USING REAL-TIME OUTPUT GAPS TO EXAMINE PAST AND FUTURE POLICY CHOICES

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Alternative measures of the UK output gap are considered for 1984–2007. The real-time series is strongly affected by the rolling-time estimation of the trend, and produces a picture of the business cycle which is not consistent with contemporary perceptions of the large fluctuations of the late 1980s and early 1990s. A new, 'nearly-real', measure developed here may be better for estimating historical reaction functions. In the context of the current recession, none of these mechanically derived measures of the output gap are useful. Policymakers should make careful estimates of the likely fall in potential output on the basis of other information.

Keywords: Output gap; real-time; quasi-real; nearly real; Taylor rule

JEL Classifications: E52; E58

1. Introduction

The real-time output gap – roughly, the difference between actual and estimated potential output as observed in real time – is a convenient way of summarising the state of the economy. It can be and has been used in analyses of how policy was made in the past, notably in regressions of Taylor rules and other reaction functions. It can also be used as an input into the making of current and future policy. Indeed, much of the contemporary debate on the use of real-time economic data has been concerned with efficient estimation of recent, current and future economic conditions – so-called 'backcasting', 'nowcasting' and 'forecasting' (e.g. Diron, 2008; Garratt *et al*, 2008; Giannone *et al*, 2008; Mitchell, 2009; Planas and Rossi, 2004; Castle, Fawcett and Hendry, 2009), in which the policymaker makes use of both the latest statistical data and information on how such data have been revised by the statistical authorities in the past.

In trying to understand the behaviour of policymakers in the past, it seems clearly desirable to use exactly the data they had available at the time when they made their decisions; the use of different data might lead to incorrect estimates of their behaviour. However, whilst the logic of using real-time data seems clear, a number of authors, including Orphanides and van Norden (2002, 2005) in the context of the US economy, Rünstler (2002) for the Euro area, and Bernhardsen *et al* (2005) for Norway – all of whom have been concerned mainly with future policymaking – have raised concerns about the unreliability of real-time measures of the output gap in particular. Part of the problem lies with the effect of subsequent revisions to output data, but the greater concern is with the implications of using real-time data releases for the contemporaneous estimation of unobservable potential output, around which the output gap is measured. In fact, with few exceptions, the literature on estimating Taylor rules has tended not to address this issue (see, for example the work by Clarida, Galí and Gertler, 1998, 2000; Nelson, 2000; Adam, Cobham and Girardin, 2005; Hayo and Hoffman, 2006).[1]

In this paper we discuss the properties of alternative measures of the output gap in the UK over the past 25 years, in particular their ability to identify the timing of turning points in the business cycle. We then consider how policymakers might take account of such measures as the UK begins to move out of the current recession. We suggest that the use of real-time output gap measures to analyse the historical behaviour of the monetary authorities – for example in the estimation of Taylor Rules – may result in a seriously misleading representation of the actual policymaking process, especially at times when the economy is subject to large variations in actual output. We show that the underlying trends of output generated by real-time estimation are not *prima facie* plausible, and we show that the turning-points in real-time output gaps have a much less good fit than the full-sample turning-points

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with the perceptions of policymakers at the time. We also introduce a new output gap measure which may sometimes provide a more accurate historical representation of the authorities' assessment of the true output gap than conventional real-time or full-sample measures, especially in relatively turbulent times.

Three preliminary points should be noted. First, we follow the bulk of the literature in this area in concentrating on output gaps derived as the difference between actual output and a 'mechanically' estimated trend series. We also confine attention to univariate estimators of the output gap.[2] There are three main alternatives to this procedure. One approach, favoured by the OECD (eg Giorno *et al*., 1995) and the European Commission (eg Denis *et al*., 2002; Denis *et al*., 2006), derives potential output directly by feeding data on factor inputs into an estimated production function.[3] A number of authors have recently made use of the output gap forecasts contained in successive December issues of the OECD's *Economic Outlook*, which use forecasts of potential output produced by the Giorno *et al.* (1995) method (e.g. Forni and Momigliano, 2004; Cimadomo, 2007; Bernoth *et al*., 2008; Darby and Mélitz, 2008).[4] A second alternative is to study what the authorities believed at each point in time about the trend in output and, using real-time data on actual output, to construct a series for the real-time output gap on that basis, as is done by Nelson and Nikolov (2003). A third, related, alternative is to make a detailed reading of the historical record of what the authorities believed at each moment in time about the output gap itself. We discuss the last two of these in a later section.

Secondly, we analyse series for the output gap derived on the basis of two popular techniques – the linear and quadratic trend (LQ) and the Hodrick-Prescott filter (HP)[5] – in order to help ensure that our results are not dependent on a specific univariate detrending technique. However, our concern is with the choice between *measures* rather than the choice between *techniques*. Thirdly, for the estimation of trend output, we use data from 1974 only, so that the issue of a break in the trend at the end of the Bretton Woods/'long boom' period of the 1950s–1960s can be ignored.

The next section of the paper presents the full-sample and real-time output gaps, together with the 'quasi-real' measure introduced by Orphanides and van Norden (2002) and a new measure, which we call 'nearly real-time' or 'nearly-real', for the period 1984 to 2007. Section 3 then asks how these measures relate to the policymakers' contemporaneous perceptions and responses. It focuses on the two large cyclical fluctuations in UK output in the period, that is the so-called 'Lawson Boom' of 1988–9 and the subsequent recession of 1991–2, and then on the smaller cyclical fluctuations since 1994 when the various measures of the output gap are closer together. Section 4 returns to the basic underlying concept to argue that while none of the possible real-time measures of the output gap are entirely satisfactory, there is little to choose between alternative measures in relatively stable periods, but when the economy is subject to significant movements in actual output, the 'nearly real' measure may offer the best characterisation of policymakers' perceptions. Section 5 then considers how useful the various measures of the output gap would be for policymakers as the UK begins to move out of its current recession, using the latest quarterly forecasts of the Bank of England to generate the alternative measures up to 2012Q3. Section 6 concludes.

