# Quarterly Bulletin

2012 Q3 | Volume 52 No. 3

BANK OF ENGLAND

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## Executive summary

**Recent economic and financial developments** (pages 185–201)

**Markets and operations.** The Markets and operations article reviews developments in financial markets covering the period between the previous *Bulletin* and 24 August 2012. Financial market sentiment continued to be dominated by concerns about the challenges facing the euro area. Against this backdrop, and in response to weaker prospects for global growth in the first part of the review period, policymakers around the world announced a number of measures aimed at providing additional support to the financial system and stimulus to their respective economies. Following these announcements, market sentiment improved in the second half of the review period. Some contacts, however, cautioned against placing much weight on this, given the seasonal lull in some financial markets during July and August, and the fact that many of the fundamental challenges facing the euro area remained. The article also describes the results of the May 2012 Money Market Liaison Group Sterling Money Market Survey and market intelligence on contacts' responses to an increased need for collateral.

**Research and analysis** (pages 203–52)

**RAMSI: a top-down stress-testing model developed at the Bank of England** (by Oliver Burrows, David Learmonth, Jack McKeown and Richard Williams). Safeguarding financial stability is one of the Bank of England's two core purposes. The Risk Assessment Model for Systemic Institutions (RAMSI) is a large-scale model of the UK banking sector that was developed at the Bank. It is designed to assess the solvency and liquidity risks faced by banks, and provides one way of evaluating the risks and vulnerabilities facing the financial system. This article offers an overview of RAMSI and describes how the results are generated and how the feedbacks within and between banks are modelled. It also illustrates its use, drawing on the example of the stress tests carried out and published as part of the IMF's 2011 UK Financial Stability Assessment Program (FSAP). The results from RAMSI suggested that a severe global downturn would have had material impacts on UK banks' profits and capital ratios, but that the UK banking system would have been resilient enough to withstand the scenario. The results are highly uncertain, however, and do not take into account changes in balance sheets, macroeconomic conditions or policy measures that have occurred since the FSAP was constructed in early 2011. They are therefore not an assessment of the current state of the UK banking system but are an illustration of the types of outputs that RAMSI can produce.

**What accounts for the fall in UK ten-year government bond yields?** (by Rodrigo Guimarães). Policymakers care about financial market measures of interest rates because they matter for the transmission of monetary policy and because they can provide useful and timely information about the state of the economy. UK ten-year government bond yields have recently fallen to historically low levels — as have yields in some other major economies — and there has been substantial debate about what is driving these movements. This article uses work undertaken in the Bank to explain the developments in UK yield curves, with an emphasis on movements since the onset of the financial crisis. Real and nominal UK interest rates have fallen substantially from the start of the crisis, with implied inflation rates relatively unchanged. A model decomposition shows that risk premia account for less than a quarter of the fall in nominal yields relative to pre-crisis averages. Together with the fact that falls have been concentrated in short-maturity forwards, the most likely explanation is that ten-year spot yields are low because monetary policy is expected to remain loose for longer than in

previous easing cycles. Despite the low level of real yields, the model estimates suggest that inflation expectations have not become less well anchored, with inflation risk premia, if anything, lower than prior to the crisis.

**Option-implied probability distributions for future inflation** (by Tom Smith). People's beliefs about future inflation affect price-setting and wage-setting, and so play a major role in determining the rate of inflation. It is important, therefore, for policymakers to take them into account when setting monetary policy. Several measures of central expectations for UK inflation are available, for instance from surveys of inflation expectations or from financial markets, and these are regularly monitored by the Monetary Policy Committee (MPC). But data on beliefs about the full distribution of possible inflation outturns is relatively scarce. One source of such data comes from a market which has recently developed in inflation options — financial instruments that allow investors to speculate on, or insure against, future inflation outturns. The prices of these options can be used to calculate implied probability density functions (pdfs), which summarise investors' beliefs about the distribution of future rates of inflation. This article describes the inflation option market and outlines the technique developed at the Bank to produce the pdfs. The results suggest that investors' uncertainty about UK inflation rose substantially during the financial crisis, particularly between three and seven years ahead, and has remained high ever since. It is likely that this higher uncertainty reflects investors' beliefs that the volatility in inflation over the past five years will persist for at least the next few years.

**The Bank of England's Real-Time Gross Settlement infrastructure** (by Andrew Dent and Will Dison). Electronic payments and securities transactions are essential to the functioning of modern economies. To reduce risk in the financial system, many of the sterling interbank obligations arising from these transactions are settled in central bank money, the most risk-free asset in the economy, across accounts at the Bank. To further reduce risk in this settlement process, many high-value payments are settled in real time. For these purposes, the Bank operates the United Kingdom's Real-Time Gross Settlement (RTGS) infrastructure. On an average day the infrastructure settles some £575 billion, equivalent to UK annual GDP every three days. This article explains the role of the RTGS infrastructure, how it operates, and why it is so important to reducing risk in the UK financial system and to fulfilling both of the Bank's core purposes — maintaining monetary and financial stability. It also highlights forthcoming developments that will further improve the infrastructure's efficiency and resilience.

Reports (pages 253–69)

**The distributional effects of asset purchases**

In its report on the 2012 *Budget*, the Treasury Committee asked the Bank to explain the distributional consequences of the MPC's asset purchase programme (often referred to as quantitative easing (QE)). Without the reduction in Bank Rate and the MPC's asset purchases in response to the sharp downturn after the collapse of Lehman Brothers, economic growth would have been lower and unemployment higher. The benefits of this highly accommodative monetary policy have not been shared evenly across households, however. Largely reflecting the low level of Bank Rate, rather than QE, some households have received lower income on their deposits, while some have paid lower interest on their debt. QE pushed up asset prices, in part reversing the large declines in equity prices seen earlier in the financial crisis. For a fully-funded defined benefit pension scheme, asset purchases are likely to have had a broadly neutral impact. Similarly, QE is likely to have had a broadly neutral impact on the value of the annuity income that could be purchased with a personal pension pot. But some pension schemes have been adversely affected by the direct effects of QE, with defined benefit schemes that were already in substantial deficit before QE began being particularly affected. Those costs are more likely to be borne by shareholders and those in work, rather than by existing pensioners.

**Monetary Policy Roundtable**

This edition also contains a summary of the main points made by participants at the most recent Monetary Policy Roundtable hosted by the Bank of England and the Centre for Economic Policy Research, on 14 June 2012.

**Research work published by the Bank is intended to contribute to debate, and does not necessarily reflect the views of the Bank or of MPC members.**

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The contents page, with links to the articles in PDF, is available at
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The speeches contained in the *Bulletin* can be found at
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Except where otherwise stated, the source of the data used in charts and tables is the Bank of England or the Office for National Statistics (ONS). All data, apart from financial markets data, are seasonally adjusted.

# Recent economic and financial developments

# Markets and operations

This article reviews developments in sterling financial markets, including the Bank's official operations, between the 2012 Q2 *Quarterly Bulletin* and 24 August 2012.[1] The article also summarises market intelligence on selected topical issues relating to market functioning.

## Sterling financial markets

### Overview

Financial market sentiment continued to be dominated by concerns about vulnerabilities associated with the indebtedness and competitiveness of several euro-area economies. Against this backdrop, and in response to weaker prospects for global growth in the first part of the review period, policymakers around the world announced a number of measures aimed at providing additional support to the financial system and stimulus to their respective economies. Following these announcements, market sentiment appeared to improve in the second half of the review period. Some contacts cautioned against placing much weight on this, however, given the seasonal lull in some financial markets during July and August, and the fact that many of the fundamental challenges facing the euro area remained.

In the United Kingdom, the Bank of England's Monetary Policy Committee (MPC) announced a further extension of its asset purchase programme. In addition, the Bank deployed its Extended Collateral Term Repo (ECTR) Facility and launched the Funding for Lending Scheme (FLS). The operation of the FLS, which is designed to boost lending to the real economy, is described in the box on page 195. Elsewhere, the European Central Bank (ECB) cut its key policy interest rates, and signalled further non-standard monetary policy measures. In the United States, the Federal Open Market Committee (FOMC) decided to continue its programme of extending the average maturity of its holdings of securities. And expectations of further monetary stimulus increased following the August FOMC minutes.

Movements in financial asset prices over the period were mixed. Equity and corporate bond prices rose, boosted by the actions policymakers had taken, and by expectations of further support measures. Yields on government bonds ended the period little changed. In the euro area, the yields on government bonds issued by some of the more vulnerable member countries were volatile and remained elevated. Bank debt issuance remained muted for most of the review period but conditions in bank funding markets improved in August.

### Monetary policy and short-term interest rates

In the United Kingdom, the MPC maintained Bank Rate at 0.5% throughout the review period. The MPC voted on 5 July to increase the size of its asset purchase programme, financed by the issuance of central bank reserves, by £50 billion to a total of £375 billion. The Committee judged that without this additional monetary stimulus it would have been more likely than not that inflation would undershoot the target in the medium term. The asset purchase programme is described in the box on pages 188–89.

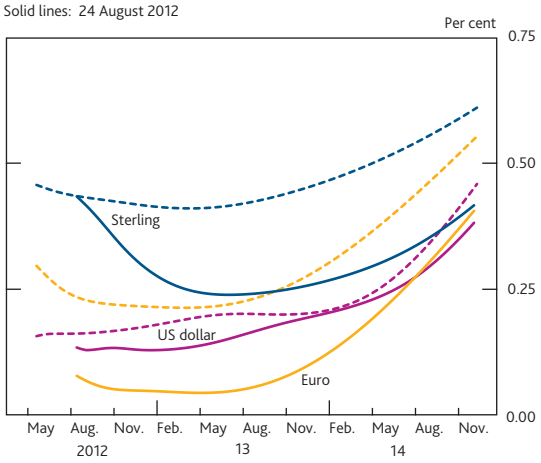
A Reuters poll conducted shortly after the end of the review period indicated that expectations of further monetary easing had increased. A majority of the economists polled expected the MPC to increase asset purchases by a further £50 billion to a total of £425 billion; at the end of the previous review period, a majority of the economists surveyed had not anticipated purchases to be extended beyond £325 billion.

According to contacts, during the review period market participants also placed a greater weight on the possibility that Bank Rate would be cut to below 0.5%. This was attributed primarily to the discussion of the merits of a cut in Bank Rate in the June and July MPC minutes. Expectations of a cut in Bank Rate receded a little following the August *Inflation Report*. Sterling overnight index swap (OIS) rates fell at all maturities over the review period (**Chart 1**).

Overnight sterling money market interest rates remained a little below Bank Rate throughout most of the review period (**Chart 2**). Contacts attributed this to a number of factors. These included a reduction in the net supply of high-quality collateral over the period, as the pace of the Bank's asset purchases outstripped that of gilt issuance by the UK Debt Management Office (DMO), pushing down on secured interest rates. Market intelligence on developments in the sterling money market, as well as market participants' responses to a greater need for collateral is described in more detail on pages 196–201.

(1) The data cut-off for the previous *Bulletin* was 31 May 2012.

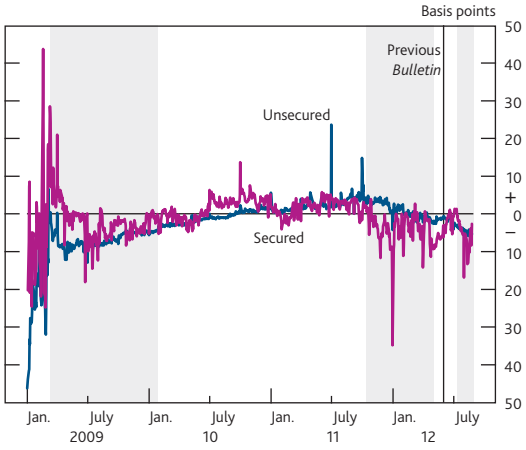
**Chart 1** Instantaneous forward interest rates derived from OIS contracts[a]




Sources: Bloomberg and Bank calculations.

(a) Instantaneous forward rates derived from the Bank's OIS curves.

**Chart 2** Spread of Bank Rate to weighted average sterling overnight interest rates[a]




Sources: Bloomberg and Bank calculations.

(a) Shaded areas indicate periods over which the Bank conducted gilt purchases under the Asset Purchase Facility.

Elsewhere, the Governing Council of the ECB decided on 5 July to cut its key policy rates by 25 basis points. This included reducing the interest rate on its deposit facility to 0%. Following this reduction in policy rates, unsecured overnight interest rates fell towards the deposit facility rate. Contacts reported that some top-tier banks had offered negative interest rates on short-term money market deposits and on repo trades secured by the highest-quality collateral. Early signs were that most contacts had not encountered material operational difficulties associated with transacting at near-zero or negative interest rates.

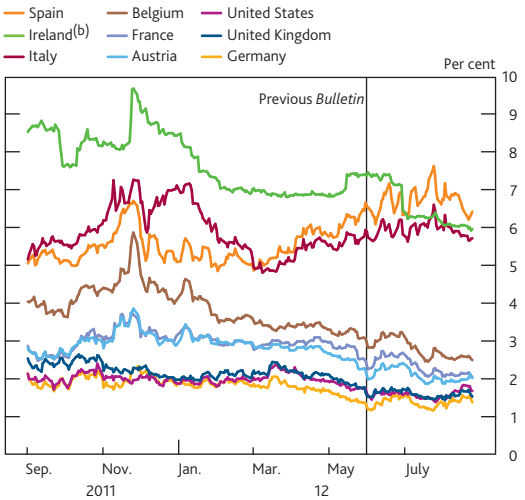
In the United States, the FOMC decided at its June meeting to continue its programme of extending the average maturity of its holdings of securities. The FOMC continued to indicate that economic conditions were likely to warrant exceptionally low levels for the federal funds rate until late 2014. US dollar OIS rates ended the period a little lower; contacts attributed this to speculation that the FOMC may cut the interest rate paid on reserves below 0.25%. Contacts' expectations of additional stimulus also rose following discussion of further asset purchases in the August FOMC minutes.

## Long-term interest rates

Investor perceptions of the risks associated with the challenges facing the euro area continued to be a key influence in government bond markets over the review period.

In the euro area, government bond yields generally ended the review period little changed. But during the course of the review period the yields of government bonds issued by some countries exhibited considerable volatility (**Chart 3**). For example, yields on Spanish and Italian government bonds rose in the first half of the review period amid increasing investor concerns about the sustainability of the fiscal outlook in these countries. Following the euro-area summit held on 28–29 June, details were outlined of a loan of up to €100 billion from the European Financial Stability Facility (EFSF)/European Stability Mechanism (ESM) for the recapitalisation of Spanish financial institutions.(1) Contacts reported that market participants interpreted the announcement as reducing the connection between Spanish fiscal concerns and the vulnerabilities in the Spanish banking sector. But the announcement had only a short-lived impact on Spanish government bond yields.

**Chart 3** Selected ten-year government bond yields[a]




Source: Bloomberg.

(a) Yields to maturity on ten-year benchmark government bonds.
(b) Yield to maturity on eight-year government bond.

(1) For details of the euro-area summit statement see www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/131359.pdf.

## Asset purchases(1)(2)

On 5 July, the Monetary Policy Committee (MPC) voted to increase the size of its asset purchase programme, financed by the issuance of central bank reserves, by £50 billion to £375 billion, with asset purchases to be conducted over a four-month period.(3) As of 23 August, outstanding asset purchases financed by the issuance of central bank reserves — in terms of the amount paid to sellers — were £346 billion.

Any purchases of high-quality private sector assets continued to be financed by the issuance of Treasury bills and the Debt Management Office's (DMO's) cash management operations, in line with the arrangements announced on 29 January 2009.(4)

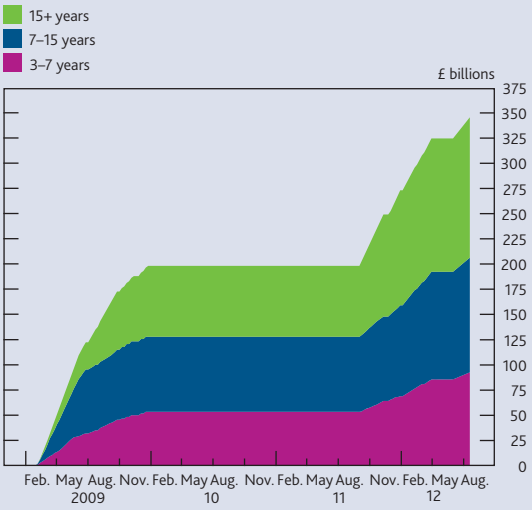
**Table 1** summarises asset purchases by type of asset.

### Gilts

Following the MPC's decision on 5 July to purchase an additional £50 billion of gilts, the Bank announced that gilt purchases would resume on 9 July, and that the Bank would normally offer to purchase conventional gilts with a residual maturity of 3–7 years on Mondays, of greater than 15 years on Tuesdays and of 7–15 years on Wednesdays. The Bank further announced that the size of the auctions would initially be £1 billion for each maturity sector, although the scale of the programme would be kept under review by the MPC.

As of 23 August 2012, the Bank had purchased £21 billion of the further £50 billion mandated by the MPC. This was split equally across the three maturity sectors via 21 gilt purchase auctions, each for £1 billion. The total amount of gilts purchased since the start of the asset purchase programme in March 2009, in terms of the amount paid to sellers, was £346 billion, of which £92.6 billion of purchases were in the 3–7 year residual maturity range, £113.8 billion in the 7–15 year residual maturity range and £139.4 billion with a residual maturity greater than 15 years (**Chart A**).

**Chart A** Cumulative gilt purchases(a) by maturity(b)




(a) Proceeds paid to counterparties on a settled basis.
(b) Residual maturity as at the date of purchase.

**Table 1** Asset Purchase Facility transactions by type (£ millions)

| Week ending(a) | Secured commercial paper | Gilts | Corporate bond | | Total(b) |
|---|---|---|---|---|---|
| | | | Purchases | Sales | |
| 31 May 2012(c)(d) | 0 | 324,753 | 261 | | 325,014 |
| 7 June 2012 | 0 | 0 | 4 | 3 | 1 |
| 14 June 2012 | 0 | 0 | 0 | 0 | 0 |
| 21 June 2012 | 0 | 0 | 0 | 18 | -18 |
| 28 June 2012 | 0 | 0 | 0 | 4 | -4 |
| 5 July 2012 | 0 | 0 | 0 | 0 | 0 |
| 12 July 2012 | 0 | 3,000 | 0 | 9 | 2,991 |
| 19 July 2012 | 0 | 3,000 | 0 | 37 | 2,963 |
| 26 July 2012 | 0 | 3,000 | 0 | 23 | 2,977 |
| 2 August 2012 | 0 | 3,000 | 0 | 33 | 2,967 |
| 9 August 2012 | 0 | 3,000 | 0 | 18 | 2,982 |
| 16 August 2012 | 0 | 3,000 | 0 | 1 | 2,999 |
| 23 August 2012 | 0 | 3,000 | 0 | 0 | 3,000 |
| Total financed by a deposit from the DMO(d)(e) | – | – | 29 | | 29 |
| Total financed by central bank reserves(d)(e) | – | 345,752 | 91 | | 345,842 |
| Total asset purchases(d)(e) | – | 345,752 | 120 | | 345,871 |

(a) Week-ended amounts are for purchases in terms of the proceeds paid to counterparties, and for sales in terms of the value at which the Bank initially purchased the securities. All amounts are on a trade-day basis, rounded to the nearest million. Data are aggregated for purchases from the Friday to the following Thursday.
(b) Weekly values may not sum to totals due to rounding.
(c) Measured as amount outstanding as at 31 May 2012.
(d) In terms of proceeds paid to counterparties less redemptions at initial purchase price on a settled basis.
(e) Data may not sum due to assets maturing over the period and/or due to rounding.

Cover in the gilt purchase auctions averaged 3.0 in the 3–7 year maturity sector, 3.0 in the 7–15 year maturity sector and 2.6 in the auctions for gilts with a maturity greater than 15 years. This was broadly in line with cover in the previous APF gilt purchases.(5)

The Bank continued to exclude gilts in which it held a large proportion (more than 70%) of the free float.

### Gilt lending facility(6)

The Bank continued to offer to lend some of its gilt holdings via the DMO in return for other UK government collateral. In the three months to 30 June 2012, a daily average of £386 million of gilts was lent as part of the gilt lending facility. This was a little below the average of £527 million in the previous quarter.

### Corporate bonds

The Bank continued to offer to purchase and sell corporate bonds via the Corporate Bond Secondary Market Scheme, with purchases financed by the issue of Treasury bills and the DMO's cash management operations. The Scheme continued to serve a backstop role, particularly during periods of market uncertainty.

Net sales of corporate bonds increased during the review period. As of 23 August 2012, the Bank's portfolio totalled £120 million, in terms of amount paid to sellers, compared to £261 million at the end of the previous review period. The increase in net sales reflected market conditions: the Bank's market contacts reported that continued end-investor demand for corporate bonds and a low level of inventories held by dealers had resulted in demand to purchase bonds from the Corporate Bond Scheme.

### Secured commercial paper facility

The Bank continued to offer to purchase secured commercial paper (SCP) backed by underlying assets that are short term and provide credit to companies or consumers that support economic activity in the United Kingdom.(7) The facility remained open during the review period but no purchases were made.

(1) For further discussion on asset purchases see the *Asset Purchase Facility Quarterly Report* available at www.bankofengland.co.uk/publications/Pages/other/markets/apf/quarterlyreport.aspx.
(2) Unless otherwise stated the cut-off date for data is 23 August 2012.
(3) For further information, see the 5 July Market Notice, available at www.bankofengland.co.uk/markets/Documents/apf/marketnotice120705.pdf.
(4) The APF was initially authorised to purchase private sector assets financed by Treasury bills and the DMO's cash management operations. Its remit was extended to enable the Facility to be used as a monetary policy tool on 3 March 2009. All purchases of assets between 6 March 2009 and 4 February 2010 were financed by central bank reserves. All purchases of private sector assets since 4 February 2010 have been financed by the issuance of Treasury bills and the DMO's cash management operations. All purchases of gilts since 10 October 2011 have been financed by central bank reserves. The Chancellor's letter is available at www.hm-treasury.gov.uk/d/chx_letter_090212.pdf.
(5) Further details of individual operations are available at www.bankofengland.co.uk/markets/Pages/apf/gilts/results.aspx.
(6) For more details on the gilt lending facility see the box 'Gilt lending facility' in the *Bank of England Quarterly Bulletin*, Vol. 50, No. 4, page 253.
(7) The SCP facility is described in more detail in the Market Notice available at www.bankofengland.co.uk/markets/Documents/marketnotice120801.pdf.

Spanish and Italian yields fell in the second half of the review period. Contacts attributed these falls to comments made by the President of the ECB in a speech on 26 July and the announcement on 2 August that the ECB was considering further non-standard monetary policy measures. Contacts reported that investors largely interpreted these statements as signalling future purchases of short-dated Spanish and Italian government bonds by the ECB.

After the end of the review period — on 6 September — the ECB announced that, subject to certain conditions, it would conduct purchases of euro-area government bonds in secondary markets.(1) These so-called 'Outright Monetary Transactions' (OMTs) would be conducted to address severe market distortions, and would be focused at the shorter end of the yield curve. Italian and Spanish bond yields fell at all maturities immediately following the announcement.

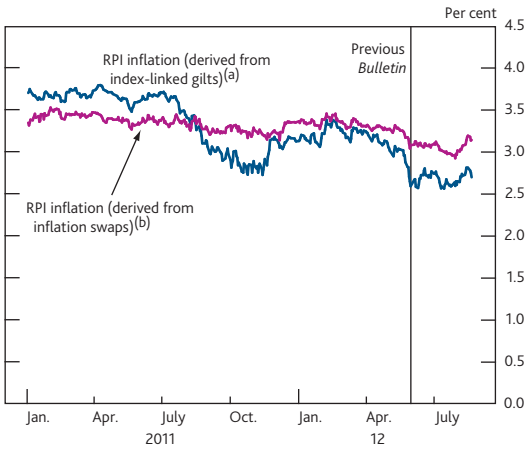
In euro-area countries where government bond yields had been less elevated, the cost of borrowing had been less volatile over the review period. Short-term yields on French, Belgian and Austrian debt fell, while yields on German bonds ended the period little changed. Contacts thought the resulting compression in spreads to bunds reflected, in part, the cut in ECB policy rates, which prompted investors to shift into slightly riskier and longer-term assets in an attempt to secure higher yields.

Towards the end of the review period, yields on government bonds perceived to be the most liquid and/or carrying the least credit risk, including those of Germany, the United States and the United Kingdom, rose, having reached record lows earlier in the review period (**Chart 3**). Contacts attributed this to an increase in risk appetite following the statements by the ECB signalling that further policy measures were being considered. This increase in risk appetite reportedly reduced demand for those assets perceived to be the least risky.

Market-based measures of shorter-term UK inflation expectations rose in the second half of the review period. Contacts thought this reflected, in part, the notable increases in the price of oil and some agricultural commodities over the review period. For example the S&P agricultural index rose by around 30%. Longer-term measures of inflation expectations also rose, but ended the review period little changed (**Chart 4**).

(1) The technical features of the OMTs are described in detail in www.ecb.int/press/pr/date/2012/html/pr120906_1.en.html.

**Chart 4** UK implied five-year RPI inflation rate, five years forward



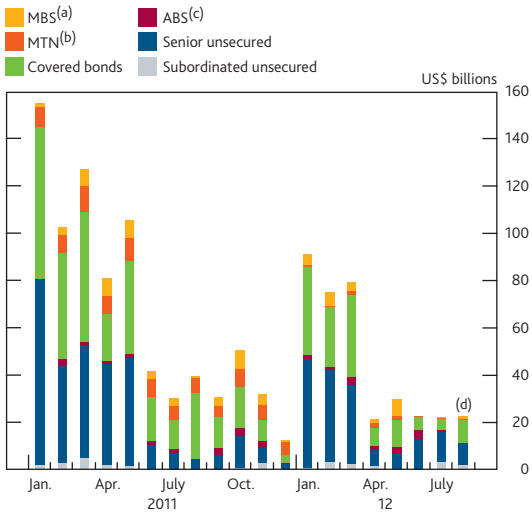

Source: Bank calculations.

(a) Derived from the Bank's government liability curve.
(b) Derived from the Bank's inflation swap curve.

## Bank funding markets

European bank debt issuance in public markets remained weak relative to the first part of 2012 (**Chart 5**). Contacts ascribed that weakness to a number of factors. First, participation in the ECB's longer-term refinancing operations (LTROs), coupled with ongoing deleveraging by some banks, meant that banks' funding needs were lower than they would otherwise have been. Second, at the start of the review period, banks had delayed issuance plans due to risks associated with impending events, including the second Greek election, the completion of a review of bank credit ratings by Moody's, and the euro-area summit held on 28–29 June. In the event, these risks did not materialise.

**Chart 5** Term issuance by European (including UK) lenders in public markets

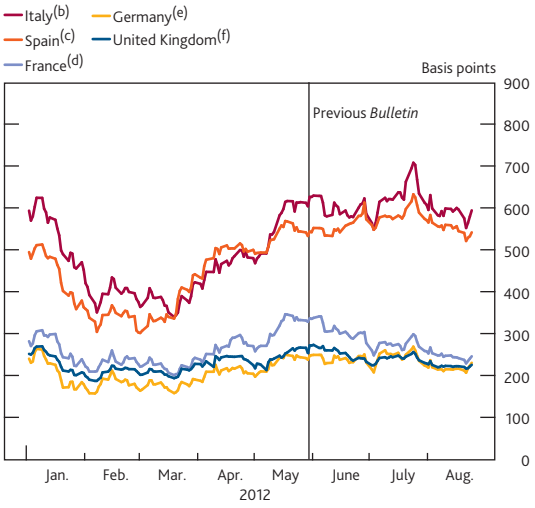



Sources: Dealogic and Bank calculations.

(a) Commercial and residential mortgage-backed securities.
(b) Medium-term notes.
(c) Asset-backed securities.
(d) Data up to 24 August 2012.

Conditions in bank funding markets improved towards the end of the review period — measures of both short-term and longer-term funding costs fell and there was some notable issuance by Spanish and Italian banks. Contacts attributed this to the comments by the ECB that it was considering further non-standard monetary policy measures. But a degree of differentiation in the cost of funding and access to the market faced by different banks remained apparent (**Chart 6**).

**Chart 6** Selected European banks' credit default swap (CDS) premia(a)




Sources: Markit Group Limited and Bank calculations.

(a) Unweighted averages of five-year, senior CDS prices.
(b) Average of Banco Popolare, Intesa Sanpaolo, Monte dei Paschi and UniCredit.
(c) Average of Banco Popular Espanol, BBVA and Santander.
(d) Average of BNP Paribas, Crédit Agricole, Natixis and Société Générale.
(e) Average of Commerzbank and Deutsche Bank.
(f) Average of Barclays, HSBC, Lloyds Banking Group, Nationwide, Royal Bank of Scotland and Santander UK.

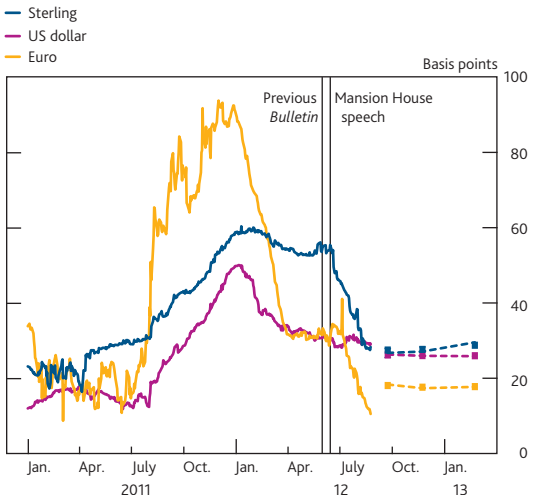
In the United Kingdom, the Bank announced two policy measures, which contacts noted had implications for conditions in bank funding markets.

Against the backdrop of the somewhat impaired market conditions, in his Mansion House speech on 14 June 2012, the Governor of the Bank of England announced that the Bank would activate the ECTR Facility. The ECTR Facility is a contingency liquidity facility designed to respond to actual or prospective market-wide stress of an exceptional nature. Usage of the Facility is described in more detail in the box on pages 192–94.

In his speech, the Governor also announced that the Bank and the Government were working together on a funding for lending scheme. On 13 July, the Bank announced the details of this Scheme, which is designed to incentivise banks and building societies to increase their lending to UK households and non-financial companies by providing longer-term funding at rates below those prevailing in the market at the time. The Scheme's drawdown window opened on 1 August 2012. The operation of the Scheme is described in the box on page 195.

Conditions in UK bank funding markets improved following these announcements. For example, the difference between the three-month London interbank offered rate (Libor) and the three-month OIS rate had fallen by around 30 basis points since the Mansion House speech (**Chart 7**). Conditions in short-term US dollar funding markets for UK banks also improved: the difference between the cost of raising US dollar funding by borrowing in sterling and swapping via the foreign exchange market and the cost of direct US dollar borrowing fell by around 20 basis points (**Chart 8**).

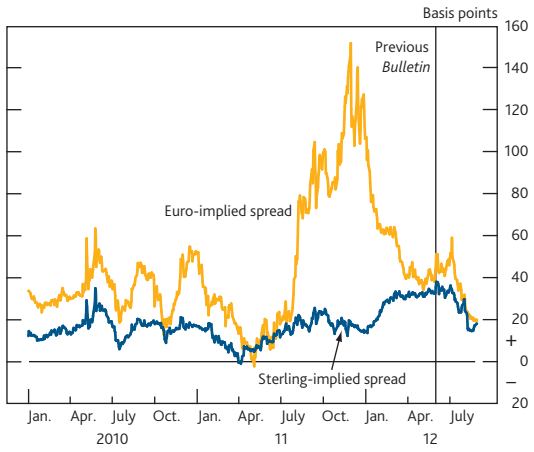
**Chart 7** International three-month spot and forward Libor-OIS spreads[a][b]




Sources: Bloomberg, British Bankers' Association and Bank calculations.

(a) Three-month Libor-OIS spreads derived from Libor fixings and OIS rates.
(b) Forward spreads derived using data as at 24 August. The squares are implied forward spreads using forward Libors and Euribor derived from forward rate agreements, and forward OIS rates derived from the OIS curve.

**Chart 8** Spread of foreign exchange implied cost of three-month US dollar funding over US dollar Libor[a]




Sources: British Bankers' Association, Reuters and Bank calculations.

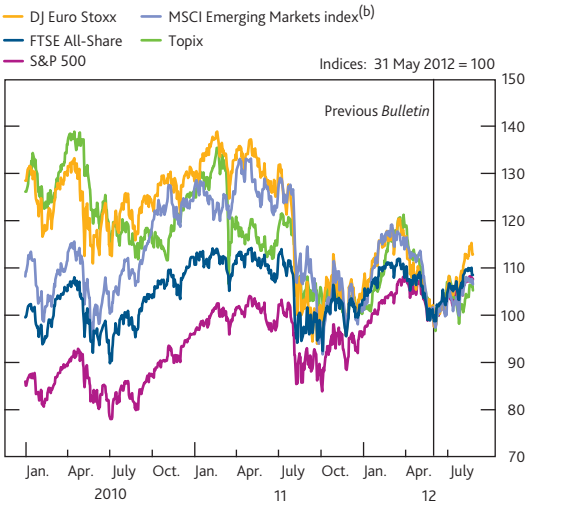
(a) Spread of three-month US dollar Libor implied from foreign exchange forwards over actual three-month US dollar Libor. For more details on the construction of these measures see *Bank of England Quarterly Bulletin*, Vol. 48, No. 2, page 134, Chart 26 and *BIS Quarterly Review*, March 2008, pages 73–86.

Notwithstanding these developments, public term debt issuance by UK banks remained negligible during the review period. Contacts attribute this predominantly to the fact that, following strong public issuance earlier in the year and ongoing issuance in private markets over the review period, UK banks remained ahead of their funding plans for 2012, allowing them to access the market opportunistically for the remainder of the year. Contacts also reported that UK banks were reconsidering their issuance plans following the launch of the FLS.

## Corporate capital markets

International equity prices rose over the review period, partly reversing the fall in prices which occurred in the run-up to the previous *Bulletin* (**Chart 9**). The FTSE All-Share and the S&P 500 rose by around 8%, while the DJ Euro Stoxx, which had fallen by more in the previous review period, rose by around 13%.

**Chart 9** International equity indices[a]




Sources: Bloomberg and Bank calculations.

(a) Indices are quoted in domestic currency terms, except for the MSCI Emerging Markets index, which is quoted in US dollar terms.
(b) The MSCI Emerging Markets index is a capitalisation-weighted index that monitors the performance of stocks in emerging markets.

Contacts thought that these increases, in part, reflected a modest improvement in investor risk appetite, associated with a more pervasive expectation of further policy measures by central banks. Some contacts also noted that later in the review period, equity prices had been supported by better-than-expected US economic data, which boosted investors' assessments of the global growth outlook. For example, the Bank of America/Merrill Lynch Fund Manager survey for August reported that the net balance of respondents expecting positive global growth in the coming twelve months had risen to +15%, from -13% in July.

Consistent with some of the factors pushing up on equity prices, corporate bond spreads narrowed during the review period. In the absence of large moves in government bond yields, both investment-grade and non-investment grade corporate bond yields fell (**Chart 10**). Some contacts attributed the reduction in spreads to a combination of stronger demand from investors seeking higher-yielding assets

## Operations within the Sterling Monetary Framework and other market operations

The level of central bank reserves was determined by (i) the stock of reserves injected via the Asset Purchase Facility (APF); (ii) the level of reserves supplied by indexed long-term repo operations and the Extended Collateral Term Repo (ECTR) Facility; and (iii) the net impact of other sterling ('autonomous factor') flows across the Bank's balance sheet. This box describes the Bank's operations within the Sterling Monetary Framework over the review period, and other market operations.

### Operational Standing Facilities

Since 5 March 2009, the rate paid on the Operational Standing Deposit Facility has been zero, while all reserves account balances have been remunerated at Bank Rate. Reflecting this, average use of the deposit facility was £0 million in each of the May, June and July maintenance periods. Average use of the lending facility was also £0 million.

### Indexed long-term repo OMOs

As part of its provision of liquidity insurance to the banking system, the Bank conducts indexed long-term repo (ILTR) operations typically once each calendar month. Participants are able to borrow against two different sets of collateral. One set corresponds with securities eligible in the Bank's short-term repo operations ('narrow collateral'), and the other set contains a broader class of high-quality debt securities that, in the Bank's judgement, trade in liquid markets ('wider collateral').

During the review period, the Bank offered £5 billion via three-month ILTR operations on both 12 June and 10 July, and £2.5 billion via a six-month operation on 14 August (**Table 1**).

The stop-out spread — the difference between clearing spreads for wider and narrow collateral — is an indicator of potential stress in the sterling short-term money market. In both the July three-month operation and the August six-month operation, there were no bids against narrow collateral, hence the clearing spreads for wider collateral were the stop-out spreads. In the June operation no bids were allocated against wider collateral so the stop-out spread was not defined.

The cover ratios — also a potential indicator of stress in the sterling short-term money market — continued to be at very low levels (**Chart A**).

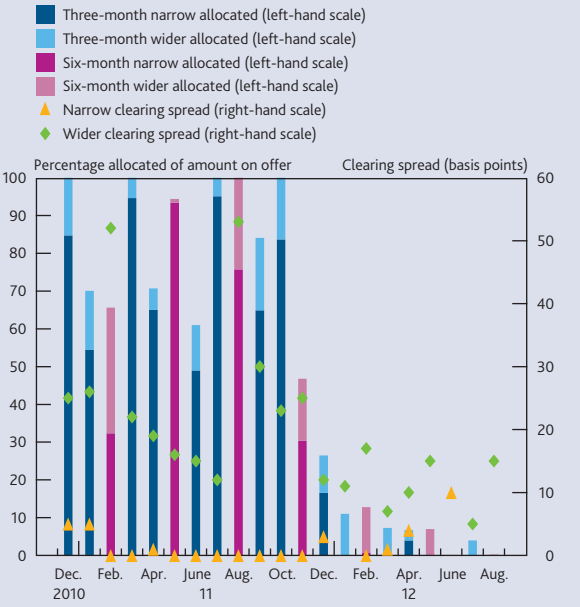
There are a number of possible reasons for the low demand seen from banks for three and six-month liquidity via the ILTR operations. First, short-term secured market interest rates remain below Bank Rate, the minimum bid rate in the ILTR operations, making repo markets a potentially cheaper source of liquidity. Second, APF gilt purchases financed by the creation of central bank reserves continued to boost the liquidity of the banking system, which may have reduced the need for counterparties to use the ILTR operations to meet

**Table 1** Indexed long-term repo operations

| | Total | Collateral set summary | |
|---|---|---|---|
| | | Narrow | Wider |
| **12 June 2012 (three-month maturity)** | | | |
| On offer (£ millions) | 5,000 | | |
| Total bids received (£ millions)[a] | 145 | 5 | 140 |
| Amount allocated (£ millions) | 5 | 5 | 0 |
| Cover | 0.03 | 0.00 | 0.03 |
| Clearing spread above Bank Rate (basis points) | | 10 | n.a. |
| Stop-out spread (basis points)[b] | n.a. | | |
| **10 July 2012 (three-month maturity)** | | | |
| On offer (£ millions) | 5,000 | | |
| Total bids received (£ millions)[a] | 200 | 0 | 200 |
| Amount allocated (£ millions) | 200 | 0 | 200 |
| Cover | 0.04 | 0.00 | 0.04 |
| Clearing spread above Bank Rate (basis points) | | n.a. | 5 |
| Stop-out spread (basis points)[b] | 5 | | |
| **14 August 2012 (six-month maturity)** | | | |
| On offer (£ millions) | 2,500 | | |
| Total bids received (£ millions)[a] | 290 | 0 | 290 |
| Amount allocated (£ millions) | 60 | 0 | 60 |
| Cover | 0.12 | 0 | 0.12 |
| Clearing spread above Bank Rate (basis points) | | n.a. | 15 |
| Stop-out spread (basis points)[b] | 15 | | |

(a) Due to the treatment of paired bids, the sum of bids received by collateral set may not equal total bids received.
(b) Difference between clearing spreads for wider and narrow collateral.

**Chart A** ILTR allocation and clearing spreads



their short-term liquidity needs. Third, the Bank announced two additional facilities. On 15 June, the Bank activated the ECTR Facility, from which eligible institutions can borrow reserves for six months at a minimum rate of 25 basis points above Bank Rate, using a much wider set of collateral than in the ILTR operations. And on 13 July, the Bank and the Government launched the Funding for Lending Scheme (FLS), which allows eligible institutions to borrow Treasury bills from the Bank for up to four years with a minimum fee of 25 basis points. The FLS is described in more detail in the box on page 195.

## Extended Collateral Term Repo Facility

The ECTR Facility is a contingent liquidity facility, designed to mitigate risks to financial stability arising from a market-wide shortage of short-term sterling liquidity.(1) On 15 June, the Bank announced that it intended to conduct an ECTR auction at least once a month until further notice, normally on the third Wednesday of each month.(2) The size of the auctions would be at least £5 billion and the term of borrowing under each auction would be six months, with a minimum bid spread to Bank Rate of 25 basis points. The Bank said it would keep the operation of the Facility under review, including in the light of market conditions.

By 24 August 2012, the Bank had conducted three ECTR auctions, offering £5 billion in each (**Table 2**). All three operations cleared at the minimum bid spread to Bank Rate of 25 basis points. The full £5 billion was allocated in the June operation, £4.2 billion was allocated in the July operation, and £1.5 billion was allocated in the August operation. Contacts attributed this fall in demand to a number of factors. These included the ample quantity of liquidity in the banking system, the passing of event risk (such as a review of UK bank ratings by Moody's), and the desire of some banks to retain their collateral for use in the FLS.

Table 2 ECTR operations

| | Total |
|---|---|
| **20 June 2012** | |
| On offer (£ millions) | 5,000 |
| Amount allocated (£ millions) | 5,000 |
| Clearing spread above Bank Rate (basis points) | 25 |
| **18 July 2012** | |
| On offer (£ millions) | 5,000 |
| Amount allocated (£ millions) | 4,175 |
| Clearing spread above Bank Rate (basis points) | 25 |
| **15 August 2012** | |
| On offer (£ millions) | 5,000 |
| Amount allocated (£ millions) | 1,500 |
| Clearing spread above Bank Rate (basis points) | 25 |

Reserves provided via ILTRs and ECTRs during the review period more than offset the reduction in reserves from maturing ILTR operations. Consequently, the stock of reserves provided through these operations increased by £9.9 billion.

## Discount Window Facility

The Discount Window Facility (DWF) provides liquidity insurance to the banking system by allowing eligible banks to borrow gilts against a wide range of collateral. On 3 July 2012, the Bank announced that the average daily amount outstanding in the DWF between 1 January 2012 and 31 March 2012, lent with a maturity of 30 days or less, was £0 million. The Bank also announced that the average daily amount outstanding in the DWF between 1 January 2011 and 31 March 2011, lent with a maturity of more than 30 days, was £0 million.

## Other operations

### US dollar repo operations

Since 11 May 2010, the Bank has offered weekly fixed-rate tenders with a seven-day maturity to offer US dollar liquidity, in co-ordination with other central banks.

On 30 November 2011, the Bank announced, in co-ordination with the Bank of Canada, the Bank of Japan, the ECB, the Swiss National Bank, and the Federal Reserve, that the authorisation of the existing temporary US dollar swap arrangements had been extended to 1 February 2013, that 84-day US dollar tenders would continue until this time, and that seven-day operations would continue until further notice. It also announced that the central banks had agreed to lower the pricing on the US dollar swap arrangements by 50 basis points to the US dollar overnight index swap rate plus 50 basis points. As a contingency measure, the six central banks agreed to establish a network of temporary bilateral liquidity swap arrangements that will be available until 1 February 2013. As of 24 August 2012, there had been no use of the Bank's facilities.

## Bank of England balance sheet: capital portfolio

The Bank holds an investment portfolio that is approximately the same size as its capital and reserves (net of equity holdings, for example in the Bank for International Settlements, and the Bank's physical assets) and aggregate cash ratio deposits. The portfolio consists of sterling-denominated securities. Securities purchased by the Bank for this portfolio are normally held to maturity, though sales may be made from time to time, reflecting for example, risk management, liquidity management or changes in investment policy.

The portfolio currently includes around £3.4 billion of gilts and £0.4 billion of other debt securities. Over the review period,

gilt purchases were made in accordance with the quarterly announcements on 2 April and 2 July 2012.

