New Rules for Monetary Policy? Interest Rates Before And After The Great Recession

Samuel Tombs, UK Economist at Capital Economics (writing in an independent capacity).[1]
19th December 2011. 3,757 words.

For much of the period of remarkable macroeconomic stability in the 1990s and early 2000s, UK monetary policy was relatively predictable, stable and apparently successful. The Monetary Policy Committee (MPC) used one tool (interest rates) to achieve one outcome (low and stable inflation). Interest rates were moved gradually; Mervyn King expressed his desire to make monetary policy "boring."

In contrast, the recession of 2008/09 and subsequent economic recovery appeared to result in a significant change in central bank policy. Official interest rates were cut aggressively until they hit the zero lower bound; quantitative easing (QE) was adopted subsequently. Then, in contrast to previous recoveries, interest rates were left unchanged for a prolonged period, despite the persistence of above target inflation. It seemed as if policymakers had begun to act in a fundamentally different way.

As we approach the 15th anniversary of the establishment of the MPC, it now seems to be a good time to look back and reflect on the consistency of monetary policy. Has a 'regime shift' in policymakers' behaviour really occurred? Are we now in a new era of monetary policy where the pre-financial crisis rules of thumb no longer apply? Does the MPC care less about inflation, as some have suggested? Does the Committee act in a more discretionary manner?

I conjecture that the answer to all these questions is a firm 'no'. Instead, I argue that the period since the establishment of the MPC can still be seen as one where policymakers set interest rates – and then went on to provide QE – in a consistent manner. The old rules of monetary policy still seem to apply.

Five sections follow. First, I provide a non-technical summary of the theory of 'Interest Rate Reaction Functions' (IRRFs), also known as 'interest rate rules', for those unfamiliar with the literature. Next, I propose that the traditional emphasis that these rules place on central banks' responsiveness to measures of the output gap is now misguided. Instead, I argue that rules should account for policymakers' response to measures of inflation expectations in the private sector.

Assessing the last fifteen years of monetary policy is not without empirical difficulties. Chiefly, how can QE be incorporated into an IRRF? I consider three different approaches to this question in section three.

The fourth section focuses on the key results of estimating five different reaction functions for the period since the establishment of the MPC. I then conclude and use the proposed IRRF to infer the extent to which the MPC may react to economic shocks in the future, assuming that it acts in a way that is consistent with its past behaviour.

What are Interest Rate Reaction Functions?

In essence, IRRFs attempt to show how central banks respond to the state of the economy over time. Most famously, Taylor's (1993) eponymous rule suggested that the level of nominal interest rates was set with reference to the deviation of current inflation from its target and output from its trend level (the 'output gap'). (Rule 1 in the box.) Taylor argued that a rule in which the coefficients on inflation (β_1) and the output gap (β_2) equal 1.5 and 0.5 respectively provided a good indication of the level of the US Federal Funds Rate between 1987 and 1992.

The main strength of the Taylor Rule is its simplicity. But there is no *a priori* reason to think that its structure or parameter values are optimal or applicable to other periods or countries.

For a start, history suggests that central banks move interest rates incrementally; perhaps reflecting their desire not to surprise markets or inject volatility into the economy, or reflecting uncertainty about the effects of interest rate changes. This 'gradualist' behaviour points to a role for a lagged interest rate amongst the explanatory variables (rule 2 in the box).

[1] Author email address: samuel.tombs@capitaleconomics.com. I would like to thank John Driffill, Andrew Kenningham, Vicky Redwood and Ron Smith for their kind advice. All errors are my own.

Taylor's Rule has also been modified to respond to *forecasts* of the explanatory variables instead of current period values (rule 3). This seems sensible, as central bankers emphasise that they set interest rates according to their expectations of economic variables, reflecting the lags in the transmission mechanism of monetary policy.

The best results of previous empirical studies on the Bank of England's reaction function over the last thirty years are summarised in the Appendix. Most use econometrics to estimate these rules and conclude that – in the post-1992 inflation targeting era, at least – the Bank provided a 'nominal anchor' for the economy and acted in a consistent, 'rule-like' manner before the recession.

Box: Interest Rate Reaction Functions

Simple Taylor Rule:
$$i_t = \alpha + \beta_1(\pi_t - \pi_t^*) + \beta_2(y_t - \bar{y}_t) \quad (1)$$

Gradualist Rule:
$$i_t = \alpha + \beta_1(\pi_t - \pi_t^*) + \beta_2(y_t - \bar{y}_t) + \beta_3 i_{t-1} \quad (2)$$

Forward-Looking Rule:
$$i_t = \alpha + \beta_1(\mathrm{E}_t[\pi_{t+j} - \pi_{t+j}^*]) + \beta_2(\mathrm{E}_t[y_{t+k} - \bar{y}_{t+k}]) \quad (3)$$

Proposed Rule A:
$$i_t = \alpha + \beta_1(\mathrm{E}_t^{\mathrm{bank}}[\pi_{t+j} - \pi_{t+j}^*]) + \beta_2(\mathrm{E}_t^{\mathrm{bank}}[y_{t+k} - \bar{y}_{t+k}]) + \beta_3 i_{t-1} + \beta_4(E_t^{bond}[\pi_{t+p}^{bond} - \pi_{t+p}^*]) \quad (4)$$

Proposed Rule B:
$$i_t = \alpha + \beta_1(\mathrm{E}_t^{\mathrm{bank}}[\pi_{t+j} - \pi_{t+j}^*]) + \beta_3 i_{t-1} + \beta_4(E_t^{bond}[\pi_{t+p}^{bond} - \pi_{t+p}^*]) \quad (5)$$

Variables: i = nominal interest rate; π = inflation; π^*= inflation target; y = output, $\bar{y}$ = trend level of output; π^{bond}= bond market break-even inflation rate. Both output terms are in logs.

Coefficients: α = constant, β_1; β_2; β_3; β_4 =response coefficients.

