UK inflation in the 1970s and 1980s: the role of output gap mismeasurement

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Abstract

Understanding the degree of measurement error in the estimates of the output gap available to policy-makers in 'real time' is important both for the formulation of monetary policy and for the study of inflation behaviour. For the United Kingdom, no official output gap series exists, but an approximate series can be deduced from analysis of statistical releases and policy-makers' statements. On this basis, we construct a real-time UK output gap series beginning in 1965 and are therefore able to obtain estimates of the extent of real-time output gap mismeasurement in the 1970s and 1980s. We find that monetary policy errors due to output gap mismeasurement contributed approximately 3.0 to 7.1 percentage points to average UK inflation in the 1970s and 0.7 to 5.5 percentage points to inflation in the 1980s.

Summary

The amount of spare capacity in the economy is a vital input for policy-makers' decisions on monetary policy. When expressed as a fraction of GDP, a frequently used summary statistic for the degree of spare capacity is the output gap—the percentage difference between actual output and the level of output consistent with sustainable full employment of resources. But the output gap available to policy-makers in real time is subject to two sources of error: both initial GDP estimates and the estimates of (unobserved) potential output may be revised subsequently.

Recent work on the United States has argued that the breakout of inflation in the 1970s was largely due to real-time output gap mismeasurement. Policy-makers, it is argued, were slow to realise that long-term US productivity growth had fallen, and therefore misinterpreted slow economic growth as indicating deficient aggregate demand. Consequently, monetary policy stimulus to the economy was excessive.

This paper concentrates on the following questions: (1) how important is the real-time output gap measurement problem in the United Kingdom?; and (2) did output gap mismeasurement play a significant part in bringing about the high inflation in the United Kingdom in the 1970s and 1980s?

In order to address our questions, the paper constructs the first real-time output gap series for the United Kingdom. It consists of a real-time GDP series (obtained from past issues of *Economic Trends*) and a real-time potential GDP series, derived using policy-makers' statements about their views on the output gap or the productive potential of the UK economy. The 'final' output gap series is a measure based on the deviations of actual GDP (2000 Q3 vintage) from a linear trend with breaks in 1973 Q4 and 1981 Q4. The measurement error in real-time output gap estimates is calculated by subtracting the real-time output gap series from the 'final series'.

The paper investigates the effect of output gap mismeasurement on UK inflation by simulating a small, forward-looking macroeconomic model, augmented with a monetary policy rule and output gap measurement error. It also presents graphical evidence in the form of interest rate prescriptions from 'Taylor rules' using both real-time and final output gap data.

The results indicate that output gap estimates have, at times, been subject to substantial measurement error. The most serious measurement errors occurred in the 1970s, when policy-makers believed that output was more than 7 percentage points further below potential than now seems to have been the case. Errors were also large in the 1980s, with the average real-time output gap measure more than five percentage points below the average final measure. This was due both to initial GDP revisions and to inaccurate estimates of potential output. Stochastic simulations suggest that, as a result of output gap measurement errors, average inflation was 2 to 7 percentage points higher in the 1970s, and 1 to $5^{1}/_{2}$ percentage points higher in the 1980s. Although output gap measurement errors made a significant contribution to average UK inflation in the 1970s and 1980s, other sources of monetary policy errors were also important.

1 Introduction

In making decisions on interest rates, an input for monetary policy-makers' deliberations is an assessment of the current amount of spare capacity in the economy—the pressure of aggregate demand relative to the economy's productive potential. When expressed in terms of gross domestic product, a frequently used summary statistic for the degree of spare capacity is the output gap—the percentage difference between the actual level of real GDP, and the level of GDP consistent with the sustainable full employment of resources.

The output gap series that is available to policy-makers when they make decisions is subject to two key sources of error. First, the observation on actual GDP that is initially released by statistical agencies is invariably subject to revision in subsequent months and years, as a wider and more reliable set of data on the level of economic activity in the quarter becomes available. Second, the level of potential GDP is subject to revisions both because of new information on its likely value and because of changes in the preferred procedure for measuring potential output, which is an unobserved variable.

One of the most important inputs for the construction of potential GDP is an estimate of the level and secular growth rate of productivity in the economy. A 1% rise in the underlying growth rate of labour productivity, for example, implies a 1% increase in the economy's potential growth rate, if labour supply conditions remain unchanged.[(1)] During periods in which the long-run growth rate of productivity in the economy is undergoing a shift, measures of potential output may become particularly unreliable, as it is difficult to interpret movements in observed productivity over the business cycle. Because productivity responds not only to underlying factors that affect its long-run behaviour, such as technological change, but also to factors that do not, including monetary policy, it takes time to disentangle the two influences.

The issue of output gap mismeasurement has been central to a great deal of recent analysis of monetary policy. Much of this has focused on what monetary policy should do in the presence of gap measurement error. For example, some authors have advocated monetary policy rules that do not rely upon measures of the output gap (eg McCallum (1999) and Orphanides (1999)); while others have derived the optimal monetary policy for models in which the output gap is measured imperfectly (eg Aoki (2000), Svensson and Woodford (2000), and Ehrmann and Smets (2001)). Another prominent recent discussion of output gap mismeasurement has been in the context of explaining the breakout of inflation in the United States during the 1960s and 1970s. Orphanides (1999) argues that poor contemporaneous measurement by policy-makers of the output gap bears the responsibility for the 'Great Inflation' in the United States. In contrast to other analysts of that period (such as Sargent (1999)), Orphanides argues that US monetary policy was not intentionally

[(1)] If we follow the common practice of using changes in logs of variables to approximate percentage changes, the growth rate of potential output (denoted by Δy^*, where y^* is the log of potential), is the sum of the underlying growth of labour productivity, $\Delta(y-n)^*$, and the growth rate of potential labour supply, Δn^*. If Δn^* is unchanged, there is a one-to-one relationship between changes in Δy^* and in $\Delta(y-n)^*$.

expansionary; it aimed for low inflation, and did not try deliberately to push output above potential. Rather, the problem was that official measures of the output gap were only belatedly revised in response to the slowing in US productivity growth that began in the late 1960s.[2] Consequently, 'real-time' measures of the output gap in the 1970s appeared to support the view that output was well below potential, therefore justifying a more relaxed monetary stance.

Orphanides shows that, if real-time data are used as the inputs, a Taylor (1993) rule for the nominal interest rate appears to match closely the movements of the nominal Federal funds rate in the 1960s and 1970s. This is a striking finding, since other work has argued that adherence by US policy-makers in the 1960s and 1970s to a Taylor-type rule would have avoided the Great Inflation (eg Taylor (1999)). According to Orphanides, such conclusions are misplaced because they neglect the measurement errors present in real-time data.[3] Lansing (2000) finds in simulation experiments that there is some merit in Orphanides' account as a partial explanation for the rise in the US inflation rate in the 1970s.

An estimate of the quantitative importance of real-time output gap mismeasurement would be valuable for the United Kingdom. Substantial effects of data revisions on *actual* output have been noted for the United Kingdom in several studies, including Hendry (1994) and Faust, Rogers and Wright (2000).[4] Hendry compares the vintages of a run of national accounts data at two points in time: the 1970s and the early 1990s. He does not consider measurement error in potential GDP, nor does he compare initial and revised GDP estimates. Faust, Rogers and Wright (2000) quantify the real-time measurement error in the quarterly GDP growth rate for G7 economies, and find that the United Kingdom has the largest error. While suggestive, their results do not address the question of output gap mismeasurement. In general, there is no necessary relationship between real-time measurement error in the quarterly growth rate of output and real-time measurement error in the output gap. Essentially, this is because both GDP and the output gap are *levels* concepts. A small measurement error in the output growth rate is consistent with large errors in the level of output; the measured levels of either GDP or potential GDP could be badly misaligned from their true values even if their current growth rates were being measured accurately. Conversely, a large revision to one quarter's real GDP growth rate is consistent with only minor revisions to the output gap series. For example, a data revision that reallocated the growth in GDP during a calendar year would have a pronounced effect on the measured quarterly GDP growth rate, but none on the levels of output or the output gap. As another example, a large revision to the latest GDP growth rate could also be associated with large revisions in the same direction to GDP growth in previous quarters. This would magnify the effect of the growth rate revision on the level of GDP; but this in turn might

[2] See also Orphanides (2001a) and Orphanides and van Norden (1999).

[3] Taylor (2000) argues that a weakness of Orphanides' argument is that the output gap series in the United States in the 1960s and 1970s was prepared by a different branch of government from the Federal Reserve Board, and the Board may not have used this series in making its interest rate decisions. Our focus on the United Kingdom is an advantage on this score, since the Treasury, whose publications are the basis for the real-time output gap series we construct, had control over UK monetary policy decisions until 1997.

[4] Croushore and Stark (2001) discuss the real-time data problem for a variety of US macroeconomic time series.

prompt revisions of *potential* GDP, reducing the extent to which the output revisions affect the measured output gap.

We therefore investigate in this paper the issue of real-time output gap measurement error in the United Kingdom. This is not a straightforward exercise, because UK policy-making agencies have typically not published their estimates of the output gap. But during certain episodes, policy-makers have disclosed their estimates of the output gap or of potential output. Some examples from the UK policy-making record illustrate the importance of misperceptions about the level of spare capacity:

- In his March 1974 Budget speech, the Chancellor of the Exchequer referred to 'the depression of early 1972'.[(5)] But estimates of the output gap today (based on fitting a broken-linear trend to GDP data[(6)]) suggest that output was only 1.9% below capacity on average in the first half of 1972, and that the gap was eliminated completely by 1972 Q4. What seemed at the time a major collapse in activity (both because of the initial GDP data, and because it was associated with unemployment of 1 million) now appears to have been a relatively mild downturn.

- The Budget of April 1976 announced a programme of 5.5% annual real GDP growth for 1976–79 to eliminate spare capacity in the UK economy. This programme was premised on a view that the economy was approximately 7.5% below capacity in early 1976. In retrospect, output appears to have been only 0.7% below capacity at that time.[(7)]

- At the time that the 1989 Budget was formed, the available estimates of expenditure on GDP suggested that real GDP had grown by 2.7% in calendar year 1988. Subsequent data revisions have raised the estimate of real GDP growth in calendar year 1988 to 4.4%.

This paper provides a comprehensive quantification of the measurement problem in the United Kingdom due to differences between real-time and final output gap data. Because no official output gap series exists for the United Kingdom, we develop a methodology for deducing policy-makers' historical real-time estimates of potential output. Using documented statements by UK policy-makers, we construct a real time potential output series. We can then construct a real-time output gap series beginning in 1965 by calculating the percentage differences between our real-time potential output measures, and the appropriate vintages of GDP data. In Section 2 we provide a summary of our construction of our real-time output gap series. Section 3 quantifies the extent of real-time output gap mismeasurement suggested by our estimates. Sections 4 and 5 analyse the consequences of this mismeasurement for policy rules and UK inflation respectively. Section 6

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(5) Denis Healey, speaking in the House of Commons, *Hansard*, 26 March 1974, page 291.

(6) Our output gap estimates based on final data, which we use here and in Sections 2–4 below, are obtained from a regression of log GDP (October 2000 vintage) for 1955 Q1–2000 Q2 on a broken-linear trend, with shifts in intercept and slope in 1973 Q4 and 1981 Q4. The 1973 Q4 break corresponds to the well-known slowdown in productivity growth in many industrialised countries, including the United Kingdom. The 1981 Q4 break corresponds to the partial reversal in the United Kingdom of the post-1973 productivity slowdown, discussed in Bean and Symons (1989) and in the appendix of this paper. Similar results obtain with other detrending procedures; for example, defining the gap as the difference between log final-data GDP and its Hodrick-Prescott based 'trend', the average gap in the first half of 1972 is –1.3%.

(7) Again, this retrospective estimate uses our output gap measure based on a broken trend in GDP.

provides concluding comments, and the appendix provides details of the construction of our real-time output gap series.

2 A real-time output gap series for the United Kingdom

In this section we briefly describe the path of the real-time output gap series that we have constructed for the United Kingdom. This series relies on a real-time GDP series constructed from successive issues, on a quarterly basis, of *Economic Trends* since the 1960s; and a real-time potential GDP series deduced from policy-makers' statements. A detailed documentation of our construction of both series appears in the appendix.

2.1 The 1960s and 1970s

Our examination of policy-makers' statements reveals that policy-makers in the mid-to-late 1960s and early 1970s viewed potential GDP as growing at approximately 3% per year. In 1972, in the wake of apparent supply-side improvements, the estimated growth rate for potential GDP in the 1970s was revised up to 3.5%. It was then revised back to 3% in early 1974. In mid-1979, after six years of weak growth, the post-1973 potential growth rate was revised down. As for the *level* of potential output, policy-makers' views can be pinpointed by statements they made in 1966, 1967 and 1976 about the size of the output gap. Table A summarises the shifting views of potential output in the 1970s suggested by our analysis.