### Bank of England and HM Treasury foreign currency operations: move to two-way collateralisation of over-the-counter derivatives transactions

On 21 June, the Bank and HM Treasury announced that they expected to make some technical changes to the terms on which they transact with market counterparties in selected foreign currency operations.(3) Specifically, they planned to move from one-way to two-way collateralisation of trades that are part of these operations.

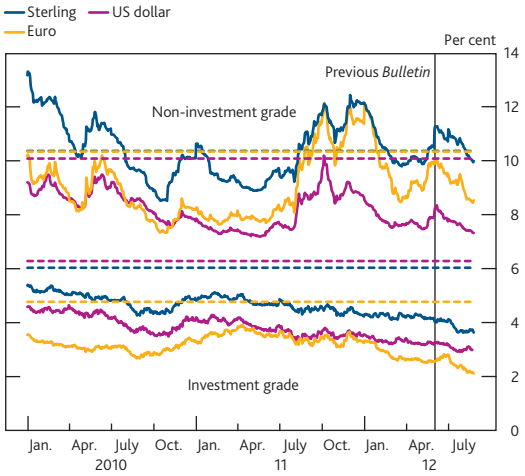
The changes would apply to over-the-counter derivatives transactions undertaken by the Bank to manage the financial impact of fluctuations in foreign exchange and interest rates on both the Bank's own balance sheet and the United Kingdom's foreign exchange reserves. Under current agreements, the Bank takes collateral when market rates move such that a counterparty owes the Bank or HM Treasury money on their derivatives trades. Under the changes, the Bank and HM Treasury intend to also provide collateral in the form of foreign currency securities to counterparties when the Bank or HM Treasury owes the counterparty money, and so allow two-way collateralisation.

The decision to make this change was driven by value-for-money considerations and was taken because the costs of transacting derivatives had been rising over the past few years. The one-way provision of collateral, in the context of the growing size of the United Kingdom's official foreign currency reserves, had contributed to the increase in these costs.

These changes were expected to come into effect during 2013.(4)

(1) Further details are available at www.bankofengland.co.uk/markets/Pages/money/ectr/index.aspx.
(2) Further details are available at www.bankofengland.co.uk/markets/Documents/marketnotice120615.pdf.
(3) See www.bankofengland.co.uk/publications/Pages/news/2012/063.aspx.
(4) For more details on the collateralisation of trades see the section 'Developments in market structure' in the *Bank of England Quarterly Bulletin*, Vol. 52, No. 2, page 109.

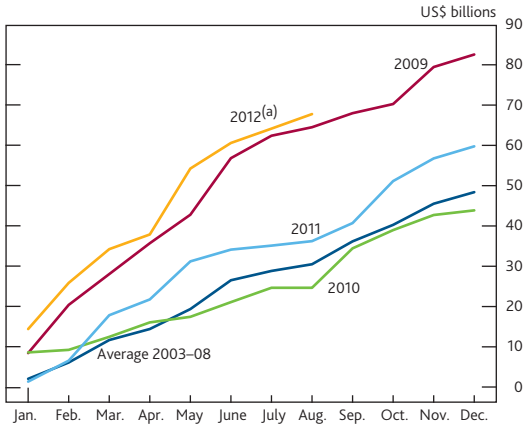
**Chart 10** International non-investment grade and non-financial investment-grade corporate bond yields(a)




Sources: Bank of America/Merrill Lynch and Bank calculations.

(a) Dashed lines: 1997–2007 averages for investment-grade bonds and 1998–2007 averages for non-investment grade bonds.

**Chart 11** Cumulative gross bond issuance by UK PNFCs




Sources: Dealogic and Bank calculations.

(a) Data up to 24 August 2012.

given the low interest rate environment, and weak net supply of corporate debt. The Bank's Corporate Bond Secondary Market Scheme was a net seller of corporate bonds, in part reflecting these market conditions. This Scheme is described in more detail in the box on pages 188–89.

In primary markets, bond issuance by UK private non-financial corporations (PNFCs) exhibited a typical seasonal lull, but picked up after the end of the review period. Although cumulative gross issuance in the year to date remains stronger than in recent years (**Chart 11**), contacts noted that net issuance had been weak relative to demand for corporate assets.

Net equity issuance continued to be negative (**Chart 12**), as gross issuance remained weak and share buyback activity increased. Contacts attributed this in part to the fact that many large corporates had substantial cash surpluses. Some contacts also associated the small number of initial public offerings with increased uncertainty around market liquidity during the summer.

### Foreign exchange

The sterling exchange rate index (ERI) appreciated by 1.3% over the review period (**Chart 13**). The move was largely accounted for by a rise against the euro — with the bilateral exchange rate reaching its highest level since October 2008. Contacts thought the move largely reflected continuing risks associated with the challenges facing the euro area, which had

## The Funding for Lending Scheme

The Funding for Lending Scheme (FLS) was launched by the Bank and the Government on 13 July. The FLS is designed to incentivise banks and building societies to boost their lending to UK households and non-financial companies, by providing term funding at rates below those prevailing in the market at the time. The quantity each participant can borrow in the Scheme, and the price it pays on its borrowing, will be linked to its lending performance. A box in the August 2012 *Inflation Report* explains why the FLS has been launched and how it will encourage banks to lend more.(1) This box outlines how the FLS will operate in practice.(2)

### Operation of the FLS

Institutions eligible to participate in the FLS are banks and building societies that are signed-up to the Bank's Discount Window Facility (DWF). All deposit-taking institutions are eligible to apply to join the DWF.

Under the FLS, participants can borrow UK Treasury bills during an 18-month drawdown window running from 1 August 2012 to 31 January 2014, in exchange for eligible collateral. The term of borrowing is four years from the date of drawdown, but participants may repay their drawings, in part or in full, at any time.

The Treasury bills borrowed from the FLS have an initial maturity of nine months, and so during the life of the Scheme must be returned to the Bank prior to their maturity in exchange for new nine-month Treasury bills. Eligible collateral in the FLS comprises all collateral that is eligible in the DWF, including portfolios of loans. The Bank's standard Sterling Monetary Framework haircuts apply to collateral delivered in the FLS.

### Quantity and price of FLS funding

The quantity and price of funding available to FLS participants is based on the quantity of sterling loans made to UK-resident households and private non-financial corporations (PNFCs). FLS participants must provide the Bank with these lending data at least quarterly, on a group basis, covering a reference period from 30 June 2012 to 31 December 2013.

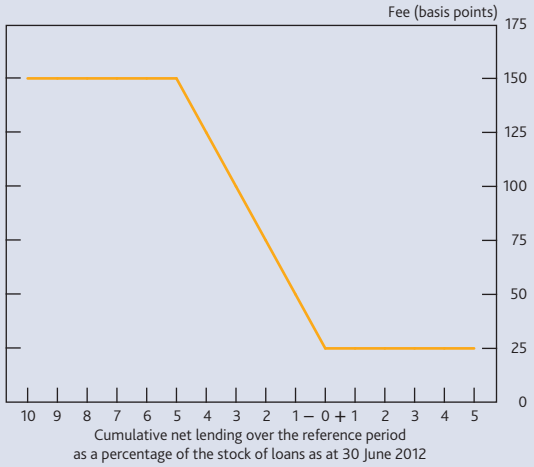
#### Borrowing allowance

The FLS borrowing allowance for each participating group is 5% of its stock of existing applicable loans as at 30 June 2012, plus 100% of any expansion of its net lending during the reference period.(3)

#### Fee

The fee on FLS drawings is determined by each group's cumulative net lending over the reference period as a whole. The fee increases linearly from 25 basis points per annum for positive or stable net lending, up to 150 basis points per annum if net lending falls by 5% or more, as shown in **Chart A**.

**Chart A** Fee on FLS drawings



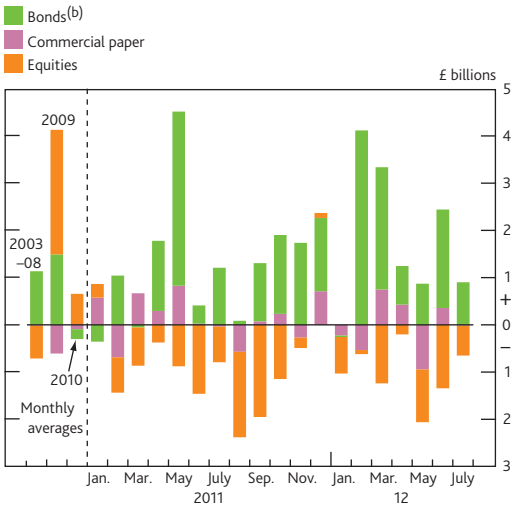

During the drawdown window participants pay a flat fee of 25 basis points per annum. Once the drawdown window has closed and the final fee has been determined, any fee above the 25 basis points already paid is then charged.

### Publication of information

The Bank will publish quarterly usage and lending data for each group participating in the FLS. This will include each group's stock of lending to UK households and PNFCs as of 30 June 2012, each group's quarterly net lending flows, and the amount of Treasury bills borrowed from the FLS by each group.

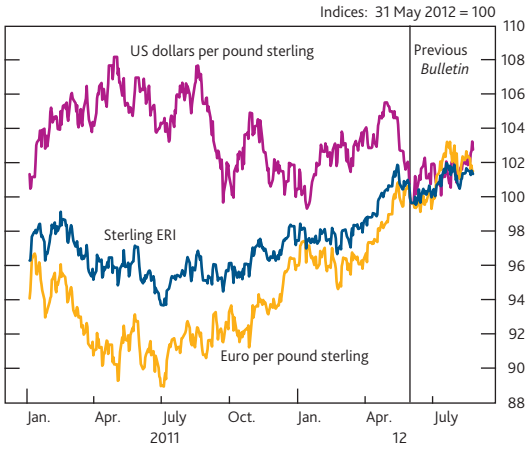
(1) See www.bankofengland.co.uk/publications/Documents/inflationreport/ir12aug.pdf.
(2) For more information see www.bankofengland.co.uk/markets/Pages/FLS/default.aspx.
(3) Net lending is defined as gross lending less repayments, and therefore excludes other effects on balances such as write-offs and reclassifications.

**Chart 12** Net capital market issuance by UK PNFCs[a]



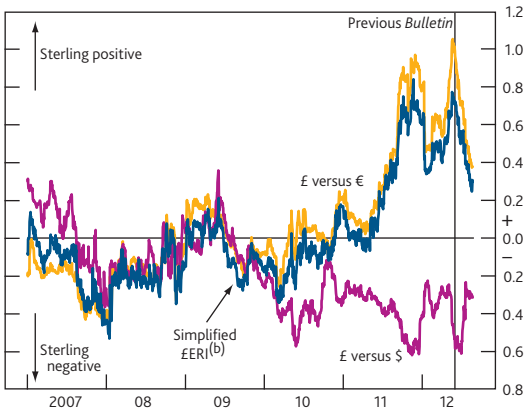

(a) Non seasonally adjusted.
(b) Includes standalone and programme bonds.

**Chart 13** Sterling ERI and bilateral exchange rates




Sources: Bloomberg and Bank calculations.

**Chart 14** Three-month option-implied skewness of foreign exchange returns[a]




Sources: Bloomberg, British Bankers' Association and Bank calculations.

(a) Returns are defined as the logarithmic difference between the current forward rate and the spot rate at the maturity date of the contract.
(b) The simplified sterling ERI places 70% weight on the euro-sterling bilateral exchange rate and 30% weight on the US dollar-sterling bilateral exchange rate.

led to stronger demand for currencies such as sterling, the Norwegian krone and the Swedish krona, which were viewed by investors as safer.

Market-based measures suggested that the balance of risks to the sterling ERI remained to the upside. But investors were placing less weight on a large appreciation of sterling against the euro (**Chart 14**). Options markets also implied that investors were placing a lower weight on a further depreciation of sterling against the US dollar.

## Market intelligence on developments in market structure

In discharging its responsibilities to maintain monetary stability and contribute to financial stability, the Bank gathers information from contacts across a wide spectrum of financial markets. This intelligence helps inform the Bank's assessment of monetary conditions and possible sources of financial instability and is routinely synthesised with research and analysis in the *Inflation Report* and the *Financial Stability Report*. More generally, regular dialogue with market contacts provides valuable insights into how markets function, providing context for policy formulation, including the design and evaluation of the Bank's own market operations. The Bank also conducts occasional market surveys to gather additional quantitative information on certain markets.

This section reports the most recent results from the Sterling Money Market Survey conducted by the Bank on behalf of the Money Market Liaison Group, supplemented with intelligence of the type described above. It also summarises the key insights from a recent round of conversations with market participants regarding trends in the demand for collateral.

### Results from the May 2012 Money Market Liaison Group Sterling Money Market Survey

The sterling money market plays a central role in the Bank's pursuit of its monetary and financial stability objectives, with the Bank operating in the market to implement the interest rate decisions of the MPC, and to provide liquidity insurance to the banking system. The money market brings together banks, other financial institutions and non-financial companies looking to borrow or lend short-term money, enabling them to manage their liquidity positions. To better understand this market, in May 2011, the Bank of England launched a regular six-monthly survey of the sterling money market on behalf of the Money Market Liaison Group.[1] The survey supplements

(1) The survey is described in more detail in Westwood, B (2011), 'The Money Market Liaison Group Sterling Money Market Survey', *Bank of England Quarterly Bulletin*, Vol. 51, No. 3, pages 247–52.

the Bank's long-standing gathering of market intelligence and, over time, it is expected to help identify emerging trends in the market, and help policymakers to assess the impact of their actions on the behaviour of market participants. This section presents a selection of results from the May 2012 survey.

## Coverage and content

The survey sample comprises over 30 institutions active in the sterling money market, the vast majority of which are commercial banks, building societies and investment banks. Selection is based on data on the scale of institutions' involvement in the sterling money market, combined with market intelligence about which banks are most active in the market.

For the purposes of the survey, sterling money market transactions are defined as wholesale (as opposed to retail) and as having a maturity of no longer than one year. Any non-sterling and intragroup trades are excluded. Participants are also asked to exclude trades with the Bank of England, but (from May 2012 on) to include transactions with the UK Debt Management Office (DMO).(1)

The survey comprises both quantitative and qualitative questions that are designed to ascertain how well market participants perceive markets to be functioning and how market liquidity and efficiency is evolving. The quantitative questions ask survey participants to record the value, volume, type and maturity of sterling money market activity conducted over the month-long survey period, on a daily average basis. The qualitative questions ask respondents to record their perception of market functioning in both the unsecured and secured money markets, as well as how different aspects of market functioning have changed since the previous survey.

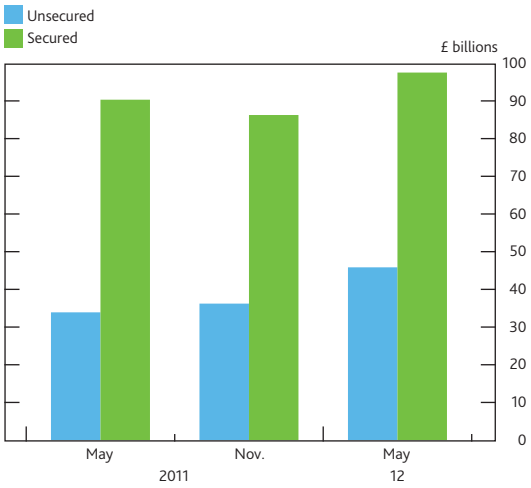
## Survey results

### *Key features of the sterling money market*

The sterling money market surveys conducted since May 2011 reveal a number of interesting features of the market. First, activity in the sterling money market is concentrated among relatively few institutions. For example, in May 2012, the top five respondents accounted for around 50% of unsecured borrowing; the equivalent share for the top five respondents in the most recent *Euro Money Market Survey* conducted by the ECB was around 30%.(2)

Second, just over two thirds of transactions by value are conducted on a secured basis (**Chart 15**).(3) Of these secured transactions, around 70% are between banks, with trades tending to be settled either bilaterally or via a central counterparty (CCP). By contrast most transactions in the US secured money market are transacted via tri-party agents.

**Chart 15** Reported daily average flows in the sterling money market(a)




(a) Daily average flows are reported as the value of sterling money market transactions in the survey month divided by the number of working days during that period.

Third, banks are net borrowers in the money market, particularly in the unsecured part of the market. Non-bank financial institutions, such as money market funds, provided around half of the cash lent unsecured to banks in May 2012, with non-financial corporates providing over 20%.

Fourth, recorded money market flows are dominated by overnight transactions; in May 2012, these accounted for around three quarters of daily turnover (**Chart 16**). Lending or borrowing at maturities of three months or beyond has been limited. However, these reported daily average flows imply that longer-dated transactions remain significant within the stock of money market transactions.

### *Recent market developments*

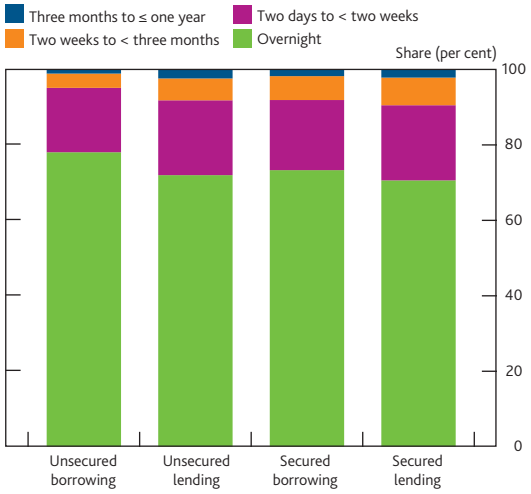
The value of reported sterling money market flows was around 15% higher in May 2012 than in November 2011, with the increase split roughly evenly between the secured and unsecured markets. This may have reflected the improvement in market sentiment since November 2011, which, according to contacts, had adversely affected money market activity at the time of the previous survey.

(1) This change was based on feedback from survey participants which suggested that they may not be able to identify the ultimate counterparty when using an automated trading system to transact via a central counterparty in the secured market. So to the extent that DMO activity in the secured market is conducted using an automated trading system and settled via a central counterparty, survey respondents may not have been able to exclude it. For more details on the DMO's money market activity see www.dmo.gov.uk.

(2) For details of the ECB's *Euro Money Market Survey* see: www.ecb.int/stats/money/mmss/html/index.en.html.

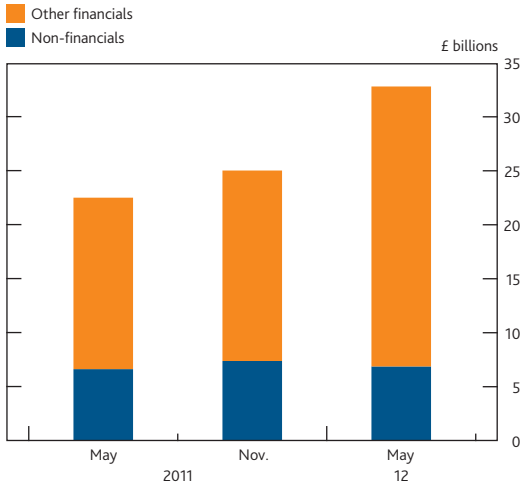
(3) These figures are adjusted to take account of estimated double counting. Double counting occurs because respondents are asked to record both borrowing and lending, so where survey participants record transactions between each other, the same transaction will appear as lending in one participant's return and as borrowing in another participant's return.

**Chart 16** Maturity of transactions, May 2012




In the unsecured part of the market, the increase in activity was largely accounted for by non-bank financials depositing significantly more cash with banks (**Chart 17**). Contacts attributed this change to asset managers, such as US money market funds, starting to return to European money markets, having reduced their lending during 2011.

**Chart 17** Unsecured deposits from non-banks




Consistent with the improvement in money markets since the November 2011 survey, the average term of money market transactions increased a little, with a smaller share of overnight deals, as lenders reportedly became somewhat less risk-averse (**Chart 18**).

In the secured money market, almost all of the increase in reported market volume between the November 2011 and May 2012 surveys was accounted for by banks borrowing more from non-banks, with the value of these transactions increasing by around 30% (**Chart 19**). Contacts reported that bank borrowing from non-banks via bilateral repo is often cheaper than borrowing through a CCP in the interbank

**Chart 18** Change in the maturity distribution of activity between May 2012 and November 2011

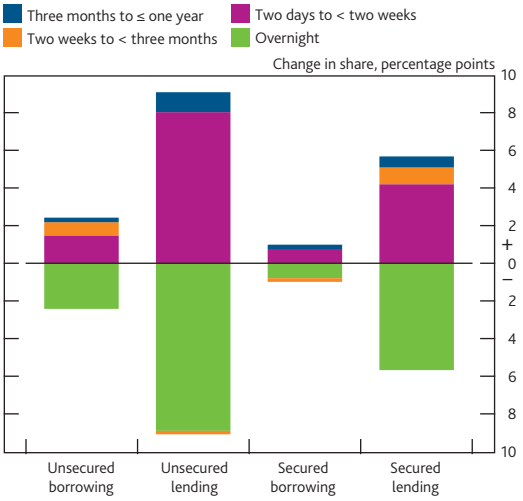
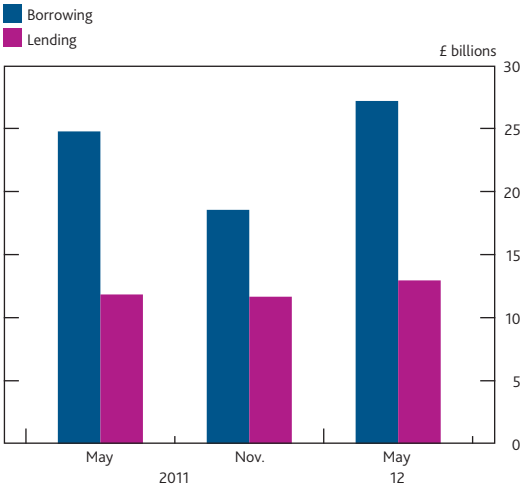



**Chart 19** Survey participants' secured money market activity involving non-banks



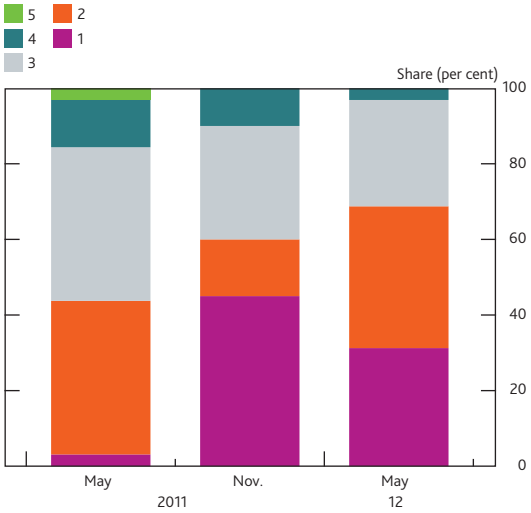

market. There were also indications that non-banks increasingly preferred to transact secured and had started to put in place the agreements and systems necessary to allow them to lend via the repo market.

## Market functioning

Since 2009, several factors have impacted the functioning of the unsecured sterling money market. For example, changes in liquidity regulation are likely to affect the incentives to trade in the money market. And contacts had suggested that the injection of excess reserves associated with the MPC's asset purchase programme had also reduced the need for some banks to actively manage their liquidity positions in money markets. Notwithstanding the increase in aggregate reported volumes in May 2012, responses to the qualitative survey questions showed that, on balance, participants reported a further slight deterioration in unsecured money market functioning between November 2011 and May 2012

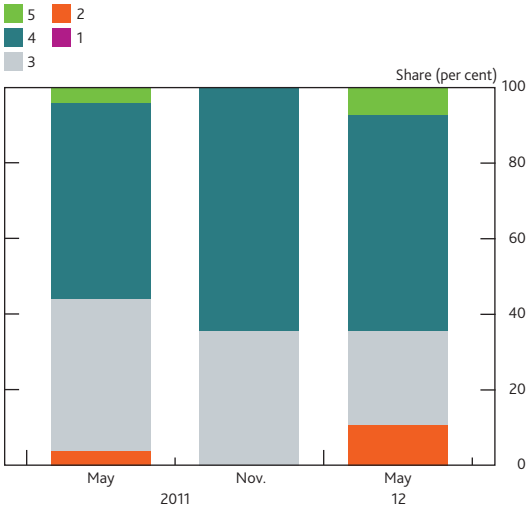
(**Chart 20**). Several survey respondents reported that the market for longer-term cash continued to function particularly poorly.

**Chart 20** Respondents' views on unsecured market functioning (1 = very poor, 5 = very good)




In contrast, the May 2012 survey results suggested that the secured market continued to function well (**Chart 21**). This indicates that factors such as the Bank's asset purchases, and increased overseas demand for gilts, which could put pressure on the available supply of high-quality collateral have not adversely affected sterling money market functioning.

**Chart 21** Respondents' views on secured market functioning (1 = very poor, 5 = very good)




## Market participants' responses to an increased need for collateral

One of the risks of transacting in financial markets is that the other party to a transaction may default on its obligations. Collateral — cash or securities that can be used to protect against losses in an event of default — can help manage such counterparty credit risk.

The use of collateralised transactions by financial firms has increased since the start of the financial crisis in the face of a reappraisal of counterparty credit risk concerns, and international regulatory reform designed to reduce systemic and firm-specific counterparty credit risks in order to make the financial sector as a whole more resilient.(1) While many of these measures had not yet come into effect, contacts reported that they were already affecting behaviour.

This section describes some of the regulatory developments and market participants' responses to an increased need for collateral, drawing on conversations with market contacts.(2)

### Recent regulatory developments

In addition to firms' higher risk aversion following the crisis, the demand for collateral will be affected by a number of regulatory developments. These include new liquidity requirements that compel firms to hold buffers of highly liquid assets and regulations requiring more robust risk management of transactions in the over-the-counter (OTC) derivative markets. According to contacts, the latter, in particular, are likely to increase demand for collateral.

Regulatory changes to OTC derivative markets include the requirement for standardised OTC derivative contracts to be cleared through a central counterparty (CCP). The CCP assumes the credit risk of the transaction by interposing itself between counterparties. It requires them each to post collateral — known as 'margin' — to protect against the risk of default. It is proposed that OTC transactions that are not cleared via a CCP will be subject to mandatory bilateral margin requirements.(3)

Margin requirements are intended to protect transacting parties against changes in credit risk exposures resulting from changes in market prices during the life of the transaction. As market prices change, the value of derivative contracts changes, creating so-called mark-to-market gains or losses. This exposes the counterparty with a mark-to-market gain to credit risk. Bilateral margining requires counterparties to post collateral (usually in the form of cash) in response to

(1) For the Pittsburgh and Cannes G20 Summit declarations, see www.g20.org.
(2) For an assessment of the financial stability implications of these developments, see Box 5 in the June 2012 *Financial Stability Report*.
(3) These proposals are available at www.bis.org/publ/bcbs226.pdf.

such price movements (known as 'variation margin'). Regulatory proposals will also require counterparties to provide collateral at the point at which the transaction is entered (usually in the form of high-quality securities) as protection against price movements that may occur after a default but before the remaining counterparty is able to replace or close out the transaction (known as 'initial margin').

The new rules will increase the demand for collateral in OTC derivative transactions in two main ways. First, there will be far greater use of initial margin than is currently the case because it is not commonly used in bilateral transactions. Second, the new regulation will prevent counterparties from reusing collateral provided to them as initial margin in other transactions.

## Financial market impact

Contacts reported that financial market participants were managing the increased need for collateral in a number of ways. These include (i) managing collateral more efficiently; (ii) using so-called 'collateral transformation services'; and (iii) loosening collateral criteria.

### *(i) Collateral management*

Contacts noted that their focus on collateral had increased markedly since the financial crisis: what had previously been an administrative function had become an important part of trading decisions and pricing.

In particular, contacts reported that they had been taking a more active approach to collateral management and were now more selective about the collateral they receive and deliver. This new approach also puts a greater emphasis on risk management: banks have improved their understanding of the collateral they hold on a group-wide basis at any one time and the types of collateral that are eligible to be transferred to them under the terms of the legal agreements underpinning their derivative transactions. In addition, rather than continuing to manage collateral by product lines — where, for example, equity, fixed-income and derivative desks have exclusive access to their own pool of collateral — collateral management was being increasingly centralised.

Contacts noted that these changes were having a number of benefits. The most direct benefit was that the active selection of securities and the centralised approach delivered a more cost-effective use of collateral across their organisation. Contacts also noted an improvement in their understanding of the cost associated with collateral received and provided, which highlighted the true cost of various business lines.

Other contacts pointed to an improvement in their understanding of the potential risks they faced due to the current terms of their legal agreements with counterparties. In particular, many banks were now adjusting derivative pricing to reflect the margin terms contained in their 'Credit Support Annexes' — legal documentation which includes the terms under which collateral is posted or transferred between counterparties to mitigate credit risk. Banks explained that they were implementing margin agreements with more counterparties and were attempting to renegotiate older agreements (which often allowed the delivery of a broad set of collateral). Some had put more rigorous processes in place to ensure new agreements were better understood, more tightly controlled and robust to forthcoming regulatory reforms.(1)

As part of a more effective collateral management strategy, use of tri-party agents has become more popular. This means that the counterparties to a trade outsource collateral management to a third party, the tri-party agent (typically a custodian bank or international clearing organisation) that is responsible for the administration of the collateral component of the transaction, including collateral allocation, marking to market and dynamic substitution of collateral. Although dealers have to pay for this service, contacts reported that the costs were outweighed by operational efficiencies. Set against this, some contacts highlighted concentration risk resulting from greater use of the few dominant tri-party agents as a concern.

### *(ii) Collateral transformation*

In contrast to widespread media commentary, contacts voiced few concerns that the increased need for collateral would lead to an overall shortage. But some were concerned about how collateral was distributed. In particular, CCP clearing of OTC derivative trades and posting of bilateral margin would affect certain market participants, such as insurance companies and pension funds, that were not used to providing collateral. The challenge for those entities would be to source and mobilise the eligible securities in a timely manner and at a reasonable cost.

Contacts noted that this might encourage banks to provide 'collateral transformation' services, which involve the exchange of securities not accepted by CCPs or as bilateral margin for cash or eligible securities. Contacts at banks reported that although these collateral upgrade transactions had existed for some time, demand for eligible collateral was boosting interest among their clients. The terms of such transactions, particularly pricing and maturity, varied considerably, however. Some contacts pointed to the risk of maturity and credit mismatches between such funding transactions and the underlying collateralised transactions.(2)

(1) The June 2012 *Quarterly Bulletin* described the development of Standardised Credit Support Annexes used in over-the-counter derivatives transactions, available at www.bankofengland.co.uk/publications/Documents/quarterlybulletin/qb1202.pdf.
(2) For more information on collateral upgrade trades and risks associated with some of these transactions, see page 40 of the June 2012 *Financial Stability Report*.

### *(iii) Loosening of collateral criteria*

One effect of the increase in demand for collateral has been a partial reversal of the post-crisis tightening of collateral criteria in some lending markets, both in the United States and Europe. For example, lenders who previously only accepted government bonds as collateral were reportedly starting to accept cash and equities. And in OTC derivative markets, some CCPs and other risk-averse counterparties were also slowly extending the range of assets eligible as collateral (against greater haircuts), with a number of market participants predicting that CCPs would become more flexible in their collateral requirements. A loosening of collateral criteria has the potential to ease pressure on higher-quality assets and was considered a helpful development by contacts, provided that adequate risk controls (including haircuts) were in place. Some contacts, however, expressed concerns that, over time, competition might lead to an excessive loosening in CCPs' collateral eligibility criteria.

# Research and analysis

# RAMSI: a top-down stress-testing model developed at the Bank of England

By Oliver Burrows, David Learmonth, Jack McKeown and Richard Williams of the Bank's Risk Assessment Division.[1]

Top-down stress testing is one way of assessing the resilience of the financial system to the risks it might face now or in the future. The Risk Assessment Model of Systemic Institutions (RAMSI) developed at the Bank of England is an example of a top-down stress-testing model and is part of the Bank's risk assessment toolkit. This article offers an overview of RAMSI and illustrates its use in the stress tests carried out during the IMF's 2011 UK Financial Stability Assessment Program.

## Introduction

The Risk Assessment Model of Systemic Institutions (RAMSI) developed at the Bank of England is a large-scale model of the UK banking sector that is designed to assess the solvency and liquidity risks faced by banks. RAMSI is a 'top-down' model: its focus is as much on the banking system as a whole as on individual institutions. Top-down stress testing applies the same model and the same set of assumptions to each bank. That allows for direct and transparent comparisons across banks, highlights particular areas of vulnerability in the banking system as a whole and captures the impact that actions by one bank can have on others in the system. The alternative, 'bottom-up' stress testing, uses a different model to assess each bank. This can capture more detailed bank-specific information than a top-down model, but does not allow for direct comparisons across banks.

In 2010, the Government outlined plans for reform of the UK regulatory framework, including the creation of an independent Financial Policy Committee (FPC) at the Bank of England. The FPC is charged with identifying, monitoring and taking action to remove or reduce systemic risks with a view to protecting and enhancing the resilience of the UK financial system. For more information on the FPC, see the box on page 206. In forming an assessment of the outlook for the stability and resilience of the financial sector, the FPC will consider a wide range of information, including outputs from models such as RAMSI.

RAMSI has been under development at the Bank of England for several years and previous publications have set out the details of the model.[2] This article provides a high-level summary of how RAMSI can be used as a tool to analyse the outlook for, and the risks surrounding, the UK banking sector. The first section gives an overview of RAMSI. The second section illustrates the use of RAMSI as a stress-testing tool, focusing on the IMF's 2011 UK Financial Sector Assessment Program (FSAP).

The FSAP was constructed in early 2011. As a result, the FSAP stress test described in the article is not reflective of current conditions and the results do not take into account the changes in balance sheets, macroeconomic conditions or policy measures that have occurred since the time of the test.

## An overview of the model

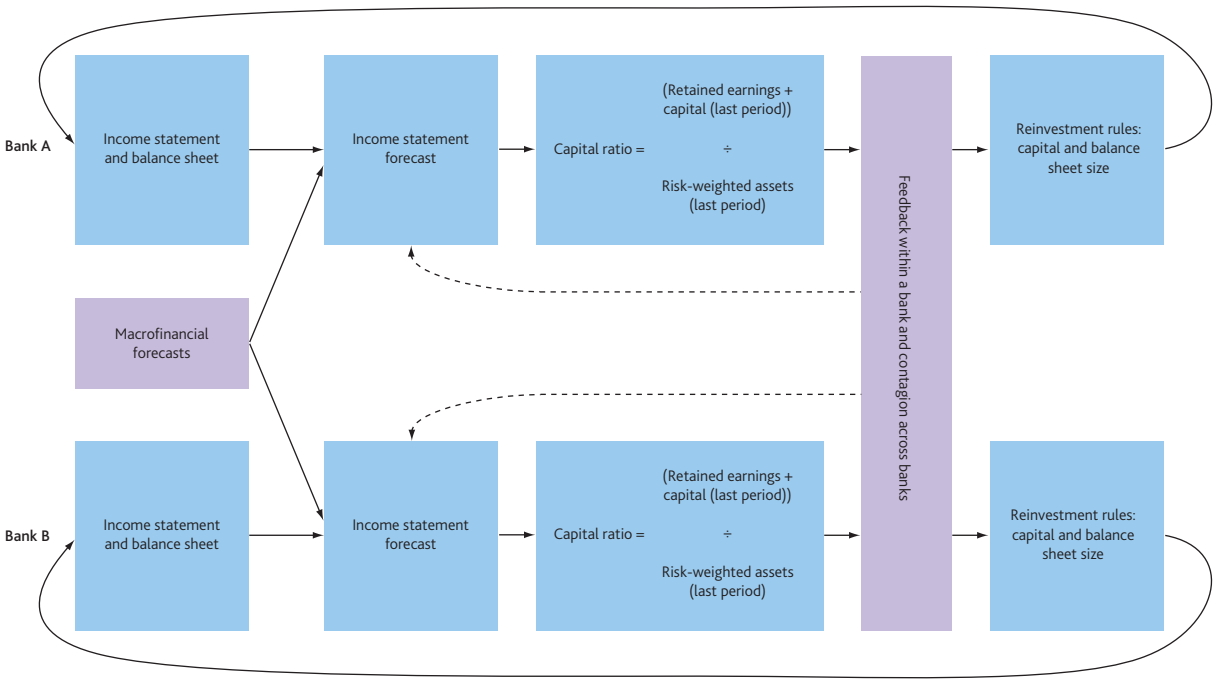
### Structure of RAMSI

RAMSI is a model that generates projections for UK banks' profits. It uses a set of equations estimated by Bank staff to map projections for macroeconomic and financial variables, such as GDP and interest rates, into profiles for profits at the largest UK banks. The equations in RAMSI model each component of each bank's income. To do this, the equations use data from each bank's income statement, data on the composition of each bank's balance sheet (its stock of assets and liabilities) and projections for macrofinancial variables.[3] Alessandri *et al* (2009) describe the estimation and robustness of each of the equations. This article does not go into such detail, but instead focuses on the intuition underlying RAMSI and how it can be used in a stress-testing context.

RAMSI is designed to be straightforward and easy to interpret. Forecasts of banks' income are largely based on simple econometric equations. And banks' responses to exogenous

(1) The authors would like to thank Aaron Clements-Partridge for his help in producing this article.
(2) Burrows, Learmonth and McKeown (2012) provide a more detailed description of the model. And previous publications have provided a description of the structure of the prototype model (see Alessandri *et al* (2009)) and an exploration of how the model might be used to generate liquidity feedbacks (see Aikman *et al* (2009)). At the time of the earlier publications, development of the model was in its preliminary stages and any results presented were purely illustrative.
(3) The macrofinancial data set used in RAMSI has a quarterly frequency, while balance sheet and income statement data for the banks are generally updated semi-annually, in line with UK banks' historical disclosure practice.

**Figure 1** Stylised overview of RAMSI




shocks are dictated by behavioural rules, not by the solution to a forward-looking optimisation problem. This makes it easy to trace the impact of a shock through the model and to provide a clear account of the result — an aspect that is particularly desirable in a policymaking context. But this approach does have some disadvantages. For example, the lack of optimising behaviour means that banks in RAMSI largely act in a passive manner, as discussed below.

**Figure 1** gives a stylised overview of the sequence of events that occur in each period in RAMSI. The diagram shows just two banks for simplicity rather than all the banks in RAMSI.

## Generating results and feedback effects

Starting from the left of **Figure 1**, there are two sets of inputs to RAMSI: banks' income statements and balance sheets, and forecasts of macrofinancial variables. These combine with the estimated equations in RAMSI to generate a projection for each individual item in each bank's income statement. Each bank's profit before tax can then be calculated as the sum of net interest income, trading income and other income, less credit losses and operating expenses. And each bank's retained earnings is that profit before tax less dividends and taxes.

Once retained earnings forecasts have been generated, each bank's capital position can be updated and its capital ratio can be calculated as the ratio of core Tier 1 capital to risk-weighted assets.(1) At this stage, feedbacks both within and across banks can occur, as represented by the dashed lines in **Figure 1**. For example, if bank fundamentals such as profitability and solvency were projected to worsen, banks would experience higher costs of funding in RAMSI. In addition, if fundamentals passed certain thresholds, banks would be shut out of certain funding markets altogether, further pushing up their funding costs.

These feedback effects extend to interactions across banks. For example, a bank that is perceived to resemble a bank that has already been shut out of funding markets would experience an increase in the likelihood of being shut out of these markets itself.

The most direct forms of contagion occur when a bank suffers losses so severe that its capital ratio falls below a set threshold and it is deemed to have failed. Feedback effects then cause losses at other banks through, for example, counterparty credit exposures (when a bank defaults, other banks may experience losses on any assets they hold related to that bank) and asset fire sales (when a bank is in trouble it may sell assets, which can push down the prices of those assets and so cause mark-to-market losses at other banks).

## Retained earnings and capital ratios

In the absence of bank failures, or after the feedback effects are completed, any retained earnings are used to update the banks' balance sheets. At this point, all top-down models have to make an assumption about what banks do with these earnings. One option is that banks use a certain proportion of their earnings to increase the amount of risk-weighted assets

(1) Core Tier 1 capital is a commonly used measure of a bank's ability to absorb losses, and is defined as common shareholders' equity, adjusted for goodwill and intangibles and regulatory deductions. Risk-weighted assets are a measure of a bank's assets, such as loans to households and companies, weighted to take account of how risky they are. The risk weightings reflect the Basel Capital Accord as implemented by the Financial Services Authority.

## The formation of the Financial Policy Committee

Safeguarding financial stability is one of the Bank of England's two core purposes. In 2010, the Government outlined plans for reform of the UK regulatory framework, including the creation of an independent Financial Policy Committee (FPC) at the Bank of England, a Prudential Regulation Authority (PRA) as a subsidiary of the Bank and a separate Financial Conduct Authority (FCA) to regulate conduct in financial markets and financial institutions not covered by the PRA.(1) In anticipation of legislation to create the FPC, the Government and the Bank announced the establishment of an interim FPC on 17 February 2011. The interim Committee comprises eleven voting members — five current executives from the Bank of England, the head of the PRA-designate, the Chairman of the Financial Services Authority (FSA), and four external members. The Head of the Conduct Business Unit of the FSA and CEO Designate of the FCA attends meetings in a non-voting capacity, as does a representative of HM Treasury.

The Government envisages that the FPC will contribute to the Bank's financial stability objective by identifying, monitoring and taking action to remove or reduce systemic risks with a view to protecting and enhancing the resilience of the UK financial system. Subject to that, a secondary objective for the FPC is to support the economic policy of the Government. The first policy meeting of the interim FPC was held in June 2011. The Government's consultation document states that the FPC will meet at least four times a year and will publish a record of its formal meetings. It will also be responsible for the Bank's twice-yearly *Financial Stability Report* (*FSR*).

The Government proposes providing the FPC with two main powers to address systemic risks. First, the FPC would have the power to make a recommendation that the PRA and FCA would have to either comply with or explain in writing to the FPC why they had not done so. The FPC could also make recommendations to bodies other than the PRA and FCA, but without the comply-or-explain mechanism. Second, the FPC would have the power of direction over certain macroprudential tools, which the PRA and FCA would be required to implement.

In March 2012, following HM Treasury's earlier request, the interim FPC agreed unanimously a statement outlining its advice on potential powers of direction for the statutory FPC. This included that the FPC should seek powers of direction over a countercyclical capital buffer, sectoral capital requirements and a leverage ratio. In addition to banks, the range of institutions to which these tools would apply could include building societies, investment firms, insurers and a variety of funds and investment vehicles. The Committee also identified a number of other potential instruments that may be desirable, but decided not to include them in its advice on initial powers of direction.(2)

Although lacking the proposed statutory powers of direction and recommendation of the statutory FPC, the interim FPC contributes to maintaining financial stability by identifying, monitoring and publicising risks to the stability of the financial system and advising action to reduce and mitigate them. For example, it has made recommendations that the major UK banks improve their disclosure of exposures and that they build a sufficient cushion of loss-absorbing capital against current risks.

In forming an assessment of the outlook for the stability and resilience of the financial sector, the FPC will consider a wide range of information, including outputs from models such as RAMSI. Recent *FSRs* provide an indication of some of the information that the FPC might consider in forming these assessments.(3)

(1) See www.hm-treasury.gov.uk/d/consult_financial_regulation_condoc.pdf.
(2) See www.bankofengland.co.uk/financialstability/Documents/fpc/statement120323.pdf.
(3) For example, the June 2012 *FSR* can be found at: www.bankofengland.co.uk/publications/Pages/fsr/2012/fsr31.aspx.

they hold, and retain whatever is left over as capital. Another option is to assume that each bank has a specific capital ratio target in mind. In that case, banks would only increase their risk-weighted assets once they have met those targets.

As a conditioning assumption, the illustrations presented in this article assume that banks behave in accordance with the second option: they have a specific capital ratio target in mind. This seems an appropriate description of observed bank behaviour, especially in the current environment where the market is focused on banks' resilience. A number of profiles for each bank's capital ratio target could be specified: for example, banks could be assumed to have targets that are unchanged from their current ratios, or to have targets that increase over time, perhaps based on prospective regulatory requirements. If a bank does not earn sufficient profit to hit its capital ratio target, it will not increase its risk-weighted assets. If, however, a bank is at or above its capital ratio target, it will increase its risk-weighted assets to ensure a ratio equal to its target.(1)

Once any reinvestment of earnings has taken place, the next period begins. The updated assets and liabilities on each

(1) Any increase in the size of a bank's balance sheet is assumed not to alter the composition of that balance sheet — so the proportions of the different types of risk-weighted assets in the balance sheet are unchanged.

bank's balance sheet combine with the macrofinancial conditions in that period, and the sequence of events shown in **Figure 1** is repeated. RAMSI is therefore a complex feedback loop. For example, if banks make sufficient income, they increase their risk-weighted assets, which can allow them to make more income, and so on.

