



# Inflation targeting and financial conditions: UK monetary policy during the great moderation and financial crisis



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## ABSTRACT

In this paper, we investigate the interest rate setting behaviour of the Bank of England (BoE) over the 16 year period covering both the Great Moderation and the 2008–9 Global Financial Crisis and Great Recession. We contribute to the literature by using the BoE's own inflation projections in our estimations. Also, we develop a novel measure of the output gap to encapsulate the array of real variables that the Monetary Policy Committee of the BoE reviews. In order to assess the BoE's responsiveness to financial markets, we estimate a new financial conditions index that covers a wide range of financial indicators that feature in the *Inflation Report*. Our study provides some new insights into the BoE's monetary policy behaviour. We show that the BoE was concerned not only with price stability but also output, employment and financial conditions during the Great Moderation. In contrast to previous studies, we find that the BoE responds relatively less to financial conditions and relatively more to inflation projections when the 2008–9 Global Financial Crisis and Great Recession period is included.

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## 1. Introduction

The Global Financial Crisis (GFC) of 2008–9 re-focused attention on inflation targeting and its efficacy in responding to financial imbalances in the run-up to the crisis and in dealing with the crisis itself. At the beginning of 2008, the effect of high commodity and fuel prices raised concerns that inflation targeting was an inadequate monetary policy strategy for the financial crisis and should be abandoned (de Carvalho Fiho, 2010). To evaluate the usefulness of the inflation targeting framework, it is important to identify whether central banks did in fact continue to act as inflation targeters or whether they changed their monetary policy rule during the crisis. In this paper we re-assess whether the interest rate response of the Bank of England (BoE) was consistent with maintaining inflation targeting during the GFC and subsequent recession. However, inflation targeting does not necessarily rule out the inclusion of financial stability considerations. The Jackson Hole view (Bernanke and Gertler, 1999) argues that financial and price stability can be managed within an inflation targeting approach – with financial conditions providing information on expected out-

put and inflation. The “Leaning Against the Wind” view (Borio and Lowe, 2002) argues that the central bank should more aggressively target financial imbalances in addition to inflation and output given their impact on the economy over longer horizons. Consequently, we want to assess whether the BoE incorporated financial stability considerations purely in relation to their impact on their forecasts of inflation or whether financial conditions formed part of their objective function prior to and during the GFC.

The UK is an interesting case to explore the links between inflation targeting and financial stability. The BoE introduced a new monetary policy framework, inflation targeting, in October 1992. While inflation targeting gives primacy to the objective of price stability by specifying an explicit target for inflation, it does not preclude the inclusion of other monetary policy objectives. The Bank of England Act 1998 (Act) affirmed this by stating that the BoE must maintain price stability and subject to that, to support the economic policy of her Majesty's government including its objectives for growth and employment. Ferguson (2002) argues that the latter could be interpreted as encompassing financial stability as an implicit central bank goal. Although not specifically mentioned in the Act, the BoE continued to retain responsibility for the overall stability of the financial system (Rogers, 1998) which it had done so previously. However, it was no longer in charge of the regulation and supervision of the banks – that role was now given to the

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Financial Services Authority (FSA) who was responsible for the prudential supervision of the whole financial sector. A memorandum of understanding (MoU) between the Treasury, the Bank and the FSA facilitated co-operation between them in the area of financial stability. In response, the BoE formed an internal financial stability committee to detect and limit systemic financial risk (Rogers, 1998). Part of the role of the BoE was to closely monitor economic and financial market developments, as part of an overview of the system as a whole.

Previous research suggests that the BoE moved away from targeting inflation during the GFC and subsequent recession. Martin and Milas (2013) find that the BoE no longer responded to inflation in the post-2007 period, instead reacting to financial conditions. "The rapid fall in the policy rate occurred despite inflation being above target and exceeding 3% for much of the crisis period" (Martin and Milas, 2013, p. 654). Consequently, they question whether the BoE abandoned inflation targeting during this time. Similarly, Baxa et al. (2013) uncover that the BoE responded only to financial stress and declining economic activity during the GFC. Research on UK monetary policy during the period of the Great Moderation (the period of low macroeconomic volatility from the mid-1980s to 2007) shows a divergence of views as to how the BoE set monetary policy. Although earlier work by Batini and Nelson (2000), Chadha et al. (2004), Montagnoli and Napolitano (2005) and Crespo-Cuaresma and Gnan (2008) point towards the BoE taking financial conditions into account in setting interest rates, later work by Castro (2011) and Martin and Milas (2013), suggest that the BoE did not respond (or indeed in a very limited way) to financial conditions prior to the GFC.

This paper contributes to this literature by using the inflation projections of the BoE to re-examine whether the BoE acted as an inflation targeter and continued in this role during the GFC and the subsequent Great Recession. The BoE publishes an *Inflation Report* every quarter which sets out the inflation projections and the economic analysis that the Monetary Policy Committee (MPC) of the BoE uses to make its monetary policy decisions. We estimate a Taylor (1993)-type rule for the BoE using a selection of the economic and financial variables that the Bank makes reference to in this report. In the forward-looking version of the Taylor Rule (Clarida et al., 1998, 2000) the central bank responds to its anticipations of future inflation and the output gap. Consistent with this forward-looking orientation, we explicitly employ the quarterly inflation projections of the BoE that are given in the *Inflation Report* which are based on the information that the Bank had at that time. This differs from previous papers (Martin and Milas, 2013; Castro, 2011 and Baxa et al., 2013), which use future inflation. For robustness we also re-estimate the Taylor Rule using (i) the BoE/TNS near-term survey of inflation expectations and (ii) future inflation as a proxy for expected inflation, using an information set that includes financial conditions.

We also differ from the literature by developing and using a composite measure of the output gap, the Economic Activity Index (EAI). The BoE does not have an explicit measure of the output gap. The MPC in the *Inflation Report* and in their monetary policy statements reviews a variety of different indicators of economic activity which may/may not move together. Consequently, the purpose of the EAI is to encapsulate the array of real variables that the MPC considers. To take account of the changes in financial markets, we estimate a financial conditions index (FCI) that is purged of its relationship to inflation and economic activity and which covers a wide range of financial variables that feature in the *Inflation Report*. Unlike earlier papers, this allows us to consider the impact of shocks in financial conditions on interest rate setting by the BoE.

Our estimation period begins in Q1 1993 with the beginning of inflation targeting and concludes in Q1 2009 which marks the beginning of the effective lower bound for interest rates and the

implementation of a new monetary policy instrument, quantitative easing. We also re-estimate a Taylor (1993)-type rule for the shorter period, Q1 1993 to Q4 2007 to investigate the Great Moderation period in greater detail.

Our results reveal that the BoE works to stabilise inflation and economic activity, as well as responding to financial market conditions. Unlike Martin and Milas (2013), we specifically find that the BoE was concerned not only with price stability and economic activity but also with financial conditions during the Great Moderation. Although the BoE's inflation projections would have embodied their view of the monetary transmission mechanism and how asset prices, spreads, etc would affect future output and inflation, we also find an independent role for financial stability considerations. Also, when we include the financial crisis period into our estimation, we find that the BoE responds less to financial conditions but more to inflation projections. This is not to argue that the BoE did not respond to financial conditions during the crisis. Rather the severity and persistent nature of the financial crisis and its impact particularly on the availability of bank credit to households and business combined with widening credit spreads caused them to revise downwards their projections of GDP and price inflation significantly (see, the November, 2008 *Inflation Report* and February, 2009 *Inflation Report*). Therefore, during this time when financial conditions deteriorated considerably and output contracted severely the BoE continued to target deviations of inflation projections from its target. For example, in the November 2008 and February 2009 *Inflation Reports*, inflation is projected to be lower than the 2% target over the forecast horizon. Dale (2009) notes that in both cases, the judgement of the Committee was that without further substantial easing of policy there was a sizeable risk of large and persistent undershooting of the inflation target. This is also verified in the MPC minutes (see, the *Minutes of the Monetary Policy Committee Meeting, November 5<sup>th</sup>-6<sup>th</sup>, 2008*; *Minutes of the Monetary Policy Committee Meeting, 3<sup>th</sup>-4<sup>th</sup> December 2008*; *Minutes of the Monetary Policy Committee Meeting, 7<sup>th</sup>-8<sup>th</sup> January 2009*). Consequently, our results confirm that the MPC adhered to inflation targeting at least until the beginning of quantitative easing with the inflation target tending to outweigh other objectives within the BoE.

This paper is structured as follows. In Section 2 we outline the motivation for this paper and its contribution to the existing literature. In Section 3 we review the interest rate and inflation projection data that we use and explain the components and construction of the economic activity index and the financial conditions index. In Section 4 we outline the Taylor Rule and provide our results. In Section 5 we estimate the augmented Taylor Rule which includes the financial conditions index and discuss our results. Section 6 concludes.

## 2. Motivation and background

Since the publication of the Taylor (1993) seminal paper on monetary policy rules, researchers have attempted to model interest rate setting behaviour by central banks. The original Taylor Rule describes the interest rate as a policy instrument to stabilise lagged inflation and current economic activity. In keeping with the more forward-looking orientation of central banks, Clarida et al. (1998, 2000) consider a forward-looking version where the central bank responds to expectations of future inflation and the output gap, based on the information available to them:

$$i_t^T = i^* + \gamma_\pi (E_t(\pi_{t+k}) - \pi^*) + \gamma_y E_t(y_{t+s} - y^*)$$

where  $i^*$  is the sum of the natural real interest rate ( $\bar{r}$ ) and the inflation target ( $\pi^*$ ),  $y^*$  denotes the potential level of real economic output and  $i_t$  is the short-term policy rate. The parameter on the

output gap ( $\gamma_y$ ) is expected to be positive. In the case of inflation targets or central banks that would like to keep inflation in check, for example the BoE, the response parameter on inflation ( $\gamma_\pi$ ) of greater than 1.0 would apply. Consequently, the central bank raises the policy rate when the output gap is positive and responds to expected inflation in excess of the target by increasing the real policy rate i.e., the Taylor Principle holds.

During the 1990s economists began to consider whether financial stability should be one of the monetary policy objectives of central banks and included in an augmented Taylor Rule. [Bernanke and Gertler \(1999, 2001\)](#), argue that price stability and financial stability should be viewed as complementary objectives and managed within a unified policy framework, flexible inflation targeting ([Bernanke and Gertler, 1999](#), p. 18). Their argument is that because asset (stocks and property) prices affect aggregate demand, setting interest rates based on the central bank's expectations of future inflation, taking into account the effect of asset prices, will stabilise the economy and financial markets. In their simulations they show that an aggressive response of the central bank to expected inflation only, without including stock prices separately into the central bank's objective function, is sufficient. They do concede that it may be difficult to forecast the effect of asset prices on price inflation. However, they contend that this is more straightforward than identifying bubbles in asset prices and using interest rates to "prick" the bubble without doing damage to the economy and the financial sector. In short, the short-term interest rate is not an appropriate policy instrument to deal with asset price bubbles ([Mishkin, 2008](#)). This view which [Smets \(2014\)](#) labels the Jackson Hole view, points to a separate instrument, macroprudential policy to deal with financial stability concerns (see, [Bernanke and Gertler, 1999](#)).