Table A: Shifting views of potential output growth in the 1970s

View held from	View held until	View
mid-1960s	1971 Q4	Potential output growth 3% a year since late 1950s
1972 Q1	1973 Q4	Potential output growth 3% a year until 1969 Q3; 3.5% a year from 1969 Q4 onward
1974 Q1	1979 Q1	Potential output growth 3% a year since late 1950s
1979 Q2	1980 Q2	Potential output growth 3% a year until 1973 Q3; 1% a year from 1973 Q4
1980 Q3	1981 Q4	Potential output growth 3% a year until 1973 Q3; 1.5% a year from 1973 Q4

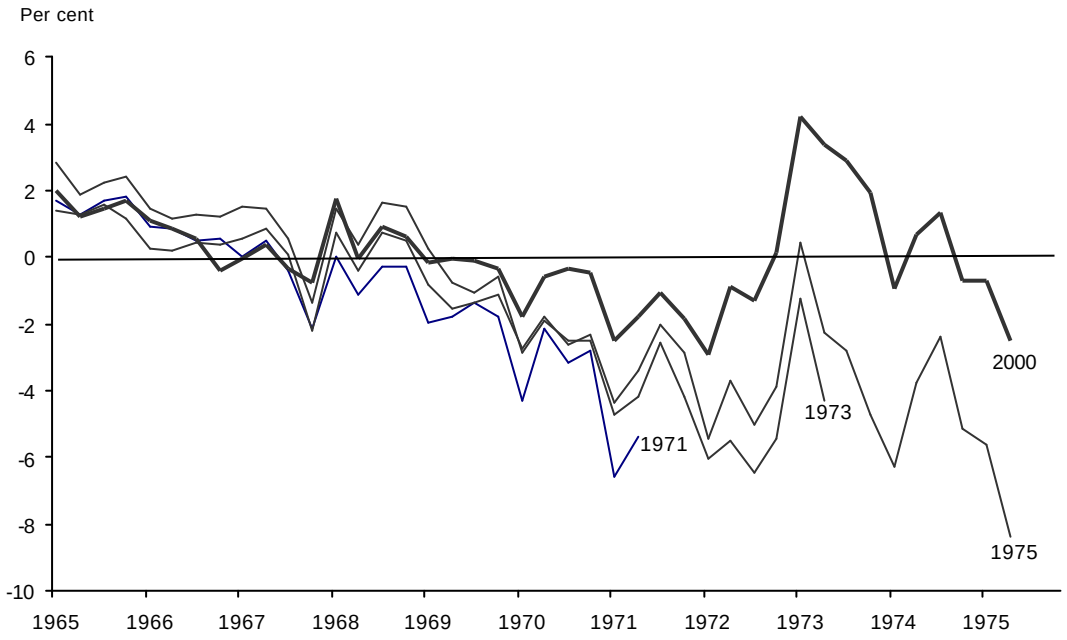
Chart 1 gives an impression of the seriousness of the output gap mismeasurement problem in the United Kingdom in the 1970s. The chart plots the output gap series on the basis of data that was available in the last quarter of three years in the 1970s: 1971, 1973 and 1975; as well as our own estimate constructed using the vintage of data available in late 2000. For example, the series labelled '1971' is the output gap series suggested by the combination of the 1971 Q4 vintage of GDP data and policy-makers' contemporaneous views of potential output behaviour.

The 1971 and 1975 estimates of the output gap in Chart 1 use identical potential output series, so the differences between the two series solely reflect revisions to the *actual* GDP series. A comparison of

these two series indicates that the initial data seriously overestimated the severity of the 1971–72 recession. Data revisions since 1975 have made the estimated level of the output gap smaller still. Arguably, the apparent tendency of data revisions to reduce the severity of the downturns in the 1970s could have led policy-makers to anticipate some of these revisions and to discount the currently available data. But as we noted in the introduction, the severity of the 1971–72 downturn, as well as that in 1974–75, seemed to be corroborated in real time by data other than GDP, most notably the rising unemployment figures.

The 1973 vintage of the output gap series indicates a considerable amount of spare capacity (more than 4%) in mid-1973. Roughly half of this estimate was due to the upward revision the Heath Government had made to the economy's potential growth rate. Neither the 1973 nor the 1975 output gap series give an accurate indication of how far (according to the data now available) real GDP exceeded capacity during 1973.

Chart 1: Changing views of the output gap in the 1970s



2.2 The 1980s and 1990s

In the 1980s, as a productivity growth revival that began during the 1979–81 recession persisted into the expansion, policy-makers' estimate of potential GDP growth was revised upward several times, culminating in 1989 when the estimate of potential GDP growth was raised to 2.75%. Table B summarises the changing views regarding potential output behaviour in the 1980s, which underlie our real-time output gap series.

As before, we combine our estimates of real-time potential output with real-time GDP data to generate a real-time output gap series. Chart 2 plots two vintages of real-time output gap data in the

1980s—those for 1988 Q4 and 1989 Q4; as well as two later revisions—the output gap series for the 1980s as given by data available in 1993 Q4; and our own estimates based on final data.
It is evident from Chart 2 that, compared with the 1993 and 2000 versions, the output gap series used in 1988 and 1989 overestimated the degree of excess capacity in the 1980s, with the discrepancy widening in the second half of the decade. From late 1986, both the 1993 and 2000 vintages of the data show a positive output gap, compared with a negative output gap according to the 1980s vintages. For 1989 Q2, the discrepancy between the initial and revised output gap number is more than 7.5 percentage points.

Table B: Shifting views of potential output growth in the 1980s

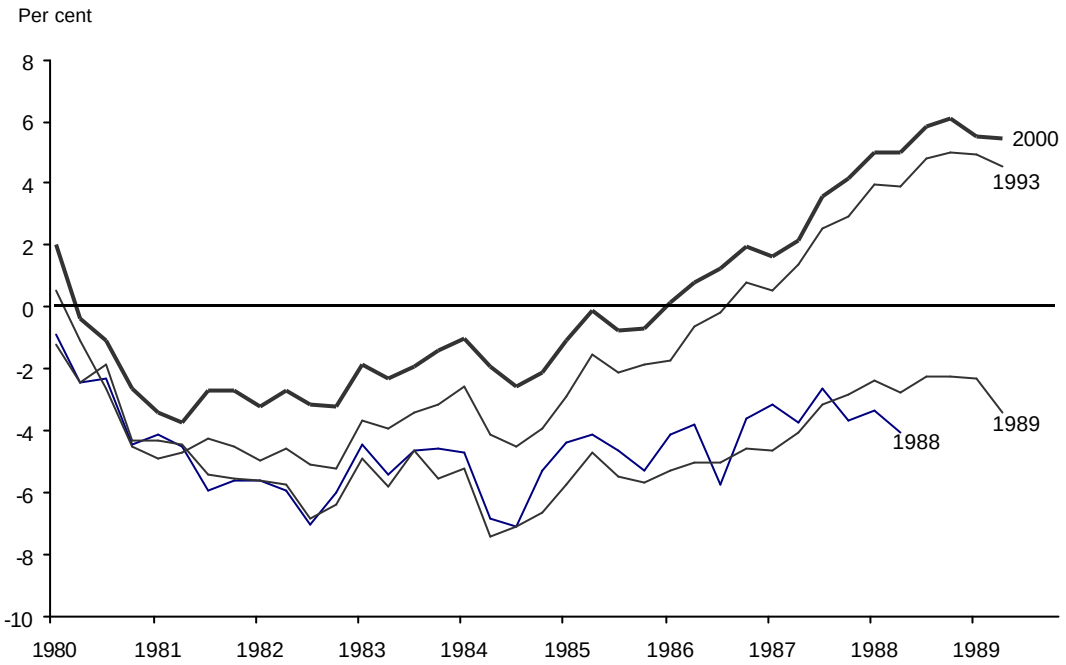
View held from	View held until	View
1982 Q1	1985 Q4	Potential output growth 3% a year until 1973 Q3; 1.5% a year 1973 Q4–1981 Q3; 2% a year from 1981 Q4
1986 Q1	1988 Q4	Potential output growth 3% a year until 1973 Q3; 1.5% a year 1973 Q4–1981 Q3; 2.5% a year from 1981 Q4
1989 Q1	1990 Q4	Potential output growth 3% a year until 1973 Q3; 1.5% a year 1973 Q4–1981 Q3; 2.75% a year from 1981 Q4

Other real-time measures of economic activity failed, like GDP, to indicate the extent of the expansion. In June 1988, John Major (Chief Secretary to the Treasury) endorsed survey evidence that showed 'very little evidence of capacity constraints'.[8] Nigel Lawson (1992, page 845), who was Chancellor during this period, does recall that it was the July 1988 trade figures that made 'clear to me that demand in the economy was pressing against the limits of capacity to a much greater degree than I had previously realised'. But both the trade and the output figures were heavily revised after 1988.

Output data (particularly the expenditure-based series that we focus on) clearly failed at the time to reveal the speed of the late 1980s expansion. Indeed, in light of the errors in the initial data on actual GDP, it is understandable that policy-makers in late 1988 were not aware that output was well above potential. On the basis of data available in 1988 Q4, for example, it appeared that real GDP had grown at an annual rate of 2.8% over 1981 Q4–1988 Q2. Since the assumed potential GDP growth rate in 1988 was 2.5% (shortly to be revised up to 2.75%), and the economy had been in a severe downturn up to late 1981, it appeared reasonable to believe that the economy in mid-1988 still had considerable spare capacity. By 1989 Q4, however, the 1981 Q4–1988 Q2 growth rate had been revised up to 3.1%; by 1992 Q4, the estimate was 3.4%; and in 1998 Q4 it stood at 3.5%. Thus the cumulative economic growth from late 1981 to mid-1988 was 5 percentage points greater in revised data than in the initial data available in 1988.

[8] From John Major's written answer to a Parliamentary question, in *Hansard*, 16 June 1988, page 266.

Chart 2: Changing views of the output gap in the 1980s



To the extent that the upward revisions to potential output growth in the 1980s were overdone, they also contributed to the mismeasurement of the output gap. For example, if in 1989 policy-makers had assumed a 2.25% post-1981 potential output growth rate instead of the 2.75% figure they actually used, that alone would have shifted the estimated output gap for 1989 Q2 upward by 3.9 percentage points.

By the early 1990s, the inflation of 1988–90 had given policy-makers reason for believing that the estimates of potential growth that they had used in the late 1980s (ie of 2.5%, subsequently raised to 2.75%) had been too high. Consequently the estimate of growth in potential was revised downward in 1991, and a further, more complicated, set of revisions to estimates of potential occurred in 1996. In 1997, the Bank of England was given responsibility for the operation of monetary policy. The appendix details the revisions to official potential output estimates that occurred in the 1990s. We do not focus heavily on comparison of initial and final output gap data for the 1990s, because it is likely that the data for GDP in the 1990s will be subject to further revision.

3 Estimates of real-time output gap mismeasurement

We now present some statistics that quantify the degree of mismeasurement in real-time estimates of the output gap in the United Kingdom. We examine the period 1965–95, stopping in 1995 because,

as of early 2001, we have little idea of the extent to which post-1995 data will ultimately be revised. Table C reports summary statistics for initial and final estimates of the output gap, denoted $\tilde{y}_t$, for various sub-samples of 1965–95.

Table C: Summary statistics on real-time output gap mismeasurement

	Initial output gap data[(a)] $\tilde{y}_t^{realt}$	Final output gap data,[(b)] $\tilde{y}_t^{final}$	Real-time output gap measurement error $(\tilde{y}_t^{final} - \tilde{y}_t^{realt})$	
	Unconditional mean	Unconditional mean	Unconditional mean	Unconditional standard deviation
Period	Percentage points			
1965 Q1–1995 Q4	–4.78	0.06	4.84	3.48
1965 Q1–1969 Q4	–0.74	0.51	1.25	1.18
1970 Q1–1975 Q4	–5.18	–0.45	4.72	2.00
1976 Q1–1979 Q4	–9.49	1.11	10.61	3.24
1980 Q1–1984 Q4	–5.82	–2.10	3.75	1.31
1985 Q1–1989 Q4	–4.46	2.78	7.24	2.26
1990 Q1–1995 Q4	–3.97	–0.95	3.02	1.85

(a) Authors' estimates of policy-makers' data as described in Section 2 and appendix.
(b) Authors' estimates of detrended output described in footnote 5 and used in Charts 1 and 2.

For the period as a whole (1965–95), we find that the real-time measurement error in the UK output gap had mean 4.8% with standard deviation 3.5%. These figures are remarkably close to the estimates for the United States in Orphanides, Porter, Reifschneider, Tetlow and Finan (2000), who report, for 1966 Q1–1994 Q4, a mean error of 3.2% and a standard deviation of 4.2%.
The figure for the whole of 1965–95 disguises major differences across sub-samples. Output gap mismeasurement appears to have been smallest in the 1960s—though it was sufficiently great to give a misleading impression about the average sign of the output gap (negative in the initial data, positive according to the final data). The errors in the output gap appear one-sided in each of the samples considered, with the initial estimates consistently suggesting more spare capacity than the final estimates. The most sizable errors are for the second halves of the 1970s and 1980s, which are both periods associated with what in retrospect seem overestimates of the economy's potential growth rate. However, in 1976–79, the worst period of output gap mismeasurement, approximately half of the 10.6% average error was due to later revisions to GDP data rather than mismeasured potential. This is consistent with Hendry's (1994) evidence on drastic differences between the late 1970s vintages of national accounts data and 1990s revisions of the same data.

This period also illustrates the difference between the concepts of real-time measurement error in the output gap and in GDP growth. Faust, Rogers and Wright (FRW) (2000) find that real-time measurement error in the *quarterly GDP growth rate* was almost as poor for the United Kingdom after 1988 as before 1988. We find, on the other hand, that real-time measurement error in the *output gap* peaked in the 1970s. This is because the 1970s featured much more *level*

misalignment—the level of GDP was underestimated, and the level of potential underestimated—which FRW's growth-rate estimates do not pick up.

Table D illustrates these points further. It shows that the average output gap measurement error was about 1.5 percentage points higher in the 1970s than in the 1980s. More than 40% of the error in the 1970s was due to overestimated potential, the remainder being due to upward revisions to the level of GDP. In the 1980s, only 20% of the average error was due to overestimated potential. The reason for this relatively small contribution is that potential was *under*estimated during 1980–86, and overestimated for the rest of the decade; the net result being a mean overestimate of potential of only 1.1 percentage points.

Table D: Split of revisions between actual and potential GDP, by decade

Mean output gap error 1970 Q1–1979 Q4	–7.08%
of which:	
Actual GDP revised up	4.08%
Potential GDP revised down	3.00%
Mean output gap error 1980 Q1–1989 Q4	–5.48%
of which:	
Actual GDP revised up	4.35%
Potential GDP revised down	1.13%

One reaction to our finding in Table D that policy-makers were too optimistic in the 1970s about potential output is that it reflects our use of policy-makers' statements to obtain real-time values for the potential estimates. It is possible that policy-makers exaggerated the economy's potential in their public statements while privately adhering to a lower estimate of potential. But the details of UK policy developments suggest that this factor was not important. From the 1960s to 1972, policy-makers' publicly stated estimates of potential seem in retrospect realistic and, as we detail in the appendix, were indeed highly conservative relative to the OECD's estimates. In 1972–74, there was indeed a move to greater public optimism by UK policy-makers about potential growth, but our documentation in the appendix establishes that this optimism was supported by internal Treasury analysis. And the belief in the late 1970s in a 3% potential output growth seemed reasonable at the time as it was less optimistic than earlier in the 1970s and was consistent with the 1960s growth record.