## The IMF's 2011 UK FSAP: illustrating the use of RAMSI as a stress-testing tool

RAMSI can be used to run stress tests of the UK banking system. Stress tests are forward-looking evaluations of the resilience of banks to a range of plausible but severe paths for the macroeconomy and financial markets. They provide supervisors, and the banks themselves, with a better understanding of weaknesses and vulnerabilities in the financial system, and can be an important input into supervisory actions and banks' planning decisions.

This section provides an example of how RAMSI can be used as a top-down stress-testing tool based on the example of the IMF's 2011 UK FSAP.(1) An FSAP is a comprehensive and in-depth analysis of a country's financial sector. For the world's 25 biggest and most interconnected economies, including the United Kingdom, these assessments happen every five years. The 2011 UK FSAP contained both top-down — using RAMSI and the IMF's Contingent Claims model — and bottom-up stress tests — run by the banks themselves under the oversight of the Financial Services Authority (FSA).

It is important to note that the 2011 UK FSAP was based on banks' balance sheets as they were at the end of 2010, and that the stress test was constructed in early 2011 — so it reflects the conditions at that time. As a result, the stress test described below is not reflective of current conditions and the results do not take into account the changes in balance sheets, macroeconomic conditions or policy measures that have occurred since the time of the test.

It is also important to note that there is always uncertainty around the results of any stress test. One reason for this is that an actual period of stress is likely to involve different paths for macroeconomic and financial variables than those assumed in the test. Moreover, even if the paths for the macrofinancial variables were correct, there would be uncertainty about how those paths would affect banks' income and capital ratios — RAMSI is only one possible model of that relationship.

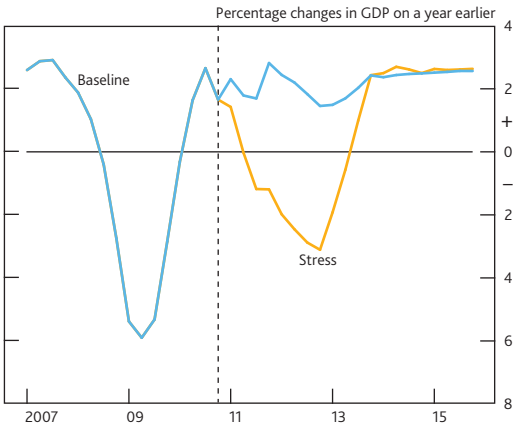
### The FSAP macroeconomic scenarios

The FSAP outlined a baseline and three distinct stress scenarios over a five-year period (2011–15). The baseline is a non-stress scenario, which provides a comparison for the stress scenarios. The baseline scenario in the 2011 UK FSAP was a projection of the profits, losses and capital growth of banks under the specific assumptions for bank behaviour described below, combined with the IMF's central macroeconomic projections from its *World Economic Outlook*.

Two of the stress scenarios simulated 'double-dip' recessions of differing magnitude, one more moderate and one severe, and shared similarities with other stress tests: the European Banking Authority (EBA) stress-test scenario in the 2011 EU-wide exercise and the FSA's 2011 anchor stress-test scenario. The two scenarios involved simultaneous adverse demand and supply shocks, emanating from a sharp fall in demand from the rest of the world for UK exports and a rise in commodity prices respectively. The third scenario was unique to the FSAP, and outlined a negative shock to productivity that markedly reduced the trend growth rate of the UK economy.

The focus in this article is on the 'severe double-dip' stress scenario.(2) It involved annual average UK real GDP growth in 2011 of -0.2% (compared with +2.2% in the baseline), -2.6% (+2.0%) in 2012 and +0.2% (1.9%) in 2013 (**Chart 1**). The assumptions for both the baseline and the stress test were provided by the IMF to ensure that the results would be comparable with those from the other stress tests carried out as part of the FSAP.

**Chart 1** UK real GDP growth in the FSAP(a)



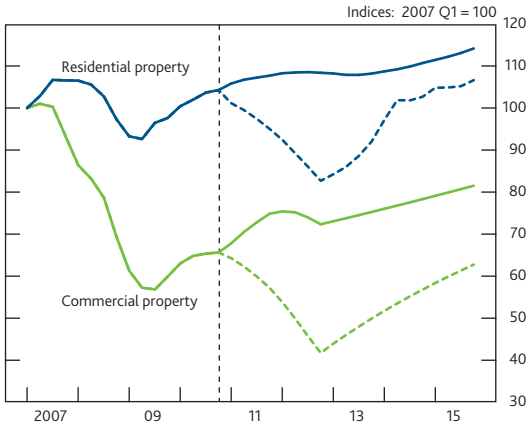

Source: IMF.

(a) Data to the right of the dashed vertical line are projections.

The severe double-dip scenario also included sharp falls in house and commercial property prices (**Chart 2**), as well as equity prices, along with a large persistent increase in the unemployment rate. Because the scenario included a shock to the United Kingdom's supply capacity, inflationary pressures were projected to remain fairly elevated, and abated only gradually. So despite depressed demand, short-term interest rates in these scenarios increased gradually over the forecast period, broadly in line with the baseline projection. Long-term

(1) For a general overview see www.imf.org/external/pubs/ft/scr/2011/cr11222.pdf.
(2) The results of the other two stresses can be seen in the Technical Note accompanying the FSAP: www.imf.org/external/pubs/ft/scr/2011/cr11227.pdf.

**Chart 2** Non-financial asset prices in the FSAP[a]




Sources: Bank of England, Department for Communities and Local Government, IMF, Investment Property Databank and Bank calculations.

(a) Solid (dashed) lines show baseline (stress) scenario. Data to the right of the dashed vertical line are projections.

interest rates were projected to be lower than in the baseline, however. Internal Bank of England macroeconomic models were used to generate projections for the other macrofinancial variables used in RAMSI but not fixed by the FSAP, such as household income gearing and unsecured debt levels.

## Underlying assumptions made in the stress test

The conditions under which any test is run are an important determinant of the results, and small changes in definitions can lead to large changes in the results. The main assumptions underlying the top-down stress tests are described below.

### Capital ratio targets

An important assumption in RAMSI is the choice of banks' capital ratio targets. As discussed earlier, these targets determine how banks use their retained earnings. For example, a high capital ratio target may lead to retained earnings being used to invest in safe assets, while a lower target might allow more room to increase risk-weighted assets. The choice will have implications for profits in the following period. On the one hand, riskier assets tend to have a higher yield. On the other hand, if capital ratios are too low then funding costs will tend to rise, eating into profits. Higher profitability will support balance sheet expansion in future periods. The FSAP stress test included relatively challenging capital targets.

The setting of capital targets is one of the ways that this particular illustration of a top-down stress test differs from the majority of stress tests. The FSAP bottom-up tests, for example, require each bank's risk-weighted assets to grow in line with nominal GDP, while the recent EBA stress tests imposed the assumption that risk-weighted assets were held constant over the projection. In the application of RAMSI illustrated here, risk-weighted asset growth is a function of banks' actual and target core Tier 1 capital ratios, and cannot be exogenously imposed.

### Dividends

It is assumed that banks' dividend policies are linked to their capital levels in the baseline and stress scenarios. If banks are on course to meet their capital targets, then dividends are paid as a proportion of profits — where the proportions are calibrated based on those observed at the end of 2010. But if banks are not on course to meet their capital targets, they do not pay out dividends, and retain all income instead. There are other plausible assumptions that could be made about banks' dividend policies. For example, competition could lead banks to increase dividends prematurely.

### Provisions

Banks set aside funds — provisions — to cover anticipated future losses, and how to treat those provisions appropriately is a challenging issue faced in all stress tests. The FSAP baseline and stress scenarios use the credit equations in RAMSI to forecast bank-by-bank write-offs. UK banks built up a stock of provisions from 2008 and, in the stress tests, banks are assumed to deplete that stock to cover some of the write-offs, using the assumption that starting stocks fall back halfway to their pre-crisis averages by the end of the projection. That is equivalent to forecasting lower credit losses than would be suggested by write-offs alone, and therefore boosts banks' profitability relative to that counterfactual.

### Asset disposals

In line with the guidelines provided for the FSAP bottom-up tests and the recent EBA stress tests, the exercise did not incorporate planned asset disposals by UK banks. In practice, however, asset disposals would boost capital ratios by reducing risk-weighted assets. In that case, both the top-down and bottom-up results would overstate the need for banks to retain earnings to build up capital.

### Haircuts

The FSAP assumed that the value of banks' holdings of certain debt instruments would be reduced in the stress scenario — those reductions in values, called haircuts, were applied to the UK banks' holdings of certain sovereign and bank debt. Banks' holdings of these assets were estimated using the most recent data available at the time of the exercise, which were Bank for International Settlements exposures data for bank debt holdings and 2010 Committee of European Banking Supervisors stress-test disclosure data for sovereigns.

## Results under the stress scenario

The baseline and stress scenarios were run for the largest five providers of banking services to the UK economy: Barclays, HSBC, Lloyds Banking Group, Royal Bank of Scotland and Santander Group. The results of the baseline scenario are described in the box on page 210.

In the stress scenario, profits were projected to be materially weaker than in the baseline. Banks in aggregate were forecast

to make a small loss in the first year of the projection (2011) (**Chart 3**), and profits in future years were significantly lower than in the baseline scenario (**Chart 4**). Over the projection as a whole, those lower aggregate profits were due to lower trading income and net interest income, as well as higher credit losses and haircuts on debt.

**Chart 3** also shows how the projections for profitability under the stress scenario compares to actual bank profitability during the financial crisis. In 2008, aggregate profits for the largest five UK banks were negative: two banks made large losses and profits dipped at the others. And profits remained low in 2009. In the stress scenario, aggregate profits in 2011 and 2012 were projected to be comparable to those made in 2008 and 2009, which suggests that the stress scenario represented a similar-sized shock to aggregate profits as that experienced during the crisis.

The total reduction in aggregate profits over the five years of the stress scenario, relative to the baseline, was around £115 billion (**Chart 4**), or 60% of profit in the baseline. The components of profit driving that result are described in more detail below.

## Components of banks' profits

### Net interest income

Across the first two years of the stress scenario, net interest income in aggregate was projected to be over £20 billion weaker relative to the baseline. In the stress scenario, banks' funding costs increased and because it was assumed that banks could not immediately pass on to customers that rise in their funding costs, banks' profitability was squeezed.

### Credit losses

Credit losses were the largest driver of the reduction in profits in the stress scenario over the five-year period, reducing profits by around £50 billion relative to the baseline. But much of this effect was slow to come through, with the peak impact of the stress scenario on credit losses in 2014 (**Chart 4**). The lags in the transmission from macroeconomic deterioration to banks' credit losses reflects the fact that it takes time for borrowers to fall into distress following a shock to their income, and that it takes banks some time to record losses once borrowers have fallen into distress.

### Trading income

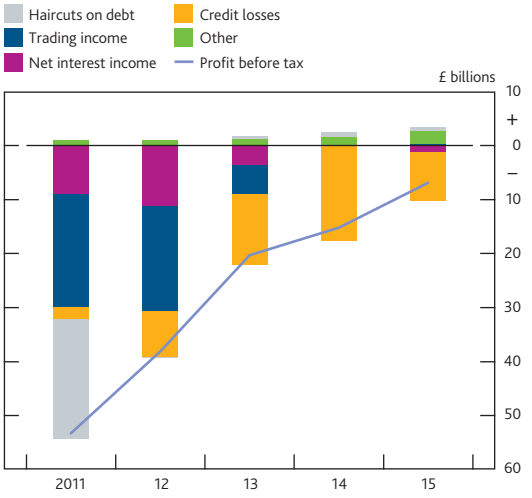
The largest impact on profits over the first few years of the stress scenario came through trading income. Trading income was about £45 billion lower than in the baseline over the first three years of the stress scenario. Trading income fell during the 2008/09 recession and this experience was used to calibrate the likely fall in income given the fall in GDP in the stress scenario.

**Chart 3** Aggregate profits in the stress scenario[a]


Sources: Published accounts and Bank calculations.

(a) Data to the right of the dashed vertical line are projections. The combination of other income and operating expenses is shown as 'Other'.

**Chart 4** Aggregate UK banks' profits, stress scenario relative to the baseline[a]




Sources: Published accounts and Bank calculations.

(a) The combination of other income and operating expenses is shown as 'Other'.

### Other income and operating expenses

Other income fell, relative to the baseline, in the stress scenario, in line with its historical procyclical relationship with GDP growth. But its effect on headline profits was muted by a fall in operating expenses, which are themselves related to income. As a result, their combined impact is negligible (**Chart 4**).

### Haircuts

The haircuts had a large impact on aggregate profits in the first year of the stress scenario. They lowered profits by more than £20 billion in 2011, relative to the baseline.

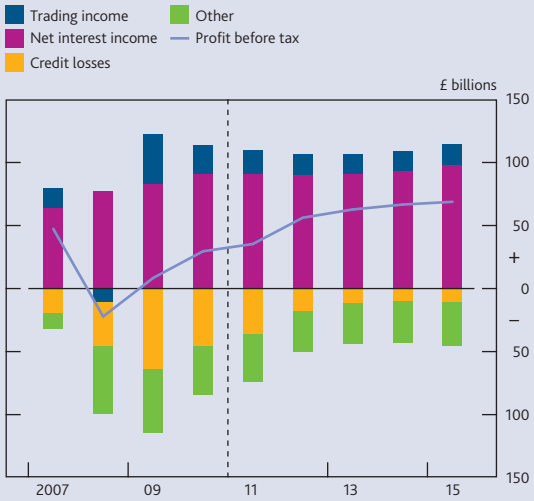
## Outcome for banks' capital ratios

The combined impact of these elements of profits pushed core Tier 1 capital ratios in the stress scenario materially

## The baseline scenario

**Chart A** shows the breakdown of UK banks' profits before tax in the baseline scenario. Profits were projected to rise steadily over the five-year projection, largely driven by smaller credit losses. There are two factors behind this. First, as the macroeconomic outlook improved and unemployment fell, write-off rates declined. Second, the assumed partial release of excess provisions built up over the crisis to cover potential write-offs further reduced credit losses.

**Chart A** Aggregate profits in the baseline scenario(a)




Sources: Published accounts and Bank calculations.

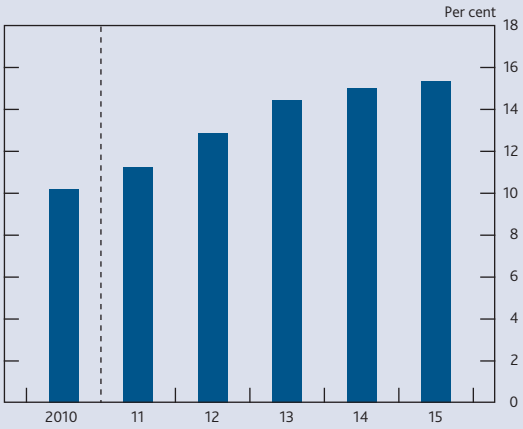
(a) Data to the right of the dashed vertical line are projections. The combination of other income and operating expenses is shown as 'Other'.

UK banks collectively generated a small increase in net interest income over the five-year period in the baseline scenario, due to the rise in short-term interest rates over the forecast period.(1)

The profitability of trading activity returned to around pre-crisis levels for most banks, although trading income over the projection was substantially lower than the level seen in 2009.

The projected increase in profitability translated into higher capital ratios across the banks. **Chart B** shows that, on a Basel II basis, UK banks' aggregate core Tier 1 capital ratios were projected to increase by 5 percentage points over the five years in the baseline scenario.

**Chart B** Aggregate core Tier 1 capital ratio in the baseline scenario(a)




Sources: Published accounts and Bank calculations.

(a) Aggregate capital ratio defined as total core Tier 1 capital as a percentage of total risk-weighted assets. Expressed in Basel II terms. Data to the right of the dashed vertical line are projections.

As noted previously, banks may choose in practice not to meet the capital targets imposed in the exercise, or capital ratios may be increased through asset disposals. In both cases that would allow banks to increase their risk-weighted assets by more than suggested here. In addition, the projections did not take account of the possibility that banks could raise capital externally, for example, through public issuance in the equity markets.

(1) See Alessandri and Nelson (2012) for evidence of how UK bank profitability is affected by interest rates.

below the baseline scenario (**Chart 5**). And although capital did not fall sufficiently far at any bank to trigger the various crisis effects modelled in RAMSI — in which banks can be shut out of funding markets and/or forced to sell liquid assets, with knock-on effects for other banks — risk-weighted assets expanded at a slower pace than in the baseline scenario.

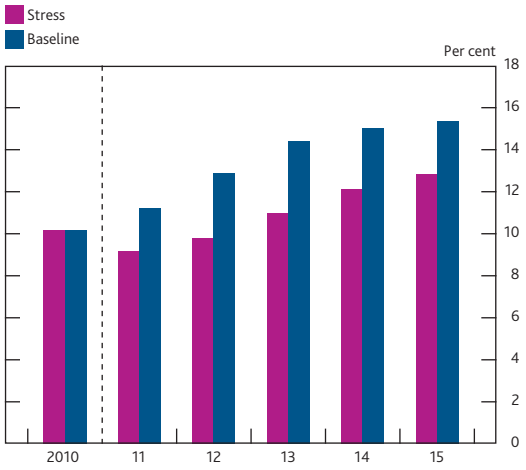
Taken at face value the results suggested that the UK banking system would have been resilient to a severe macroeconomic downturn. But the results are highly uncertain and are sensitive both to the top-down approach using RAMSI and to the particular assumptions that have been used.

### Identification of system-wide risks

Although the UK banking sector appeared to be relatively resilient, the FSAP stress test highlighted some areas in which the UK banking sector might be vulnerable to specific shocks. One such risk is the potential for overreliance on wholesale funding. A prolonged period of higher funding costs could have a damaging impact on banks' aggregate profits.

The FSAP exercise also identified that haircuts on sovereign and bank debt could have a significant impact on system-wide profitability. In the second half of 2011, following the publication of the FSAP, banks' exposures to certain European sovereigns came under close scrutiny by financial markets.

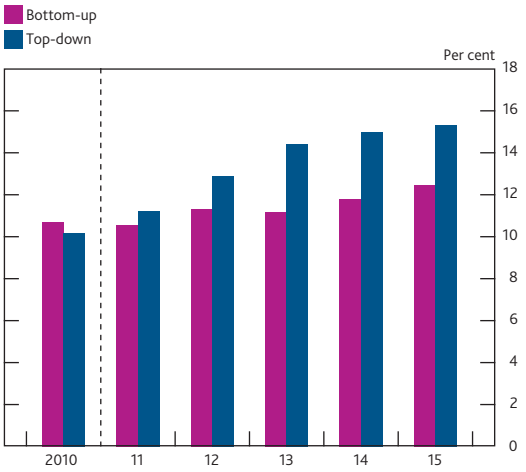
**Chart 5** Aggregate core Tier 1 capital ratios: stress and baseline scenarios[a]




Sources: Published accounts and Bank calculations.

(a) Aggregate capital ratio defined as total core Tier 1 capital as a percentage of total risk-weighted assets. Expressed in Basel II terms. Data to the right of the dashed vertical line are projections.

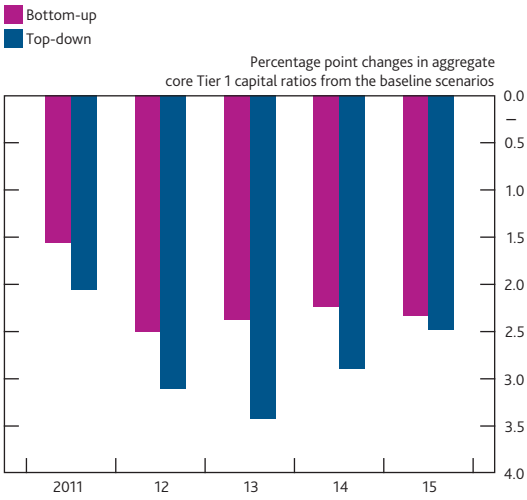
**Chart 6** Aggregate core Tier 1 capital ratios: bottom-up and top-down baseline scenarios[a]




Sources: FSA, published accounts and Bank calculations.

(a) Aggregate capital ratio defined as total core Tier 1 capital as a percentage of total risk-weighted assets. Data to the right of the dashed vertical line are projections.

**Chart 7** Impact of the stress scenario on aggregate core Tier 1 capital ratios: bottom-up and top-down results[a]




Sources: FSA, published accounts and Bank calculations.

(a) Aggregate capital ratio defined as total core Tier 1 capital as a percentage of total risk-weighted assets.

And haircuts could potentially be larger than those assumed in the stress test.

In contrast, an increase in credit losses following a severe global recession was not identified as a prominent risk to the banking system. It is possible that that result reflected conservative provisioning by banks over the period before the test was run, in which case the results are informative. But equally, it could be the case that the modelling of credit losses in RAMSI understated the possible impact. And it is important to note that although the exercise suggested that UK banks could have withstood a generalised global slowdown, it could say little about their resilience to sharp downturns in specific regions of the world.

### Comparison with the bottom-up results

An important check on the conclusions taken from the top-down stress test is to compare it with the aggregate bottom-up results, as shown in **Chart 6**. A notable difference between the results from the two tests is that the baseline core Tier 1 capital ratio projection was higher in RAMSI. It is difficult to identify exactly what drove that difference. One possible cause is the assumption about risk-weighted asset growth. Risk-weighted assets were assumed to grow in line with nominal GDP in the bottom-up tests, but were held flat until capital targets were met in RAMSI. The higher risk-weighted asset growth in the bottom-up tests would reduce capital ratios.

But despite the different baseline projections, comparisons of the impact of the stress scenario relative to those baselines is still useful. And the impacts on capital ratios of the stress scenario were broadly similar (**Chart 7**). But it is difficult to know whether this is due to the tests identifying the same risks and vulnerabilities to UK banks, or is simply due to chance.

Overall, however, the similarity of the stress-test impacts provides some reassurance about the robustness of the results.

## Conclusion

Top-down stress testing is a way of assessing the resilience of the financial system and can shed light on the vulnerabilities facing the system and the institutions within it. RAMSI is a top-down stress-testing model that has been developed at the Bank of England. The model makes it possible to consider the impacts of different macroeconomic stress scenarios on the UK financial system.

The RAMSI model was used as part of the IMF's 2011 UK FSAP exercise, alongside bottom-up stress tests run by banks and other top-down stress tests run by the IMF. It is important to note that the FSAP was based on banks' balance sheets as they were at the end of 2010, and that the stress test was constructed in early 2011 — so it reflects the conditions at that time. As a result, the stress test described in the article is not reflective of current conditions and the results do not take into account the changes in balance sheets, macroeconomic conditions or policy measures that have occurred since the time of the test. For example, the stress tests were carried out before the heightening of concerns, from the summer of 2011, about the sustainability of imbalances within the euro area.

The FSAP exercise tested the resilience of the UK banking system to a severe global downturn, which included large falls in UK output and property prices. The results from the RAMSI model suggested that such a scenario would have material impacts on UK banks' profits and capital ratios. In particular, the results highlighted the potential vulnerability of UK banks to wholesale funding market stresses and to substantial sovereign debt haircuts. But, despite these material impacts, the results suggested that the UK banking system was resilient enough to withstand the severe scenarios considered in the exercise. The results from RAMSI were consistent with the results from the other stress-test elements of the FSAP.

Looking ahead, the Bank hopes to develop RAMSI further to understand better the second-round effects that are the hallmarks of systemic crises. RAMSI already includes some prototype feedback mechanisms — for example, for funding liquidity and asset fire sales — but the aim is to improve these mechanisms as well as to introduce macroeconomic feedback loops.

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# What accounts for the fall in UK ten-year government bond yields?

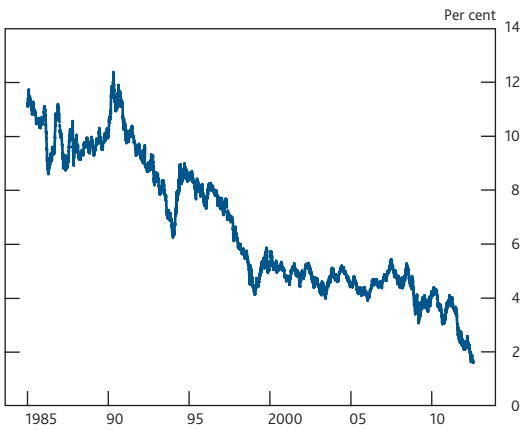
By Rodrigo Guimarães of the Bank's Macro Financial Analysis Division.[1]

Financial market measures of future interest rates and inflation rates can provide useful and timely information for policymakers. Recent advances in yield curve modelling have improved the Bank's capacity to extract policy-relevant information from these market measures. Such models suggest that the fall in the yield on UK ten-year nominal government bonds since the onset of the financial crisis largely reflects lower expectations of real interest rates at shorter horizons, consistent with an expectation that policy rates will remain low for some time. The model estimates also indicate that inflation expectations have been relatively stable, and suggest that there are no signs that they have become less well anchored.

Market interest rates play a crucial role in the transmission mechanism of monetary policy.[2] They also contain timely information on financial market participants' expectations of future policy rates, which will be related to their perceptions of current and expected future economic developments. Market participants' perceptions of risk are also reflected in these interest rates.

One measure of market interest rates is the yield on government bonds. UK government ten-year nominal spot yields[3] (**Chart 1**) — a key benchmark for government borrowing costs — have recently been at a historical low, at less than half their average rate between 1997 and 2007. The low level of government bond yields in the United Kingdom and in several other major economies[4] has received extensive coverage.

**Chart 1** UK ten-year nominal spot rates




Sources: Bloomberg and Bank calculations.

In order to extract policy-relevant information from yields, it is important to understand what has driven these rates lower. Decompositions can be carried out along a number of dimensions to shed light on the drivers. First, movements in ten-year spot rates can be split into movements at different points within the ten-year maturity to assess whether the changes are mainly at shorter or longer horizons. Second, movements in nominal rates can be decomposed into changes in real interest rates and changes in implied inflation rates. And third, movements in nominal rates can be divided into the part that reflects changes in market participants' expectations and the part associated with changes in their required compensation for risk ('risk premia').

Policymakers care about these decompositions because influencing the expected path of the policy rate plays an important role in the transmission mechanism of monetary policy. Because monetary policy controls short-term rates, but has much less discretion in affecting longer-term rates, the maturity profile matters. In addition, beliefs about future inflation play a role in determining the rate of inflation, so it is important for the Monetary Policy Committee (MPC) to monitor indicators of inflation expectations, such as those derived from financial markets. And estimating risk premia can give policymakers an indication of market participants' assessments of risks.

(1) The author would like to thank David Latto for his help in producing this article.
(2) See Bank of England (1999) for a discussion of the transmission mechanism.
(3) All yields in this article are zero-coupon, continuously compounded, government bond yields. UK data and further information are available at www.bankofengland.co.uk/statistics/Pages/yieldcurve/default.aspx.
(4) Government bond yields in the United States and Germany have behaved similarly, although they have risen for some other countries. For details of recent moves in government bond yields, see the 'Markets and operations' article on pages 186–201 in this *Bulletin*. Here the focus is on UK yields.

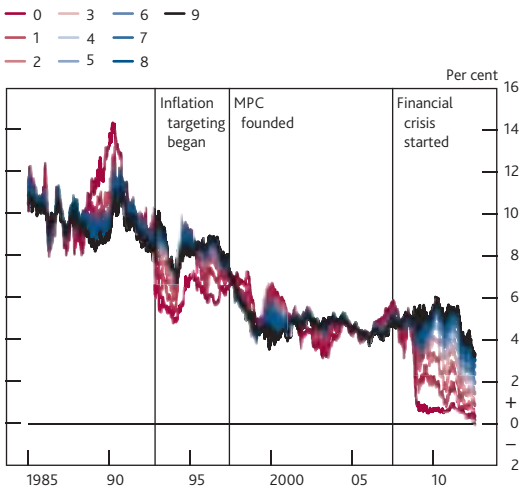
This article carries out these decompositions and assesses which of the components can account for the fall in ten-year nominal spot rates since the start of the financial crisis. The first section decomposes movements in UK ten-year nominal spot rates into changes at different maturities. It also splits nominal yields into real and implied inflation rates. The second section explains what risk premia are and how they can be disentangled from expectations of future interest rates and inflation. The third section uses recent work undertaken at the Bank of England to decompose yields into the components reflecting expectations of future rates and the risk premium. A final section concludes.

## Decomposing nominal rates by maturity and into real and inflation rates

The ten-year spot rates shown in **Chart 1** are the average rates that apply over a ten-year period. But there can be substantial variation in shorter-term rates within that ten-year maturity. The ten-year spot interest rate can be decomposed into a series of short-term forward interest rates using yields at different horizons (the yield curve).(1) Forward interest rates are the rates that apply today to borrowing between some specified future periods; for example, the one-year forward rate four years ahead is the current rate at which it is possible to borrow for a one-year period starting in four years' time.

**Chart 2** shows a decomposition of the ten-year nominal spot rate into the ten successive one-year forward rates that cover that period. For example, the line labelled '4' shows the one-year forward rate four years ahead. On each date, the average of the ten one-year forward rates is equal to the ten-year nominal spot rate shown in **Chart 1**.

Chart 2 UK nominal one-year forward interest rates up to nine years ahead




Sources: Bloomberg and Bank calculations.

This decomposition shows that the fall in the ten-year spot rate since 2008 reflects the impact of one-year forward rates at different horizons falling at different times rather than a gradual but simultaneous decline of rates at all maturities. In 2008–09, shorter-horizon forward rates fell markedly as monetary policy was loosened. This largely reflects the Bank's response to the deterioration in the UK economic outlook — Bank Rate was cut from 5% in October 2008 to 0.5% in March 2009, and the asset purchase programme was announced.(2) By July 2011, one-year forward rates out to three years ahead were less than half their 1997–2007 averages. They have continued to fall since then, and are currently close to zero. That is consistent with an expectation that policy rates will remain low for some time.

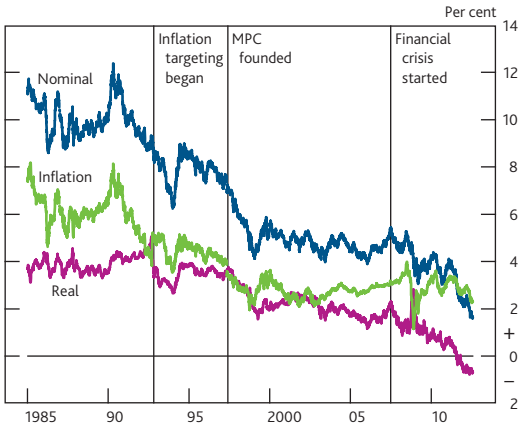
In contrast, longer-horizon forward rates remained closer to their averages over the decade to 2007 until recently. And despite the falls in longer-horizon forward rates over the past year, the short end of the yield curve still accounts for most of the fall in ten-year spot rates since 2008. While this is perhaps not surprising given the amount of policy easing, it shows that the fall in ten-year spot rates should not be taken to necessarily imply a decline in longer-term forward rates. Looking at even longer horizon forwards beyond ten years confirms this picture: the further ahead the horizon, the smaller are the observed falls in interest rates relative to their average level in the decade prior to the financial crisis.

Nominal spot rates can also be decomposed into real rates and implied inflation rates. UK real spot rates are extracted from retail prices index (RPI) index-linked government bonds. And the implied RPI inflation rate is calculated as the difference between the nominal and real rates. In this article, all inflation measures shown are based on the RPI, unless otherwise stated. **Chart 3** shows the UK government ten-year nominal spot rates along with the real and implied inflation rate components. It is clear from **Chart 3** that the ten-year spot implied inflation rate was the main driver of the fall in the nominal rate between the late 1980s and the 2000s, but since 2008 almost all of the fall in nominal rates is explained by decreasing real rates.

The difference in the main drivers of the fall in ten-year spot rates over these two periods is summarised in **Table A**, which presents data on the nominal interest rate, and its real interest rate and implied inflation rate components in more detail. The table presents average rates covering the eight-year period before the start of inflation targeting (1985–92 column) and the period between the creation of the MPC and the beginning of the financial crisis (1997–2007 column) to illustrate the

(1) For a review of interest rate concepts and the relation between spot and forward rates see Joyce, Sorensen and Weeken (2008), page 165. For a description of the methodology used to construct spot and forward yields used in this article see Anderson and Sleath (1999).
(2) See Joyce, Tong and Woods (2011) for evidence of quantitative easing announcement effects on bond yields.

**Chart 3** UK ten-year spot rates




Sources: Bloomberg and Bank calculations.

change in the average levels seen in the 1980s relative to those seen in the 2000s.(1) It also shows the changes in rates in each of the past three years relative to their 1997–2007 pre-crisis averages. Alongside data on the ten-year spot rate, data covering the first five years (five-year spot) and the second five years (five-year, five-year forward) of that ten-year period are shown for nominal, real and implied inflation rates.

**Table A** UK government rates since 1985

**Percentage points**

| | Averages | | Changes relative to pre-crisis[a] | | |
|---|---|---|---|---|---|
| | 1985–92[b] | 1997–2007[c] | July 2010 | July 2011 | July 2012 |
| **Nominal** | | | | | |
| Ten-year spot | 10.0 | 4.9 | -1.4 | -1.8 | -3.3 |
| Five-year spot | 10.1 | 5.0 | -2.8 | -3.3 | -4.5 |
| Five-year, five-year forward | 9.9 | 4.8 | 0.1 | -0.2 | -2.2 |
| **Real** | | | | | |
| Ten-year spot | 3.9 | 2.2 | -1.3 | -2.2 | -2.9 |
| Five-year spot | 3.6 | 2.3 | -2.4 | -3.5 | -3.7 |
| Five-year, five-year forward | 4.2 | 2.0 | -0.3 | -0.9 | -2.0 |
| **Inflation** | | | | | |
| Ten-year spot | 6.1 | 2.8 | -0.1 | 0.4 | -0.5 |
| Five-year spot | 6.5 | 2.8 | -0.5 | 0.2 | -0.7 |
| Five-year, five-year forward | 5.6 | 2.8 | 0.3 | 0.7 | -0.2 |

Sources: Bloomberg and Bank calculations.

(a) End-of-month values minus average from June 1997 to June 2007.
(b) Average from January 1985 to October 1992.
(c) Average from June 1997 to June 2007.

The table shows that ten-year nominal spot rates fell from an average of 10% in the pre-inflation targeting period to an average of 4.9% in the 1997–2007 period, with implied inflation rates accounting for two thirds of that fall. The recent fall in nominal ten-year rates relative to 1997–2007 has been almost entirely due to a decline in real rates, while implied inflation rates have remained more stable.(2) The table also shows that the fall in nominal ten-year rates in the 1990s was evenly distributed across the different horizons: the five-year spot and the five-year, five-year forward rates both fell by similar amounts. The fall since 2007 has been more concentrated in shorter maturities.

## Extracting information from asset prices and accounting for risk premia

Typically, investors dislike uncertainty about future income and require additional compensation for holding assets that have uncertain returns. That additional compensation is called a risk premium. In general terms, a risk premium is the difference between the expected return from a risky asset and the expected risk-free rate. Risk premia will be related to how uncertain people are about asset returns and how much they care about exposure to risk. For example, the more investors care about risk, the larger risk premia will be in absolute terms. But risk premia also depend on the economic outlook more generally, since this will influence the impact that risks have on investors. If returns on risky assets tend to be particularly low during bad times — when investors would value some additional income most highly — they will require extra compensation to hold the asset (relative to a risk-free asset). But if returns on risky assets tend to be high during bad times, 'risky' assets actually help to insure investors. Investors will therefore be willing to pay a premium to hold the asset. In the first scenario risk premia will be positive, and in the second scenario risk premia will be negative.

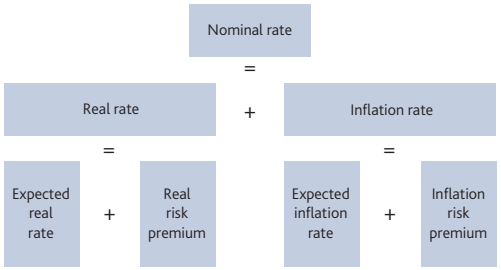
Index-linked bonds pay out a pre-specified real rate, so the only risk is what real risk-free rates will be in the future. The risk premium part of real rates derived from index-linked bonds is referred to as the real risk premium. The cash flows on conventional bonds (nominal bonds) are specified in terms of a fixed amount of money. This means that investors are also exposed to uncertainty over future inflation rates, which erodes the real value of the cash flows. That additional risk premium part of the nominal bond rate is referred to as the inflation risk premium. **Figure 1** shows how nominal rates can be decomposed into expected and risk premium components for both their real and inflation parts.

If risk premia were negligible or constant, then changes in expectations about the future could be inferred in a straightforward way from changes in asset prices. But there is considerable evidence that risk premia in all markets are significant and time varying.(3) That means that, in order to extract expectations from asset prices correctly, risk premia have to be estimated. In addition, risk premia themselves can

(1) See Benati (2005) for a discussion of the evolution of the implementation of the inflation-targeting regime in the United Kingdom and King (2007) for a discussion of the operational independence of the Bank of England and creation of the MPC.
(2) This result also holds for the United States and a composite of German and French yields for the past five years. But the data are not available for the entire sample considered here.
(3) See Cochrane (2011) for a recent comprehensive survey.

contain useful information for policy, for example on investors' perceptions about the balance of risks around the outlook for inflation.

**Figure 1** Decomposing nominal yields




In order to disentangle the expected and the risk premia components of an observed change in market rates, economic models or survey information (or a combination of both) can be used. Surveys of private forecasters can be used to infer expectations directly, but they tend to be published only monthly or quarterly, are generally available for only a subset of time horizons, and typically have a shorter span of historical data than yield curves. In contrast, economic models allow decompositions for any period and maturities for which yields are available. Some models can incorporate information from both surveys and yield curves and thus capture the advantages of both.

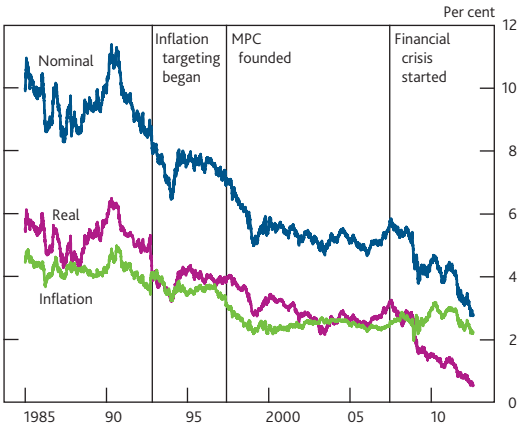
That approach of using information from both yield curves and survey expectations is the one taken in this article, building on previous Bank research. Joyce, Lildholdt and Sorensen (2009) used a Gaussian affine dynamic term structure model (G-ADTSM) — a standard method of modelling interest rates — to extract risk premia from UK nominal and real yields. In that model, one-month risk-free nominal interest rates, inflation rates and bond yields are modelled as a standard vector autoregression (VAR) — a system of equations where each variable depends on the past values of all the variables in the model. The model then allows the decomposition into separate risk premia and expectation components; the VAR allows us to calculate expected future rates, and the risk premia is then the difference between the model-implied bond yields and the expected future rate. Surveys give additional information on the expected nominal interest and inflation rates and so can be included in the model. The box on page 217 discusses these models in more detail.

Recent work undertaken in the Bank extends the model of Joyce, Lildholdt and Sorensen (2009) to, among other things, better fit the short end of the yield curve, which, as discussed in the previous section, has accounted for the majority of the change in yields over the past five years. In part, that is done by incorporating survey information on short-term interest and inflation rate forecasts in the model estimation. The box on page 217 also has more details on the model used in this article. In the next section the decomposition of the ten-year spot rate into its different components, as illustrated in **Figure 1**, is shown based on this new model.

## Historical model decomposition of UK yield curves

The model decomposition suggests that both inflation and real rate expectations contributed to the fall in nominal expected rates during the 1990s, but that since the beginning of the crisis, expected real rates have accounted for most of the fall in expected nominal yields (**Chart 4**). This is not surprising given the breakdown shown in **Chart 3** and **Table A**, which showed that real rates accounted for most of the recent fall in nominal rates.

**Chart 4** Model estimates of ten-year spot expected rates




Source: Bank calculations.

The model decomposition also suggests that risk premia have varied over time (**Chart 5**). There were particularly large falls in inflation risk premia during the 1990s. In part, that might be related to the adoption of the UK inflation-targeting regime in 1992 and the operational independence of the Bank of England in 1997.(1) Between 1997 and 2007, real and inflation risk premia moved within a relatively narrow range. Over the past five years, however, there has been more substantial variation in risk premia, which accounted for a large part of the variation in the implied inflation rate and the temporary spike in real rates seen just after the bankruptcy of Lehman Brothers (**Chart 3**). But despite the volatility within the past five years, the recent levels of risk premia have been little different from their pre-crisis averages. **Table B** shows that the nominal risk premium was only 0.7 percentage points below its pre-2007 average in July 2012 (compared to a fall of 2.7 percentage points in the expected component) and it accounted for less than a quarter of the fall in the level of yields relative to their 1997–2007 average.

(1) This is consistent with the international evidence in Gürkaynak, Levin and Swanson (2010) and Wright (2011).

## G-ADTSMs and the role of surveys

Gaussian affine dynamic term structure models (G-ADTSMs) are, and have been for a long time, a widely used approach to interest rate modelling. They owe their popularity to their simplicity: the risk-free rate and the price of risk are modelled as linear functions of a few latent state variables, which proxy for the fundamental shocks driving the economy. These latent variables evolve according to a standard vector autoregression (VAR). Yet despite their simplicity these models can fit historical yield curves very well.

### Estimation

In G-ADTSMs, model-implied yields will be linear functions of the latent state variables. The coefficients will be a function of the underlying VAR dynamics and prices of risk, and will vary with the maturity of the yield in a way that precludes arbitrage opportunities. Estimation for G-ADTSMs can be done using the Kalman filter (KF), which is designed to deal with linear models with latent variables. The KF is also a good method for dealing with missing data, so it can easily accommodate the use of survey forecasts of interest rates and inflation, which are typically observed at different frequencies than the yield and implied inflation data. Since the expectation of rates is a linear function of state variables, all that is needed is to add additional observation equations matching the model-implied expectations to the corresponding survey forecasts (see Kim and Orphanides (2005) or Joyce, Lildholdt and Sorensen (2009) for details).

### Use of surveys

Kim and Orphanides (2005 and 2007) have argued that including survey forecasts is a good way to avoid instability in ADTSM estimates. And Carroll (2003) shows evidence that professional market forecasters' expectations lead households' and businesses' expectations, and so can serve as leading indicators of general expectations of policy and inflation. In addition, Chernov and Mueller (2011) — in a model in which they explicitly allow for the possibility that survey expectations differ from those priced in bond yields — find no evidence that expectations from professional forecasters are not the same as those implicit in yield curves. For these reasons recent internal Bank research has attempted to include more survey forecasts.

### Recent Bank work

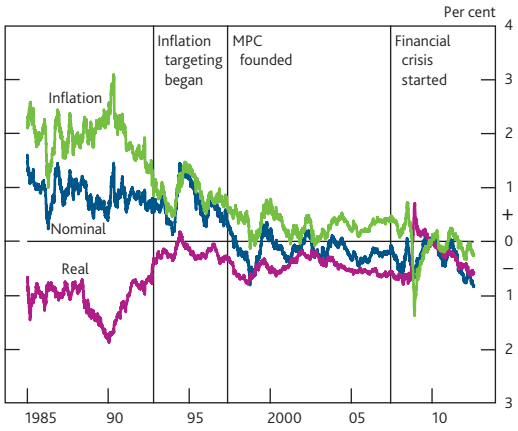
The model of Joyce, Lildholdt and Sorensen (2009) had four factors driving the nominal yield curve: the observed RPI inflation rate, and three latent factors. Only two of the latent factors were allowed to explain the real yield curve. In their model inflation and the real yield curve were driven by separate factors. In the model used in this article these assumptions have been relaxed, allowing all of the factors that determine nominal yields to affect both real and inflation rates. This is in line with most fully specified general equilibrium models, in which all factors determining the equilibrium will typically affect both inflation and real yields. For more information, see the discussion in Andreasen (2011) and Chernov and Mueller (2011). The preferred model specification has four factors without the restrictions imposed by Joyce, Lildholdt and Sorensen (2009).