On the other hand, [Borio and Lown \(2002\)](#) of the Bank for International Settlements argues for a more direct response to financial conditions. Rather than only focusing on asset bubbles per se, which they consider unhelpful, they point to how the combination of events, asset price rises and increasing leverage and credit during periods of low inflation, sow the seeds of future financial instability. In fact, they argue that inflation targeting by anchoring inflation expectations, can stop asset price increases from impacting on price inflation and the absence of a tighter monetary policy can allow asset price bubbles to continue. Financial stability concerns should be part of the secondary monetary policy objectives of central banks ([Smets, 2014](#)). Monetary policy by responding not only to short-term inflation pressures but also, at least occasionally, to financial imbalances such as rapid credit growth and rising asset prices, may ultimately deliver a better combination of monetary and financial stability ([Borio and Lowe, 2002](#), p. 22). The justification for doing so could be that the higher interest rates could help contain the financial excesses, and in so doing reduce the probability of future financial instability and possibly a sustained undershooting of the inflation objective ([Borio and Lowe, 2002](#), p. 22). This implies a longer perspective of central bankers as financial cycles are necessarily longer than business cycles.<sup>1</sup> Financial conditions may capture important information about long term developments in output and inflation, beyond the normal forecast horizon ([Vredin, 2015](#)).

Combining these ideas, financial conditions matter to central banks both as a threat to financial and economic stability and because they provide extra information on future output and inflation ([Chadha et al., 2004](#)). [Vickers \(1999\)](#), chief economist and member of the MPC, argued against the inclusion of asset prices (house prices and stock prices) in the policy objective function in a speech to the *Money, Macro and Finance* group on *Monetary Policy*

and Asset Prices. He instead pointed to the role of asset prices in helping the MPC form its projections for inflation and growth and the key role of asset prices in the monetary transmission mechanism. However, importantly he acknowledged the difficulty of assessing the possible implications for demand and price inflation of asset price developments regarding it as a "highly uncertain matter" ([Vickers, 1999](#), p. 19). Later work by [Batini and Nelson \(2000\)](#), using a small scale model calibrated on UK data, also find that there were no additional welfare benefits by a central bank responding specifically to real exchange rates under the assumption of uncovered interest parity although there was a stronger argument for its inclusion as a separate goal once the parity condition was violated. [Goodhart and Hofmann \(2000\)](#), conclude that asset prices (stock prices and house prices) contain useful information about future demand conditions and argue that in a backward-looking model, these financial conditions need to be targeted. Consequently, this suggests that once financial conditions have been incorporated in forward looking inflation then there would appear to be no reason for including financial conditions separately as in [Vickers \(1999\)](#).

Although, early estimates by [Nelson \(2000\)](#) of a forward looking (linear) Taylor Rule for the UK, using Instrumental Variables (IV) over the period October 1992 to December 1997 finds that the BoE focused on inflation and output only, later studies do find evidence that the BoE responded to financial conditions in an augmented Taylor Rule. [Chadha et al. \(2004\)](#), using Generalised Methods of Moments (GMM), presents evidence, for the period September 1979 to December 2000, that the BoE adjusted the Bank Rate to offset deviations of asset prices and exchange rates from their long-term trends in addition to targeting inflation and the output gap. The explanations that they put forward for these results are that asset prices are a proxy for that part of expected inflation and output not already explained and that the BoE may have targeted major misalignments at specific times, pointing to the sterling appreciation in the late 1990s ([Chadha et al., 2004](#), p. 548). [Montagnoli and Napolitano \(2005\)](#), building on the research of the previous authors combine the deviation of real share prices, real property prices and the real effective exchange rate from its long run equilibrium into a financial conditions index and discover that the BoE responded to this index, over the period May 1985 to May 2005. Using quarterly data, for the period 1999–2005, [Crespo-Cuaresma and Gnan \(2008\)](#) find evidence to support the argument that the BoE adjusts interest rates more rapidly in times of financial stress – where financial stress is proxied by the volatility of the FTSE100. [Barker \(2007\)](#) formally of the MPC, also points to the quicker interest rate response when including financial conditions (as proxied by the equity risk premium) into a simple Taylor Rule during the pre-crisis period. Extending the period to 2007 and estimating a linear Taylor Rule using GMM for the Great Moderation period (prior to the crisis), [Castro \(2011\)](#) discovered that the BoE responded only to the corporate bond spread in addition to inflation (adhering to the Taylor principle) and the output gap.

More recent studies that encompass the financial crisis period suggest somewhat different results. [Boinet and Martin \(2010\)](#), estimate the monetary policy rules implied by a variety of alternative Phillips curves and find that the policy rate does not respond to inflation when the output gap is small, a situation that mostly corresponds to the Great Moderation period. Estimating a linear Taylor Rule using GMM for the Great Moderation period (prior to the crisis), [Martin and Milas \(2013\)](#) conclude that the BoE responded to both inflation (adhering to the Taylor principle) and the output gap only but not to financial conditions. However, after the financial crisis, [Martin and Milas \(2013\)](#) argue that there was a complete change in BoE behaviour. Extending the sample period to include the financial crisis period, they find support for a shift in monetary policy with financial stress, as measured by the IMF and the Federal Reserve Bank of Kansas, becoming the dominant influence on mon-

<sup>1</sup> This approach, known as the Leaning Against the Wind (LAW) approach has been heavily criticised by [Svensson \(2019\)](#).

**Table 1**  
Description Statistics of Actual and Projected Inflation (1–6 quarters ahead).

Panel A: Description Statistics - Full Sample Period, Q1 1993 - Q1 2009												
	1q ahead		2q ahead		3q ahead		4q ahead		5q ahead		6q ahead	
	Actual Future	Projected Inflation	Actual Future	Projected Inflation	Actual Future	Projected Inflation	Actual Future	Projected Inflation	Actual Future	Projected Inflation	Actual Future	Projected Inflation
Mean	1.91	2.46	1.89	2.42	1.88	2.38	1.89	2.37	1.91	2.36	1.93	2.37
Median	1.78	2.43	1.78	2.29	1.78	2.27	1.78	2.33	1.78	2.34	1.78	2.37
Maximum	4.69	4.76	4.69	4.79	4.69	4.13	4.69	3.73	4.69	3.63	4.69	3.63
Minimum	0.60	1.12	0.60	0.77	0.60	0.68	0.60	1.38	0.60	0.96	0.60	0.64
Std. Dev.	0.76	0.63	0.76	0.63	0.75	0.61	0.76	0.55	0.79	0.55	0.80	0.55

Panel B: Description Statistics - The Great Moderation, Q1 1993 - Q4 2007												
	1q ahead		2q ahead		3q ahead		4q ahead		5q ahead		6q ahead	
	Actual Future	Projected Inflation	Actual Future	Projected Inflation	Actual Future	Projected Inflation	Actual Future	Projected Inflation	Actual Future	Projected Inflation	Actual Future	Projected Inflation
Mean	1.78	2.38	1.80	2.37	1.83	2.37	1.85	2.37	1.86	2.39	1.86	2.42
Median	1.73	2.37	1.73	2.28	1.73	2.27	1.73	2.33	1.73	2.36	1.73	2.38
Maximum	2.86	3.54	3.34	3.44	4.69	3.44	4.69	3.73	4.69	3.63	4.69	3.63
Minimum	0.60	1.12	0.60	1.27	0.60	1.37	0.60	1.52	0.60	1.52	0.60	1.62
Std. Dev.	0.60	0.50	0.63	0.50	0.72	0.51	0.76	0.53	0.77	0.52	0.77	0.49

Panel C: Correlation between BoE/TNS Survey Inflation Next 12 m and the BoE's Inflation Projection, Q4 1999 - Q1 2009												
	Correl. 1 yr vs 1q=0.675		Correl. 1 yr vs 2q=0.724		Correl. 1 yr vs 3q=0.673		Correl. 1 yr vs 4q=0.550		Correl. 1 yr vs 5q=0.380		Correl. 1 yr vs 6q=0.172	
	Survey Next 1 yr	Projection Next 1q	Survey Next 1 yr	Projection Next 2q	Survey Next 1 yr	Projection Next 3q	Survey Next 1 yr	Projection Next 4q	Survey Next 1 yr	Projection Next 5q	Survey Next 1 yr	Projection Next 6q
Mean	2.43	2.28	2.43	2.22	2.43	2.14	2.43	2.09	2.43	2.06	2.43	2.06
Median	2.27	2.15	2.27	2.14	2.27	2.06	2.27	2.02	2.27	2.07	2.27	2.11
Maximum	4.31	4.76	4.31	4.79	4.31	4.13	4.31	3.08	4.31	2.77	4.31	2.61
Minimum	1.49	1.12	1.49	0.77	1.49	0.68	1.49	1.38	1.49	0.96	1.49	0.64
Std. Dev.	0.54	0.71	0.54	0.69	0.54	0.59	0.54	0.39	0.54	0.40	0.54	0.41

Panels A–B show description statistics of actual future inflation rates versus the BoE's inflation projection for the full sample period and great moderation respectively. Panel C presents description statistics of BoE/TNS Survey Inflation Next 12 m along with the BoE's inflation projection. Since data on BoE/TNS Survey Inflation Next 12 m is only available from Q4 1999, we restrict the sample period in Panel C for the period from Q4 1999 to Q1 2009.

etary policy. From this they question whether the UK abandoned inflation targeting during the financial crisis and the subsequent recession. [Baxa et al. \(2013\)](#) supports this view, finding that the BoE responded quite aggressively to financial conditions and economic activity only during the crisis.

The motivation behind this paper is to reassess the BoE's adherence to inflation targeting and its responsiveness to financial market conditions during the Great Moderation and the onset of the GFC. Previous research has generally used a combination of the RPIX (Retail Price Index excluding mortgage repayments) measure of the inflation rate from 1992 to 2003 and CPI inflation from 2004 onwards ([Castro, 2011](#); [Martin and Milas, 2013](#)) and measures of the output gap as the gap between Industrial Production and its Hodrick and Prescott trend ([Castro, 2011](#); [Martin and Milas, 2013](#)). What makes our study different from earlier papers is our use of the BoE's own inflation projections combined with two new indices, an Economic Activity Index (EAI) and both an unpurged and a purged

Financial Conditions Index (FCI) that cover a broader range of economic activity and financial indicators relative to other studies and that feature in the BoE's own *Inflation Report*. We also compare our results with alternative measures of inflation expectations. Firstly, we use the one year ahead inflation expectations from the BoE/TNS Survey data and secondly, we assume that the BoE forms their expectations of future inflation based on an information set that includes financial conditions. In the next section we discuss in detail the data that we use and the construction of our indices.

### 3. Data and index construction

In this section we outline the data that we use and the construction of our indices of economic activity and financial conditions.

The data set is quarterly as this is the frequency at which the BoE updates their inflation forecasts.

#### 3.1. Bank of England data

As monetary policy takes time to affect economic activity and inflation, what matters is not the current or past inflation rate but the outlook for inflation in 18 months to 2 years. To account for expected inflation, much of the existing literature (e.g., [Orphanides, 2001, 2003](#); [Clarida et al., 1998, 2000](#); [Castro, 2011](#)) uses a 'substitution method' by substituting actual values for unobserved ones, for example,  $E_t(\pi_{t+k}) = \pi_{t+k}$  where the  $k$  subscripts denotes the number of periods ahead. When there is an unexpected disturbance, the actual inflation rate that emerges will not reflect the prior expectation that was used in the interest rate decision. In order to account for this, we use the BoE's inflation projections which are given in the *Inflation Report* and which are used by the MPC to make its interest rate decisions. The inflation projection data is updated quarterly and presents the BoE's best judgement of future inflation. For the initial period February 1993 to November 1997 we use the BoE's inflation projections under the condition that the current policy rate is maintained over the forecast horizon as this is the only projection that they provide. Subsequent to this we use their inflation projections assuming that official interest rates follow market expectations over the next two years because this is now included and features more prominently in the *Inflation Reports*. The *Inflation Reports* are published quarterly in the middle of the months of February, May, August and November ([Schultefrankenfeld, 2010](#)).

