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Inflation modelling

2008 was an extraordinary year in financial markets. As the year progressed it became increasingly clear that many financial institutions were in serious trouble. The key question was no longer about how the macro economy can be insulated from events in financial markets, but was how to minimise the inescapable impact of such events upon the macro economy. This led to a significant slowing of global output and subsequently lower pressure on inflation. The downward pressure on consumer and retail prices was exacerbated by the collapse in commodity prices in the final quarter of 2008 and deflation has now become a real possibility. We can never guard ourselves completely against such unexpected events and need to allow for uncertainty in our projected inflation distributions even if central banks credibly steer policy rates to keep inflation on target.

After the events over the past year, we might be looking for answers to the following questions:

1. Can we trust market prices and the information they contain about future inflation? Can we trust the economists?
2. What probability should we have attached to the inflation events in 2008?
3. Can we be confident in our projected inflation distributions?
4. What probability should we attach to deflation in our short and long term inflation projections going forward?

This insight note summarises key inflation developments in 2008 and attempts to answer the questions outlined above based on the projections from our ESG models at end December 2007 and end March 2009.

Key inflation developments over 2008

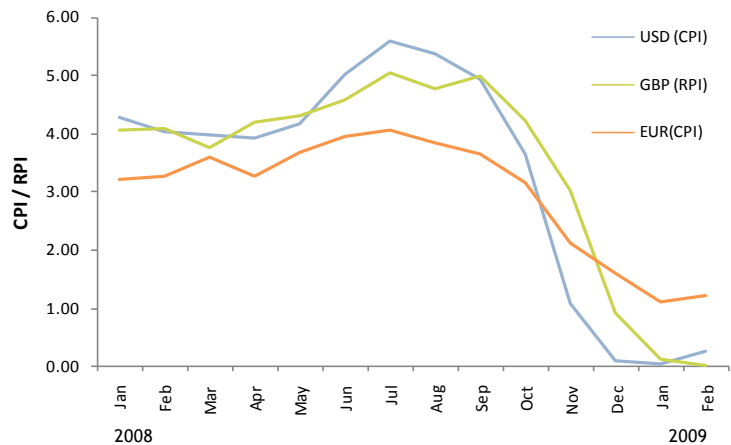
Over the past 15-20 years a liquid exchange-traded option market has emerged from which we can back out an estimate of market expectations of equity return volatility. Exhibit 1 compares one month return volatility from at the money option markets against realised return volatility over the following month for Euro Stoxx 50. The difference between the two is one measure of unexpected volatility.

Inflation fell strongly in the second half of 2008 (exhibit 1). While inflation in major developed economies peaked around the middle of the year, there was a very significant fall in inflation in the last quarter of 2008. Disinflation was one result of the collapse of commodity prices and the significant slowing of the international macro economy.

2008 saw a strong fall in global inflation

Exhibit 1

Annual consumer and retail (CPI and RPI) inflation developments since early 2008



Data source: IMF.

It is important, however, to be very clear about which inflation measure we are modelling. In the UK, for example, RPI fell strongly while CPI has remained at a rather elevated level compared to the inflation target by the Bank of England.

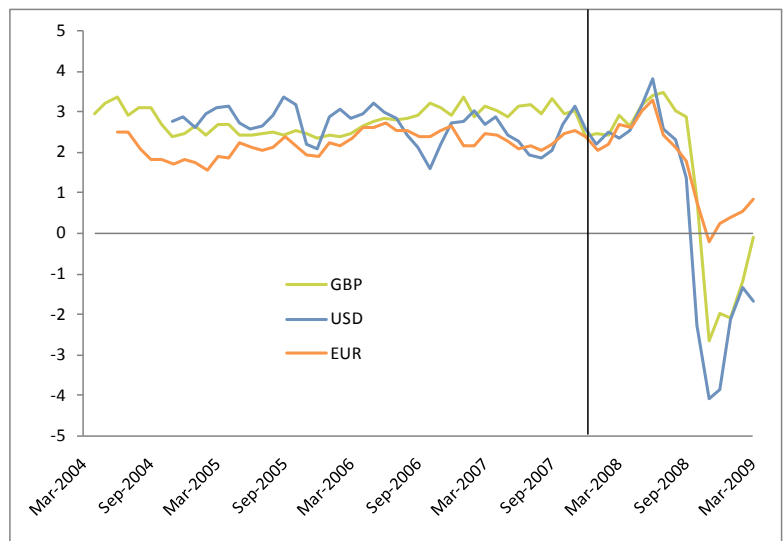
Nevertheless, by the end of 2008 we were not so worried about inflation overshooting targets set by central banks but rather by deflation. What probability should we attach to deflation in our inflation projections?