Time periods: t = current quarter; j, k & p reflect the number of quarters that agents' look ahead. E_t indicates that the dependent variable responds to expectations of the variables within the brackets.

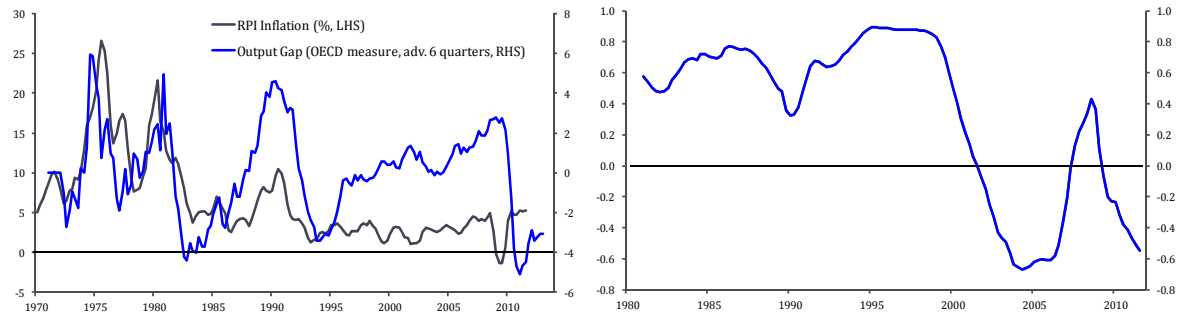
Taylor Rules for the Twenty First Century

Such findings are appealing for economic historians. However, the IRRF literature falls short of the current needs of business economists in two ways. First of all, the Bank's behaviour since the financial crisis has yet to be assessed, perhaps because QE provides an additional complication. Few inferences can therefore be made about the MPC's current stance relative to its past behaviour. A second oversight appears to be the omission of any response by the MPC to *private sector* expectations of inflation. Their inclusion in an IRRF is justified on four grounds:

1) The output gap has become less important in the formation of inflation in recent years.

Up until the mid-1990s, the domestic output gap appears to have played a key role in determining UK inflation. But as Charts 1-2 show, the relationship between the output gap and RPI inflation six quarters ahead has broken down significantly in recent years.[2]

Charts 1 & 2 – RPI Inflation & The Output Gap (LHS) & 10-Year Rolling Correlation (RHS) (Q1/1970-Q3/2011)

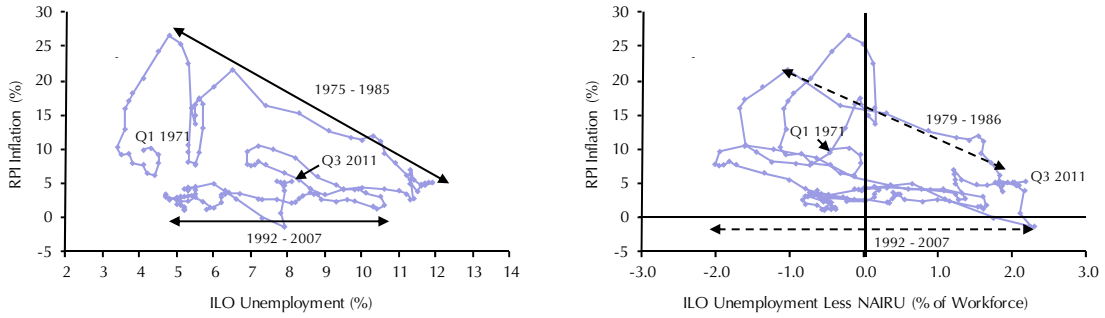


Source: Thomson Datastream & OECD

[2] These results are robust to altering the length of the lag between the output gap and inflation.

Similarly, Chart 3 shows that spare capacity, represented by the unemployment rate, had a much bigger influence on inflation in the 1970s and 1980s than in the 1990s and 2000s. Admittedly, variations in the supply potential of the economy are likely to have meant that there was not a constant trade-off between inflation and unemployment over this whole period. However, variations of the unemployment rate around its 'NAIRU'[3], depicted in Chart 4, still appear to have had a much weaker effect on inflation over the last twenty years. This trend may reflect the diminishing relevance of measures of spare capacity in the formation of inflation as the economy's structure has evolved away from manufacturing and towards services. The increasing openness of the economy also suggests that *global* instead of domestic spare capacity has played a more important role in influencing UK inflation in recent years. (Iakova, 2007; Sentance, 2011.)

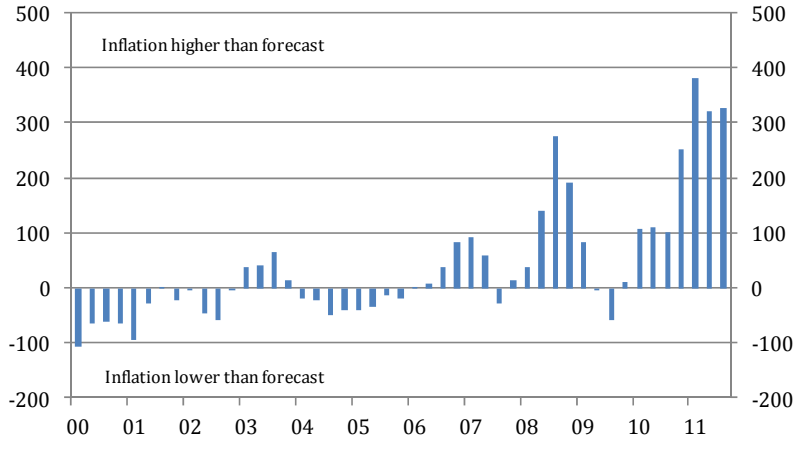
Charts 3 & 4: UK Inflation & Labour Market Slack (Q1/1971-Q3/2011)



Source: Thomson Datastream

Despite these developments, the Bank of England's Quarterly Model (BEQM) used for its inflation forecasts still places considerable weight on the output gap. In partial reflection of this, BEQM has done an increasingly poor job of forecasting inflation – as Chart 5 shows, it has systematically underestimated inflation since 2006. As a result, BEQM's poor forecast record may have persuaded MPC members to consider a wider variety of information when setting policy.