We use the median inflation projection of the BoE as this is consistent with the central projection in the *Inflation Report*. [Fig. 1](#) and [Table 1](#) (Panels, A, B and C) show the difference between the BoE's



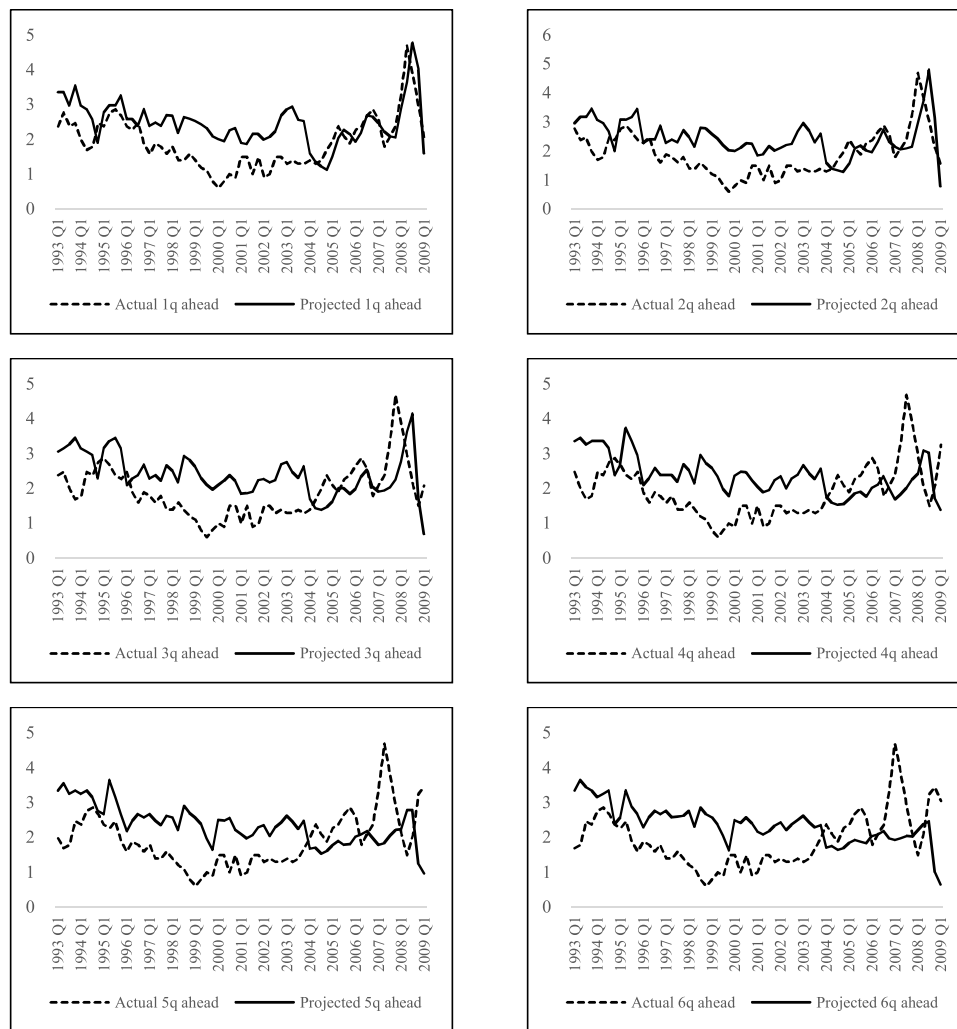


Fig. 1. Actual versus Projected Inflation Rates (1–6 quarters ahead).

median inflation projection up to 6 quarters ahead and the actual rate of inflation at that time.<sup>2</sup> The measures of inflation projections that we use match the inflation target measures of inflation. Initially, the inflation target in the UK was specified as a range for the RPIX of 1%–4% a year. In June 1995 a point target of 2.5% was introduced and in November 2003 the price index was redefined as the CPI (Consumer Price Index) and the target re-specified to 2%. Consequently, we use the projections for RPIX inflation up to Q3 2003 and CPI for the remainder of the period.

For all horizons over the entire period, the BoE on average forecasts a higher rate of inflation than the actual outcome (see, Panel A and B of Table 1). However, from Q4 2003 in the period before and during the Financial Crisis, the BoE under predicts the actual inflation rate (see, Fig. 1). It is also interesting to see that as compared to inflation projections over 1–4 quarters there exist some larger gaps between the official target and the BoE's projection over 5–6 quarters (see, Fig. 1), particularly at the end of our sample period.

Although the Monetary Policy Committee believes that it is appropriate to frame its policy guidance in terms of its own assessment of the inflation output, it also recognises the impor-

tance of external measures of inflation expectations (see, [Monetary Policy Trade-offs and Forward Guidance August, 2013](#)) to assess its judgement of the outlook for inflation. Hence, we source the BoE/TNS Survey of Inflation expectations for next 12 months from Bloomberg<sup>3</sup> and test its correlation with the BoE's central projection of inflation. As shown in Panel C of Table 1, the BoE's projections over 1–4 quarters are closely correlated with the BoE/TNS Survey, another short-term measure of inflation expectation. This result supports our choice of the BoE's inflation projection data, because not only does it represent the MPC's outlook for inflation but is also consistent with the trend of external inflation expectations.

The monetary policy instrument that is relevant over the period under review is the short-term interest rate. Decisions on interest rates are made at monthly meetings. To reduce the effect of endogeneity and allow for changes in interest rates during the quarter, we use the average quarterly interest rate. However, it is interesting and noteworthy that our preliminary analysis has tested the (augmented) Taylor Rule using the end-quarter rate of interest and discovers that parameter estimates of the Taylor Rule are not subject to the choice between quarterly-average and end-quarter

<sup>2</sup> The BoE gives inflation projections for 1–6 quarters ahead from Q1 1993 to Q2 1997. This was further extended to eight quarters ahead. However, as we are working with the entire time period, we use median inflation projections up to six quarters ahead.

<sup>3</sup> Data on the BoE/TNS Survey of Inflation Expectations is only available from Q4 1999. Consequently, we calculate the correlation coefficient between the BoE/TNS survey and the BoE's projected inflation for the period running from Q4 1999 to Q1 2009.

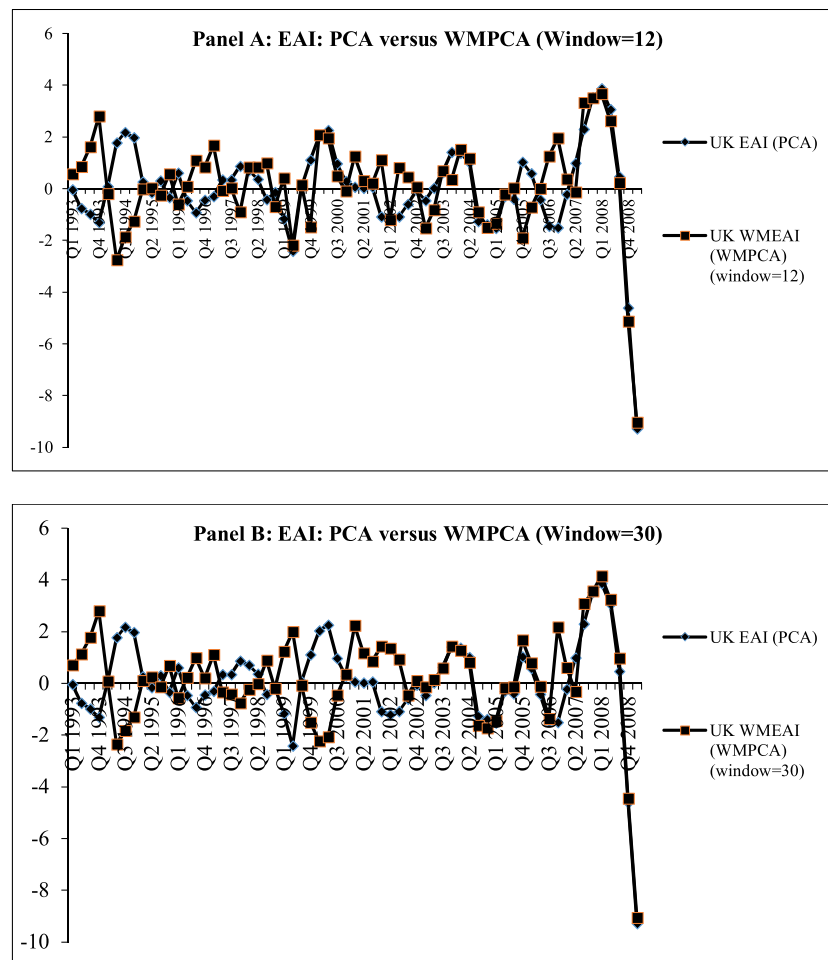


Fig. 2. UK Economic Activity Indices.

interest rates. Our results are available on request. As noted by Nelson (2000), actual interest rate instruments used by the BoE have changed over time.<sup>4</sup> Thus, we follow the existing literature (Nelson, 2000; Martin and Milas, 2004; Castro, 2011) we use the three-month T-bill as this rate follows the path of the various monetary policy instruments used by the BoE.

### 3.2. Development of new indices

According to the *Monetary Policy Trade-offs and Forward Guidance*, no single indicator provides an adequate description of real economic activity in the UK. Drawing on the output and supply data that is included in the *Inflation Report*, we construct a new index of economic activity – the Economic Activity Index – that combines six output measures into a summary index. The first three that we include – the output gap, real GDP growth and the unemployment rate, feature in the discussion by the BoE of potential indicators of economic activity for forward guidance (see, *Monetary Policy Trade-offs and Forward Guidance*, p. 26–32). The output gap, the difference between real GDP and its potential level, is used as a measure of slack in the economy. However, the large degree of uncertainty surrounding the evolution of the supply capacity of the economy raises questions about its precision. Orphanides and Williams (2002) argue that when the output gap is uncertain it may

be better to relate monetary policy to real GDP growth rather than the level because there is less uncertainty about the changes in the output gap than its starting level. An indicator of labour market slack is the gap between the unemployment rate and the medium-term equilibrium rate. However, as the latter is unlikely to change sharply, changes in the unemployment rate will capture changes in labour market slack over short horizons. The unemployment rate is also considered as a useful overall measure of slack in the economy.

The remaining three indicators include (i) unit labour costs, as the gap between unit labour costs and its steady state is used as a proxy for the output gap (Gali and Gertler, 1999), (ii) labour productivity growth can also help to gauge movements in spare capacity in business (see, the *November, 2006 Inflation Report*) and (iii) the industrial production index as an alternative measure of economic activity. Appendix A summarises the data to be included.

We form a PCA of the six output indicators. To ensure our estimates of EAI are interpretable, we use the de-trended economic activity indicators in the PCA. We use the usual HP filter (Hodrick and Prescott, 1997) to de-trend real GDP, real GDP growth, real labour productivity, real unit labour costs and the industrial production index. To approximate the medium-term equilibrium unemployment rate, we use the threshold value of 7% as given in the *Monetary Policy Trade-offs and Forward Guidance* statement. This also approximates the mean unemployment rate over the sample period. From this we can calculate the gap between the unemployment rate and the threshold value. Including all the variables, the resulting EAI can be interpreted as the deviation of real economic activity from its long-term trend.

<sup>4</sup> Between January 1993 and April 1997, the Minimum Band 1 dealing rate is used. This switches to the Repo rate between May 1997 and July 2006. This is replaced by the Official Bank Rate as the policy rate between March 2006 and March 2009.

