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Treasury Economic Working Paper No.6

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Inflation and the output gap in the UK

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Abstract

The analysis in this paper demonstrates that the level of the output gap has an important role in explaining inflation and suggests that the lagged effect of the large negative output gap will generate significant downward pressure on inflation over the next few years. The analysis also finds strong empirical evidence of the influence of import prices on inflation, with a one-off shock to import prices taking around 1 year to fully feed through to inflation. The paper also investigates the impact of the change in the output gap on inflation, known as 'speed limit' effects, and finds very limited evidence for this effect when output is below trend. The analysis has informed the Treasury's view on recent inflation developments and underpins judgements on the prospects for inflation.

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The opinions expressed in this paper are those of the authors and do not necessarily reflect those of HM Treasury.

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Contents

1 Summary

1.1 The analysis in this paper demonstrates that the level of the output gap has an important role in explaining inflation and suggests that the lagged effect of the large negative output gap will generate significant downward pressure on inflation over the next few years. The analysis also finds strong empirical evidence of the influence of import prices on inflation, with a one-off shock to import prices taking around 1 year to fully feed through to inflation. The paper also investigates the impact of the change in the output gap on inflation, known as 'speed limit' effects, and finds very limited evidence for this effect when output is below trend. This analysis has informed the Treasury's view on recent inflation developments and underpins judgements on the prospects for inflation.

Context

1.2 Over recent years the annual rate of CPI inflation has exhibited increased volatility as a result of large movements in commodity prices, the depreciation of the sterling exchange rate and the temporary reduction in the standard rate of VAT. There has also been a big fall in output as a result of the recession and, while there are significant uncertainties surrounding current estimates of the output gap, it is likely that a large degree of spare capacity has opened up.

1.3 Temporary upward influences on inflation, such as those arising from the depreciation in sterling may have masked the effect of domestic disinflationary pressure on overall CPI inflation to date. However this large degree of spare capacity is likely to be an important factor putting downward pressure on inflation going forward.

1.4 This paper estimates a Phillips curve model over the past 30 years to seek to understand both recent trends and prospects for inflation. The model includes the lagged level and one-quarter change in the output gap along with import prices as important influences on inflation.

1.5 This analysis is particularly relevant at the current juncture with a great deal of uncertainty and debate surrounding:

- the degree of spare capacity in the economy and the extent to which this will bear down on inflation; and
- inflation prospects as the recovery gathers pace, but with a large degree of spare capacity expected to remain for some time.

1.6 Reflecting the uncertainty around these issues, there is a range of external views on the prospects for inflation. In the latest comparison of independent forecasts for March compiled by the Treasury, the forecasts for CPI inflation in Q4 2011 ranged from 0 to 3.3 per cent. As well as reflecting uncertainty regarding the degree of domestic disinflationary pressure, this range is also likely to reflect, among other things, differing views on the prospect of additional pass through of sterling's depreciation to consumer prices. This large degree of uncertainty highlights the importance of carefully assessing the evidence base to understand recent movements in inflation and help inform prospects.

Analysis and results

1.7 The results of the analysis in this paper support the conclusion that the level of the output gap has an important role in explaining inflation. This result is robust across a range of output gap measures and for the all items CPI, goods CPI and services CPI. The results also point to a larger role for the external influence of import prices on CPI goods inflation. The analysis finds very limited evidence of an effect on inflation from lagged changes in the output gap when the output gap is negative, but that this channel is stronger when the output gap is positive.

1.8 It is important to highlight that these results depend on a long sample of observations for CPI all items and the sub-indices,[1] and there is a question of how applicable the results are to the current period. Restricting the analysis to the post-1997 period, the results lack clear interpretation. Up until the recent global crisis, inflation and the output gap had moved within a narrow range since 1997, which makes it difficult to identify a strong effect from the output gap to inflation. It may also be the case that the delegation of operational independence over monetary policy to the Bank of England in 1997 has reduced the effect of the output gap on inflation by anchoring inflation expectations more tightly to the inflation target, and this should also be considered in interpreting the results.

1.9 Bearing in mind these considerations, the regression results have been used to analyse recent and prospective developments in inflation. In explaining inflation outturns since 2007 the regression attributes a large part of the upward pressure on inflation in 2008 to the lagged pass through of higher import prices and the downward pressure on inflation over 2009 to the temporary VAT cut and the lagged effect of the output gap as the recession took hold. However, a significant proportion of actual inflation outturns remain unexplained by the regression, particularly in 2008, when food and fuel prices were unusually strong. This highlights the importance of applying judgement in interpreting results and an awareness of the effects not explained by the equation.

1.10 Looking ahead, combining the regression models with Treasury projections for trend and actual output suggests that the output gap will exert persistent downward pressure on inflation. However, an important judgement relates to whether inflation outcomes will be pulled down as much as is implied by the regression results. The Budget 2010 inflation projections are informed by a judgement that the inflation target will provide a stronger anchor for inflation outcomes than implied by the historical relationship between the output gap and inflation. Furthermore, different scenarios are presented to illustrate the sensitivity of the analysis to different assumptions about both the size of the output gap and the impact that the output gap has on inflation outcomes, two sources of great uncertainty.

1.11 The remainder of the paper sets out the economic context for the analysis in Chapter 2, a short review of the relevant theory and literature in Chapter 3, the data and model used for analysis in Chapter 4, the results in Chapter 5 and finally an assessment of developments in inflation in Chapter 6.

[1] 1981Q1-2009Q4 for CPI all items and 1989Q1-2009Q4 for the sub indices.

2 Introduction

2.1 The analysis in this paper has informed the Treasury view on recent developments and the prospects for inflation. This chapter sets the economic context for this analysis, considering recent trends in inflation, the latest HM Treasury view on the output gap and the Budget 2010 inflation forecast.

Economic context

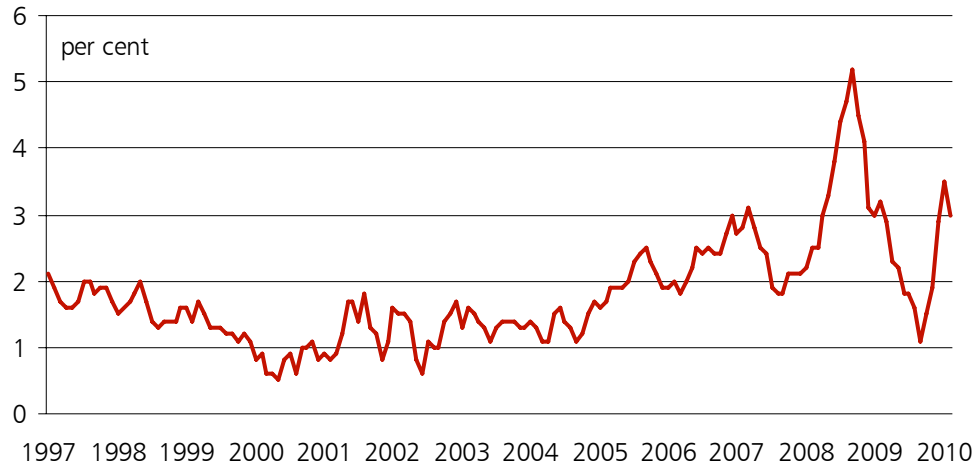
2.2 The UK economy stabilised in the second half of 2009, following a substantial fall in output in the wake of the global financial crisis. The cumulative decline in output through the recession is estimated at around 6 per cent, similar to the loss in output seen in the 1980s recession, but greater than that in the early 1990s. Through 2009, the pace of decline eased as the substantial policy stimulus fed through into the economy, and global and domestic confidence picked up.