2. Full sample, real-time, quasi-real and nearly real gaps

The real-time output gap at any point in time is computed as the deviation of actual output from an estimated trend where both are based exclusively on the data available to policymakers at that time. There are two differences between this series and one computed on the basis of a 'full' sample of data extending beyond this point. The first is that the real-time series is constructed from contemporary unrevised data on output rather than the revised data which become available later and are used in the full sample series, and the second is that the estimated trend in output is estimated on a rolling basis on data only up to the date of each observation, whereas the full sample series uses the whole range of the data to compute the trend. Between the real-time and full-sample measures we can define two alternative measures. The first is the 'quasi-real' output gap, proposed by Orphanides and van Norden (2002), which is computed using the final (full-sample) revised data but only for the period up to each observation; the second, which we will term the 'nearly real' gap, uses contemporary unrevised data on actual output but takes the trend from the full sample data. Thus, while the quasi-real series eliminates the effect of data revisions (but not the effect of estimating the trend in 'real time'), the nearly-real series eliminates the effect of real-time estimation of the trend but keeps the original real-time data. The way these four measures of the output gap relate to each other is as follows:

Alternative measures of the output gap

		Data	
		Contemporary	Revised
Estimation of trend	Rolling Full sample	Real-time Nearly real	Quasi-real Full sample

Figures 1 and 2 show the full sample and real-time output gaps for the UK estimated using the linear and quadratic (LQ) and Hodrick-Prescott filter (HP)[6] techniques from 1984.[7] In figure 1 it is noticeable that the LQ series fluctuates more widely than the HP series, particularly in the Lawson boom and the subsequent recession. This is less true for the real-time series in figure 2, but more importantly there is a prolonged period, from 1993 Q3 to 1996 Q4, when the HP gap is positive and the LQ gap negative.

Figure 1. Full-sample output gaps 1984:2–2007:4

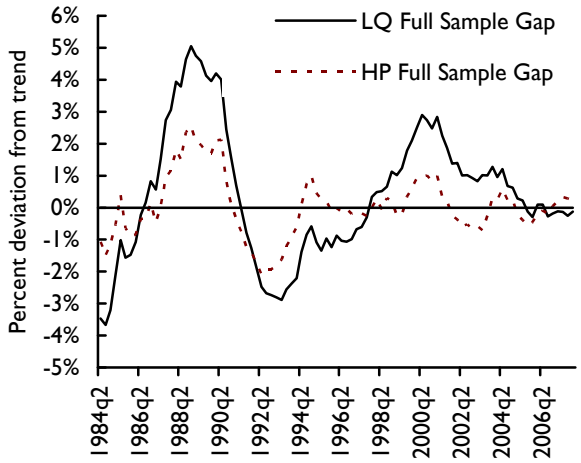
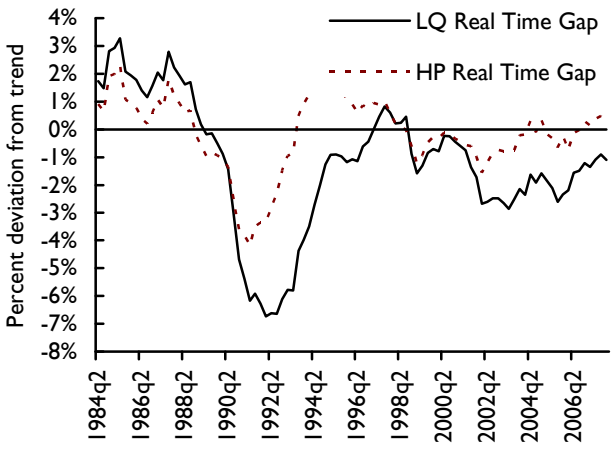


Figure 2. Real-time output gaps 1984:2–2007:4



Figures 3 and 4 show the full sample and real-time series for the LQ and HP techniques respectively. In both cases the real-time series turns down in late 1987 well before the full sample series, and falls in 1991–2 well below the full sample series. The implication is that policymakers using the real-time series would have underestimated the size and duration of the boom (as shown by the full sample series), but then would have exaggerated the depth and the extent of the subsequent recession.

The same figures also show the series for the 'quasi-real' output gap. In both cases the quasi-real series is nearly always closer to the real-time series than to the full sample series. In particular, both the quasi-real series start to fall in late 1987 or early 1988 around the same

