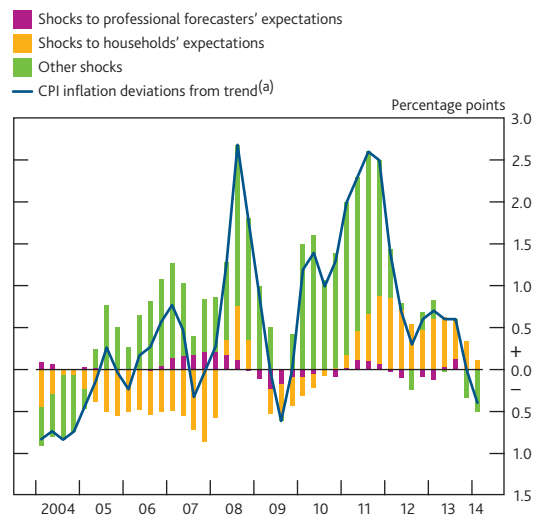
(a) The chart shows the impact on CPI inflation of a one-period shock to households' inflation expectations occurring in period zero. The swathe covers one standard error either side of the impulse response.

The impact of inflation expectations on inflation

Bringing together information on the shocks to inflation expectations, and the estimated impact of those on inflation, it is possible to decompose movements in CPI inflation away from its model-implied trend into those attributed to shocks to inflation expectations and those caused by shocks to the other variables within the system.

Chart 10 shows that, since 2008, deviations of inflation from trend have been large relative to the preceding period in which inflation was more stable. In large part, those deviations of inflation above trend have been driven by shocks to variables in the model other than inflation expectations — for example, oil prices. These are shown by the green bars.⁽⁴⁾

Chart 10 Historical decomposition of movements in CPI inflation relative to trend



Sources: Bank of England, Barclays Capital, Bloomberg, GfK NOP, ONS and Bank calculations.

(a) Deviations in CPI inflation from the model-implied trend over the period 1998–2014 Q1.

In the most recent quarter, shocks to households' expectations have exerted little upwards or downwards pressure on inflation relative to trend. The model suggests that shocks to households' inflation expectations have played a bigger role in the past, though — pushing down CPI inflation between 2004 and 2008, but tending to push inflation above trend during 2011 to 2013. Shocks to professional forecasters' expectations appear to have had little impact on CPI inflation over the entire period.

- (1) See Mehra and Herrington (2008) for a detailed discussion.
- (2) Changing the ordering of the variables does not lead to a material change in the shape of the impulse response functions.
- (3) While companies' inflation expectations are not included in the SVAR due to the short backrun of data, previous analysis by the Bank suggests that companies' inflation expectations (for the industries in which they compete) have a large impact on the prices they set. See Maule and Pugh (2013).
- (4) The restrictions imposed on the model allow shocks to households' and professional forecasters' inflation expectations to be identified. However, without imposing further restrictions it is not possible to identify which shocks in the model are driving the contributions from 'Other shocks' in **Chart 10**.

What are the drivers of households' inflation expectations?

Given the evidence suggested by the SVAR that households' inflation expectations are important determinants of CPI inflation, it is important to understand what influences them and how they are formed. There are a number of theories about how households might form their expectations, and the factors that are important might differ depending on the monetary policy regime.

Many conventional economic models are based on the assumption that individuals make decisions and form their expectations using all of the relevant information available to them. Individuals who behave in this way are said to have 'rational expectations'. But gathering the latest information about the economy can be time-consuming and costly. Some individuals may update their information about the economy and their expectations infrequently.⁽¹⁾ Alternatively, it might be the case that some individuals form their inflation expectations using a limited amount of information. For example, one simple rule of thumb would be to assume that inflation in the future will be similar to its level in the recent past. When individuals form their expectations in this way, using backward-looking information, they are said to have 'adaptive expectations'.