Can we rely on market prices or economists?

Had we expected, or attached a significant probability to, the inflation outcomes in 2008 at the end of December 2007? There are a number of ways we can derive inflation expectations by investors at the end of December 2007 from financial market instruments. The inflation swap market has become one of the most liquid instruments trading on inflation outcomes in the short as well as long term. For the UK, US and euro area there has been a liquid inflation swap market going back to 2004¹. An inflation swap rate should provide a measure of average anticipated inflation over the life of the swap.

Exhibit 2

Inflation expectations over the next year derived from inflation swaps



Data source: Bloomberg derived.

...market based measures of inflation did not suggest that inflation would slow in 2008 but expectations were strongly revised downwards in the last months of the year

¹ For a discussion on the UK inflation swap market, see Bank of England Quarterly Bulletin article: 'Recent developments in sterling inflation-linked markets' by McGrath and Windle, December 2006.

At the end of December 2007, inflation expectations for 2008 derived from inflation swaps were 2.4%, 2.4% and 2.6% for the UK, euro area and US respectively. The actual inflation outcomes in 2008 were 0.90%, 1.60% and 0.10%. To the extent that inflation derived from inflation swaps provides a pure measure of market expectations of inflation, the outcomes in 2008 were surprisingly low. The inflation swap market, however, contains information about the central projection of inflation only and says nothing about the uncertainty around the central projection.

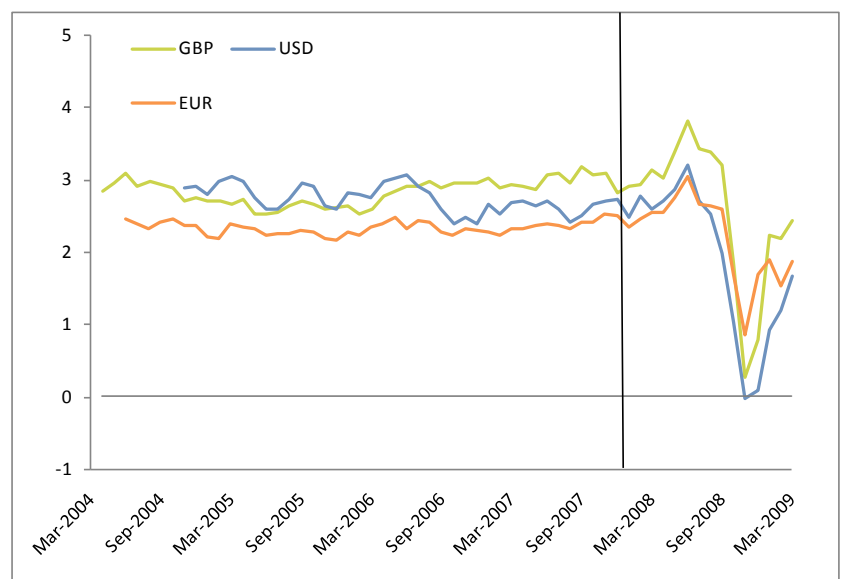
Over the year, as inflation and real economic shocks were realised, market expectations fell strongly to unprecedented low levels from September onwards. Given the pronounced negative inflation shocks in the last quarter of the year, this is perhaps not that surprising. It is harder to explain the equally strong fall in five year inflation derived from inflation swaps – a measure of average expected inflation over the next five years (exhibit 3).