Joyce, Lildholdt and Sorensen (2009) included Consensus survey forecasts for the five-year average of inflation, five years ahead in the estimation of their model. The model used in this article includes inflation forecasts from Consensus for each of the next five years, as well as the five-year average five years ahead forecasts. In addition, the model used in this article includes forecasts from the Bank's survey of external forecasters. This survey is conducted by the Bank each quarter, and has forecasts for Bank Rate at one, two and three years ahead, which are available since 1999. The combination of fewer restrictions in the real curve dynamics and the use of the short-term survey forecasts leads to a better fit at short maturities, particularly for the real yield curve. The added flexibility in the model is required to be able to match the yield curve data and surveys at all maturities.

### Differences between models

The big difference between the models in the G-ADTSM class and more structural models, such as dynamic stochastic general equilibrium (DSGE) models, is that G-ADTSMs are agnostic about what the underlying drivers of movements in interest rates are. Even in a DSGE model, the risk-free rate and risk premia may be linear functions of underlying latent state variables (as in Andreasen (2011)). But in those DSGE models, a full set of assumptions on preferences, production and other constraints will be imposed that give a structural interpretation to the underlying state variables. The coefficients linking risk-free rates and risk premia to the state variables will also be functions of all the assumptions. Whereas in a G-ADTSM, the only restrictions imposed are those that guarantee bonds do not offer arbitrage opportunities.

**Chart 5** Model estimates of ten-year spot risk premia




Source: Bank calculations.

**Table B** Model decomposition of UK ten-year spot yields

**Percentage points**

| | Averages | | Changes relative to pre-crisis[a] | | |
|---|---|---|---|---|---|
| | 1985–92[b] | 1997–2007[c] | July 2010 | July 2011 | July 2012 |
| **Nominal** | | | | | |
| Fitted rate[d] | 10.0 | 4.9 | -1.4 | -1.8 | -3.3 |
| Expected rate | 9.5 | 5.4 | -1.3 | -1.6 | -2.7 |
| Risk premium | 0.9 | -0.2 | -0.1 | -0.2 | -0.7 |
| **Real** | | | | | |
| Fitted rate[d] | 3.9 | 2.1 | -1.3 | -1.9 | -2.5 |
| Expected rate | 5.3 | 2.9 | -1.6 | -1.9 | -2.4 |
| Risk premium | -1.1 | -0.5 | 0.3 | 0.1 | -0.1 |
| **Inflation** | | | | | |
| Fitted rate[d] | 6.2 | 2.8 | -0.1 | 0.1 | -0.8 |
| Expected rate | 4.2 | 2.5 | 0.4 | 0.4 | -0.3 |
| Risk premium | 1.9 | 0.3 | -0.4 | -0.2 | -0.6 |

Sources: Bloomberg and Bank calculations.

(a) End-of-month values minus average from June 1997 to June 2007.
(b) Average from January 1985 to October 1992.
(c) Average from June 1997 to June 2007.
(d) The fitted rate is the model-implied rate. The differences between rates shown here and those in **Table A** are the model residuals.

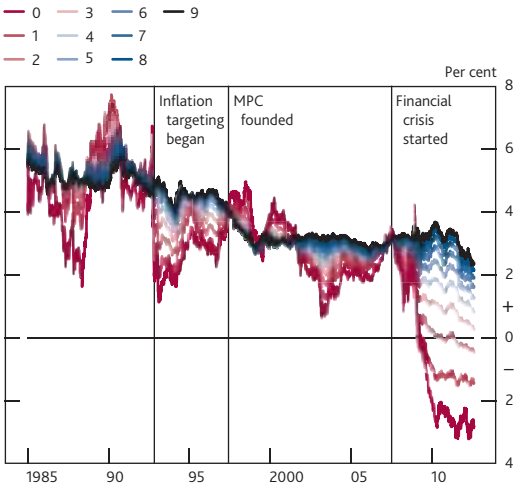
The changes in the levels of expected inflation and inflation risk premia over the past few years relative to their 1997–2007 averages have been relatively small, although they accounted for a large fraction of the fall in ten-year nominal yields over the past year (**Table B**).

The next two subsections take each of the real and inflation expected rate and risk premium parts shown above, and decomposes them further by maturity.

## Model decomposition of the real yield curve

As discussed above, the change in the level of the ten-year nominal spot rate relative to its pre-crisis average was due in large part to developments in the ten-year real rate (**Table A**), mainly reflecting changes in the expectations component of real rates (**Table B**). The model decomposition of the real yield curve (**Chart 6**) shows that, since the start of the financial crisis, expected real rates at shorter horizons fell by more, and earlier, than longer-term expected real rates. The fall in expected real rates at maturities up to three years accounted for more than half of the fall in the ten-year average expected real rate from 1997–2007 to July 2012. And the fall in rates at maturities up to five years accounted for three quarters of the fall. Expected real rates at shorter horizons tend to move procyclically with monetary policy: they tend to increase as the policy rate rises and fall as the policy rate falls. So the pattern during the current crisis is not particularly unusual. For example, when Bank Rate was cut in September 1992, shorter-term expected real forward rates also fell much more than longer-term forwards. But in the current crisis period, those moves have been larger and are expected to persist for longer than in previous monetary policy cycles.

**Chart 6** Model estimates of one-year forward expected real rates up to nine years ahead

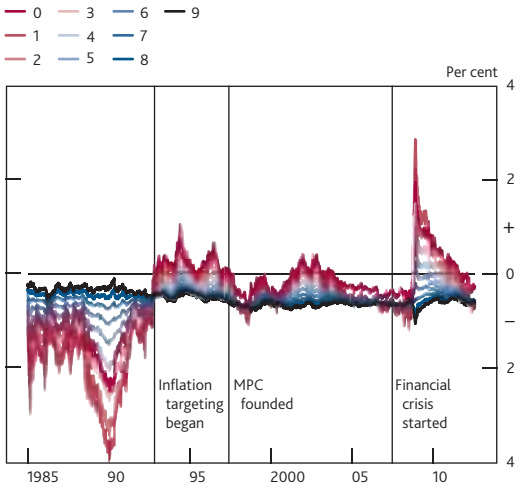



Source: Bank calculations.

Changes in real risk premia since 2008 also largely reflect movements at shorter horizons (**Chart 7**). On average, real risk premia have been negative, suggesting that real bonds offer investors insurance.(1) Following the adoption of inflation targeting, real risk premia were more stable and less negative. This could reflect greater monetary policy credibility, which reduces the short-term hedging value of real bonds as real rate uncertainty falls. But real risk premia moved sharply higher during the height of the crisis. In part, the spike in 2008 is likely to reflect market disruptions around the time of Lehman Brothers' bankruptcy that might have affected real yields.

(1) In return for inflation indexation, investors are willing to accept a smaller return. See Campbell, Shiller and Viceira (2009).

**Chart 7** Model estimates of one-year forward real risk premia up to nine years ahead

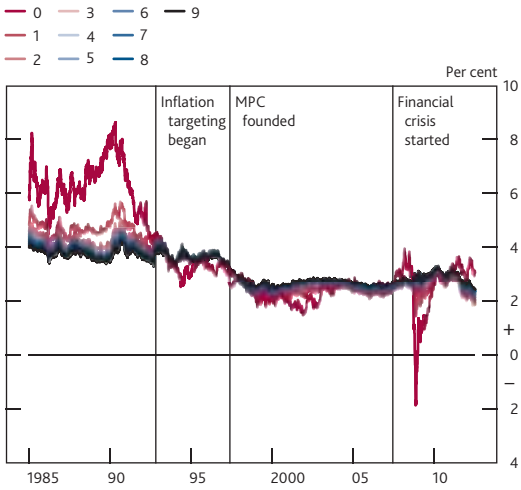



Source: Bank calculations.

## Model decomposition of the implied inflation curve

Shorter-term inflation expectations fell sharply in late 2008 as the outlook for the United Kingdom, and the world economy, weakened markedly (**Chart 8**). That fall unwound quite quickly. It also did not feed through to inflation expectations at longer horizons, which is why the ten-year average expected rate fell only slightly (**Chart 4**). Expected inflation appears to have been less cyclical than the expected real rate. The model estimates suggest that there are no signs that inflation expectations have become less well anchored.

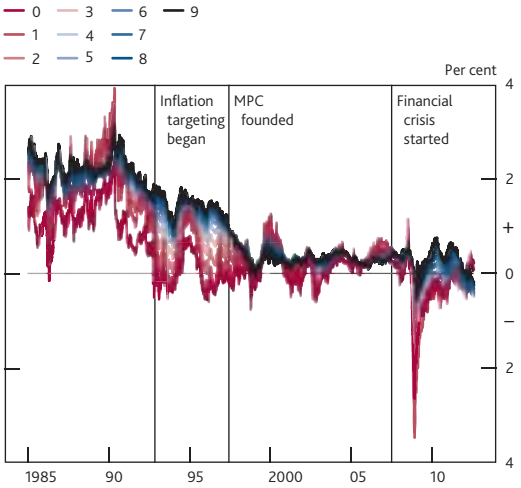
**Chart 8** Model estimates of one-year forward expected inflation up to nine years ahead




Source: Bank calculations.

Inflation risk premia also fell sharply during 2008 (**Chart 9**). The fall was much more persistent than the fall in expected inflation rates: it both stayed for longer and affected longer forward maturities. This is likely to be associated with the nature of the concerns about the economic outlook: if the occurrence of deflation is seen to coincide with a bad state of the world, then nominal assets become a good hedge for investors and hence should command a negative risk premium for the insurance they provide.(1) More generally, inflation risk premia remain much lower than they were in the 1980s. Particularly for long-horizon inflation risk premia, that is likely to have been associated, at least in part, with the introduction of the inflation-targeting regime and Bank of England operational independence.

**Chart 9** Model estimates of one-year forward inflation risk premia up to nine years ahead




Source: Bank calculations.

While the downward spikes in the components of implied inflation might also have been affected by market disruption following the collapse of Lehman Brothers, the magnitude of the fall in the model estimates of expected inflation is consistent with survey forecasts. For example, the forecast of the RPI inflation rate for 2009 from independent private forecasters, compiled by HM Treasury (HMT),(2) fell from 2.3% in August 2008 to -1.9% in February 2009. Inflation swap rates also fell sharply during this period, as did the option-implied measures discussed in the article by Smith on pages 224–33 in this *Bulletin* and financial market measures of expected inflation in other countries.

The decomposition of the sharp fall in implied inflation rates during the financial crisis illustrates the importance of disentangling expectations of future inflation and inflation risk premia in market-implied inflation rates. If policymakers had taken the market-implied inflation rate as a direct measure of expectations, they might have thought that inflation was expected by financial market participants to be much lower than surveys implied was the case. Furthermore, they might have concluded that the fall in inflation expectations would be

(1) See Campbell, Sunderam and Viceira (2012). If the deflationary scenario is associated with a bad macroeconomic environment, and weak growth of consumption, then nominal bonds are a good hedge and investors will be willing to pay for the deflation insurance they provide.
(2) Available at www.hm-treasury.gov.uk/data_forecasts_index.htm.

very persistent. The decomposition from the model, which uses short-term survey forecasts of nominal rates and inflation, implies a smaller and less persistent fall in implied inflation expectations. This is consistent with survey forecasts of inflation. And the large negative inflation risk premium estimated by the model is consistent with some of the evidence from option prices, shown in the article by Smith on pages 224–33 in this *Bulletin*, as discussed in the next section.

## Assessing the robustness of the model decompositions

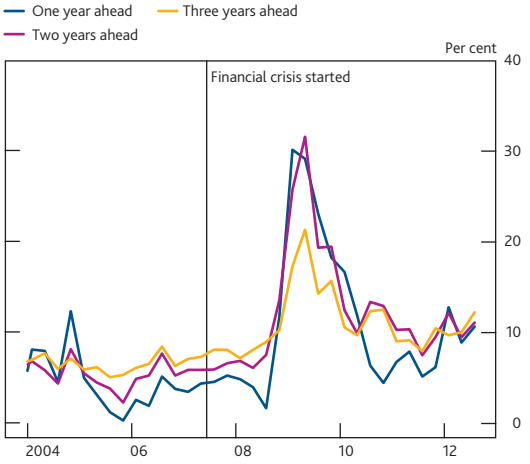
For policymaking purposes, it is important to assess the robustness of any particular model decomposition of yield curves. One way to do that is to estimate a large variety of models to investigate whether changes in model specification can make big changes to the results. Recent work undertaken at the Bank suggests that a range of different model specifications provides a similar qualitative message and estimate for the decomposition, and that the inclusion of surveys in the estimation of the model delivers robust estimates. That evidence is summarised in the box on page 221.

An alternative cross-check is to look at independent evidence. This includes evidence from other data sources for the United Kingdom that were not used in the model, as well as evidence for other countries that have experienced similar yield curve moves.

One possible independent cross-check is provided by the information contained in the article by Smith on pages 224–33. That article focuses on the distribution of future UK inflation around forward RPI inflation rates that can be extracted from option prices. The option-implied probability distributions of future RPI inflation also point to significant deflation concerns at the height of the crisis. For example, the measure of the balance of risks to inflation three years ahead fell sharply in late 2008, rose during 2009 and has remained stable since then (see **Chart 11** on page 231 of that article).

Another independent check (also discussed in the article by Smith) can be provided by using information from surveys not used in the analysis presented here. One such measure is the probability of low inflation from the Bank's survey of external forecasters (SEF). The SEF asks respondents to assign probabilities to inflation falling within pre-specified ranges for its three forecasting horizons.(1) **Chart 10** shows that the perceived likelihood of low consumer prices index (CPI) inflation increased sharply during 2008. Although the probability of higher inflation also increased, the balance of risks(2) around the inflation target fell sharply. That balance of risks was negative at the height of the crisis, but rose through 2009 and has remained broadly stable since then (see **Chart 11** on page 231 of the article by Smith). This evidence on the perceived direction of risks to future inflation is consistent with the movements — and the negative sign — of the model-implied inflation risk premia (**Chart 9**).

**Chart 10** Probability of low CPI inflation(a) from survey of probability forecasts




Source: Bank calculations.

(a) Probability of annual CPI inflation being less than 1% at one, two and three-year horizons.

In addition, the average central forecasts for inflation of respondents to a number of other surveys not used in the model presented here also show that the fall in expectations was temporary and not expected to persist for long, similar to the estimates for inflation expectations suggested by the model. And central forecasts for the path of expected real rates implied by forecasts from the HMT survey mentioned earlier are consistent with the model-implied expected real yield curve.

Ten-year nominal yields in the United States and some euro-area countries have moved in similar ways to those for the United Kingdom. Studies focusing on bond yields for these countries during the recent crisis period have reached similar conclusions to this article. For example, Garcia and Werner (2011) find that developments in inflation risk premia in the euro area were also consistent with euro-area survey measures of the balance of risks around inflation expectations. And Christensen, Lopez and Rudebusch (2012) find similar evidence of a significant deflation probability implied by US inflation-linked bond markets at the height of the crisis. Although not shown in Smith's article on pages 224–33, option-implied distributions for inflation in the euro area and the United States also behaved similarly to those in the United Kingdom.

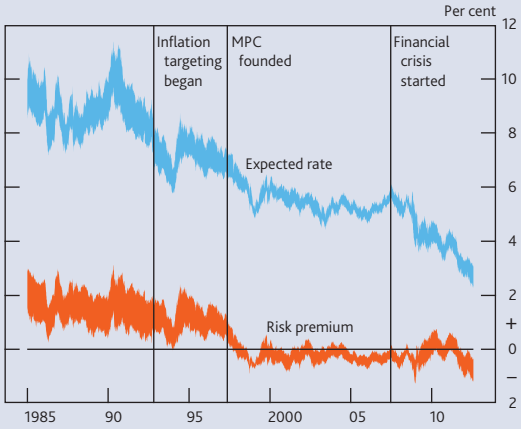
(1) This information was not used in deriving the model decompositions.
(2) Defined as probability inflation will overshoot the target rate by more than 1% minus the probability it will undershoot the target by more than 1%.

## Assessing robustness of G-ADTSMs

Recent research by Joslin, Singleton and Zhu (2011) has led to a drastic reduction in the computational time required for estimating Gaussian affine dynamic term structure models (G-ADTSMs). This has made it feasible to estimate several models with different specifications, sample periods and combinations of surveys and restrictions on risk premia. This in turn allows inference about the features that are robust and those that are sensitive to particular modelling choices. Recent work undertaken in the Bank has done just that, estimating a large range of models.

**Chart A** shows the swathe of model estimates from six different models. The models vary according to the number of latent factors allowed and the survey forecasts used. All the models shown in this article have been estimated using monthly nominal yields since 1972 and real yields since 1985.

Chart A Range of model decompositions of ten-year nominal spot yields




Source: Bank calculations.

The model sizes vary from three factors, which is considered to be the minimum number of factors to explain the variation in yield curves (see Duffee (2002) and references therein), to five factors, which is the number used in some more recent studies (see Chernov and Mueller (2011) and Joslin, Singleton and Zhu (2011)).

For each model size two sets of survey forecasts were used. In both, the Bank Rate forecasts for one, two and three years ahead from the Bank's survey of external forecasters (SEF) (see the box on page 217) were used (available quarterly since 1999). For one set, the SEF forecasts for inflation one, two and three years ahead (available quarterly since 1996) were also used. Since these refer to CPI inflation rates since 2004, a 0.8 percentage point wedge (as an approximation to account for the RPI-CPI inflation wedge) was added to the forecasts from this date. The other set used forecasts for RPI inflation from Consensus for the next five years and the five-year average five years ahead in the estimation of the model (available half-yearly since 1990).

**Chart A** shows the range of estimates for all the models for the ten-year spot nominal risk premia and expected rates. **Chart A** shows that there is greater uncertainty about the decomposition for the first half of the sample, through to the late 1990s. But that does not affect the qualitative results discussed in this article.

The uncertainty is more pronounced for the real decomposition (not shown here). The swathe of model estimates is particularly wide (relative to the magnitude) for real term premia estimates, which might reflect the lack of availability of survey forecasts for interest rates before the 1990s. Survey data for Bank Rate, which come from the Bank's quarterly SEF, are only available since 1999, while the longest-running survey data for inflation (available from Consensus) start in the early 1990s. This highlights the importance of survey data in stabilising the model estimates. However, the qualitative message is not affected, particularly concerning the recent crisis period for which the swathes are narrower.

## Conclusion

This article has shown that the drivers of the recent fall in UK ten-year nominal spot rates to historically low levels have been very different to those that drove the fall that occurred between the 1980s and the 2000s, both in terms of the horizon at which forward rates fell and the breakdown into real rates and implied inflation rates. Whereas the fall between the 1980s and the 2000s was evenly split along the maturity spectrum, the recent fall in nominal ten-year spot interest rates has been concentrated in shorter-term forward rates. And the data show that the vast majority of the recent fall of nominal yields was accounted for by a decrease in real interest rates, while the fall between the 1980s and the 2000s largely reflected a decline in implied inflation rates.

To understand what might lie behind the recent movements in the data, a model can be used to decompose real and inflation rates into expected rates and compensation for risk. The model estimates presented in this article imply that recent low ten-year nominal spot rates largely reflect low expected real rates, which have fallen most at shorter horizons. Expected real rates tend to move with the monetary policy cycle, particularly at shorter horizons. So given that the MPC cut Bank Rate sharply during 2008 and 2009, to its lowest level in history, and subsequently embarked on a programme of asset purchases to loosen policy further,(1) it is perhaps not surprising that expected real rates have fallen by more and for longer in recent years than in previous cycles.

Short-term market-implied inflation rates fell markedly at the height of the crisis, reflecting sharp declines in both inflation expectations and inflation risk premia. Inflation risk premia subsequently rose, but they remain a little lower than their pre-crisis average. The model-implied measure of inflation expectations also rose, and has since been relatively stable at close to its 1997–2007 average level, suggesting that inflation expectations have not become less well anchored.

Overall, the analysis in this article suggests that the low level of long-term nominal yields does not reflect low long-term risk premia. That is clear both from the maturity analysis of the data, and the model decomposition of yields, which suggests that less than a quarter of the fall in the ten-year spot rate is due to the compression of nominal risk premia.

(1) See the letter from the Governor to the Chancellor, available at www.bankofengland.co.uk/monetarypolicy/Documents/pdf/govletter090305.pdf.

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# Option-implied probability distributions for future inflation

By Tom Smith of the Bank's Macro Financial Analysis Division.[1]

Beliefs about future inflation play a major role in determining the rate of inflation, and so it is important for the Monetary Policy Committee to take them into account when making their policy decisions. A number of measures of central expectations for inflation are available, such as surveys of inflation expectations or measures derived from financial markets. But until recently far fewer measures of beliefs about the full distribution of possible future inflation rates have been available. This article describes a new method for producing option-implied probability density functions for future inflation, which can be used as a measure of that distribution, and examines the recent rise in uncertainty about future inflation that they reveal.

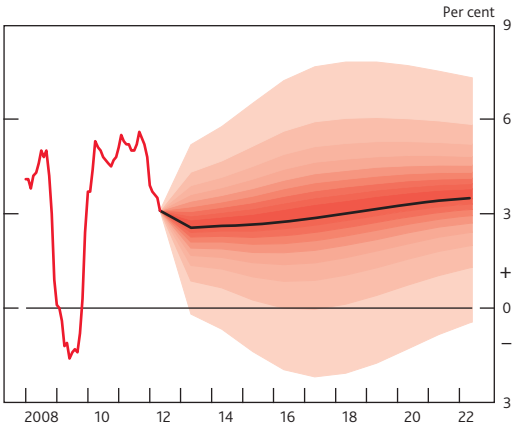
## Introduction

Beliefs about future inflation play a major role in determining the rate of inflation. If people believe, for instance, that prices are likely to rise sharply in the future, they may demand higher wages today: this could push up prices, raising the current rate of inflation. So it is important for the Monetary Policy Committee (MPC) to monitor people's beliefs about future inflation, and to take them into account when making their policy decisions.

A number of measures of central expectations for inflation are available, such as surveys of households' and firms' inflation expectations or measures of implied inflation derived from financial markets. Measures like these are regularly used by the MPC to assess the risk to inflation from inflation expectations moving away from target.[2] But until recently far fewer measures of beliefs about the full distribution of possible future inflation rates have been available, particularly beyond a two or three-year horizon. Such measures would allow the MPC to examine in much more detail how close inflation expectations were to target, while also providing a source of information on investors' beliefs about the risks around the outlook for inflation.

In the past few years, however, a market has developed in inflation options, from which a measure of people's beliefs about the distribution of future inflation can be obtained. An inflation option is a financial instrument that allows investors to speculate on, or insure against, future inflation outturns. As with options on any asset, the prices of these options can be used to calculate implied probability density functions (pdfs), in this case for inflation. These pdfs summarise investors' beliefs about the distribution of future inflation rates. And by combining pdfs for inflation at different points in the future it is also possible to examine how investors believe inflation rates could evolve over a number of years — **Chart 1**, for example, illustrates investors' beliefs about how UK retail prices index (RPI) inflation is likely to evolve over the next decade.

**Chart 1** Option-implied probability distributions for UK RPI inflation, 31 July 2012




Sources: Bloomberg, ONS and Bank calculations.

This article describes the technique developed at the Bank of England to produce these pdfs, and analyses what they reveal about investors' views on future inflation. The first section describes the underlying instruments and the markets in which they are traded. The second section discusses the interpretation of the implied pdfs and their relationship to the underlying distributions of investors' beliefs about inflation. The third section uses the pdfs to discuss the evolution of

(1) The author would like to thank Michael Chin for his help in producing this article.
(2) See Harimohan (2012) for more details.

uncertainty about UK inflation, and compares them with other measures of uncertainty.

## The inflation option market

An option is a financial contract in which one party (the seller) pays the other (the buyer) only if a certain pre-agreed outcome occurs — often, but not always, if the price of some other asset ends up above (or below) some threshold, called a strike price. In exchange for that state-contingent future payout, the buyer pays the seller a price upfront. Inflation options are based on the rate of annual inflation in a given month. Typically, the seller pays out if inflation is higher than a pre-agreed strike rate.

Investors use inflation options to hedge against high or low inflation outturns or to speculate on the future path of inflation. For instance, an investor who is worried that he will suffer losses if inflation turns out to be particularly high can insure himself by buying an inflation option which will pay out in exactly that situation. The other investor who sells him the option may do so because he believes inflation is likely to be lower, and so is willing to bet against a high future rate.

The price agreed by the two investors in this example then reflects a collective judgement on their part on the probability that the option will pay out. Each investor will only be willing to enter into the option contract if he believes that the price he pays or receives upfront is worth taking on the risk of making or receiving an uncertain future payment. Fitting the implied pdfs shown in this article essentially amounts to reversing this process — that is, finding a probability distribution under which buyers of inflation options would be willing to pay the set of observed option prices in exchange for receiving the payouts that would be made by the sellers of those options.

For the simplest classes of options, it is easy to fit pdfs using standard techniques.(1) But most inflation options have a more complex structure. They are typically traded as caps and floors: bundles of simple inflation options called caplets and floorlets, all with the same strike price but each with a different expiry date. The structure of these options is explained in more detail in the box on page 226. Since caplets and floorlets are not directly traded, their prices are not observable; they must instead be recovered from the observed cap and floor prices. If those were available at a full range of annual maturities, this would be straightforward; but cap and floor prices are usually only available for a small number of maturities. The Bank's new technique (which is described in detail in the appendix) overcomes this problem by interpolating cap and floor prices at the missing maturities. The interpolated prices are used to decompose the caps and floors into caplets and floorlets, which are then used to produce the implied pdfs.(2)

### Characteristics of inflation option markets

Most inflation options are traded on UK RPI, US consumer prices index (CPI) or euro-area CPI inflation, at maturities ranging from 1 to 30 years.(3)(4) The payouts from the options are determined by the annual inflation rate observed two (for the United Kingdom) or three months (for the United States and euro area) before contract expiry. For instance, UK inflation options expiring in April 2015 refer to the annual RPI inflation rate published for February 2015; and so, therefore, will the implied pdf calculated from those options.

The inflation option market is entirely 'over the counter': trading takes place directly between individual investors in the market, rather than being co-ordinated through a central exchange. As a result it is hard to measure characteristics such as trading volumes and market liquidity quantitatively. Instead this section uses qualitative information from the Bank's market-making contacts. **Table A** summarises the main features of the three markets considered here.

**Table A** Features of inflation option markets

| | United Kingdom | United States | Euro area |
|---|---|---|---|
| Inflation rate | RPI | CPI | CPI (HICPxT)[a] |
| Liquidity | Fairly liquid | Least liquid | Most liquid |
| Major buyers and sellers | Pension funds (longer maturities) | Some structured product hedging | Pension funds (longer maturities); structured product hedging (shorter maturities) |

(a) Harmonised index of consumer prices excluding tobacco.

All three of the markets considered in this article are relatively young and small. Trading activity is sporadic, and was particularly so in 2007 and 2008 when markets first developed. The UK inflation option market is more liquid than the US market, but less liquid than the market in the euro area.

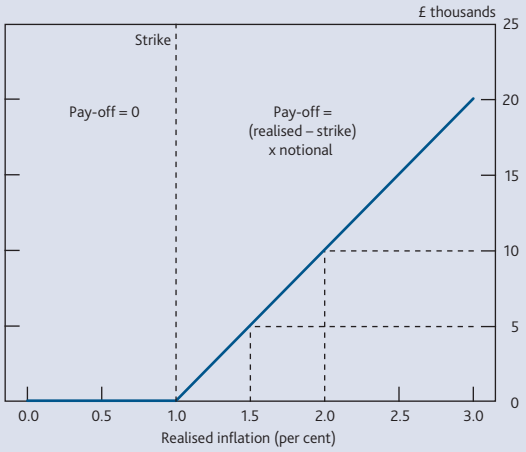
Lack of liquidity does not mean that the implied pdfs contain no information. But they may be noisy or slow to react to news, so care is needed when interpreting day-to-day movements in the implied pdfs. In addition, some of the observed prices can be affected by trading flows from major actors in the markets. In particular, many UK pension fund liabilities are linked to RPI inflation in a way which induces them to buy and sell certain caps and floors.(5) At long maturities, particularly at 20 to 30 years, these structural

(1) Clews, Panigirtzoglou and Proudman (2000) describe these techniques.
(2) One alternative would be to produce implied distributions for average inflation across the entire maturity of each option. Kitsul and Wright (2012) do something similar for US CPI inflation data, although using a slightly different underlying class of instruments.
(3) Almost all UK inflation-linked financial instruments are based on RPI rather than CPI. This is a legacy of the fact that, until recently, many UK pension schemes were linked to RPI.
(4) There is also a market in options on French CPI inflation, which this article does not discuss.
(5) This is because some pension schemes, under the terms of the Pensions Act 1995, have liabilities which increase in line with RPI inflation up to a maximum rate of 5%, and are never permitted to decrease — this is known as limited price indexation (LPI). That gives them an incentive to buy 0% RPI floors and sell 5% RPI caps.

## Caps, caplets, floorlets and floors

When an inflation *caplet* is traded, the buyer and the seller agree an *expiry date*, a *strike rate* and a *notional* — a hypothetical sum of money which the seller agrees to insure for the buyer. The buyer pays the seller an upfront premium — the *option price*. On expiry the seller then pays the buyer the difference between the realised inflation rate and the strike rate multiplied by the notional, if realised inflation is above the strike rate. Otherwise no money changes hands. An example in which the notional is £1 million and the strike rate is 1% is shown in **Chart A**. If realised inflation on the expiry date was 1.5%, the seller would pay the buyer (1.5%–1%) x £1 million = £5,000. If realised inflation was 2%, the seller would pay £10,000. But if realised inflation was 1% or below, the buyer would receive nothing.

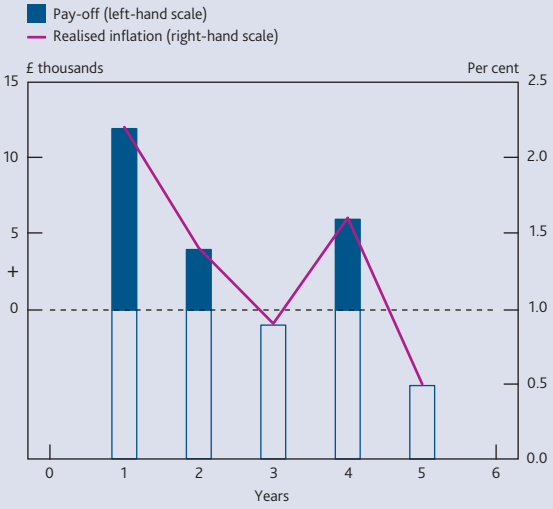
**Chart A** The pay-off from an inflation caplet




Thus if the buyer of the caplet really did have a liability equal to the rate of inflation multiplied by the notional value, the maximum he would actually have to pay would be capped at 1%, with the seller of the caplet bearing the cost of any additional payout. So caplets provide protection to the buyer against upside risks to inflation.

An inflation *cap* is a bundle of caplets all of which have the same strike rate and notional, but whose expiry dates fall on consecutive years. For example, a three-year cap bought on 1 October 2010 would consist of one caplet which expired on 1 October 2011, one which expired on 1 October 2012 and one which expired on 1 October 2013. **Chart B** shows an example set of pay-offs from a hypothetical five-year inflation cap, again with a 1% strike and a £1 million notional. The cap pays out only in years when realised inflation is above 1%.

**Chart B** The pay-offs from an inflation cap




The corresponding instruments which provide protection against downside risks to inflation are called *floorlets* and *floors*. The seller of an inflation floorlet pays the buyer the difference between the strike rate and the realised inflation rate multiplied by the notional if realised inflation is below the strike rate, and zero otherwise.

flows dominate the UK market. Similar structural flows are also present in US and euro-area markets, but they are less significant.

Despite some structural issues, there is likely to be enough information in published option prices to make the implied pdfs a useful measure of investors' beliefs about future inflation. Information from the Bank's market-making contacts suggests that quoted prices are a fair reflection of what investors are prepared to pay for inflation options.

## Interpreting the implied distributions

The next section discusses what the option-implied inflation distributions say about the evolution of uncertainty around UK inflation in recent years. Before examining the data in detail, however, it is important to understand how the implied pdfs can and cannot be interpreted: this section sets out the key points.

### Interpreting the data

Implied pdfs derived from option prices describe investors' collective beliefs about the future level of some asset price or macroeconomic variable. Particular features of those beliefs can then be described using standard summary statistics. The standard deviation of the implied pdf, for example, can be thought of as summarising investors' uncertainty about that price or variable, while the skewness of the pdf represents their collective views about the balance of risks around their central expectation.

In most cases, the mean of the distribution is equal to the price of another asset that it is linked to. For options whose payout is linked to the price of an underlying asset, this is the futures price of that asset. But for inflation options, whose payout is linked to the inflation rate rather than to an underlying asset, the mean of the implied distribution is the forward inflation swap rate. This is the price of a contract in which the seller pays a buyer a sum of money equal to the realised future inflation rate — effectively a futures contract on the inflation rate.(1)

As UK inflation options refer to RPI inflation, the implied pdfs obtained from them cannot be used as a direct measure of investors' beliefs about CPI inflation, the measure targeted by the Bank. It might appear as though this problem could be fixed by shifting the whole distribution by a constant 'wedge' based on the average historical difference between RPI and CPI inflation. But that would implicitly assume that there was no uncertainty about the future size of this wedge, which would be unrealistic. For example, the RPI inflation rate includes mortgage interest payments, which tend to vary with interest rates. By assuming a constant wedge, uncertainty about future interest rates would be ignored, as would the relationship between interest rates and the level of CPI inflation.(2) Nevertheless, RPI and CPI inflation do contain many common components, and so implied pdfs describing RPI inflation are still useful to policymakers, especially at long horizons where few other measures of the distribution of beliefs about inflation are available.

## What the implied distributions measure

The probability distributions for inflation implied by option prices reflect the underlying probability distributions perceived by investors, but they are not exactly the same as those underlying distributions. That is because when people buy or sell options or other financial assets, they consider not only the probability that the option will pay out, but also how much they would value the payout in each state of the world.(3)

To understand why the distributions are different, consider the example of a fire insurance contract — this is the same as an inflation option in that it pays out different amounts in different states of the world. When someone buys fire insurance on their house, they are willing to pay much more than they expect to get back on average. That is because if the house did burn down, they would face high costs to rebuild or replace it, they would have lost a lot of their wealth, and they would suffer distress from the loss of their house and possessions, as well as significant inconvenience in the weeks that followed. In that state of the world, they would value the extra income from the insurance contract very highly; so they are willing to pay well over the odds to guarantee a payout. To an observer who only knew about the size of the possible payout, and did not understand how highly the payout would be valued in the event of a fire, it would appear that the owner thought that the property was much more likely to burn down than was really the case. In other words, the implied probability of a fire derived from the price of the insurance contract would be higher than the actual probability, because the event of a fire would be so painful to the buyer of the insurance.

In a similar way, people trading options adjust the prices that they are prepared to pay depending on how much they think they would value the payout from each option. Options that pay out in relatively painful states of the world, for instance in states when investors' consumption is likely to be relatively low, will be valued more than options that pay out in relatively painless states of the world, as investors want to hedge against the painful states. So the implied probabilities of painful events derived from those options will be relatively high compared to the underlying probabilities; likewise, the implied probabilities of painless events will be relatively low.(4)

The difference between the implied and underlying distributions has implications for how the implied distributions should be interpreted. For instance, the mean of the distribution — the futures price, or for inflation options, the inflation swap rate — will not be the same as the expected price of the underlying asset. The difference between inflation rates implied by asset prices and underlying inflation expectations is discussed in more detail in the article by Guimarães on pages 213–23 in this *Bulletin*.(5) More generally, since the implied probabilities do not match the underlying probabilities, the absolute levels of the implied probabilities contain little information by themselves. And changes in the implied probabilities will only reflect changes in the underlying probabilities if investors' desire to hedge against the most painful states has not changed.

Nevertheless, the implied distributions can still provide useful information about the underlying distributions. It is hard to make general statements about exactly how the two distributions are related, and there is no perfect method for separating them.(6) But by using the economic arguments outlined above, it is often possible to deduce something about the relationship between the two distributions.

(1) It is a 'swap' in the sense that the buyer swaps a payment which is known in advance — the price — for a payment of uncertain size.
(2) That is, it ignores the last two terms in the identity var(RPI) = var(CPI) + 2 cov(CPI, wedge) + var(wedge).
(3) In the language of finance theory, the implied distribution is the risk-neutral pdf. This differs from the underlying pdf due to the presence of a stochastic discount factor.
(4) From this perspective, the 'trading flow' effects described in the previous section can be seen as particularly large price adjustments. Pension funds with LPI-linked liabilities, for example, would suffer losses if their RPI-linked asset returns fell below 0%. So they find those states of the world particularly painful, and are prepared to pay a high price to insure against them.
(5) For an explanation in elementary terms of why the futures price does not equal the expected spot price, see Nixon and Smith (2012).
(6) Some progress has been made, however, both in the Bank and elsewhere (Bliss and Panigirtzoglou (2004) and de Vincent-Humphreys and Noss (2012)).

- In many cases, events in the tails of the distribution seem likely to be relatively painful. Inflation is one such case: very high inflation, for instance, erodes investors' nominal savings, while very low inflation often coincides with periods of recession. The implied tail probabilities and the standard deviation of the implied pdfs will then be relatively high compared to those of the underlying distribution.(1)

- That in turn means that implied uncertainty, as measured by the standard deviation, may well increase more than one-for-one with investors' uncertainty. Small increases in the tails of the underlying distribution will be amplified by investors' dislike of tail events, leading to larger increases in the tails of the implied pdf.

- It may also be the case that events in one tail of the distribution are more painful than those in the other tail. If investors thought that episodes of deflation were likely to be even more painful than episodes of high inflation, then the left tail of the implied pdf would be larger than the left tail of the underlying pdf; or *vice versa*. In the first case, the implied pdf would then be more negatively skewed than the underlying distribution, and the mean of the implied pdf lower than that of the underlying distribution.

There are also some technical factors that affect the interpretation of the implied distributions. Option prices are only available for strike prices between 0% and 6%, so pdfs cannot realistically be produced when inflation is more likely than not to fall outside that range — in particular, this makes it difficult to produce short-maturity pdfs for trading dates in late 2008 and early 2009, when realised RPI inflation was negative. More generally, the fact that the pdfs are extrapolated outside that range is another reason to be cautious about interpreting the exact level of any summary statistic. In addition, the precise shape of the individual pdfs for the first couple of years depends quite heavily on the technique used to fit them.(2)

Overall, there are a number of reasons why the implied pdfs cannot be thought of as direct measures of the underlying distributions for inflation perceived by investors. But the pdfs are still a valuable source of information on investors' beliefs about the distribution of future inflation. The next section presents the implied pdfs and examines the information that they do contain.

## The evolution of uncertainty about UK inflation

**Charts 2–7** show implied pdfs for UK RPI inflation produced using the Bank's new technique for selected dates from early 2008 to July 2012. The central, darkest coloured band on each chart contains the 10% of the implied distribution which includes the mode: that is, the set of inflation rates that the pdfs imply are the most likely outturns. Each pair of identically coloured bands around that central band contains a further 10% of the distribution, with the coloured bands covering 90% of the distribution in total. The final 10% of the distribution lies outside the coloured bands. The black line on each chart shows the mean of the implied distribution, which, as explained in the previous section, corresponds to the inflation swap rates.

There are several striking features of the distributions over this period. The mean of the distributions — the RPI swap rate — beyond the first three years has been relatively stable over time. But the uncertainty around inflation, measured by the standard deviation of the distributions, has increased substantially since 2008, particularly between three and seven years ahead. Of course, as discussed in the previous section, underlying uncertainty among investors is likely to be lower than the implied pdfs would suggest. But unless investors' desire to hedge against the most painful outcomes has changed substantially, this seems likely to reflect a genuine increase in underlying uncertainty about RPI inflation.

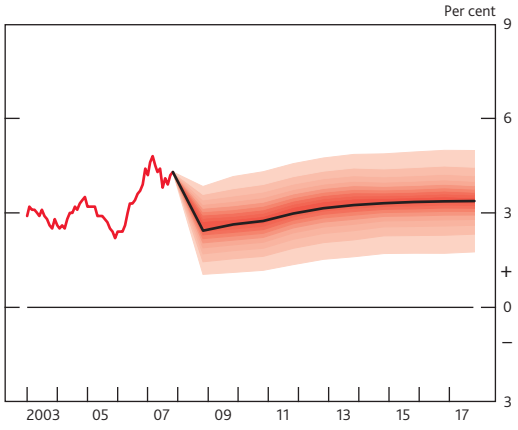
The balance of risks has been more variable, particularly at short maturities. Between Autumn 2008 and Summer 2010 there was a strong downside skew in the distributions at short maturities, reflecting investors' worries that there would be an episode of RPI deflation. This is consistent with the negative inflation risk premia discussed in the article by Guimarães on pages 213–23 in this *Bulletin*. But more recently the pdfs have been broadly symmetrical.

### Understanding inflation uncertainty during the financial crisis

There are at least two possible factors underlying the rise in uncertainty. One possibility is that investors believe that inflation will continue, as in the past four years, to be subject to the effects of larger or more persistent shocks than in the pre-crisis period for at least the next few years. That could be because investors anticipate larger or more persistent exogenous shocks. Or it could be that market participants believe that any given shock will have a larger or more persistent impact on inflation than it would have done before the crisis. A second possibility is that the rise in uncertainty reflects a perception that policymakers have become more willing to tolerate — or, without excessive volatility in output, less able to prevent — deviations of inflation from target.

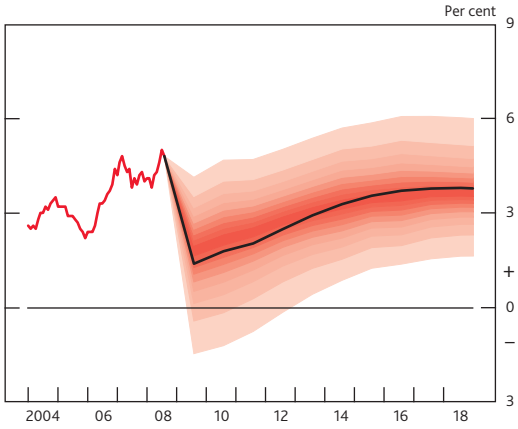
(1) Consistent with this, Kitsul and Wright (2012) find that their option-implied pdfs for US CPI inflation put more weight on very high or very low inflation than would be implied by statistical forecasts.
(2) Specifically, the (weighted) sum of the pdfs for the first three years is pinned down by the observed prices, but how that sum is distributed between those three years depends to a large extent on how the option prices are interpolated. In theory this is true for all the pdfs but in practice it is much less of an issue at longer maturities.

**Chart 2** Option-implied probability distributions for UK RPI inflation, 2 January 2008



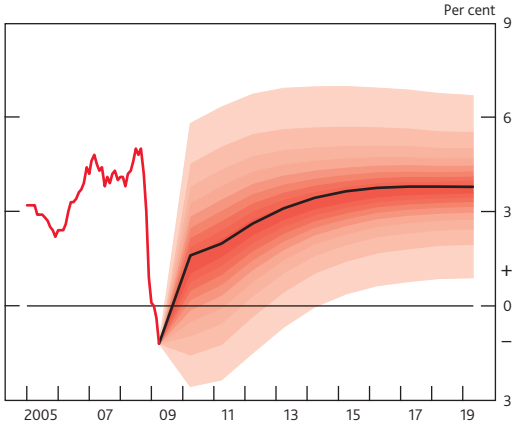

Sources: Bloomberg, ONS and Bank calculations.

**Chart 3** Option-implied probability distributions for UK RPI inflation, 28 October 2008



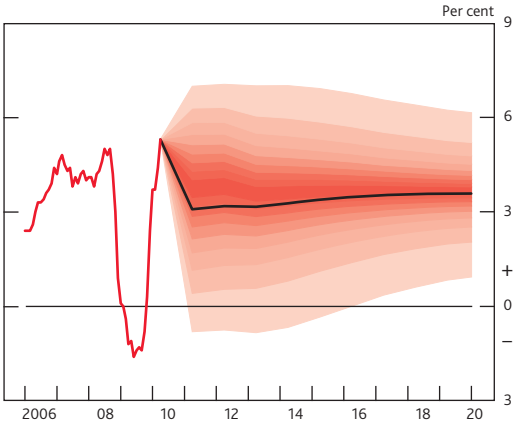

Sources: Bloomberg, ONS and Bank calculations.