4 The effect of output gap mismeasurement on policy rules

In this section, we present graphical evidence for the United Kingdom analogous to that provided by Orphanides (1999) for the United States. Orphanides compares the prescriptions for the nominal interest rate from a Taylor rule (Taylor (1993)) using real-time data, with the prescription from final revised data. Orphanides finds that the actual short-term nominal interest rate in the 1970s tracks

closely the real-time Taylor rule, so that monetary policy in the 1970s does not look loose according to this rule. On the other hand, the rule based on final data does suggest policy was excessively loose in the 1970s. As the Taylor rule is capable in a wide variety of macroeconomic models of stabilising inflation around target (see Taylor (1999)), Orphanides' results suggest that inaccurate contemporaneous measurements of the output gap—largely arising from overestimates of potential output—were responsible for the monetary policy mistakes in the United States in the 1970s.

To begin our look at the UK evidence, we first compare the prescriptions of a simple Taylor rule using real-time and final output gap data with the actual short-term nominal interest rate that prevailed at the time.

Chart 3 displays the actual values of the end-of-quarter nominal Treasury bill rate in the United Kingdom (R) against the value which, at each point in time, is suggested by a Taylor rule from real-time data. The specific form of the Taylor rule we use is:

$$RTay_t = r^{ss} + 4\pi^* + 1.5((100*[P_t - P_{t-4}])/P_{t-4}) - 4\pi^*) + 0.5(100*(\tilde{y}_{t-1}^{realt})) \qquad \textbf{(1)}$$

where P_t is the quarterly average of the retail price index (RPI) and $\tilde{y}_{t-1}^{realt}$ is our real-time output gap series denoting the initial data on the output gap for $t-1$.[9] The right-hand-side variables in rule **(1)** are lagged to allow for realistic delays in data collection, and multiplied by 100 to be in units comparable to the nominal interest rate. The inflation target, $4\pi^*$, that appears as part of the intercept term, is set to 2.5%, which corresponds to the actual UK inflation target since 1992. We set the steady-state real interest rate (r^{ss}) to 2%, the same value used in Taylor (1993). The response coefficients to inflation of 1.5, and of 0.5 to the output gap, are Taylor's recommended values.

We first note two possible reservations about treating the Taylor rule as a benchmark for comparison with actual policy. The first objection is that the Taylor rule baseline does not incorporate a response to the exchange rate. In practice, the exchange rate has played a role both as a variable that UK monetary policy was concerned with (especially before the floating of the exchange rate in 1972, and in the 1990–92 period of ERM membership) and as an influence on output and inflation. But the Taylor rule benchmark does take account of the exchange rate indirectly. To the extent that variations in the exchange rate are relevant for output gap and inflation behaviour, they alter the Taylor rule's recommended interest rate. For example, during the 1979–81 recession, the downward pressure on the output gap and inflation from exchange rate appreciation would reduce the values of the right-hand-side variables in equation **(1)**. This would lead to a Taylor rule prescription for interest rates to be set lower than would have been appropriate in the absence of the appreciation.

[9] We use in rule **(1)** the actual percentage-change formula (given by $(P_t - P_{t-4})/P_{t-4}$) to calculate inflation, rather than the logarithmic approximation $\log(P_t/P_{t-4})$. The log approximation is poor when inflation reaches double-digit levels, as it did in the United Kingdom for much of the period 1973–90.

A second objection is that UK monetary authorities in the 1960s and 1970s believed they had several other instruments beside the short-term interest rate at their disposal.[10] In particular, administered changes in long-term interest rates were thought an important part of monetary policy, and official operations in long-term securities markets were used for monetary policy purposes until 1985.[11] As a related matter, there tended to be a close relationship between fiscal deficits and base money creation in the 1970s.[12] While we concur that a policy-induced change in long-term rates[13] or a monetisation of budget deficits would constitute a change in monetary conditions for a given short-term interest rate, we contend that it is nevertheless legitimate to evaluate the stance of monetary policy by reference to the deviation of the short-term rate from the Taylor rule benchmark. For since fiscal policy and long-term rates tend to produce changes in the components of the Taylor rule—the output gap and inflation—they would change the appropriate setting for the short-term rate, and it would be valid to judge policy according to whether short-term rates had moved to the new Taylor rule baseline.

Chart 3 indicates that the nominal interest rate is close on average to the prescription from rule **(1)** during the 1960s. But after 1969 actual nominal interest rates are well below the rule recommendation, and remain so until 1981. Most notably, during the period of 25% inflation in 1975, the Taylor rule prescribes an interest rate of more than 35%, while the actual rate never exceeded 11%. We stress that these are 'point-in-time' prescriptions, referring to what the rule recommends, *given* actual past data. Had the Taylor rule **(1)** actually been followed in the United Kingdom in the early 1970s, it is very unlikely that the 25% inflation rate of 1975, and therefore the 35%-plus interest rate prescription, would ever have occurred. All in all, Chart 3 provides considerable evidence that policy was indeed too loose in the 1970s even when evaluated using real-time output gap data.

The case of the 1980s is interesting in that policy appears tight when evaluated against the Taylor rule benchmark.[14] And yet inflation rose to above 10% in 1990, suggesting the opposite conclusion. An important factor is the high level of real interest rates that prevailed in the United Kingdom during the 1980s. While short-term *ex post* real interest rates were negative in the 1970s, they rose to average levels of 5% to 6% in the 1981–91 period. To the extent that these high rates reflected a rise

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[10] Two of these, quantitative controls on lending and cash reserve ratios, were of greatly diminished importance after the 1960s. A quantitative control that was used in the 1970s, the 'Corset', which limited growth in bank deposits, does not seem to have had a significant braking effect on aggregate demand or inflation. Rather, as argued in Nelson (2001), its principal effects were to discourage the growth of particular types of bank liabilities and to encourage the growth of deposit substitutes, and it did not serve as a genuinely restrictive monetary policy measure.

[11] A 1966 article in the *Bank of England Quarterly Bulletin* (reprinted in Bank of England (1984, pages 75-82)) stated that 'the authorities can pursue their aims for interest rates throughout the economy by seeking to influence the behaviour of prices and yields in the gilt-edged [ie long-term securities] market.' Later—until 1985—intervention in the long-term bond market was seen as a method of hitting the Government's target for broad money growth at unchanged short-term rates. See Bank of England (1984), Schwartz (1985), and Goodhart (1992).

[12] Using the *IFS Yearbook* for fiscal data, the correlation between the UK government deficit (as a ratio to GDP) and the growth rate of the monetary base is 0.85 for 1960–79; for 1980–95 it is zero.

[13] Goodhart (1992, pages 326–7) and Woodford (1999, page 301) conclude that the empirical evidence does not support the position that central banks can, in fact, affect long-term interest rates for a given setting of short-term rates.

[14] See Stuart (1996), McCallum (2000), and Nelson (2001) for further discussion.

in the steady-state real interest rate (r^{ss} in equation **(1)**), the Taylor rule prescriptions in Chart 3, which presume a 2% steady-state real rate, are too low, and should be raised by the amount of the increase in r^{ss}.[15]

Chart 4 plots the Taylor prescription using both real-time and final data. The latter is identical to the prescription generated from equation **(1)** except that the output gap data used are the final data, $\tilde{y}_{t-1}^{final}$. The chart provides some evidence against the hypothesis that the bulk of the monetary policy mistakes of the 1970s and 1980s arose from incorrect real-time information about economic conditions. The major swings of the two Taylor rule series are very similar, despite the inaccurate initial gap data. This reflects the fact that the inflation data, which *were* available in real time, dominate the Taylor rule prescription because of the sustained double-digit inflation rates in the 1970s.

The Taylor rule recommendations in Charts 3 and 4 are subject to a number of criticisms. Most notably, the rule, as formulated in **(1)**, does not distinguish between increases in inflation associated with once-and-for-all price level increases, and more lasting increases in inflation. OPEC oil shocks and increases in value added tax (VAT) can be regarded as falling into the first category. Arguably, monetary policy should respond to shocks such as these by permitting a permanent increase in the price level but only a temporary increase in inflation. This consideration affects the comparisons of interest rates with the Taylor rule recommendation, especially over 1979–81, a period characterised by the second oil shock and a near-doubling of the VAT rate.

To see the effect of these factors on the Taylor rule, Chart 5 plots the actual interest rate for 1979–95 against the real-time and final-data Taylor rule prescriptions, when the latter have been adjusted so that they accommodate the impact effects of the 1979 VAT and oil price increases.[16] This adjustment shifts down the real-time and final-data Taylor rules of Chart 4 by an equal amount. The spike in the Taylor rule graphs in mid-1980 is greatly moderated, peaking at 22% instead of 32%. The discrepancy in the early 1980s between actual policy and the Taylor rule recommendations is much reduced, which is in keeping with the idea that monetary policy over that period was reasonably tight—certainly much tighter than in the 1970s.

[15] This includes the possibility that the higher *ex post* real rates in the 1980s largely reflected the fact that financial markets built high risk premia into the returns on UK nominal assets, after the inflationary experience of the 1970s. In that case, high *ex post* real rates need not imply that monetary policy was tight.

[16] We assume that the impact effect of the VAT increase on the price level was 3.5% in 1979 Q3, and that the oil price increase affected the price level by the same amount, with the increase spread evenly over 1979 Q3–1980 Q2. These adjustments are in line with estimates at the time, as well as those given by Allsopp and Mayes (1985). The adjustments affect the four-quarter inflation series until 1981 Q2.

Chart 3: The actual UK nominal interest rate and the prescription from a real-time Taylor rule

Per cent

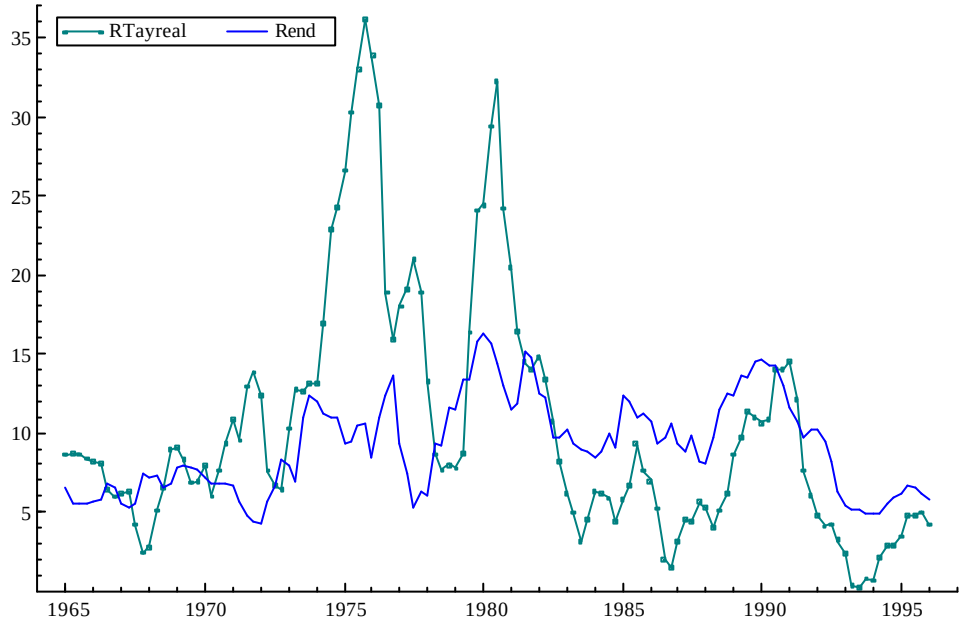
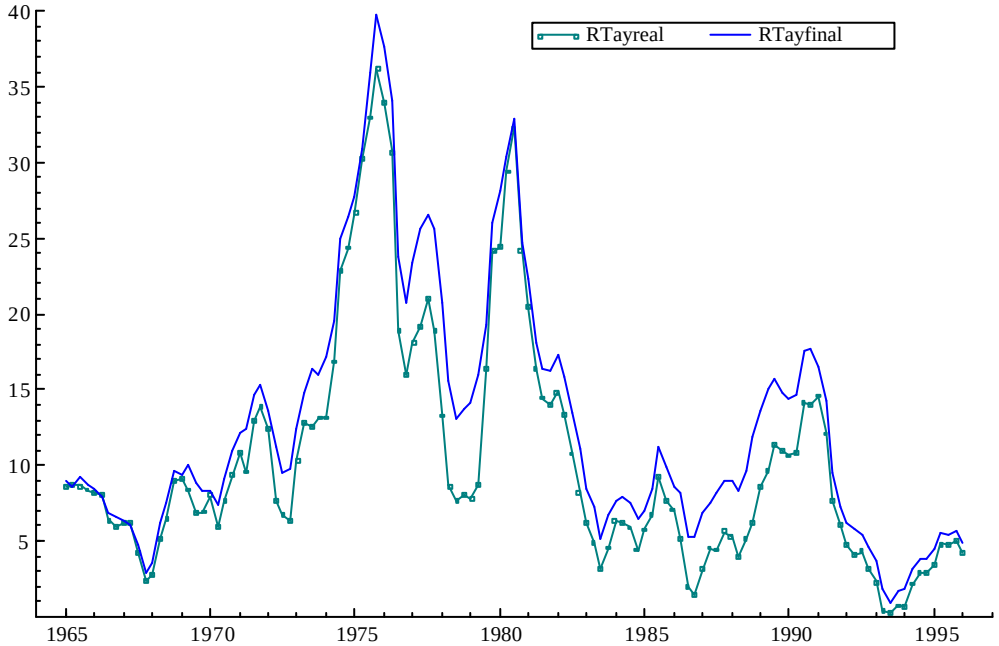


Chart 4: Taylor rule prescriptions using real-time and final data

Per cent



Orphanides (1999) finds that periods of inflationary monetary policy in the United States are not associated with major deviations of actual interest rates from the Taylor rule. In Charts 3 to 5, we have found that this result does not carry over to the UK case, largely because of the violent swings in UK inflation. This finding does not mean, however, that output gap mismeasurement did not at times make an important contribution to monetary policy errors in the United Kingdom. Chart 4 shows, for example, that by the late 1970s the Taylor rule prescription is more than 750 basis points higher on final than on real-time data; and that for the late 1980s, the divergence stands at 500 basis points. Both periods coincided with over-optimistic potential output estimates.

Further graphical evidence that output gap mismeasurement has contributed to the United Kingdom's inflation record is provided in Chart 6, which plots the annual averages for 1966–97 of RPI inflation against the real-time output gap measurement error of two years earlier (ie 1964–95). The two-year lag is used to capture the idea that monetary policy responds to the real-time estimate of the output gap, and that monetary policy exerts its main effect on inflation with a two-year delay. The chart indicates a reasonably close relationship between the two series: the correlation is 0.50 for 1966–97, 0.90 for 1966–75 and 0.61 for 1976–97.[(17)] Again, this chart suggests that output gap mismeasurement alone cannot explain the scale of the 1970s monetary policy errors and resultant inflation. But from 1979, the real-time measurement error tracks the swings in inflation quite well.