As central banks in the euro area and the UK have a strict mandate to keep CPI inflation at or close to 2% (which roughly corresponds to a target for long-term RPI of 2.6%-2.7% in the UK), it is surprising that the negative inflation shocks would have such major impact on average inflation expectations over the next 5 years². If the inflation target is credible, we would not expect major changes in longer term inflation expectations based on current surprise inflation. Obviously we cannot rule out that the ability of central banks to meet the inflation target is being questioned by market participants in the current environment. But there could be other factors at play.

We have to be careful when interpreting inflation expectations derived from inflation swaps and other financial market instruments. An inflation linked instrument is an agreement today to swap inflation at a specified future date. Although we may have a strong view about the mean path of inflation over the next five years we know, as was the case in the last quarter of 2008, that a number of shocks can alter the actual inflation profile over the life of the swap. For this reason swap prices may include a premium to compensate for the event of unexpected inflation. Such a premium may be positive or negative and is likely to be higher in absolute magnitude in periods of high inflation uncertainty.

Exhibit 3

Five year inflation derived from inflation swaps



Data source: Bloomberg derived.

...there was a pronounced fall in longer term inflation expectations. Such significant changes at the long end are hard to rationalise if the inflation targeting regime of a central bank is credible

² Notice that the inflation swap will be a measure of average inflation expected over the period inflation is swapped.

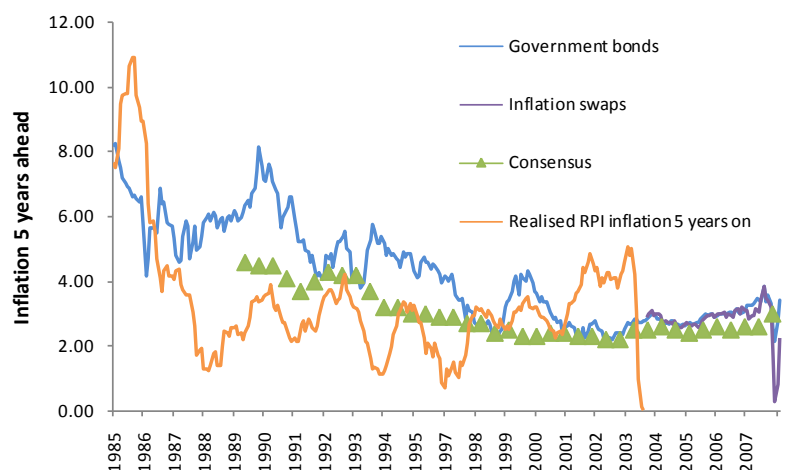
Inflation risk premia are not observable. This may cause some disagreement on the extent to which such premia distort the function of market prices as a pure measure of inflation expectations. Such premia, everything else equal, are likely to be larger (in magnitude) at higher maturities. Do we have any evidence on the presence of inflation risk premia? Given the short period of time we can derive inflation from inflation swaps - a period of low and stable inflation - it is difficult to reach firm conclusions.

In the UK there has been an actively traded indexed linked government bond market since 1985. From the early 1990s, RPI inflation indexed linked bonds have been liquid enough to allow us to interpret the difference between nominal and real zero coupon bonds of the same maturity as a measure of expected inflation and inflation risk premia. We can compare the information from government bonds on future inflation with measures of inflation expectations that do not contain inflation risk premia. Inflation forecast from Consensus Economics would be one source; we have 5 year forward inflation based on UK forward curves derived from government bonds available since the early 1990s.