**Chart 4** Option-implied probability distributions for UK RPI inflation, 4 June 2009



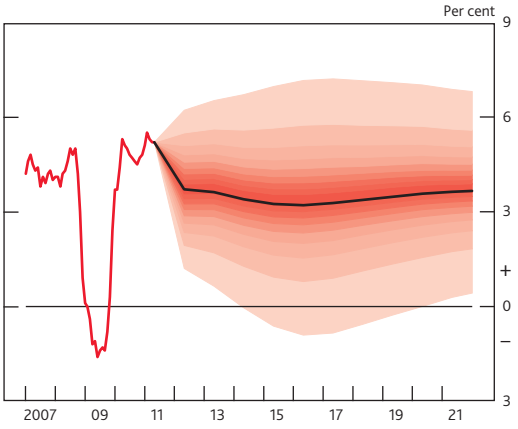

Sources: Bloomberg, ONS and Bank calculations.

**Chart 5** Option-implied probability distributions for UK RPI inflation, 2 June 2010



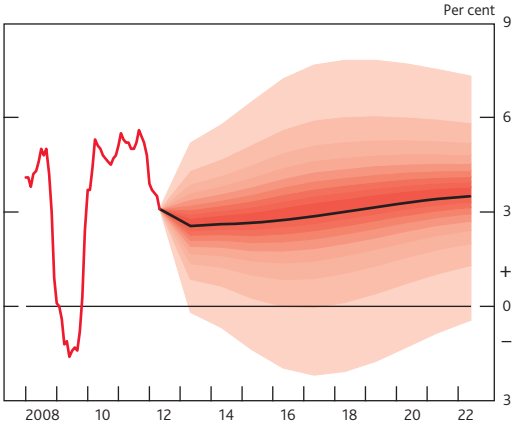

Sources: Bloomberg, ONS and Bank calculations.

**Chart 6** Option-implied probability distributions for UK RPI inflation, 1 July 2011




Sources: Bloomberg, ONS and Bank calculations.

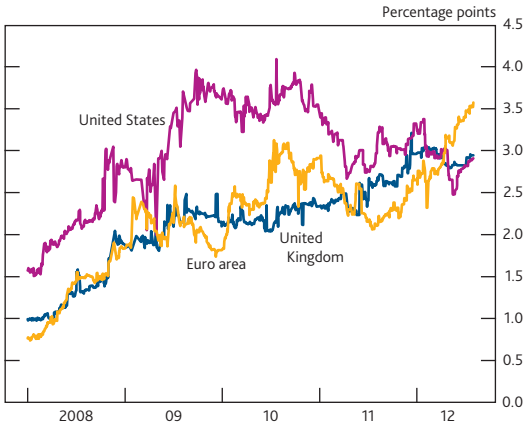
**Chart 7** Option-implied probability distributions for UK RPI inflation, 31 July 2012




Sources: Bloomberg, ONS and Bank calculations.

These two possibilities are not mutually exclusive, and they are hard to disentangle. But there is some evidence to support the first possibility rather than the second, although it is by no means conclusive. For example, comparing the standard deviation of the UK inflation pdfs with those in the United States and euro area suggests that uncertainty has increased in a broadly similar way across all three markets (**Chart 8**). So, if investors do believe that policymakers have become more willing to tolerate, or less able to prevent, deviations of inflation from target, they must believe this to be the case for all three markets. Moreover, such a belief might be expected to have a very persistent impact on inflation uncertainty. The fact that the pdfs become narrower at longer maturities perhaps suggests that this has not happened. And again, this pattern is evident across all three markets.

**Chart 8** Standard deviation of five year ahead option-implied inflation pdfs

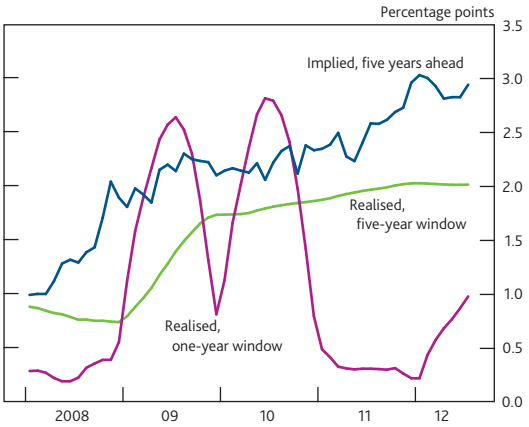



Sources: Bloomberg, Eurostat, ONS, US Bureau of Labor Statistics and Bank calculations.

But there are other possible explanations for the rise in inflation uncertainty. One other possibility is that the rise in uncertainty reflects increased disagreement among individual investors about future inflation. The implied pdf aggregates the beliefs of all investors; so if all investors became less certain about future inflation rates, then the implied pdf would become wider. But even if no individual investor had become more uncertain about future inflation, an increase in the dispersion of individual views could also cause the pdf to become wider.

Another possibility is that the rise in uncertainty simply reflects the unexpectedly large movements in inflation seen since 2008. There probably is a mechanical link between the size of past movements in inflation and the uncertainty embodied in inflation option prices, as dealers and investors often use the volatility of realised inflation rates to calibrate their pricing models. But that does not imply that the option prices are purely backward looking, or that they contain no useful information about the future. In any case, the relationship between implied uncertainty and realised volatility is not a precise one: as **Chart 9** shows, the rise in option-implied uncertainty since mid-2011 does not seem to reflect a rise in the realised volatility. And the use of realised volatility by investors still represents a judgement that the recent volatility in inflation is likely to persist, for the next few years at least.

**Chart 9** Realised and implied standard deviation of UK RPI inflation




Sources: Bloomberg, ONS and Bank calculations.

## Comparing the implied distributions with other measures of beliefs about inflation

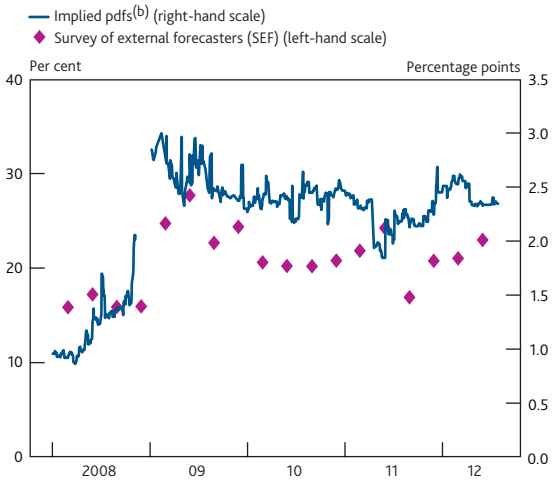
One way of checking that the messages from the implied distributions are plausible is to compare them against the messages from other measures of beliefs about inflation. At longer horizons this is not possible: there are relatively few measures of inflation expectations available beyond five-year maturities, and no measures of inflation uncertainty. And while for some surveys the underlying dispersion of individual responses is observable, this measure will reflect disagreement between individuals rather than aggregate uncertainty. But there are some comparable measures available at shorter horizons.

One such measure is available from the Bank's survey of external forecasters (SEF). As part of this survey, a sample of external forecasters are asked every three months for an assessment of the risks around their central projections for CPI inflation. **Charts 10** and **11** compare option-implied measures of uncertainty and of the balance of risks for UK RPI inflation three years ahead with measures of uncertainty and of the balance of risks around CPI inflation from the probability distributions given by that survey.

These measures are not directly comparable — the SEF measures pertain to CPI inflation, not RPI; and the SEF measures are in different units to the option-implied data.(1) But the SEF measures track the option-implied measures relatively well. As in the option-implied pdfs, uncertainty

(1) The SEF asks respondents to assign probabilities to inflation outturns falling within discrete buckets, making it hard to construct comparable measures.

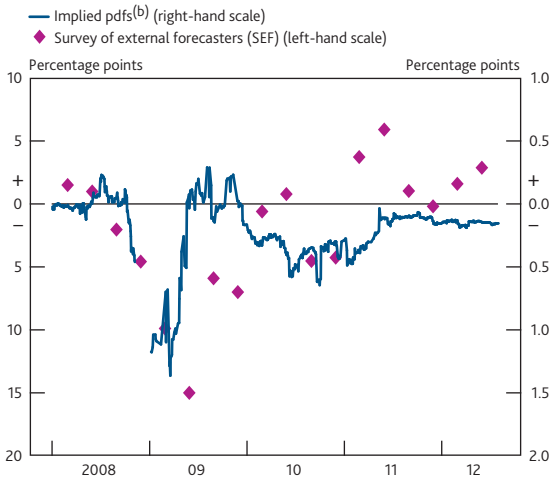
**Chart 10** Measures of uncertainty about inflation three years ahead[a]




Sources: Bloomberg, ONS and Bank calculations.

(a) For SEF: average weight given by respondents to CPI inflation being more than 1 percentage point away from target. For implied pdfs: standard deviation.
(b) Missing data in late 2008 and early 2009 are due to technical problems relating to the very low level of RPI inflation — see previous section for details.

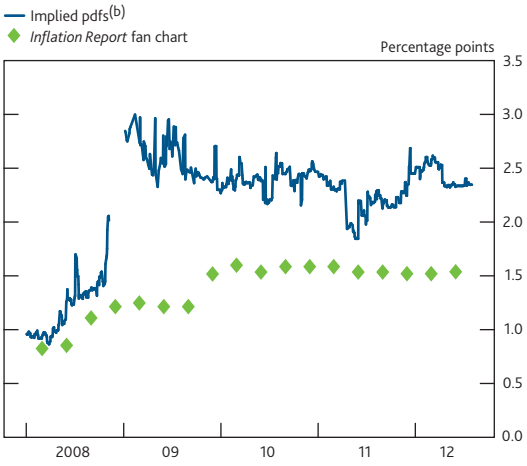
**Chart 11** Measures of the balance of risks to inflation three years ahead[a]




Sources: Bloomberg, ONS and Bank calculations.

(a) For SEF: measured as net balance of average weights given by respondents to CPI inflation being more than 1 percentage point above or below target. For implied pdfs: measured as mean minus mode.
(b) Missing data in late 2008 and early 2009 are due to technical problems relating to the very low level of RPI inflation — see previous section for details.

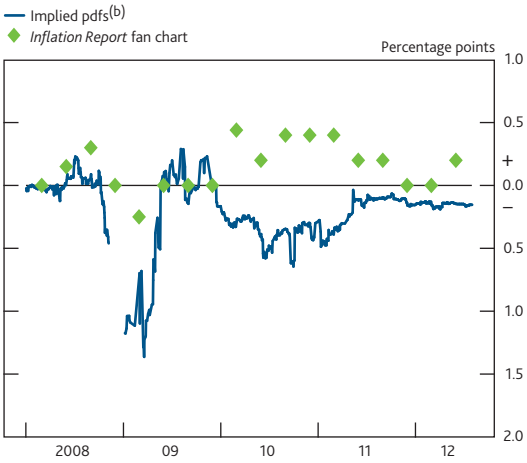
**Chart 12** Measures of uncertainty about inflation three years ahead[a]




Sources: Bloomberg, ONS and Bank calculations.

(a) Measured as standard deviation for both distributions.
(b) Missing data in late 2008 and early 2009 are due to technical problems relating to the very low level of RPI inflation — see previous section for details.

**Chart 13** Measures of the balance of risks to inflation three years ahead[a]




Sources: Bloomberg, ONS and Bank calculations.

(a) Measured as mean minus mode for both distributions.
(b) Missing data in late 2008 and early 2009 are due to technical problems relating to the very low level of RPI inflation — see previous section for details.

among external forecasters about inflation three years ahead rose through 2008 and 2009 and has remained relatively flat since then. And both measures of the balance of risks fell sharply in late 2008 and early 2009, rose again later in 2009 and have remained relatively stable since then.

Another measure is based on the fan charts for inflation published in the Bank's *Inflation Report*. **Charts 12** and **13** compare the option-implied three year ahead measures with the standard deviation and skewness parameter of those fan charts.(1) Again, these measures are not directly comparable. The fan charts describe CPI inflation, not RPI inflation. And the fan charts are produced using conditioning assumptions for the paths of some financial market variables, such as policy rates, whereas the implied distributions will include investor uncertainty about these variables.

The uncertainty embodied in the *Inflation Report* fan charts has also risen over the past few years, although it has increased by somewhat less than that from the option-implied distributions. That could reflect the differences between the two measures.

(1) The standard deviation of the *Inflation Report* fan chart is not strictly the same as the uncertainty parameter published by the Bank, except in the special case when the skewness parameter is zero. The difference between the two is usually small. See Wallis (1999) for details.

But, as described in the previous section, the rise in investors' actual uncertainty is also likely to have been amplified in the implied data by their desire to hedge against the worst outturns — this would not affect the *Inflation Report* fan charts.

In contrast, the balance of risk measures have evolved somewhat differently; the skewness of the MPC's forecast underlying the fan charts fell only a little in 2008–09, unlike the option-implied skewness, and in 2010–11 the two measures moved in roughly opposite directions.

## Conclusion

The option-implied inflation distributions presented in this article are a valuable tool for examining people's beliefs about future inflation rates. In particular they are available at much longer time horizons than any other measures, and so provide a unique window onto investors' views about the range of possible inflation outturns for many years ahead. If the inflation option market continues to develop it may become possible to use the implied pdfs to extract much more detailed information about investors' beliefs about possible outturns for inflation, including over the MPC's forecast horizon.

The implied pdfs demonstrate that uncertainty around inflation has risen substantially since 2008 at all maturities. That does not necessarily mean that central inflation expectations have become less well anchored. Indeed, the mean of the distributions has been relatively stable over time. Instead, much of the increase in uncertainty seems likely to reflect investors' beliefs that the volatility in inflation seen since the financial crisis will persist for at least the next few years.

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## Appendix
## How the implied pdfs are produced

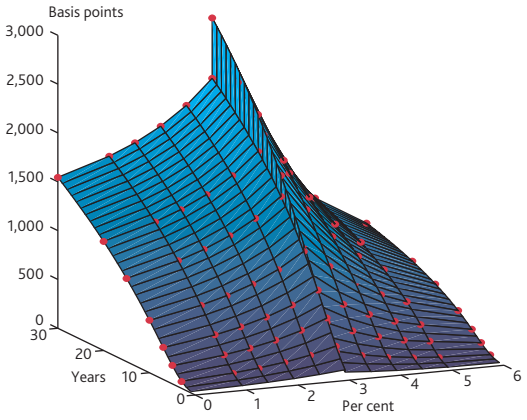
Fitting option-implied pdfs relies on a well-known result in finance, ultimately due to Breeden and Litzenberger (1978). The result relates the price $c(K)$ of a call option with strike price $K$ and expiry date $t$ to the probability density function $f$ describing the value of the underlying variable at $t$, via the equation

$$f(K) = e^{rt} \frac{\partial^2 c(K)}{\partial K^2}$$

where $r$ is the risk-free rate. That is, the probability density function is proportional to the second derivative of the *call-price function* with respect to the strike. For most assets, option prices are observed at a finite number of strike prices and expiry dates. Once a call-price function has been interpolated, implied pdfs can be obtained by numerically calculating the second derivative and rescaling it.(1)

For inflation, prices for annual call and put options (ie caplets and floorlets) are not directly available; instead, cap and floor prices are quoted at a small number of maturities. So calculating inflation pdfs requires the extra step of *caplet stripping*: interpolating cap and floor prices at the unobserved maturities (shown in **Chart A1**), and then recovering the caplet and floorlet prices which make up those caps.

**Chart A1** Fitted and observed option prices




Sources: Bloomberg, ONS and Bank calculations.

There is no standard way to carry out this procedure. The Bank's method is as follows:

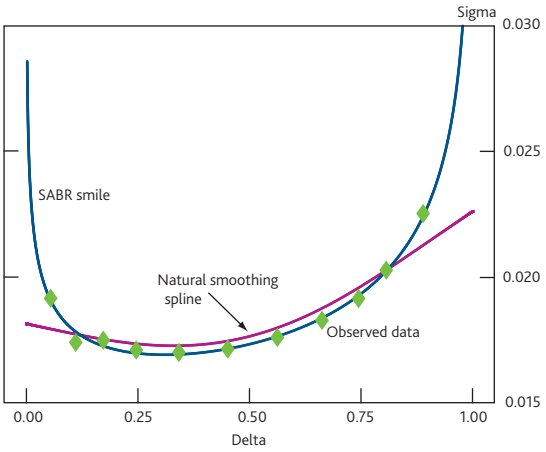
- First, convert the upfront option prices into the annual premia that would be paid if the payments were made on a per-year basis (like credit default swap contracts). This effectively standardises the option prices, stripping out the effects of contract length and the shape of the yield curve.

- Second, interpolate across time to obtain the annual premia for the missing maturities. Each interpolation is performed using a natural smoothing spline: this is a standard curve fitting technique which attempts to fit the data while keeping the curve as smooth as possible. To allow for the fact that beliefs about inflation are likely to vary more at short maturities, more deviation from smoothness is permitted at the short end of the curves.

- Finally, convert all the fitted premia back into upfront prices and calculate the associated caplet and floorlet prices. This is now straightforward: each caplet price is equal to the difference between two caps with consecutive maturities. These prices are then passed on to the standard toolkit for processing as usual.

There is one other notable difference between the technique used for these options and the standard toolkit. Before the standard toolkit interpolates across the observed prices, it transforms the price-strike pairs into *sigma-delta space*; the interpolated curve in this space is called the *volatility smile*. Like the transformation described above for the inflation option prices, this is purely for fitting convenience. However, it turns out that the natural smoothing spline usually used for interpolation does not fit the inflation option data well. A technique called a *SABR smile* gives a much better fit, as **Chart A2** shows.(2)

**Chart A2** Fitting the volatility smile




Sources: Bloomberg, ONS and Bank calculations.

(1) This is the 'non-parametric method' described in more detail in Clews, Panigirtzoglou and Proudman (2000).
(2) SABR stands for Stochastic Alpha Beta Rho: the fitting method was originally derived from a stochastic volatility model for interest rates. The model is set out in Hagan *et al* (2002).

# The Bank of England's Real-Time Gross Settlement infrastructure

By Andrew Dent and Will Dison of the Bank's Market Services Division.[1]

The Bank of England operates the United Kingdom's Real-Time Gross Settlement (RTGS) infrastructure for the settlement of electronic sterling transfers. This infrastructure plays a vital role in the safe functioning of the UK financial system and in fulfilling the Bank's core purposes — maintaining monetary and financial stability. This article explains the role of the RTGS infrastructure, how it operates, and how it reduces risk in the UK financial system. It also outlines how the design of the infrastructure will develop in the coming years.

## Introduction

Electronic payments are essential to the functioning of modern economies. In the United Kingdom, over 98% of sterling payments, by value, are made electronically, with less than 2% made by notes, coins or cheques. The majority of electronic payments are retail: for example they are used by companies to pay salaries, individuals to pay bills and governments to pay benefits. But electronic payments are also used for high-value wholesale market transactions, for example by banks to lend to each other.

Securities transactions, such as purchases and loans of bonds, equities and money market instruments, are also vital to the functioning of modern economies. These transactions are also made electronically and enable governments to finance their budget deficits, companies to raise funds in capital markets, and banks to lend and borrow against collateral in the money markets. They also allow households to invest savings via pension funds and companies to invest their retained profits.

Safe, efficient and reliable settlement of payments and securities transactions is vital. As Alan Greenspan, former Chairman of the Federal Reserve Board, remarked:

'We'd always thought that if you wanted to cripple the US economy, you'd take out the payment systems. Banks would be forced to fall back on inefficient physical transfers of money. Businesses would resort to barter and IOUs; the level of economic activity across the country would drop like a rock.'[2]

The Bank of England operates the United Kingdom's Real-Time Gross Settlement (RTGS) infrastructure, which lies at the heart of the settlement of sterling payments and securities transactions. On an average day, it settles some £575 billion, equivalent to UK annual GDP every three days. This article explains the role the RTGS infrastructure plays, how it operates, and the ways that it will develop over the coming years.

The RTGS infrastructure acts as an accounting system, allowing banks and building societies to hold sterling balances, called reserves, at the Bank. These balances are held overnight for balance sheet management purposes and form part of the monetary policy transmission mechanism. In addition, these balances can be used during the day to settle the interbank obligations arising from payments and securities transactions made by banks and their customers.

The RTGS infrastructure is a critical component of the United Kingdom's two principal funds transfer systems: CHAPS, the same-day electronic funds transfer service for high-value sterling payments; and CREST, the securities settlement system. The RTGS infrastructure also settles the net interbank obligations arising from several of the major retail sterling payment schemes.[3] One principal design feature of the infrastructure is its ability to make certain types of transfers continuously throughout the day.

The RTGS infrastructure plays a vital role in the safe functioning of the UK financial system and in fulfilling both of the Bank's core purposes — maintaining monetary and financial stability. It therefore needs to be extremely operationally reliable.

(1) The authors would like to thank Joanna McLafferty for her help in producing this article.
(2) See Greenspan (2007).
(3) The CPSS-IOSCO principles define a payment scheme as a set of instruments, procedures and rules for the transfer of funds between or among participants. See Committee on Payment and Settlement Systems and Technical Committee of the International Organization of Securities Commissions (2012).

The first section of this article provides a high-level explanation of interbank settlement. It explains how transfers of funds give rise to interbank obligations, the role central banks play in settling these obligations, and the two principal settlement models available. The second section sets out the history of the development of the United Kingdom's RTGS infrastructure and how it supports both of the Bank's core purposes. The third section gives a more detailed account of the infrastructure: its different uses, the provision of intraday liquidity, and how its very high service levels are achieved. Since its inception, the United Kingdom's RTGS infrastructure has evolved continually to keep pace with the changing payments environment. This continues today, and the fourth section of the article highlights forthcoming developments that will further improve the infrastructure's efficiency and resilience.

## Why central banks operate RTGS infrastructures

### The role of the settlement agent

A 'settlement agent' facilitates the transfer of funds between the customers of different banks. Since not all bank accounts are held at the same commercial bank, transfers between accounts create interbank obligations. To settle these obligations, an asset must be transferred between banks. The role of a settlement agent is to provide accounts to banks for this purpose.

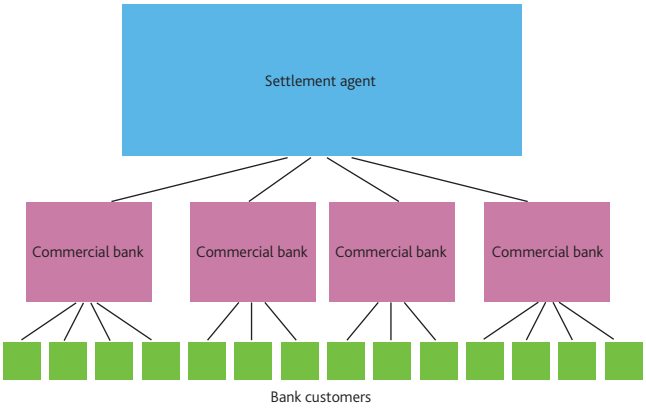
A simple example illustrates how these interbank obligations arise. Suppose a customer of a gas company wants to pay a bill using an electronic payment. If the customer and the gas company happen to have accounts with the same commercial bank, the payment can be made very simply: the bank just debits the customer's account and credits an equal amount to the company's account. No obligation between banks arises.

But if the customer and the gas company have accounts with different commercial banks, then an interbank obligation does arise. To achieve the transfer from the customer to the company, the customer's bank debits the customer's account, and the company's bank credits an equal amount to the company's account. At this stage the customer has in effect made a transfer to their bank, and the company's bank has made a transfer to the company. An obligation has been created: the customer's bank owes the company's bank the value of the payment. To eliminate this exposure, and complete the end-to-end transfer from the customer to the company, a transfer must be made from the customer's bank to the company's bank. This final transfer is known as 'settlement'.

The asset used for this interbank settlement is known as the settlement asset and its provider as the settlement agent.

Historically, the settlement asset was gold and, later, banknotes. Today, it is usually electronic money held in an account at a bank.(1) It follows that, to settle an interbank obligation between two commercial banks, both banks must themselves hold accounts at a single bank designated for this purpose. This latter bank is the settlement agent. The resulting structure of accounts, sometimes referred to as the 'payment pyramid', is illustrated, in a simplified format, in **Figure 1**.

**Figure 1** The payment pyramid account structure




The settlement agent could be either a commercial or a central bank. If the settlement agent is a commercial bank, the settlement asset is 'commercial bank money'.(2) Commercial bank money is the balances held in accounts at commercial banks, which includes the money individuals have in their own bank accounts. Indeed, in modern economies, most money held by individuals and companies is commercial bank money.

But for systemically important payment schemes, there is a clear financial stability rationale for the settlement agent being a central bank. In this case, the settlement asset is 'central bank money', ie the balances held in accounts at a central bank. If a settlement agent defaults, account holders lose both the value of their deposits and the mechanism for settling interbank obligations. As a central bank is financially supported by its government, its default risk is generally considered to be the lowest of any agent in the economy and its liabilities close to risk-free. The risk of the settlement agent defaulting is therefore largely eliminated by settling in central bank money.

### The choice of settlement model

Interbank settlement via the settlement agent usually follows one of two principal models: deferred net settlement (DNS) or real-time gross settlement (RTGS).

(1) For more detail on the history of interbank settlement arrangements, see Norman, Shaw and Speight (2011).
(2) For example, in the United Kingdom, credit and debit card payments are settled in commercial bank money.

Under the DNS model, payments are exchanged between participant banks during a 'clearing cycle', at the end of which the net obligations between participants are calculated and presented to the settlement agent for settlement. This process of clearing and settlement may be achieved several times a day, or the whole end-to-end process may take several days. By contrast, under the RTGS model, payment instructions are exchanged and settled individually on a gross basis throughout the business day.

Settlement will only occur if the bank being debited has sufficient money (often termed 'liquidity') available on its account with the settlement agent. Any settlement model will therefore generate a demand for liquidity. The 'liquidity efficiency' of a model refers to the value of payments that can be settled for a given amount of liquidity. The DNS model is more liquidity efficient than the RTGS model as only the net obligations incurred between banks during a clearing cycle are settled, and these will always be less than (or equal to) the gross values. The box on page 237 presents an example of payment flows and their liquidity needs under the two models.

Although the DNS model is more liquidity efficient than the RTGS model, it is likely to increase settlement risk to some extent. Under the DNS model, a payment between two banks generates a credit exposure for the recipient bank. This exposure is only extinguished at the end of the clearing cycle when settlement occurs. The exposure could crystallise into a loss for the recipient bank if the paying bank defaults during the cycle and before settlement has been completed. The default of a participant could have systemic consequences, particularly if the values passing through the payment scheme are large: a failure to settle by one participant could have repercussions on the ability of other participants to settle, potentially compounding the adverse effects of the first settlement failure. DNS payment schemes can adopt various controls to mitigate this credit risk. These include default funds, loss-sharing agreements, net debit caps, and prefunding requirements.

Under the RTGS model this settlement risk does not occur: all payments are settled individually and on a gross basis, so there is no scope for unintended credit exposures between banks to build up within the settlement process. Receiving banks can credit customer accounts or use incoming funds to pay other banks in the certain knowledge that settlement of each payment has already occurred.

An additional risk arises in securities settlement, as transfers of both cash *and* securities need to be settled. 'Principal risk' refers to the risk that one party to a trade defaults before fulfilling its obligation, leaving the buyer without securities or the seller without cash. This risk is addressed by settling under the delivery versus payment (DvP) principle, whereby the cash is transferred if and only if the securities are also transferred.

Intuitively, this logical link is best achieved when both cash and securities settle under the RTGS model. However, different securities settlement systems around the world apply different models of DvP. In some systems, for example, the associated cash transfers settle on a DNS basis.

## The development of the United Kingdom's RTGS infrastructure

### The move to real-time gross settlement

The Bank has provided accounts for the settlement of interbank obligations since the mid-19th century. Early accounting systems were paper-based, but developments in technology meant that by the mid-1980s, CHAPS payments settled electronically across the Bank's books. By the early 1990s, the interbank cash obligations arising from transactions in gilts and sterling money market instruments also settled electronically at the Bank, as did the main electronic and paper-based retail clearings. They all did so, however, on an end-of-day multilateral net settlement basis.

During the 1980s and 1990s, central banks around the world progressively moved to settling their high-value domestic payment schemes using the RTGS model. In 1980, of the major developed economies, only the United States had an RTGS infrastructure; by the end of the 1990s, such infrastructures had been established in all the G10 countries except one.(1) Advances in technology made real-time accounting operationally feasible. But the key policy driver of the change was the recognition by public authorities of the systemic risks inherent in settling high-value or wholesale payments under the DNS model.

In the United Kingdom, Robin Leigh-Pemberton, the then Governor of the Bank of England, used his 1989 Ernest Sykes Memorial Lecture(2) to open a debate on 'the future of the wholesale payment system in the United Kingdom'. In 1992, the Association for Payment Clearing Services announced(3) that an infrastructure would be developed for settling CHAPS payments under the RTGS model. The Bank's RTGS infrastructure was subsequently launched in 1996. In 2001, securities settlement in CREST moved to an RTGS-equivalent model of DvP.

The benefit of this move to the RTGS model was demonstrated in 2008 during the financial crisis. Risk appetites in the sterling money markets shrank, but the absence of credit risk in the settlement process contributed to the willingness of market participants to continue transacting with one another.

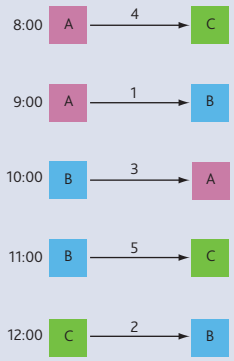
(1) For a comparison of the infrastructures for settling payments in different countries, see Committee on Payment and Settlement Systems (2005).
(2) The lecture was reprinted in Bank of England (1989).
(3) See Bank of England (1994).

## Real-time gross settlement versus deferred net settlement

This box presents an example illustrating the differences between the deferred net settlement (DNS) and real-time gross settlement (RTGS) models and demonstrating the higher liquidity needs of the RTGS model.

Suppose three banks, A, B and C, make payments to each other at the indicated times (**Figure A**).

**Figure A**



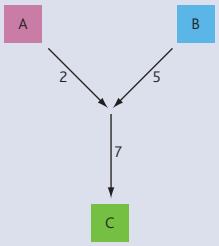

Under the DNS model, and assuming that all the payments are processed in the same clearing cycle, only the net obligations resulting from the payments would be settled at the end of that cycle. These end-of-cycle positions are calculated in the following table: payments sent by a bank are shown as a negative figure, while payments received are shown as a positive figure (**Figure B**).

**Figure B**

| A | B | C |
|---|---|---|
| -4 | | +4 |
| -1 | +1 | |
| +3 | -3 | |
| | -5 | +5 |
| | +2 | -2 |
| -2 | -5 | +7 |

Banks A and B have end-of-cycle net obligations of 2 and 5 respectively, while bank C has a net claim of 7. Settlement on a multilateral net basis would therefore consist of the following transfers across the accounts the banks hold at the settlement agent (**Figure C**).

**Figure C**




For settlement to occur, banks A and B need only have balances of 2 and 5 respectively on their accounts at the start of the day, while bank C needs no balance at all. The liquidity usage under the DNS model would therefore be 2 + 5 + 0 = 7.

Alternatively, suppose that the payments settle under the RTGS model. Assuming each bank has a sufficient balance on its account, each payment would settle individually at the time it is made. If banks A, B and C start the day with balances of 5, 7 and 0 respectively, then hourly snapshots of the balances on their accounts at the settlement agent, just after each payment has settled, would be as follows (**Figure D**).

**Figure D**

| | A | B | C |
|---|---|---|---|
| Start of day | 5 | 7 | 0 |
| 8:01 | 1 | 7 | 4 |
| 9:01 | 0 | 8 | 4 |
| 10:01 | 3 | 5 | 4 |
| 11:01 | 3 | 0 | 9 |
| 12:01 | 3 | 2 | 7 |

If any one of the banks begins the day with a lower starting balance than this, then at least one of the payments would not be able to settle, as there would be an insufficient balance on the payer's account at the time the payment was to be made. The liquidity usage under the RTGS model is therefore 5 + 7 + 0 = 12.

## Supporting the Bank's core purposes

The Bank of England's two core purposes are to ensure monetary and financial stability. The United Kingdom's RTGS infrastructure plays a key role in helping the Bank to meet both these aims.

The RTGS infrastructure supports the Bank's monetary stability core purpose in three ways. First, the reserves held in the infrastructure are a key component of the Sterling Monetary Framework (SMF). This framework implements the Monetary Policy Committee's decisions by aiming to maintain overnight interbank money market rates in line with Bank Rate.(1) The interbank money market is a market in central bank reserves

(1) For an explanation of the SMF and how monetary policy is implemented, see Bank of England (2012).

and so needs a mechanism to transfer reserves between banks. Second, monetary policy influences the real economy through the interest rates faced by households and companies when they lend and borrow. When these transactions are between customers of different banks they create interbank obligations and hence a need for a settlement agent. So while these transactions are typically made in commercial bank money, they usually settle in central bank money across the RTGS infrastructure. And third, the Bank's monetary policy operations settle across the infrastructure. These operations include asset purchases using newly created central bank money ('quantitative easing') and the more traditional open market operations that lend reserves to banks.

The RTGS infrastructure also supports financial stability in three ways. First, it facilitates the safe transfer of funds between parties: settling in central bank money mitigates the risk of the settlement agent defaulting, and settling under the RTGS model prevents credit exposures between banks building up in the settlement process. Second, as one of the most liquid and risk-free assets in the economy, the reserves that banks hold in accounts in the RTGS infrastructure provide a buffer against unexpected liquidity shocks. And third, many of the Bank's financial stability operations settle across the RTGS infrastructure. These operations include lending funds against high-quality securities that have become temporarily less liquid due to stressed market conditions (referred to as liquidity insurance) and providing emergency liquidity assistance to individual financial institutions.

## The operation of the United Kingdom's RTGS infrastructure

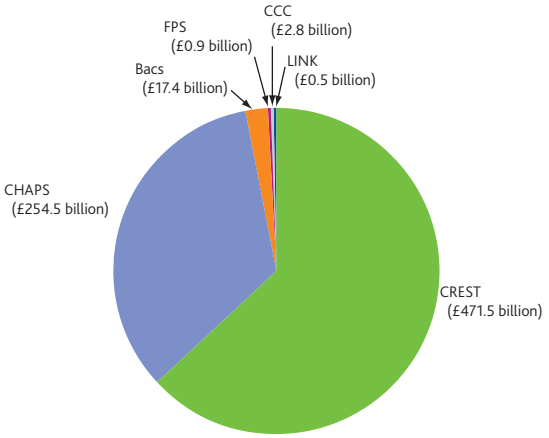
### Users of the infrastructure

The Bank acts as the settlement agent for the CREST securities settlement system, the CHAPS high-value payment scheme, and four retail payment schemes: Bacs, the Faster Payments Service (FPS), Cheque and Credit Clearing (CCC) and LINK. The sterling interbank obligations arising from these systems and schemes are settled using transfers of central bank money between accounts that commercial banks hold in the RTGS infrastructure.

Much of the operation of the infrastructure is automated, allowing hundreds of thousands of transfers to occur daily, with minimal manual intervention by the operators. The account-holding banks communicate with the infrastructure via the international financial telecommunication network operated by SWIFT.

Although CHAPS and the four retail payment schemes all settle across the RTGS infrastructure, only CHAPS payments settle under the RTGS model; the retail payment schemes settle using the DNS model. The RTGS model is most appropriate for CHAPS because of its systemic importance to UK financial stability and the large values passing through it compared with the other payment schemes (**Chart 1**). The retail payment schemes, which process a much higher volume but lower value of payments (**Charts 1** and **2**), use the DNS model. Although credit exposures between banks can still build up in the settlement process of the retail schemes, they implement controls to mitigate the risks these cause.

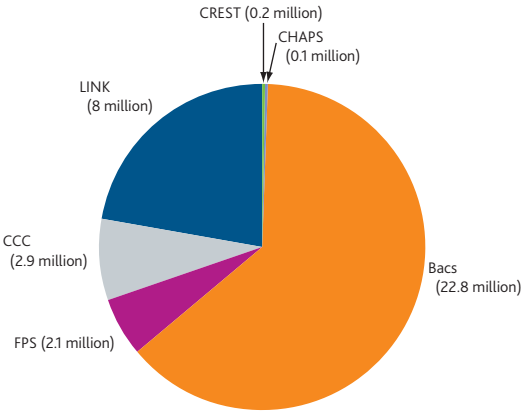
**Chart 1** Average daily gross values transferred through UK payment systems in 2011[a][b]




Sources: Bank of England, Euroclear UK and Ireland Ltd, LINK and UK Payments Administration Ltd.

(a) CREST figures refer to the value of cash movements within CREST (and will therefore include the value of transactions settled between CREST participants who use the same settlement bank). CREST figures refer to sterling transactions.
(b) CCC figures refer to sterling cheques and paper bank giro credits exchanged in Great Britain.

**Chart 2** Average daily gross volumes transferred through UK payment systems in 2011[a]




Sources: Bank of England, Euroclear UK and Ireland Ltd, LINK and UK Payments Administration Ltd.

(a) See footnotes to **Chart 1**.

CHAPS is primarily used for high-value wholesale sterling payments, such as interbank loans, but also for some lower-value but time-critical payments such as those for house purchases. Consequently, the average value of a CHAPS payment is large, some £1.9 million in 2011. The banks that participate directly in the CHAPS scheme, by holding settlement accounts in the RTGS infrastructure at the Bank, are called CHAPS settlement banks. There are currently

18 CHAPS settlement banks, while several hundred other banking institutions access the scheme indirectly via one of these. When a CHAPS settlement bank wants to make a CHAPS payment, it sends a message to the RTGS infrastructure via the SWIFT network. Assuming there is a sufficient balance on the paying bank's settlement account at the Bank, the infrastructure then automatically transfers the money from this account to the recipient bank's settlement account, before notifying the recipient bank that the payment has settled.

The four retail payment schemes settle different types of payments. The Bacs scheme processes bulk electronic direct debits and direct credits, such as salaries, pensions and utility bill payments. It operates on a three-day clearing cycle. FPS, launched in 2008, processes many payments initiated by internet and telephone banking, and is also used for standing orders. FPS transfers occur almost immediately after initiation, with the net interbank obligations settling three times a day across the RTGS infrastructure. The LINK scheme settles the interbank obligations that arise when cash is withdrawn from an ATM by another bank's customer. Interbank obligations arising from the use of sterling cheques and paper-based credits also settle across the RTGS infrastructure.

The Bank and Euroclear UK and Ireland Limited (the operator of the CREST securities settlement system) together deliver a particular model of real-time gross DvP settlement in sterling central bank money for transactions in UK securities. The cash transfers arising from securities transactions between CREST participants are settled across the CREST settlement accounts that the fourteen CREST settlement banks hold at the Bank. This relies on technical and legal links between the Bank's RTGS infrastructure and the CREST infrastructure.

The international Continuous Linked Settlement (CLS) system settles foreign exchange transactions on a so-called 'payment versus payment' (PvP) basis. As with securities settlement, foreign exchange settlement has to address the issue of principal risk (explained on page 236), often referred to in this context as 'Herstatt risk'. This risk is removed by settling transactions PvP, whereby the two currency transfers of a foreign exchange transaction settle simultaneously. Sterling transfers to and from CLS are made using the CHAPS payment scheme and settle across accounts held at the Bank.

Purchases and sales of wholesale quantities of Bank of England notes between the UK banking sector and the Bank are effected via the Bank's Note Circulation Scheme.(1) These high-value daily transactions are settled by start-of-day and end-of-day payments between the Bank and the settlement account that the transacting bank holds at the Bank.

The Bank recovers the costs of operating the RTGS infrastructure from its users. The Bank neither subsidises the infrastructure nor seeks to generate a profit from it. Settlement banks are charged per-item fees for CHAPS and CREST settlement, as well as annual account management fees and annual fees for settling their DNS payment scheme obligations.

The Bank acts as overseer for some of the payment schemes that settle across the RTGS infrastructure. The 2009 Banking Act made the Bank responsible for ensuring that systemically important schemes take sufficient measures to mitigate risks. Payment scheme oversight and the operation of the RTGS infrastructure are carried out by separate areas of the Bank.

## Liquidity provision

The central bank liquidity needed intraday for settlement in the RTGS infrastructure arises from three sources.

- First, reserves held overnight in the RTGS infrastructure can be used intraday.

- Second, once a CHAPS payment has settled, the CHAPS settlement bank receiving the payment can immediately reuse the funds credited to its settlement account to make outgoing payments. CREST settlement banks can reuse the incoming funds from securities transactions in a similar manner. The box on page 240 explains this concept in more detail.

- Third, the Bank provides collateralised intraday loans to both CHAPS and CREST settlement banks. CHAPS settlement banks can also convert euro balances into sterling liquidity using a link to the euro high-value payment system TARGET2. The provision of this 'intraday liquidity' to settlement banks means that the Bank's intraday balance sheet is currently around 15% larger than its end-of-day balance sheet.

The mechanisms for providing intraday loans for CHAPS and CREST settlement work in different ways. Intraday liquidity provision to a CHAPS settlement bank requires an active decision by the settlement bank to enter into each intraday loan with the Bank. Typically, CHAPS intraday liquidity is supplied at the start of the business day; these loans automatically unwind at the end of the day before commencing again at the start of the next business day.

The CREST system's intraday liquidity mechanism with the Bank, on the other hand, is automatic once a liquidity need is identified. If a CREST settlement bank would otherwise have insufficient funds to settle a CREST transaction, a secured intraday loan is automatically generated using as collateral either the purchased security (if eligible) or other securities

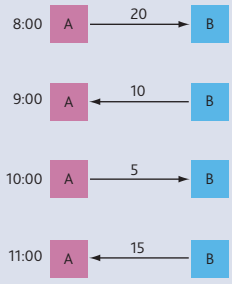
(1) See Allen and Dent (2010).

## Liquidity recycling

This box illustrates how liquidity can be recycled, with the same unit of liquidity being used to make multiple payments.

Consider the sequence of payments between two banks shown in **Figure A**.

**Figure A**




Suppose banks A and B start the day with balances of 20 and 0 respectively. If the payments settle under the RTGS model, then hourly snapshots of the balances on their accounts at the settlement agent, just after each payment has settled, would be as follows (**Figure B**).

**Figure B**

| | A | B |
|---|---|---|
| Start of day | 20 | 0 |
| 8:01 | 0 | 20 |
| 9:01 | 10 | 10 |
| 10:01 | 5 | 15 |
| 11:01 | 20 | 0 |

The key point is that although bank B starts the day with no balance, it is able to make its payments using the liquidity it receives from bank A's payments. And despite only starting the day with a balance of 20, bank A is able to make payments of total value 25. In aggregate, a total payment value of 50 is settled, despite the system only containing liquidity of value 20. This illustrates how liquidity recycling can significantly reduce the liquidity needed for settlement in RTGS.

held by the settlement bank in CREST. This mechanism, known as an 'Auto Collateralising Repo' (ACR) is described in more detail in the 'Markets and operations' article in the 2012 Q2 *Quarterly Bulletin*.

The ACR mechanism is operated within the CREST system and activated without direct control by the Bank. But the mechanism automatically generates sterling central bank money, thereby creating an exposure for the Bank and increasing the size of the Bank's intraday balance sheet. Consequently, all CREST settlement flows, including ACR generation, are automatically monitored by both the Bank and Euroclear UK and Ireland Limited. In addition, the Bank has the capability to cap the amount of ACR liquidity generated, both by each individual bank and in aggregate.

The Bank carefully manages the liquidity that it provides in order to protect its balance sheet. The banks eligible to receive this liquidity must pass the Bank's prudence and risk standards before it will grant them an account in the RTGS infrastructure or allow them access to credit facilities. All intraday loans are collateralised by high-quality securities. If a bank to which the Bank has extended intraday credit defaulted during the day, the Bank could realise the value of these securities to cover the loss. The Bank also applies haircuts to collateral, whereby banks only receive a proportion of the current market value of the securities pledged. These haircuts protect the Bank against adverse movements in the value of the collateral: for all but the most extreme declines in the value of the securities, this will still exceed the value of the cash lent.(1)

### Operational reliability

Given its critical role in the settlement of sterling payments and securities transactions, the RTGS infrastructure needs to maintain extremely high levels of operational reliability. Under a service level agreement, the Bank aims for 99.95% availability of the settlement services the RTGS infrastructure provides to CHAPS. Over the past four years, the infrastructure has been available for 99.997% of its usual operating hours. So on average it has been unavailable for settlement for just six minutes out of the 2,700 business hours each year. To ensure that the infrastructure can cope with spikes in payment activity, and can make up for processing time lost during operational outages, it must be able to process in just three hours in excess of the highest daily volume of CHAPS payments to date — a target it surpasses comfortably in regular tests.