2.3 The UK economy returned to growth in the fourth quarter of 2009. The Office for National Statistics (ONS) estimate GDP to have risen by 0.3 per cent, as government consumption continued to support the economy and household consumption rose. Nominal GDP rose by 1.9 per cent in the second half of 2009, although in the fourth quarter it remained 3 per cent below its pre-recession peak in the second quarter of 2008.

Recent trends in inflation

2.4 Inflation in the recent past has been shaped by a number of elements that feature in the analysis of this paper. Import prices have risen strongly, as a result of developments in both oil and commodity markets, and from the depreciation of sterling since mid-2007. These inflationary pressures have been countered by the recession, which has generated a large negative output gap. In addition, the reduction in the VAT rate between December 2008 and December 2009 has affected the profile for prices. As a consequence, over the past few years the annual rate of CPI inflation has exhibited increased volatility compared with the preceding decade (Chart 2.A).

Chart 2.A: Annual rate of CPI inflation



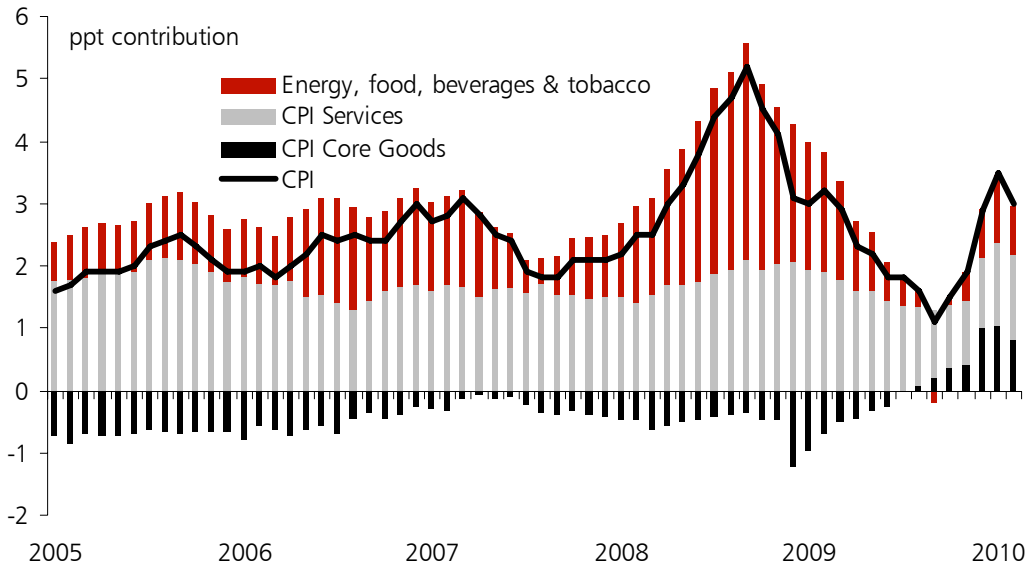
Source: ONS

2.5 Through their effect on fuel prices, large movements in oil prices contributed to the most recent increase in CPI inflation and the inflation spike in summer 2008. Increases in food prices also contributed to the peaks in the annual rate of CPI inflation in 2007 and 2008. Furthermore, as these commodity price spikes have receded and dropped out of the annual comparison of prices, they have contributed to the subsequent troughs in inflation, resulting in greater overall volatility.

2.6 The sterling trade weighted exchange rate has depreciated by around 25 per cent since mid-2007. This depreciation has fed through to a large increase in import prices over 2008, and put upward pressure on retailers' costs. Retailers may respond to increased cost pressures by increasing consumer prices, reducing nominal wages and other costs or reducing their margins. Given the many other influences on consumer prices, the precise degree of pass through of sterling's depreciation to consumer prices is difficult to determine. However, the observed strength of goods price inflation relative to services price inflation over the past year is indicative of a strong pass through effect as goods have a higher import content than services that are less tradable.

2.7 Chart 2.B illustrates the contribution of 'core' goods (goods excluding energy, food, beverages and tobacco which are shown separately) and services prices to the annual rate of CPI inflation over the past five years. While core goods prices have made an increasing contribution to the annual rate of CPI inflation over 2009, services prices have made a declining contribution, most likely reflecting the growing influence of domestic disinflationary pressure arising from the large negative output gap. This suggests that the recent upward influences on core goods and energy prices may have masked the downward pressure on prices from the large degree of spare capacity in the economy.

Chart 2.B: Contributions to the annual rate of CPI inflation



Source: ONS, HM Treasury calculations

2.8 CPI inflation has also been affected over the past year by the temporary cut in the main rate of VAT. If it had been passed through in full, the ONS estimate that this would have reduced the annual rate of CPI inflation by 1.5 percentage points from December 2008 to December 2009.[1] While complete pass through is unlikely,[2] the change in the VAT rate is still likely to have had a substantial effect on the annual rate of inflation, and the upward effect of the reversal will remain in the annual comparison until January 2011. The fact that the VAT cut will have reduced goods prices over 2009 relative to a year earlier underlines the importance of import price effects over this period, with core goods prices making an increasing contribution to the annual rate of CPI inflation over this period despite the VAT cut.

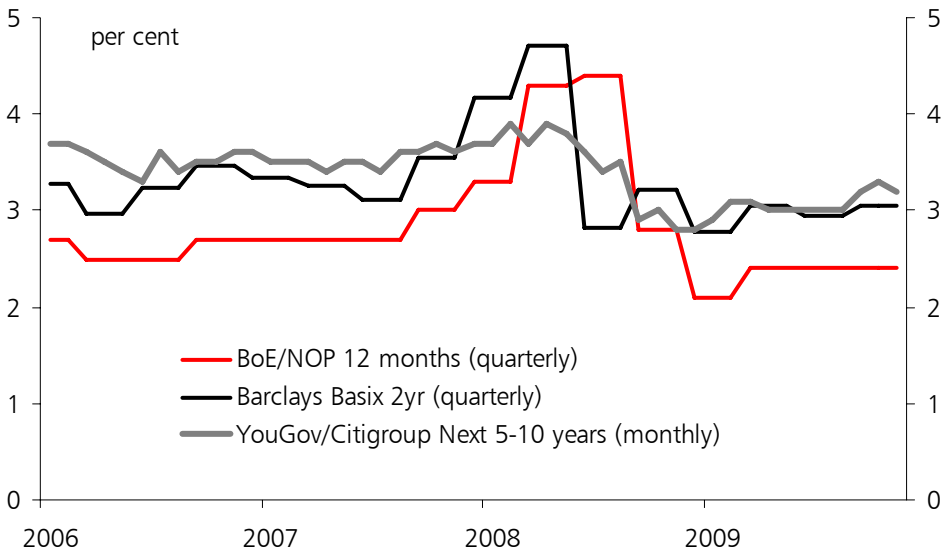
2.9 Uncertainty over the degree of pass through of higher import prices and the impact of the VAT cut on prices led forecasters to underestimate the rise in inflation over 2009. At Budget 2009, the average of independent forecasts was for inflation to fall to 0.7 per cent in the final quarter of 2009, compared with an outturn of 2.1 per cent.[3] However, despite this increased uncertainty, household inflation expectations have been far more stable than actual inflation outturns and remain anchored by the inflation target on a range of survey measures, shown in Chart 2.C.