We can compare the 5 year forward Consensus Economics inflation forecast with the 5 year forward government bond break-even inflation rate which is the difference between an instantaneous nominal and real forward rate of a 5 year maturity. While the forward break even rate from government bonds is a measure of expectations 5 years ahead, the inflation swap rate is a measure of average inflation over the next 5 years. The comparison shows that the forward inflation break-even rate has been consistently above the forecast by Consensus Economics over the entire period we have had consensus forecasts available (exhibit 4). This suggests that government bonds and inflation swaps in the UK might contain an inflation risk premium³. Moreover, on average, the Consensus Economics expectations have been more aligned with actual inflation outcomes.

Exhibit 4

5 year inflation expectations derived from inflation swaps, government bond forward curve and Consensus Economics compared with inflation realised 5 years later



Data source: Bloomberg derived, Bank of England and Consensus Economics.

...market based measures of future inflation have consistently been above Consensus Economics forecasts. This could indicate the presence of a significant positive inflation risk premium in the UK

³ For similar conclusions on the presence of inflation risk premia, see 1) Joyce et al (2009), 'Extracting inflation expectations and inflation risk premia from the term-structure: a joint model of the UK nominal and real yield curve', Bank of England working paper 360 or Hordahl et al (2007), 'The term-structure of inflation risk premia and macroeconomic dynamics', ECB working paper 734.

2008 and projections from our ESG models

Projecting inflation forward we should attempt to utilise forward looking information on inflation from financial market instruments and Consensus Economics forecast. But we need to be careful about how we use this information in our calibrations. Forecasts from Consensus Economics are usually available in the first couple of weeks each month and may therefore not be appropriate as a measure of inflation expectations at the end of the month where we usually perform our calibrations. As we have seen in the past year, although usually not the case, an awful lot of surprises can happen over a month. Market based measures of inflation expectations are more timely available but may embed an inflation risk premium and could be distorted if markets are not sufficiently liquid. Projecting real-world inflation is not a trivial task!

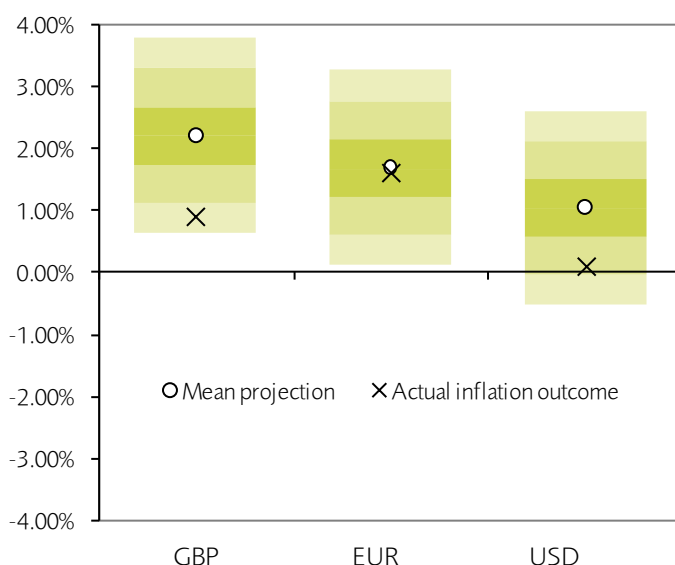
Central banks, and economists, tend to build large complex models of the macro economy to forecast inflation⁴. The main advantage of such models is the ability to detect and explain key factors that impact the future path of inflation and distribution of unexpected inflation. There is, however, little evidence to suggest that such complex models lead to a better inflation forecast relative to less theoretical approaches.

In our ESG models we use a relatively simple approach to project inflation. In economies with traded nominal and real government bonds, inflation is modelled as the difference between the path of nominal and real interest of the same maturity. We do believe that nominal and real bond yields might contain term premia and technical convexity adjustments. For this reason, we need to decompose the forward curve into an expected short rate, a risk premium and a technical convexity effect. The path, and distribution, of future inflation is therefore obtained as the difference between the term premia and convexity adjusted nominal and real forward curves. At present we determine the term premium based on a very long term view of nominal forward interest rates. Our view on the inflation risk premium is thus determined by our long-term view of nominal and real term premia and interest rate expectations.