Figure 3. Linear quadratic output gaps 1984:2–2007:4

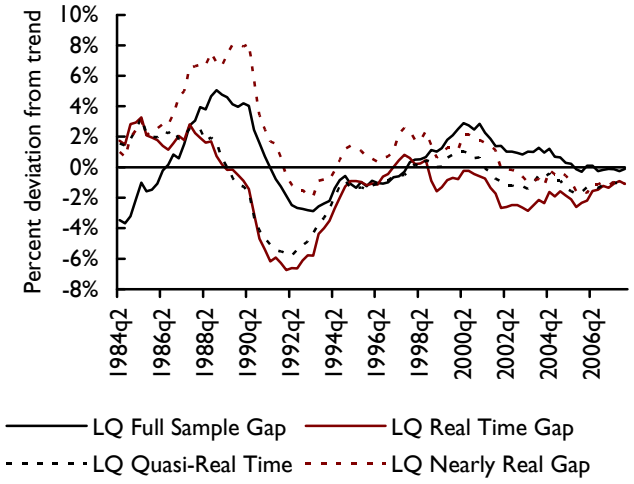


Figure 4. Hodrick-Prescott output gaps 1984:2–2007:4

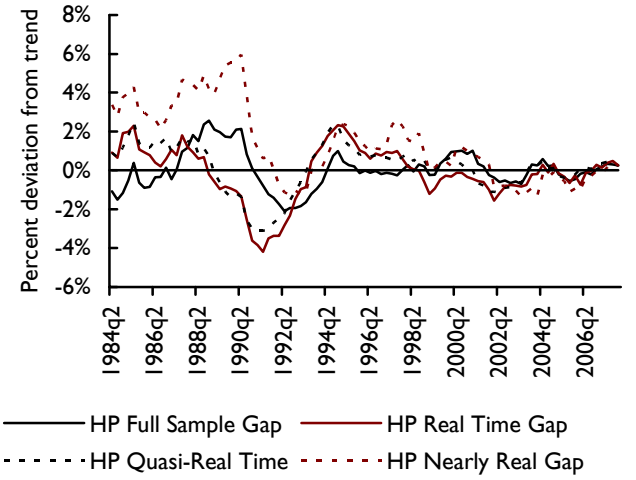


Table 1. UK Output gap measures, 1984 Q2–2007 Q4, summary statistics

	Linear Quadratic				Hodrick-Prescott			
	Full sample	Real-time	Quasi-real time	Nearly-real time	Full sample	Real-time	Quasi-real time	Nearly-real time
1984:2 to 2007:4								
Mean	0.43%	–1.23%	–0.75%	1.55%	0.03%	–0.13%	0.12%	1.31%
s.d.	0.020	0.024	0.021	0.027	0.010	0.014	0.012	0.020
1984:2 to 1993:4								
Mean	0.42%	–1.12%	–0.79%	3.26%	–0.03%	–0.48%	–0.13%	2.57%
s.d.	0.029	0.036	0.032	0.033	0.014	0.018	0.017	0.022
1994:1 to 2007:4								
Mean	0.43%	–1.30%	–0.72%	0.36%	0.08%	0.12%	0.30%	0.44%
s.d.	0.012	0.010	0.008	0.012	0.005	0.009	0.008	0.011
Correlations between gap measures								
1984:2 to 2007:4								
Full sample	1.00				1.00			
Real time	0.29	1.00			0.22	1.00		
Quasi-real	0.36	0.96	1.00		0.23	0.95	1.00	
Nearly real	0.68	0.52	0.45	1.00	0.60	0.33	0.25	1.00
1984:2 to 1993:4								
Full sample	1.00				1.00			
Real time	0.32	1.00			0.20	1.00		
Quasi-real	0.30	0.99	1.00		0.17	0.97	1.00	
Nearly real	0.94	0.57	0.53	1.00	0.84	0.48	0.39	1.00
1994:1 to 2007:4								
Full sample	1.00				1.00			
Real time	0.10	1.00			0.31	1.00		
Quasi-real	0.76	0.64	1.00		0.48	0.88	1.00	
Nearly real	0.27	0.78	0.69	1.00	0.44	0.70	0.65	1.00

Note: See text for description of alternative output gap measures.

time as the real-time series, and both fall well below the corresponding full sample series in the early 1990s.

Table 1 gives basic statistics on the various gap measures and the correlation between them over the whole period and for the subperiods 1984–93 and 1994–2007, while table 2 reports the turning points, amplitude and duration of the output gap series using the Bry-Boschan business-cycle dating algorithm.[8] The statistics confirm the evidence of the figures that the real time and quasi-real output gaps are very close, with correlations of 0.96 for the LQ and 0.95 for the HP series over the sample as a whole. On the other hand, the correlations between the real time and full sample gaps are 0.29 and 0.22 respectively, while the corresponding correlations between the quasi-real and full-sample gaps are 0.36 and 0.23. The implication is that for the UK over this period only a small part of the difference between full sample and real time gaps is the result of the subsequent revisions to the data themselves. Rather, the bulk of the difference reflects the basis on which the underlying trend in output is estimated.

The use of rolling real-time estimation of the trend appears to introduce a systematic distortion, reflecting what Orphanides and van Norden (2002, p. 582) refer to as the 'pervasive unreliability of end-of-sample estimates of the output trend'. To see this we examine the implied trends in output which lie behind each of the gap series. Figures 5 and 6 show the trends for the full sample, real-time and quasi-real series as estimated by the LQ and HP techniques respectively. In figure 5, while the full sample trend output grows at a roughly constant rate (i.e. there is minimal non-linearity), the real-time and quasi-real trend outputs grow rapidly in the late 1980s but stagnate or even, for a few quarters of the real-time trend, fall in the early 1990s. The same feature can be seen in figure 6; while the full sample HP trend fluctuates a little more than the full sample LQ trend in figure 5, the real-time and quasi-real HP trends actually turn down significantly in the early 1990s, reaching levels in early 1993 which are well below the peaks of 1990. Such reductions in potential output are implausible: the recession of the early 1990s was not due to a negative technology shock, or even an oil price

Table 2. Output gap characteristics

Gap measure	Peak[a]	Trough[a]	Amplitude[b]	Trough[a]	Peak[a]	Amplitude[b]	Cycle duration[c]
Linear quadratic							
Full sample	88:4	93:2	–7.9%	93:2	00:2	5.8%	47
	00:2	03:1	–2.1%	03:1	04:2	0.3%	17
	04:2	05:4	–1.5%	03:2			
Real-time	85:2	86:3	–2.1%	86:3	87:3	1.6%	10
	87:3	92:1	–9.5%	92:1	97:3	7.6%	41
	97:3	99:1	–2.4%	99:1	00:3	1.3%	13
	00:3	03:2	–2.6%	03:2	04:4	1.3%	18
	04:4	05:3	–1.0%	05:3	07:3	1.7%	12
Quasi-real	85:2	92:2	–9.0%	92:2	98:3	6.3%	54
	98:3	99:1	–0.4%	99:1	00:1	1.0%	7
	00:1	03:2	–2.5%	03:2	04:2	1.0%	18
	04:2	05:3	–1.3%	05:3	07:2	0.7%	13
Nearly real	90:2	93:2	–10.0%	93:2	95:1	3.3%	20
	95:1	96:2	–1.1%	96:2	97:3	2.2%	11
	97:3	99:1	–1.9%	99:1	00:2	1.5%	12
	00:2	03:2	–3.1%	03:2	04:4	0.7%	19
	04:4	06:1	–1.4%	06:1	07:3	0.9%	12
Hodrick-Prescott							
Full sample	88:4	92:2	–4.6%	92:2	94:4	3.1%	25
	94:4	97:3	–1.3%	97:3	00:3	1.3%	24
	00:3	03:2	–1.7%	03:2	04:2	1.3%	16
	04:2	05:3	–1.1%	05:3	07:2	0.9%	13
Real-time	85:2	86:3	–2.0%	86:3	87:3	1.6%	10
	87:3	91:2	–5.9%	91:2	94:4	6.5%	30
	94:4	99:1	–3.5%	99:1	00:2	1.1%	23
	00:2	02:1	–1.4%	02:1	04:4	1.9%	19
	04:4	06:1	–1.4%	06:1	07:3	1.2%	12
Quasi-real	85:2	91:1	–5.5%	91:1	94:3	5.4%	38
	94:3	99:2	–2.3%	99:2	00:1	0.6%	23
	00:1	02:2	–1.8%	02:2	04:2	1.6%	18
	04:2	05:3	–0.9%	05:3	07:2	0.9%	13
Nearly real	85:2	86:3	–2.1%	86:3	90:2	3.8%	21
	90:2	92:3	–7.2%	92:3	95:1	3.6%	20
	95:1	96:2	–1.4%	96:2	97:3	1.6%	11
	97:3	99:1	–2.6%	99:1	00:2	1.2%	12
	00:2	03:2	–2.5%	03:2	04:4	1.3%	19
	04:4	05:3	–1.0%	05:3	07:3	1.5%	12

Notes: (a) Peaks and troughs identified by Bry-Boschan (1971) technique. (b) Amplitude measures percentage point movement around trend from peak-to-trough and trough-to-peak. (c) Cycle duration measured peak-to-peak.

shock which required serious restructuring, it was the result of a tightening of monetary policy designed to bring inflation back under control after the boom of the late 1980s. In each case the real-time and quasi-real trends come more or less back into line with the full sample trends in the late 1990s/early 2000s.