[1] See: http://www.statistics.gov.uk/CCI/nugget.asp?ID=2075&Pos=1&ColRank=1&Rank=176

[2] The ONS estimate that in December 2008 the effect on the CPI from retailers and service providers passing on both the VAT reduction and increases to excise duty was to reduce the 12-month rate by around 0.5 percentage points. The ONS methodology is likely to have underestimated pass through by disregarding prices changes greater than 2.9 per cent that may have also incorporated a VAT reduction, and also by not capturing lagged pass through that may have occurred after December. However, this still indicates the likelihood of less than full pass through to consumer prices with some retailers choosing to absorb the benefit of the cut in margins. http://www.statistics.gov.uk/CCI/article.asp?ID=2258&Pos=6&ColRank=1&Rank=176

[3] See: HM Treasury, Forecasts for the UK economy: A comparison of independent forecasts, April 2009 http://www.hm-treasury.gov.uk/d/200904forecomp.pdf

Chart 2.C: Inflation expectations



Source: Barclays, Citi/Yougov, BoE

The output gap

2.10 The output gap is the difference between actual output and the estimated trend, or potential, level of output.[4] The Budget 2010 forecast assumes a reduction to the level of trend output of just over 5 per cent between mid-2007 and mid-2010. Beyond mid-2010, trend output growth is assumed to return to 2¾ per cent, in line with the rate observed over the second half of the most recently completed economic cycle. Taken together with the latest National Accounts data, the Budget 2010 trend output assumptions imply that a significant negative output gap opened up over the course of 2009, reaching over 6 per cent by the end of 2009.

2.11 Evidence drawn from a range of cyclical indicators is used to inform the latest assessment of the cyclical position of the economy. In general, these indicators suggest that the economy fell below trend during the second half of 2008 and that the degree of spare capacity increased markedly from the end of 2008. Some survey indicators suggest that there was some moderation in the degree of spare capacity in the second half of 2009. The degree of slack implied varies across indicators and there remains significant uncertainties surrounding current estimates of the output gap:

- the British Chambers of Commerce (BCC) capacity utilisation indicator for services remained flat over the second half of 2009, following falls to below their long-term averages over late 2008 and early 2009. The manufacturing sector indicator has picked up from lows in the first half of 2009. Consistent with the BCC survey, capacity utilisation indicators from the Confederation of British Industry (CBI) and the Bank of England's Regional Agents show some small increases in the latter part of 2009, but tend to suggest more spare capacity than the BCC indicators; and
- demand for labour also fell, with the number of vacancies declining from a peak of almost 700,000 in early 2008 to around 430,000 in the third quarter of 2009. The ILO unemployment rate has increased from 5.5 per cent in the second half of 2006 to 7.8 per cent in the second quarter of 2009. Since then, the number of vacancies

[4] For more details of the Treasury's approach to estimating trend growth, see *Trend growth: new evidence and prospects*, HM Treasury, December 2006 and *Trend growth: recent developments and prospects*, HM Treasury, April 2002.

has picked up slightly through the fourth quarter of 2009 and into early 2010, and the unemployment rate has remained broadly flat. While a number of survey indicators of recruitment conditions registered small rises over 2009, they continue to point to a substantial degree of slack in the labour market. Significant reductions in average hours worked, partly reflecting a shift towards part-time work, also suggests that some spare capacity exists within employment.

2.12 Survey based cyclical indicators would tend to suggest a smaller but still substantial output gap opened up over the course of 2009. The difference between these alternative approaches and the Treasury's mechanical estimates of the output gap[5] could reflect a number of factors:

- the size and timing of the overall impact of the financial crisis on trend output is very uncertain;
- the degree to which the survey indicators of the cyclical position of the economy are affected by shorter-term supply constraints, including, for example, temporary constraints on working capital that might be expected to dissipate as the economy recovers; and
- there may be potential measurement issues associated with both the survey indicators and official data. In particular, survey indicators typically capture the number of firms operating below capacity, but may not necessarily capture the depth of the fall in resource utilisation within individual firms during a downturn. Any revisions to National Accounts data would change the size of mechanical output gap estimates.

[5] For more details of the Treasury's approach to estimating trend growth, see *Trend growth: new evidence and prospects*, HM Treasury, December 2006 and *Trend growth: recent developments and prospects*, HM Treasury, April 2002.

The Budget 2010 forecast

2.13 Economic forecasting inevitably involves judgement about the uncertain path of future events and also about the current position of the economy. The Treasury's general approach to forecasting macroeconomic developments is set out in detail in Budget 2007 (HM Treasury (2007)).

2.14 The Budget 2010 inflation forecast is informed by a simple relationship between the output gap and inflation (Phillips curve), supplemented by a view on the impact of external factors such as commodity prices and import prices on inflation. Within this framework, the inflation forecast is based on a judgement on the balance of inflationary pressures in the economy and how they are likely to evolve over the forecast period. The forecast is also heavily influenced by the role of monetary policy in meeting the inflation target and successfully anchoring inflation expectations to target. The analysis in this paper provides empirical evidence on the inflation process to evaluate the forecast judgement.

2.15 In the near term, CPI inflation is expected to remain above the target, reflecting the impact of the VAT change. Fuel prices and the pass through of sterling's depreciation will have a positive but declining impact on inflation over the coming year, while the lagged effect of the large degree of spare capacity becomes a more dominant influence. Consequently, inflation is expected to weaken and reach 2 per cent by the end of 2010 and then to fall further through the first half of 2011, as the negative output gap continues to exert downward pressure and the effect of the VAT change drops out of the annual comparison

2.16 CPI inflation is expected to rise back to target by the end of 2012, as the economy continues to grow at above trend rates. Although a degree of spare capacity is expected to remain throughout the forecast, the resulting downward pressure on inflation is expected to be offset by the effect of the monetary policy framework anchoring inflation expectations close to the inflation target. This effect could be additionally bolstered by inflationary pressure arising from the rate at which the output closes, so called 'speed limit' effects.[6] However, the analysis in this paper finds very limited evidence for this effect when output is below trend.

[6] See for example Turner (1995).

3 Inflation and the output gap: theory and literature

3.1 This chapter describes the analytical framework of the Phillips curve and previous findings in some of the literature on the relationship between the output gap and inflation.

3.2 After a brief review of the development of the Phillips curve model, the discussion focuses on four areas that may be particularly important in explaining recent inflation trends and the prospects for inflation: external influences on inflation, 'speed limit' effects, asymmetries and non-linearities in the Phillips curve relationship, and the effects of monetary policy regime on the nature of the inflation and output trade-off.

The Phillips curve relationship

3.3 The Phillips curve is one of the oldest-established and most empirically tested relationships in economics. Since a clear statistical relationship between wage inflation and unemployment was first identified by Bill Phillips back in the 1950s, the possibility and nature of a trade-off between unemployment or output and inflation has been the source of huge debate.

3.4 In its most basic form, the Phillips curve describes a trade-off between inflation and activity, whereby inflation is positively related to the output gap, the difference between actual and trend output. In general, when the level of the output gap is positive, this relationship suggests that there will be an excess demand for output exerting upward pressure on inflation. Conversely, if the level of the output gap is negative, this reflects an excess supply of resources, which in turn will be reflected in downward pressure on inflation.

3.5 However, Milton Friedman and Edmund Phelps argued that the trade-off implied by the Phillips curve was inherently unstable. They developed the expectations-augmented Phillips curve, which implied that the apparent trade-off between inflation and output would tend to be a temporary phenomenon. Specifically, wage-bargainers would respond to attempts to hold unemployment down. As agents' inflation expectations adapted to higher inflation, the short-run Phillips curve would shift up and therefore the long-run Phillips curve would be vertical. In other words, the natural rate of unemployment is determined independently of prices and there can only be a short-run trade-off between output and inflation. The experience of falling output and high inflation in the 1970s provided empirical support to their analysis.

3.6 However, even the existence of a short run trade-off between inflation and output was challenged by the theory of rational expectations. Under the theory of rational expectations, agents are assumed to make optimal use of all available information in forming their expectations of the future and forecast errors are random. Therefore within this model inflation expectations adjust instantaneously to any inflationary or deflationary shocks, implying that both the short and long run Phillips curves are vertical. Hence any attempt by policy makers to take advantage of a short-run trade off between inflation and output will fail as expectations instantaneously adjust to higher inflation. This is a particular example of the Lucas critique, that policy prescriptions should be based on so-called structural models, whose predictions would prove robust to changes in policy-makers' objectives.