Fig. 2 plots the three indices: an Economic Activity Index (EAI) which extracts the first principal component of the six economic activity indicators using standard PCA and two window moving economic activity indices (WMEAI) which refer to the first principal component using the window moving PCA (WMPCA).<sup>5</sup> As explained by Wacker et al. (2014), the first principal component explains the maximum variation in all the observed indicators. Hatzius et al. (2010) consider extracting one to three principal components and discover that the one-PC version performs at least as well as the other two versions. Generally, the three indices follow a similar pattern, all increasing during the pre-crisis period of 2007 and falling sharply in the great recession of 2008–9 and in the Russian debt default of late 1998. However, the EAI lags the WMEAI in some periods such as 1993 and 2005–6. This is not surprising since the two algorithms use different window sizes and the differences are not substantial. The use of WMPCA allows us to investigate whether our parameter estimates of the Taylor Rule in Section 4 are subject to different economic activity proxies used in the estimation.

To capture changes in financial conditions we develop a financial conditions index. There is no universally-agreed measure of financial conditions. For example, the FCI<sup>6</sup> estimated by Castro (2011) implies that UK financial markets underperformed the long-term trend during the period 2005–6, but the financial conditions proxy used in Martin and Milas (2013)<sup>7</sup> suggests that the markets were above the trend in the same period. Therefore, it may be the case that some FCIs can result in different conclusions.

Given the number and variety of indicators, financial conditions are usually synthesised into one indicator. We include exchange rates, equity prices, house prices and commodity prices as four important proxies of financial market conditions (Goodhart and Hofmann, 2001; Chadha et al., 2004; Castro, 2011) and which also feature in the *Transmission Mechanism of Monetary Policy* (May, 1999) of the Bank of England. Furthermore, we incorporate indicators to account for safe spreads (TED spread), private sector spreads (credit and futures spreads), lending markets (quarterly changes in mortgages and mortgage rates) and equity market risks (FSTE volatility). As explained by Wacker et al. (2014), the rationale for incorporating risk measures is because spreads measure the relative prices at which finance is available to certain market participants. The inclusion of lending variables is in line with Hatzius et al. (2010) and Koop and Korobilis (2014) to reflect the ease of accessing finance.

Overall, we employ eleven variables covering a wider range of constituent financial indicators than most UK FCIs including Goodhart and Hofmann (2001); Guichard et al. (2009) and

<sup>5</sup> It updates at each time point while restricting observations used in the estimation to those which fall within a specified window of time. We assume that the BoE only considers the most recent 12 periods (i.e., 3 years) when estimating the UK EAI (WMPCA) and thus choose the window size as 12 in the estimation. For robustness purposes, we also test whether our estimates of the (augmented) Taylor rule are subject to the choice of the window size of 12 by extending the window size to 30 periods.

<sup>6</sup> The Castro (2011) FCI consist of four variables, the real interest rate, the stock price index, the housing price index and the effective exchange rate index. He includes two additional indicators, the credit spread and the future spread, to estimate an extended FCI.

<sup>7</sup> Two indices are considered in Martin and Milas (2013), the Federal Reserve Bank of Kansas City Financial Stress Index in the US and the IMF index of financial stress in the UK. The former is a composite index of the 3-month LIBOR/T-bill spread, the 2-year swap spread, the Aaa/10yr Treasury spread, the Baa/Aaa spread, the off-the-run/on-the-run 10yr Treasury spread, the high-yield bond/Baa spread, the consumer asset-backed securities/5yr Treasury spread, the correlation between returns on stock and Treasury bonds, the implied volatility of overall stock prices, the idiosyncratic volatility of bank stock prices and the cross-section dispersion of bank stock returns. The latter is a composite of the TED, term and corporate debt spreads, returns and volatility in equity markets and exchange rate volatility.

Castro (2011). Appendix B summarises these variables under six categories.<sup>8</sup>

Recently, FCI studies (e.g., Hatzius et al., 2010; Koop and Korobilis, 2014; Zhu et al., 2020) remove the endogenous response of financial variables to current macroeconomic conditions. As explained by Hatzius et al. (2010), if the only information contained in a financial variable about the future economy were of this endogenous variety, there is no reason to create an FCI as all information about future economic activity would be contained in current and lagged output. Both of these studies construct FCIs with the purpose of predicting future economic conditions rather than understanding movements in financial markets. There is still a continuous debate on whether an FCI summarising the current state of financial markets should be purged of its relationship to inflation and economic activity. To account for this, we use two different information sets,  $x_t$  and  $v_t$  to estimate two FCI's using PCA:

$$x_t = A \times z_t + v_t \quad (1)$$

where  $x_t$  is a  $11 \times 1$  vector of de-trended financial variables,  $z_t = (\pi_t, \bar{y}_t^g)'$  where  $\pi_t$  is the inflation rate and  $\bar{y}_t^g$  denotes the de-measured real GDP growth and  $v_t$  is a  $11 \times 1$  vector of financial conditions proxies uncorrelated with the current macroeconomic performance  $z_t$ . As before the HP filter is used to detrend the data.

The un-purged FCI (first principal component of  $x_t$ ) and the purged FCI (first principal component of  $v_t$ ), are plotted in Fig. 3 with a rise in the index suggesting improvement in financial conditions and a decline indicating deterioration. It is anticipated that for the purpose of stabilising inflation and financial conditions the central bank will raise its policy rate in response to an increase in the FCI and *vice versa*. Generally, the two indices (purged and un-purged FCIs) follow a similar trend with declines in 1994 (due to political uncertainty arising from the sterling's exit from the exchange rate mechanism), 2001–2 (the US corporate accounting irregularities), 2003 (the Iraq war) and 2008–9 (the GFC), and with improvements in 2004 (recovery from the impacts of the Enron scandal and the end of the Iraq war) and the pre-crisis financial boom in 2007. However, there are significant differences between the two at some peaks and troughs.

A robustness check is to test the sensitivity of the BoE's response to the information in financial markets when different estimates of FCIs are used. We source three alternative measures, the ECB's UK Financial Stress Index,<sup>9</sup> the Federal Reserve Bank of Kansas City Financial Stress Index and the Federal Reserve Bank of Chicago National Financial Conditions Index (see, Fig. 4), and investigate the response of monetary policy to financial conditions and stress when an 'external' estimate is used. Contrary to our estimated FCIs that concentrate on the state of UK financial markets, the three indices provide a measure of stress in the financial sector and thus have opposite signs. The ECB's UK FSI is UK-specific while both the Kansas City FSI and the Chicago FCI are for the US markets. The correlation coefficient between the ECB's measure of UK financial stress and the Fed's US financial stress is quite significant.<sup>10</sup> This suggests that the two financial markets are highly correlated in the era of economic globalisation. They increase sharply in the 2008–9 crisis and also rise during the Russian debt default of late 1998 and

<sup>8</sup> As reported in Appendix B, some financial variables have missing values in that they do not begin until 1995 or even later. We follow Koop and Korobilis (2014) by replacing missing values of the financial variables with zeros.

<sup>9</sup> The ECB's UK Financial Stress Index is only available on a monthly basis. To use it in our sensitivity analysis, we take the quarterly average of the original data.

<sup>10</sup> The correlation coefficient between the ECB's UK FSI and the Fed Bank of Kansas City's FSI is around 0.78. The correlation coefficient between the ECB's UK FSI and the Fed Bank of Chicago FCI is about 0.83.

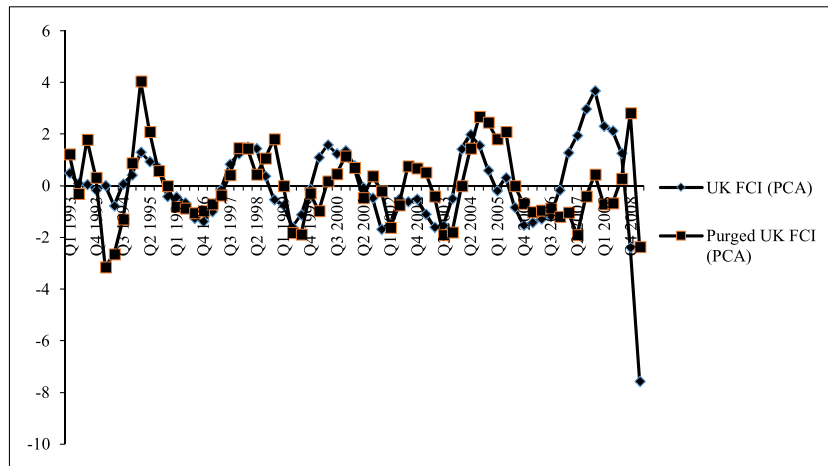


Fig. 3. UK Financial Conditions Indices.

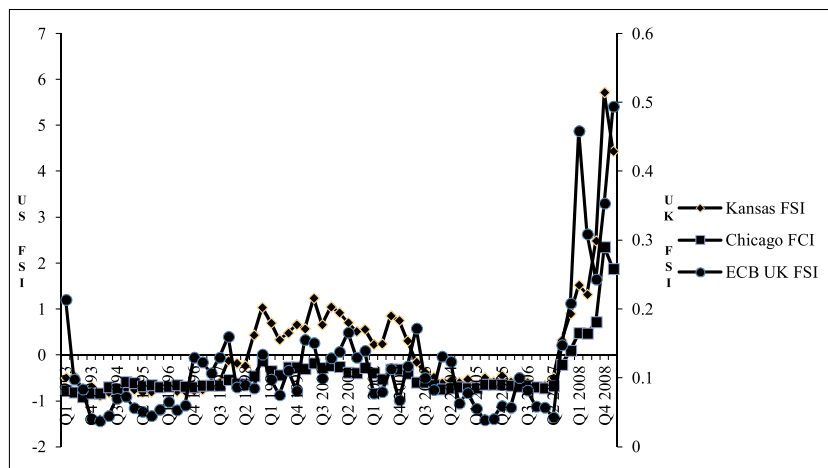


Fig. 4. Financial Stress Indices.

the dot-com crash of 2000 indicating that financial conditions are depressed during these periods.

**4. The Taylor rule during the great moderation and the financial crisis**

In this section we present estimates of Taylor (1993)-type rules using quarterly data for the period Q1 1993 to Q1 2009. We begin with outlining the model to be estimated.

As demonstrated by Clarida et al. (1998, 2000), the central bank has a target rate of interest ( $i_t^*$ ) which is a function of expected inflation and the output gap (see, Section 2). However, central banks do not adjust the policy interest rate to its target in every period but instead they tend to smooth changes in interest rates. Following the literature, we use a partial adjustment process to capture these interest rate dynamics:

$$i_t = \left( 1 - \sum_{j=1}^n \rho_j \right) \left[ i^* + \gamma\pi \left( E_t(\pi_{t+k}) - \pi^* \right) + \gamma y E_t(y_{t+s} - y^*) \right] + \sum_{j=1}^n \rho_j i_{t-j} \quad (2)$$

where  $i^*$  is the sum of the natural real interest rate ( $\bar{r}$ ) and the inflation target ( $\pi^*$ ),  $y^*$  denotes the potential level of real economic output and  $i_t$  is the short-term policy rate. It is usually assumed in

the literature that  $\bar{r}$  equals the average of real interest rates over a long sample period. Following the approach of Castro (2011), we use the Durbin Watson (DW, 1951) test to determine the number

of lagged interest rates in the partial adjustment process,  $\sum_{j=1}^n \rho_j i_{t-j}$ .

Thus, the sum of the coefficients on lagged interest rates,  $\sum_{j=1}^n \rho_j$ ,

gauges the degree of monetary policy smoothing.

Defining  $\gamma_0 = i^* - \gamma\pi\pi^*$  and  $\bar{y}_{t+s} = y_{t+s} - y^*$  yields:

$$i_t = \left( 1 - \sum_{j=1}^n \rho_j \right) \left[ \gamma_0 + \gamma\pi E_t(\pi_{t+k}) + \gamma y E_t(\bar{y}_{t+s}) \right] + \sum_{j=1}^n \rho_j i_{t-j} + \mu_t \quad (3)$$

where  $\mu_t$  is an IID stochastic error.