Chart 5: Difference between Two-Year Ahead Inflation Forecast & Inflation Outturn (Q1/2000-Q3/2011, percentage points)



Source: Thomson Datastream & Bank of England

2) Deriving a reliable measure of the output gap for monetary policy is a near impossibility.

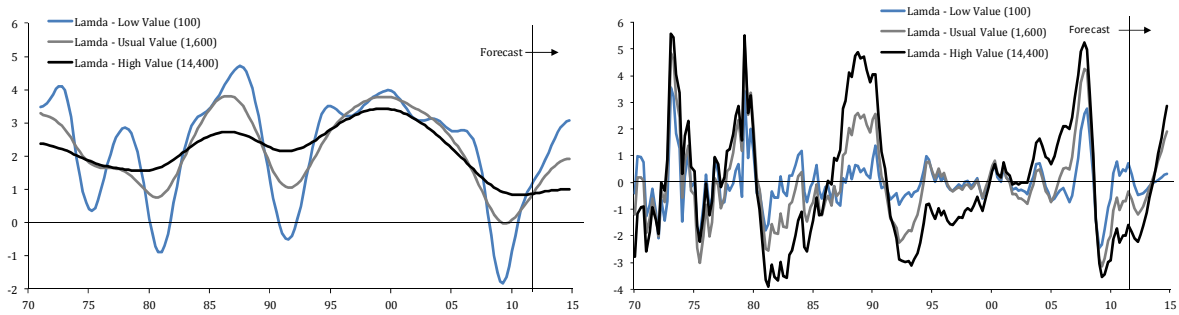
Deriving a measure of the output gap requires a calculation of the trend level of GDP. This can be inferred from surveys or complicated structural models of the economy. However, for simplicity, most economists have tended to use statistical methods, such as the Hodrick-Prescott (HP) filter, which essentially derive a

[3] The Non-Accelerating Inflation Rate of Unemployment, a measure of the natural or equilibrium rate of unemployment.

measure of trend GDP by calculating a line of best fit through past GDP data. The degree to which the trend line moves over time is determined by a smoothing parameter. This parameter can take different values to reflect, for example, judgement on the amount of potential GDP permanently lost during the recession.

Using the latest GDP data and the Bank's most recent GDP forecasts contained in the November 2011 *Inflation Report,* Charts 6-7 show how varying this smoothing parameter makes a big difference to the estimated size of the output gap. A high value indicates that the Bank expects all spare capacity to be eliminated by 2013 and output to be above trend in 2014. This does not support the Bank's view that spare capacity would persist for a prolonged period, despite a period of above-trend growth.[4] Selecting a smaller value of the smoothing parameter eliminates this problem as the trend rate of growth varies more. However, it implies that a large degree of the economy's supply potential was lost during the recession and therefore perhaps underestimates the size of the output gap that the economy now has.

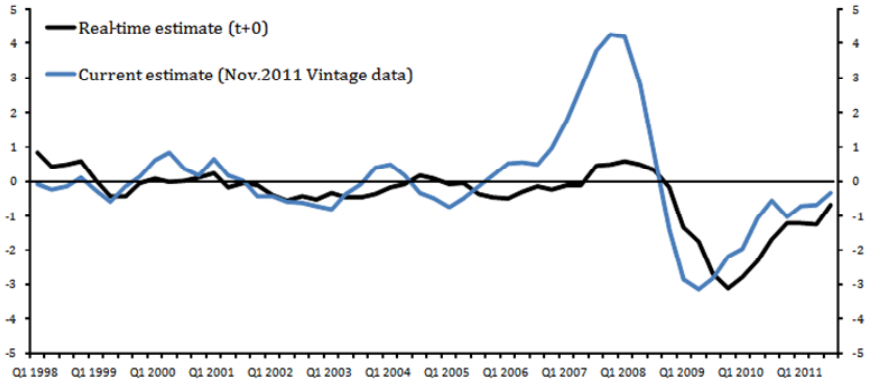
Charts 6-7: Trend GDP Growth (% y/y, LHS) & Output Gap (%, RHS) Estimates Using a HP filter on Nov. 2011 Vintage GDP Data & Bank of England Nov. 2011 GDP Forecasts (Q1/1970-Q3/2011)



Source: Thomson Datastream, Bank of England & Author Calculations

The problem for policymakers is further compounded by the fact that initial estimates of past GDP growth are often revised significantly. Consider Chart 8; the black line depicts estimates of the output gap using an HP filter on all the GDP data available *at that time* – it is a 'real-time' estimate. The blue line depicts an estimate of the output gap using the latest vintage of GDP data (November 2011). Notice that a 'real-time' estimate would have failed to show the MPC that the economy was operating above capacity in the pre-recession period. (Orphanides (1997) demonstrates that revisions had similarly large effects in the US.) In the presence of such uncertainty and inaccuracy, it seems reasonable to believe that the MPC may have placed much less weight on estimates of the output gap than simple Taylor rules suggest.

Chart 8: Current and Real Time Estimates of the Output Gap Using a Hodrick-Prescott Filter on GDP (Q1/1998-Q3/2011, %)



Source: Office for National Statistics & Author Calculations

[4] As Mervyn King stated in November 2010, for example, "...the large fall in output during the recession means that some spare capacity is likely to persist over the forecast period." (Opening Remarks by the Governor Mervyn King, Inflation Report Press Conference, Wednesday 10 November 2010, http://www.bankofengland.co.uk/publications/inflationreport/irspnote101110.pdf.)

3) Credibility determines the extent to which official interest rates must move to bring inflation back to target.