3.7 Partly in response to the Lucas critique, the structural models of New Keynesian economics showed how it was possible to generate a short-run trade-off between inflation and output in a model with forward-looking agents with rational expectations. This relationship could arise if

economic agents periodically adjusted relative prices. For example, the Taylor (1980) staggered contracts model assumes that every period, a fraction of firms set their prices for a fixed number of periods. Alternatively, the Calvo (1983) price-setting model has been widely used, as a whole economy Phillips curve can be readily derived from aggregating the price setting behaviour of individual firms. In this model in each period a firm has a fixed probability that it will keep its price unchanged with the probability independent of the time elapsed since the firm last changed its price.

3.8 Within the Calvo-type model, forward-looking firms set prices to take account of (discounted) expected future marginal costs. Thus, in the New Keynesian Phillips curve (NKPC) models, inflation can be thought of as a discounted stream of expected future deviations of marginal costs from equilibrium, or as a combination of real disequilibria and future expected inflation.[1]

3.9 Since real marginal costs are not directly observable, empirical estimation of this curve requires some assumption about what measure to use as a proxy for real marginal costs. Traditional empirical work on the Phillips curve has tended to focus on the output gap as the appropriate indicator of inflationary pressures in an economy and, under certain assumptions[2] it can be shown that there is an approximate log-linear relationship between the output gap and real marginal costs.

3.10 However, it is important to acknowledge that there are a number of theoretical and empirical problems with the choice of the output gap as a proxy for marginal cost. First, the unobservable nature of potential output makes the output gap susceptible to possible, and perhaps sometimes very large, degrees of measurement error (Nelson and Nikolov (2004)). This is true regardless of the method used to estimate potential output, whether it is a statistical filter approach or a production function.[3] Second, movements in the level of potential output itself are subject to significant uncertainty and this is particularly true in current economic conditions. Finally, inflation lags rather than leads the output gap over the cycle. This lead of the output gap over inflation explains why the lagged output gap enters with a positive coefficient in 'old' Phillips curves, whereas the theoretical derivation of the NKPC implied that the expected future output gap should outperform the past output gaps in explaining inflation. Nonetheless, structural estimates of the NKPC based on the output gap have generally had only limited success in generating a role for inflation expectations and often have a strong reliance on lagged inflation entering the equation as an explanatory variable. Thus the 'new' Keynesian Phillips curve often ends up looking rather like the old one (Galí and Gertler (1999)).

3.11 Although the NKPC is forward-looking in its pure form, it is also widely acknowledged that there is a role for lagged inflation in the Phillips curve model as the inflation process exhibits considerable persistence. In theory, it is possible to distinguish a number of different potential sources of persistence in the inflation process:

1 persistent fluctuations in the real marginal cost, 'extrinsic' persistence, due to the presence of nominal price stickiness;

2 dependence on past inflation due to the price setting mechanism: 'intrinsic' persistence;

3 persistence due to the formation of inflation expectations; and

[1] See Galí and Gertler (1999) for a derivation.

[2] In the standard sticky price framework without variable capital there is an approximate proportionate relationship between marginal cost and output (Galí and Gertler (1999)).

[3] Although note that HM Treasury (2005) presented analysis showing that HM Treasury real time-output gap estimates have been somewhat less prone to revision than HP statistical filtering based estimates. The advantage of the Treasury's approach to dating on-trend points using the cyclical indicators is that it tends to give greater stability to estimates of trend output growth. This is because the approach is based on analysis of a much wider range of indicators and many are surveys, which are not revised.

4 persistence in the stochastic error term.

3.12 To account for inflation persistence, variations of the NKPC model were developed, to generate a more pertinent role for lagged inflation. For example, Galí and Gertler (1999) adjust the Calvo-pricing model so the new price chosen by firms adjusting in that period is determined by two different pricing rules: a proportion of firms who are able to change prices in a period set prices in a backward-looking manner, and a proportion set prices in a forward-looking manner. Therefore, in this 'hybrid' model inflation depends on a combination of expected future inflation and lagged inflation. Similarly, Fuhrer and Moore (1995) amend a Taylor staggered contracts model so that firms care about relative real prices over time, which again generates an inflation process similar to the Galí and Gertler hybrid model. Smets and Wouters (2003) introduce lagged inflation through indexation behaviour.

3.13 Although these models allow for a more explicit role for lagged inflation and forward-looking expectations in the inflation process, their inability to explain the disinflation of the 1980s and 1990s accompanied by an increase in the coefficient on forward-looking inflationary expectations[4] led to the development of alternative mechanisms to generate inertia in the inflation process. These alternative models rely on imperfect information about the future path of nominal aggregate demand. Mankiw and Reis (2002) set up a "sticky information" model, as opposed to a "sticky price" model, whereby rather than firms only being able to change prices with a fixed probability as in the Calvo model, firms are able to change prices in every period, but they only come across "new information" which influences them to change their prices with a fixed probability. Hence, stickiness is driven by rigidities in new information disseminating through the economy, rather than rigidities in being able to change prices. In this model, current surprises compared with previous expectations play an important role in the inflation process, as opposed to changes in forward-looking expectations.

3.14 In all, these 'hybrid' models succeed in generating some kind of inertia in the inflation process and have many advantages over the more standard NKPC, which is a purely forward looking specification. In general, they more accurately reflect the varying sources and degrees of inflation persistence that might be expected theoretically, and critically which are observed in the data.

Domestically generated inflation and external influences

3.15 While the domestic output gap may be expected to be a key influence on the price of less tradeable domestically produced goods and services, the UK is an open economy and it is also important to acknowledge external influences in modelling UK inflation. For example, Batini, Jackson and Nickell (2005) estimate an open economy NKPC for the UK over 1972Q3-1999Q2 and find that real import prices have an important role in explaining UK inflation.

3.16 In particular, the exchange rate may be expected to play a key role in determining externally generated inflation, since changes in the exchange rate directly affect the sterling value of any product whose price is set in foreign currency terms. A proportion of final consumption goods in the CPI inflation basket are directly imported, while imported goods and services serve as key inputs into production, and hence affect the costs of production. Furthermore, the change in the price of domestically produced goods that are close substitutes for imported goods may also follow a similar path to the imported goods for which they are substitutes. As discussed in Chapter 1, increasing import prices appear to have played a strong role in the strength of goods prices over the past two years.

[4] For example Bayoumi and Sgherri (2004) note that it is difficult to see why a reduction in inflation and inflationary uncertainty would be accompanied by lower persistence in a model relying on staggered contracts or menu costs to explain nominal inertia. Lower and more stable inflation would seem to more likely result in a lengthening of contracts, implying greater persistence in inflation. Similarly, costs of adjustment would be lower as inflation is reduced and stabilised, again implying greater inflationary persistence.

3.17 In theory, if all domestically produced goods and services were tradeable and domestic and foreign goods and services were homogenous, then there would be full pass-through from changes in the exchange rate into inflation and inflation would simply equal the world rate of inflation, adjusted by changes in the exchange rate. In practice, not all goods and services are tradable, and domestic and foreign varieties may be imperfect substitutes for each other. Consequently, there is incomplete pass-through from changes in the exchange rate into import prices. Nonetheless, at least some role for the exchange rate in determining inflation can be observed. To the extent that there is not an immediate pass-through from changes in the exchange rate into import prices in the short run, then import prices themselves may play a more significant role in explaining inflation than the exchange rate.