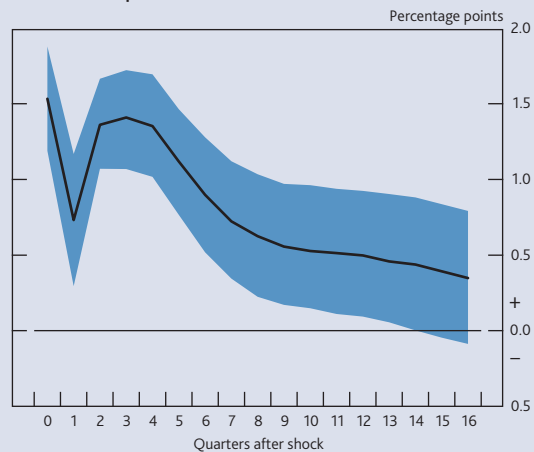
Some individuals might use newspaper reports and other forms of media as a source of information, since it is unlikely that they gather all of the latest information themselves. This is one mechanism through which professional forecasters' expectations could affect households' expectations. For example, Carroll (2003) presents a formal model in which households' inflation expectations are influenced by what is reported in the media. In the model, only a fraction of households update their inflation expectations in each period of time. Those households that do update each period are assumed to mimic the expectations of rational professional forecasters (which are reported in the media).

Conclusion

People's expectations about the likely evolution of prices play an important role in determining inflation. The analysis in this article suggests that shocks to households' inflation expectations are important, perhaps in part because they also provide information about the expectations of companies. Professional forecasters' expectations appear to have a smaller impact on inflation, but seem to play a role in providing information to households on which to base their expectations.

The SVAR model provides a way of assessing whether households' inflation expectations respond to shocks to professional forecasters' inflation expectations. The results are shown in **Chart A**, which presents the response of households' inflation expectations to a 1 percentage point shock to professional forecasters' inflation expectations.

Chart A Response of households' inflation expectations to a 1 percentage point shock to professional forecasters' inflation expectations^(a)



Sources: Bank of England, Barclays Capital, Bloomberg, GfK NOP and Bank calculations.

(a) The chart shows the impact on households' inflation expectations of a one-period shock to professional forecasters' inflation expectations occurring in period zero. The swathe covers one standard error either side of the impulse response.

The model suggests that a 1 percentage point shock to professional forecasters' inflation expectations increases households' inflation expectations by more than one-for-one at the one-year horizon. This implies that households are very sensitive to the movements in professional forecasters' expectations which cannot be accounted for by other variables in the model. In contrast, the model suggests that professional forecasters do not respond to shocks to households' inflation expectations. These two results provide some support for the framework suggested by Carroll (2003) in which households update their inflation expectations by adopting the forecasts of professional forecasters.

(1) See, for example, Mankiw and Reis (2002).

In the most recent data, indicators of inflation expectations remain consistent with expectations being anchored. And those few measures that statistically signal that expectations may be away from the target are currently relatively evenly split between those pointing to upside and downside risks. Consistent with that, an SVAR model suggests that shocks to inflation expectations are currently exerting little upward or downward pressure on inflation relative to trend. But the MPC will continue to monitor these indicators closely and they remain an important factor in policy decisions.

Annex 1

Available indicators of inflation expectations

| | Time horizon | Start of data | Survey question/measure of inflation |
|--|-------------------------------------|-------------------------------------|--|
| Surveys of households | | | |
| Bank/GfK NOP | 1 year 2 and 5 years | Dec. 1999 Mar. 2009 | How much would you expect prices to change over the next one, two and five years? |
| Barclays Basix | 1 and 2 years 5 years | Dec. 1986 Sep. 2008 | What do you expect the rate of inflation to be over the next twelve months and over the next five years? |
| YouGov/Citigroup | 1 and 5–10 years | Nov. 2005 | How do you expect consumer prices of goods and services will develop over the next one and five to ten years respectively? |
| Surveys of companies | | | |
| BCC | 3 months | Feb. 1997 | Over the next three months, has your intention to increase prices increased/remained the same/decreased? |
| CBI | 1 year | June 2008 | Over the next twelve months, what do you expect the percentage change to be in the general level of selling prices in the UK markets that your firm competes in? |
| Surveys of professional forecasters | | | |
| Bank | 1, 2 and 3 years | Feb. 2006 | Point forecasts for CPI. |
| HM Treasury | 1 and 2 years 3 years 4 years | Feb. 2004 Feb. 2005 Feb. 2006 | Point forecasts for CPI. Point forecasts for CPI. Point forecasts for CPI. |
| Consensus | 5–10 years | Oct. 2004 | Point forecasts for CPI. |
| Measures derived from financial instruments | | | |
| Swaps | 1 to 25 years ahead | Oct. 2004 | RPI-linked. |
| Gilts | 1 to 25 years ahead | Jan. 1985 | RPI-linked. |