In the next section, we use a model to quantify the effect on inflation resulting from output gap mismeasurement in the United Kingdom.

[(17)] The correlation is 0.53 for 1976–97 if the inflation series is adjusted for the 1979 VAT and oil price increases in the manner described earlier.

Chart 5: The UK nominal interest rate and the prescriptions from a Taylor rule, 1979–97, adjusted for impacts of 1979 VAT and oil price increases

Per cent

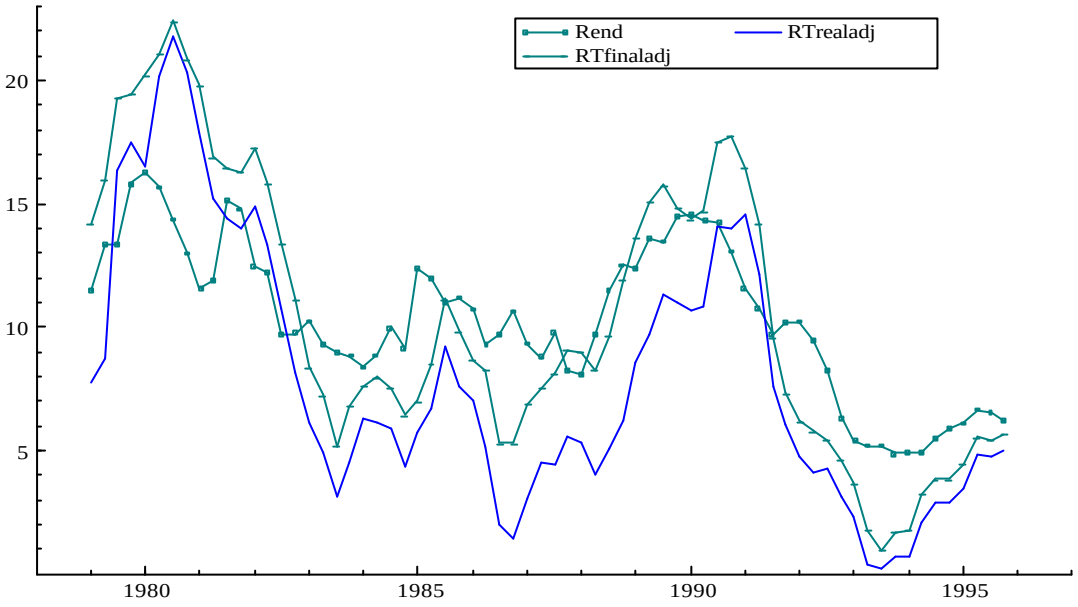
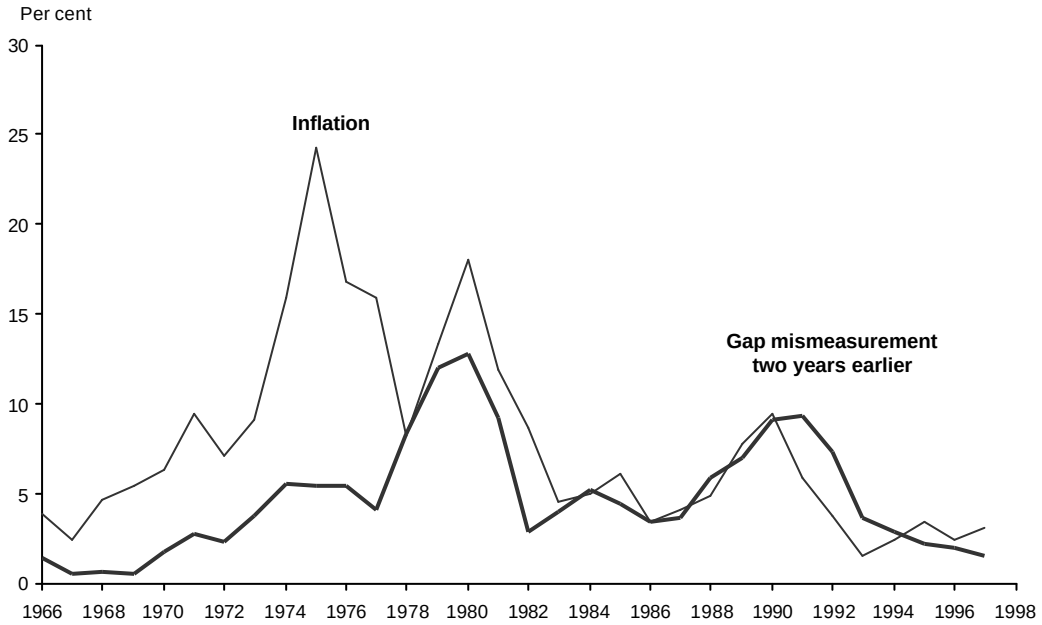


Chart 6: RPI inflation against output gap mismeasurement two years earlier, 1966–97



5 The effect of output gap mismeasurement on UK inflation

In this section we use a small-scale macroeconomic model to illustrate and quantify the extent to which real-time mismeasurement of the output gap contributed to the inflation record of the UK economy in the 1970s and 1980s.

We use a small, calibrated, forward-looking model. This model is given in Table E. The model does not incorporate open-economy influences explicitly, but their effect can be approximated by appropriate calibration of the interest elasticity of aggregate demand, and the variances of the models' shocks, as shown in Neiss and Nelson (2001).

Table E: Model equations

(2) IS curve	$y_t = \mathrm{E}_t y_{t+1} - s(R_t^q - \mathrm{E}_t p_{t+1}) + v_t$
(3) Phillips curve	$p_t = b\mathrm{E}_t p_{t+1} + a(y_t - y_t^*) + u_t$
(4) Potential output (cyclical component)	$y_t^* = 0.95 y_{t-1}^* + e_{yt}^*$
(5) Taylor rule	$R_t^q = 1.5\pi_t + (f_y/4)(y_t - y_t^* + \eta_t) + e_{Rt}$
(6) Output gap mismeasurement	$h_t = (1-r_\eta)m_h + r_\eta h_{t-1} + e_{ht}$
Note: R_t^q is the nominal interest rate expressed in quarterly units, ie $R_t^q = 0.25R_t$.	

Equation **(2)** is an IS function, based on private sector optimisation, which determines current aggregate private demand as a function of expected future demand and the current real interest rate. The IS disturbance term has the interpretation of a government spending or a preference shock.

Equation **(3)** is the 'New Keynesian Phillips curve' described in Roberts (1995), Galí, Gertler and López-Salido (2001) and Woodford (2001). It determines the quarterly rate of inflation (p_t) as a function of expected future inflation as well as the current output gap and a disturbance term. We follow Roberts (1995) by setting the coefficient on expected future inflation, b, to unity. A b value somewhat below unity on the expected future inflation term is suggested by the microfoundations of equation **(3)**. But in our experiments, that would lead to the implausible result that the output gap is non-zero on average, a serious violation of the natural rate hypothesis.[18]

The cyclical component of potential output (equation **(4)**) is assumed to follow an AR(1) process. In practice, policy-makers tend not to model this cyclical component, concentrating—as we document in the appendix—on the modelling of the trend or growth component. To concentrate on the effects of mismeasuring the trend in potential, we assume that policy-makers observe the cyclical

[18] Our experiments will treat equation **(3)** as an equation that holds globally, including situations where the central bank misses its inflation target by a finite amount. For such experiments, the long-run properties of **(3)** are important, and unless a coefficient of 1.0 on $\mathrm{E}_t p_{t+1}$ is imposed, the equation implies that misses of inflation from target lead to a non-zero output gap in the long run (see McCallum and Nelson (1999, page 27), and Rotemberg and Woodford (1999, footnote 19)).

component correctly. The measurement error in the real-time output gap, denoted h_t in equation **(6)**, then corresponds to the combination of the real-time error in GDP data, and the discrepancy between policy-makers' estimate of trend GDP and the actual trend.

The nominal interest rate is set by a standard Taylor rule (equation **(5)**), which reacts to current values of inflation and the output gap. Our baseline calibration uses an output gap response coefficient of $f_y = 0.5$, as in Section 4. A crucial issue in evaluating our results below is whether it is realistic to describe the historical response of UK monetary policy by an output gap response as high as 0.5. There is considerable evidence that this is a plausible value. Nelson (2001) estimates the long-run empirical output gap response in the United Kingdom as 0.5 for 1972–76, 1987–90 and 1992–97.[19] Clarida, Galí and Gertler (CGG) (1998) find a response coefficient of 0.3 for the 1979–90 period. We therefore report results for the baseline value of $f_y = 0.5$ as well as CGG's estimate of $f_y = 0.3$. Note that these estimated output gap responses are fully consistent with policy actually responding to other measures of the gap, such as unemployment-based measures, since Okun's Law-style relations imply an approximately proportional relationship between output-based and unemployment-based measures of the gap. In addition, these estimated empirical responses of policy to the output gap are not based on a presumption that central banks used the output gap to model or forecast inflation. For example, we argue in Nelson and Nikolov (2001) that UK policy-makers in the 1970s did not use an output gap-based model of inflation (such as the Phillips curve), but rather regarded inflation as largely determined by exogenous factors. Nevertheless, they responded to output gap movements in order to stabilise real activity.

The policy response to inflation has undergone greater historical variation, so our coefficient of 1.5 on inflation is high in relation to the estimated UK policy response before inflation targeting.[20] In these exercises, however, we use this relatively high level because it would, in the absence of output gap measurement error, keep inflation close to target. We do this in order to isolate the degree to which one-sided output gap errors, as opposed to other features of UK monetary policy, contributed to high UK inflation prior to the 1990s.

In calibrating the model, we assume that the potential output innovation has a standard deviation of 0.7%, and the Phillips curve and IS shocks are white noise with standard deviations of 0.5% and 1.0% respectively. We set the interest elasticity of aggregate demand (s) to 0.6 and the response of inflation to the output gap (a) to 0.05. These choices affect the outcomes for the variability of

[19] These estimates were based on final data. Nelson (2001) obtains similar estimates when estimating reaction functions using real-time data.

[20] Nelson (2001) finds responses to inflation below 1.0 in estimated interest rate reaction functions for the United Kingdom in the 1970s, even when real-time data are used. This is contrast to estimates for the United States by Orphanides (2001b) and Perez (2001), who report greater than unit response to inflation once real-time data (on both the output gap and inflation forecasts) are employed. In part, the lower UK responses reflect the fact that control of inflation was delegated for much of the 1960s and 1970s to incomes policies (wage and price controls); see Blackaby (1978) for a detailed account. But most economists would agree that for incomes policies to be successful at keeping inflation down, the setting of monetary policy must also be consistent with the inflation target. It is therefore still legitimate to evaluate monetary policy, in periods where incomes policies are in effect, by whether it is providing appropriate anti-inflationary restraint. See Nelson and Nikolov (2001) for further discussion.

inflation and the output gap, but (provided $b = 1$ in equation **(3)**) not the long-run mean of inflation, which depends only on the policy rule coefficients.

The only constant term in the model is that in the output gap measurement error equation **(6)**. This means that real variables are measured as deviations from their steady-state value, while inflation is measured as deviation from target. If policy did not respond to the output gap, or if measurement error in the output gap had a zero mean, the steady-state value of inflation would be its target value. With a non-zero response by policy to the observed output gap, any mean error in the measurement of the output gap could lead to an average inflation rate that differed from target. Therefore, we present results for the model both with and without output gap mismeasurement.

Table F reports model statistics; these are the moments implied by solution of the model.[21] Our first set of results is the case with no output gap mismeasurement. Here the mean of the $4p$ variable is zero, indicating that inflation is on target on average.

In the next set of results we introduce output gap mismeasurement. We calibrate the time series process of the measurement error h_t according to our estimate of $(\tilde{y}_t^{final} - \tilde{y}_t^{realt})$ for 1962 Q3–1996 Q1. These estimates suggest an error with a mean of $m_h = 4.62\%$ (ie the initial estimates suggested that output was 4.62% further below potential than did the final estimates) and that the error is persistent, with first-order serial correlation of 0.88. The standard deviation of innovations to this measurement error is 1.67%. As the measurement error process in the United Kingdom may have changed over time, we also report results based on estimating the h_t process on 1970s or 1980s observations alone.

As Table F shows, the effect of this measurement error is to make inflation overshoot its target by an annual rate of 2.8 to 7.1 percentage points, depending on the policy response to the output gap and the period used to calibrate the measurement error process. The measurement error also raises the variability of inflation by a modest amount.

One reservation about Table F is that, as data on actual GDP were persistently revised upward, a rational policy-maker would have taken this into account and formed an estimate of revised GDP (based on the predictable component in future revisions) prior to constructing an output gap series. As it happens, our examination of the UK evidence suggests that, generally, this process did not take place, and that initial GDP data were often taken at face value. Nevertheless, in Table G we check the robustness of our results by solving the model under the alternative assumption that the future revisions of GDP data were *fully* anticipated, so the only source of error is measuring the economy's capacity. The calibration of the h_t process in Table G is therefore based solely on the differences between initial and final estimates of potential output. As the assumption that revisions to actual GDP were perfectly anticipated is extreme, this exercise provides a reasonable lower bound on the amount of UK inflation due to gap mismeasurement.

[21] The moments reported are the analytical means and standard deviations, which we have checked against the statistics that emerge from 100 stochastic simulations of the model.

Table F: The effects of output gap mismeasurement on the model

Results under alternative parameterisations		
	$f_y = 0.5$	$f_y = 0.3$
Case 1: No measurement error		
s.dev $(4p)$	2.17	2.20
Mean$(4p)$	**0.00**	**0.00**
s.dev$(y_t - y_t^*)$	1.01	1.04
Case 2: Gap mismeasurement calibrated to its 1962–96 time series process		
s.dev $(4p)$	2.48	2.34
Mean$(4p)$	**4.62**	**2.77**
s.dev$(y_t - y_t^*)$	1.26	1.15
Case 3: Gap mismeasurement calibrated to its 1970–79 time series process		
s.dev $(4p)$	2.25	2.23
Mean$(4p)$	**7.08**	**4.25**
s.dev$(y_t - y_t^*)$	1.23	1.13
Case 4: Gap mismeasurement calibrated to its 1980–89 time series process		
s.dev $(4p)$	2.26	2.24
Mean$(4p)$	**5.48**	**3.29**
s.dev$(y_t - y_t^*)$	1.14	1.10

Note: The h_t process is either assumed to be zero (Case 1), or calibrated according to the estimates of **(6)** for 1962 Q3–1996 Q1 and two sub-samples.
Estimates of **(6)** for full sample: $m_h = 4.62$, $r_h = 0.8772$; s.d.$(e_h) = 1.67\%$.
For 1970–79: $m_h = 7.08$, $r_h = 0.7716$; s.d.$(e_h) = 2.37\%$.
For 1980–89: $m_h = 5.45$, $r_h = 0.8332$; s.d.$(e_h) = 1.43\%$.