To achieve these operational service levels, the RTGS infrastructure and risk controls need to be of the highest standard. The IT processor that holds the accounts and records the credits and debits to them runs on fault-tolerant computers. Additionally, a standby site duplicates the hardware and software at the Bank's principal site. The Bank's operators control the infrastructure from both sites every business day and changes to the database at one location are automatically copied to the database at the other in real time.

(1) For more information on the Bank's collateral management, see Breeden and Whisker (2010).

In some developed economies, central banks have decided to outsource the development and operation of their RTGS infrastructures to commercial infrastructure companies. In the United Kingdom, outsourcing of the operation of the RTGS infrastructure is not being considered.

The value of the infrastructure's reliability was seen in Autumn 2008. In the aftermath of Lehman Brothers' bankruptcy, as risk appetites diminished and the terms of interbank loans shrank, the daily value flowing through the infrastructure grew. Until mid-September 2008, the maximum daily value ever settled by CREST was £450 billion. In mid-January 2009, a new peak of £630 billion was hit, nearly twice the pre-crisis 2008 average. Any faltering of the RTGS infrastructure during this period could have greatly exacerbated the crisis, but its resilience ensured that this was avoided.

## The future

### A changing environment

The authorities' response to the financial crisis has changed the environment in which the RTGS infrastructure operates. In particular, the Financial Services Authority (FSA) has revised its liquidity regulations so as to reduce the risk that banks experience liquidity shortfalls.(1)

This change has had a particular impact on settlement banks' liquidity management. A settlement bank holds a buffer of liquid assets for two purposes: to maintain prudential balance sheet resilience and to meet intraday payment needs. These liquid assets may be reserves held at the Bank or high-quality securities that can be used to generate reserves either through outright sale or by pledging them as collateral in intraday loans from the Bank. Under the pre-crisis regulatory framework, the size of a bank's liquid asset buffer was calibrated to be sufficient to meet prudential resilience needs alone. But intraday, the buffer could also be used to fund payment activity. This practice is known as 'double duty'.

The problem with this approach was that the same assets were charged with meeting two separate shortfalls: prudential liquidity buffers exist to fund outflows at times of stress, so may not always be available to fund intraday payment activity. Under the new regulatory framework, liquid asset buffers are calibrated to be sufficient to meet both needs simultaneously, thereby removing double duty.

This change has made intraday liquidity more costly: previously, if a bank's intraday liquidity usage was less than the amount of liquid assets it was required to hold by the regulator, then intraday liquidity had no opportunity cost, as the bank could use for this purpose the liquid assets it already held. Furthermore, liquid asset buffers are now calibrated based on historical intraday liquidity usage. It follows that the more intraday liquidity a bank uses to make its payments, the larger its liquid asset buffer will need to be in future. This regulatory change could therefore incentivise banks to demonstrate economies in their liquidity usage.

### Forthcoming developments to the United Kingdom's RTGS infrastructure

To meet this change to the payments landscape, and further strengthen the operational resilience of the United Kingdom's payments infrastructure, the RTGS infrastructure will develop in a number of ways over the coming years. Two principal forthcoming developments are the introduction of a Liquidity Saving Mechanism (LSM) in 2013, and the launch of the Market Infrastructure Resiliency Service (MIRS) in 2014.

The LSM functionality, a similar form of which is already used in a number of other countries' RTGS infrastructures, will reduce the liquidity needed for the settlement of CHAPS payments between banks. Its development is motivated by the changes to the FSA's liquidity regulations described above.

The LSM will contain a flow management system, housed within the RTGS infrastructure, called the 'central scheduler'. Settlement banks currently control their payment flows before their payments leave their own internal systems. After the LSM is introduced, banks will manage their payment flows using the central scheduler, which will have similar functionality to banks' existing systems.

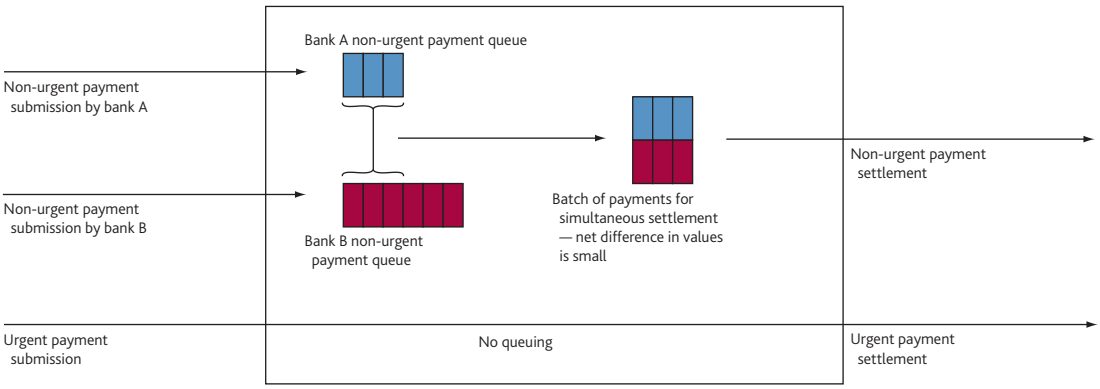
A key development is that the LSM will contain offsetting algorithms that will match batches of broadly offsetting payments from different banks to be settled simultaneously. The liquidity needed to settle a batch of payments will be the net difference between their values, a considerable change from the current system (**Figure 2**). Consistent with the philosophy of the RTGS model, offsetting payments will still settle gross from a legal standpoint. The mechanism will therefore combine the risk-reduction benefits of the RTGS model with the liquidity efficiency of the DNS model.

Many payments have a contractual deadline of the end of the business day. But some payments, such as transfers to CLS, need to be settled more urgently, for example by a certain time during the day. The LSM will process these urgent payments immediately. To enable it to do so, settlement banks will decide whether to submit each payment to an urgent or a non-urgent queue.

By design, the LSM will most of the time only be available to settle urgent payments, and it will do so in a similar manner to the existing RTGS model. But, every few minutes, the LSM will briefly suspend processing urgent payments and switch to a 'matching cycle'. During the matching cycles, which are each

(1) For more detail on the changes to the FSA's liquidity regulations, see Ball *et al* (2011).

**Figure 2** Settlement in the LSM




expected to last around fifteen seconds, offsetting algorithms will be run to match and settle batches of non-urgent payments. Any non-urgent payments not settled by the end of a matching cycle will remain in the queue until the start of the subsequent cycle in a few minutes' time. This process will ensure that urgent payments settle much more quickly than non-urgent payments: typically in a matter of seconds rather than minutes.

The key design feature of the LSM is that while urgent payments will have access to all the liquidity that the paying bank has available for payment settlement, banks will be able to constrain the liquidity available for settling their non-urgent payments. This design ensures that urgent payments will have the best opportunity to settle without delay, while it is intended that non-urgent payments will generally queue awaiting incoming payments against which they can be offset, and so settle with lower liquidity usage. Banks will be able actively to control the liquidity available for settling their non-urgent payments throughout the business day.

The Bank has performed simulation studies(1) which suggest that the introduction of the LSM could reduce the total liquidity needed for CHAPS settlement by around 30%. Liquidity savings will be maximised if all banks submit payments into the central scheduler as soon as possible, as there will then be a greater likelihood that the offsetting algorithms can identify offsetting payments.

Another forthcoming development is MIRS, which will provide an additional contingency RTGS infrastructure that could be invoked should the infrastructures at the Bank's principal and standby sites ever fail simultaneously. MIRS will be developed and hosted by SWIFT and is expected to launch in 2014.

As well as offering an additional contingency option, MIRS will increase operational resilience in two key ways. First, it will be technically operated from outside the United Kingdom, so bringing greater geographic diversity to the sites hosting the infrastructure. And second, MIRS achieves technical diversity as it will be based on a different technology platform. This addresses a problem common in contingency arrangements that sites share software and hardware configurations and so could be susceptible to the same risks.

The generic design of MIRS by SWIFT means that it could be adopted by multiple central banks, thus lowering its cost to each user. To further reduce costs, the service provided will be simpler than that offered by the Bank's main RTGS infrastructure — it will be designed to maintain only essential functionality in the event of a low-probability but very high-impact event.

## Conclusion

The RTGS infrastructure is essential to the functioning of the UK economy and supports both of the Bank's core purposes. It therefore needs to meet extremely high standards of service, availability and resilience. The infrastructure's record against these criteria is impressive, as evidenced in particular by its smooth functioning during the financial crisis.

But the environment in which the infrastructure operates is constantly changing: in particular new FSA regulations will raise the cost of accessing intraday liquidity.

To keep pace with this changing landscape, the RTGS infrastructure must itself evolve. Upcoming developments to the infrastructure will improve its efficiency and resilience to ensure it continues to meet the challenges it faces.

(1) See for example Denbee and McLafferty (2013).

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# Bank behaviour and risks in CHAPS following the collapse of Lehman Brothers

**Summary of Working Paper No. 451** Evangelos Benos, Rodney Garratt and Peter Zimmerman

During the period of financial stress, in the wake of the Lehman Brothers' default, infrastructures used by banks to make payments to one another held up well. The Bank of England's *Payment Systems Oversight Report 2008* explains that although the crisis placed unprecedented demands on payment and settlement systems, these continued to provide a robust service. We examine how this stress affected payment patterns in CHAPS, the United Kingdom's large-value wholesale payment system. This is important to the Bank in its role as the overseer of recognised interbank payment systems, including CHAPS, and as host of the infrastructure that supports the operations of CHAPS.

CHAPS payments data show that, in the two months following the failure of Lehman Brothers, banks on average made payments at a slower pace than prior to the failure. This delay was partly explained by concerns about bank-specific and system-wide risks. 'Turnover', which is defined as the average number of times each unit of liquidity employed by banks to make payments is used during the day, was 30% lower in the period from 15 September 2008 to 30 September 2009 than in the period preceding the Lehman default. In the immediate aftermath of Lehman this was due to payment delay, but later may have been related to increased reserves balances associated with quantitative easing. This may have led to banks being more willing to make payments with their own liquidity rather than relying on liquidity from payments received from others.

We also find that the payment delays observed in the months following the failure of Lehman Brothers modestly increased the liquidity risks associated with operational outages. An operational outage is an event during which a single settlement bank (ie a bank which is a member of CHAPS and is able to submit payments directly into the system) may be unable to send payments. Since such a settlement bank is unable to provide liquidity to the payment system, the impact of an operational outage depends on the liquidity that the affected bank would have provided to the system during the outage.

We compute two estimates of the impact of operational outages. One measure considers the impact of a single outage that occurs at the worst possible time on a given business day, while the other measure computes the expected impact of a single outage occurring at a random point in time during the day. Both measures of risk show a statistically significant increase in the period following the collapse of Lehman Brothers. Thus, our results show that, although operational risks did not crystallise, the potential for disruption in CHAPS did increase during the period of financial stress in the wake of the collapse of Lehman Brothers.

To provide some indication of the economic cost of these risks, we calculate how much additional money banks would on average have had to pay to insure themselves against the loss of liquidity due to an operational outage. Although the amount of liquidity loss to be insured against increased in the wake of the Lehman Brothers' collapse, a mitigating factor to this increase was a sharp decline in the cost of obtaining liquidity during the same period. The combined effect was an increase in the hypothetical premium until mid-October 2008, followed by a fall to levels lower than those seen in Summer 2008, on account of lower borrowing rates. Despite the temporary increase, the daily hypothetical premium was about £6,700 per bank during the month after the Lehman Brothers' collapse. While the economic cost was low, in absolute terms, an interesting question is whether the cost — and the underlying risk exposure — would have increased to a greater extent in the absence of CHAPS throughput requirements, which oblige settlement banks to settle minimum proportions of their payments by specific times of the day.

# Simple banking: profitability and the yield curve

**Summary of Working Paper No. 452** Piergiorgio Alessandri and Benjamin Nelson

This paper examines the relationship between bank profitability and interest rates. Understanding this link is important for policymakers. If interest rates have a systematic effect on bank profitability, and if in the short run profitability is a major determinant of bank capital, it follows that monetary policy may have implications for the resilience of the financial system. We investigate the effects of interest rates on profitability using a new, unique panel data set containing information on the UK activities of UK and foreign banking groups for 1992–2009. We find evidence of a systematic effect of market interest rates on bank profitability. In the long run, high yields and a steep yield curve boost banks' income margins. In the short run, though, an increase in short-term yields depresses income, which is consistent with the presence of frictions affecting the repricing of banks' assets and liabilities in an asymmetric way.

We begin with a simple theoretical model of a bank which is subject to credit and interest rate risk, which chooses its interest margin to maximise expected profits. The model provides us with a number of testable implications. First, in equilibrium the net interest margin (NIM) is likely to be positively related to short-term interest rates, as banks raise their loan rates and shrink their lending quantities in response to higher market rates. Second, the short-run and long-run effects of interest rates can differ. In particular, if banks borrow short and lend long, and if their interest rates are not fully flexible in the short run, banks will be exposed to 'repricing' risk. The combination of maturity mismatch and repricing frictions is indeed a popular explanation for why sharp changes in interest rates might compress bank profits.

We find that high interest rates are associated with large interest income margins, as predicted by the model. We also find that the slope of the yield curve matters positively for interest income: after all, banks indeed seem to borrow short and lend long. The short-run impact of an increase in short-term market rates, however, is negative. This is consistent with the existence of significant repricing frictions that prevent banks from implementing their pricing decisions instantaneously. We also find that level and slope of the yield curve affect the net interest margin and trading income in opposite directions, which suggests that banks hedge interest rate risk through derivatives. Even after accounting for hedging, however, large banks appear to retain a residual exposure to UK interest rates: the interest rate effects in the banking book 'pass through' into operating profitability. Thus monetary policy — set for the economy as a whole — appears to have systematic effects on bank profitability, providing one potential motivation for the use of macroprudential policy tools.

We present two applications of our estimated model. First, we explore the interaction of level and slope effects and short and long-run multipliers by running a 'monetary policy shock' through the model. A typical policy tightening raises short-term rates and flattens the yield curve, thus depressing banks' income through two distinct channels. This effect is fairly short-lived, and somewhat attenuated by hedging. Higher rates have an unambiguously positive effect on bank profits in the long run. Second, we use our estimated NIM equation to decompose the sources of profitability since 1992, examining the model-implied contributions of the level and slope of the yield curve to the average net interest margin over the sample.

# Estimating probability distributions of future asset prices: empirical transformations from option-implied risk-neutral to real-world density functions

**Summary of Working Paper No. 455** Rupert de Vincent-Humphreys and Joseph Noss

There is a strong tradition of central banks and other policymakers extracting information from the prices of financial securities. Derivatives contracts can provide information on the expected future path of their underlying asset's price that goes beyond its central expectation. They therefore offer an insight into the level of uncertainty surrounding future cash flows. The Bank of England regularly estimates probability density functions (pdfs) from options prices in order to obtain an indication of the weight investors place on different future prices.

However, such option-implied pdfs may not provide a true indication of the actual probabilities investors ascribe to certain outcomes. This is because such pdfs give an indication only of the probabilities investors would have in mind if they were 'risk-neutral', and did not consider the uncertainty around an asset's future pay-offs in assessing its value. In the likely case that investors are averse to this risk, this would lead to differences between the risk-neutral densities backed out of options prices, and the true 'real-world' probability densities considered by investors.

The resulting estimated 'real-world' pdfs offer a number of advantages over their risk-neutral counterparts. First, they afford an insight into market participants' actual views on future asset prices, and offer an improved quantification of the uncertainty around financial variables. Second, a comparison of the risk-neutral and estimated real-world pdfs reveals new information as to how investors' risk preferences are affecting derivatives prices. Finally, estimated real-world probability densities are directly comparable with other forecasts considered by policymakers that are *not* based on derivatives prices, for example those of GDP growth and inflation.

The approach examined here is empirical in that it compares the risk-neutral distribution generated directly from options prices to the *actual* distribution of prices as they are later observed. To the extent that the two show a systematic disparity over time, this may be exploited to adjust the risk-neutral densities over as yet unobserved future prices to estimate the agents' real-world expectations.

This work offers a robust means of transforming risk-neutral densities obtained from options contracts on the FTSE 100 and short sterling. The resulting real-world probability densities offer a superior average fit across the distribution of observed prices than their risk-neutral counterparts. The resulting parameters appear stable over time, at least until the end of our data sample in June 2007. To the extent that this remained the case when the methodology was applied to prices since, it could form the basis of an operational method to better predict their future prices and enhance conjunctural analysis. It could also form the basis of more advanced work that aimed to condition this transformation on some other (macroeconomic) observable variable which may increase the method's predictive power.

# Liquidity risk, cash-flow constraints and systemic feedbacks

**Summary of Working Paper No. 456** Sujit Kapadia, Mathias Drehmann, John Elliott and Gabriel Sterne

Although the failure of a financial institution may reflect solvency concerns, it often manifests itself through a crystallisation of liquidity risk associated with a loss of funding. In such funding crises, the bank's solvency position no longer fully determines its survival; and its cash-flow constraint becomes critical.

This paper develops a framework that promotes an understanding of the triggers and system dynamics of liquidity risk during periods of financial instability and simulates the impact of these effects in a quantitative model of systemic risk. By using simple indicators and analysing bank-specific cash-flow constraints, we assess the onset and evolution of liquidity stress at individual institutions in various phases. And we capture several systemic feedbacks which may arise during funding liquidity crises, mostly linked to defensive actions taken by banks in distress, and many of which have been important during the current financial crisis. A key contribution of this paper is to demonstrate how systemic risk may escalate and contagion may spread to other institutions as a bank's funding conditions deteriorate, irrespective of whether the bank ultimately survives or fails. By applying the model to the UK banking system based on the balance sheet vulnerabilities that existed at the end of 2007, we illustrate how liquidity feedbacks may markedly amplify other sources of risk.

The severity of an individual bank's funding distress is calibrated using a simple 'danger zone' approach that scores each bank according to eight indicators that proxy solvency, liquidity profile, and confidence. Two indicators in particular play an important role in the transmission dynamics of funding crises modelled here. The first is short-term wholesale maturity mismatch (between contractually maturing liabilities and assets); a bank with a larger share of short-term borrowing faces greater funding liquidity risk. The second is that distress at one bank may adversely affect 'similar' banks through a pure confidence channel.

A danger zone score beyond a first threshold triggers the initial phase of distress, in which long-term unsecured funding markets close to the bank. The bank has to refinance a larger volume of liabilities in short-term markets each period, which further worsens its maturity mismatch score. The bank takes the defensive action of hoarding liquidity (reducing the maturity of its own intra-financial system lending), which improves its own mismatch score but worsens mismatch and increases danger zone scores at counterparty banks.

A second phase of distress is triggered beyond a further danger zone threshold. In the model, this results in shorter-term unsecured funding markets closing to the distressed bank, which then takes further defensive actions in an attempt to meet its cash-flow constraint. If profits earned over the period are insufficient to meet liquidity needs, the bank in the first instance withdraws all maturing intra-financial system assets, using the proceeds to pay off liabilities due. Its next line of defence is to sell or encumber its liquid assets. Finally, it resorts to fire-selling its illiquid assets, precipitating falls in asset prices and generating systemic feedbacks as other banks holding those assets are assumed to suffer temporary losses, worsening their solvency position and potentially increasing their danger zone score. If the combined effect of these defensive actions is insufficient for the bank to meet its cash-flow constraint, it fails. At this point, it defaults on its obligations to other banks, with the associated counterparty credit losses determined using a network model of bilateral interbank exposures. In extreme circumstances, the spillover effects linked to liquidity hoarding, asset fire sales, confidence channels and counterparty default may also generate sufficient contagion to cause other banks to suffer funding liquidity crises, and potentially fail.

The paper provides illustrative simulations using a version of the Bank of England's 'RAMSI' stress-testing model to highlight these dynamics quantitatively. RAMSI uses disaggregated balance sheets covering the largest UK banks. For the simulations, we use data up to 2007 Q4 and draw 500 realisations from a macroeconomic model on a three-year forecast horizon to end-2010. The results highlight the role of contagion due to the systemic feedbacks. The distribution of total system assets at the end of the simulation period has a long left-hand tail, which is a direct consequence of the feedbacks, which can in some cases cause several institutions to default. This fat tail emerges in spite of the underlying shocks to macroeconomic variables having no such tail. These illustrative results point towards the importance of considering funding liquidity risk and systemic feedbacks in quantitative models of systemic risk.

The model could be extended in several ways. For example, rather than generating all shocks from a macroeconomic model, it would be interesting to allow for direct shocks to banks' cash-flow constraints, perhaps linked to some market-wide liquidity shock. It would also be helpful to capture the evolution of systemic liquidity crises incorporating more developed behavioural assumptions, and over a shorter time period than the three months used here. Finally, it would be interesting to use the framework to explore the role that macroprudential policies such as time-varying liquidity buffers might be able to play in containing systemic risk.

# What do sticky and flexible prices tell us?

**Summary of Working Paper No. 457** Stephen Millard and Tom O'Grady

Much recent research has looked at the microdata that make up price indices such as the UK consumer prices index (CPI). This work reaches three key conclusions. First, the microdata do support the underlying premise of the New Keynesian project, namely that there is a substantial amount of price stickiness. But second, underlying the headline inflation measures — which appear to be smooth and relatively autocorrelated (that is, current inflation is correlated with its own lags) — are inflation rates at the sub-component level that are much more volatile, and differ in terms of persistence. Third, and most importantly, the degree of price stickiness varies substantially across sectors. These results could potentially help us think about how inflation persistence arises. Inflation persistence may occur because the prices of different components of the CPI basket change at different speeds; some firms react to a shock immediately, whereas others take time to respond.

If that is the case, then prices that change at different speeds may also give us differing signals about the state of the economy. For example, relatively flexible prices may react more to the output gap than stickier prices: prices that change very frequently may be set on the basis of the current state of the economy. In contrast, relatively stickier prices may be more forward looking. If a firm knows that its price will last for a long time, it may think more about the future state of the economy when setting it. One implication is that sticky prices could tell us about firms' inflation expectations. Another is that we might want to look to flexible prices to see the impact of the output gap on inflation. And finally, the sticky component of inflation might be more useful than the aggregate for forecasting medium-run inflation, given that it drives persistence. This paper assesses these three claims against empirical evidence, and looks at how they hold up in the context of a formal model.

The paper first presents some empirical evidence that relatively flexible prices react more to deviations of output from trend than stickier prices, suggesting that prices that change very frequently are set on the basis of the current state of the economy. Some further evidence suggests that sticky prices contain information about firms' inflation expectations and that sticky price inflation may be useful in forecasting aggregate inflation two years out. These empirical results are then investigated further in the context of a dynamic stochastic general equilibrium model (which takes into account interactions between forward-looking optimising agents' choices in an economy subject to random shocks) containing a sticky price sector and a flexible price sector. Results generated by this model suggest that you would expect flexible price inflation to be more strongly related to the current output gap and sticky price inflation to medium-term inflation and inflation expectations, given standard economic theory.

Taken together, the results of this paper suggest that calculations of 'flexible price' inflation could, potentially, be used to provide monetary policy makers with a steer on the current state of the economy, in particular, the current output gap, which is notoriously hard to measure. In addition, calculations of 'sticky price' inflation could, potentially, be used to provide monetary policy makers with a steer on the medium-term inflation expectations of price-setters within the economy, again something about which it is hard to obtain any direct evidence.

# A network model of financial system resilience

**Summary of Working Paper No. 458** Kartik Anand, Prasanna Gai, Sujit Kapadia, Simon Brennan and Matthew Willison

The complex and opaque nature of modern financial systems poses a considerable challenge for the analysis of systemic resilience. An intricate web of claims and obligations links households and firms to a wide variety of financial institutions such as banks, insurance companies, and investment firms. The rapid development of securitisation and credit derivative markets has also made exposures between agents more difficult to assess and monitor in the absence of trade repositories. The global financial crisis illustrates how intertwined the financial network has become, while also making clear the potential for widespread losses and instability.

Recent efforts by central banks to measure and assess systemic risk have emphasised the important role played by network effects, fire-sale externalities, and funding liquidity risk in financial stability. A general insight is that these factors generate 'fat tails' in the distribution of aggregate losses for the banking system. That is, the financial system may incur very large losses with small probabilities.

Central bank studies typically rely on highly detailed, and relatively static, balance sheet data to establish precise linkages between banks in the domestic financial system and to derive banking system losses. This can be constraining when true linkages are not known (such as with credit risk transfer or off balance sheet activity) or when shocks strike financial institutions external to the core banking system. The pre-defined balance sheet interlinkages in these models also preclude analysis of how network structure matters for system resilience. The crisis has emphasised how network linkages and interactions between financial institutions are critical to understanding systemic risk. And the growing importance of 'stress-testing' exercises in the policy debate about financial stability points to the need for analyses that help overcome such limitations.

In this paper, we set out a general framework to gauge systemic risk in circumstances when data about the reach of financial exposures are limited and shocks are international in nature. We present a statistical model of a financial system involving a diverse set of financial agents, namely domestic banks, overseas banks, and firms, which are linked together by their claims on each other. We calibrate the model to advanced country banking sector data to illustrate how macroeconomic fluctuations, asset market liquidity and network structure interact to determine aggregate credit losses and contagion. Although the calibration is deliberately broad brush so as to emphasise the qualitative nature of the results, we obtain plausible loss distributions and can quantify, within the context of our model, the size of the macroeconomic or financial sector shock that may be necessary for system-wide failure to occur.

The model highlights how shocks are propagated through the direct interlinkages of claims and obligations among (and between) domestic banks and overseas banks. But it also shows how defaults across the network are amplified by asset fire sales and curtailed lending in the macroeconomy as 'credit crunch' effects take hold in the event of distress. In addition, we illustrate how greater heterogeneity of bank balance sheets leads to more realistic outcomes, characterised by the failure of some — but not all — banks in extreme scenarios. We also demonstrate how the model can be used to 'stress test' the banking system. The results obtained are entirely illustrative and only intended to demonstrate the usefulness of the framework.

# Inflation and output in New Keynesian models with a transient interest rate peg

**Summary of Working Paper No. 459** Charles T Carlstrom, Timothy S Fuerst and Matthias Paustian

Monetary models often assume that firms adjust their prices only slowly in response to changes in the economy. The most common assumption is that only some fraction of firms update their price in any period, as in the work of Calvo. At the same time firms and households are forward looking. They base their decisions not only on today's economic conditions but also on the outlook for the future, including expectations of future interest rates. The recent experience of low interest rates for an extended period of time provides a natural benchmark for testing such monetary models.

This paper examines the effects of an unconditional lowering of the nominal interest rate for an extended period of time in a model with infrequent price adjustment. One would expect that keeping the nominal interest rate low stimulates demand and thus increases inflation and output. In contrast, we show that the commonly used model of Calvo pricing implies unusual behaviour of inflation and output in such an environment.

First, the anticipated unconditional lowering of the interest rate for an extended period of time can make initial inflation and output response from the model unusually large. Second, as interest rates are kept low for a sufficiently long period of time, inflation and output may actually fall in the model we consider. We show that this counterintuitive result is not simply due to using a linear model, but also obtains in the full non-linear sticky price model.

This is not an econometric test of sticky price models. Nor is it a statement about other possible shocks hitting the system. It is instead a question of *prima facie* plausibility. Our results suggest that these models can produce implausible behaviour under transient interest rate pegs. Future research should therefore examine whether similar results obtain under alternative models of price-setting or expectations formation.

# Too big to fail: some empirical evidence on the causes and consequences of public banking interventions in the United Kingdom

**Summary of Working Paper No. 460** Andrew K Rose and Tomasz Wieladek

Beginning in late 2007, the public sector around the world helped their struggling financial sectors in a number of different ways. Some banks were offered government funding or central bank liquidity insurance schemes, others received capital injections or were nationalised outright, and some were offered no support at all. To maintain future financial stability, it is important to not only understand the vulnerabilities that led the public sector to assist banks during the global financial crisis of 2008, but also assess the effectiveness of public sector help in stabilising individual banks' funding.

In the first part of this study, we therefore ask empirically what determined the style and recipients of public interventions. We use a confidential Bank of England bank-level data set using information on the balance sheets of all UK-resident banks. Our results suggest that the size of a bank is an important determinant of key public British banking interventions: capital injections, nationalisations, and government funding or central bank liquidity insurance schemes. In particular, the size of a bank relative to that of the entire banking system increases the probability of an intervention, suggesting that large banks are more likely to receive public sector assistance. This finding is consistent with the idea that some banks in the British banking system were deemed to be 'too big to fail'.

In the second part of this study, we study the consequences of public sector interventions in the British banking system. We argue that during the global financial crisis, financial institutions were subject to a bank run in wholesale markets. To improve our understanding of the effectiveness of these various public sector interventions, we study their effect on individual banks' wholesale to total liabilities ratio. Typically it would be difficult to credibly isolate cause and effect in our question of interest, since the banks that received government help were also the ones that were obviously most affected by a run on their wholesale liabilities. Fortunately, we established that bank size is an important determinant of government intervention in the first part of our investigation. This is a structural feature and changes only slowly over time. It is unlikely to be affected by sudden movements in bank liabilities and can be used to predict government intervention. We therefore use a bank's relative size with respect to the whole banking system to isolate the causal effect of British public sector interventions on an individual bank's wholesale funding. We find that these interventions mattered in a tangible sense: they seemed to restore access to wholesale funding. More precisely, the share of wholesale (non-core) funding rose significantly following intervention. As one objective of UK public sector intervention during the global financial crisis was precisely to stabilise flighty financial market funding, it seems to have been effective.

# Labour market institutions and unemployment volatility: evidence from OECD countries

**Summary of Working Paper No. 461** Renato Faccini and Chiara Rosazza Bondibene

The interest in how unemployment responds to output fluctuation is long-standing. Okun's rule of thumb, the empirically observed relationship between changes in unemployment and changes in output, has been a useful guide for policymakers since it was proposed in 1962. However, the relationship between unemployment and output is not stable over time and differs markedly across countries. Despite its importance, the factors underlying the response of unemployment to output fluctuations are not well understood. We investigate whether laws regulating the labour market, typically referred to as labour market institutions, can help explain cross-country and time variation in this relationship.

The sensitivity of unemployment to cyclical changes in output differs considerably across OECD countries and has changed over time in most cases. In particular, the United States, together with other Anglo-Saxon economies including the United Kingdom, Canada and New Zealand, are characterised by average values of the sensitivity of unemployment to output movements. Compared to the Anglo-Saxon economies, unemployment volatility is lower in Mediterranean countries and higher in Scandinavian economies. So can differences in labour market institutions account for this heterogeneity?

We find that labour market institutions are indeed an important factor affecting the response of unemployment rates to changes in output. The impact of most labour market institutions is found to be statistically significant; for some, such as employment protection and unions, the quantitative impact is particularly strong. In particular, we find that employment protection strongly reduces the cyclical response of unemployment. In addition, we find that the precise nature of union bargaining has important consequences for cyclical unemployment dynamics: while union coverage (the proportion of employees covered by collective agreements) significantly increases fluctuations of unemployment rates, union density (the proportion of employees who are members of a trade union) has the opposite effect. Our interpretation of these findings is that union bargaining generates real wage rigidities, whose impact increases with the spread of union agreements (union coverage). As a consequence of stronger real wage rigidities unemployment becomes more volatile. However, unions also care about job security for their members and therefore the sensitivity of unemployment fluctuations to changes in aggregate production will decrease with density. These findings are consistent with previous results showing that union coverage is positively related with downward real wage rigidities and with evidence that union membership decreases the probability of dismissals.

The benefit replacement rate, the duration of unemployment benefits and taxation are found to have a limited impact on the sensitivity of unemployment fluctuations. All of these institutions appear to slightly reduce the cyclical response of unemployment. These results do not support the theoretical predictions that labour market institutions could increase the volatility of unemployment by reducing the available 'surplus' divided by firms and workers in the bargaining process.

Overall, we find that institutions explain about one quarter of the explained variation, which in turn is about half of the total observed variation. So, we conclude that labour market institutions are an important factor governing cyclical unemployment fluctuations, but they are not the entire story. Finally, we find some evidence supporting the hypothesis that interactions between shocks and institutions matter for cyclical unemployment dynamics.

# Reports

# The distributional effects of asset purchases

In its report on the 2012 *Budget*, the Treasury Committee highlighted the redistributive impact of monetary policy, and asked the Bank, and MPC members in particular, to improve their efforts to explain the costs and benefits of their policy actions to groups that are perceived to have been particularly badly affected.[1] This report[2] forms part of the Bank's response.[3]

## Summary

- The Monetary Policy Committee (MPC) sets monetary policy for the economy as a whole in order to achieve the Government's inflation target. Changes in interest rates and asset purchases financed by issuing reserves (commonly referred to as quantitative easing (QE)) unavoidably have distributional implications.

- Without the Bank's asset purchases, most people in the United Kingdom would have been worse off. Economic growth would have been lower. Unemployment would have been higher. Many more companies would have gone out of business. This would have had a significant detrimental impact on savers and pensioners along with every other group in our society. All assessments of the effect of asset purchases must be seen in that light.

- The Bank's asset purchases have been almost entirely of gilts, causing the price of gilts to rise and yields to fall. But this in turn has led to an increase in demand for other assets, including corporate bonds and equities. As a result, the Bank's asset purchases have increased the prices of a wide range of assets, not just gilts. In fact, the Bank's assessment is that asset purchases have pushed up the price of equities by at least as much as they have pushed up the price of gilts.

### The implications of QE for savers

- Changes in Bank Rate — not asset purchases — have been the dominant influence on the interest households receive on bank deposits and pay on bank loans.

- By pushing up a range of asset prices, asset purchases have boosted the value of households' financial wealth held outside pension funds, but holdings are heavily skewed with the top 5% of households holding 40% of these assets.

### The implications of QE for pension funds and pensioners

- The pension income of those already in receipt of a pension before asset purchases began has not been affected by QE.

#### Defined benefit pension schemes

- The retirement incomes of people coming up to retirement in a defined benefit pension scheme have not been affected by QE.

- When assessing the impact of QE on the value of defined benefit pension funds, it is important to remember that asset purchases increase the value of a pension fund's assets as well as its liabilities.

- For a typical fully-funded pension scheme, asset purchases are likely to have had a broadly neutral impact on the net value of the scheme. The fall in gilt yields raised the value of the pension fund's liabilities. But the associated increase in bond and equity prices raised the value of their assets by a similar amount.

- For a defined benefit pension scheme in substantial deficit, asset purchases are likely to have increased the size of the deficit. That is because although QE raised the value of the assets and liabilities by a similar proportion, that nonetheless implies a widening in the gap between the two. The burden of these deficits is likely to fall on employers and future employees, rather than those coming up for retirement now.

#### Other pension schemes

- Asset purchases are likely to have had a broadly neutral impact on the value of the annuity income that could be purchased with a personal pension pot. By pushing down gilt yields, QE has reduced the annuity rate. But the flipside of that fall in yields has been a rise in the price of both bonds and equities held in those pension pots. Another way of explaining this is that the income flows from a pension pot (dividends in the case of equities and coupons in the

(1) See www.publications.parliament.uk/pa/cm201012/cmselect/cmtreasy/1910/191002.htm.
(2) The following people helped to prepare this report: Venetia Bell, Michael Joyce, Zhuoshi Liu and Chris Young. This version contains some small clarifications and corrections relative to the version sent to the Treasury Committee.
(3) For recent comments by MPC members on this topic, see, for example, Bean (2012) and Miles (2012).

case of bonds) will not be reduced by QE. Indeed, if the pension pot contains equities, then the flows could even be higher than they otherwise would have been as a result of increased dividend payments from the boost to the wider economy from QE.

- Over the past five years, the main factor driving both the widening of deficits in defined benefit schemes and the decline in the annuity income that can be purchased from other pension funds has been the fall in equity prices relative to gilt prices. This fall in the relative price of equities was not caused by QE. It happened in all the major economies, much of it occurred prior to the start of asset purchases, and stemmed in large part from the reluctance of investors to hold risky assets, such as equities, given the deterioration in the economic outlook, almost certainly as a result of the financial crisis. Indeed, by boosting the economy, monetary policy actions in the United Kingdom and overseas probably dampened this effect.

## Introduction

The MPC's objective is to maintain price stability, where stable prices are defined by the Government's inflation target, which is currently 2% as measured by the annual change in the consumer prices index (CPI). Subject to that, the MPC is also tasked with supporting the Government's other economic objectives, including those for growth and employment. In pursuing its objectives, the MPC sets monetary policy for the economy as a whole.

Changes in the monetary policy stance will unavoidably have distributional implications. That is the case regardless of the instrument used to implement policy. Such distributional effects typically balance out over the course of a policy cycle: some groups benefit relative to others as interest rates are increased, but that is reversed as interest rates are lowered.

In response to the severe global financial crisis and the subsequent deep and prolonged recession, UK monetary policy has, however, been exceptionally accommodative for an unusually long time. Bank Rate has been at an historic low of 0.5% since March 2009. And since then, the MPC has authorised the purchase of £375 billion of assets, financed by the issuance of central bank reserves, through its asset purchase programme. The Bank's asset purchases, commonly referred to as quantitative easing, have depressed longer-term yields. Consequently, some groups have borne a greater burden than usual from the sustained period of low interest rates. But, on the other hand, the benefits have also been greater than usual, by helping to avoid a far worse outcome for the economy as a whole.

This report sets out the distributional effects of QE, drawing out the parallels with the distributional effects of a low level of Bank Rate. The first section of this paper discusses the aims of QE and how it affects the economy. The second section discusses the impact that QE is estimated to have had on the economy in aggregate. The third and fourth sections set out the economic channels through which QE leads to distributional effects for savers and pensioners respectively, and provides a rough quantification of the direct financial implications of QE for these groups. A final section concludes.

## 1 How quantitative easing affects financial markets and the real economy

The MPC began QE in March 2009 following the intensification of the financial crisis after the collapse of Lehman Brothers and the associated sharp contraction in output. The MPC had reduced interest rates sharply, with reductions of 3 percentage points in Bank Rate during 2008 Q4 and a further 1½ percentage points in early 2009, such that by early March 2009, Bank Rate had been reduced to 0.5%. But, despite this substantial relaxation of policy, the MPC judged that, without additional monetary easing, nominal spending would be too weak to meet the 2% CPI inflation target in the medium term. The aim of QE was, therefore, to ease monetary conditions further in order to boost nominal spending and thus help to achieve the inflation target. The MPC completed £200 billion of asset purchases between March 2009 and January 2010, and a further £125 billion of purchases between October 2011 and May 2012. At its July 2012 meeting, the Committee voted to increase the size of its asset purchase programme by a further £50 billion to a total of £375 billion, which is expected to take four months to complete. The analysis in this paper focuses on the effects of the £325 billion of asset purchases that the Bank has already completed.

There are a number of potential channels through which such asset purchases affect spending and inflation.[1] Purchases of financial assets — which in the United Kingdom have largely been UK government debt (gilts)[2] — from the non-bank private sector financed by the issuance of central bank money increased private sector broad money holdings. In turn, that affected a wide range of asset prices through three main channels. The first is through *portfolio balance* effects. When the central bank purchases gilts, the monetary deposits of the sellers are increased. Unless that money is regarded as a perfect substitute for the gilts sold, the sellers will seek to rebalance their portfolios by buying other assets that are better substitutes for the gilts that they have sold. That shifts the excess money balances to the sellers of those assets who will, in turn, attempt to rebalance their portfolios by buying other assets — and so on. That process will raise the prices of

(1) For more details, see Benford *et al* (2009) and Joyce, Tong and Woods (2011).
(2) A key reason for concentrating purchases on gilts was that the gilt market was judged to be deep and liquid enough to accommodate the volume of purchases thought necessary.

all assets to the point where investors, in aggregate, willingly hold the overall supplies of assets and money. Higher asset prices mean lower yields, and so lower borrowing costs for companies and households, which acts to stimulate spending.(1) In addition, higher asset prices stimulate spending by increasing the net wealth of asset holders.

The second channel is through *policy signalling* effects. This channel includes anything that market participants conclude about the likely path of future monetary policy from the MPC's asset purchases. For example, QE may have led market participants to expect policy rates to remain low for longer than would otherwise have been the case.

The third channel is through *liquidity* effects. When financial markets are dysfunctional, central bank asset purchases can improve market functioning by increasing market liquidity through actively encouraging trading. Asset prices may consequently increase as a result of lower illiquidity premia.

In addition to these asset price channels, QE may also have a stimulatory impact through its broader effects on *expectations*. To the extent that QE leads to an improved economic outlook, it may directly boost consumer confidence, and thus people's willingness to spend. Some of this more general improvement in confidence may also be reflected back in higher asset prices, especially by reducing risk premia.(2)

## 2 The impact of QE in aggregate

Previous Bank analysis has sought to quantify the impact of QE on the economy in aggregate. Joyce, Tong and Woods (2011) present a range of estimates of the macroeconomic impact of QE using a number of different methodologies. None of the methods used fully capture all the transmission channels discussed above. The effects of QE nevertheless appear economically significant, though subject to considerable uncertainty. According to the reported estimates of the peak impact, the £200 billion of QE between March 2009 and January 2010 is likely to have raised the level of real GDP by 1½% to 2% relative to what might otherwise have happened, and increased annual CPI inflation by ¾ to 1½ percentage points. Assuming that the additional £125 billion of purchases made between October 2011 and May 2012 had the same proportionate impact, this would translate into an impact from the £325 billion of completed purchases to date of roughly £500–£800 per person in aggregate. For comparison, a simple ready-reckoner from the primary forecasting model used by the Bank of England suggests that a cut in Bank Rate of between 250 and 500 basis points would have been required to achieve the same effect. This suggests that, in the absence of QE, the UK recession would have been even deeper. Moreover, these calculations do not explicitly incorporate impacts of QE operating through the exchange rate and confidence.

Of course, these figures do not translate into extra cash for each individual in the economy. One reason is because they are an attempt to gauge the impact of QE relative to what would otherwise have happened, so the benefits might show up as smaller falls in wages than employees would otherwise have experienced, and lower job losses. In addition, there will have been distributional consequences, with some groups being affected more than others. The remainder of this note explores the particular implications of QE for savers and pensioners.

When considering these distributional impacts, however, it is important to remember that without the Bank's asset purchases, most people in the United Kingdom would have been worse off. Economic growth would have been lower. Unemployment would have been higher. More companies would have gone out of business. That would have had a detrimental impact on savers and pensioners along with every other group in our society. All assessments of the effect of asset purchases must be seen in that light.

## 3 The implications of QE for savers

'Savers' can be defined in several different ways, and the impact of QE will vary depending on the group that is considered. One definition is households who have a higher value of financial assets than financial liabilities (eg debt): put another way, savers are those with positive net financial assets.(3) Another commonly used definition of savers is households that have any gross savings, even if their debt is larger than their assets (ie they have *negative net* financial assets). Households may think of themselves as savers if they regularly save money out of their income, even if their net financial assets are negative. In this section, we use this wider definition, and focus on the impact of QE on those with gross financial assets.(4) Limited data are available on the number of savers in the economy, but data from the 2011 NMG survey suggest that around 80% of households typically have some gross savings, although not all will yield interest.