Figures 3 and 4 also show our proposed 'nearly real' measure of the output gap, which uses the full sample trend but the contemporary unrevised output data, and Tables 1 and 2 include the basic statistics and turning points for this measure. It turns out that the nearly real gaps are typically closer to the full sample gaps than to the real-time gaps. In particular, both the LQ and HP nearly real gaps are a bit above the corresponding full sample gaps in 1989–90, they fall more or less in line with the full sample gaps during 1991–2, and they are relatively close to the full sample gaps from the mid-1990s. The correlations between these two series in table 1 for the period as a whole are 0.68 for the LQ, and 0.60 for the HP; in both cases these are the highest correlations with the full-sample series.

Figure 5. Linear quadratic output trends 1984:2–2007:4

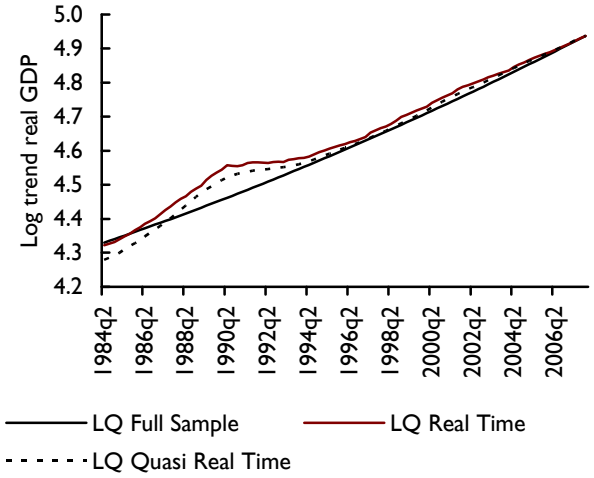
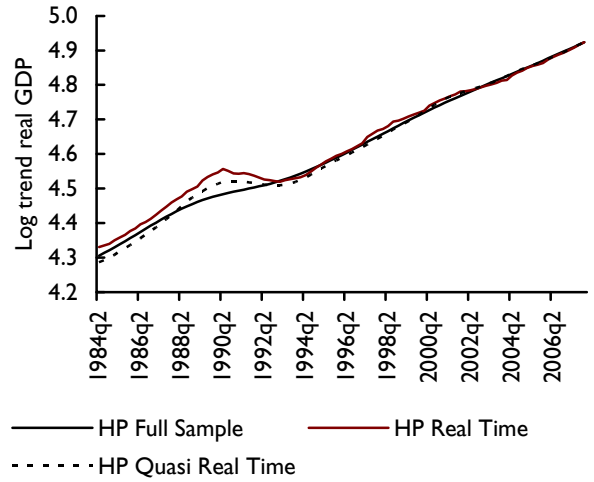


Figure 6. Hodrick-Prescott output trends 1984:2–2007:4



3. Policymakers' perceptions and responses

As is already evident from the figures, there were two large cyclical fluctuations in this period: a strong boom in the late 1980s, often referred to as the 'Lawson boom' after the Chancellor of the Exchequer of the time, and the deep recession of the early 1990s. From the mid-1990s to the outbreak of the current financial crisis the amplitude of the fluctuations was much smaller.

The Lawson boom

There are a number of alternative explanations for the origin of the boom, which reflected a surprising loss of control by a government that was genuinely concerned about price stability (see Cobham, 1997, and 2002, chapter 4), but for present purposes what is important is how the policymakers saw the state of economic activity, summarised here as the size of the output gap, during the course of the boom. The full sample output gaps shown in figure 1 and reported in table 2 identify the peak for the output gap as 1988Q4 with a secondary peak in 1990Q1 or Q2, and only after that a strong downward trend which makes the gaps turn negative in 1991Q1 (HP) and Q3 (LQ). Figure 2 shows the real time gap as reaching a peak in 1987Q3, with a small secondary peak in 1988Q3, but becoming negative in 1988Q4 (HP) or 1989Q2 (LQ). From figures 3 and 4 the quasi-real series are always close to the real-time series, while the nearly real series reach their peak later than the full sample series, in 1990Q2, but fall precipitately from that point.

In the initial stages of the boom policymakers believed that the whole UK supply side had improved and underlying economic growth with it.[9] Indeed Lawson explains in his memoirs that he first became convinced that there was a serious problem only when he saw the trade figures in mid-1988: "it was clear to me that demand in the economy was pressing against the limits of capacity to a much greater degree than I had previously realized, and that decisive action was required" (Lawson, 1992, p. 845). There was a further deterioration in the trade balance in November 1988 (p. 847), while in May 1989 "evidence that the steady monetary tightening that I had embarked on as far back as the beginning of June 1988 was cooling the economy down adequately was disappointingly thin on the ground" (p. 848).[10] At the time, identifying the state of economic activity was complicated by problems in the official statistics (notably the different growth rates of different measures of GDP), but in February 1989 the Bank of England was still reporting very high demand growth in at least the first three quarters of 1988 (*Bank of England Quarterly Bulletin*, February 1989, pp. 13–15). Even in May 1989 the Bank was cautious about the extent of the slowdown in growth in 1988Q4, while noting that the labour market had tightened further and underlying inflationary pressures were still strong (*Bank of England Quarterly Bulletin*, May 1989, pp. 178–9 and 187–9). By May 1990 the Bank was reporting that "the domestic economy is on course and domestic policy would seem to be tight enough", but it talked of "imbalances that are now starting to be corrected" (*Bank of England Quarterly Bulletin*, May 1990, pp. 162 and 173) and while in this period the Bank never