It is widely acknowledged that credibility in the central bank's ability to meet the inflation target influences the degree to which interest rates need to respond in order to bring inflation back to target. As MPC member Paul Tucker has recently argued:

"Our ability to provide and sustain that stimulus [QE] depends absolutely on the credibility of our commitment to the 2% inflation target. If our credibility were to slip and medium-term inflation expectations were to rise, we would have to run with a tighter monetary stance than otherwise in order to put the genie back into the bottle."[5]

In this sense, the deviation of private sector inflation expectations from the inflation target can be seen as a *credibility gap* or a *credibility index* to which the central bank will respond. Expectations that inflation will be above target in the long run, for example, would result in a rise in this index and a response from the central bank through higher interest rates to keep them anchored. While the MPC has yet to deal with such a crisis of confidence, episodes of such responses in history are numerous. Perhaps most famously, Chairman Volcker defended the continuation of restrictive US monetary policy in the early 1980s even after a sharp fall in inflation and stated that policy should stay tight until Treasury yields suggested that long-term inflation expectations had fallen.[6]

4) The term structure of nominal interest rates, which partly depends on bond traders' inflation expectations, is a key transmission mechanism of monetary policy.

Financial markets' expectations of future inflation play a key role in determining asset price values. Theory emphasises that the key transmission mechanism of monetary policy is through altering the term structure of interest rates, which is set by bond markets. This in turn affects broader asset values and then activity and lending in the real economy. It is therefore a major oversight that traditional IRRFs do not account for markets' expectations of real interest rates and inflation.

As a result, this article proposes that IRRFs should account for a measure of private sector inflation expectations. (See the Box on page 2.) Rule 4 adds to Rule 3 a measure of the deviation of bond markets' break-even inflation rates – broadly a measure of inflation expectations – from a level consistent with the inflation target.[7] Rule 5 removes the output gap measure from Rule 4 to see whether it played any role in the interest rate setting process.

Accounting for Quantitative Easing

If the proposed rules are to apply to the whole period, the interest rate variable must account for QE. Between March 2009 and January 2010, the MPC purchased £200bn worth of assets, primarily gilts ("QE1"). And in October 2011, the Committee pledged to purchase a further £75bn worth of gilts by February 2012 ("QE2"). How can these purchases be converted into equivalent interest rate movements?

In theory, QE might have boosted economic activity and inflation via the five channels depicted in Chart 9. However, in practice, only one of these channels appears to have been significant.

Initially, the MPC emphasised QE's role in boosting bank lending, but this emphasis was subsequently abandoned as the relationship between the measures of the narrow and broad money supply broke down.[8] In addition, since QE was almost exclusively focussed on purchasing gilts, which are highly liquid, the effects of the asset purchases on overall financial market liquidity seem likely to have been relatively small.

---

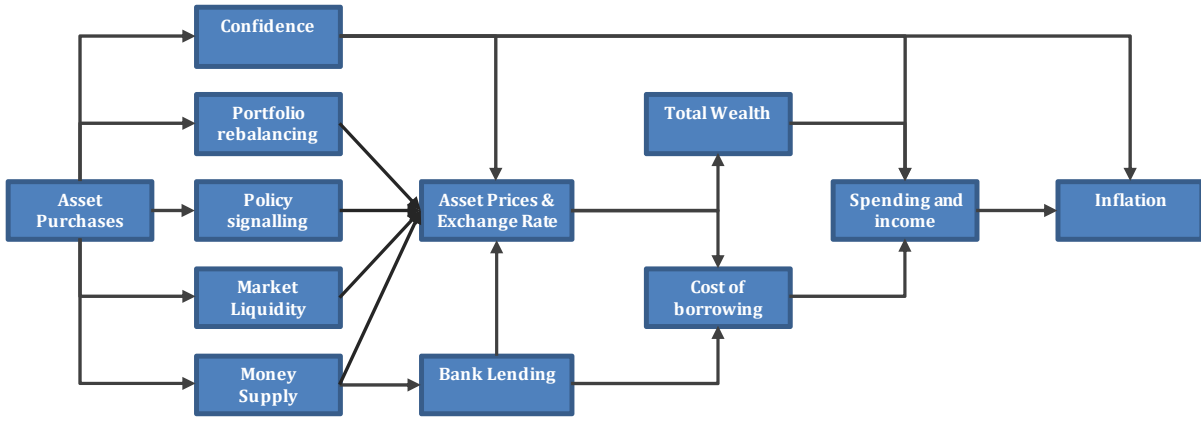
[5] Tucker, P. (2011), 'A few remarks on current monetary policy in a rebalancing Economy,' Speech to the Joint 1900/City Club Lunch, London, 22nd November.

[6] Volcker said: *"Nothing would please me more than for interest rates to decline... But, I also know that it would be short-sighted for the Federal Reserve to abandon a strong sense of discipline in monetary policy in an attempt to bring down interest rates. When long-term interest rates decline decisively, it will be an indication of an important change in attitudes about the prospects for the economy. One essential element in this process must be a widespread conviction that inflation will be contained in the long run."*

[7] Break-even inflation rates are the difference between yields on nominal and index-linked government bonds and should approximately equal markets' expectations for RPI inflation over the term of the bond. RPI inflation has usually been 0.7% higher than CPI inflation, so a break-even inflation rate of 2.7% is probably consistent with expectations that inflation will hit the target.

[8] The "money multiplier" – the ratio of M4 to M0 – fell from 21.5 in February 2009 to 10.6 in January 2010. The annual growth rate of M4 lending fell from 11.9% in February 2009 to 6.8% in January 2010 – the rate has turned negative since September 2010.

Chart 9: Possible Transmission Channels for QE



Source: Bank of England

QE also appears to have imparted little monetary stimulus through a 'policy signalling' channel – overnight index swap (OIS) rates (the best measure of markets' expectations of official interest rates) barely fell in the aftermath of QE announcements and rose across the QE1 period. Meanwhile, QE's effects on confidence are likely to have been too diffuse and intangible to estimate.