'Speed limit' effects

3.18 The relationship between the output gap and inflation is normally considered in the simple 'slack' Phillips curve model described above, where inflationary pressure is judged in proportion to the size and sign of the output gap. Additionally, the relationship between the change in the output gap and inflation may be important, this is known as a 'speed limit' effect.

3.19 A 'speed limit' effect exists when the change in the output gap causes inflation to increase even if the level of the output gap is negative. When a negative output gap closes and the change in the output gap is positive as growth increases, then upward pressure on inflation may arise. Within the speed limit model, both the level and change in the output gap can be important for inflation.

3.20 There are a number of channels through which inflationary pressures may be generated by the speed at which the output gap changes rather than by the level of the output gap. One such channel is the possibility that temporary supply bottlenecks may develop when activity is rising rapidly. It can take time to plan and install new capacity, and hence, temporary supply constraints can arise if demand increases more rapidly than capacity can be put in place. For example, the rapid growth in the manufacturing sector in 1994 and the service sector in 1995-1996 caused the economy to run into bottlenecks, leading to higher inflation, even though the output gap was still negative. These bottlenecks may also occur when a positive output gap opens quickly, adding to the degree of upward pressure on inflation.

3.21 Such bottlenecks may exist in physical and human capital.[5] Within the labour market, unemployed workers may lose skills during a downturn and require retraining before returning to work at full capacity. The effective labour supply may also be reduced as a result of search frictions. Long-term unemployment and inactivity may increase generating hysteresis effects, reducing the labour supply. As the economy recovers, inactive workers may be drawn back into the labour market only gradually. Consequently, wages may be responsive to the change in unemployment, not just the level. However, such labour market effects could potentially be less important in this recovery with increased emphasis on active labour market policies and evidence of greater labour market flexibility. In addition, access to immigrant labour might reduce the chances that significant labour supply bottlenecks could develop.[6]

[5] Caballero (2007) highlights that production processes will generally rely on specific skills or equipment, which may take time to acquire, and hence limit the speed at which output in individual industries can be expanded.

[6] As discussed in Chapter 2, these temporary supply effects may be picked up in some indicators, e.g. survey indicators of the degree of spare capacity, and not necessarily in output gap measures based an estimate of trend output. This implies that the presence of these sort of effects might be dependent on the precise way the output gap is measured. This means that care must be taken in comparing the results of different studies.

3.22 There may also be a link to the composition of demand. While the whole economy output gap may still be negative, excess demand in certain industries could still place upward pressure on inflation. 'Unbalanced' growth may result in upward pressure on prices in some sectors while considerable spare capacity remains in others. Temporary supply bottlenecks in the labour market may be exacerbated if there is regional or skills mismatch in the source of growth as the output gap closes or opens up, even if excess capacity remains in other regions or occupations.

3.23 Compositional effects could also lead to measurement error in the level of the output gap. A loss of effective capital as some sectors of the economy decline may not be captured in the aggregate measure of capital used to estimate trend output, such that the impact of these effects is observed through the speed limit channel rather than in the level of the output gap influencing inflation. Considering speed limit effects in the context of optimal monetary policy, Walsh (2003) states that measurement error in the level of the output gap may be one factor favouring a speed limit policy.

3.24 The extent to which growth is led by exports may also be important. For example, in Sweden during the 1990s, a depreciation of the exchange rate raised demand for exports rapidly and lifted industrial capacity utilisation, despite the whole economy output gap remaining negative (Riksbank (1999)). Such effects could be relevant to the UK if capacity utilisation in exporting industries were to increase quickly during the recovery, generating inflationary pressure.

3.25 In recent years, there have been few studies on speed limits. This is partly because of the move to inflation targeting, which has been credited with reducing both the volatility of output and the level and volatility of inflation over the 1997 to 2007 period.[7,8]

3.26 Turner (1995) looked specifically at evidence for speed limits effects in seven major economies, estimating on annual data over the period 1960-93. This study found little evidence of a speed limit effect operating in the UK although speed limit effects were found in Japan, Italy and Germany.

3.27 The IMF (2005) did find statistically significant speed limit effects on UK inflation, however. Using an inflation expectations-augmented Phillips curve including the effect of external shocks and estimating on quarterly data from 198Q4 to 2004Q3, the IMF found that both the level of the output gap a year ago and the speed at which the gap is closed over the preceding three quarters affected inflation with the expected positive sign.

Asymmetry and non-linear effects

3.28 The majority of analysis using Phillips curves is based on the assumption that the trade-off between inflation and activity is linear and symmetric,[9] i.e. that the response of inflation to a positive output gap is identical to that of a negative output gap of the same size.

3.29 It is possible that the magnitude of effects from the level and change of the output gap depend on the sign of the output gap so that the relationship is asymmetric. For example, the relationship between the output gap and inflation may be stronger when the output gap is positive rather than when the output gap is negative. A possible explanation might be that relatively weaker disinflationary pressure from a negative output gap could be due to employees resisting downward pressure on the rate at which their earnings grow.

[7] Between 1997 and 2007 the average of RPIX inflation was 2.5 per cent and the standard deviation was 0.4 percentage points while the standard deviation of output was 0.7 percentage points; between 1976 and 2007 these figures were 5.7 per cent, 4.6 and 1.8 percentage points respectively.
[8] There is an extensive literature that debates the reasons behind the "Great Moderation" era of reduced macroeconomic volatility. See Blanchard and Simon (2001), Stock and Watson (2003) Bernanke (2004) and Benati (2008).
[9] Indeed the NKPC imposes this symmetry by log-linearisation of the structural equation for the price level.

3.30 The Phillips curve relationship may also be non-linear. For example, a deeper more prolonged recession with a larger output gap may result in a greater deskilling of the labour force, therefore leading to temporary supply constraints becoming more binding. There may also be greater difficulties for firms in obtaining working capital to meet demand in the recovery.

3.31 Laxton et al (1994) find that estimating a model on pooled data for the G7 over 1967-1991 strongly supports the view that the Phillips curve relationship is non-linear, with high levels of activity increasing inflation more than low levels of activity decrease inflation. Laxton et al take two approaches to modelling non-linearity: a flexible approximation employing a power series expansion and an alternative that pre-specifies the functional form of non-linearity, including asymmetries, based on theoretical priors. In evaluating the alternative approaches, they find that estimating with a cubic output gap term provides only a marginally better fit than estimating a conventional linear Phillips curve. However, the greater improvement in fit with alternative non-linear models that include asymmetries suggests that a more important role is played by asymmetries as opposed to non-linearities in the output-gap and inflation relationship.

3.32 Turner (1995) also found evidence of asymmetries in the relationship between the output gap and inflation: estimating over the 1960-1993 period the inflationary effects of a positive output gap were found to be greater than the deflationary effects of a negative output gap for most countries in the G7.

3.33 However, Turner (1995) also found that in the UK, a negative output gap had a greater impact on inflation than a positive output gap. This was contrary to the findings for the US, Japan and Canada where the impact of a positive gap on inflation was found to be at least two to three times greater than the impact of a negative output gap.

3.34 Baghlia, Cahnb, and Fraissec (2007) investigate the case for an asymmetric inflation-output trade-off in the Euro area and in the individual countries of France, Germany, and Italy, estimating over periods starting in the early 1970s to 2003Q4. Within a nonparametric framework, they found an asymmetric relationship in the Euro area at both aggregated and individual country levels and that ' (large) excess demand has a stronger effect in increasing inflation than (large) excess supply has in decreasing it'.