Exhibit 5

Our one year inflation projections at end December 2007 against actual inflation outcome, 99% confidence interval

The inflation projections from our ESG models had attached a reasonably high probability to the 2008 inflation outcomes



One disadvantage of modelling inflation based on government bonds is the absence of indexed linked bonds at very short maturities. This leaves us with little market information about the short-term inflation profile. To get some information at the short end of the inflation curve, we create a pseudo one year real bond yield obtained as the difference between the one year nominal

⁴ See for instance the Bank of England Quarterly model, <http://www.bankofengland.co.uk/publications/other/beqm/beqmfll.pdf>.

rate and one year inflation expectations by Consensus Economics. If the inclusion of this pseudo yield affects the fit to market implied real bond yields, however, we attach less weight to the pseudo yield and aim to fit the observed market prices as well as we can due to the Consensus Economics 'lagged' effect we discussed above. The final ingredient in our real-world inflation projection is an assumption about inflation uncertainty. We make these assumptions based on the volatility of historical data of nominal and real interest rates.

Whilst our calibrations are constructed to be suitable for a longer term projection, it is always useful to validate the performance of the models over a shorter projection horizon. In the context of the discussion above, we can ask whether our real-world inflation projections would have attached a significant probability to the 2008 inflation outcome. At the end of December 2007, our mean projection for inflation was 2.2% in the UK, 1.7% in the euro area and 1.1% in the US (exhibit 5). In the euro area, our central projection was close to the actual outcome whereas in the UK and US inflation turned out to be considerably lower relative to our mean projection, surprisingly by -1.3 percentage points in the UK and -0.95 percentage points in the US. In both cases we had attached a probability higher than 5% to the actual inflation outcomes. The fact that we are so far out in the tails of the distribution is not to worry about – 2008 was simply an extraordinary year.

The real economy is continuously hit by a number of shocks, some of which can be material. While it is very difficult to get the central projections right, even in an environment where central banks have a clear target for inflation, it is prudent to allow for sufficient uncertainty in our inflation projections. Central bank independence and credibility in keeping average inflation at a lower level should anchor medium to long-term inflation expectations but cannot prevent nominal and real macroeconomic shocks. For this reason it is necessary to make appropriate assumptions about the volatility in the inflation distributions to reflect the inflation uncertainty we are facing.

Inflation over the coming years

What is the inflation outlook for the coming years? As inflation has been very low in the first three months of the year we would expect some probability of deflation. Based on our end March 2009 calibration, the probability of deflation over the next year appears particularly large in the US and UK (exhibit 6). In the euro area, our central projection for CPI is around 80 bps but we attach a probability of around 10% for inflation to be close to the euro area inflation target. Our central projection suggests that deflation in the UK (RPI) and US (CPI) is a real possibility.

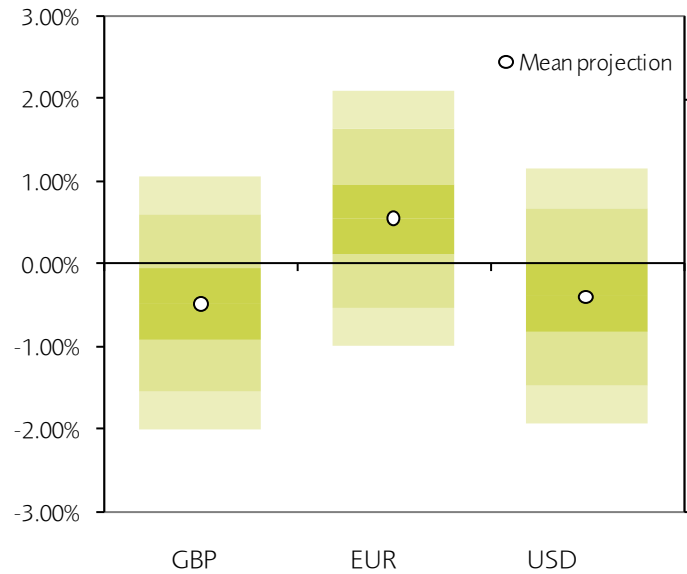
How does our inflation projection look over a longer horizon? We would expect central banks to be credible in their efforts to combat inflation/deflation and bring it back to a target around 2% (2.6-2.7% in the UK as we model RPI and not CPI which the Bank of England targets). While inflation may differ from the targets over the next year or two, we would expect inflation to return to its target level over the medium to long term. But the uncertainty surrounding the central projection is material. Our projection of inflation in 10 years time (exhibit 7) at the end of March 2009, suggest that inflation will revert to an average level around 2-2.5% but the range of inflation outcomes, with a 99% probability, can be anything between -3.5% to 12%.