Annex 2

A summary measure of inflation expectations

The MPC looks at a wide range of indicators of the level of inflation expectations, from surveys of households, companies and professional forecasters, as well as those derived from financial market instruments. The Committee does not have a preferred indicator: each of the external measures has value and can shed some light on developments in inflation expectations, and each indicator has strengths and drawbacks. But the numerical forecasts of each measure vary considerably. To try and assess the overall signal contained in the various indicators of inflation expectations, while ignoring the 'noise' in individual series, a summary measure can be constructed. This annex outlines how this is done.

Constructing the summary measure

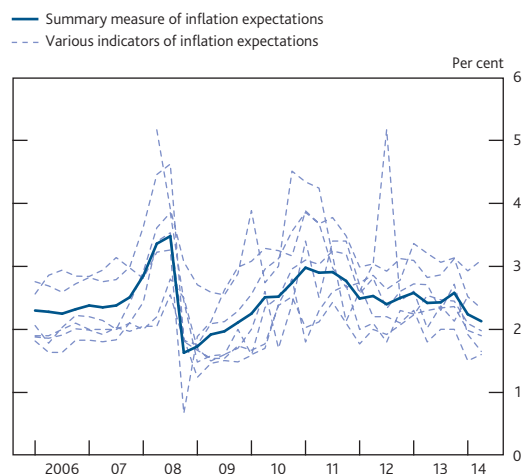
The broad approach taken is to use factor methods to extract the underlying signal from different indicators of inflation expectations that are presumed to be subject to some measurement error. The underlying series used include indicators from three different surveys of households, the CBI survey of distribution sector companies' inflation expectations, two surveys of professional macroeconomic forecasters and a series inferred from financial market inflation swaps. For each indicator, expectations at all the horizons for which they are available are used. For the estimation, data are used from 2006 onwards, or when the series starts if later than that. These indicators are not all directly comparable, as they do not all measure expectations about the same measure of inflation. For example, measures derived from financial instruments reference RPI inflation, and the surveys of households ask about general price movements, not a specific price index. So as a first step, each of these series is transformed by removing an estimate of the wedge between the measure of inflation that they explicitly or implicitly reference and CPI inflation.⁽¹⁾

To extract the common factors underlying the various indicators, we use a dynamic statistical model to estimate the term structure of inflation expectations, using a similar method to the Nelson-Siegel approach to modelling the term structure of interest rates.⁽²⁾ The term structure is fitted using three factors, which are interpreted as representing the level, slope and shape of the yield curve. The factors are assumed to evolve over time according to an autoregressive process.

The model allows for the presence of multiple measures of each given maturity of inflation expectations, and the three common factors are estimated across all of the different measures of inflation expectations simultaneously. And a summary measure of inflation expectations at each horizon can then be constructed by taking an average across all of the fitted values of different measures of inflation expectations at each maturity.

Chart A1 shows a time series of the derived summary measure for one year ahead inflation expectations alongside all of the transformed individual measures of one year ahead inflation expectations. The summary measure appears to capture the broad movements in the data, abstracting from the volatility in individual series.

Chart A1 One year ahead inflation expectations: summary measure and individual components^(a)



Sources: Bank of England, Barclays Capital, Bloomberg, CBI (all rights reserved), Citigroup, GfK NOP, HM Treasury, ONS, YouGov and Bank calculations.

(a) Data are non seasonally adjusted. Data for the CBI measure of expectations are to 2014 Q1. Data point for 2014 Q2 for YouGov/Citigroup is an average of April and May 2014 data and for the financial markets measure is an average of daily data from 1 April 2014 to 20 May 2014.

- (1) We have adjusted the survey measures that do not ask about CPI inflation specifically by the average wedge between CPI inflation and inflation perceptions, where available, or one year ahead inflation expectations between the start of the series and 2013 Q2. We have done the same for the financial market implied series at shorter horizons. At longer horizons, we have subtracted a fixed wedge of 95 basis points, based on information from market contacts about their expectations for the RPI-CPI inflation wedge in the long run. See the box on pages 34–35 of the February 2014 *Inflation Report* for more information; www.bankofengland.co.uk/publications/Documents/inflationreport/2014/ir14feb.pdf. No attempt has been made to adjust for the risk premium implicit in financial market prices. Professional forecasters are asked about their expectations for CPI inflation.
- (2) See Nelson and Siegel (1987).