The Phillips curve and the monetary policy framework

3.35 There are good theoretical reasons for believing that the trade-off between inflation and some activity measure (such as the output gap) could have been affected by changes to the monetary policy framework. For example, greater credibility in monetary policy making should reduce the sensitivity of price setters to temporary shocks to the economy if expectations of future inflation remain close to target. Further, if firms are likely to change prices less frequently when inflation is low then this should lead to a weaker short-term impact of demand fluctuations on prices. Thus the Phillips curve may also be flatter when inflation is low.

3.36 The appearance of a flattening of the Phillips curve since the introduction of inflation targeting can be detected in the UK data. Chart 3.A plots inflation against unemployment in the UK from the 1970s to the present day. This shows a clear flattening of the 'Phillips relationship' over the plotted time period. Having appeared almost vertical throughout much of the 1970s, the curve then seemed to ease in slope throughout the 1980s and early 1990s, before becoming almost completely horizontal upon the introduction of inflation targeting (in October 1992).

3.37 If the Phillips curve relationship has flattened since 1992, this may well be due to the changes in the monetary policy framework, which has succeeded in anchoring expectations at target. A further complication is that in the 1990s the structural unemployment rate (the NAIRU) fell, allowing for falling unemployment while inflation remained stable (Nickell (2001)). While Bean (2006) has suggested that this flattening of the output-inflation trade-off is a consequence

of "increased specialization resulting from globalization [that] *reduces* the response of inflation to the domestic output gap and makes it more sensitive to the world output gap."

3.38 The most recent observations, since 2008Q1 are also shown in Chart 3.A. This appears to illustrate a slight shift in the relationship again, with a slight downward slope possibly re-emerging in the most recent data. However, as described in Chapter 2, there have been a large number of influences contributing to a more volatile path for inflation over the past few years and it is not possible to draw conclusions from this simple relationship.

Chart 3.A: UK inflation and unemployment

Source: ONS (RPI inflation to 1971Q1-1975Q4, CPI inflation 1976Q1-2009Q4, LFS unemployment rate)

3.39 More generally, it is important to be careful in assessing the economic implications of Chart 3.A. The Chart does not show the Phillips curve per se, namely the possible combinations of inflation and unemployment outcomes at any given point in time, instead it shows the combinations that have obtained throughout the period. Therefore this Chart does not define a structural relationship between inflation and unemployment or provide conclusive evidence of a weakening of the short-run trade-off between the two.

3.40 In order to draw firmer conclusions about the underlying structure of the Phillips curve relationship and the possible influence of the monetary policy regime and external factors it is necessary to estimate the Phillips curve directly. This may help to discern the changing nature of the short-run relationship of the Phillips curve trade-off as both the structure of the economy and the monetary policy regime have evolved over time.

4 Data and model specification

4.1 This chapter describes the data used for analysis and, following on from the theoretical discussion above, the Phillips curve model specification.

Data

4.2 The dataset used for the analysis is summarised in Annex A. It consists of a range of inflation measures to capture different sources of inflationary pressure in the economy and to test how these may be related to different estimates of the level and change in the output gap. The analysis focuses on the CPI measure of inflation as this is the Government's key measure for the inflation target.

4.3 Although the CPI time series officially began in 1996, the ONS has constructed historical proxies for the series back until 1975, derived from RPI indices and weights.[1]

4.4 As well as the all items CPI, the paper makes use of sub indices, including CPI all goods, CPI core goods[2] and CPI services. These sub indices comprise 55 per cent, 31 per cent and 45 per cent of the CPI basket respectively. Core goods inflation excludes more volatile components and may give an indication of underlying goods price inflation. To better proxy a measure of domestically generated inflation, services CPI inflation is included in the analysis. In principle, one would expect services inflation to be better correlated with the level or change in the output gap than goods inflation.

4.5 A range of output gap estimates have been used to measure spare capacity to test the robustness of the analysis to different measures. The three measures of the output gap used are:[3]

- the HMT output gap: based on an on-trend point methodology;[4]
- the OECD output gap: based on a production function methodology;[5] and
- an output gap derived from using a Hodrick-Prescott (HP) filter to derive the trend.[6]

4.6 Chart 4.A shows that the HP and OECD estimates of output gap have moved broadly in line with the HM Treasury estimate of the output gap since the late 1980s. However, the OECD estimate follows the HM Treasury estimate more closely than the HP filtered output gap and the OECD and HM Treasury output gaps are very close currently.

[1] For more details about the methodology used to construct back series for CPI refer to: http://www.statistics.gov.uk/articles/economic_trends/HICP_Historical_Estimates.pdf

[2] CPI non-energy industrial goods. This is all goods excluding food and non-alcoholic beverages, alcoholic beverages, tobacco and energy.

[3] For a full description of each approach to estimating trend growth see HM Treasury (2008).

[4] For more details of the Treasury's approach to estimating trend growth, see *Trend growth: new evidence and prospects*, HM Treasury, December 2006 and *Trend growth: recent developments and prospects*, HM Treasury, April 2002.

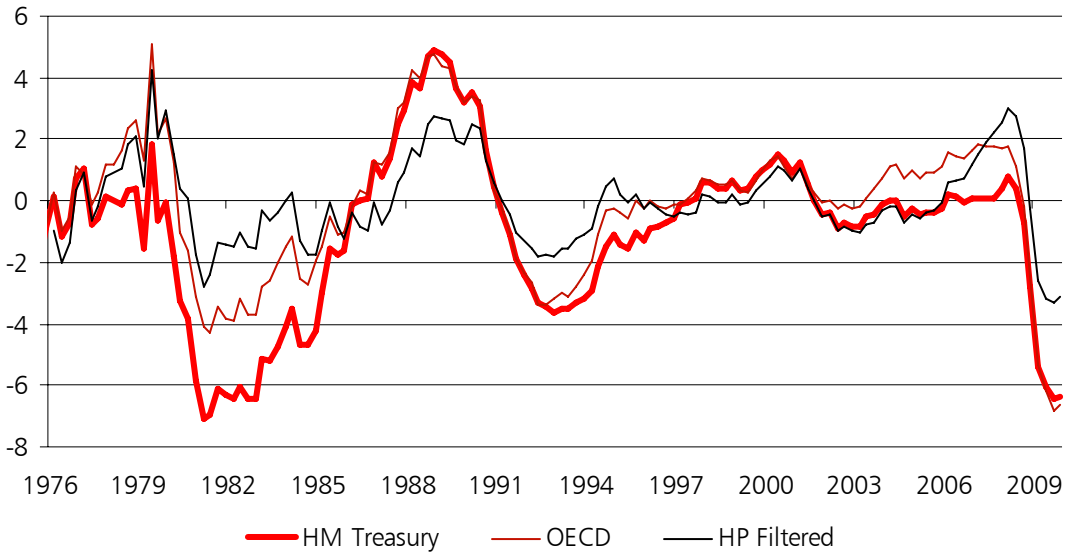
[5] Source: OECD Economic Outlook 86, December 2009

[6] The HP filter is a statistical method to decompose time-series into a trend component and a cyclical component. The relative weight given to the components is set at 1600. For further discussion of this approach please see HMT (2002), Annex D.

4.7 Excluding the most recent years, estimates of the output gap based on the HP filter have a much lower amplitude than estimates based on the Treasury's on-trend point approach or the OECD production function approach. However, since the OECD production function approach also uses inputs that have been statistically filtered to obtain trend values, it is not surprising that the OECD estimate of the output gap has moved more closely to the HP estimate over some periods.