It is not a trivial task to model inflation. Even if we think that inflation is going to be close to 2%-2.5% there are a number of shocks that can hit the economy and bring inflation out of line with central bank target level. While we may be confident that inflation will be at a relatively low level over a 5-10 year projection horizon we would attach some probability that inflation can become as high as 10%. This can have a material impact on expenses related to these measures of inflation which could be 8-10% higher than relative to our expectations.

There is a significant probability of deflation in the UK and US over the next year

Exhibit 6

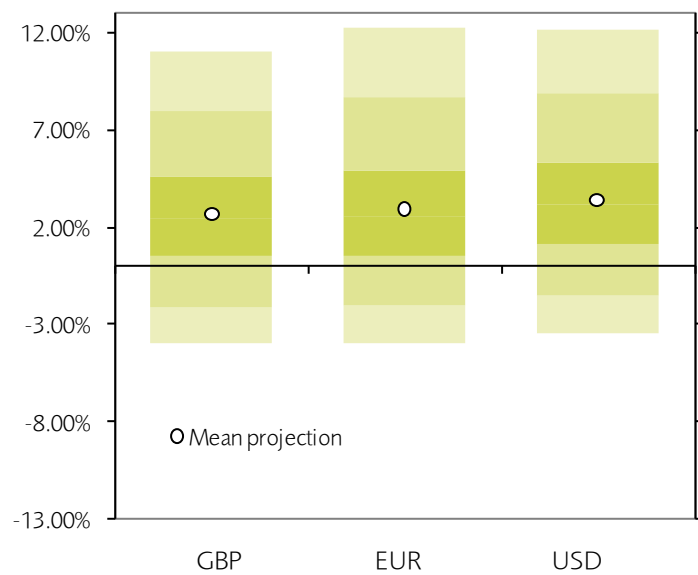
Our one year inflation projections at end March 2009, 99% confidence interval



...but in the longer term, say 10 years, we would expect inflation to revert to its long-term level and the range of possible outcomes becomes wider

Exhibit 7

Our ten year inflation projections at end March 2009, 99% confidence interval



Concluding remarks

The independence of central banks and an explicit target for inflation may have helped anchor our inflation expectations in the medium to long term. But a credible inflation target cannot prevent inflation shocks. 2008 made it very clear. Forecasting inflation is not a trivial task and expectations derived from market prices may be distorted by inflation risk premia. Even the economists can get it terribly wrong.

If unexpected inflation is undesirable, we can hedge ourselves against RPI inflation in the UK and CPI inflation in the US and euro area by making an inflation swap or buying an indexed linked government bond. Such hedges are, however, only possible for these key inflation measures. There is no real government bond linked to CPI inflation in the UK, RPI inflation in the euro area or any one sub components of the key inflation indices. We cannot hedge fully against shocks to these inflation measures. When there is no obvious hedge to the inflation measure of relevance, you may want to think about how the particular inflation measures correlate to the inflation measures that we can hedge ourselves against.

For all these reasons, it is necessary to think carefully about the volatility and correlation parameters to be included in models for projecting inflation to get an idea about the worst case scenario for a particular inflation measure.

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