The calculations in this section relate to the impact of QE on savers in terms of direct financial flows. They are therefore partial, and omit wider impacts of QE on savers. For instance,

(1) The first stage of this process is that companies respond to higher equity and bond prices by increasing their use of capital markets to raise funds. There was some evidence of that in 2009, with both net equity and corporate bond issuance by UK private non-financial corporations particularly strong relative to the 2003–08 period.
(2) Other channels include the effects of QE on bank lending. When assets are purchased from non-banks (either directly or indirectly via intermediate transactions), the banking sector gains both new reserves at the Bank of England and a corresponding increase in customer deposits. A higher level of liquid assets could then encourage banks to extend more new loans than they otherwise would have done. But, given the strains in the financial system at the time and the resultant pressures on banks to reduce the size of their balance sheets, the MPC expected little impact through this channel when it first started its asset purchase programme.
(3) For many households, however, their mortgage is the largest component of their financial liabilities, so for them, the relevant asset concept may include housing wealth, as well as financial assets.
(4) Detailed information on the composition and distribution of household net financial assets are not readily available.

in the absence of QE, savers may have been more likely to lose their jobs, or seen companies that they owned go out of business. In addition, they do not take account of the impact of QE on inflation, and hence how these financial flows translate into real spending on goods and services. Other things being equal, increased inflation as a result of QE reduced the volume of goods and services that a household could purchase with a fixed amount of money spending. There are likely to be distributional consequences of that higher inflation.(1)

Monetary policy affects households in a number of ways.(2) First, looser monetary policy pushes down the nominal interest rates paid on the stock of deposits and loans. That reduces both the interest income savers receive on their savings and the interest payments made by debtors (what is sometimes called an 'income effect'). There is also an additional 'substitution effect', as lower interest rates encourage households to bring forward spending at the expense of saving. Looser monetary policy also typically pushes up asset prices (sometimes referred to as the 'wealth effect'), so those households with significant asset holdings will benefit by more than those without. There will also be an effect on the exchange rate, which would be expected to depreciate, raising the price of imported goods and services and reducing the price of exports. All of these channels would tend to raise spending in the economy in the near term. The income and wealth channels, in particular, will give rise to important distributional effects on savers. These effects would operate for changes in both Bank Rate and QE. But the strength of these channels is likely to vary across the two policy instruments.

One difference between the transmission channels of Bank Rate and QE to spending and inflation is that a change in Bank Rate acts largely by affecting short-term market interest rates, while QE acts largely through longer-term interest rates.(3) Households can hold their savings directly or indirectly, for instance via a pension fund. The majority of households' direct savings are held as deposits in banks and building societies, and generally in forms that are easily accessible: over the past year, around 55% of the stock of deposits was held in relatively short-term accounts (sight and non interest bearing deposits), with the remainder being time deposits. And only around 10% was in accounts with interest rates fixed for more than two years. As a consequence, households tend to receive a return linked to short-term rather than long-term interest rates. That suggests that deposit holders are likely to have been affected much more by the cuts in Bank Rate than by downward pressure on longer-term interest rates as a result of QE.

Reduced interest rates have depressed the aggregate interest payments received by households on deposits. Lower interest receipts on deposits compared with September 2008 levels cumulated to a total of around £70 billion by April 2012 (**Table A**). By contrast, the household sector may have benefited by around £100 billion by having to pay less on outstanding loans. The gap between interest paid on deposits and interest received on loans over the period would have been absorbed in the first instance by the banking sector, but ultimately that would have resulted in lower profits and hence potentially lower dividends or remuneration, or in higher banking costs and fees. Either way, much of that would feed back eventually to household incomes.

**Table A** Estimated impact of changes in interest rates since September 2008(a)

| | Change in effective interest rates (basis points) | Effect on income from change in interest payments (£ billions) |
|---|---|---|
| Memo: Bank Rate | -450 | |
| **Deposits** | | **-70.0** |
| *of which, sight* | *-206* | *-37.4* |
| *of which, time* | *-218* | *-32.6* |
| **Secured lending** | | **94.4** |
| *of which, floating rate* | *-312* | *89.1* |
| *of which, fixed rate* | *-102* | *5.9* |
| **Unsecured lending** | | **7.9** |
| *of which, credit cards* | *-116* | *0.7* |
| *of which, overdrafts* | *3* | *1.2* |
| *of which, personal loans* | *-109* | *6.1* |
| **Total** | | **32.3** |

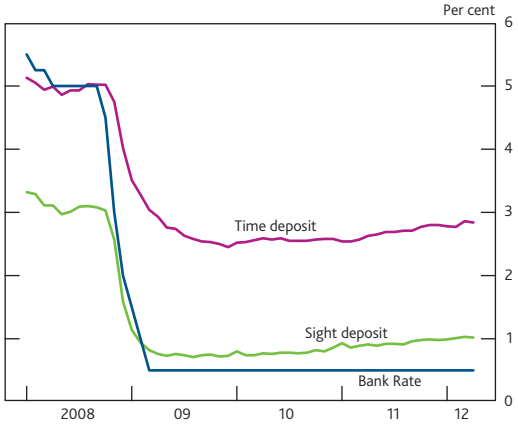
Sources: Bank of England and Bank calculations.

(a) Latest data are for April 2012. In estimating the effect on interest payments and receipts, the calculations assume that the stocks of loans and deposits were as actually occurred. In practice, the stock of deposits and loans are likely to have been higher if interest rates had remained at 2008 levels.

These estimates are likely to represent a lower bound on the impact that monetary policy has had on interest flows, however, as other factors have tended to raise deposit rates over the past few years. Bank Rate was cut by 450 basis points between September 2008 and March 2009, and has remained at 0.5% since then. But effective rates on the stock of sight and time deposits were only around 200 basis points lower in April 2012 than in September 2008 (**Chart 1**). In part, that is likely to reflect the zero lower bound on nominal interest rates: sight deposit rates tended to be significantly below Bank Rate before the crisis, so banks were not able to reduce deposit rates by as much as the fall in Bank Rate. Deposit rates have drifted up since mid-2009, despite Bank Rate remaining flat at 0.5%. In part, that may reflect banks competing more aggressively for deposits as part of a wider strategy to reduce their reliance on wholesale market funding. Without these factors, deposit rates received by households are likely to have been even lower.

(1) See Galli and van der Hoeven (2001) for a review of the empirical literature on the complex distributional effects of inflation.
(2) For a fuller account of the transmission mechanism of monetary policy, see www.bankofengland.co.uk/publications/Documents/other/monetary/montrans.pdf.
(3) The bulk of the gilts purchased during the QE period have maturities of between 5 and 25 years.

**Chart 1** Household deposit rates and Bank Rate[a]




(a) Monthly average of UK-resident monetary financial institutions' effective interest rates on the stock of outstanding deposits.

**Chart 2** Equity prices and corporate bond yields


Sources: Bank of America/Merrill Lynch and Thomson Reuters Datastream.

(a) Non-financial companies (excluding utility companies) sterling investment-grade corporate bond yield.

There will have been differences in experiences across households too. For example, savers with floating-rate products were affected soon after the cuts in Bank Rate, with their rates falling from around 3% in September 2008 to under 1% by February 2009 (the green line in **Chart 1**). In contrast, households with savings in fixed-rate products and accounts would not have been affected until later. Moreover, around 10% of the stock of deposits pay no interest at all. Similarly, there will have been different experiences among debtors.

One channel through which expansionary monetary policy will have benefited some individuals is by raising asset prices, including government and corporate bonds, and equities (**Chart 2** shows movements in equity prices and corporate bond yields). Moreover, by supporting activity, QE will also have boosted dividend payments and reduced corporate defaults (raising the returns on corporate bonds). So the larger the share of these types of assets in households' portfolios, the greater the boost from QE relative to reduced interest payments on money held in the form of deposits. QE may also have supported non-financial asset prices. For example, to the extent that QE prevented a deeper recession and a sharper fall in employment, the fall in house prices during the crisis is likely to have been smaller than would otherwise have been the case.

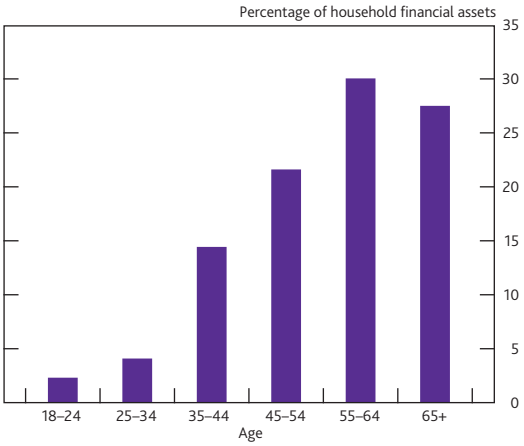
The impact of these changes in asset prices on a given individual's welfare is, however, complex. If the market price of an asset such as equity rises because corporate earnings and dividends rise, then he will be able to sustain a higher level of consumption than before, and he will be better off. If, however, the rise in the market price of the asset is a reflection of a fall in the interest rate used to discount future dividends — as will in large part be the case with QE — then the impact on his welfare is less clear. For instance, if he expected to retain the asset and just spend the dividends as they are received, then he will be no better off than before. But if he expected to sell part of his asset holdings in order to finance his spending — for instance, if he is in the latter stages of his life — then he will have been made better off, as he can now finance a higher level of future consumption. Conversely, if he expected to be acquiring more of the asset — for instance, because he is saving for future retirement — then he will have been made worse off, as he now has to pay more to acquire the associated future stream of income. Thus whether individuals are made better or worse off as a result of an increase in asset prices as a result of QE will depend on whether they are initially 'long' or 'short' in their asset holdings. Generally speaking, those later in their life cycle will tend to be long in assets, while those earlier in their life cycle will tend to be short in assets. For both sets of individuals, however, the fall in the discount rate will encourage them to bring forward spending from the future to the present, thus boosting aggregate demand today.

The overall impact of QE on household wealth is likely to have been substantial. Joyce, Tong and Woods suggest that the £200 billion of asset purchases made between March 2009 and January 2010 lowered gilt yields by around 100 basis points. The effect on a wider range of financial asset prices is more uncertain. Taking into account the estimated composition of household net financial assets, their analysis suggests an overall boost to UK households' net financial wealth (which includes partial estimates of pension wealth) of about 16%. Assuming that the £125 billion of asset purchases made between October 2011 and May 2012 had the same proportionate impact as the first round of asset purchases, that would give an estimate of the total increase in household wealth stemming from the Bank's £325 billion of asset purchases up to May 2012 of just over £600 billion, equivalent to around £10,000 per person if assets were evenly distributed across the population.

In practice, the benefits from these wealth effects will accrue to those households holding most financial assets. Evidence from the 2011 survey by NMG Financial Services Consulting,[1]

(1) For a detailed discussion on the results of this survey, see Kamath *et al* (2011). Analysis of the survey data has suggested that households tend to underreport the value of the assets, but that issue ought not to affect the distribution of assets across households.

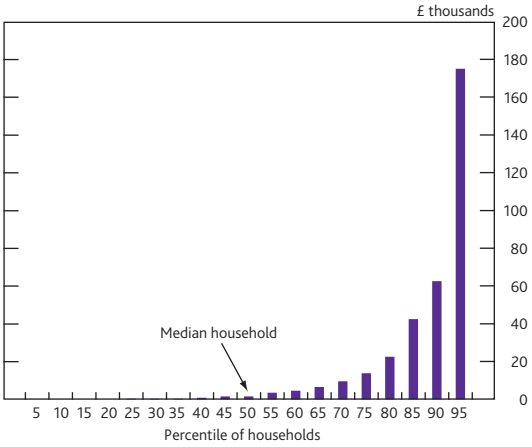
**Chart 3** Distribution of household financial assets by age group[a]




Sources: NMG Consulting survey 2011 and Bank calculations.

(a) Respondents to the NMG survey are asked: 'How much do you (or any member of your household) currently have in total, saved up in savings and investments? Include bank/building society savings accounts or bonds, stock and shares, ISAs, Child Trust Funds, NS&I account/bonds and premium bonds. Please exclude any pensions you may have.'

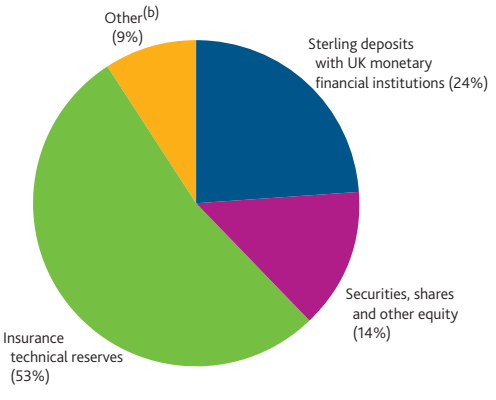
**Chart 4** Distribution of household financial assets[a]




Sources: NMG Consulting survey 2011 and Bank calculations.

(a) See footnote to **Chart 3** for details of the question asked.

**Chart 5** Composition of stock of household gross financial assets in 2011 Q4[a]




(a) Includes households and non-profit institutions serving households.
(b) Includes currency, other deposits, loans and other accounts receivable/payable.

carried out on behalf of the Bank, suggests that close to 80% of financial assets (excluding pension wealth, but including deposits) are held by those above the age of 45 (**Chart 3**).[1] And the survey suggested that the median household held only around £1,500 of gross assets, while the top 5% of households held an average of £175,000 of gross assets (**Chart 4**), or around 40% of the financial assets of the household sector as a whole. Without knowing the precise composition of assets held by each percentile of households, it is difficult to assess the size of the boost to wealth provided by QE across these groups. The data from the NMG survey exclude pension wealth, and that is also distributed unevenly across the population. Compared with non-pension wealth, however, households might be less likely to sell assets earmarked for pension provision to fund current consumption. The distributional issues associated with pension wealth are discussed below.

The balance between the income and wealth effects from QE depends on the distribution of assets across households. In aggregate, sterling deposits with UK monetary financial institutions (deposit-taking banks and building societies) make up around 25% of households' financial wealth, while around 15% is held directly in equities and other securities (**Chart 5**).[2] According to the 2006/08 *Wealth and Assets Survey*,[3] the vast majority of households hold deposit accounts, with the median household holding around £1,000 in current accounts, excluding overdrafts. In the same survey, around 15% of households reported that they directly held UK shares, ie in addition to shares held indirectly via pension funds, and 10% held stocks and shares ISAs.

To conclude, monetary policy has reduced interest rates and supported asset prices in order to stimulate spending and avoid an even deeper and more prolonged recession following the financial crisis. Largely as a result of the sharp reductions in Bank Rate — and not of QE — nearly all savers have seen the interest payments on their deposits fall since 2008. The vast majority of households hold deposit accounts, so these lower rates have affected most households to some extent. But some households have been affected more than others. Working against the effect of lower interest rates on deposits, some savers will have seen an increase in the value of their holdings of other financial assets as a result of the low level of Bank Rate and QE. In aggregate, such assets make up a larger share of households' total portfolio of financial assets than

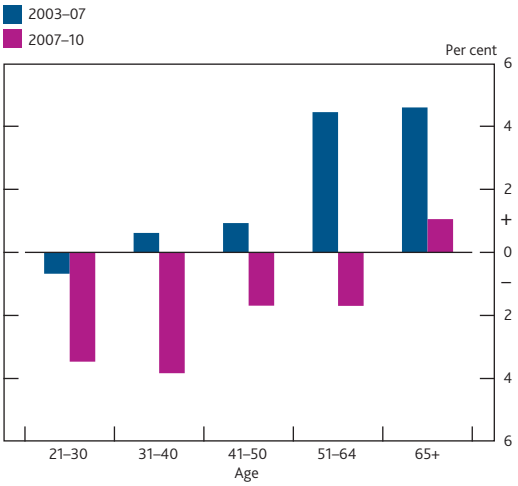
(1) By contrast, financial liabilities are less skewed towards older groups, with only around 30% of liabilities held by those aged over 45. Those aged 35–44 have the largest liabilities, at around 45%.
(2) Consistent with the importance of pension-related issues for savers, the largest share of household assets is made up of assets held on behalf of the household sector by insurance companies and pension funds (referred to as 'insurance technical reserves'), making up a little over 50%.
(3) Since the version of this report that was sent to the Treasury Committee was finalised, the ONS has released the 2008/10 *Wealth and Assets Survey*. The figures in this version of the report have not been updated to reflect that release.

deposits. Holdings of financial assets, including deposits, are heavily concentrated among certain households.

## 4 The implications of QE for pensions

This section discusses the implications of QE for pensioners, and for those approaching retirement. It also considers the implications for pension providers,(1) because developments for these companies will affect the pensions provided to the individuals participating in these schemes as they retire. People in, or close to, retirement make up a relatively large share of the UK population. According to the latest available population estimates (data for mid-2010), people older than the relevant state pension age(2) account for around 20% of the UK population. The pension incomes of the bulk of these individuals — those who had already retired prior to the start of the financial crisis — will not have been adversely affected by QE.(3) Indeed, some individuals may even have benefited if they were net holders of financial wealth, because QE increased the prices of bonds and equities. Data on real consumption growth rates by age group show that the over-65s are the only group that has been able to maintain positive consumption growth during the crisis (**Chart 6**).(4) Those who have reached the state pension age since mid-2007 — around three million people, approximately 5% of the population — will have potentially been more affected.(5) This section includes calculations of changes in the position of hypothetical pension schemes over four periods within the past five years.

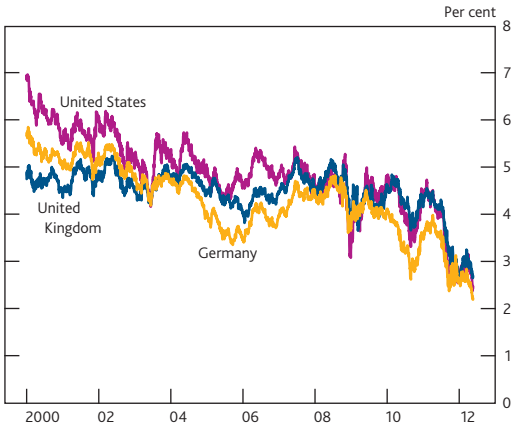
**Chart 6** Average annual real consumption growth rates by age group




Sources: EFS, FES, LCF and Bank calculations.

It is worth noting at the outset that, just as deposit rates have been affected by factors other than monetary policy in recent years, there have been factors other than QE affecting pensioners and pensions too. Although UK monetary policy has put downward pressure on gilt yields in recent years, it cannot explain all of their fall. The broadly similar trend in UK and other international government bond yields over the past decade (**Chart 7**) suggests that there have been other important global factors driving the reduction in yields apart from monetary policy. Some have suggested that downward pressure on interest rates has arisen from unusually high levels of savings in some emerging market economies, especially China, which have been more than enough to finance the high levels of investment there.(6) Other factors that may have pushed down gilt yields include a shortage of high-quality safe assets, and the sharp declines in corporate investment during the crisis. Pension wealth is normally held in the form of equities and corporate bonds in addition to government bonds. The prices of such assets have been affected by many factors other than QE over the past five years, including the weak economic environment. Continued increases in life expectancy have also affected pension schemes, raising the average costs of pension providers and increasing the amount that people need to save for their retirement. In addition, many pension funds were in deficit before the crisis, and, as discussed below, this was an important contributory factor in the deterioration of their financial deficits during the current crisis.

**Chart 7** Fifteen-year spot government bond yields(a)




Sources: Bloomberg and Bank calculations.

(a) Zero-coupon yields.

Pensioners, people saving specifically for their retirement and pension providers are affected by many of the same issues as savers in general. For example, lower Bank Rate and QE reduce interest rates received on deposits and raise the value of asset holdings in exactly the same way as for savers. So, as for savers in general, both the composition of assets and type

(1) That includes both institutional investors, such as insurance companies and pension funds, and employers providing pensions to their past and future employees. But it excludes the provision of state pensions, and other related payments during retirement such as Pension Credit.
(2) The state pension age is likely to rise over time to 68 for both females and males.
(3) To the extent that QE pushed up inflation, that would have reduced the real income of some pensioners. But that has to be seen in the context of the wider benefits of QE. Analysis in this section focuses on the direct impact of QE on interest rates and asset prices.
(4) See Weale (2012).
(5) That does not equate to the precise number of people drawing pensions, for example because some above the state pension age remain in employment, while others below that age will have begun to draw on pensions.
(6) See Bernanke (2005).

of deposits will be important. One difference, however, is that assets held in order to save for retirement are likely to be in a more illiquid form than other savings, so they are more likely to receive a return based on longer-term interest rates. As a result, downward pressure on longer-term interest rates from QE has played a more important role than cuts in Bank Rate in determining the overall impact on this group. And pension wealth (ie dedicated savings for retirement) is more likely to be held in the form of non-deposit assets.

There are several different ways that individuals may save for their retirement, and the channels through which QE affects these individuals will vary depending on the methods that they use. Historically, the most common types of scheme are those that provide defined benefits (eg final or career average salary schemes), where the employer/shareholder bears the main risks. According to Towers Watson (2012), around 60% of wealth held by pension funds was in defined benefit (DB) schemes in 2011. An alternative model is one in which individuals, or their employers, pay in a fixed contribution per period, and there is not a pre-defined income in retirement. These are commonly referred to as 'defined contribution' — DC — or 'money purchase' schemes. Upon retirement, individuals use the assets accumulated in the scheme(1) to purchase an insurance (or annuity) contract paying out a stream of payments for the remainder of their life. Here, the main risks are borne by the individual.(2) Assets held in DC schemes made up the remaining 40% of pension fund assets in 2011. Alternatively, individuals may save for their retirement independently. In that case, they could either live off the income from their assets during retirement, or else they use their savings on retirement to buy an annuity. If individuals take up the latter option, the channels through which QE affects them are likely to be similar to those individuals in DC schemes. In practice, many individuals are likely to use a combination of these approaches to provide for their retirement.(3)

## Defined benefit schemes

The net impact of QE on DB pension schemes' overall position reflects two additional factors to the general channels discussed above.

First, the extent to which there is a mismatch between the funds' assets and liabilities. If a pension fund is fully funded and holds government debt with coupon payments that exactly match the future flow of its liabilities, then a change in gilt yields would have no net impact.(4) But many pension funds hold a mix of assets, including equities and other types of securities. Estimates by the Bank suggest that QE increased the value of equities by a broadly similar amount to gilts, so even with a mix of gilts and equities, a fully-funded pension fund would not have been materially affected by QE. But over the period since the start of the financial crisis, equity prices have fallen relative to gilt prices for reasons unrelated to QE, causing pension deficits to open up. The mismatch between assets and liabilities, which is common across many pension funds, has had an important bearing on the performance of pension funds over the past five years or so.

Second, if a DB pension scheme is in deficit, then QE can lead to a widening in that deficit. That comes about because although QE causes the assets and liabilities of a pension scheme to rise by similar proportionate amounts, because the pension fund's liabilities are greater than its assets, the absolute size of the deficit increases. The larger the size of the deficit, the larger the detrimental impact of QE. The average pension fund deficit was equal to about 35% of total liabilities in March 2007, calculated on a full buy-out basis, falling to 33% in 2011.(5)

In order to illustrate the importance of the asset and liability structure of the pension scheme when assessing the effect of QE, both in terms of underfunding and asset and liabilities mismatch, **Table B** sets out illustrative scenarios for how the deficits of different hypothetical DB pension schemes would have evolved over time, given actual movements in asset prices and yields. The calculations are sensitive to the precise assumptions used, so they should be treated as indicative only.

The table considers three hypothetical pension schemes. The first column sets out a baseline case, in which the scheme is assumed to be fully funded in March 2007 (with £100 million assets and £100 million liabilities), and the expected future cash flows from the assets and liabilities of the scheme are matched as the scheme holds only gilts. That is then compared with two alternative schemes. Scheme 1 is assumed to be fully funded in March 2007, but its assets are composed of 60% equities and 40% bonds (column 2). Scheme 2 has the same asset structure as Scheme 1, but is assumed to start in March 2007 with a deficit of £30 million (column 3), ie liabilities are £100 million compared with assets of £70 million. Scheme 1 therefore has an asset-liability mismatch but was fully funded in March 2007; Scheme 2 has an asset-liability mismatch but was under-funded in March 2007.

The table traces out changes in the deficit of each pension scheme from March 2007 to the following four dates: February 2009 (ie just before the start of QE), February 2010 (ie after the first £200 billion of purchases had been

(1) That would typically include the accumulated income from those assets (less any fees).
(2) Until the annuity is taken out, all the risks are borne by the individual. After the annuity is taken out, the balance of risk-sharing depends on the type of annuity chosen. For example, for an index-linked annuity, the individual would always receive the same real income, and the provider would bear the risk of inflation evolving in a way that it had not expected. For a 'with-profits' scheme, the individual bears the risk of the return proving less than expected.
(3) For example, an individual may have been part of a DB scheme with one employer, but subsequently moved into a DC scheme with a new employer.
(4) Pension fund liabilities will normally be uprated in line with RPI inflation, so index-linked gilts might be a better match for them than conventional gilts.
(5) See *Purple Book* (2011).

**Table B** Illustrative examples of DB scheme deficits[a]

**£ million deficit for £100 million (valued at March 2007) DB pension schemes**

| | Baseline scheme<br>Fully funded at March 2007<br>Matched asset/liability | Scheme 1<br>Fully funded at March 2007<br>Asset/liability mismatch | Scheme 2<br>Under-funded at March 2007<br>Asset/liability mismatch |
|---|---|---|---|
| Deficits at: | | | |
| End-March 2007 | 0.0<br>(100/100) | 0.0<br>(100/100) | -30.0<br>(70/100) |
| End-February 2009 | 0.0<br>(102.9/102.9) | -26.5<br>(76.4/102.9) | -49.4<br>(53.5/102.9) |
| End-February 2010 | 0.0<br>(99.3/99.3) | -9.6<br>(89.7/99.3) | -36.5<br>(62.8/99.3) |
| End-September 2011 | 0.0<br>(125.0/125.0) | -26.5<br>(98.5/125.0) | -56.1<br>(69.0/125.0) |
| End-May 2012 | 0.0<br>(140.1/140.1) | -33.5<br>(106.6/140.1) | -65.5<br>(74.6/140.1) |
| Changes March 2007–February 2009 | 0 [0%] | -26.5 [-26.5%] | -19.4 [-27.8%] |
| *due to QE* | *0* | *0* | *0* |
| *due to other factors* | *0* | *-26.5* | *-19.4* |
| Changes March 2007–February 2010 | 0 [0%] | -9.6 [-9.6%] | -6.5 [-9.3%] |
| *due to QE* | *0* | *0.0* | *-4.1* |
| *change in assets* | *13.8* | *13.9* | *9.7* |
| *change in liabilities* | *-13.8* | *-13.8* | *-13.8* |
| *due to other factors* | *0* | *-9.6* | *-2.4* |
| Changes March 2007–September 2011 | 0 [0%] | -26.5 [-26.5%] | -26.1 [-37.2%] |
| *due to QE* | *0* | *-2.4* | *-6.9* |
| *change in assets* | *17.4* | *15.1* | *10.5* |
| *change in liabilities* | *-17.4* | *-17.4* | *-17.4* |
| *due to other factors* | *0* | *-24.1* | *-19.2* |
| Changes March 2007–May 2012 | 0 [0%] | -33.5 [-33.5%] | -35.5 [-50.7%] |
| *due to QE* | *0* | *-5.1* | *-12.6* |
| *change in assets* | *30.3* | *25.2* | *17.7* |
| *change in liabilities* | *-30.3* | *-30.3* | *-30.3* |
| *due to other factors* | *0* | *-28.4* | *-22.8* |

Note: Negative figures indicate deficits or any increase in deficits/liabilities. Numbers in ( ) are the values of assets/liabilities at point in time; numbers in [ ] are the changes in deficits as a proportion/percentage of the initial asset level.

Sources: Bloomberg, Thomson Reuters Datastream and Bank calculations.

(a) In all the schemes, liabilities are assumed to be discounted using fifteen-year gilt (spot) yields, and the value of gilts held as assets is assumed to move in line with fifteen-year gilts. The baseline scheme is assumed to hold 100% gilts. Schemes 1 and 2 each hold 40% gilts and 60% equities. Scheme 2 is 70% funded, while Scheme 1 is fully funded. The value of equities is assumed to follow the FTSE All-Share index. The impact from QE on gilt yields and equity prices are based on the estimates in Joyce, Tong and Woods (2011). In particular, it is assumed that the £200 billion of QE between March 2009 and January 2010 led to an immediate 100 basis point fall in gilt yields and a gradual 20% increase in equity prices over the period of the purchases. A similar proportionate impact is assumed for the £125 billion of QE between October 2011 and May 2012; that is, a 62.5 basis point fall in gilt yields and a 12.5% rise in equity prices. Estimates are rounded to the nearest £0.1 million, so the impacts may not add up due to rounding. As a property of the approach taken here, the estimated changes in assets and liabilities as a result of QE continue to grow after the completion of the first £200 billion of QE in January 2010 and before the start of the £125 billion of QE in October 2011.

completed), September 2011 (ie just before the announcement of further purchases) and May 2012 (ie after the completion of a further £125 billion of purchases).

The table also contains some illustrative estimates that isolate the impact of QE. In each example, QE has two effects: first, it increases the scheme's assets by pushing up the value of the gilts and equities held by the scheme; second, it increases the scheme's liabilities by reducing the discount rate the pension scheme applies to its *future* liabilities, and hence increasing the *current* value of its liabilities. The impact of 'other factors' affecting deficits is calculated by residual, and includes movements in gilt and equity prices that are unrelated to QE (as discussed on page 260).

In the case of the baseline scheme, which is fully funded and whose assets and liabilities are matched, the scheme remains fully funded, ie there is no deficit and the net impact of QE is zero. The fall in gilt yields, which is used to discount the pension fund's future liabilities, causes the current value of its liabilities to rise. But this is exactly matched by the rise in the value of the gilts that it holds. That is the case for all movements in gilt yields, irrespective of whether they are caused by QE or not.

In contrast, although Scheme 1 is assumed to have been fully funded in March 2007, the mismatch between its assets and liabilities means that a deficit gradually opens up over the subsequent period, such that by February 2009 Scheme 1 is estimated to have a deficit of around £27 million. That widening deficit largely reflects the sharp fall in equity prices that occurred between March 2007 and February 2009. The impact of QE on Scheme 1 is very similar to that of the baseline scheme; it raises its assets and liabilities by a similar proportionate amount.[1] That means that, had Scheme 1

(1) In fact, Bank estimates suggest that QE raised equity prices by slightly more than gilt prices — see footnote (a) in **Table B** for more details.

been fully funded at the point at which the asset purchase programme was started, the impact on the scheme would have been broadly neutral. But since the scheme was in deficit by February 2009, by increasing its assets and liabilities by similar amounts, QE acted to increase the absolute size of the deficit. Even so, the vast majority of the widening in the deficit in Scheme 1 over the entire period considered (£28 million out of £34 million) was not caused by QE.

The results for Scheme 2 are qualitatively similar, but the fact that Scheme 2 was assumed to start in deficit means that the deterioration in the portfolio is more pronounced. QE accounts for around £13 million (just over a third, ie 13/36) of the increased deficit by May 2012. That is a larger proportionate effect than in Scheme 1, reflecting the fact that the scales of the funding deficits at the points when the asset purchases were conducted were greater.

Increases in costs for DB schemes are borne in the first instance by employers, rather than by employees. So there would be no implications for existing pensioners on a DB scheme, nor for those on a DB scheme close to retirement. But, faced with higher costs of providing pensions, employers might seek to increase contributions or bear down on other staff costs including pay; it may also make them more likely to close, or alter the terms of, such pension schemes. For example, individuals on a final salary scheme might receive smaller pay rises than they had been expecting, potentially reducing their future retirement income. The extent to which that occurs may in part reflect the speed with which sponsors are required by the Pensions Regulator to make up any deficits in their funds.

The increased costs for some DB schemes needs to be set against what would have happened in the absence of QE, however. For example, by supporting nominal demand in the economy, QE has cushioned many companies from the financial crisis and ameliorated the rise in company closures and insolvencies. As well as the effect that had on supporting asset prices, it may have protected some individuals from the closure of their pension scheme.

### Defined contribution schemes and individuals taking out an annuity

In assessing the channels through which QE affects individuals with DC pension schemes, and those taking out an annuity, it is helpful to split out two time periods. First, the period in which individuals are accumulating assets to fund their retirement. Second, the period from which they wish to begin drawing down on those assets by purchasing an annuity.

During the accumulation phase, the impact of QE arises via its impact on the value of their asset portfolio. The net impact will therefore depend on the same factors as those affecting savers in general, namely the composition and type of those assets. During this accumulation period, the composition of assets held by an individual may well change, for example with equities being held at early life stages, gradually shifting into fixed-income assets such as gilts as the point of retirement approaches. For simplicity, our analysis assumes a constant asset allocation over time.

When an individual wishes to begin drawing down their pension, they normally exchange their pension fund for a life annuity. There could be some flexibility in terms of the point at which they take out that annuity; some individuals may be able to choose to delay taking out their annuity for a period if they expect annuity rates to pick up. The annuity offered to an individual is a function of the value of the pension fund and the prevailing annuity rate in the market. In turn, the annuity rate will depend on the discount rate — which will be affected by long-term interest rates — and the annuity provider's estimates of the likely longevity of the individual. So the net impact of QE will depend on two factors: its positive impact on the value of asset holdings on the one hand and, on the other, its negative impact on annuity rates through longer-term interest rates. In assessing the impact of QE, some commentators have focused solely on the latter.

**Table C** considers an illustrative example of the average life annuity income that would have been available to a 65 year old male with a lump sum of £100,000 before the financial crisis in March 2007. In the upper half of the table, the first three columns show the annuity income that he would have received as a result of purchasing an annuity at the same four dates considered in **Table B**. The changes in the annuity incomes take into account changes in the value of the pension pot and the annuity rate over those periods.(1) The three columns differ according to the assumed split of assets between gilts and equities in three pension pots: 'conservative' (100%, 0%), 'balanced' (50%, 50%) and 'high risk' (0%, 100%). The final column is based on actual annuity market data and shows the level or standard annuity rate offered to a 65 year old male at each point in time. For example, based on the annuity rate shown in the final column, a male with a pension pot of £100,000 in February 2010 could have received an annual pension income of around £6,800 (market annuity rate of 6.8% multiplied by £100,000), but would have only got £5,900 with a £100,000 pot in May 2012 (market annuity rate of 5.9% multiplied by £100,000).

In the lower half of the table, the first three columns decompose changes in annuity income for each of the three hypothetical portfolios over the different time periods. The fourth column shows the change in the actual annuity rate based on market data broken down into the contribution from

(1) These simple calculations assume that the age of the individual taking out the annuity remains at 65 for the whole period. In practice, by delaying the point at which the annuity is taken out, the individual would be offered a higher annuity rate because he would be expected to live for fewer years.

**Table C** Illustrative examples of annuities[a]

**£ per year from a pension fund valued at £100,000 at end-March 2007**

| | Portfolio 1 'Conservative' | Portfolio 2 'Balanced' | Portfolio 3 'High risk' | Annuity rate (per cent/percentage points (pp)) |
|---|---|---|---|---|
| Annuity bought at: | | | | |
| End-March 2007 | 7,140 | 7,140<br>(100,000) | 7,140<br>(100,000) | 7.14%<br>(100,000) |
| End-February 2009 | 7,160<br>(102,940) | 5,630<br>(80,860) | 4,090<br>(58,780) | 6.96% |
| End-February 2010 | 6,710<br>(99,330) | 6,170<br>(91,340) | 5,630<br>(83,360) | 6.76% |
| End-September 2011 | 7,700<br>(125,020) | 6,340<br>(102,930) | 4,980<br>(80,850) | 6.16% |
| End-May 2012 | 8,200<br>(140,130) | 6,560<br>(112,210) | 4,930<br>(84,280) | 5.85% |
| Changes March 2007–February 2009 | 20 | -1,510 | -3,050 | -0.18pp |
| *due to QE* | *0* | *0* | *0* | *0pp* |
| *due to other factors* | *20* | *-1,510* | *-3,050* | *-0.18pp* |
| Changes March 2007–February 2010 | -430 | -970 | -1,510 | -0.38pp |
| *due to QE* | *80* | *160* | *240* | *-1pp* |
| *of which, impact from higher asset value* | *1,080* | *1,160* | *1,240* | |
| *of which, impact from lower annuity rate* | *-1,000* | *-1,000* | *-1,000* | |
| *due to other factors* | *-510* | *-1,130* | *-1,750* | *0.62pp* |
| Changes March 2007–September 2011 | 560 | -800 | -2,160 | -0.98pp |
| *due to QE* | *0* | *80* | *160* | *-1pp* |
| *of which, impact from higher asset value* | *1,000* | *1,080* | *1,160* | |
| *of which, impact from lower annuity rate* | *-1,000* | *-1,000* | *-1,000* | |
| *due to other factors* | *560* | *-880* | *-2,320* | *0.02pp* |
| Changes March 2007–May 2012 | 1,060 | -580 | -2,210 | -1.29pp |
| *due to QE* | *-10* | *130* | *260* | *-1.63pp* |
| *of which, impact from higher asset value* | *1,620* | *1,760* | *1,890* | |
| *of which, impact from lower annuity rate* | *-1,630* | *-1,630* | *-1,630* | |
| *due to other factors* | *1,070* | *-710* | *-2,470* | *0.34pp* |

Note: Negative figures indicate reduction in annuity. Numbers in ( ) are the values of assets/liabilities at point in time.

Sources: Bloomberg, Thomson Reuters Datastream, William Burrows Annuities and Bank calculations.

(a) Based on a male aged 65. Life annuity rates are on a guaranteed five-year and level payment basis. The value of the gilts held in the portfolios is assumed to move in line with fifteen-year gilts. The impacts of QE are based on the same assumptions as those underlying **Table B**. As a simplifying assumption, QE is assumed to have the same impact on the annuity rate as it does on gilt yields. Estimates are rounded to the nearest £10, so impacts may not add up due to rounding.

QE and other factors. The reduction due to QE is calculated by assuming that the estimated reduction in gilt yields due to QE is fully passed through to lower annuity rates. This may exaggerate the negative impact of QE, as the historical relationship between gilt yields and annuity rates suggests a less than 100% pass-through from gilt yields.

Take as an example the results for the 'conservative' portfolio. If an individual had invested £100,000 solely in gilts in March 2007, that would have given an annuity of £7,140. By February 2010, the annuity value would have fallen by £430, to £6,710. That would not have reflected QE, which would have had a broadly neutral effect, as the increase in the value of the pension pot associated with the rise in gilt prices would have broadly offset the reduction in the annuity rate associated with the lower gilt yields. Over the period from March 2007 to May 2012, the annuity income from this fund would have increased by £1,060. Within that, QE would again have had a broadly neutral effect.[1]

The overall performance of the balanced and high-risk portfolios (shown in columns 2 and 3 of **Table C**) was worse than the conservative one. Over the period March 2007 to May 2012, annuity income fell, by £580 for the balanced portfolio and by £2,210 for the high-risk portfolio. This mainly reflected other factors, and particularly the sharp fall in equities over the period up to February 2009. The net impact of QE on both these portfolios was actually to boost annuity income by £130 in the case of the balanced portfolio and by £260 for the high-risk one. This reflects the fact that QE is estimated to have increased equity prices by a little more than gilt prices.[2]

(1) The net impact of QE on annuity income is not exactly zero, with a positive estimated impact of £80 up to February 2010 and a negative impact of £10 in the period up to May 2012. The intuition for this result is that there is a small mismatch between the assets held in the portfolio and the annuity rate used. The gilts held in the portfolio are assumed to move in line with fifteen-year gilts. The annuity rates used in the calculations do not have a specified maturity: they are always quoted for a 65 year old, and there is no fixed date at which the annuity will cease. This maturity mismatch means that, for a given fall in gilt yields, the increase in the value of the pension pot associated with the rise in gilt prices does not generally exactly offset the reduction in the annuity rate associated with lower gilt yields (they would only exactly offset if the annuity rate were equal to 1/15, ie the inverse of the gilt maturity). This maturity mismatch effect is similar to that driving the difference in the estimated impact of QE between the DB baseline scheme and Scheme 1 in **Table B**.

(2) See footnote (a) in **Table B** and Joyce, Tong and Woods (2011).

This section has set out the implications of QE for pensioners and pension providers. In making that assessment, it is important to consider that QE affects the value of pension fund assets as well as their liabilities. For a fully-funded DB scheme, QE had a broadly neutral impact. But, in practice, many DB schemes were under-funded at the point that QE began, and, as such, QE is likely to have increased those deficits. By contrast, it is likely that QE had a broadly neutral impact on the annuities offered to those approaching retirement on DC pension schemes. And those already in receipt of a pension before QE began would have been unaffected. In general, other factors have been more important than the Bank's asset purchases in widening pension fund deficits and weighing on annuities over the past five years. In particular, the main factor affecting pensions has been the fall in equity prices relative to gilt prices since 2007.

## Conclusion

The past few years have been extremely difficult for many households, with weak growth and above-target inflation being the painful but unavoidable consequences of the severe financial crisis and the associated deep recession, as well as a sharp rise in oil and other commodity prices. In response to these difficult circumstances, monetary policy has been exceptionally expansionary for an unusually long period of time. That has supported nominal spending and incomes in the economy as a whole, mitigating the adverse effects of the financial crisis and subsequent recession. Without the loosening in monetary policy, it is likely that the economic downturn would have been far more severe, to the detriment of almost everyone in the economy, including savers and pensioners.

The benefits of loose monetary policy have not been shared equally across all individuals, however. Some individuals are likely to have been adversely affected by the direct effects of QE. Many households have received lower interest income on their deposits. But changes in Bank Rate — not asset purchases — have been the dominant influence on the interest households receive on bank deposits and pay on bank loans. By pushing up a range of asset prices, asset purchases have boosted the value of households' financial wealth held outside pension funds, although holdings are heavily skewed with the top 5% of households holding 40% of these assets.

Some pension schemes have been adversely affected by the direct effects of QE. In particular, for a DB pension scheme in substantial deficit, asset purchases are likely to have increased the size of the deficit. That is because although QE raised the value of the assets and liabilities by a similar proportion, that nonetheless implies a widening in the gap between the two. By contrast, for a typical fully-funded DB pension scheme, asset purchases are likely to have had a broadly neutral impact on the net value of the scheme. The fall in gilt yields raised the value of the pension fund's liabilities. But the associated increase in bond and equity prices raised the value of their assets by a similar amount. Likewise, asset purchases are likely to have had a broadly neutral impact on the value of the annuity income that could be purchased with a personal pension pot. The fall in gilt yields reduced the annuity rate. But this was offset by the rise in the value of equities and bonds held in the fund. Furthermore, the pension income of those already in receipt of a pension before asset purchases began has not been affected by QE, and the same is true for the retirement incomes of people coming up to retirement in a DB pension scheme. The main factor affecting the valuation of DB pension schemes and DC pension pots over the past five years has been the fall in equity prices relative to gilt prices. That fall in the relative price of equities was not caused by QE, and stemmed in large part from the reluctance of investors to hold risky assets, such as equities, given the deterioration in the economic outlook, almost certainly as a result of the financial crisis.

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# Monetary Policy Roundtable

On 14 June, the Bank of England and the Centre for Economic Policy Research hosted the eighth Monetary Policy Roundtable. These events are intended to provide a forum for economists to discuss key issues pertaining to monetary policy in the United Kingdom.(1) As always, participants included a range of economists from private sector financial institutions, academia and public sector bodies. There were two discussion topics:

- prospects for household saving; and
- cost, demand or uncertainty: why has the level of business investment been so weak, and when will it pick up?

This note summarises the main points made by participants.(2) Since the Roundtables are conducted under 'Chatham House Rule', none of the opinions expressed at the meeting are attributed to individuals. The views expressed in this summary do not represent the views of the Bank of England, the Monetary Policy Committee (MPC) or the Centre for Economic Policy Research.

## Prospects for household saving

The onset of the financial crisis was followed by a marked decline in household consumption. This decline exceeded the fall in disposable income, and consequently the savings rate rose from its pre-recession low in 2008 to something close to its historical average in 2011, although with interest rates and inflation low relative to some periods in the past, this may not indicate a 'normal' level. Inflation adjusted, the current savings rate is in fact below that of both the 1980s and 1990s. While the 1980s and 1990s recessions were also associated with rising savings rates, the recent change has been longer-lived.

Speakers considered what might lie behind this increase, noting that under the consumption-smoothing hypothesis a recession should instead be associated with a fall in the savings rate. Several candidate explanations were put forward, including a permanent fall in income, a greater need to save for retirement and the need to offset declines in wealth by rebuilding balance sheets. The latter was thought to be amplified by the extent to which households are leveraged. Highly indebted households were thought to be more likely to undertake dramatic and persistent cuts to consumption. Additional possible explanations why the savings rate could be temporarily higher included: an increase in the uncertainty faced by households, a change in preferences leading to an enhanced desire to simply pay down debt more rapidly, and a decline in the supply of new credit. If these latter factors were the drivers, then the savings rate was likely to fall as the source of the decline moderated.

The importance of considering which age groups had been responsible for the increase in the savings rate in the current recession was highlighted, because potentially this could shed light on the cause of the rise. It was noted that an increase in the savings rate resulting from a tightening in the supply of new credit was likely to affect the young disproportionately. Savings rates of older groups, in contrast, should be less affected by a reduction in the supply of credit, as they are at the stage in their life cycle where they are more likely to have paid off mortgage and other borrowing and to have accumulated financial assets.