4.8 At the end of the period under consideration, the HP filter estimate of the output gap is much smaller than the alternative estimates. However, it is important to note that statistical filters such as the HP filter are unreliable at estimating the output gap at the end of the sample, as they are unduly influenced by the latest data points (known as end-point bias).[7]

Chart 4.A: Different estimates of output gaps

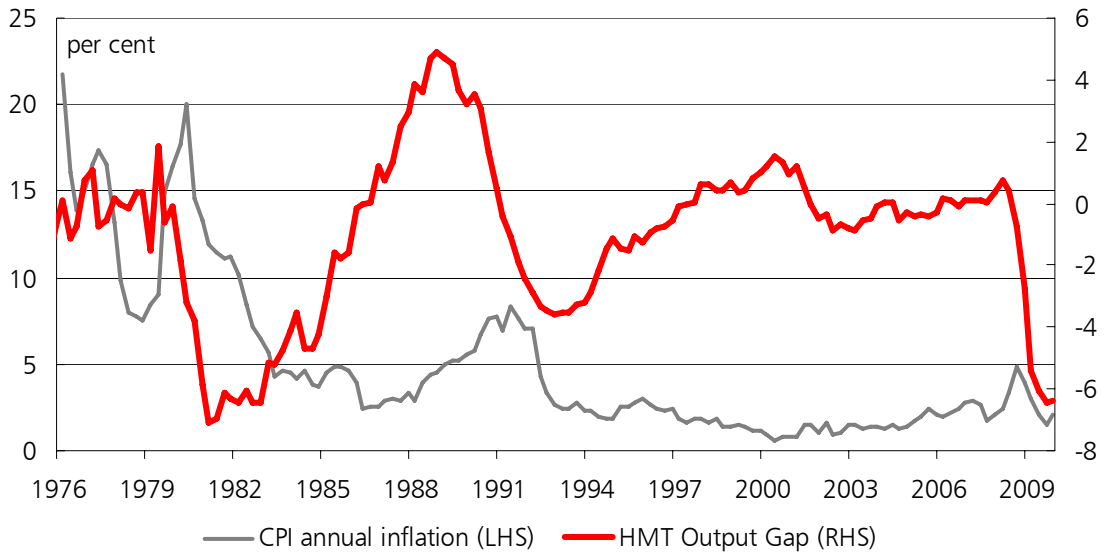


Source: HM Treasury calculations, OECD

[7] See Annex D in HM Treasury (2002) for a discussion of some of the problems with using the HP filter to estimating trend growth.

4.9 Chart 4.B shows the time series for the CPI annual rate of inflation and the HM Treasury estimate of the output gap. The inflation series was very volatile during the late 1970s, largely driven by the oil shocks of this period. The late 1970s are therefore excluded from the sample in the analysis below to avoid this unusually volatile period biasing the results. In addition to the volatility experienced over this period, the incomparability of the late 1970s monetary policy regime with the current one would make results obtained using this data less relevant to understanding inflation developments in the current period.

Chart 4.B: CPI inflation and the HM Treasury output gap



Source: ONS, HM Treasury calculations

4.10 Furthermore, as noted in Chapter 3, the data is consistent with a flattening in the Phillips curve relationship since the move to inflation targeting and this may justify splitting the sample into a pre- and post- inflation targeting periods for analysis. However, Haldane and Quah (1999) suggest that this flattening may in fact be observed in the data from 1980, after which the Phillips curve is practically horizontal and hence this could support the choice of an estimation period starting in the early 1980s.

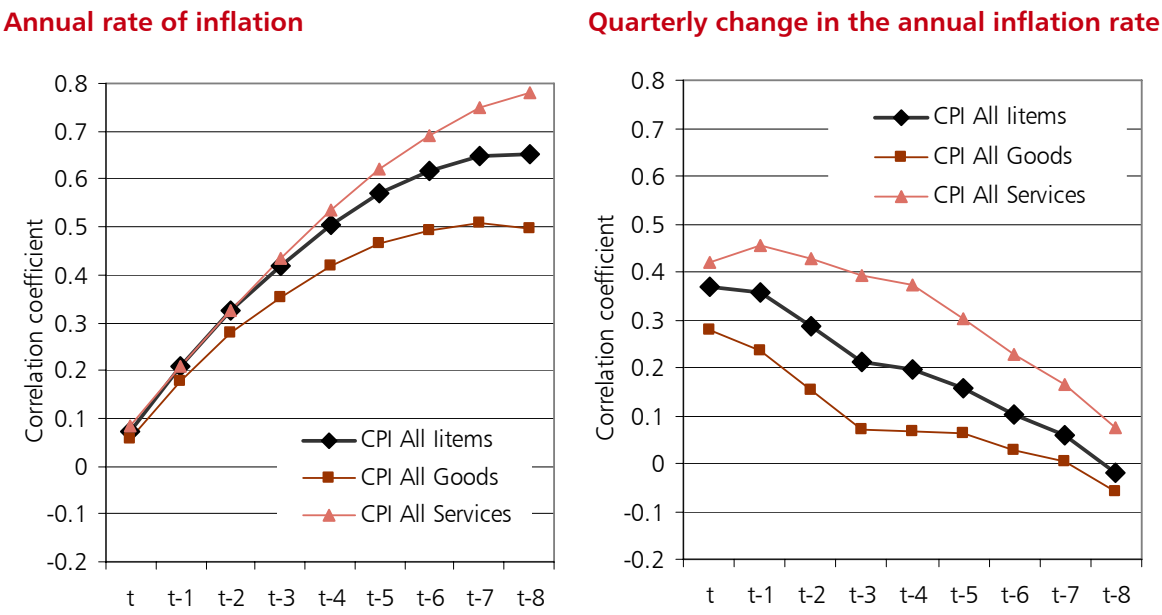
4.11 Chart 4.C plots the correlations between the level of the HM Treasury output gap and the annual rate and the one-quarter change in the annual rate of various inflation measures at different time lags estimated over the period from 1989Q1 to 2009Q4.[8]

4.12 It appears that the strongest positive correlation between the level of output gap and the annual rate of all the inflation measures is after 7 quarters. CPI goods inflation has a weaker correlation with the output gap. This is likely to be because goods tend to have a greater import content and may be more driven by external factors, such as oil prices and exchange rate movements. CPI services inflation exhibits a stronger and slightly longer lagged relationship with the output gap level, possibly reflecting the bigger proportion of labour costs in the services sector where inflationary pressure from the level of the output gap may take longer to feed through to consumer prices. The correlation between the quarterly change in inflation and the level of output gap is also positive but somewhat weaker and with the strongest correlations occurring in the first 2 quarters (right panel of Chart 4.C).

[8] Although a longer run of the all items CPI series is available, this is the period available for the CPI sub-indices.

4.13 Although these correlations can be interpreted as consistent with theoretical priors about the relationship between the output gap and inflation, is not possible to draw conclusions on the direction of causality from the output gap to inflation from this and it is possible that causation may run in the opposite direction. For example, higher inflation could result in a higher output gap by reducing the real interest rate and boosting demand. The potential endogeneity problem arising from reverse causality is discussed further below. Additionally, the output gap and inflation may both be driven by some common third factor.

Chart 4.C: Correlation coefficient between CPI annual inflation and the level of the HMT output gap



Source: ONS, HM Treasury calculations

4.14 For the regression analysis that follows, inflation is measured as the annualised quarterly inflation rate. As a seasonally adjusted CPI is not available, this is addressed by explicitly modelling seasonal effects by including fixed seasonal dummies and the four-quarter lag of quarterly inflation to allow for shifts in the seasonal pattern over time. An alternative would be to seasonally adjust the CPI series using a standard statistical package for this purpose. However, the approach of explicitly modelling seasonality is preferred.

4.15 The annual inflation rate of import prices from the National Accounts is included as an additional explanatory variable, where all import prices are captured. This captures the effect of the sterling exchange rate and global inflation pressures, such as changes in global commodity prices, on UK consumer prices.[9] As discussed in Chapter 3, to the extent that there is not immediate pass through from changes in the exchange rate into import prices in the short run, then import prices themselves may play a more significant role in explaining inflation than the exchange rate[10].