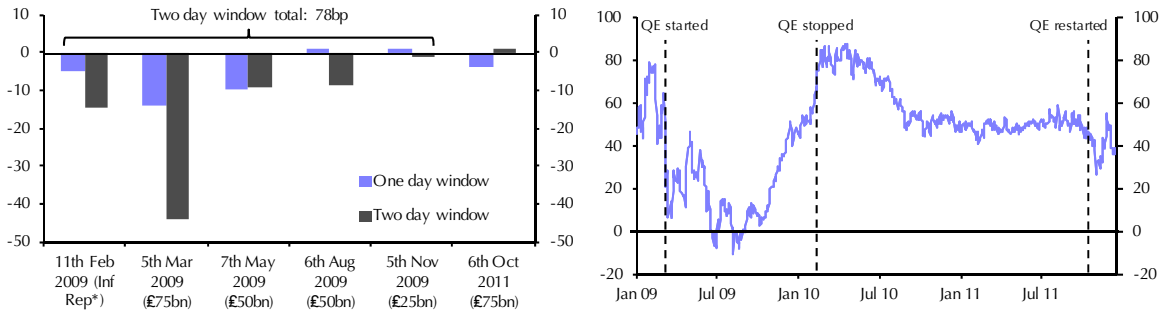
A consensus has recently emerged that the bulk of QE's effects came through its impact on lowering the spread of gilt yields over OIS rates, encouraging investors to purchase higher-yielding, riskier assets such as corporate bonds and equities – so-called 'portfolio rebalancing.' In turn, higher asset prices should raise wealth and reduce borrowing costs, thereby increasing economic activity and eventually boosting inflation.

Unfortunately, the relative infancy and complexity of QE means that there is no established way of quantifying its effects and calculating its corresponding interest rate reduction. Three approaches are considered here.

One approach is to determine the extent to which QE lowered gilt yields and then to use evidence concerning the historical relationship between official interest rates and government bond yields to convert this into an effective reduction in Bank Rate. This can be done either by examining the fall in gilt yields in the immediate aftermath of the authorisation of asset purchases – QE's so-called "announcement effect" – or by examining the change in gilt yields across the whole period.

Summing together the drop in the gilt-OIS spread over a two-day window suggests that QE lowered gilt yields by around 80 basis points (bp). (See Chart 10.) Meanwhile, Chart 11 also suggests that the first batch of QE had a peak effect of reducing the 10-year gilt-OIS spread by around 80bp.

Charts 10-11: Reduction in 10-Year Gilt-OIS Spread Following QE Announcements (bp, LHS) & Its Level (bp, RHS) (2009-2011)



Note: * The Bank of England's Inflation Report in February 2009 strongly indicated that a policy of asset purchases was likely.
Source: Bank of England & Bloomberg

A regression on monthly data between January 1998 and December 2008 indicates that a 1% reduction in Bank Rate is normally associated with a 24bp fall in 10-year nominal bond yields. This result seems to be broadly in line with previous studies of the relationship between long bond yields and official interest rates. (See Table 1.) So, the 80bp reduction in 10-year gilt yields that seems to be attributable to the asset purchases suggests that the first batch of QE was equivalent to reducing interest rates by around 3%.

Table 1: Estimates of the Relationship between Official Interest Rates & Long Bond Yields

Paper	Period	Country	Coefficient on Bond Yield	Reduction in Short Rates Implied by Gilt-OIS Spread (bp)	
				QE1	QE2
Chung, Laforte, Reifschneider, and Williams (2011)	1987-2007	US	0.25	320	120
Poole (2005)	1984-2005	US	0.30	267	100
Evans and Marshall (1998)	-	(Model)	0.25	320	120
Nelson (2011)	1984-2007	UK	0.37	216	81
Tombs (2011)	1998-2008	UK	0.24	333	125

The second approach is to examine estimates of QE's direct effects on GDP and inflation using economic models. Work in this area is ongoing; early results are summarised in Table 2. Assumptions of the effects of changes in interest rates on GDP and inflation from BEQM can then be used to broadly establish what change in interest rates would be equivalent to QE.[9] Averaging across the results of these papers suggests that QE1 effectively reduced Bank Rate by around 340bp.

Table 2: Estimates of QE's Impact on Macroeconomic Variables

Paper	Approach	GDP Estimates				Inflation Estimates			
		Impact on GDP (%)		Equivalent I-Rate Cut (bp)		Impact on Inflation (%)		Equivalent I-Rate Cut (bp)	
		Estimated for QE1	Implied for QE2	Estimated for QE1	Implied for QE2	Estimated for QE1	Implied for QE2	Estimated for QE1	Implied for QE2
UK									
Joyce et al. (2011)	SVAR	1.50%	0.56%	429	161	0.75%	0.28%	150	56.25
	Bottom-up approach	1.5%-2.5%	0.56%-0.94%	429-714	161-269	0.75%-2.5%	0.28%-0.94%	150-500	56-188
Bridges and Thomas (2011)	Monetary model	2.00%	0.75%	571	214	1.00%	0.38%	200	75
Kapetanios et Al. (2011)	Time-series model	1.50%	0.56%	429	161	1.25%	0.47%	250	93.75
Posen (2011)	Rough estimates	1.50%	0.56%	429	161	-	-	-	-

The third approach is to draw inferences from the US' experience of QE, which has been analysed in greater depth. A range of studies suggest that the Fed's second round of asset purchases were equivalent to around a 0.6%-0.8% cut in interest rates. (For a summary, see Williams, 2011). Using GDP to normalise that estimate suggests that the first batch of QE in the UK (which was proportionally bigger than the Fed's second round of asset purchases) may have been approximately equivalent to a 2.1%-2.8% reduction in Bank Rate.

These three approaches therefore converge on a plausible conclusion that QE1 effectively lowered official interest rates by around 3%. There are question marks, however, over whether the £75bn of asset purchases sanctioned under QE2 will be as effective, pound for pound. So far, the evidence suggests that QE2 is having *smaller* effects – the 'announcement effect' following the resumption of QE was slighter (see Chart 10 again); the reduction in the gilt-OIS spread has been less pronounced (see Chart 11); riskier asset prices (such as UK equities and corporate bonds) have not outperformed those in the other economies where further QE has not been undertaken.