Table 3. UK interest rate changes 1984–95

Dates of changes	Change (%)	New level	Context	Main reason(s) for change given in official sources
7.3.84–15.3.84	–3/8	8.625	Sterling stable, £M3 growth.	To unwind preceding rises, encourage growth.
10.5.84–27.6.84	+5/8	9.25	Rising US rates, weaker confidence.	To keep in line with US and maintain confidence, plus technical.
9.7.84–12.7.84	+2¾	12	Rising US rates, sterling weak.	To stabilise sterling.
9.8.84–23.11.84	–2 3/8	9.625	Sterling stabilised.	To unwind preceding rises.
11.1.85–28.1.85	+4½	14	Dollar strong, sterling very weak.	To control sterling crisis.
21.3.85–19.4.85	–1¼/–1½	12.625	Dollar weaker.	To unwind preceding rises.
12.6.85–29.7.85	–1/–1¼	11.5	US interest rate cut.	As before and to maintain domestic activity.
9.1.86	+1	12.5	Oil price fall.	To counter sterling fall in response to oil price fall.
19.3.86– 23.5.86	– 2½	10	Overseas interest rate cuts March.	To undo last rise and maintain domestic activity.
14.10.86	+1	11	Sterling very weak.	To counter 'excessive' depreciation of sterling.
10.3.87–11.5.87	–2	9	Louvre accord February.	To moderate sterling appreciation.
6.8.87	+1	10	Sterling weak.	To reverse cuts unjustified on domestic grounds.
23.10.87– 4.11.87	–1	9	Concerted overseas interest rate cuts.	To counter equity market crash.
4.12.87	–½	8.5	German interest rate cuts.	As before and to prevent rise of sterling against DM.
2.2.88	+½	9	Stronger evidence of domestic boom.	To counter domestic inflation.
17.3.88–17.5.88	–1½	7.5	Abandonment of DM–shadowing.	To moderate sterling appreciation.
2.6.88–28.6.88	+2	9.5	Rising overseas interest rates.	To undo previous falls and to counter domestic inflation.
4.7.88–25.8.88	+2½	12	Rising overseas interest rates.	To counter domestic inflation.
25.11.88	+1	13	Further evidence of boom conditions.	To counter domestic inflation.
24.5.89	+1	14	Slow response to policy tightening.	To counter domestic inflation and depreciation.
5.10.89	+1	15	Other European interest rate rises.	To counter domestic inflation.
8.10.90	–1	14	UK enters ERM.	To relax monetary tightening which now taking effect.
13.2.91–12.7.91	–3	11	Sterling stable within ERM.	To stimulate domestic recovery.
4.9.91	–½	10.5	Sterling stable within ERM.	To stimulate domestic recovery.
13.2.91–12.7.91	–3	11	Sterling stable within ERM.	To stimulate domestic recovery.
4.9.91	–½	10.5	Sterling stable within ERM	To stimulate domestic recovery.
5.5.92	–½	10	Narrowing UK–German interest gap.	To stimulate domestic recovery.
16.9.92	+2 (+3)	12 (15)	Severe ERM turbulence.	To keep sterling within ERM.
17.9.92–22.9.92	–3	9	Sterling now suspended from ERM.	To undo last rise.
16.10.92–13.11.92	–2	7	New monetary policy framework.	To stimulate domestic recovery.
26.1.93	–1	6	Strong disinflationary pressures.	To stimulate domestic recovery.
23.11.93	–½	5.5	Improved inflation prospects.	To stimulate domestic recovery.
8.2.94	–¼	5.25	Likely impact of November Budget.	To stimulate domestic recovery.
12.9.94	+½	5.75	Above trend growth.	To forestall inflation.
7.12.94	+½	6.25	Government defeat on VAT.	To forestall inflation.
2.2.95	+½	6.75	Evidence of strong growth.	To forestall inflation.
13.12.95	–¼	6.5	Improving inflation prospects.	To allow growth.

Source: Extracted from Table 8.1 in Cobham (2002), which is based largely on a more detailed study of the official concerns expressed in conjunction with each change in the official policy rate.

refers to output gaps as such there is no statement that could be read as inferring that the output gap was anything other than still positive. By November 1990, however, the Bank was talking of 'domestic retrenchment', and it seems to have used the word 'recession' first in February 1991 (*Bank of England Quarterly Bulletin*, November 1990, p. 442; February 1991, pp. 3 and 6).

There seems no doubt, therefore, that policymakers' perceptions of the state of the economy in this period were much closer to the full sample or nearly real gaps than to the real time or quasi-real gaps.[11] Indeed, the timing is if anything closer to the nearly real series, which peaked in 1990Q2. In addition, the path of interest rates, with the final rise taking place in October 1989, makes better sense in terms of the nearly real

rather than the full sample, which peaked in 1988Q4. On the other hand it makes no sense in terms of the real time or quasi-real gaps, which went well below zero long before the end of the rise in interest rates. Table 3 shows the changes in interest rates over the period, together with an assessment of the main concerns underlying the changes, as identified from the *Bank of England Quarterly Bulletin*. It makes clear that from July 1988 until November 1988 the major reason for raising interest rates was concern about inflation, which in these years (as opposed to the 1960s or early 1970s) was seen by the authorities as the result of overheating of the economy, and the further rises in May and October 1989 were also driven by this concern, together with a concern about sterling depreciation.[12]

The recession of the early 1990s

On the standard definition (GDP falling for two successive quarters) the UK economy was in recession in 1991–2. The full-sample output gaps go negative in the first half of 1991, and remain negative until 1994Q2 (HP) or 1997Q4 (LQ). The nearly-real gaps go negative slightly later in 1992Q1 and remain negative until 1994Q3 (LQ) or 1993Q4 (HP). The real-time gaps, on the other hand, had fallen below zero in 1988 or 1989 but become positive in 1993Q3 (HP) or 1997Q1 (LQ). The quasi-real series are very close to the corresponding real-time series. The slowdown in growth which was occurring in 1989 was temporarily halted and marginally reversed in the first half of 1990, according to both the Bank's contemporary commentaries (*Bank of England Quarterly Bulletin*, November 1990, p. 456) and the full sample gaps in figure 1 (there is a smaller corresponding phenomenon in the real time gaps for 1989Q3 in figure 2). By 1991, when the Bank was referring to 'recession', the UK had entered the Exchange Rate Mechanism (ERM) of the European Monetary System, and with sterling stabilised interest rates were successively reduced through 1991 and the first half of 1992 in order to stimulate recovery from what was turning out to be a deeper recession than expected. The UK's exit from the ERM in September 1992 was followed by further cuts in rates designed to 'rebalance' the economy and the construction of a new monetary framework (Cobham, 2002, chapters 5–6).