Table G: Results with potential output mismeasurement: GDP measured perfectly

Results under alternative parameterisations		
	$f_y = 0.5$	$f_y = 0.3$
Mismeasurement of potential calibrated to its 1962–96 time series process		
s.dev ($4p$)	2.36	2.28
Mean($4p$)	**1.19**	**0.71**
s.dev($y_t - y_t^*$)	1.14	1.09
Mismeasurement of potential calibrated to its 1970–79 time series process		
s.dev ($4p$)	2.35	2.28
Mean($4p$)	**3.00**	**1.79**
s.dev($y_t - y_t^*$)	1.23	1.14
Mismeasurement of potential calibrated to its 1980–89 time series process		
s.dev ($4p$)	2.24	2.23
Mean($4p$)	**1.13**	**0.68**
s.dev($y_t - y_t^*$)	1.06	1.06

Note: The h_t process is calibrated according to the estimates of **(6)** for 1962 Q3–1996 Q1 and two sub-samples, where the real-time output gap error is here defined as the difference between final and initial estimates of potential.
Estimates of **(6)** for full sample: $m_h = 1.19$, $r_h = 0.8890$; s.d.(e_h) = 1.11%.
For 1970–79: $m_h = 3.00$, $r_h = 0.8438$; s.d.(e_h) = 1.80%.
For 1980–89: $m_h = 1.13$, $r_h = 0.8871$; s.d.(e_h) = 0.70%.

Table G shows that errors in estimating potential alone are a smaller, but still substantial, source of inflation: inflation exceeds target on average by 0.7 to 3.0 percentage points.

UK inflation, measured by the annual change in the RPI, averaged 12.6% in the 1970s and 7.5% in the 1980s. According to the results in Tables F and G, policy errors arising from output gap mismeasurement contributed approximately 3.0 to 7.1 percentage points to the 12.6% rate in the 1970s and 0.7 to 5.5 percentage points to 1980s inflation.[(22)] We thus find that output gap mismeasurement alone can account for a substantial portion of the high inflation rate observed in both the 1970s and the 1980s. Particularly for the 1970s, there is a substantial amount of inflation that cannot be accounted for by output gap mismeasurement, and therefore might be attributable to

[(22)] The lower bound for the 1970s range would appear to be 1.9% (the $f_y = 0.3$ case in Table G). But the $f_y = 0.3$ value comes from a study (CGG) that excluded pre-1979 data, so judging the 1970s, it seems better to consider only the $f_y = 0.5$ case. That leads to a lower bound of 3%.

other shortcomings of monetary policy in the United Kingdom during this period.[23] We analyse some alternative explanations for the United Kingdom's high inflation record in Nelson and Nikolov (2001).

6 Conclusions

In this paper we have constructed a real-time output gap series for the United Kingdom for the period since 1965. While, for most of this period, monetary policy makers did not lay out their estimates of the output gap explicitly, our analysis of policy-makers' statements allows us to construct a real-time series for potential output and hence the output gap.

Our analysis indicates that upward revisions to the potential output growth rate were made in 1972 and 1989 that do not appear justified by the data now available. As these revisions had the effect of exaggerating the extent to which output was below capacity, they probably led to more loose monetary policy than otherwise, and so exacerbated the inflation problem in those periods. But measurement error in actual GDP was important too, in overstating the severity of the 1971–72 recession and understating the speed of the late 1980s expansion. Taking both sources of error into account, our results suggest that monetary policy mistakes due to output gap mismeasurement contributed 3.0 to 7.1 percentage points to average UK inflation in the 1970s, and 0.7 to 5.5 points in the 1980s.

Advances in data collection and in measuring the productive capacity of the economy may imply that the output gap mismeasurement problem in the United Kingdom is now less than our estimates suggest that it was in the 1970s and 1980s. Nevertheless, as a precaution, it may be useful for inflation-targeting central banks to design monetary policy so that policy decisions are insulated as much as possible from errors due to output gap mismeasurement. One approach would be to undertake an optimal control exercise that explicitly takes into account the fact that initial output gap data are subject to error, as in Aoki (2000). Another approach is to use what Orphanides (1999) terms 'prudent' simple policy rules to guide policy. One of these rules, also discussed in Bean (1983), McCallum (1999) and Rudebusch (2002), aims to control inflation indirectly by stabilising the growth rate of nominal GDP, a macroeconomic variable which can be observed without requiring data on the output gap or potential output. A second 'prudent' rule is what Orphanides terms an 'inflation targeting' rule—moving the interest rate in response to realised inflation. Again, this insulates the policy reaction function from output gap mismeasurement. On the other hand, forward-looking central banks will typically prefer to respond to *expected future* inflation. Since, in general, inflation forecasts are a function of both lagged inflation data and estimates of the output gap, this scheme would appear to lose the advantages of Orphanides' 'prudent' rules. One option is to check inflation forecasts that use output gap data against inflation forecasts that are constructed from growth rate data (such as inflation predictions based on data on lags of inflation and of growth

[23] In this respect our findings agree with Lansing's for the United States (Lansing (2000)). They are also consistent with the graphical evidence in Charts 3 and 4.

rates of economic activity).[24] This approach could combine the advantages of 'prudent' and forward-looking monetary policy.

The potential output series which we deduce from UK policy statements is a series whose level rises by a fixed amount each period in a trend-like manner (though with occasional breaks in the trend, due to perceived productivity growth shifts). This is in keeping with how policy-makers actually viewed potential output, which they regarded as the same as 'trend' GDP.[25] But economic theory suggests, instead, that potential output corresponds to the output level that would prevail in the absence of nominal wage or price rigidity. As such, potential output, while containing a trend component, also contains a cyclical component, reflecting the response of potential output to all the real shocks in the economy (see, for example, Galí, Gertler and López-Salido (2001), Neiss and Nelson (2001), and Woodford (2001)). An extension of our investigation of the output gap mismeasurement problem in the United Kingdom could take into account not only the mismeasurement of the output gap due to errors in real-time data, but also mismeasurement due to failing to take into account the cyclical movements in potential output.

[24] Such equations would fall into the class of models, discussed in Clements and Hendry (1995), that use growth-rate data to 'robustify' forecasts against shifts (and measurement error) in the levels of variables.
[25] See, for example, the *Financial Statements and Budget Reports* for 1993/94 (page 2) and 1994/95 (page 17).

Appendix: Details of the construction of the real-time output gap series

In this appendix we describe in detail our procedure for constructing our real-time output gap series for the United Kingdom.

A1 Real-time data on actual GDP

For actual output, we collect a real-time series by using successive vintages, on a quarterly basis from 1962 to 2000, of the levels of expenditure on real gross domestic product, seasonally adjusted. The January, April, July and October issues of *Economic Trends* are used as the sources of the data. An April issue, for example, typically provides data on GDP up to the previous December quarter. The specific GDP series that we use is the GDP series as reported in the *Economic Trends* table on expenditure on real GDP. This series corresponds to: real GDP, expenditure based, at factor cost in the *Economic Trends* issues from 1962 Q4 to 1992 Q3; to real GDP at factor cost, average estimate, from 1992 Q4 to 1998 Q3; and from 1998 Q4 (when factor cost price series were no longer published in *Economic Trends*), GDP at market prices (code: ABMI). The last of these series is the GDP series reported in both the 'Expenditure on Gross Domestic Product' in *Economic Trends* from October 1998 and the real GDP series reported in the 'National Accounts' subsection of the UK section of the IMF's *International Financial Statistics* and *IFS Yearbook*. This series is known as GDP(A), as it is an average of alternative estimates of real GDP. By contrast, the series that we use prior to 1992 is known as GDP(E), the expenditure-based measure of GDP. Thus some of the differences between our initial and final GDP data series reflect changes in the GDP concept used. This broad definition of 'data revisions' is consistent with Orphanides (1999) and Faust, Rogers and Wright (2000), for whom the shift from the GNP to the GDP concept as the main measure of output in the United States is treated as one of the revisions to the output data.

Typically, revisions to GDP data affect mainly the past few years' observations of the series. More comprehensive revisions of GDP data can occur, sometimes revising the data back to 1955 Q1.[(26)] Historically, these revisions have typically occurred prior to the October issue of *Economic Trends*; however, the October *Economic Trends* would not publish the entire back-run of the revised series. We use the *Economic Trends Annual Supplement* (published from 1975) to obtain a longer back-run of each vintage of the GDP data.[(27)] Because the base year for the real GDP series changed several times, we normalise all data vintages by setting the 1959 Q4 observation on GDP to 1.0. The October 2000 vintage of the real GDP series (covering data up to 2000 Q2) is used as the 'final' output series.

Our choice of the 'expenditure on real GDP' series is motivated by its widespread use and its availability, in real time, since the 1960s. In Section A5.4 below we present evidence on the comparative real-time measurement problem from an alternative series, output-based GDP—GDP(O). Another issue is that during the Civil Service strike of 1981, there was an unusual delay in the reporting of data on expenditure on real GDP for 1981 Q2 and 1981 Q3, which were not available in 1981 Q4 and 1982 Q1 respectively. For these quarters, our real-time GDP

[(26)] This occurs especially when the base year for the real GDP series is changed.
[(27)] Until 1996, the data published in the *Supplement* typically coincided with the data published in the October *Economic Trends.*

series consists of the GDP(O) measure—which was available in real time—spliced into the latest available observation on expenditure-based GDP.[28]

A2 Real-time data on potential GDP

We now describe our approach to constructing real-time estimates of potential output, and hence of the real-time output gap. As we use this real-time output gap series to study its influence on government economic policy (particularly monetary policy), the real-time output gap series that we are interested in is that used by policy-makers, rather than by outside agencies. As we noted in the introduction, no official output gap series was available, so instead we draw out the real-time output gap series implied by policy-makers' statements. Specifically, we rely on statements by:

(i) the Prime Minister (the First Lord of the Treasury);
(ii) the Chancellor of the Exchequer (the Cabinet member with principal responsibility for the Treasury);
(iii) other Treasury Ministers, such as the Chief Secretary to the Treasury and the Minister representing the Treasury in the House of Lords;
(iv) the Treasury and Treasury officials;
(v) the Governor of the Bank of England; and
(vi) the Bank of England in other official proclamations.

In keeping with our aim for real-time information, the statements studied are those made by the individuals while they were in office (or recounting the reasoning behind decisions they made when they were in office). Since the Treasury was in charge of monetary policy decisions until May 1997, we attach greatest weight to statements by the Treasury and by the Government members in charge of the Treasury, when constructing a real-time series for 1965–97. Nevertheless, we include in the above list Bank of England statements. The Bank of England's official statements (such as its 'Economic Commentary' in the *Quarterly Bulletin* in the 1960s and 1970s) had to be cleared with the Treasury in advance, with amendments imposed prior to release if there were perceived contradictions with the Government's official position. A similar policy applied to speeches by the Governor and other Bank of England officials.[29] Furthermore, assessments of the economy by the Bank of England as reported in its 'Economic Commentary' may have been an input into the Government's own analysis.[30]

Our sources for statements are the following:

(*a*) Budget statements by the Chancellor;
(*b*) other statements in Parliament, in testimony to Parliamentary committees, or in speeches, by the Prime Minister, the Chancellor and other Treasury Ministers while they were in office;

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[28] The GDP(O) observations were taken from Table 6 of *Economic Trends* (October 1981 and January 1982 issues). The GDP(O) series was used by the Bank of England in its 'Economic Commentary' in the September 1981 *Bank of England Quarterly Bulletin*, during the Civil Service strike.
[29] In February 1965, after the Bank of England's Governor, Lord Cromer, had made public calls for fiscal measures contrary to Government policy, he was summoned for a warning from the Chancellor of the Exchequer (Morgan (1997, pages 219–20)).
[30] We only treat the unsigned 'Economic Commentary' in the *Bank of England Quarterly Bulletin*, and not signed articles by staff, as official Bank of England statements.

(*c*) memoirs and other biographical material detailing specific economic assessments by the Prime Minister, the Chancellor, and Treasury officials while they were in office;
(*d*) speeches, statements and testimony by the Governor of the Bank of England and by Treasury officials while they were in office;
(*e*) supporting documentation for the Government's Budgets by the Treasury in the annual *Financial Statement and Budget Report* (the *FSBR*, or 'Red Book');
(*f*) the 'Economic Situation' assessment by the Treasury that appeared—usually on a monthly basis—in *Economic Trends* from 1967 to 1974; and
(*g*) the 'Economic Commentary' in the *Bank of England Quarterly Bulletin*.

As the above list indicates, to enable replicability, our series is constructed entirely using published sources.

A3 The 1960s

In this section we describe our construction of a real-time output gap series for the 1960s, beginning in 1965. We first determine what was the growth rate of potential output as perceived by policy-makers in the 1960s. Then we obtain a series for the *level* of real-time potential output by using information on real-time GDP and policy-makers' assessments of the state of the economy.