Eliminating unobserved forecasted variables from this equation, Eq. [3] can be re-written in terms of realised variables:

$$i_t = \left( 1 - \sum_{j=1}^n \rho_j \right) \left[ \gamma_0 + \gamma\pi\pi_{t+k}^F + \gamma y \bar{y}_{t+s} \right] + \sum_{j=1}^n \rho_j i_{t-j} + \varsigma_t \quad (4)$$



**Table 2**  
Estimating the Standard Taylor Rule.

	$\gamma_\pi$	Std. Error	$\gamma_y$	Std. Error	$\gamma_{FM}$	Std. Error	$\pi^*$ , %	rho	J-stat.	adj. R2	DW	
R1	***1.78	(0.746)	**0.80	(0.352)	—	—	2.24	0.922	14.141	[0.980]	0.883	0.873
R2	***1.34	(0.297)	***0.25	(0.071)	—	—	2.57	0.875	13.676	[0.977]	0.922	1.934
R3	***0.90	(0.304)	***1.13	(0.298)	—	—	2.32	0.913	12.451	[0.988]	0.934	2.023

R1–3 show the GMM estimates of the standard Taylor rule, where the instrument set has a constant and 1–6 lags of the de-trended unemployment rate, Yield10 yr, ERI, US3 m and inflation rates. The sample period used in R1–3 is q1 1993 - q1 2009.

$$i_t = \left( 1 - \sum_{j=1}^n \rho_j \right) \left[ i^* + \gamma_\pi (E_t(\pi_{t+k}) - \pi^*) + \gamma_y E_t(y_{t+s} - y^*) \right] + \sum_{j=1}^n \rho_j i_{t-j}$$

We use the BoE's central projection of inflation (5-quarters ahead) as inflation expectations ( $E_t(\pi_{t+k})$ ) and also use the 2-quarters ahead Economic Activity Index in R1 (i.e.,  $k = 5$  and  $s = 2$ ). Only one lagged interest rate is included in R1 (i.e.,  $j = 1$ ) to test the BoE's monetary policy smoothing. In R2, we repeat our analysis of R1 but use two lags of interest rates (i.e.,  $j = 2$ ). R3 repeats the analysis in R2 but applies to a shorter sample period (i.e., the Great Moderation period only, q1 1993 - q4 2007). The lead length of inflation projections and future economic activity is determined by the SIC (see, Appendix C). The significant level at which the null hypothesis is rejected: \*\*\*1%, \*\*5%, \*10%.

where  $\pi_{t+k}^F$  is the MPC's projected inflation rate. The error term  $\zeta_t$  is expressed as a linear combination of the forecast errors of output and the disturbance  $\mu_t$ .

In practice, we consider the reduced form of Eq. [4]:

$$\dot{i}_t = \varphi_0 + \varphi_\pi \pi_{t+k}^F + \varphi_y \bar{y}_{t+s} + \sum_{j=1}^n \rho_j \dot{i}_{t-j} + \zeta_t \tag{5}$$

The monetary policy rule Eq. [5] is estimated using the Generalised Method of Moments (GMM) estimator because some of the variables are not available to central bankers when they make their interest rate decisions. Let  $w_t$  be a vector of instruments at the time the central bank chooses the real rate of interest and that are orthogonal to  $\zeta_t$ . The following orthogonality condition is imposed:

$$E \left\{ i - \left[ \varphi_0 + \varphi_\pi \pi_{t+k}^f + \varphi_y \bar{y}_{t+s} \right] - \sum_{j=1}^n \rho_j \dot{i}_{t-j} \mid w_t \right\} = 0 \tag{6}$$

Our collections of instruments contain 1–6 lags of the de-trended unemployment rate, the 10-year government benchmark bond yield, the US three-month T-bill rate, the Sterling effective exchange rate index and inflation rates that help to predict the movement of future real interest rates, the output gap and inflation. We use an optimal weighting matrix which accounts for various forms of heteroskedasticity and autocorrelation in  $\mu_t$  in the estimation. The weighting matrix is estimated with the Bartlett kernel method of Newey and West (1987). We set the initial parameters using two-stage least squares and then calculate the weighting matrix with the last updated parameter estimates. Since the dimension of the vector  $w_t$  exceeds the number of parameters being estimated, the model is over-identified, in which case it is straightforward to implement the Hansen (1982) over-identification test (using the J-statistic). Under the null, our over-identifying restrictions are valid (see, Clarida et al., 1998, 2000).

Due to the uncertainty around the length of time it takes for changes in the official rate to affect the economy, we use the Schwarz Information Criterion (SIC) to determine the horizons of inflation and economic activity forecasts. The results are presented in Appendix C. It shows that when the BoE's projected inflation ( $\pi_{t+k}^F$ ) is employed to proxy for inflation expectations and the EAI is used to measure movements in the output gap, the SIC value is minimised at  $s = 2$  and  $k = 5$  (see, Panel A). This means that the MPC attempts to achieve its pre-determined objective of providing supports to real activity in the short-term provided that such action remains consistent with inflation being targeted in the medium term.

Given the estimates of the parameters obtained from Eq. [5] above, we can recover the implied estimates of the parameters

and the standard errors using the delta method. The results are presented in Table 2.

For the full sample period, Q1 1993 – Q1 2009, the Monetary Policy Committee (MPC) tends to raise the real interest rate by 0.34% for a one-percentage point increase in inflation expectations (i.e., the Taylor Principle holds) and the nominal policy rate by 0.25% for a one-percentage point rise in economic activity and vice versa (see, R2).<sup>11</sup> When restricting our sample to the Great Moderation in R3, we obtain a much smaller point estimate of  $\gamma_\pi$  ( $\gamma_\pi = 0.9$  in R3 versus  $\gamma_\pi = 1.34$  in R2)<sup>12</sup> which means the BoE's response to inflation rates was considerably less during the Great Moderation whereas their reaction to deviations in the output gap was stronger ( $\gamma_y = 1.13$  in R3 versus  $\gamma_y = 0.25$  in R2). The medium-term inflation target is estimated to be 2.32%<sup>13</sup> for the pre-crisis period. This also confirms that the BoE maintained its target inflation rate close to 2%. On the other hand, the medium-term inflation target rises to around 2.57% when we include the period of the GFC and the subsequent recession (see, R2). Our results suggest that the Monetary Policy Committee of the BoE accepted a rise in the inflation target to accommodate specific shocks to the inflation rate or exogenous changes in inflation while reacting more aggressively to expectations of price inflation during the GFC and subsequent recession.

Interestingly the parameter, rho ( $= \sum_{j=1}^n \rho_j$ ), that denotes the

degree of monetary policy smoothing, is relatively lower in R2 as compared to that in R3. In other words, there is less inertia in monetary policy once we introduce the 2008–9 financial crisis. Hence, we provide further evidence to support Crespo-Cuaresma and Gnan (2008) who suggest that the BoE responds much faster when financial market risks are sizeable.

<sup>11</sup> Similar to the Castro (2011) findings, our DW test shows that two lagged interest rates are sufficient to account for the smoothing behaviour of the BoE (see, R1–2).

<sup>12</sup> Although a t-test shows that the parameter of 1.34 is only statistically significantly different from 0.9 at 20% significance (i.e., insignificant at the 10% level), we would continue to compare changes in the response parameter  $\gamma_\pi$  later in Table 5 vs. 6 and also in Table 8 in order to judge whether the claim of the response to inflation being less during the Great Moderation is purely random or a robust finding. The reader is referred to Section 5 for further evidence.

<sup>13</sup> The implicit medium-term inflation target pursued by the central bank is esti-

$$\text{mated as } \pi^* = \frac{\varphi_0 - \bar{r} \left( 1 - \sum_{j=1}^n \rho_j \right)}{\left( 1 - \sum_{j=1}^n \rho_j \right) - \varphi_\pi}$$

**Table 3**  
Estimating the Standard Taylor Rule Using Alternative Output Gap Measures.

	$\gamma_\pi$	Std. Error	$\gamma_y$	Std. Error	$\gamma_{FM}$	Std. Error	$\pi^*$ , %	rho	J-stat.		adj. R2	DW
R4	***1.36	(0.264)	**0.17	(0.064)	—	—	2.65	0.876	13.334	[0.981]	0.918	2.017
R5	***1.10	(0.275)	***0.26	(0.062)	—	—	3.15	0.895	12.330	[0.989]	0.924	1.978
R6	***1.24	(0.308)	**0.20	(0.083)	—	—	2.62	0.882	13.509	[0.979]	0.922	1.975
R7	***1.86	(0.247)	***0.41	(0.075)	—	—	2.62	0.841	13.317	[0.981]	0.916	2.053

R4–7 show the GMM estimates of the standard Taylor rule, where the instrument set has a constant and 1–6 lags of the de-trended unemployment rate, Yield10 yr, ERI, US3 m and inflation rates. The sample period used in this table is q1 1993 - q1 2009.

$$\hat{i}_t = \left( 1 - \sum_{j=1}^n \rho_j \right) \left[ \hat{i}^* + \gamma_\pi \left( E_t(\pi_{t+k}) - \pi^* \right) + \gamma_y E_t \left( y_{t+s} - y^* \right) \right] + \sum_{j=1}^n \rho_j \hat{i}_{t-j}$$

In this table, we employ the BoE's central projection of inflation (5-quarters ahead) as inflation expectations ( $E_t(\pi_{t+k})$ ) but estimate the standard Taylor rule with different future output gaps. 2-quarters ahead WMEAI (window = 12) is employed to proxy for expected economic activity in R4, 4-quarters ahead WMEAI (window = 30) in R5, the 2-quarters ahead demeaned real GDP growth rate in R6 and the 2-quarter ahead OBR output gap in R7. The lead length of inflation projections and future economic activity is determined by the SIC. The significant level at which the null hypothesis is rejected: \*\*\*1%, \*\*5%, \*10%.

**Table 4**  
Estimating the Standard Taylor Rule Using Alternative Inflation Expectations.

	$\gamma_\pi$	Std. Error	$\gamma_y$	Std. Error	$\gamma_{FM}$	Std. Error	rho	J-stat.		adj. R2	DW	Sample Period
R8	***0.68	(0.195)	**0.10	(0.040)	—	—	0.872	9.172	[0.999]	0.908	1.930	q4 1999 - q1 2009
R9	***1.06	(0.114)	***0.16	(0.012)	—	—	0.891	8.169	[0.999]	0.913	2.327	q4 1999 - q4 2007
R10	0.20	(0.305)	***1.10	(0.298)	—	—	0.930	12.970	[0.984]	0.934	1.991	q1 1993 - q1 2009
R11	0.32	(0.286)	***1.43	(0.477)	—	—	0.931	12.659	[0.987]	0.917	2.114	q1 1993 - q4 2007

R8–11 show the GMM estimates of the standard Taylor rule using alternative measures of inflation expectations, the BoE/TNS inflation survey in R8–9 and the actual future inflation rate in R10–11. Since the BoE/TNS survey only started from q4 1999, we have a shorter sample period for R8–9. The instrument set used in R8–11 has a constant and 1–6 lags of the de-trended unemployment rate, Yield10 yr, ERI, US3 m and inflation rates.

$$\hat{i}_t = \left( 1 - \sum_{j=1}^n \rho_j \right) \left[ \hat{i}^* + \gamma_\pi \left( E_t(\pi_{t+k}) - \pi^* \right) + \gamma_y E_t \left( y_{t+s} - y^* \right) \right] + \sum_{j=1}^n \rho_j \hat{i}_{t-j}$$

where 6-quarter ahead actual future inflation is used in R10 and 3-quarter ahead actual future inflation is employed in R11. In relation to the lead length of the EAI, we set  $s = 2$  in R8,  $s = 3$  in R9,  $s = 2$  in R10 and  $s = 3$  in R11. As mentioned earlier, the lead length of inflation and the output gap is decided by the SIC. The significant level at which the null hypothesis is rejected: \*\*\*1%, \*\*5%, \*10%.