Annex 3 Calculating standard errors for the Bank of England/GfK NOP inflation attitudes survey

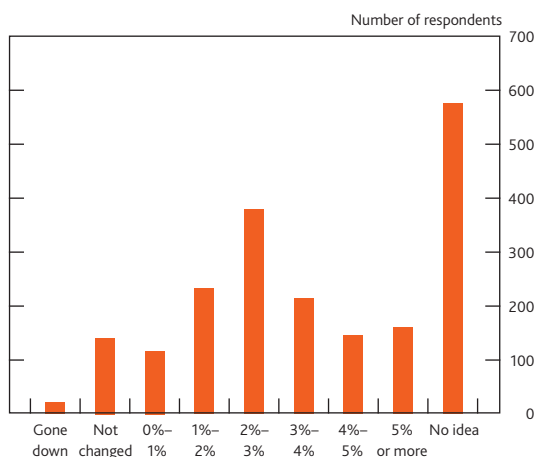
Standard errors measure the standard deviation of sample statistics. They are useful because they provide an indication of the degree of uncertainty around the sample statistics. This annex explains the process for calculating the standard errors of the statistics reported in the Bank of England/GfK NOP inflation attitudes survey, one of the indicators the MPC draws on when assessing developments in inflation expectations (see **Tables A and B**).

The Bank of England/GfK NOP inflation attitudes survey
Typically when responding to UK surveys about inflation expectations, individuals are asked to select a range in which their expectations lie. In the Bank of England/GfK NOP inflation attitudes survey, individuals are asked to choose from the following options:

- 1 Gone down.
- 2 Not changed.
- 3 Gone up by 1% or less.
- 4 Gone up by 1% but less than 2%.
- 5 Gone up by 2% but less than 3%.
- 6 Gone up by 3% but less than 4%.
- 7 Gone up by 4% but less than 5%.
- 8 Gone up by 5% or more.
- 9 No idea.

Chart A2 shows the number of respondents in each bucket for the question about two year ahead inflation expectations in the 2014 Q2 survey.

Chart A2 Two year ahead inflation expectations responses in the 2014 Q2 Bank/GfK NOP survey



Sources: Bank of England and GfK NOP.

The tables of results published on the Bank of England’s website show the proportion of respondents in each of the buckets listed above, as well as an estimate of the median

expectation. The median is the ‘middle’ expectation, when the responses are ordered from highest to lowest. For this survey, it is calculated by first converting the categorical data into a continuous data set. To do this, it is assumed that within buckets responses are uniformly distributed.⁽¹⁾ Once the continuous data set has been created, the data are ordered by size and the median is calculated in the conventional way.⁽²⁾

To provide an indication of the uncertainty around this estimate, it is possible to calculate the standard error of the sample median. Since the precise nature of how inflation expectations in the population are distributed is unknown, a bootstrapping technique is used to calculate the standard error of the sample median.⁽³⁾

First, as described above, the *n* observations in the original sample are converted into specific values by assuming that responses within buckets are uniformly distributed. Second, using this sample, a number of other samples of size *n* are then created by sampling with replacement. For each generated sample, the median is computed. As a result, we generate a series of estimates for the median, and the standard error of the sample median can then be computed by calculating the standard deviation of those.

Table A3 reports estimates of median expectations in the 2014 Q2 survey, with standard errors for the estimates reported in parentheses. Typically there were around 2,000 responses to each of the inflation expectations questions. This sample size is judged to be appropriate to produce reliable results, given the trade-off between sample size and the cost of the survey.

Table A3 Median inflation expectations in the 2014 Q2 Bank/GfK NOP survey

| Horizon | Median expectations and standard errors |
|------------------|---|
| One year ahead | 2.56 (0.05) |
| Two years ahead | 2.51 (0.05) |
| Five years ahead | 2.92 (0.07) |

Sources: Bank of England, GfK NOP and Bank calculations.