The term 'output gap' was not used in the *Bank of England Quarterly Bulletin* in the period up to the end of 1992, but the first few issues of the Bank's quarterly *Inflation Reports* which were published from February 1993 contained substantial discussions of the size of the output gap. The Bank reported a number of different methods for measuring the gap which showed similar turning points but gave very different estimates of the magnitude of the gap (between 2 and 8 per cent) (*Quarterly Bulletin*, May 1993, pp. 166–8 and August 1993, pp. 309–10). The Bank expressed no clear preference between these estimates, but noted in May 1993 (p. 168) that "it is not clear that such estimates are useful without the additional piece of information about the impact of the measured gap on inflation in the past. But most models would be consistent with the view that the output gap remains sufficiently large that it is continuing to exert downward pressure on inflation." The August 1994 *Inflation Report* stated that "Inflation appears to respond to the size of the output gap, the rate at which actual output is growing relative to its long-run potential rate, and the rate at which output is growing relative to the growth rate of capacity in the short run" (p. 27). In 1995 the concept and size of the output gap were gradually displaced in the *Inflation Reports* by an emphasis on the rate of growth (absolutely or relative to some trend), supplemented in some cases by a discussion of capacity utilisation based on disaggregated survey measures for manufacturing and services; there is no mention of the output gap as such in the *Reports* from 1996 onwards.

The graphs in the May and August 1993 *Inflation Reports* show the output gap still widening as of early 1993, but the November 1993 *Inflation Report* says on one measure the gap "has closed" (p. 430), and the February 1994 *Report* notes that the different methods agree that the "gap stopped widening in 1992 and is almost certainly beginning to narrow" (p. 23). The full sample and nearly real gaps in the figures show a strong rise only from the second half of 1993, while the real-time and quasi-real gaps rise strongly from 1991Q3 (HP) or late 1992 (LQ). Thus, once again, the full sample and nearly real gaps would seem to be more consistent here with the contemporary perceptions of the policymakers. By late 1994, on the other hand, all the gap series are showing at least a local peak around 1994Q4, although they differ in size (and sign), so the decisions to raise interest rates pre-emptively for the first time since 1989 in late 1994 and early 1995 (see table 3) make sense in terms of any of the series.[13]

Smaller cyclical fluctuations from 1994 to 2007

While 1984–93 includes the major fluctuations of the Lawson boom and the subsequent recession, those between 1994 and 2007 are much smaller, and all the

various measures of the output gap are closer together. The basic characteristics of the series are reported in tables 1 and 2. In nearly all cases the means and standard deviations of the gaps in 1994–2007 are smaller than those in 1984–93. While in the first subperiod the highest correlations are those between the full sample and nearly real series (0.94 and 0.84 for the LQ and HP measures), and between the real-time and the quasi-real series (0.99 and 0.97), between 1994 and 2007 the patterns are different. Of the various LQ series the correlations between quasi-real and full sample, and between nearly real and real-time, are the highest, which is strikingly different from the first period. Between the HP series the highest correlations are those between quasi-real and real-time (as before) and between nearly real and real time. A large part of the reason for the change between this and the previous period is that, particularly in the LQ case, the underlying trends are not moving around relative to each other as much in this period as in the previous one (figures 5 and 6).

These features are also reflected in table 2. In contrast to the significant differences in the dating, duration and amplitude of the various output gap measures that emerged during the period of the Lawson boom and subsequent recession, the period from 1994, where there is greater stability in the level and growth of GDP, is characterised by a much greater degree of coherence between the various measures of the output gap, particularly the LQ measures. Although some differences exist, the turning points are generally close, with most series showing peaks in 2000 and 2004, and troughs in 2003 and 2005, and some showing a peak in 1997 or 1998. Moreover, these general movements make sense in relation to the trends in interest rates, which were rising from May to November 1997, peaked in the second half of 1998, reached their floor in mid-1999 and were at their next peak from early 2000 to early 2001, fell to their next low in summer 2003 and rose to a new peak in 2004–5. As between the different measures, the nearly real gaps (which are very similar for each of the techniques) possibly fit the pattern implied by the interest rate movements best, with their peak in 1997Q3, a minor peak in 1998Q3 (which does not, however, qualify as a peak under the Bry-Boschan algorithm), a trough in 1999Q1 and a peak in mid-2000.[14] However, since the various gap measures do not differ greatly here, in contrast to the earlier period, it seems unlikely that it would make much difference which measure was used in, for example, Taylor rule regressions for the post-1994 period. Indeed, in work referred to but not reported in our earlier paper (Adam, Cobham and Girardin, 2005) we found little difference between regressions using the full-sample and real-time gaps for the period May 1997–July 2002.

In this period the *Inflation Report* continued to make little or no reference to the concept of the output gap, even after the establishment of the Monetary Policy Committee in 1997. Between 1996 and 2001 the typical *Report* talked about the rate of growth of GDP relative (explicitly or implicitly) to trend, but did not refer to the output gap or put any number on it and only occasionally mentioned survey measures of capacity utilisation;[15] it then went on to talk about labour market tightness. Similarly the *Minutes* of the MPC do not use the term and only occasionally refer to output relative to potential or capacity.[16] In November 2002, however, there is a whole section in the *Report* on output and supply which includes a subsection on capacity utilisation presenting survey data on utilisation in manufacturing and services, and a discussion of various measures of labour market activity and tightness. This structure and content continue *mutatis mutandis* for the rest of the period, with greater emphasis at times on factor utilisation or capacity pressure within companies or productivity growth. But the term output gap remains as absent as before, and there is no attempt to put a number on the difference between actual and potential output.[17] The reason is clear; the MPC did not believe it was possible to measure the overall output gap in a reliable manner, and this view is spelt out in, for example, Lambert (2005), Bean (2005) and Bell (2004).

4. Real-time output gaps for analysing past policy: interim conclusions

We have argued that for periods with large fluctuations rolling-time estimation introduces serious distortions, so that both the real-time and the quasi-real measures are suspect; the nearly-real series is close to, but may have some advantages over, the full sample series. For more stable periods, the differences seem to be of much less importance. However, none of the measures of the output gap used here really corresponds to what policymakers look at and act upon. The full sample measures assume the policymakers have remarkably good foresight about both data revisions and the trend. The real-time measures use contemporary data as it was available to the policymakers, but, to the extent that these estimates are based on standard univariate techniques to de-trend the data on output, they imply what might be called remarkably poor foresight about

the trend. The quasi-real measures keep the poor foresight on the trend but assume perfect foresight about the data. And the nearly real measures keep the contemporary data but assume good foresight on the trend.