What evidence can be brought to bear on this? The microdata (ie from households) up to 2010 (the latest available) shows that the 1980s, 1990s and 2008 recessions saw a transitory increase in the savings rate across all age groups. It also shows that in the current recession in particular, younger age groups have seen the largest reductions in the level of consumption. But they have also seen the largest falls in income, leaving the impact on savings rates not markedly different from other age groups. Another feature revealed by the household data is that mortgagors have reduced consumption significantly, implying that leverage might be playing an important role. The implication may be that credit restrictions *per se* were not the driver, but a desire to rebalance — whether coming from raised uncertainty or a simple change in preferences.

Notwithstanding the household evidence, some favoured a reduction in credit availability as the explanation, rather than households actively increasing saving. This view was justified by data showing a decline in household borrowing since the crisis, with households' net acquisition of financial liabilities as a percentage of household disposable income dropping to very low levels, whereas households' net acquisition of financial and housing assets have remained broadly flat. Others thought that the increase in the savings rate had less to do with tight

(1) Roundtables are held twice a year. The next Roundtable is scheduled for Winter 2012.
(2) For both this and previous summaries, see www.bankofengland.co.uk/publications/Pages/other/monetary/roundtable/default.aspx.

credit and more to do with the impact of uncertainty, supported by the apparent increase in savings rates across all age groups mentioned above.

To the extent that households intend to run down borrowing and accumulate savings relative to the pre-crisis period, then it is relevant that although the savings rate has returned to its long-run average, this was preceded by a significant period of lower-than-average saving. It therefore follows that a larger-than-average increase in savings might be needed to offset this and rebuild balance sheets. A speaker noted that while households had built up both debt and assets, debt as a percentage of wealth was still likely to be historically high over the next few years. To the extent that household consumption behaviour reacts to changing wealth, one speaker suggested that responses to falling house prices had much more impact than falls in the value of other forms of wealth, such as equities. Generally, it would be good to be able to look at individual household data to help shed light on behaviour in households with different compositions of debt and assets, but the available microdata were unfortunately not that helpful in understanding household-level debt and wealth distributions.

There was agreement that further increases in the UK savings rate remained a possibility, bearing down on consumption, despite a potential moderation in the real income squeeze. Previous recessions had seen a tendency for savings to increase when income began to grow. Current weak income growth might therefore likely have prevented complete adjustment to a higher desired savings rate. Current low interest rates have probably also resulted in less pressure to pay off debt rapidly.

The discussion at the Roundtable was mainly about the United Kingdom and cyclical behaviour, but one speaker reminded us that there are long-run factors at play regarding national savings and demographics and that some observers take the position that the UK savings rate is unsustainably low. When considering these trends it is instructive to note that UK savings lie below that of many other comparable countries. That might suggest a sustained rise in the savings rate was on the cards.

## Cost, demand or uncertainty: why has the level of business investment been so weak, and when will it pick up?

Business investment fell dramatically during the financial crisis. And it remains below its pre-crisis level. Much of the Roundtable discussion focused on the relative importance of weak final demand, uncertainty and tight credit conditions in explaining the fall in investment.

Some speakers offered evidence from the *CBI Industrial Trends Survey* in answering this question. The survey showed most firms reporting 'uncertainty about demand' as a factor limiting investment. It was noted that this had almost always been the case in past recessions, and that the questions may conflate genuine uncertainty and low demand. One factor unique to the recent downturn was an increase in the number of firms reporting tight credit conditions, although this was still cited by a relatively small proportion of firms. One presenter reported an econometric estimation of the determinants of the survey measures of investment intentions. They suggested that weak expected demand and tight credit conditions were significant factors, but that uncertainty did not appear to cause much of the variation in investment. Another participant argued that although demand expectations had been the driver of weak investment in 2009, it was less clear that this was the case in 2012.

One speaker suggested to wide agreement that there were several obvious reasons uncertainty may have increased recently. These included the financial crisis itself, a succession of countries experiencing sovereign debt crises and ongoing uncertainty about the future of the euro. This higher level of uncertainty could have both temporary and longer-lasting effects on the level of business investment. Temporary effects may be due to the irreversibility of some types of investment. In these circumstances a higher level of uncertainty could mean firms need larger 'trigger' levels of demand before they invest, effectively meaning that they postpone investment. If driven by this mechanism, investment would rebound when uncertainty dissipated, or when those triggers were reached. But there were also other channels through which uncertainty may lead to a longer-term fall in investment. These included higher risk premia in required rates of return. Firms facing increased risk may choose to make less use of debt because of the consequences of defaulting in the event of a bad outcome, even though tax advantages may make debt cheaper than other forms of finance. Theory also suggests that the demand for capital falls with volatility in the presence of increasing marginal adjustment costs. But some participants cautioned against assuming that theory is unambiguous about the impact of uncertainty on investment. Long-run effects can be ambiguously signed, and much of the formal economic analysis is of permanent shifts in uncertainty, rather than temporary. There was also some discussion about the best policy response to increased uncertainty, with one suggestion that increased government investment could improve confidence.

In discussing the role of tight credit conditions over the past few years, there was debate about the extent to which Britain had been suffering from a decline in credit supply or a credit demand — in principle it is very hard to distinguish between the two drivers. One participant felt that surveys can give a misleading indication of whether demand or supply factors are behind movements in credit. The inability to distinguish between the two explanations complicates policy setting, as

the prescription for each would be different. Another felt that the increase in the cost of credit since the crisis, measured by corporate bond spreads, was a sign of a credit supply shock. But others argued that this cost would also increase with uncertainty, so it remains difficult to differentiate between this and tight credit conditions.

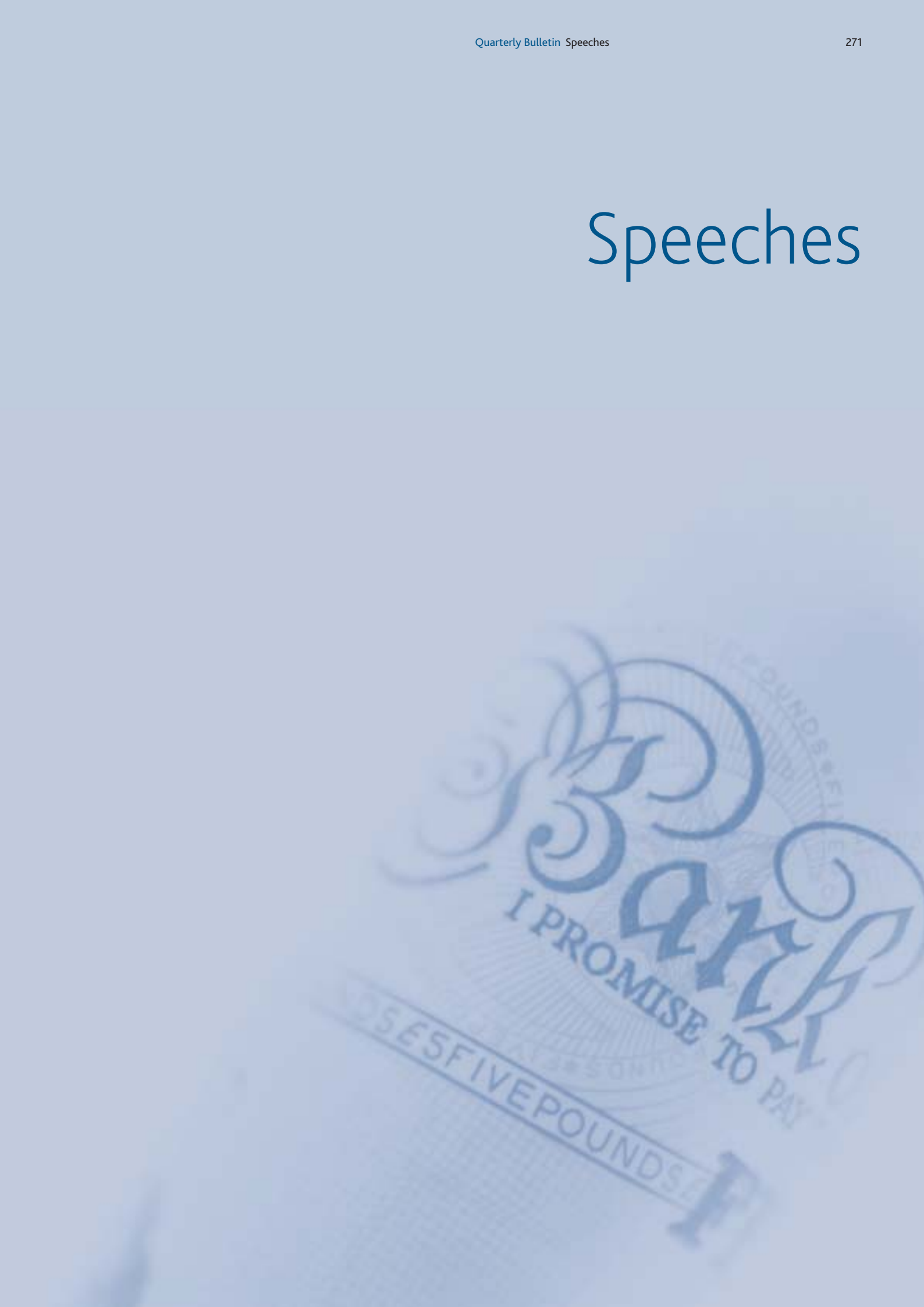
A piece of evidence discussed in detail was the build-up of a large surplus of cash and other financial assets by UK companies in recent years. One participant posited that with large amounts of cash, it seemed unlikely that a lack of available credit had been constraining firms' investment. An explanation for firms' financial surpluses could be that they had been holding cash as a form of precautionary saving in anticipation of future liquidity constraints. One participant felt that the increase in cash holdings was mostly down to an increase in financial activity by companies in recent years. Nevertheless, it was pointed out that companies' cash surpluses may not be inconsistent with tight credit conditions if those positions were mostly held by large international firms, while smaller companies were unable to borrow for investment. Another speaker showed survey evidence that small and medium-sized enterprises (SMEs) in the manufacturing sector were particularly suffering from a lack of available credit. They mentioned that this is consistent with the Bank's own *Trends in Lending* report. They felt one problem for SMEs was a lack of alternative sources of finance, as they were unable to issue in capital markets.

Although the level of business investment has fallen markedly, as a share of GDP, the fall is no greater than that seen in the 1990s recession, or even during the early 2000s. (It was pointed out, though, that care must be taken when looking at trends to take account of relative price changes — real and nominal proportions behave very differently.) Some participants suggested that the biggest puzzle related to the fall in investment was its persistence rather than its depth. Discussants debated what had driven the longer-term decline in real investment seen over the past decade, independently of the financial crisis, and when this trend would reverse. One suggestion was uncertainty, as discussed above. Another participant suggested that increases in corporate governance had led to overmonitoring and pressure on companies to pay out higher dividends instead of investing.

Another speaker discussed the long-term decline in investment with a focus on manufacturing. They argued that over the past ten years, there had been less investment in manufacturing as a share of its output in Britain than in other European countries. One reason given for this was the appreciation in sterling over this period. Another was that it was partly driven by low-cost competition from Eastern Europe and Asia, with many firms moving parts of their supply chains abroad. There was also some discussion about how important manufacturing investment was, given that it is a small proportion of the total. One participant argued that it was disproportionately important, both because manufacturing makes up a large share of exports and because its investment was often irreversible, so offered a sign of a possible market failure.

In conclusion, with regard to the question posed, there is no shortage of analysis of the weakness in investment: but it remains hard to know when the numbers will pick up.

# Speeches



# Bank of England speeches

A short summary of speeches and *ad hoc* papers made by Bank personnel since publication of the previous *Bulletin* are listed below.

### The dog and the frisbee

Andrew Haldane, Executive Director for Financial Stability, and Vasileios Madouros, Economist, Financial Stability, August 2012.

www.bankofengland.co.uk/publications/Documents/speeches/2012/speech596.pdf

In a paper co-authored with Vasileios Madouros, Andrew Haldane explored why the complex financial regulation developed over recent decades may be a suboptimal response to the increasing complexity of the financial system. He used a range of examples from other disciplines to illustrate how decision-making in a complex environment has benefited from simple rules of thumb or 'heuristics'. Andrew argued that complex rules can have punitively high information costs, can yield unreliable predictions, especially in the presence of limited samples of data and might induce defensive behaviour. Andrew used a set of empirical experiments to assess the relative performance of simple versus complex rules in a financial setting. He found that simple metrics, such as the leverage ratio and market-based measures of capital, outperformed more complex risk-weighted measures and multiple-indicator models in their capacity to predict bank failure. In line with evidence from other settings, a consistent message from these experiments was that complexity of models or portfolios can generate robustness problems in finance. Andrew outlined five policy lessons from these findings, covering both the design of financial regulation itself and possible measures aimed at reducing complexity of the financial system more directly. These might include taking a more sceptical view of internal risk models used as part of the regulatory framework, treating simple leverage ratios equal to complex ratios, applying more judgement to supervisory approaches and applying price and quantity-based restrictions on banks to encourage them to simplify their balance sheets.

### We are not 'risk nutters' stifling the recovery

Andrew Haldane, Executive Director for Financial Stability, July 2012.

www.bankofengland.co.uk/publications/Documents/speeches/2012/speech595.pdf

In an article published in *The Times*, Andrew Haldane discussed the mandate of the Bank of England's Financial Policy Committee (FPC) and addressed concerns that it will focus exclusively on reducing risk, to the detriment of growth and lending.

The FPC has a main statutory objective to preserve the resilience of the financial system. But, mirroring the Monetary Policy Committee's dual inflation and growth mandate, the FPC is also required to support the Government's growth and employment objectives, so long as they do not conflict with stability.

Indeed, recent FPC actions have aimed to achieve precisely this. In particular, the FPC has recommended UK banks temporarily raise capital levels as insurance against eurozone risks, a policy aimed at supporting credit growth at the same time as increasing resilience. It has also recommended the FSA adapt regulatory guidance on UK banks' liquid asset buffers, with the aim of allowing more of those assets to support credit growth. Going forward, the FPC will continue in this vein, with eyes on both stability and supporting the real economy.

### Let's make a deal

Robert Jenkins, Financial Policy Committee member, July 2012.

www.bankofengland.co.uk/publications/Documents/speeches/2012/speech593.pdf

In this speech, Robert discussed three concerns voiced by bankers about the rise in regulation; they complain that regulations are too tough, damaging and numerous.

First, Robert disagreed that regulation was too onerous or severe. He suggested that pre-crisis rules — that required banks to have no capital for government bond exposures and minimal levels of capital for complex securitisations — were inadequate. And he noted that the backstop introduced by the forthcoming Basel III regulations — of 33 times leverage — remained relatively loose.

Second, he argued that higher capital levels would not be damaging, but instead would be consistent with the supply of lending to the real economy and long-term shareholder value. Higher capital requirements were just not compatible with non risk-adjusted banker pay.

Finally, Robert conceded the possibility that regulations were too numerous, noting that the regulatory establishment was not exempt from culpability. But, speaking in a private capacity, he proposed a moratorium on all new regulation followed by a review and rollback of the rule book, conditional

on banks raising their tangible equity capital to 20% of assets, to protect the taxpayer from future collective failures of bankers and regulators.

### FPC: one year young

Robert Jenkins, Financial Policy Committee member, July 2012.

www.bankofengland.co.uk/publications/Documents/speeches/2012/speech594.pdf

In this article, Robert reflected on the recommendations of the Bank's Financial Policy Committee (FPC) in its first year. During the past twelve months, systemic fragility and troubles in the eurozone had been key threats; restoring confidence in the UK banking system has been the priority.

In response, the FPC has urged banks to increase levels of loss-absorbing capital, as opposed to capital ratios. This reflected the Committee view that balance sheet strength is compatible with the supply of credit to the UK economy — while lack of resilience, real or perceived, would curtail it.

Robert noted that the nature of the UK banking system permitted a differentiated approach to the resiliency recommendations. He encouraged vulnerable banks to continue to build capital, while suggesting that those less exposed to risks and who are well-positioned by their franchise to lend to the domestic economy should feel free to utilise any excess liquidity buffers to do so.

Reflecting the recent announcement of an additional objective for the FPC, to capture economic growth as well as financial stability, Robert noted that the Committee were already there, and the tension between the two would be the timing and not the goal.

### Monetary policy: navigating rough waters

Martin Weale, Monetary Policy Committee member, June 2012.

www.bankofengland.co.uk/publications/Documents/speeches/2012/speech590.pdf

In a speech delivered at the Hart Brown Economic Forum, Martin Weale reviewed the outturns for inflation and growth compared to the first forecasts he contributed to as a Monetary Policy Committee member. In considering the weaker-than-expected growth he noted that the productivity lost seems unlikely to be recouped, but that it could return to trend growth if demand were more buoyant and that the recent easing of inflationary pressures reduced the risks associated with this. Looking at the more immediate prospects for the economy, Dr Weale said he shared the view of other Committee members at the June meeting that further monetary stimulus could be applied to the economy without putting the inflation target at risk, but he wanted to wait for the outcome of the discussions between the Bank and the Treasury on possible new measures before he felt able to come to a view on the appropriate stimulus. After commenting on some of the new measures announced by the Governor, Dr Weale concluded that the Bank and the Treasury have taken important steps to provide extra monetary support for the financial system and thus the economy as a whole.

### Shining a light in the shadows — reflections on transparency in the securities lending and repo markets

Andrew Hauser, Head of Sterling Markets Division, June 2012.

www.bankofengland.co.uk/publications/Documents/speeches/2012/speech591.pdf

In a speech delivered to the annual International Securities Lending Association conference in Madrid, Andrew Hauser set out the key conclusions of a recent review of transparency in the securities lending and repo markets by market practitioner members of the Bank's Securities Lending and Repo Committee (SLRC).

The review had concluded that there were clear transparency gaps in certain parts of the securities lending and repo markets. A well-designed trade repository would be one way to help throw light on those markets, give timely insight into the build-up of potential systemic risks, and thereby provide for a more targeted and proportional response by regulators. For a repository to succeed, SLRC practitioners felt that regulators needed first to give a clear steer on the data they would require and ensure they had the analytical tools needed to interpret those data effectively. The group had also stressed a strong preference for a single, global solution which paid close attention to operational and legal details. The group had concluded by stressing the need to maintain the momentum for change, and had fed its conclusions into the Financial Stability Board's review of shadow banking, which would be making policy recommendations later in the year.

### View from the macroprudential bridge

Robert Jenkins, Financial Policy Committee member, June 2012.

www.bankofengland.co.uk/publications/Documents/speeches/2012/speech589.pdf

In this speech, Robert discussed developments in the eurozone, the stability of the global financial system and the nature of market liquidity.

First, Robert recognised that the notion of cross-border risk would need to be banished in order to prevent the economic recovery in the euro area from being constrained. Cross-border risk — the risk that borrowers might not be able

to repay euro lenders due to fears about re-denomination or exchange controls — had previously been assumed absent from the fabric of the eurozone, but had recently been impairing the free flow of capital within the euro area.

Second, the global financial system was highly accident prone due to both the size and interconnectedness of the system. The size of the system was problematic because even small moves in percentage terms could lead to large losses; and, the system had now become large even relative to sovereign balance sheets. This led Robert to question whether systemic risks exceeded the system's ability to absorb potential losses.

Third, Robert recognised that the days of instant market pricing and limitless liquidity were fading. He suggested that the risk that governments might intervene in the interests of stability might undermine the perception that market liquidity was limitless and free, even for seemingly more liquid assets.

### The Governor's speech at the Mansion House

Sir Mervyn King, Governor, June 2012.

www.bankofengland.co.uk/publications/Documents/speeches/2012/speech587.pdf

In his speech, the Governor commented on three themes: the prospects for the UK economy; measures to ease the flow of credit to the economy; and the new approach to banking supervision under the Prudential Regulation Authority.

The prospects for a recovery and rebalancing of the UK economy remained difficult. Unexpected increases in world energy and commodity prices had led to a squeeze in take-home pay and weak consumer spending. The cost of credit to households and firms had also risen, prompted by the 'black cloud of uncertainty' from the euro area, which was also acting as a brake on growth.

The Governor noted the case for further action by the authorities to ease the flow of credit. Central bank purchases of private sector assets were one option. But the decision of which assets to buy, and hence, which risks to expose taxpayers to, remained a decision for elected governments.

The Governor explained that measures to ease conditions in the banking sector could complement monetary policy easing. The Bank had set up and activated its Extended Collateral Term Repo Facility to provide short-term sterling liquidity to banks. The Bank was also working with HM Treasury on a Funding for Lending Scheme that would provide funding to banks for several years, at rates below market rates, and linked to the performance of banks in lending to the real economy.

The Governor concluded by noting the three key principles on which prudential supervision, under the new Prudential Regulation Authority, would be based. First, the need for banks to have adequate loss-absorbing capacity, as measured using both capital and leverage indicators of risk. Second, the importance of a resolution mechanism to successfully resolve failing banks, doing away with the 'too big to fail' problem. Third, a shift from rules-based supervision to judgement-led supervision, focusing more on the big risks, and less on unnecessary details. The new approach would be a positive change for banks, regulators and taxpayers alike.

### Property booms, stability and policy

Paul Tucker, Deputy Governor, June 2012.

www.bankofengland.co.uk/publications/Documents/speeches/2012/speech586.pdf

Paul Tucker identified three lessons from past excess in property markets. Losses on lending demonstrated commercial banking can be just as risky as investment banking. The costs of bank failure can be greater when the industry is concentrated. And persistently easy monetary policy can fuel exuberance. He then set out thoughts on policy in the current conjuncture. Credit conditions had tightened following increases in bank funding costs. That reflected the risk of a bad outcome in the euro area. The authorities, including the Bank, needed to consider what more could be done to alleviate tight credit conditions. On regulatory policy, while threats persisted banks should take what opportunities they had to build capital levels. When threats recede, capital planning should then normalise. Liquidity was different. Central banks stand ready to provide liquidity in stressed conditions. As such, there was currently less of a case for banks to maintain their stock of liquid assets. Liberating this part of balance sheets could free up reserves injected through QE.

### Making the most of doing more

Adam Posen, Monetary Policy Committee member, June 2012.

www.bankofengland.co.uk/publications/Documents/speeches/2012/speech585.pdf

In this speech, Dr Posen called for new means of monetary policy stimulus in the United Kingdom and abroad. Policy defeatism was unjustified because targeted monetary ease would alleviate investors' risk aversion and spur investment. The weak UK recovery reflected insufficient policy stimulus to date, given the forces weighing on the economy, but also signalled the need for more targeted policy given high and rising spreads on mortgages and on loans to small and medium-sized enterprises (SMEs). Dr Posen advocated the purchase by the Bank of SME loans bundled into securities by a Government entity. The pooling of risk would insulate the Bank from credit risk while Bank purchases would deepen the market for securitised SME lending. Dr Posen dismissed worries about asset purchases diminishing central bank

independence from politicians, calling on finance ministries to follow HM Treasury in indemnifying central banks from losses incurred in performing their duties.

### Tails of the unexpected

Andrew Haldane, Executive Director for Financial Stability, and Benjamin Nelson, Economist, Financial Stability, June 2012.

www.bankofengland.co.uk/publications/Documents/speeches/2012/speech582.pdf

In a speech at the University of Edinburgh Business School, Andrew Haldane and Benjamin Nelson discussed risks to financial stability arising from overreliance on use of the normal distribution to measure tail risk.

Since Galileo, the normal distribution has become a cornerstone of statistical analysis — first in the physical sciences, then in the statistics of social, economic and financial systems. But real-world interactions rarely conform to normality. Whether natural or economic, complex systems are prone to fat tails, meaning assumptions of normality can lead to massive underpricing of catastrophe risk.

Accounting for fat tails will be a key challenge in avoiding future crises. There is a need to incorporate complexity and uncertainty into economic theory and for a fundamental review of institutional risk management tools. Policymakers will have a key role to play. This includes through: the introduction of systemic oversight agencies, including the Financial Policy Committee in the United Kingdom; efforts to develop data and common languages to map economic interactions; and recognition that system robustness may be found in structural simplicity, rather than complex regulatory rules.

### Resolution through the lens of corporate restructuring

Andrew Gracie, Director, Special Resolution Unit, June 2012.

www.bankofengland.co.uk/publications/Documents/speeches/2012/speech583.pdf

In a speech delivered to the International Association of Deposit Insurers' conference, Andrew Gracie, Director of the Special Resolution Unit, discussed the parallels between bank resolution and corporate debt restructuring. It was noted that while bank failures pose a different set of challenges to corporate failures — including the risk of severe disruption to the rest of the financial system — clear similarities between the two processes can be drawn. Both bail-in within resolution and corporate debt restructuring return an institution to solvency by reducing the company's outstanding debt burden through the imposition of losses on certain creditors and/or by converting certain creditors into equity. Both processes seek to avoid the value-destructive process of insolvency and liquidation, both maintain continuity of core functions provided by the institution and both respect the hierarchy of claims in insolvency law to the extent possible. These parallels have informed the resolution policy making process, and should give G-SIFI creditors and other stakeholders increased comfort around the tools and objectives of G-SIFI resolution regimes.

### Banking myths and shibboleths

Robert Jenkins, Financial Policy Committee member, June 2012.

www.bankofengland.co.uk/publications/Documents/speeches/2012/speech584.pdf

In this article, Robert rebutted concerns that an increase in regulation had become the greatest risk facing the banking sector.

Robert conceded that regulators were not exempt from culpability from the recent crisis. The regulatory establishment misjudged the breadth and depth of the risks that banks were running. And regulators also misjudged the ability of bankers to judge those risks.

But he dismissed bankers' concerns that higher capital requirements were not compatible with economic growth and shareholder value. First, Robert argued that more capital would not necessarily lead to lower lending. And second, he argued that return on equity was a poor measure of shareholder value, as it did not adjust for risk. On a risk-adjusted basis, investors may prefer less-leveraged firms; Robert noted that the market was attaching relatively higher valuations to the relatively less leveraged as evidence of this.

# Appendices

# Contents of recent Quarterly Bulletins

The articles and speeches that have been published recently in the *Quarterly Bulletin* are listed below. Articles from May 1994 onwards are available on the Bank's website at:

www.bankofengland.co.uk/publications/Pages/quarterlybulletin/default.aspx.

## Articles and speeches

*Speeches are indicated by (S)*

### 2008 Q1

- Capital inflows into EMEs since the millennium: risks and the potential impact of a reversal
- Recent developments in portfolio insurance
- The Agents' scores: a review
- The impact of low-cost economies on UK import prices
- The Society of Business Economists' survey on MPC communications
- The Governor's speech in Bristol (S)
- The impact of the financial market disruption on the UK economy (S)
- The return of the credit cycle: old lessons in new markets (S)
- Money and credit: banking and the macroeconomy (S)
- Financial markets and household consumption (S)

### 2008 Q2

- Public attitudes to inflation and interest rates
- Recent advances in extracting policy-relevant information from market interest rates
- How do mark-ups vary with demand?
- On the sources of macroeconomic stability
- A review of the work of the London Foreign Exchange Joint Standing Committee in 2007
- Sovereign wealth funds and global imbalances (S)
- Monetary policy and the financial system (S)
- Inflation and the global economy (S)
- Does sterling still matter for monetary policy? (S)
- Strengthening regimes for controlling liquidity risk: some lessons from the recent turmoil (S)
- Inflation, expectations and monetary policy (S)

### 2008 Q3

- Market expectations of future Bank Rate
- Globalisation, import prices and inflation: how reliable are the 'tailwinds'?
- How has globalisation affected inflation dynamics in the United Kingdom?
- The economics of global output gap measures
- Banking and the Bank of England (S)
- The Governor's speech at the Mansion House (S)
- A tale of two cycles (S)
- The financial cycle and the UK economy (S)
- The credit crisis: lessons from a protracted 'peacetime' (S)
- Financial innovation: what have we learnt? (S)
- Global inflation: how big a threat? (S)
- Remarks on 'Making monetary policy by committee' (S)

### 2008 Q4

- The financial position of British households: evidence from the 2008 NMG Research survey
- Understanding dwellings investment
- Price-setting behaviour in the United Kingdom
- Monetary Policy Roundtable

### 2009 Q1

- Price-setting behaviour in the United Kingdom: a microdata approach
- Deflation

### 2009 Q2

- Quantitative easing
- Public attitudes to inflation and monetary policy
- The economics and estimation of negative equity
- A review of the work of the London Foreign Exchange Joint Standing Committee in 2008

### 2009 Q3

- Global imbalances and the financial crisis
- Household saving
- Interpreting recent movements in sterling
- What can be said about the rise and fall in oil prices?
- Bank of England *Systemic Risk Survey*
- Monetary Policy Roundtable

### 2009 Q4

- The financial position of British households: evidence from the 2009 NMG survey
- Accounting for the stability of the UK terms of trade
- Recent developments in pay settlements

### 2010 Q1

- Interpreting equity price movements since the start of the financial crisis
- The Bank's balance sheet during the crisis
- Changes in output, employment and wages during recessions in the United Kingdom
- Monetary Policy Roundtable

### 2010 Q2

- Collateral risk management at the Bank of England
- The impact of the financial crisis on supply

- Public attitudes to inflation and monetary policy
- A review of the work of the London Foreign Exchange Joint Standing Committee in 2009

### 2010 Q3

- Understanding the price of new lending to households
- Interpreting the world trade collapse
- What can we learn from surveys of business expectations?
- Residential property auction prices
- Chief Economists' Workshop: state-of-the-art modelling for central banks
- Monetary Policy Roundtable

### 2010 Q4

- The history of the *Quarterly Bulletin*
- Index of articles 1960–2010
- The UK recession in context — what do three centuries of data tell us?
- The Bank's money market framework
- Managing the circulation of banknotes
- Understanding the weakness of bank lending
- Evolution of the UK banking system
- The financial position of British households: evidence from the 2010 NMG Consulting survey
- The foreign exchange and over-the-counter interest rate derivatives markets in the United Kingdom
- Global finance after the crisis

### 2011 Q1

- Understanding the recent weakness in broad money growth
- Understanding labour force participation in the United Kingdom
- Global imbalances: the perspective of the Bank of England
- China's changing growth pattern
- Monetary Policy Roundtable

### 2011 Q2

- Assessing the risk to inflation from inflation expectations
- International evidence on inflation expectations during Sustained Off-Target Inflation episodes
- Public attitudes to monetary policy and satisfaction with the Bank
- The use of foreign exchange markets by non-banks
- Housing equity withdrawal since the financial crisis
- Using internet search data as economic indicators
- A review of the work of the London Foreign Exchange Joint Standing Committee in 2010

### 2011 Q3

- The United Kingdom's quantitative easing policy: design, operation and impact
- Bank resolution and safeguarding the creditors left behind
- Developments in the global securities lending market
- Measuring financial sector output and its contribution to UK GDP
- The Money Market Liaison Group Sterling Money Market Survey
- Monetary Policy Roundtable

### 2011 Q4

- Understanding recent developments in UK external trade
- The financial position of British households: evidence from the 2011 NMG Consulting survey
- Going public: UK companies' use of capital markets
- Trading models and liquidity provision in OTC derivatives markets

### 2012 Q1

- What might be driving the need to rebalance in the United Kingdom?
- Agents' Special Surveys since the start of the financial crisis
- What can the oil futures curve tell us about the outlook for oil prices?
- Quantitative easing and other unconventional monetary policies: Bank of England conference summary
- The Bank of England's Special Liquidity Scheme
- Monetary Policy Roundtable

### 2012 Q2

- How has the risk to inflation from inflation expectations evolved?
- Public attitudes to monetary policy and satisfaction with the Bank
- Using changes in auction maturity sectors to help identify the impact of QE on gilt yields
- UK labour productivity since the onset of the crisis — an international and historical perspective
- Considering the continuity of payments for customers in a bank's recovery or resolution
- A review of the work of the London Foreign Exchange Joint Standing Committee in 2011

### 2012 Q3

- RAMSI: a top-down stress-testing model developed at the Bank of England
- What accounts for the fall in UK ten-year government bond yields?
- Option-implied probability distributions for future inflation
- The Bank of England's Real-Time Gross Settlement infrastructure
- The distributional effects of asset purchases
- Monetary Policy Roundtable

# Bank of England publications

The Bank of England publishes information on all aspects of its work in many formats. Listed below are some of the main Bank of England publications. For a full list, please refer to our website:

www.bankofengland.co.uk/publications/Pages/default.aspx.

## Working papers

An up-to-date list of working papers is maintained on the Bank of England's website at:

www.bankofengland.co.uk/publications/Pages/workingpapers/default.aspx

where abstracts of all papers may be found. Papers published since January 1997 are available in full, in portable document format (PDF).

No. 449 Misperceptions, heterogeneous expectations and macroeconomic dynamics (May 2012)
*Richard Harrison and Tim Taylor*

No. 450 Forecasting UK GDP growth, inflation and interest rates under structural change: a comparison of models with time-varying parameters (May 2012)
*Alina Barnett, Haroon Mumtaz and Konstantinos Theodoridis*

No. 451 Bank behaviour and risks in CHAPS following the collapse of Lehman Brothers (June 2012)
*Evangelos Benos, Rodney Garratt and Peter Zimmerman*

No. 452 Simple banking: profitability and the yield curve (June 2012)
*Piergiorgio Alessandri and Benjamin Nelson*

No. 453 Neutral technology shocks and employment dynamics: results based on an RBC identification scheme (May 2012)
*Haroon Mumtaz and Francesco Zanetti*

No. 454 Fixed interest rates over finite horizons (May 2012)
*Andrew P Blake*

No. 455 Estimating probability distributions of future asset prices: empirical transformations from option-implied risk-neutral to real-world density functions (June 2012)
*Rupert de Vincent-Humphreys and Joseph Noss*

No. 456 Liquidity risk, cash-flow constraints and systemic feedbacks (June 2012)
*Sujit Kapadia, Mathias Drehmann, John Elliott and Gabriel Sterne*

No. 457 What do sticky and flexible prices tell us? (July 2012)
*Stephen Millard and Tom O'Grady*

No. 458 A network model of financial system resilience (July 2012)
*Kartik Anand, Prasanna Gai, Sujit Kapadia, Simon Brennan and Matthew Willison*

No. 459 Inflation and output in New Keynesian models with a transient interest rate peg (July 2012)
*Charles T Carlstrom, Timothy S Fuerst and Matthias Paustian*

No. 460 Too big to fail: some empirical evidence on the causes and consequences of public banking interventions in the United Kingdom (August 2012)
*Andrew K Rose and Tomasz Wieladek*

No. 461 Labour market institutions and unemployment volatility: evidence from OECD countries (August 2012)
*Renato Faccini and Chiara Rosazza Bondibene*

## External MPC Unit discussion papers

The MPC Unit discussion paper series reports on research carried out by, or under supervision of, the external members of the Monetary Policy Committee. Papers are available from the Bank's website at:

www.bankofengland.co.uk/publications/Pages/externalmpcpapers/default.aspx.

The following papers have been published recently:

No. 36 Did output gap measurement improve over time? (July 2012)
*Adrian Chiu and Tomasz Wieladek*

No. 37 Disaggregating the international business cycle (August 2012)
*Robert Gilhooly, Martin Weale and Tomasz Wieladek*

## Monetary and Financial Statistics

*Monetary and Financial Statistics* (*Bankstats*) contains detailed information on money and lending, monetary and financial institutions' balance sheets, banks' income and expenditure, analyses of bank deposits and lending, external business of banks, public sector debt, money markets, issues of securities, financial derivatives, interest and exchange rates, explanatory notes to tables and occasional related articles.

*Bankstats* is published on a monthly basis, free of charge, on the Bank's website at:

www.bankofengland.co.uk/statistics/Pages/bankstats/default.aspx.

Further details are available from: Leslie Lambert, Monetary and Financial Statistics Division, Bank of England: telephone 020 7601 4544; fax 020 7601 5395; email leslie.lambert@bankofengland.co.uk.

Articles that have been published in recent issues of *Monetary and Financial Statistics* can also be found on the Bank's website at:

www.bankofengland.co.uk/statistics/Pages/ms/articles.aspx.

## Financial Stability Report

The *Financial Stability Report* is published twice a year under the guidance of the interim Financial Policy Committee (FPC). It covers the Committee's assessment of the outlook for the stability and resilience of the financial sector at the time of preparation of the *Report*, and the policy actions it advises to reduce and mitigate risks to stability. The Bank of England intends this publication to be read by those who are responsible for, or have interest in, maintaining and promoting financial stability at a national or international level. It is of especial interest to policymakers in the United Kingdom and abroad; international financial institutions; academics; journalists; market infrastructure providers; and financial market participants. It is available at a charge, from Publications Group, Bank of England, Threadneedle Street, London, EC2R 8AH and on the Bank's website at:

www.bankofengland.co.uk/publications/Pages/fsr/default.aspx.

## Payment Systems Oversight Report

The *Payment Systems Oversight Report* provides an account of how the Bank is discharging its responsibility for oversight of recognised UK payment systems. Published annually, the *Oversight Report* identifies the most significant payment system risks to financial stability and assesses progress in reducing these risks. Copies are available on the Bank's website at:

www.bankofengland.co.uk/publications/Pages/psor/default.aspx.

## Handbooks in central banking

The series of *Handbooks in central banking* provide concise, balanced and accessible overviews of key central banking topics. The *Handbooks* have been developed from study materials, research and training carried out by the Bank's Centre for Central Banking Studies (CCBS). The *Handbooks* are therefore targeted primarily at central bankers, but are likely to be of interest to all those interested in the various technical and analytical aspects of central banking. The *Handbook* series also includes '*Technical Handbooks*' which are aimed more at specialist readers and often contain more methodological material than the *Handbooks*, incorporating the experiences and expertise of the author(s) on topics that address the problems encountered by central bankers in their day-to-day work. All the *Handbooks* are available via the Bank's website at:

www.bankofengland.co.uk/education/Pages/ccbs/handbooks/default.aspx.

## The framework for the Bank of England's operations in the sterling money markets (the 'Red Book')

The 'Red Book' describes the Bank of England's framework for its operations in the sterling money markets, which is designed to implement the interest rate decisions of the Monetary Policy Committee while meeting the liquidity needs, and so contributing to the stability of, the banking system as a whole. It also sets out the Bank's specific objectives for the framework, and how it delivers those objectives. The framework was introduced in May 2006. The 'Red Book' is available at:

www.bankofengland.co.uk/markets/Documents/money/publications/redbookjune2012.pdf.

## The Bank of England Quarterly Model

*The Bank of England Quarterly Model*, published in January 2005, contains details of the new macroeconomic model developed for use in preparing the Monetary Policy Committee's quarterly economic projections, together with a commentary on the motivation for the new model and the economic modelling approaches underlying it.

www.bankofengland.co.uk/publications/Pages/other/beqm/default.aspx.

## Cost-benefit analysis of monetary and financial statistics

The handbook describes a cost-benefit analysis (CBA) framework that has been developed within the Bank to ensure a fair balance between the benefits derived from good-quality statistics and the costs that are borne by reporting banks. Although CBA is a well-established approach in other contexts, it has not often been applied to statistical provision, so techniques have had to be adapted for application to the Bank's monetary and financial statistics. The handbook also discusses how the application of CBA has enabled cuts in both the amount and the complexity of information that is required from reporting banks.

www.bankofengland.co.uk/statistics/Pages/about/cba.aspx.

## Credit Conditions Survey

As part of its mission to maintain monetary stability and financial stability, the Bank needs to understand trends and developments in credit conditions. This survey for bank and non-bank lenders is an input to this work. Lenders are asked about the past three months and the coming three months. The survey covers secured and unsecured lending to households and small businesses; and lending to non-financial corporations, and to non-bank financial firms. Copies are available on the Bank's website at:

www.bankofengland.co.uk/publications/Pages/other/monetary/creditconditions.aspx.

## Trends in Lending

This quarterly publication presents the Bank of England's assessment of the latest trends in lending to the UK economy. The report draws mainly on long-established official data sources, such as the existing monetary and financial statistics collected by the Bank of England. These data have been supplemented by the results of a new collection, established by the Bank in late 2008, to provide more timely data covering aspects of lending to the UK corporate and household sectors. The report also draws on intelligence gathered by the Bank's network of Agents and from market contacts, as well as the results of other surveys. Copies are available on the Bank's website at:

www.bankofengland.co.uk/publications/Pages/other/monetary/trendsinlending.aspx.

## Quarterly Bulletin

The *Quarterly Bulletin* provides regular commentary on market developments and UK monetary policy operations. It also contains research and analysis and reports on a wide range of topical economic and financial issues, both domestic and international. The *Quarterly Bulletin* is available at:

www.bankofengland.co.uk/publications/Pages/quarterlybulletin/default.aspx.

## Inflation Report

The Bank's quarterly *Inflation Report* sets out the detailed economic analysis and inflation projections on which the Bank's Monetary Policy Committee bases its interest rate decisions, and presents an assessment of the prospects for UK inflation. The *Inflation Report* is available at:

www.bankofengland.co.uk/publications/Pages/inflationreport/default.aspx.

The *Report* starts with an overview of economic developments; this is followed by five sections:

- analysis of money and asset prices;
- analysis of demand;
- analysis of output and supply;
- analysis of costs and prices; and
- assessment of the medium-term inflation prospects and risks.

## Publication dates

Copies of the *Quarterly Bulletin, Inflation Report* and *Financial Stability Report* can be bought separately, or as combined packages for a discounted rate. Current prices are shown overleaf. Publication dates for 2012 are as follows:

*Quarterly Bulletin*

| | |
|---|---|
| Q1 | 27 March |
| Q2 | 20 June |
| Q3 | 13 September |
| Q4 | 18 December |

*Inflation Report*

| | |
|---|---|
| February | 15 February |
| May | 16 May |
| August | 8 August |
| November | 14 November |

*Financial Stability Report*

29 June
29 November

## Quarterly Bulletin, Inflation Report and Financial Stability Report subscription details

Copies of the *Quarterly Bulletin* (*QB*), *Inflation Report* (*IR*) and *Financial Stability Report* (*FSR*) can be bought separately, or as combined packages for a discounted rate. Subscriptions for a full year are also available at a discount. The prices are set out below:

| Destination | 2012 | | | | | |
|---|---|---|---|---|---|---|
| | *QB, IR* and *FSR* package | *QB* and *IR* package | *IR* and *FSR* package | *QB* only | *IR* only | *FSR* only |
| **United Kingdom** | | | | | | |
| First class/collection[1] | £31.50 | £27.00 | £13.50 | £21.00 | £10.50 | £5.25 |
| *Students/schools* (concessionary rate UK only) | *£10.50* | *£9.00* | *£4.50* | *£7.00* | *£3.50* | *£1.75* |
| *Academics* (concessionary rate UK only) | *£21.00* | *£18.00* | *£9.00* | *£14.00* | *£7.00* | *£3.50* |
| **Rest of Europe** | | | | | | |
| Letter service | £38.50 | £33.00 | £17.00 | £25.00 | £13.00 | £6.50 |
| **Outside Europe** | | | | | | |
| Surface mail | £38.50 | £33.00 | £17.00 | £25.00 | £13.00 | £6.50 |
| Air mail | £50.00 | £43.00 | £21.50 | £34.00 | £17.00 | £8.50 |

(1) Subscribers who wish to collect their copy (copies) of the *Bulletin, Inflation Report* and/or *Financial Stability Report* may make arrangements to do so by writing to the address given below. Copies will be available to personal callers at the Bank from 10.30 am on the day of issue and from 8.30 am on the following day.

Readers who wish to become **regular subscribers**, or who wish to purchase single copies, should send to the Bank, at the address given below, the appropriate remittance, payable to the Bank of England, together with full address details, including the name or position of recipients in companies or institutions. If you wish to pay by **Visa, MasterCard, Maestro** or **Delta**, please telephone +44 (0)20 7601 4030. Existing subscribers will be invited to renew their subscriptions automatically. Copies can also be obtained over the counter at the Bank's front entrance.

The **concessionary** rates for the *Quarterly Bulletin*, *Inflation Report* and *Financial Stability Report* are noted above in *italics*. Academics at UK institutions of further and higher education are entitled to a concessionary rate. They should apply on their institution's notepaper, giving details of their current post. **Students and secondary schools** in the United Kingdom are also entitled to a concessionary rate. Requests for concessionary copies should be accompanied by an explanatory letter; students should provide details of their course and the institution at which they are studying.

These publications are available from Publications Group, Bank of England, Threadneedle Street, London, EC2R 8AH; telephone +44 (0)20 7601 4030; fax +44 (0)20 7601 3298; email publications@bankofengland.co.uk or fsr_enquiries@bankofengland.co.uk.

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