A3.1 The perceived potential output growth rate in the 1960s

Much evidence suggests that UK policy-makers' perceived growth rate of potential output in the 1960s and early 1970s was 3% per year. This figure was used repeatedly in Budget speeches and Treasury statements in the late 1960s. For example, Chancellor Callaghan in his 1967 Budget speech said that '3 per cent… [is] a rate not far different from that of productive potential… the rate we can sustain in the medium term' (11 April 1967, pages 993–94).[31] In his 1969 Budget speech, Chancellor Jenkins described 3½% annual increase in GDP as growth 'slightly in excess of productive potential' (15 April 1969, page 1,001). Similarly, the Treasury in the *FSBR 1969/70* said that a 'rate of expansion of around 3 per cent is probably roughly in line with what can currently be achieved out of the normal growth in productive potential' (page 11). In his 1971 Budget speech Chancellor Barber said that 'the rate of growth of productive potential… is estimated to be about 3 per cent' (30 March 1971, page 1,370).[32]

The Wilson Government did announce a 'National Plan' in November 1965, which had a target of 4% annual growth for the rest of the 1960s. It was recognised that the 4% rate was a target rather than the currently prevailing potential output growth rate (eg Cairncross (1997, page 30)). Furthermore, and most importantly, the Plan was

[31] Unless otherwise noted, our page references to statements by politicians refer to the column number in the volume of the House of Commons *Official Report* (*Hansard*) that contains the proceedings for the date indicated.
[32] The principal alternative hypothesis is that policy-makers conditioned on a 3.25% annual growth assumption. There is no use of this figure in Budget speeches, but it might be regarded as the implication of some policy-makers' statements that potential growth was about 3 to 3½ per cent (eg Cairncross (1996, page 71) and Richardson (1975, 1976)). A value of 3.25% does less well in accounting for policy-makers' assessments of the output gap in the 1960s and 1970s: it implies a negative output gap in 1966 Q1 rather than the positive gap suggested by Chancellor Callaghan's statement in July 1966 (see Section A3.2). Furthermore, the size of the output gap in early 1976 implied by a 3.25% trend is over –10%, not the –7.5% figure implied by the 1976 Budget's assessment (see Section A4.3). Thus, it appears that the 3% figure was the point estimate used in growth and output gap calculations, and that is the number we use.

formulated by the Department of Economic Affairs (DEA), not the Treasury, and it was the latter body which was responsible for monetary and fiscal policy. In general, the Treasury did not defer to the DEA on matters,[33] and, specifically, Treasury officials rejected the 4% growth rate figure (even as a target) because they 'were not convinced that productivity had accelerated very much or would continue to accelerate' (Cairncross (1997, page 30)).[34] The 4% growth rate was accordingly not used by the Treasury in its policy formulation, and was repudiated even as a target for the rest of the decade by Chancellor Callaghan in July 1966 (Morgan (1997, page 241)). The *FSBR 1969/70* stated that a 'rise of 4 per cent a year is probably in excess of the present growth of productive potential' (page 11), and the Treasury said in the August 1971 *Economic Trends* that 4 to 4½% annual growth was 'greater than the rate of increase of productive potential' (page ii).

Accordingly, our real-time potential output series for all quarters from 1965 to 1971 is based on steady 3% annual growth (0.75% per quarter).

A3.2 The perceived level of the output gap in the 1960s

Now that we have the growth rate of potential output as it was perceived in the 1960s, we need information on where policy-makers thought the economy stood in relation to the *level* of potential output, to obtain series for real-time potential output and the output gap.

In 1965, the Head of the Government Economic Service, Alec Cairncross, observed privately that the 'labour market [being] in balance' meant 'eg 1.8% unemployment' (Cairncross (1997, page 96)). In light of this statement, we locate a point prior to 1965 when unemployment was 1.8% and pin down the associated output level as consistent with a zero output gap. (Looking for similar positions after 1965 has the disadvantage that as early as 1968 the Treasury had recognised publicly that the level of unemployment consistent with a zero output gap had risen in the late 1960s.)[35]

The unemployment rate—seasonally adjusted, referring to 'wholly unemployed' excluding school leavers[36]—was 1.9% in October 1959, 1.8% in November and December 1959, 1.7% in January 1960, and 1.6% in February–April 1960.[37] On this basis, 1959 Q4 seems to be a good candidate as a period regarded (as of the mid-1960s) as a point where output equalled potential. Alternatively, 1959 Q3 could also be a candidate, given the Treasury's statement that unemployment reflects 'the level of output in the preceding three months or so' (*Economic Trends*, November 1968, page ii). Because GDP grew by almost 10% at an annual rate from 1959 Q3 to 1959 Q4, the choice between

[33] See Morgan (1997, page 249) for accounts of complaints that Chancellor Callaghan made about the DEA's role.
[34] In the late 1960s, the Treasury noted some evidence that productivity had accelerated, but repeatedly cautioned that it was too early to identify the acceleration as an increase in the potential growth rate, rather than a cyclical increase (*Economic Trends*, October 1967, page vi; May 1969, page v).
[35] In October 1968, the Treasury observed that '[m]ovements in unemployment have diverged to an unusual extent from other indicators of the demand for labour in recent months' (*Economic Trends*, page iv). In January 1971, it stated that 'the economic and social measures taken during the period 1965–67 altered the historical relationships between the levels of registered wholly unemployed and of notified unfilled vacancies' (*Economic Trends*, pages iv–v). The Bank of England stated in its March 1970 'Economic Commentary' that 'unemployment is apparently higher now for a given level of industrial activity than in the past' (page 19).
[36] This was the unemployment rate focused on in the 1960s by the Treasury (eg *Economic Trends*, January 1967, page iii) and by Cabinet (eg Castle (1990, page 149)).
[37] *British Labour Statistics, Historical Abstract 1886–1968*, Department of Employment and Productivity, HMSO (1971, page 318).

the two dates is crucial. Fortunately, statements by policy-makers in the 1960s help discriminate between 1959 Q3 and 1959 Q4 as candidates:

- On 12 July 1966, Chancellor Callaghan gave a paper to Cabinet judging that the economy was in '[an] inflationary condition' with 'labour short, wages rising fast...' (Morgan (1997, page 241)).[38] Thus, on the basis of economic activity indicators available in July 1966 (namely, GDP data up to 1966 Q1 and various labour and activity data for 1966 Q2) it appeared to policy-makers that output was greater than potential.[39] Using 1959 Q3 as a zero output gap point, real-time GDP data for 1966 Q1 imply an output gap of +3.1% (ie output 3.1% above potential); using 1959 Q4 as a zero output gap point, real-time GDP data imply an output gap of +1.5% in 1966 Q1. Thus both 1959 Q3 and 1959 Q4 zero-output-gap alternatives are consistent with the information on the 1966 real-time output gap supplied by Callaghan's statement.[40]

- Speaking on 5 October 1967, the Governor of the Bank of England said that 'at the moment', output was below capacity (O'Brien (1967b, page 981)). This suggests an assessment that output was below potential in 1967 Q2 (the period for the latest GDP data). Using 1959 Q3 as the period of a zero output gap, real-time GDP data for 1967 Q2 suggest a *positive* output gap of +1.0%; but using 1959 Q4 as the zero output gap point, real-time GDP data for 1967 Q2 suggest an output gap of –0.7%, consistent with O'Brien's statement. Therefore, we choose 1959 Q4 as the point at which output equalled potential output, because it is consistent with both of the above statements by policy-makers in the mid-1960s about the level of the output gap.

Thus, for the period 1965–71, our real-time potential output series, normalised at 1.0 in 1959 Q4, grows at a steady 3% annual rate. We also normalise successive vintages of the real GDP series to 1959 Q4 = 1.0, reflecting the idea that by the mid-1960s, 1959 Q4 was considered by policy-makers to be a point corresponding to a zero output gap.

How do these real-time views of the output gap look in retrospect? As we discussed in Section 4, the measurement of the output gap by UK policy-makers in the 1960s seems to have been quite realistic, in the sense that the differences between real-time and final data on the output gap are relatively small. In addition, policy-makers were considerably more realistic and conservative in their estimate of potential over the 1960s than were outside agencies such as the OECD. For example, the OECD (1973) produced a half-yearly output gap estimates for the 1960s that suggested that the United Kingdom had a negative output gap for 15 of the 20 half-yearly periods in 1961–70 and that the gap was –1.4% on average (OECD (1973, pages 37–39)). By contrast, we estimate that (as of late 1972) UK policy-makers viewed the output gap as having been negative in only 8 of the 20 half-years in 1961–70, and as having averaged zero.

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[38] This incident, as well as speeches by the Governor of the Bank of England (such as O'Brien (1967a, 1967b)) clearly indicates that policy-makers were aware of the distinction between the concepts of *maximum possible* output, and *potential* output, and defined the output gap with reference to the latter.

[39] Similarly, in a recently declassified July 1966 brief to the Prime Minister, the Cabinet Secretary wrote that 'inflationary pressure (which appears in the balance of payments context as an excess of imports) persists at too high a level' (quoted in Hennessy (2000, page 308)).

[40] On the other hand, two output gap series constructed by later outside researchers—those of the *National Institute Economic Review* (February 1973) and Backhouse (1983, page 213)—were premised on the assumption that output was equal to, or below, potential on average in 1966. These seem to be inappropriate assumptions, as (whether one uses real-time information or revised data) the economy seems to have been operating above potential on average in 1966.

A4 The 1970s

In this section we describe our construction of a real-time output gap series for the 1970s.

A4.1 The perceived increase in the potential growth rate in the early 1970s

As noted in Section A3, the belief in a 3% growth rate of potential GDP continued from the 1960s into 1971. But in early 1972, there was a revision by the Government of the estimate of the potential GDP growth rate. In the 1972 Budget, Chancellor Barber forecast that 'output will have risen by 10 per cent over the two-year period from the first half of 1971 to the first half of 1973' (21 March 1972, page 1,353). There are several statements that help decompose how much this forecast growth was seen as part of a cyclical recovery and how much was perceived growth in potential output.

- Much of the 5% per annum growth was viewed as a closing of a negative output gap. In his speech, the Chancellor stated that 'the present high level of unemployment is… one which no Government could tolerate' (page 1,346) and that 'we are starting from a position where there are more unused resources than there were at the beginning of any previous period of rapid expansion since the war' (page 1,354). Supporting this, the *FSBR 1972/73* (accompanying the March 1972 Budget) stated that the forecast 1971–73 growth of 5% per annum would be 'faster than the estimated growth of productive potential, so that… the level of unemployment should decline' (page 9).

- Part of this expansion, however, was perceived as a switch to a higher long-run growth rate. The Chancellor stated that the United Kingdom's entry into the European Economic Community (EEC) 'provides us with a new opportunity for faster growth' and that '[the] enlarged outlet for our goods and services together with the present scope for expansion provide our country with an unparalleled opportunity over the coming years' (page 1,343). Notably, he added that 'our potential growth of productivity is greater than it was on… earlier occasions' (page 1,343). In keeping with this, Blackaby's (1978, page 63) assessment of this period is that '[t]he estimate of national productive potential was probably quite high at the time, for productivity had, in an unprecedented way, improved in both 1970 and 1971.' Similarly, speaking in the House of Lords on 9 November 1971, Lionel Robbins observed that 'in recent months productivity per head has risen so considerably…' (reprinted in Robbins (1978, page 50)).[41] The 1972 Budget speech suggested that supply-side reforms by the Government and efficiency gains from EEC membership were reasons why the higher potential growth rate, to which the economy had shifted, could be sustained.[42]

The new potential output growth rate assumed by the Government was given by Lord Windlesham, the Heath Government's minister for Treasury matters in the House of Lords, as 3½% (House of Lords speech, 6 November 1973, page 254)—ie 0.5 percentage points per annum greater than the potential growth rate of the 1960s.

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[41] And, speaking in Spring 1972, Alec Cairncross observed, 'We in fact seem to have made, if anything, *more* rapid progress… in the last two or three years in terms of productivity than we ever did through the boom years of previous cycles' (in Cairncross and Kaldor (1972)).

[42] In addition to the reference to EEC entry in the Budget speech, other Government documents stated that EEC membership would increase the United Kingdom's growth rate, due to the economies of scale from the larger market for goods and services and greater competition from other member countries (Tomlinson (1985, page 179)).

Consistent with the above statements, Brendon Sewill, Special Adviser to Chancellor Barber from 1970 to 1974, revealed that at the time of the 1972 Budget, 'Treasury forecasts showed the possibility, without strain on the economy, of 5 per cent growth for some time, thereafter declining to a long-term rate of about 3½ per cent' (Sewill (1975, page 45); Campbell (1993, page 523)).

We can pin down the authorities' implied perceived output gap level by drawing on the 6 March 1973 Budget. The Government's 5% per annum target growth rate had thus far been achieved, and Chancellor Barber predicted that 'the economy will continue to grow at an annual rate of around 5 per cent over the 18 months from the second half of 1972 to the first half of 1974' (page 249). In Parliament on 22 March 1973, he added that '[a]lmost all commentators agree on one point, namely, that there are still plenty of spare resources to sustain a fast growth rate for some time to come' (page 645).

Together these statements imply a belief that growth of the economy of 5% a year from 1971 Q3 to 1974 Q2—cumulative growth in real GDP of 15%—was consistent with output not being above potential in 1974 Q2. On the basis of the Chancellor's 6 March 1973 statement that growth to mid-1974 would be 'a steady movement toward the full use of our productive capacity' (page 248), we assume that the output gap was expected to reach exactly zero in 1974 Q2 under this growth path.

We can deduce the assumed date of the shift from 3% to 3.5% per annum potential output growth as follows. In the vintage of GDP data available at the time of the March 1973 Budget speech, actual real GDP in 1971 Q2 (expressed in logarithmic units with 1959 Q4 = 0) was 0.309. For consistency with the growth aims of the March 1973 Budget, this number must be 15% below the level of potential output foreseen for 1974 Q2 (which must therefore be 0.459). With potential output growing steadily by 3.5% per annum (in logarithmic units, approximately 0.0088 per quarter), the shift from 3% to 3.5% steady growth must have been believed to have occurred in 1969 Q4. Therefore, our real-time potential output series for the period 1972 Q1 until the Heath Government's last full quarter in office, 1973 Q4, is one which grows at 3% per annum until 1969 Q3 and at 3.5% per annum thereafter.

By early 1974, the tremendous increase in inflation and a growing current account deficit suggested that the assessments of spare capacity used in setting policy in 1972 and 1973 had been serious overestimates. In his first Budget in March 1974, the new Chancellor, Denis Healey, repudiated the Heath Government's assumption of a higher potential growth rate. Reassessing the early 1970s, he observed that '[d]emand had outstripped capacity' in the 1972–73 expansion (26 March 1974, pages 291–92) and that 'there is no evidence that the underlying growth rate of the economy as a whole has improved' (page 279). The new Government thus reverted to the pre-1972 assumptions about potential growth, namely, steady growth of about 3% per year since the 1960s.[43]

A4.2 The perceived impact of the oil shocks

The OPEC oil price shocks of 1973 and 1979 have given rise to many questions regarding their implications for the UK economy. These include the effect of the oil price increases on the efficiency of the United Kingdom's capital stock, and how North Sea oil (discovered in 1968, but not 'on-stream' until 1975) affected the level, growth rate, and structure of the United Kingdom's potential output.[44] For our purposes, however, we only need to know the

[43] We show in Section A4.3 below that the 1976 Budget's estimate of the output gap is consistent with this assumption.
[44] On these questions, see, for example, Chrystal (1984), Bean (1987), Allsopp and Rhys (1989), and Forsyth and Kay (1989).

answer to one question: how did policy-makers revise their estimates of potential output in the wake of the oil shocks? That is the subject of this section.