**Table 5**  
Estimating the Augmented Taylor Rule for the Entire Sample Period (Q1 1993 - Q1 2009).

	$\gamma_\pi$	Std. Error	$\gamma_y$	Std. Error	$\gamma_{FM}$	Std. Error	$\pi^*$ , %	rho	J-stat.		adj. R2	DW
R12	***1.40	(0.227)	**0.14	(0.055)	***0.39	(0.096)	2.66	0.874	14.176	[0.996]	0.927	1.814
R13	***1.08	(0.247)	***0.30	(0.088)	***0.84	(0.174)	3.61	0.909	13.297	[0.998]	0.935	1.916
R14	***1.28	(0.262)	**0.15	(0.070)	**−5.07	(1.909)	N/A	0.890	14.120	[0.996]	0.922	1.954
R15	***1.11	(0.284)	**0.22	(0.093)	***−0.99	(0.187)	N/A	0.898	14.353	[0.995]	0.929	1.782
R16	***1.11	(0.263)	*0.16	(0.086)	***−1.58	(0.489)	N/A	0.890	14.360	[0.995]	0.926	1.835

R12–16 show the GMM estimates of the augmented Taylor rule for the entire sample period of q1 1993 - q1 2009, where the instrument set has a constant and 1–6 lags of the de-trended unemployment rate, Yield10 yr, ERI, US3 m, inflation rates and respective proxies of financial conditions:

$$\hat{i}_t = \left( 1 - \sum_{j=1}^n \rho_j \right) \left[ \hat{i}^* + \gamma_\pi \left( E_t(\pi_{t+k}) - \pi^* \right) + \gamma_y E_t \left( y_{t+s} - y^* \right) + \gamma_{FM} FM_{t+h} \right] + \sum_{j=1}^n \rho_j \hat{i}_{t-j}$$

In this table, we employ the BoE's central projection of inflation (5-quarters ahead) as inflation expectations ( $E_t(\pi_{t+k})$ ) and 2-quarters ahead EAI but estimate the augmented Taylor rule with different proxies of financial market expectations. The un-purged FCI (1-quarter ahead) is used to proxy for financial markets in R12, purged FCI (2-quarters ahead) in R13, contemporaneous ECB FSI in R14, contemporaneous Kansas FSI in R15 and contemporaneous Chicago FCI in R16. The lead length of inflation projections, future economic activity and financial conditions is determined by the SIC (see, Appendix C). The significant level at which the null hypothesis is rejected: \*\*\*1%, \*\*5%, \*10%.

For robustness, we also examine whether our results are dependent on different measures of economic activity and other measures of inflation expectations.

In Table 3, we use four alternative measures of the output gap. Since the EAI lags the 12-period-window WMEAI (WMEAI\_12) in 1993 and 2005–6 (see, Fig. 2), we are interested in repeating R2 but employ the WMEAI\_12 (rather than EAI) to investigate whether our point estimates in the Taylor Rule are subject to different economic activity proxies used in our analysis. The results are presented in R4, where we continue to find a response to inflation in excess of unity and the point estimate of  $\gamma_y$  between 0 and 1.0. This confirms that the BoE raises the real interest rate in reaction to rise in inflation expectation and adjusts its nominal rate to stabilise economic activity. Given the concern about the relatively small window size in WMEAI\_12, we use a 30-period-window WMEAI (WMEAI\_30) in R5 and have obtained similar estimates. Also, for robustness we re-

estimate R2 for the entire sample period in R6 where the demeaned real GDP growth rate is taken as a proxy of the output gap and in R7 where the Office for Budget Responsibility (OBR) output gap (Pybus, 2011) is employed. We discover that there is no material difference between the point estimates of R6–R7 relative to R2.

In Table 4, we turn to explore the performance of alternative measures of inflation expectations for modelling and understanding the BoE's policy decisions. We use two estimates of inflation expectations – the BoE/TNS Inflation Survey at a 1-year horizon and future inflation as a proxy for expected inflation (as in previous research by Castro (2011) and Martin and Milas (2013)). Since the BoE/TNS Inflation Survey is only available since Q4 1999, we estimate the BoE's reaction function for the time period, Q4 1999 – Q1 2009 and for the Great Moderation period, Q4 1999 to Q4 2007. In contrast to our earlier results for the full sample period (R2 in Table 2), the BoE's response to inflation is much less. The Bank does

not respond fully to the public's inflation expectations (See R8) and does not respond at all when the future inflation rate is used as a proxy (See R10). However, if we focus on the period prior to the crisis only, we find that the Bank does respond to the public's inflation expectations and the Taylor Principle holds (See R9) but not at all when future inflation is used as a proxy (See R11). The inconsistency across the results and the fact that the BoE's response may not be stabilising, raises questions about the simple Taylor Rule as an approximation of the BoE's monetary policy behaviour.

## 5. The augmented Taylor rule during the great moderation and the financial crisis

As motivated by studies such as Crespo-Cuaresma and Gnan (2008) and Baxa et al. (2013) which maintain that financial conditions are a major concern for central banks in the conduct of monetary policy, in this section we extend the baseline model Eq. [2] to examine whether adding a financial conditions index, that summarises the financial information in the UK financial sector, can provide further insights into UK monetary policy. In other words, does the BoE react to financial conditions over and above what is embodied in the inflation projection. We noted earlier that the BoE continued to retain responsibility for financial stability throughout this period.

The augmented Taylor Rule is written as:

$$i_t = \left( 1 - \sum_{j=1}^n \rho_j \right) \left[ i^* + \gamma_\pi (E_t(\pi_{t+k}) - \pi^*) + \gamma_y E_t(y_{t+s} - y^*) \right. \\ \left. + \gamma_{FM} FM_{t+h} \right] + \sum_{j=1}^n \rho_j i_{t-j} + \zeta_t \quad (7)$$

where  $FM_t$  is the proxy of financial markets, e.g., FCIs and FSIs introduced in the data section, and  $h$  refers to the forecasting horizon of financial conditions. We continue to apply the Schwarz Information Criterion (SIC) to determine the lead length (i.e.,  $h$  in Eq. [7]) for each proxy of financial markets. Panel B, Appendix C shows the estimates. It suggests that the Bank of England behaves in a forward-looking manner by targeting 1–2 quarters ahead financial conditions (see, the first two columns). However, when we turn to using alternative measures of financial markets, such as the ECB's UK FSI, the Kansas City FSI and the Chicago FCI (see, the last three columns), the SIC value is minimised at  $h = 0$ . These three indices appear to lead our FCI estimates throughout the sample period e.g., correlation analysis indicates that our un-purged FCI lags the ECB's index by three quarters and the two Fed's indices by one quarter.

Tables 5 and 6 report parameter estimates of the augmented Taylor Rule for the full sample period (Table 5) and the Great Moderation (Table 6) respectively, where the MPC's 5-quarter ahead inflation projection and the 2-quarter ahead EAI are employed to capture any movements in inflation rates and the output gap.

The two tables are organised so that the results with the un-purged FCI as the financial condition indicator are displayed in R12 (see, Table 5) and R17 (see, Table 6). Following Hatzius et al. (2010) argument we also use the purged FCI as an alternative measure in R13 (see, Table 5) and R18 (see, Table 6), ECB's UK FSI in R14 (see, Table 5) and R19 (see, Table 6), the Kansas City FSI in R15 (see, Table 5) and R20 (see, Table 6) and the Chicago FCI in R16 (see, Table 5) and R21 (see, Table 6).

First, our results support the augmented Taylor Rule. It indicates that the BoE responds to changes in financial conditions across the full sample period. As mentioned earlier in the data section, a higher FCI implies looser financial conditions and *vice versa*. The recovered values of  $\gamma_\pi$ ,  $\gamma_y$  and  $\gamma_{FM}$  in R13 provides  $\gamma_\pi =$

1.08,  $\gamma_y = 0.3$  and  $\gamma_{FM} = 0.84$ . Thus, holding inflation expectations and expected economic activity unchanged, a one-percentage point increase in the purged FCI will induce the BoE to raise the policy rate by 0.84% points. The model's linearity also implies that symmetrically the policy rate will fall by the same amount following a same-size decline in financial conditions as measured by the FCI. Our result is similar to Martin and Milas (2013) who report that the BoE's response to movements in the financial sector was significant for a similar period of 1992:M10–2009:M10. Also, the purged FCI receives a higher response of monetary policy than the un-purged one (see,  $\gamma_{FM}$  in R13 versus R12), which suggests that the BoE is more concerned about fundamental shocks in financial conditions in asset markets, spreads, etc. than those which are related to current macroeconomic conditions. This finding supports the Hatzius et al. (2010) argument that removing the impacts of inflation and economic activity when constructing a financial conditions index could be more informative.

Overall, we find that the BoE not only reacted to their own forward-looking projections of inflation and the output gap but also to financial conditions for the entire sample period which includes the GFC. These results are invariant to the measure of financial stress used.

To investigate the implications of this further, we re-estimate the augmented Taylor Rule for the Great Moderation period only in Table 6. In contrast to our results for the full sample period, we find that when we use the purged FCI (and indeed the other measures of financial stress) the BoE does not respond at all to inflation projections but reacts relatively more to financial conditions.

Possible explanations for this are that the BoE was very effective at achieving its inflation target in the period prior to the crisis with inflation projections close to the inflation target (see, Fig. 1) whereas during the financial crisis, we find that the BoE's projections of inflation into the future undershot the target significantly. The severity and persistent nature of the financial crisis and its impact particularly on the availability of bank credit to households and business combined with widening credit spreads caused them to revise downwards their projections of GDP and price inflation significantly (see, the November 2008 *Inflation Report* and February 2009 *Inflation Report*). The changing financial conditions were strongly embedded into the median inflation projection. In contrast the higher coefficient on financial conditions during the Great Moderation suggests that the low inflation facilitated the BoE in reacting to specific misalignments over that period e.g., Chadha et al. (2004) point to the real exchange rate appreciation of the mid-late 1990s; the *Inflation Reports of November, 2002*,<sup>14</sup> *February, 2003*,<sup>15</sup> and again *November, 2004*, refer to the risks to spending and the inflation projection based on the BoE's concern that the expansion in house prices at the time was unsustainable and; risks arising from geopolitical events. We are also using the mid quarter inflation projections and as financial conditions act as a leading indicator, new information on future output and inflation may have become available during the quarter.

The sensitivity analysis (see, R15–16 and R20–21), using the Kansas and Chicago Financial Stress Indices (with the exception of the ECB index), provides the same conclusions. Following an anticipated fall in financial conditions i.e., an increase in stress in the financial sector, the BoE will lower the policy rate to stabilise the

<sup>14</sup> The BoE states that "But the longer house prices rise at an unsustainable pace, and the larger the build-up of household debt, the greater the risk of a sharp correction at some point" (p.60).

<sup>15</sup> The BoE states that "Current rates of house price inflation are unsustainable: the longer rapid house price inflation persists, the greater is the chance of a subsequent sharp slowdown, and the more extended is the likely adjustment needed to restore equilibrium in the market" (p. 56).