Actual policymakers, in contrast to all of these, use contemporary data but also have some ability to use other information in thinking about the state of the economy, for example, direct evidence on capacity utilisation and skills shortages and indirect evidence from current inflation rates; they have what might be termed imperfect but intelligent foresight.[18] Nelson and Nikolov (2003) try to make use of part of that information by identifying official beliefs about the underlying trends in the productive potential of the economy. Their exercise is of intrinsic interest, but the need for a precise measure of the gap which can be used in estimation inevitably leads to an element of over-simplification. In effect Nelson and Nikolov consider variations in trend growth rates in minimum units of 0.25 per cent or 0.5 per cent, and they assume that official views are changed abruptly, rather than changing more gradually over time. For example, according to their Table B between 1986 Q1 and 1988 Q4 the official view on potential output growth since 1981 Q4 was that it had been 2.5 per cent per year; one quarter later, in 1989 Q1, this changed to 2.75 per cent.

What Nelson and Nikolov do is essentially to identify official announcements about the trend of potential output. But policymakers, who have discretion, are at any time trying to gauge where the economy is and where its potential is, using a wide set of information and with their own views able to evolve more or less gradually at any point. Moreover, as the Bank of England has been keen to emphasise in recent years, what matters is not just the point estimate of the output gap but also its probability distribution, and the latter (as well as the former) varies over time.

An alternative procedure would be to make a detailed reading of the historical record of the making of monetary policy with a view to gauging the monetary policymakers' direct beliefs about the output gap at each point in time. But as we have seen in sections 3 and 4 UK policymakers focused explicitly on the output gap only for a brief period in 1993–4, and even then they never committed themselves to any precise statements about the size of the gap. Such a procedure is therefore even less likely to produce a measure of the output gap as perceived by the policymakers at each moment in time which is sufficiently precise and convincing to be accepted for use in regressions of reaction functions.

5. Real-time output gaps for making policy in the recession

As of late 2009 it is without dispute that there is a large negative output gap in the UK economy, and policymakers can be confident that policy should be relatively expansionary. But as and when that gap begins to close over the next two years the crucial judgement for policymakers will be how soon and by how much to tighten policy. An accurate estimate of the output gap would facilitate that judgment.

In this case, unlike that of the recession of the early 1990s, there are good reasons for thinking that potential output will be affected by the financial crisis. Indeed, successive issues of the *Inflation Report* have identified a range of effects including a reduction in total factor productivity growth due to credit shortages; reductions in potential output due to reductions in company R&D spending; and reductions in potential output from credit-shortage-induced reductions in investment (see, for example, *Inflation Report*, May 2008, p. 28; February 2009, pp. 26–7).[19] But the size of these effects is unclear.

We now use the latest published data for GDP up to 2009Q1, together with forecast data up to the third quarter of 2012 derived from applying the Bank of

Figure 7. Projected output gap estimates. Real-time gaps computed using BoE output projections August 2009. NR projections based on trends projected from 2007:4

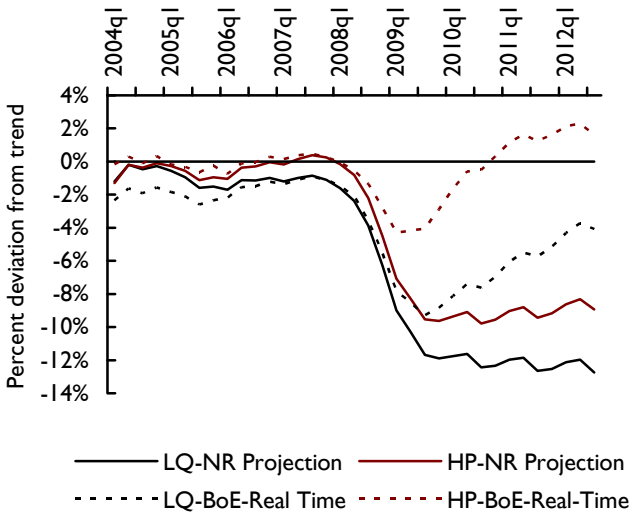
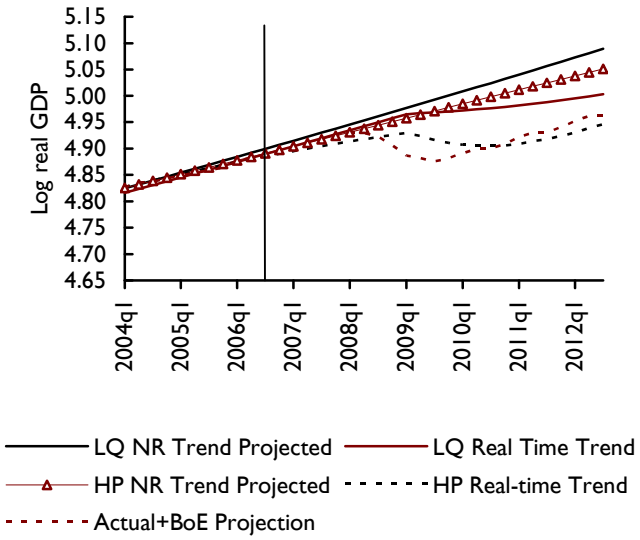


Figure 8. Alternative trend projections 2008q1–2012q3



England's growth projections in its August 2009 *Inflation Report* to the earlier actual GDP estimates. These projections[20] are for percentage growth relative to four quarters before. We then calculate the real-time output gaps from these data in the usual way, up to 2012Q3, together with nearly real gaps based on a projection of the trends in output from the full-sample calculation up to 2007Q4.[21] These projections of the output gap are shown in figure 7.

It is clear that the real-time gap measures turn up from 2009Q1 (HP) and 2009Q3 (LQ), well before most observers have been convinced or expect that the economy is moving out of recession. The reason is obviously that the real-time measures begin to assume and incorporate decreases in the trend output, as can be seen in figure 8. The nearly-real measures, on the other hand, incorporate no decline in trend growth at all, and hence show much larger (negative) output gaps through to the end of the period, with only a small tendency for the gaps to diminish.

Both of these measures of the output gap give poor guidance for policymakers with respect to the exit from the current recession. The real-time series derive a change in potential output in a purely mechanical way which is likely to be misleading; the nearly real series assume no change in trend output, which is implausible. What the policymakers need to do is to think hard about the exact effect of the crisis and recession on potential output, by using other information of the kind discussed in the Bank of England references given above. In that case the better starting point would probably be the nearly real series, to be corrected by an explicit, conscious estimate of the crisis-induced fall in trend output.