It is also possible to estimate the standard errors around the proportions of responses that lie within each bucket. To calculate the standard errors of the sample proportions, it is

(1) So, for example, if there were three individuals in the bucket ‘Up by 4% but less than 5%’, those individuals are assumed to be located at 4.25%, 4.5% and 4.75%.
 (2) Those responding ‘No idea’ are excluded from the median calculation. Respondents answering ‘Gone down’ or ‘5% or more’ are asked to provide more detail on how much they think prices have fallen or risen respectively. The lowest possible response is ‘Down by 5% or more’ and the highest possible response is ‘Up by 10% or more’. For those answering ‘Down by 5% or more’, a lower bound of -10% is assumed. For those answering ‘Up by 10% or more’, an upper bound of 15% is assumed. Given the nature of how the sample median is calculated, the standard error of the sample median is not very sensitive to these two assumptions.
 (3) For a discussion of bootstrapping techniques, see Greene (2012).

assumed that the number of observations within a given bucket follows a multinomial distribution. The true proportion of the population in bucket j is given by π_j . The estimated probability of being in bucket j is given by the observed proportion of individuals from the sample in that bucket, $\hat{\pi}_j$.

Under a multinomial distribution, the sample proportion has a standard error given by:

$$\text{standard error}_j = \sqrt{\frac{\pi_j(1-\pi_j)}{n}} \quad (1)$$

where n is the number of observations in the sample.

Because the true population proportion is unknown, the sample proportion is used in the place of the population proportion in equation (1) to estimate the standard error.

For example, in the 2014 Q2 survey, 12% of the 1,986 respondents reported that their expectations for prices at the two-year horizon were for them to go up by 1% but less than 2%. The estimated standard error of this sample proportion is given by:

$$\begin{aligned} \text{standard error}_{1\%-2\%} &\approx \sqrt{\frac{0.12(1-0.12)}{1,986}} \\ &= 0.007 = 0.7\% \end{aligned}$$

References

- Carroll, C (2003), 'Macroeconomic expectations of households and professional forecasters', *The Quarterly Journal of Economics*, Vol. 118, No. 1, pages 269–98.
- Coibion, O and Gorodnichenko, Y (2013), 'Is the Phillips Curve alive and well after all? Inflation expectations and the missing disinflation', *NBER Working Paper No. 19598*.
- Greene, W (2012), *Econometric analysis*, 7th edition, Prentice Hall.
- Gürkaynak, R, Levin, A and Swanson, E (2006), 'Does inflation targeting anchor long-run inflation expectations? Evidence from long-term bond yields in the US, UK and Sweden', *Federal Reserve Bank of San Francisco Working Paper No. 2006-09*.
- Haddow, A, Hare, C, Hooley, J and Shakir, T (2013), 'Macroeconomic uncertainty: what is it, how can we measure it and why does it matter?', *Bank of England Quarterly Bulletin*, Vol. 53, No. 2, pages 100–09, available at www.bankofengland.co.uk/publications/Documents/quarterlybulletin/2013/qb130201.pdf.
- Harimohan, R (2012), 'How has the risk to inflation from inflation expectations evolved?', *Bank of England Quarterly Bulletin*, Vol. 52, No. 2, pages 114–23, available at www.bankofengland.co.uk/publications/Documents/quarterlybulletin/qb120201.pdf.
- Mankiw, N and Reis, R (2002), 'Sticky information versus sticky prices: a proposal to replace the New Keynesian Phillips curve', *The Quarterly Journal of Economics*, Vol. 117, No. 4, pages 1,295–328.
- Maule, B and Pugh, A (2013), 'Do inflation expectations currently pose a risk to the economy?', *Bank of England Quarterly Bulletin*, Vol. 53, No. 2, pages 110–21, available at www.bankofengland.co.uk/publications/Documents/quarterlybulletin/2013/qb130202.pdf.
- Mehra, Y and Herrington, C (2008), 'On the sources of movements in inflation expectations: a few insights from a VAR model', *Federal Reserve Bank of Richmond Economic Quarterly*, Vol. 94, No. 2, pages 121–46.
- Nelson, C and Siegel, A (1987), 'Parsimonious modeling of yield curves', *The Journal of Business*, Vol. 60, No. 4, pages 473–89.
- Smith, T (2012), 'Option-implied probability distributions for future inflation', *Bank of England Quarterly Bulletin*, Vol. 52, No. 3, pages 224–33, available at www.bankofengland.co.uk/publications/Documents/quarterlybulletin/qb120303.pdf.