**Table 6**  
Estimating the Augmented Taylor Rule for Great Moderation (Q1 1993 - Q4 2007).

	$\gamma_\pi$	Std. Error	$\gamma_y$	Std. Error	$\gamma_{FM}$	Std. Error	$\pi^*$ , %	rho	J-stat.	adj. R2	DW	
R17	***1.24	(0.209)	***0.66	(0.145)	***0.89	(0.142)	2.47	0.899	13.316	[0.998]	0.943	1.877
R18	0.60	(0.458)	***1.68	(0.348)	***1.82	(0.382)	1.70	0.942	12.867	[0.998]	0.949	2.011
R19	0.61	(0.392)	***1.32	(0.328)	-9.03	(6.178)	N/A	0.923	13.222	[0.998]	0.935	1.994
R20	0.34	(0.371)	***1.49	(0.281)	***-2.16	(0.349)	N/A	0.935	13.354	[0.998]	0.944	1.962
R21	*0.62	(0.343)	***1.44	(0.337)	***-7.08	(1.344)	N/A	0.932	13.200	[0.998]	0.943	1.947

R17–21 show the GMM estimates of the augmented Taylor rule for the Great Moderation period of q1 1993 - q4 2007, where the instrument set has a constant and 1–6 lags of the de-trended unemployment rate, Yield10 yr, ERI, US3 m, inflation rates and respective proxies of financial conditions:

$$i_t = \left(1 - \sum_{j=1}^n \rho_j\right) \left[ i^* + \gamma_\pi (E_t(\pi_{t+k}) - \pi^*) + \gamma_y E_t(y_{t+s} - y^*) + \gamma_{FM} FM_{t+h} \right] + \sum_{j=1}^n \rho_j i_{t-j}$$

R17–21 are regressions of the augmented Taylor rule for q1 1993 - q4 2007, where the un-purged FCI (1-quarter ahead) is used to proxy for financial markets in R17, purged FCI (2-quarters ahead) in R18, contemporaneous ECB FSI in R19, contemporaneous Kansas FSI in R20 and contemporaneous Chicago FCI in R21. The lead length of inflation projections, future economic activity and financial conditions is determined by the SIC. The significant level at which the null hypothesis is rejected: \*\*\*1%, \*\*5%, \*10%.

financial system. These results are in contrast to those of Martin and Milas (2013) who fail to obtain a statistically significant response of UK monetary policy to proxies of financial markets and therefore argue that a simple Taylor Rule of Eq. [2] is sufficient to describe the BoE's policy decisions before entering into the 2008–9 crisis period.

The importance of financial conditions continues when we use the two alternative measures of inflation expectations in Table 7. Firstly, for the full sample period, using the near-term BoE/TNS inflation expectations,<sup>16</sup> the BoE continues to respond to financial conditions while attaching much less importance to inflation (see, R22). This is not surprising given the much more negative forward-looking inflation projections of the BoE around the time of the financial crisis as we noted earlier, relative to the public's inflation expectations. It also suggests the advantage of using inflation projections of the BoE as they incorporate the full range of data that the bank uses to make its forecasts. Supporting this is the use of future inflation as a proxy using an instrument set that includes purged financial conditions (see, R 24). Again, both the BoE acts to target inflation (adhering to the Taylor Principle) and financial conditions during the full sample period.

When we narrow the period to the Great Moderation (see, R23 and 25 in Table 7), regardless of which measure is used, the BoE acts as an inflation targeter and responds to financial conditions with a slightly higher response to financial conditions in this period, which is in line with our earlier results in Tables 5–6. A possible explanation for the higher response of monetary policy to future inflation rates (compared to the BoE's response to inflation projections in Table 6) during the Great Moderation period is that our purged financial conditions index contains important information regarding the future inflation rate. Therefore, it is not surprising that including 1–6 lags of the purged FCI into the instrument set in Table 7 results in an increase in the parameter,  $\gamma_\pi$ . This indeed supports our earlier findings that financial conditions are important to the BoE's conduct of monetary policy because of its role as a leading indicator of inflation over the policy horizon and also as a separate policy objective.

Interestingly, we continue to obtain higher estimates of the smoothing parameter,  $\rho$  ( $= \sum_{j=1}^n \rho_j$ ) in Table 6 than those in Table 5,

which indicates that not only did the BoE react to inflation, the output gap and financial conditions when financial market risks are

sizeable, but also reacts to the three indicators in a much faster manner.

As Tables 5–7 all indicate that a change in monetary policy once took place with a lower response on financial conditions after including the GFC, we are motivated to dig deeper by investigating whether this is a 'smooth' change in the BoE's monetary policy or a rather abrupt one due to the GFC. We implement a recursive window method to GMM estimates of Eq. [7] in order to capture shifts in the parameter,  $\gamma_{FM}$ . Table 8 shows some interesting findings.

For comparison purposes, we re-display the results of R13 and R18, as obtained from Table 5 and 6 respectively, in Table 8. It shows the response parameter  $\gamma_{FM}$  is getting smaller after including more periods during the GFC. Also, a quick look at  $\gamma_\pi$  shows that this parameter ( $\gamma_\pi$ ) is insignificant at R18 but turns to be larger and statistically significant when moving from R18 to R26–29, R13. Hence, we can conclude that instead of taking an abrupt change in its monetary policy, the BoE prefers to adjust its preference over inflation and financial conditions gradually and smoothly, which is in line with its macro prudential policy.

Given the concern that shifts in the inflation target in June 1995 and November 2003 may change the BoE's monetary policy reaction function, it is also interesting to examine the response of the short-term interest rate to inflation expectations. We explore this possibility by estimating the coefficient on a dummy variable within the (augmented) Taylor Rule. We estimate the following dummy variable-extended models:

i) The dummy-extended Taylor Rule (2 factor model):

$$i_t = \left(1 - \sum_{j=1}^n \rho_j\right) \left[ i^* + (\gamma_\pi + \lambda_1 * D_1) (E_t(\pi_{t+k}) - \pi^*) + \gamma_y E_t(y_{t+s} - y^*) \right] + \sum_{j=1}^n \rho_j i_{t-j} \tag{8}$$

$$i_t = \left(1 - \sum_{j=1}^n \rho_j\right) \left[ i^* + (\gamma_\pi + \lambda_2 * D_2) (E_t(\pi_{t+k}) - \pi^*) + \gamma_y E_t(y_{t+s} - y^*) \right] + \sum_{j=1}^n \rho_j i_{t-j} \tag{9}$$

<sup>16</sup> The Bank of England finds a very close correspondence between the BoE/TNS survey of inflation expectations and current inflation (Bank of England, 2007).



**Table 7**  
Estimating the Augmented Taylor Rule Using Alternative Measures of Inflation Expectations.

	$\gamma_\pi$	Std. Error	$\gamma_y$	Std. Error	$\gamma_{FM}$	Std. Error	rho	J-stat.		adj. R2	DW	Sample Period
R22	*0.40	(0.222)	***0.27	(0.064)	***0.75	(0.051)	0.864	9.565	[0.999]	0.902	1.776	q4 1999 - q1 2009
R23	***1.70	(0.318)	***0.65	(0.063)	***0.88	(0.105)	0.907	7.774	[0.999]	0.925	2.016	q4 1999 - q4 2007
R24	***1.50	(0.389)	***1.11	(0.212)	***2.28	(0.429)	0.944	13.636	[0.997]	0.935	1.684	q1 1993 - q1 2009
R25	***1.73	(0.303)	***2.09	(0.339)	***2.39	(0.398)	0.940	12.791	[0.998]	0.944	1.915	q1 1993 - q4 2007

R22–25 show the GMM estimates of the augmented Taylor rule using alternative measures of inflation expectations, the BoE/TNS inflation survey in R22–23 and the actual future inflation rate in R24–25. Since the BoE/TNS survey only started from q4 1999, we have a shorter sample period for R22–23. The instrument set used in R22–25 has a constant and 1–6 lags of the de-trended unemployment rate, Yield10 yr, ERI, US3 m, inflation rates and respective proxies of financial conditions:

$$i_t = \left(1 - \sum_{j=1}^n \rho_j\right) \left[ i^* + \gamma_\pi (E_t(\pi_{t+k}) - \pi^*) + \gamma_y E_t(y_{t+s} - y^*) + \gamma_{FM} FM_{t+h} \right] + \sum_{j=1}^n \rho_j i_{t-j}$$

where 6-quarter ahead actual future inflation is used in R24 and 3-quarter ahead actual future inflation is employed in R25. In relation to the lead length of the EAI, we set  $s = 2$  in R22,  $s = 3$  in R23,  $s = 2$  in R24 and  $s = 3$  in R25. The lead length of financial conditions is 2 quarters for R22–25. As mentioned earlier, the lead length of inflation, the output gap and financial conditions is decided by the SIC. The significant level at which the null hypothesis is rejected: \*\*\*1%, \*\*5%, \*10%.

**Table 8**  
"Recursive Window" Estimates of the Augmented Taylor Rule.

	$\gamma_\pi$	Std. Error	$\gamma_y$	Std. Error	$\gamma_{FM}$	Std. Error	rho	J-stat.		adj. R2	DW	Sample Period
R18	0.60	(0.458)	***1.68	(0.348)	***1.82	(0.382)	0.942	12.867	[0.998]	0.949	2.011	q1 1993 - q4 2007
R26	0.80	(0.485)	***1.40	(0.311)	***1.71	(0.359)	0.938	12.839	[0.998]	0.949	2.002	q1 1993 - q1 2008
R27	*0.88	(0.481)	***1.02	(0.228)	***1.64	(0.320)	0.933	13.291	[0.998]	0.944	1.893	q1 1993 - q2 2008
R28	**0.93	(0.441)	***0.90	(0.204)	***1.42	(0.276)	0.927	13.393	[0.996]	0.942	1.865	q1 1993 - q3 2008
R29	**1.00	(0.402)	***0.91	(0.184)	***1.27	(0.254)	0.921	13.608	[0.997]	0.942	1.910	q1 1993 - q4 2008
R13	***1.08	(0.247)	***0.30	(0.088)	***0.84	(0.174)	0.909	13.297	[0.998]	0.935	1.916	q1 1993 - q1 2009

R26–29 show the 'Recursive Window' GMM estimates of the augmented Taylor rule which aims to examine whether changes in the Bank of England's preference over financial stability is a smooth change in policy or an abrupt one. The instrument set has a constant and 1–6 lags of the de-trended unemployment rate, Yield10 yr, ERI, US3 m, inflation rates and respective proxies of financial conditions:

$$i_t = \left(1 - \sum_{j=1}^n \rho_j\right) \left[ i^* + \gamma_\pi (E_t(\pi_{t+k}) - \pi^*) + \gamma_y E_t(y_{t+s} - y^*) + \gamma_{FM} FM_{t+h} \right] + \sum_{j=1}^n \rho_j i_{t-j}$$

where the purged FCI (2-quarters ahead) is used as a proxy of financial market evolution in this table. As mentioned earlier, the lead length of inflation, the output gap and financial conditions is decided by the SIC. The significant level at which the null hypothesis is rejected: \*\*\*1%, \*\*5%, \*10%.

ii) The dummy-extended augmented Taylor Rule (3 factor model):

$$i_t = \left(1 - \sum_{j=1}^n \rho_j\right) \left[ i^* + (\gamma_\pi + \lambda_1 * D_1) (E_t(\pi_{t+k}) - \pi^*) + \gamma_y E_t(y_{t+s} - y^*) + \gamma_{FM} FM_{t+h} \right] + \sum_{j=1}^n \rho_j i_{t-j} \tag{10}$$

$$i_t = \left(1 - \sum_{j=1}^n \rho_j\right) \left[ i^* + (\gamma_\pi + \lambda_2 * D_2) (E_t(\pi_{t+k}) - \pi^*) + \gamma_y E_t(y_{t+s} - y^*) + \gamma_{FM} FM_{t+h} \right] + \sum_{j=1}^n \rho_j i_{t-j} \tag{11}$$

where  $D_1$  is a dummy variable that takes the value of 1.0 from Q1 1993 to Q2 1995, during which the UK inflation target was specified as a range for the RPIX of 1%–4% a year and a value of zero over the remainder of the sample period to Q1 2009. The other dummy,  $D_2$  equals 1.0 during the period, Q4 2003 - Q1 2009 when the inflation target was re-specified to 2.0%. A positive (negative) value for the coefficient on the dummy variable ( $\lambda_1$  or  $\lambda_2$ ) indicates that the BoE was more aggressive (conservative) against deviations of expected inflation from the inflation target than other periods. We use 5-quarter ahead inflation projection and 2-quarter ahead EAI as also employed in R2 to estimate Eqs. [8]–[9]. For the augmented Taylor Rule, the 2-quarter ahead purged FCI (same as in R9) is used to

capture the evolution of UK financial markets. Table 9 displays the parameter estimates of Eqs. [8]–[11].