In the aftermath of the first oil shock, Chancellor Healey acknowledged some negative effects on the UK's real GDP:

> '[T]he savage lurch in the terms of trade against us between 1973 and 1974 meant that the nation's real income actually fell by about 4 per cent last year' (15 April 1975, page 273).
> '[T]he increase in oil and other commodity prices cut our real national income by nearly 5 per cent.' (6 April 1976, page 239).[45]

These statements, however—like those of Chancellor Barber in his Mini-Budget in December 1973 in the immediate wake of the oil shock—referred not to the supply-side effects of the shock, but instead purely to the *demand-side* effects. In 1973–74, it was thought that the OPEC oil shock constituted a sharp negative shock to UK (and other industrial countries') aggregate demand, due to the large transfer of oil revenues to the oil-producing countries. As Chancellor Healey explained:

> '[O]ne effect of the rise in oil prices is to deflate demand both in Britain and in the world economy… Since the money is paid by the consumers but not spent by the producers, it represents a net reduction in world demand. Unless means can be found of recycling these surpluses so that the oil-exporting countries can spend them, we could be in for a world slump of 1931 proportions…' (23 July 1974, page 1,315).

The '5 per cent' reduction in income referred to by Healey above was not an estimate of the supply-side effect of the oil shock, but instead one measure of its impact of UK aggregate demand—namely, the 5 percentage point increase (relative to GDP) in the current account deficit from 1973 to 1975. This was made more explicit in his statement that 'I cannot afford to increase demand further today when 5p in every £ we spend at home has been provided by our creditors abroad' (15 April 1975, page 282).[46]

The evidence suggests that supply-side effects of the first OPEC oil price rise were not taken into account into policy-makers' mid-1970s estimates of the level of potential output. Nor, until 1979, was the slowdown in productivity which is now widely believed to have occurred in industrial countries around 1973, incorporated into estimates of the potential output growth rate. There are several pieces of evidence for this. Regarding the *growth rate*, in speeches in 1975 and 1976, Governor Richardson continued to use the 3% figure for the annual growth rate of potential that was used in the 1960s (Richardson (1975, 1976)), as did the Bank of England in its March 1977 'Economic Commentary' (page 10). Regarding the *level*, the 1976 Budget was based (as discussed in Section A4.3 below) on an output gap estimate that was consistent with potential output growing steadily since the 1960s at a 3% rate with no breaks in level.[47] Accordingly, our real-time potential output series from 1974 until 1979 is one that has these properties.

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[45] Healey (1989, page 379) gives a simplified version: 'the increase in oil prices… reduced our Gross Domestic Product… by five per cent.'

[46] In addition, the *FSBR* for the 1975 Budget makes clear that the reference by Healey to the '4 per cent' fall in 'the nation's real income' due to the terms of trade shift was to a fall in real disposable income, not in GDP (*FSBR 1975/76*, page 3).

[47] Similarly, the Bank of England's March 1975 'Economic Commentary' attributed the rise in unemployment in 1974 to '[t]he increasing gap between actual and potential output' (page 11), without any discussion of a fall in potential output. Its September 1975 'Economic Commentary' stated that '[s]ince the third quarter of 1973, potential output has

By the time of the 1979 oil shock, there was greater awareness of the supply-side consequences of oil shocks. From 1975, however, the United Kingdom was producing North Sea oil, becoming a net exporter in 1980, and the effect of the 1979 oil shock on potential GDP was therefore ambiguous. The Government's position, expressed in a speech by the Governor of the Bank of England in 1980 (Richardson (1980)) was that North Sea oil and the 1979 shock together had little net effect on the United Kingdom's real income because the extra North Sea output was largely offset by resources absorbed in extracting the oil. In line with this position, we make no adjustment to the real-time potential output series in the wake of the oil price changes in 1979 or afterwards.

One final point regarding oil should be mentioned. In the late 1980s policy-makers distinguished between the potential growth rate of the whole economy and of the 'non-oil' economy (see Section A5.2). The number we focus upon is their estimate of the growth rate of the whole economy.

A4.3 The 1976 Budget

In the April 1976 Budget, Chancellor Healey announced a three-year programme for 'the fastest possible return… to full employment' (6 April 1976, page 232). This Budget therefore provides useful information on the authorities' perception of the degree of spare capacity.

The Budget planned for the economy to grow by 5.5% a year on average from 1976 Q1 to 1979 Q1 (6 April 1976, page 240). Taking the end of 1979 Q1 as the period when potential output was assumed to equal actual output,[48] this implies an assessment that in 1976 Q1 the output gap in 1976 Q1 was (in logarithmic units), $3\cdot(g-0.055)$, where g is the annual growth rate of potential output. If, as the evidence suggests, from 1974 policy-makers conditioned on a 3% growth rate of output, the implied estimate in March 1976 of the output gap in 1976 Q1 is –0.075 (ie –7.5%).[49] Our real-time output gap observation for 1976 Q1 (which did not become available until after the Budget) is –0.0742, a very close match. The 1976 Budget figures therefore support our contention that policy-makers' views of potential output implied actual output being equal to potential in 1959 Q4 and potential growing at 3% per annum thereafter.

A4.4 The revision of potential output growth in 1979

By early 1979, the accumulation of five successive years of slow growth and generally high inflation was causing a re-think of whether the weak GDP growth rates after 1973 were purely a cyclical phenomenon. A downward revision of the economy's potential growth rate was likely to happen in 1979 even in the absence of a change of government; the Bank of England's March 1979 'Economic Commentary' noted that 'productivity performance… has been comparatively poor over the last five years' (page 6). In the event, the new Conservative Government took the opportunity in its June 1979 Budget to revise the trend growth assumption. Chancellor Howe stated that the slow economic growth of 1973–78 did not reflect deficient demand, as 'demand was rising strongly, and inflation remained high, [rather] the economy was almost unable to increase supply' (12 June 1979, page 236). He

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probably expanded by around 5%', and an accompanying table confirmed that this calculation was based on 'the exponential trend of output (about 3% per annum) calculated over 1956–74' (pages 214–15). The March 1978 commentary stated that '[c]apacity utilisation remains low' (page 11).

[48] Chancellor Healey said that his aim for 3% unemployment was an objective to be hit 'by 1979' (6 April 1976, page 245).

[49] This estimate of the size of the United Kingdom's output gap was in line with estimates for other OECD countries. For example, the June 1977 report to the OECD by McCracken *et al* estimated that the output gap for a group of nine OECD countries was –8.3% in first-half 1976, and –7.3% in a group of six European countries (1977, page 340).

also stated that '[p]roductivity is rising half as fast as in the early 1970s. There is no sign of any change for the better there' (page 237).

Consistent with this, the *FSBR 1980/81* (March 1980) observed that 'In most industrial countries there is strong evidence of a slowdown in productivity growth in recent years… The consequence of the slower growth in productivity in the 1970s is that there has been less excess capacity in the economy than might have been expected, on earlier experience, given the slow growth of output' (pages 17–18). Using the mean growth rates of real GDP as a measure of potential output growth, the March 1980 *FSBR* found that this was 3.0% in 1964–73 and 1.0% after 1973 (page 17). It conditioned its forecasts for future years on continuation of this 1.0% per annum trend (page 18).

From 1979 Q2 to 1980 Q3 inclusive, we therefore assume that policy-makers believed that potential output grew at 3.0% per annum until 1973 Q3 and 1.0% thereafter.

A revision to GDP data in late 1980 actually retrospectively raised the growth rate of GDP from 1974 Q1–1979 Q2 from 1.0% to 1.9% per annum—nearly double the estimate of a year earlier.[(50)] This higher average rate for 1974–79 was approximately maintained in all the subsequent GDP revisions during the 1980s. Since the mean rate of 1974–79 growth had heavily influenced policy-makers' assessment of potential growth, the upward revision in this mean presumably raised their potential growth estimate. On the other hand, most of the upward revision was concentrated in the years 1978 and 1979, both of which (as the rise in inflation in 1978–80 suggested) were suspected of being years in which output overshot capacity. Upward revisions to the data on GDP growth in 1978 and 1979 may have been interpreted as partly reflecting improved measurement of how much output had grown beyond potential, rather than as implying a revision to potential growth. Balancing these conflicting considerations, the growth rate we assume as policy-makers' estimate of post-1973 growth after the 1980 data revision is 1.5%. This value seems consistent with policy-makers' statements on the level of the output gap made after 1980 (see Section A6.1).

A5 The 1980s

In this section we describe our real-time output gap series for the 1980s. In Sections A5.1 to A5.3 we document changing views on potential output in the 1980s, and in Section A5.4 show the real-time output gap series that is implied by combining the potential output series with real-time GDP data.

A5.1 First revision of potential growth: 1982

Beginning in early 1982, policy-makers progressively raised their estimate of potential output growth. As Bean and Symons (1989) note, such a higher growth rate appeared justified by an increase in productivity growth, notably in manufacturing. Initially, however, the assumed rise in the growth rate was small, because there was the possibility that the higher productivity growth rate reflected 'batting average' effects during the 1979–81 recession. For example, the 1983/84 *FSBR* noted that '[i]n manufacturing, there is convincing evidence of an above average gain in productivity since 1980, though the extent of the fall in output makes the precise size of this gain difficult to assess' (page 19).[(51)]

[(50)] The growth rate for 1973 Q4–1979 Q2 was retrospectively raised from 0.8% to 1.6% by the same revision.
[(51)] Further evidence that accrued during the 1980s argued against the 'batting average' interpretation of the improvement in manufacturing productivity (Oulton (1987); Bean and Symons (1989)).

In evidence to the Treasury Select Committee, F Cassell, a Treasury official, put the Treasury's estimate of potential growth at between 2 and 2.5% per annum (testimony on the 1982 Budget to the Treasury and Civil Service Committee (TCSC), 17 March 1982, page 7). The following November, the Chief Economic Adviser to the Treasury, Terence Burns, stated that the potential output growth rate was above 1.75% (testimony to the TCSC on the Autumn 1982 Statement, 16 November 1982, page 8). The *FSBR 1983/84* stated that '[g]rowth of total output in the range 2–2.5%… is probably consistent with no great change in unemployment' (page 19). In testimony to the TCSC on his 1984 Budget, Chancellor Lawson said that the assumption of 2% average growth after 1984/85 was 'prudent' (28 March 1984 testimony in TCSC Report on the 1984 Budget, page 86).

On the basis of these statements, we assume that from 1982 Q1 policy-makers' estimate of potential output growth during the recovery that commenced in 1981 Q4 was 2% per annum. The reason for not using 2.25% (the mid-point of the 2 to 2.5% range in some of the statements above) is that the nominal GDP projections that were published in 1985 (see Section A5.2) conditioned on a 2% potential growth rate for real GDP. It is unlikely, given the favourable productivity data that accrued in the early and mid-1980s, that the potential output growth rate was actually revised *down* between 1982 and 1985. Therefore, we assume that policy-makers in the early to mid-1980s preferred the lower end of the 2% to 2.5% range as the most likely potential growth number.

A5.2 Second revision of potential growth: 1986

As the UK economy recovered from late 1981 onwards, it continued to generate considerably better productivity growth than observed in the 1970s. The realisation that a shift to a higher long-run productivity growth rate had probably occurred, led in 1986 to another upward revision in the Treasury's estimate of potential GDP growth.

Multi-year Government projections for nominal GDP began in the *FSBR* for 1985/86, dated March 1985. In the following year's *FSBR*, the nominal GDP growth rate to which the economy was projected to converge in 1989–90 was 5.5%, compared to an ultimate rate of 5% for 1988/89 in the March 1985 *FSBR*. The reason given for the change was that the 'path allows for higher growth of productive potential and slower decline in oil production than was assumed last year' (page 10). This ultimate rate of 5.5% was kept in the 1987/88 and 1988/89 *FSBR*s, but was recast as a projection for 1990/91 or 1991/92 (*FSBR 1987/88*, page 9; *FSBR 1988/89*, page 8).

In testimony to the TCSC on his Autumn 1987 budgetary statement, Chancellor Lawson was asked, 'What do you feel is the long-run sustainable growth rate, if it is not 4 per cent?'. He answered, 'That is very difficult to say but if I had to pluck a round number I would choose three per cent for non-North Sea output' (9 December 1987 TCSC testimony, page 14). As he noted, '2½ per cent growth [in total GDP] implies 3 per cent growth for the non-oil economy' (page 14). Indeed, Treasury forecasts around this time routinely conditioned on a 0.5% wedge between the growth rates of aggregate output and non-oil GDP (eg Nigel Lawson, Budget speech 15 March 1988, page 994; John Major, answer to written question in Parliament, 21 June 1988, page 503). Hence, 3% potential growth in the non-oil economy implied an overall growth rate of potential GDP of 2.5%.

In his 1988 Budget speech Chancellor Lawson indicated (15 March 1988, page 994) that he expected the 3% output growth forecast for 1988 (3½% in non-oil GDP) to be associated with a decline in unemployment (though a less rapid decline than in 1987). This implies that the assumed potential GDP growth rate was below 3%, and is consistent with his 1987 TCSC testimony as well as the 2.5% per annum potential growth assumption accompanying the 1988/89 *FSBR*'s Nominal GDP target.

On the basis of the above evidence, we assume that the estimated potential GDP growth rate was raised by 0.5% in 1986 Q1, applied retrospectively to the entirety of the 1980s recovery, to 2.5% a year.