Nevertheless, for the purposes of formulating an IRRF, it is policymakers' *expectations* of QE's effectiveness that matters. It therefore seems reasonable to assume that, when the Committee decided to launch QE2, it thought the asset purchases would be as effective as the first round. The £75bn of QE2 can therefore be treated as an additional 1% cut in official rates. Collectively then, these estimates suggest that Bank Rate is currently effectively around *minus 3.5%*.

[9] Specifically, the Bank's model assumes that an unanticipated 100bp cut in the short-term nominal interest rate for one year boosts the level of GDP by 35bp after a year and increases CPI inflation by about 50bp after 18 to 24 months.

Results

So, how well do the proposed rules describe the level of (QE-adjusted) interest rates over the last fifteen years? (Table 3 summarises the results). The results *shout* that UK monetary policy cannot be seen through the prism of a traditional Taylor rule. Estimation of Rule 1 – the simple, current period rule – yields a *negative* coefficient on the inflation variable, implying that the MPC acted in a procyclical way (i.e. it cut interest rates when inflation was above target!). The standard error of the regression is large and the errors cannot be treated as 'white noise'. Rule 2 – the gradualist Taylor rule – yields similarly dubious results.

Table 3: Summary of Results

	Simple Taylor Rule	Gradualist Taylor Rule	Forward-looking Taylor Rule	Proposed Rule A	Proposed Rule B
	(1)	(2)	(3)	(4)	(5)
Constant	5.01	0.83	0.14	-0.26*	-0.03*
Inflation	-1.25	-0.31	1.51	1.49	1.42
Output Gap	2.88	0.63	-0.01*	-0.17*	-
Inflation Expectations	-	-	-	0.55	0.47
Lagged Interest Rate	-	0.82	0.94	0.99	0.95
R-squared	0.86	0.97	0.98	0.98	0.98
S.E. of regression	1.20	0.61	0.45	0.42	0.42
F-statistic	165.15	473.98	865.01	753.44	995.22
Akaike info criterion	3.26	1.91	1.32	1.19	1.18
Durbin-Watson stat	0.71	1.15	1.27	1.35	1.23

Note: * Indicates insignificant at the 95% confidence level

Rule 3 – the forward-looking Taylor Rule – does a somewhat better job of predicting the level of interest rates during this period. In particular, the coefficient on the inflation variable (the deviation of the two-year-ahead inflation forecast from target) is positive and greater than 1, suggesting that the MPC 'leaned against the wind' and increased interest rates by more than inflation to bring it back to target. Indeed, the coefficient of 1.5 is in line with Taylor's recommended value and the results of previous studies. (See the Appendix.) However, the coefficient on the output gap is small and insignificant, suggesting that the MPC did not try to target stabilise output fluctuations around its trend. Crucially, this result is robust to variations in the method of calculating the output gap[10] and to variations in the time horizon at which the MPC is thought to have responded to the gap.[11]

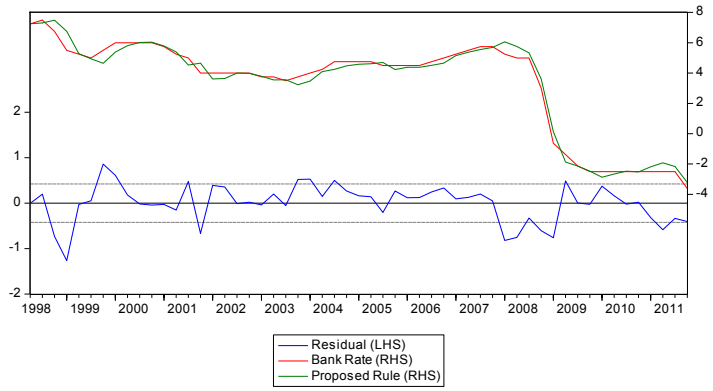
Introducing the measure of bond markets' long run inflation expectations to the rule (rule 4) improves the results significantly.[12] In contrast to the output gap term, the inflation expectations term is highly significant. Removing the insignificant output gap term from this rule – rule 5 – improves the results further.[13] The results of rule 5 are depicted in Chart 12.

The proposed rule suggests that the MPC acted in a broadly consistent way over the whole period – there are few occasions when the rule suggests a substantially different interest rate. Indeed, the MPC's decision to cut interest rates sharply in 2008/09 seems to have been consistent with its past behaviour. This implies that the relative stability of interest rates during the pre-financial crisis period reflected a stable economy, rather than any inherent conservativeness of the MPC. In addition, the decision to undertake asset purchases in 2009/10 – and restart QE in Q4-2011 – also seems to have been consistent

[10] The coefficient on the output gap was insignificant for both the higher and lower values of lambda – the aforementioned smoothing parameter used for calculating the output gap.
[11] A weak correlation was present between interest rates and estimates of the output gap a few quarters' ahead. However, this just reflected the influence of the output gap estimate on the Bank's inflation forecast, rather than any direct response by the MPC to it.
[12] For example, the standard error of the regression falls and there is little additional information contained in the errors.
[13] The F-statistic of rule 5 exceeds those for other equations. The standard error of the equation is low and econometric tests suggest that the errors can be approximately treated as white noise.

with the MPC's past behaviour.[14] As a result, even though the MPC does not follow a pre-determined rule, it seems as if it has acted in a 'rule-like' manner.

Chart 12: Proposed Rule B (%)



Source: Author Calculations

Conclusions and Scenarios

Evidence has been presented to support three conclusions. First, the MPC set monetary policy over the last fifteen years with reference to more than its own inflation forecasts. Indeed, adding a measure of bond markets' inflation expectations to a forward-looking IRRF substantially improved its ability to explain the level of nominal interest rates during this period. This suggests that policymakers used interest rates to try to anchor private sector inflation expectations to the inflation target, possibly to establish the credibility of the newly independent MPC. It also provides a role for the constraint placed on policymakers from financial markets where previously there was none in the Taylor rule literature.