Several results stand out. First, consistent with our prior expectations we have obtained similar estimates of  $\gamma_y$  for Eqs. [8] and [9] (see, R30) and  $\gamma_{FM}$  for Eqs. [10] and [11] (see, R31). This confirms robustness of our findings when extending the (augmented) Taylor Rule for the two dummies,  $D_1$  and  $D_2$ . Second, since we have no evidence of significant  $\lambda_1$  for either Eq. [8] or [10], it is possible that introducing the point inflation target of 2.5% in June 1995 did not change the BoE's preference over price stability. Third, we find that the parameter estimate,  $\lambda_2$  is insignificant in Eq. [9] (see, R30) but turns to be statistically significant (at the 10% level) in Eq. [11] (see, R31). Hence, although we have very limited evidence from Table 9 to confirm that shifts in the UK official inflation target may change the BoE's preference over inflation expectations, it is still reasonable to conclude that price stability, output stability and financial stability enters jointly into the UK monetary policy framework with significant  $\gamma_\pi$ ,  $\gamma_y$  and  $\gamma_{FM}$ .

**6. Conclusions**

Our study investigates the interest rate setting behaviour of the BoE over the 16-year period covering both the Great Moderation and the 2008–9 Global Financial Crisis (GFC) and subsequent recession. We contribute to the existing literature by using the BoE's own inflation projections in our estimation. Comparing the BoE's inflation projections with the actual out-turn for inflation suggests that this matters. This is confirmed in our results. From Q4 2008, the BoE's inflation projections were consistently lower than actual future inflation over the forecast horizon. The BoE responded to these lower projections of inflation, by lowering their policy rate.

**Table 9**  
A Robustness Analysis: Changes in Inflation Targets.

	R30: Robust Analysis of R2		R31: Robust Analysis of R13	
	D1	D2	D1	D2
$\gamma_\pi$	**1.00 (0.432)	***1.56 (0.364)	***1.30 (0.412)	***1.41 (0.309)
$\lambda_1$	0.27 (0.196)	—	−0.17 (0.147)	—
$\lambda_2$	—	0.18 (0.163)	—	**0.28 (0.134)
$\gamma_y$	***0.28 (0.092)	**0.22 (0.085)	***0.31 (0.088)	***0.35 (0.104)
$\gamma_{FM}$	—	—	***0.85 (0.177)	***0.91 (0.182)
rho	0.884	0.880	0.904	0.914
J-stat.	13.599 [0.968]	12.868 [0.978]	13.329 [0.996]	13.347 [0.996]
adj. R2	0.922	0.920	0.933	0.934
DW	1.933	1.949	1.902	1.914

This table shows robustness analysis of the standard Taylor rule (R2) and the augmented rule (R13) for the full sample period running from q1 1993 to q1 2009. As in R2, we use the BoE's central projection of inflation (5-quarters ahead) as inflation expectations ( $\pi_{t+k}^F$ ) and 2-quarters ahead EAI to proxy for the output gap. To estimate the augmented Taylor rule, we add the purged FCI as in R13. For the standard Taylor rule, the instrument set has a constant and 1–6 lags of the de-trended unemployment rate, Yield10 yr, ERI, US3 m, inflation rates. Again, we add 1–6 lags of the purged FCIs to our instrument set when estimating the augmented rule. In this robustness analysis we include dummy variables to test how changes in the BoE's official inflation target (June 1995 and November 2003) affect monetary policy:

Standard Taylor Rule:

$$i_t = \left(1 - \sum_{j=1}^n \rho_j\right) \left[ \bar{i} + (\gamma_\pi + \lambda_1 * D_1) (E_t(\pi_{t+k}) - \pi^*) + \gamma_y E_t(y_{t+s} - y^*) \right] + \sum_{j=1}^n \rho_j i_{t-j}$$

$$i_t = \left(1 - \sum_{j=1}^n \rho_j\right) \left[ \bar{i} + (\gamma_\pi + \lambda_2 * D_2) (E_t(\pi_{t+k}) - \pi^*) + \gamma_y E_t(y_{t+s} - y^*) \right] + \sum_{j=1}^n \rho_j i_{t-j}$$

Augmented Taylor Rule:

$$i_t = \left(1 - \sum_{j=1}^n \rho_j\right) \left[ \bar{i} + (\gamma_\pi + \lambda_1 * D_1) (E_t(\pi_{t+k}) - \pi^*) + \gamma_y E_t(y_{t+s} - y^*) + \gamma_{FM} FM_{t+h} \right] + \sum_{j=1}^n \rho_j i_{t-j}$$

$$i_t = \left(1 - \sum_{j=1}^n \rho_j\right) \left[ \bar{i} + (\gamma_\pi + \lambda_2 * D_2) (E_t(\pi_{t+k}) - \pi^*) + \gamma_y E_t(y_{t+s} - y^*) + \gamma_{FM} FM_{t+h} \right] + \sum_{j=1}^n \rho_j i_{t-j}$$

D1 = 1 for the period of q1 1993 - q2 1995 and D2 = 1 for the period q4 2003 - q1 2009. The lead length of inflation projections, future economic activity and financial conditions is determined by the SIC. The significant level at which the null hypothesis is rejected: \*\*\*1%, \*\*5%, \*10%.

In keeping with their remit (see, [Remit for the Monetary Policy Committee, 2017](#)), they adhered to inflation targeting throughout the period and at least until the beginnings of quantitative easing with inflation stability tending to outweigh other objectives during this period of unprecedented economic disturbances and uncertainty. At the same time our results indicate that the BoE tended to pursue a higher implicit inflation target thus allowing them to lower the policy rate further to accommodate specific shocks outside of their control.

Our robustness test, employing future inflation, suggests that the reason for our different results from [Martin and Milas \(2013\)](#) and [Baxa et al. \(2013\)](#) is due to our use of inflation projections. The lower response of interest rates to future inflation for the full sample period encompassing the GFC, relative to the Great Moderation period only, contrasts with the higher and significant coefficient on inflation projections that we find for the full sample period. This is reinforced by our recursive window estimates of the augmented Taylor Rule.

Our second contribution is the discovery that the BoE did react to financial conditions during the Great Moderation. Inflation targeting does not prohibit the central bank from considering financial markets and conditions. Clearly conditions in the financial markets (as represented by asset markets, asset prices and interest rate spreads) were reviewed by the BoE in their *Inflation Report* and our results suggest that the Bank reacted to them during the Great Moderation. The inclusion of the BoE's inflation projections suggests a

rationale for why, unlike previous studies for the period 1993–2007 ([Castro, 2011](#); [Martin and Milas, 2013](#)), the BoE reacts to overall financial conditions. We provide strong evidence that when inflation projections are around the inflation target as in during the Great Moderation, the BoE is likely to have a higher response to financial markets - as the primary objective of price stability has been achieved and maintained. In contrast, the results for the full estimation period, that includes the GFC and Great Recession, gives a smaller weight to the purged FCI and a larger weight to inflation projections. This suggests that the more pessimistic outlook of the BoE regarding inflation incorporated the worsening financial conditions and their potential impact on future inflation and output.

Consequently, our results provide information to market investors on how the BoE conducts its monetary policy. When the BoE is adhering to the inflation target, they can respond more to financial market conditions. Whereas when inflation projections are out of line with the target, targeting inflation again becomes more important.

Another important point that deserves to be analysed in more detail is the BoE's preference over financial stability, particularly when the effective lower bound for the interest rate is reached and alternative instruments of monetary policy are employed. As these questions are beyond the scope of this paper, we leave it to be explored in our future paper.

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**Appendix A. Description of the Economic Activity Indicators**

Economic Activity Indicators	Sources	Sample Period
Real GDP	ONS	Q1 1993 - Q1 2009
Real GDP Growth	ONS	Q1 1993 - Q1 2009
Unemployment Rate	ONS	Q1 1993 - Q1 2009
Industrial Production Index, CPI deflated	ONS	Q1 1993 - Q1 2009
Unit Labour Costs, CPI deflated	ONS	Q1 1993 - Q1 2009
Real Labour Productivity	ONS	Q1 1993 - Q1 2009

**Appendix B. Description of the Financial Conditions Indicators**

Financial Conditions Indicators	Sources	Sample Period
<b>1. Foreign Exchange Markets</b>		
- Effective Exchange Rate Index, Sterling	ONS	Q1 1998 - Q1 2009
<b>2. Asset Prices</b>		
- FTSE All Share index	DataStream	Q1 1993 - Q1 2009
- National Wide House Price Index	DataStream	Q1 1993 - Q1 2009
- Reuters Commodity Index, Sterling	DataStream	Q1 1993 - Q1 2009
<b>3. Equity Market Risks</b>		
- FTSE 100 Volatility	DataStream	Q2 2000 - Q1 2009
<b>4. Lending</b>		
- Quarterly Changes in Total Mortgage Lending	DataStream	Q1 1993 - Q1 2009
- Nationwide Base Mortgage Rate	BoE	Q1 1993 - Q1 2009
- Unsecured Lending Rate for Personal Loans	BoE	Q1 1995 - Q1 2009
<b>5. Private Spreads</b>		
- Credit Spread <sup>a</sup>	DataStream	Q1 1993 - Q1 2009
- Future Interest Rate Spread <sup>b</sup>	DataStream	Q1 1993 - Q1 2009
<b>6. Safe Spreads</b>		
- TED Spread <sup>c</sup>	BoE	Q1 1993 - Q1 2009

Note: <sup>a</sup> Credit spread is the difference between the yield on corporate bonds and that on government bonds (10 yr maturity); <sup>b</sup> Future interest rate spread refers to changes in spread between the future interest rate last quarter and the current 3 m Treasury bills discount rate; <sup>c</sup> TED spread is defined as the difference between the three-month Libor rate and the three-month Treasury bills discount rate.

**Appendix C. Lead Length Selection: Inflation, EAI and Financial Conditions (SIC)**

Panel A: BoE Inflation Projection and EAI						
k=						
s=	k = 1	k = 2	k = 3	k = 4	k = 5	k = 6
s = 0	1.1092	1.1318	1.1457	1.1431	1.1199	1.0915
s = 1	1.0253	1.0274	1.0125	1.0194	0.9979	0.9820
s = 2	0.7897	0.7887	0.7887	0.7919	***0.7882	0.7906
s = 3	0.8138	0.8136	0.8188	0.8227	0.8190	0.8164

Panel B: Financial Conditions					
FCI=					
h=	The UK FCI (PAC)	The UK Purged FCI (PAC)	The ECB UK FCI	The Kansas FCI	The Chicago FCI (FSI effectively)
h = 0	0.8096	0.7965	***0.8078	***0.7668	***0.7879
h = 1	***0.7771	0.7573	0.8180	0.8094	0.8091
h = 2	0.7813	***0.7310	0.8194	0.8074	0.8048

Note: The choice of lead length of inflation and the output gap is studied using the sample period from Q1 1993 to Q1 2009. The SIC value is minimised at \*\*\*. The choice of lead length of financial conditions/stress is tested using the same period, Q1 1993 - Q1 2009. Also, the SIC value is minimised at \*\*\* for each financial market indicator.

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