Figure 8 also shows the actual levels of GDP up to 2009Q1 and the subsequent levels implied by the Bank of England's projections. These give output in 2010–11 some 8–9 per cent below the HP projected trend and some 11–12 per cent below the LQ projected trend. Policymakers need to consider how much of that gap will consist of a change in the trend, and how much a shortfall of output relative to potential.

6. Conclusions

In this paper we have examined alternative measures of the output gap. With respect to the analysis of past policy decisions, we have shown that the real-time output gap estimated using univariate detrending methods gives a poor reflection of the state of the economy as perceived by UK policymakers in the large fluctuations in the late 1980s and the early 1990s, and should not therefore be used in estimating reaction functions over this period. On the other hand the new measure produced here, the nearly real output gap, may be marginally better than the full sample series. For the more tranquil period from 1994 to 2007 the various measures differ much less, so that it matters less which is used.

With respect to the making of current or future policy, none of the mechanically derived output gap series considered can deal adequately with the likely fall in potential output resulting from the financial crisis. Perceptive policymakers need to think about the size of this fall in a more detailed and disaggregated way. There is every sign that the Monetary Policy Committee has acted in this way in the past and continues to do so.

NOTES

1 The exceptions include papers by Orphanides (2003) for the US, Nelson and Nikolov (2003) for the UK, Clausen and Meier (2005) for Germany, and Gerdesmeier and Roffia (2005) for the euro area.

2 Flexible multivariate estimates of the output gap which combine real-time output data with additional data including on inflation (see, for example, Laubach and Williams, 2003) may moderate some of the extreme features of the univariate methods highlighted in this paper and deliver more plausible (from the perspective of policymakers) real-time estimates of the output gap.

3 A variant on the production function approach is the growth accounting approach used by the US Congressional Budget Office (see, for example, CBO, 1995 and 2004). CBO data for potential output have been used in some estimates of US Taylor rules, e.g. Rudebusch (2005).
4 These authors have been working on fiscal policy. As far as we know measures of the output gap produced in this way have not been used in estimates of monetary policy rules, presumably because they are of much lower frequency than that required for estimating such rules.
5 An alternative, less commonly-used method entails modelling potential output as the smoothed stochastic trend from an estimated Unobserved Components ARIMA model for output (see, for example, Harvey and Jaeger, 1993, and Orphanides and van Norden, 2002). In an earlier version of this paper we extended our analysis to include UC-ARIMA based measures of the output gap (Adam and Cobham, 2004). However, UC-ARIMA offers an approach to modelling trend output rather than a unique model specification. Since the optimal specification of the model may well change with the data sample, the approach sits uneasily with the purely mechanical LQ and HP methods used in this paper.
6 We follow conventional practice with quarterly data and implement the HP filter using a smoothing parameter of 1600.
7 The real-time output series is that in Eggington *et al.* (2002), updated from *Economic Trends* and *Economic Trends Annual Supplement*. A similar database, which covers components of GDP as well as the aggregate, can be found on the Bank of England's website (see Castle and Ellis, 2002).
8 The Bry-Boschan (1971) algorithm first identifies all peaks and troughs in the output gap series as the locally highest and lowest values. It then smoothes over the cycle by eliminating two types of 'false' cycles, those where a peak and trough are separated by less than three quarters, and those where the amplitude from peak to trough, or trough to peak is less than 0.5 per cent of GDP.
9 Lawson later conceded that he had probably in part mistaken "an usually long cyclical upswing for a permanent supply-side improvement" (Lawson, 1992, pp. 804–5), while the Bank of England referred to "better supply performance offering the chance of continuing growth at a rate sufficient to reduce unemployment" (*Bank of England Quarterly Bulletin*, August 1987, p. 321).
10 Lawson's story is broadly supported by the Governor of the Bank of England, who later claimed that "Although we did not know just how fast domestic demand and output were growing, we did know that demand was running away from output. This was made plain enough by the deterioration of the trade balance." The Governor also noted that "Although I have referred to statistical difficulties, those merely made the job more complex." (Bank of England, 1990, p. 216)
11 It is possible that the difference might be less severe in practice if policymakers formed their inflation expectations from more flexible estimates of the output gap which incorporated information on inflation. But work for the US suggests that supplementing univariate series with inflation may not help (Orphanides and van Norden, 2005).
12 Interest rate changes between 1982 and May 1988, in contrast, had been made in large part with an eye to trying to stabilise the international value of sterling.
13 The Bank of England Governor noted in his comments at the July 1994 Monthly Monetary Meeting (between Governor and Chancellor of the Exchequer) that "the output gap – whatever its size – was undoubtedly closing" (Minutes of the Monthly Monetary Meeting, 28 July 1994, p4). But this is almost the only mention of the gap in the minutes of these meetings. For example, the Chancellor did not attempt to use data on the size of the gap – apparently still significant – to bolster his case for not raising interest rates (as advised by the Governor) in the meetings of May, June or July 1995. The Minutes of the MPC, from June 1997, make virtually no reference to the concept or magnitude of the output gap.
14 Cobham (2003, pp. 489–91) gives a narrative of the MPC's decision-making between 1997 and 2001, which makes clear that movements in the exchange rate and other data also had significant influences upon interest rate decisions.
15 Moreover, in the 'Demand and output' section of the Report the subsections on domestic and external demand typically took up 6–8 pages and the subsection on output 1–2 pages only.
16 See, for example, the Minutes for August 2000, p.2.
17 The MPC Minutes also contain little or no references to the output gap. However, Stephen Nickell argued in February–April 2006 that the combination of spare capacity in the economy and slow growth required an interest rate cut.
18 Lomax (2004) provides a useful discussion of the sources of information used by the MPC. Bean (2005, p. 81) says that, "A particularly pernicious form of data uncertainty relates to measuring the level of aggregate demand relative to supply", and goes on to say that "on the MPC we prefer to build up our picture of the inflationary pressures in the economy by considering the pressure of demand relative to supply separately in the product and labour markets rather than relating inflation to a single catch-all measure of the aggregate output gap. But unfortunately neither of these is directly observed either."
19 See also Fisher (2009) and De Paoli, Hoggarth and Saporta (2009).
20 Available at www.bankofengland.co.uk/publications/inflationreport/irprobab.htm. We use the modal projection for GDP growth based on market interest rate expectations and £175bn asset purchases under the Bank's QE programme.
21 We do not calculate the quasi-real time gaps because over this period, where we do not have different vintages of GDP data, the quasi-real must coincide with the real-time. And it would not be interesting to calculate the full sample gaps because there is general agreement that the trend potential output must have changed as the result of the crisis, and the full-sample gaps would take inadequate account of that.

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