Second, no direct role could be found for the output gap in an IRRF, supporting arguments that it has become a less important determinant of inflation and interest rates in recent years. Only its effect on the Bank's inflation forecast mattered – the MPC appears to have had no desire to achieve wider output objectives, suggesting that it has been a pure inflation targeter.

Third – and perhaps most importantly – the zero lower bound and the adoption of unconventional policy measures were shown **not** to impede the application of IRRFs to recent monetary policy. Quite the contrary; the results show that the decision to undertake QE can be modelled as a consistent extension of its prior 'reaction function'.

This final conclusion may yield considerable insights, since it enables inferences to be made about the likely future pace of monetary loosening or tightening based on policymakers' past behaviour, contingent on certain scenarios. Charts 13-14 set out illustrative paths for Bank Rate, given scenarios of deviations of inflation and inflation expectations from their respective targets.[15] Policy communications suggest that it can be assumed that any monetary tightening will be delivered first of all through higher interest rates, while further monetary easing will be delivered through additional asset purchases.

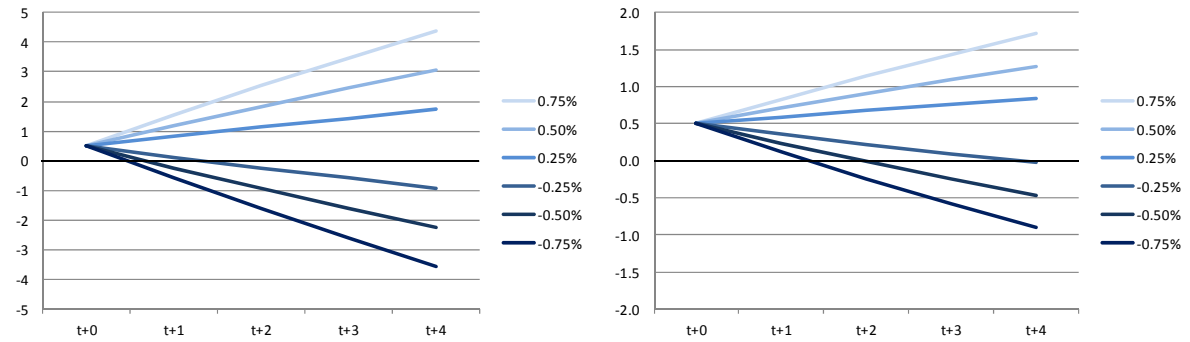
The proposed rule suggests that interest rates would rise to around 3% by the end of the year if the MPC expected two-year-ahead inflation to be 0.5% above the target for four consecutive quarters. Conversely, if it projected inflation to be 0.75% below the target for the same period (as indeed, it predicted in the November 2011 *Inflation Report*), then the MPC may purchase assets to impart stimulus equivalent to a 4% cut in interest rates. The earlier rule of thumb suggests that around £270bn of assets would be

[14] For the econometricians amongst us, recursive residuals analysis suggested that there was no evidence of a structural break beyond 2008. Meanwhile, Chow Breakpoint and Forecast tests suggest that the null hypothesis of no difference in variance of the errors between the periods before and after the proposed structural break cannot be rejected at any quarter from 2009 onwards.
[15] In the case of inflation expectations, 'target' is used to refer to the level of break-even inflation rates consistent with expectations of CPI inflation hitting the 2% target.

purchased.[16] Similarly, if financial markets feared deflation, resulting in 10-year break-even inflation rates falling to 0.5% below the level consistent with the inflation target for four quarters, the rule suggests that around £70bn of assets might be purchased to affect a 1% cut in official interest rates. [17]

Clearly, these projections are illustrative – no doubt the MPC will exercise discretion in the years ahead. Nonetheless, they should prove to be a useful guide for the likely timing and extent of changes in interest rates during the MPC's next fifteen years.

Charts 13-14: Scenarios for Bank Rate under Assumed Deviations of the MPC's Inflation Forecast (LHS) & Bond Market Inflation Expectations (RHS) from Target (%)



Source: Author Calculations

[16] £200bn was shown to be broadly equivalent to reducing interest rates by 300bp. So £270bn more QE would be required to effect a 400bp reduction in interest rates.
[17] Using the same methodology as the above footnote points to £67bn of purchases.