A5.3 Third revision of potential growth: 1989

In the *FSBR* that accompanied the March 1989 Budget, the Nominal GDP projections were accompanied by the statement: 'The medium-term trend in output growth consistent with declining inflation is now put at 2¾ per cent, compared with 2½ per cent assumed last year; the medium-term trend in non-oil output growth consistent with declining inflation is put at 3 per cent.' (*FSBR 1989/90*, page 10). (The term 'consistent with declining inflation' suggests perhaps that the growth rate is one that delivers a negative output gap, but the projected decline in inflation was intended to be an anticipated decline, so that output would grow at potential.) Again, we assume that this revision was applied retrospectively to potential output for the whole of the 1980s expansion, that is, since 1981 Q4.[52]

A5.4 The real-time behaviour of alternative GDP measures in the 1980s

As noted in Section A2, we have used in this paper a real-time series for actual output that corresponds (until the 1990s) to the expenditure-based measure of GDP in the national accounts. In practice, there are several measures of GDP available in real time, and during the 1980s and 1990s *Economic Trends* published three such series: the 'expenditure-based' measure, an 'income-based' measure, and an 'output-based' measure, GDP(O). It has been noted that during the late 1980s expansion, the measurement error in the expenditure-based measure was greater than in the output-based measure, in the sense that the rapid expansion of GDP in 1987–88 was much more evident in real time in the GDP(O) series, whereas it only appeared in revisions to the expenditure-based series. Because of this, there is the possibility that our use of the expenditure series exaggerates the measurement error in real time of the output gap. We now examine this issue.

As a representative 'real-time' vintage of data, we look at the data available in 1988 Q4 (as published in the October 1988 *Economic Trends*). Chart 7 plots the four-quarter growth rates of our 'final' GDP series against the corresponding growth rates of the 1988 Q4 vintages of the output-based and expenditure-based GDP series. So 'D4yO884' plots the annual growth rate (log fourth difference) of GDP(O) for 1985 Q1–1988 Q2 according to the 1988 national accounts, while 'D4yE884' is the corresponding growth rate of the expenditure based measure, and 'D4yfinal' depicts the final data. In 1987–88, the real-time GDP(O) series is clearly much closer to the final series than is the expenditure-based measure. The GDP(O) series does appear to have captured the speed of the late 1980s expansion quite accurately, although the 1988 vintage of GDP(O) data appears to have understated the growth that occurred in 1985 and 1986.

However, our paper is concerned essentially with a *levels* concept, the output gap. Chart 8 plots the log-levels of actual GDP according to the 1988 vintages of expenditure-based and output-based GDP measures. As in the rest of

[52] Our justification for assuming that this revision was applied retrospectively to the whole of the 1980s expansion, rather than (eg) dating from the start of the major privatisation programme in the Government's second term, or from the defeat of the coalmining strike in 1985, is Chancellor Lawson's statement that 'we have had growth now at a very satisfactory rate for the past eight years. That has been associated above all with a dramatic improvement in the supply side of the economy' (Lawson's 30 November 1988 testimony, given in the TCSC's Report on the 1988 Autumn Statement, page 32). In addition, as Bean (2000, page 100) observes, 'The privatisation programme did not really get underway until the latter part of… Mrs Thatcher's premiership, and thus cannot be the explanation for the pick-up in productivity growth, which began early in the decade'.

this paper, the series are normalised so that their 1959 Q4 log-levels are zero. The levels of the series exhibit serious divergences throughout the 1970s and 1980s, with slower growth in the GDP(O) measure in the late 1970s and early 1980s than in the expenditure measure, followed by faster average growth in the GDP(O) during the 1980s expansion. By 1988 Q2, the last observation available in October 1988, the levels of the series almost coincide. This implies that, for a given potential output series, the two series would essentially *agree* on the *level* of the output gap in 1988. In this sense, the output gap mismeasurement problem would still have been present in the late 1980s if policy-makers had used the output-based GDP measure.

A6 The 1990s

In this section we describe the real-time output gap series that we have constructed for the 1990s.

A6.1 Treasury estimates of potential output from 1990 to 1997

The multi-year nominal GDP projections in the *FSBR* continued until the 1997/98 Budget (presented in November 1996). These continue to be our basis for identifying shifts in policy-makers' views about potential output growth. However, an important change is noticeable in the supporting documentation for these projections. Instead of—as in the 1980s—the final year in the multi-year projection being one where the economy was forecast as growing at its long-run potential rate, output growth was forecast to exceed potential growth throughout the years being projected. Indeed, all the *FSBR*s from 1991/92 to 1996/97 projected that the real GDP growth rate five years into the future would be higher than the potential growth rate, reflecting a closing of the output gap after the early 1990s recession. For example, the 1993/94 *FSBR* stated that as the economy was at 'the trough of a recession', the forecast was for a recovery which 'continues to gather pace in 1994, and that output then grows somewhat faster than its trend growth for a number of years' (page 2). The accompanying projection envisaged GDP growing at 2.75% in 1997/98, so by now potential output growth had been revised down from the 2.75% value used in the late 1980s. The *FSBR 1994/95* similarly expected output growth 'at 3 per cent a year over the medium term' (page 17) as unused resources were employed.

Further information about the Treasury's perception of the potential growth rate can be gleaned from other statements in the *FSBR*s. The *FSBR 1992/93* stated that 2% growth a year was 'well within the potential growth rate of the economy' (page 12). The *FSBR 1995/96* stated that the trend growth of GDP was 'estimated to be 2 to 2½ per cent' (page 51), a view reiterated by Alan Budd (Chief Economic Adviser to the Treasury) on 6 December 1994 (testimony in TCSC Report on the 1994 Budget, page 30).[53] The 1996/97 *FSBR* stated that the 'economy has on average grown above its trend rate' since 1993; at the time (November 1995) that this was written, the average per annum GDP growth rate since 1993 Q1 was 3.2%.

While the 1990/91 *FSBR* restated the previous year's estimate of potential output growth of 2.75%, the 1991/92 *FSBR* did not. This suggests that the shift from a 2.75% assumed potential output growth to the 2.25% rate (ie the mid-point of the estimate given in the 1992/93 *FSBR*) occurred in the course of the formation of the 1991/92 Budget, that is, in 1991 Q1. By that time, the inflation of 1988–90 had given policy-makers reason for believing that the estimates of potential growth that they had used in the late 1980s (that is, of 2.5%, subsequently raised to 2.75%) had been an overestimate.

[53] The number quoted in the *FSBR* was for growth in non-North Sea GDP, but the table accompanying this number indicated that total GDP and non-North Sea GDP were now viewed as having identical trend growth rates.

Chart 7: Four-quarter GDP growth according to final data, and October 1988 vintages of output-based and expenditure-based measures

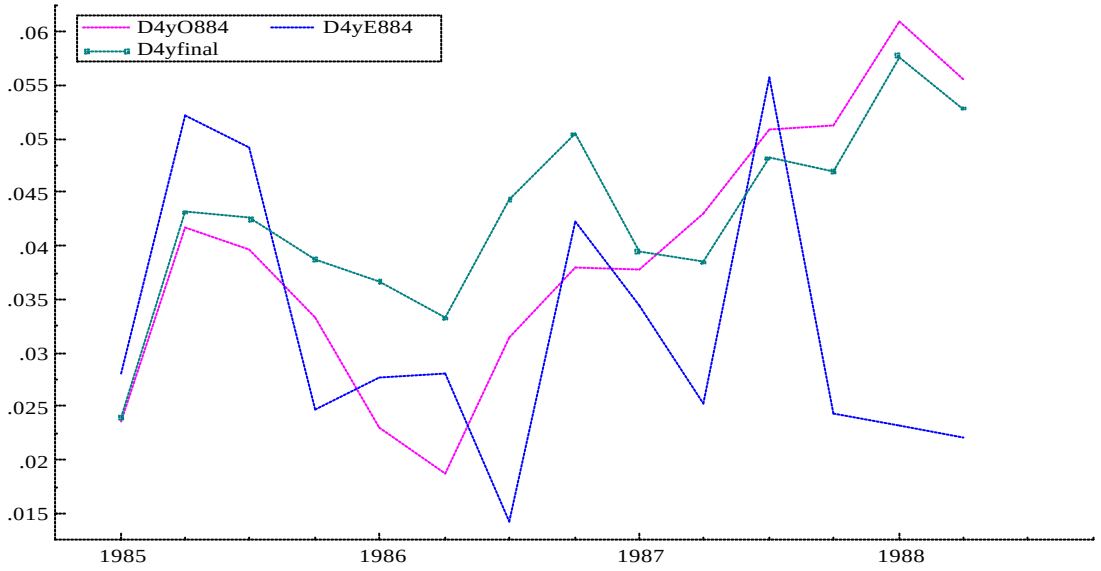
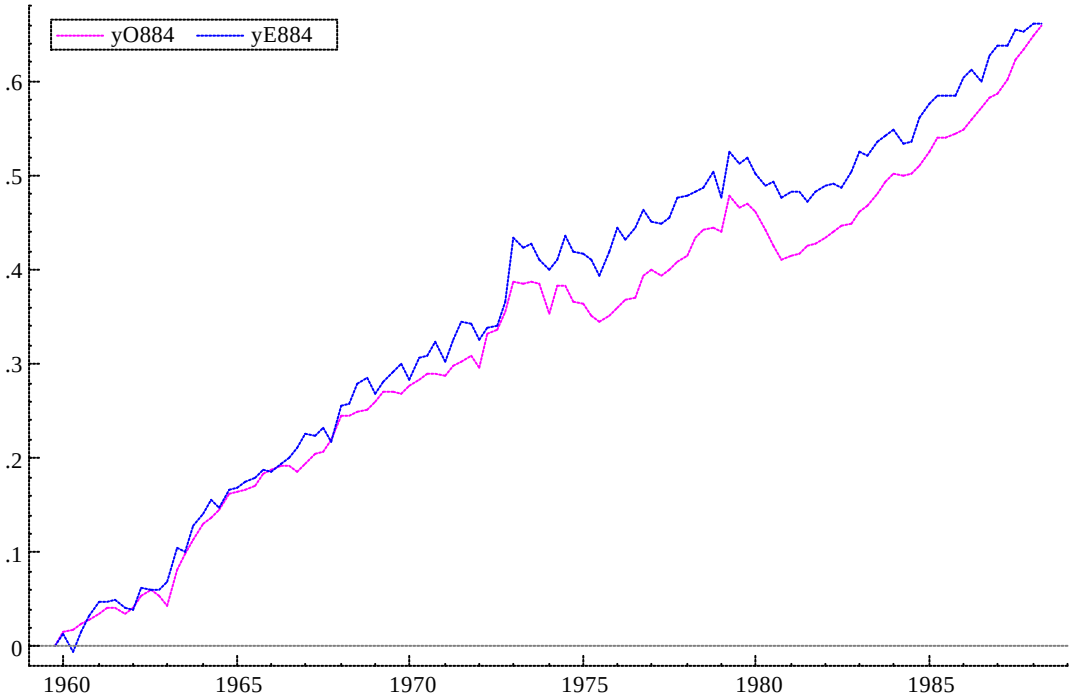


Chart 8: The log-levels of output-based and expenditure-based measures of GDP, October 1988 data vintage (1959 Q4 = 0)



Therefore, we assume that from 1991 Q1 to 1996 Q3 policy-makers took the potential growth rate of the economy since 1981 Q4 to be 2.25%. Combined with 3% annual growth up to 1973 Q3 and 1.5% growth for 1973 Q4–1981 Q3, this gives us a real-time potential output series for 1991–96.

In testimony on 15 December 1993, Chancellor Clarke gave the government's view of the output gap as 'somewhere between 3 and 7' per cent (quoted in TCSC's Second Report on the November 1993 Budget, page 94). Using the real GDP data available in 1993 Q4 and the real-time potential output series given above, we obtain a real-time output gap for 1993 Q2 (the last quarter for which figures were available at the time of Chancellor Clarke's statement) of –0.0494, or –4.9%, close to the mid-point of the range given by Clarke.

In his 6 December 1994 testimony, Alan Budd put the output gap at between 1% and 4% (TCSC Report on the 1994 Budget, page 37). Our real-time output gap series for 1994 Q2 (the last GDP release available at the time of Budd's statement) is –3.4%, inside the range given by Budd.

In the 1997/98 *FSBR*, released in November 1996, the Treasury provided an extensive discussion of potential output growth. The upshot of the discussion was:

- Trend labour productivity growth had been 1.75%–2% in the 1980s and 1990s.

- Trend labour supply growth usually expanded at a 0.25%–0.5% rate per year, and was expected to again in the rest of the decade, but had been negative in 'the early 1990s' due to 'the rapid expansion of numbers in further and higher education, earlier retirement, and continued growth in the number of Invalidity Benefit claimants' (page 56).

- A further **3**% per annum contribution to growth in potential was expected because of a decline in the unemployment rate from supply-side changes.

The *FSBR* concluded that 'it seems plausible to assume that there is still a negative output gap of between 0 and 3 per cent of GDP'.

Thus, the potential output series as viewed in 1996 Q4 grows at approximately 2.25% in the 1980s, slows down to below $1^{7}/_{8}$% in the early 1990s, and then shifts to approximately 2.5%. If we had made no adjustment to the real-time potential output series for the 1990s so far constructed, the real-time output gap for 1996 Q2 would be –2.75%. We adjust the potential series so that the real-time output gap for 1996 Q2 is –1.5%, the mid-point of the range given in the *FSBR*. We take 'the early 1990s' to be 1990–94, and the shift to 2**2**% as occurring thereafter, ie in 1995 Q1. A –1.5% real-time output gap in 1994 Q2 then implies average 1.75% growth in potential over 1990–94, which, for simplicity, we assume is evenly spread over those years.

A6.2 1997–2000

While we have collected real-time data on GDP for each quarterly vintage of data for the period 1997–2000, we have not used this series in our analysis of revisions to GDP estimates. Nor have we attempted to construct a parallel series for real-time estimates of potential output over 1997–2000. The reason is that our 'final' data on GDP is from 2000 Q3, and therefore of a similar vintage to the initial estimates of GDP for 1997–2000. As of this writing, presently available GDP data for 1997–2000 are probably too far from their final, revised versions for meaningful comparisons of real-time and final output gap data.

A6.3 Summary: the 1990s

Table A1 provides a summary of the potential output series underlying our real-time output gap estimates for the 1990s.

Table A1: Shifting views of potential output growth in the 1990s

View held from	View held until	View
1991 Q1	1996 Q3	Potential output growth 3% a year until 1973 Q3; 1.5% a year 1973 Q4–1981 Q3, 2.25% a year from 1981 Q4
1996 Q4	1997 Q1	Potential output growth 3% a year until 1973 Q3; 1.5% a year 1973 Q4–1981 Q3, 2.25% a year 1981 Q4–1989 Q4; 1.75% a year 1990 Q1–1994 Q4; 2.5% a year 1995 Q1 onward

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