Appendix 1: Previous Best Estimates of IRRFs for the United Kingdom

* Indicates significant at the 95% level

		Coefficients					
Paper	Period	Inflation	Output Gap	Exchange Rate	Lagged Interest Rate	Other variables	Notes
Clarida et al. (1998)	1979M6–1990M10	0.98*	0.19*	—	0.92*	—	Baseline variant; policymakers respond to one-year ahead forecasts of inflation and output gap.
	1979M6–1990M10	0.48*	0.28*	0.60*	0.87*	—	Baseline with German interest rate variant.
Dornbusch et al. (1998)	1986M4–1995M4	0.20	0.29	—	0.98*	Lagged INF 0.26, GER IR 0.64, lagged GER IR, 0.63	Short run coefficients; Unit root problem so no long run coefficients given
Angeloni and Dedola (1999)	1980M1–1987M12	0.32*	0.60*	1.32*	0.87*	M3, real ER	Bivariate GMM estimation of reaction functions for GER and UK; backward and forward inflation variants.
	1988M1–1997M4	0.93*	0.73*	0.45*	0.86*	$/DM ER	—
Kuttner and Posen (1999)	1984M1–1989M12	1.64*	[-0.21]	—	0.86*	—	Unemployment in place of output gap; long run coefficients calculated from short-run results reported.
	1992M10–1999M4	0.52	[-0.29*]	—	0.79*	—	—
Muscatelli et al. (2000)	1985Q1–1996Q3	1.40*	0.64*	—	—	—	Recursive least squares; variable addition tests also carried out for money growth, ER, German IR.
Nelson (2000)	1979Q2–1987Q1	0.38*	0.15*	—	0.37*	—	Forward-looking
	1987M3–1990M9	0.00	0.45*	1.11*	0.52*	—	Inflation coefficients are restricted to zero
	1992Q4–1997Q1	1.27*	0.47*	—	0.29*	—	Forward-looking
Adam et al. (2001)	1990M10-1997-M4	1.1*	0.39*	—	—	0.29* on German IR, 0.27* on US IR	—
	1997M6-2000M8	2.04*	1.15*	—	—	—	—
Chadha et al. (2004)	1979M9-2000M12	1.04*	0.24	—	0.79*	—	One quarter ahead for inflation and output gap
	1979M9-2000M12	1.03*	0.54*	0.06*	0.89*	0.01* on asset prices	One quarter ahead for inflation and output gap
Martin and Milas (2004)	1992Q4-2000Q1	1.40 / 2.61	—	—	0.47	—	1.40 below target, 2.61 above target. No response to output gap
Adam et al. (2005)	1985M4-1990M9	1.19*	-0.45	—	0.87*	US and German IR highly significant	Based on current inflation and output gap
	1992M10-1997M4	0.69*	0.32*	—	0.64*	US and German IR significant	Forecast for inflation nine months ahead used
	1997M4-2002M7	1.89*	1.30*	—	0.85*	US and German IR insignificant	Forecast for inflation nine months ahead used
	1992Q4-2005Q4	1.76*	0.91*	0.10*	0.82*	USD exchange rate, 0.4* on US IR	Forecast for inflation nine months ahead used
	1992Q4-2005Q4	1.84*	1.09*	0.06*	0.84*	German (euro) ER, 0.31* on German IR	Forecast for inflation nine months ahead used
Goodhart (2005)	1997Q3-2003Q3	2.29*	-0.18	—	0.92*	—	Forecast for inflation and output gap eight quarters ahead.
Cobham (2006)	1999Q1-2005Q4	0.01	0.76*	—	0.61*	—	Forecast for inflation three quarters ahead used
	1999Q1-2005Q1	0.27	0.43*	—	0.51*	0.86* on serial correlation parameter	Forecast for inflation three quarters ahead used
Groth and Wheeler (2008)	1997Q1-2007Q3	1.52*	0.09	—	0.97*	—	Forecast for inflation and output gap six quarters ahead.
Paez-Farrell (2009)	1992M4-2004M4	1.10*	1.67*	—	0.79*	—	Forward-looking rule, four quarters horizon for both inflation and the output gap.
Baxa et al. (2010)	1975Q1 -2007Q4	0 - 1*	0.2 - 0.3*	—	0 - 0.4*	—	Time-varying parameters

Detailed references available on request.

Bibliography

Bridges, J. and Thomas, R. (2011), 'The impact of QE on the UK economy — some supportive monetarist arithmetic', Bank of England Working Paper, forthcoming.

Chen, H., Curdia, V. and Ferrero, A. (2011), 'The Macroeconomic Effects of Large-Scale Asset Purchase Programs', Federal Reserve Bank of New York Working Paper, 1st November.

Chung, H., Laforte, J.P., Reifschneider, D. and Williams, J.C., (2011), 'Estimating the Macroeconomic Effects of the Fed's Asset Purchases', FRBSF Economic Letter, 31st January.

Evans, C.L., and Marshall, D.A., (1998), "Monetary Policy and the Term Structure of Nominal Interest Rates: Evidence and Theory," Carnegie-Rochester Conference Series on Public Policy, Vol. 49(1), pp.53-111.

Goodfriend, M., (1993), Interest Rate Policy and the Inflation Scare Problem: 1979-1992. Federal Reserve Bank of Richmond Economic Quarterly 79 (Winter), pp.1–23.

Iakova, D., (2007), 'Flattening of the Phillips Curve: Implications for Monetary Policy,' IMF Working Paper, WP/07/76.

Joyce, M., Tong, M. and Woods R., (2011), 'The United Kingdom's quantitative easing policy: design, operation and impact', Bank of England Quarterly Bulletin, Q3 2011, pp.200-212.

Kapetanios, G., Mumtaz, H., Stevens, I. and Theodoridis, K. (2011), 'Assessing the economy-wide effects of quantitative easing', Bank of England Working Paper, forthcoming.

Mishkin, F. S., (2007), Inflation Dynamics, Speech at the Annual Macro Conference, Federal Reserve Bank of San Francisco, San Francisco, California, 23rd March 2007.

Nelson, E., (2011), Key Aspects of Quantitative Easing in the United States and the United Kingdom. Prepared for "Monetary Policy Before, During, and After the Crisis," Heriot-Watt University, Edinburgh, 29th-30th September.

Orphanides, A., (1997), 'Monetary Policy Rules Based on Real-Time Data,' FEDS discussion paper no. 1998-3, Federal Reserve Board, December.

Poole, W., (2005), "Understanding the Term Structure of Interest Rates," Federal Reserve Bank of St. Louis Review, Vol. 87(5), pp.589-595.

Posen, A., (2011), 'How to do more', Speech given at Wotton-under-Edge, Gloucestershire, 12th September.

Sentance, A., (2011b), 'The Challenges of the 'New Global Economy'?' Speech at the Jersey Chamber of Commerce, St Helier, 25th May.

Taylor, J.B., (1993), 'Discretion versus policy rules in practice,' Carnegie-Rochester Conference Series on Public Policy, Elsevier, vol. 39(1), pp.195-214, December.

Tucker, P. (2011), 'A few remarks on current monetary policy in a rebalancing Economy,' Speech to the Joint 1900/City Club Lunch, London, 22nd November.

Williams, J., (2011), 'Unconventional Monetary Policy: Lessons from the Past Three Years'. Federal Reserve Bank of San Francisco Economic Letter, 3rd October, 2011.