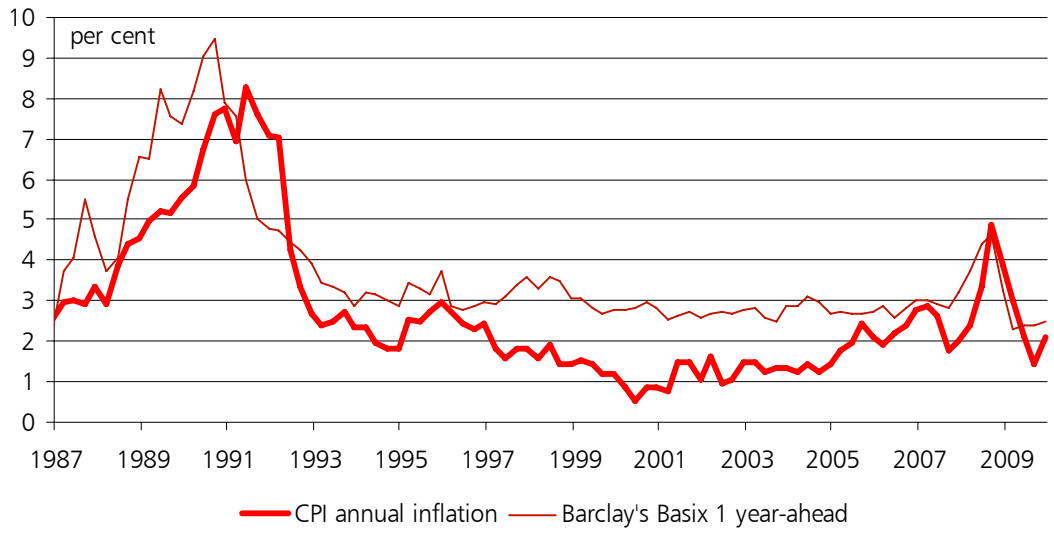
4.16 To directly capture inflation expectations and any shifts in these that may have occurred as a result of a changing monetary policy change regimes, Barclay's Basix, a household survey of annual inflation expectations 1 year ahead, is included in the analysis. The approach of directly

[9] A model specification was also tested where oil prices and non-oil imported goods prices were modelled separately. However, the oil price coefficient was insignificant.

[10] Correlations of the annual change in the exchange rate and import prices show a strong negative contemporaneous correlation, and this is stronger in more recent periods, this suggests that changes in the exchange rate pass through relatively quickly to import prices.

including survey measures of inflation expectations rather than modelling expectations is similar to the approach adopted in Roberts (1995). The inflation expectations series is available from 1986Q4 and Chart 4.D shows that this moves broadly in line with actual inflation and appears to be relatively stable from the mid-1990s.

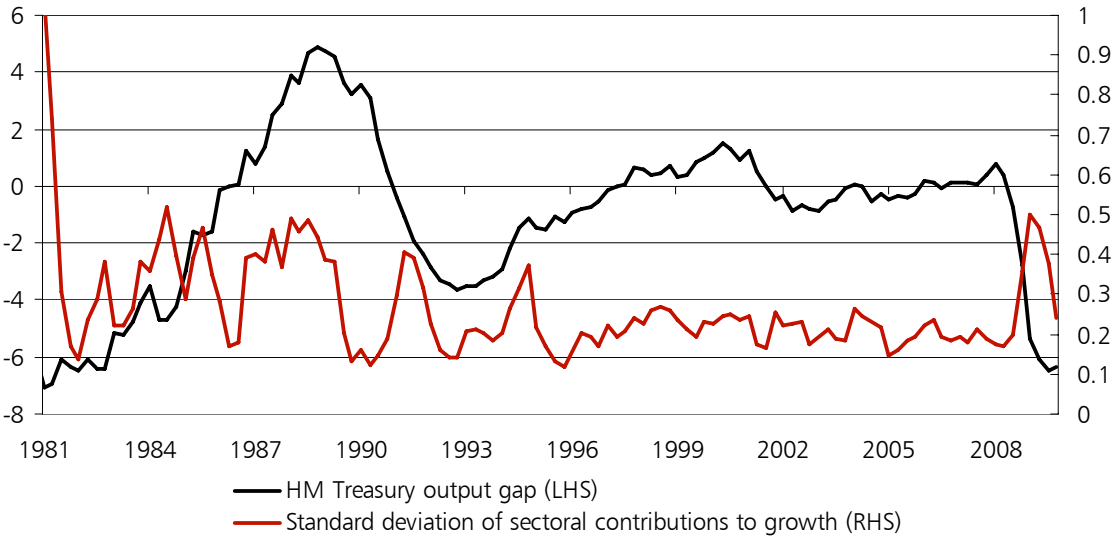
Chart 4.D: CPI and inflation expectations



Source: ONS, Barclays

4.17 As described in Chapter 3 it is possible that 'unbalanced' growth may be one source of speed limit effects on inflation. To try and capture this effect, a variable has been defined to capture the variation in growth across different sectors of the economy, measured as the standard deviation of sectoral contributions to whole economy growth. This variable will take a higher value the more unbalanced contributions to growth across different sectors of the economy. As shown in Chart 3.E, this variable may reflect a degree of cyclicality as some sectors are more cyclically sensitive than others and hence the standard deviation of sectoral contributions to growth may be larger when the economy is away from trend.

Chart 4.E: Cross sectional standard deviations to growth



Source: ONS, HM Treasury calculations

Model specification

4.18 Adopting a general to specific modelling strategy, a Phillips curve relationship is estimated including both a lagged output gap term and the lagged one-quarter change in the output gap to capture both the level and speed limit effect on inflation. The most general form of the model includes four lags of the one-quarter change in the output gap and four lags of the annualised quarterly log change in import prices.[11]

4.19 For the preferred specification, two lags of the one-quarter change in the output gap are selected to model the effect of momentum on inflation. Longer lags of changes in the output gap are found to be highly insignificant. As the coefficients on all four lags of the quarterly change in import prices are of similar size, a single lag of the annual log change in import prices is included in the preferred specification on the grounds of parsimony. Consistent with the empirical evidence on the transmission of monetary policy (Bank of England (1999)), which suggests there may be a lag of around a year in the transmission from activity to inflation, the fifth lag of the level of the output gap was included in the preferred specification.

4.20 The preferred model specification is shown below:

$$\pi_t = \alpha_0 + \alpha_1 \pi^a_{t-1} + \alpha_2 \pi_{t-4} + \beta_1 GAP_{t-5} + \beta_2 \Delta GAP_{t-1} + \beta_3 \Delta GAP_{t-2} + \alpha_3 IMP^a_{t-1} + \alpha_4 \Delta VAT$$

$$+ \alpha_5 DQ1 + \alpha_6 DQ2 + \alpha_7 DQ3 + \varepsilon_t$$

Where: π is annualised quarterly inflation, α_0 is the constant, π^a is annual inflation, GAP is the output gap, ΔGAP is the one-quarter change in the output gap, IMP^a is the annual change in log import prices, ΔVAT is the quarterly change in the main VAT rate and DQ1, DQ2 and DQ3 are quarterly dummies.

4.21 This specification encompasses an "accelerationist" model of inflation, in which the change in inflation is a function of the output gap. A feature of the accelerationist model is that there is no effective anchor to the inflation process, so that inflation can only be raised or lowered via movements in the output gap. In the model specification, this would occur if the sum of the coefficients on lagged consumer price inflation were equal to one. However, if these coefficients sum to less than one, the specification implies that inflation will tend to move in a range around a long-run value. As the objective of the monetary policy framework is to ensure that inflation reverts to the inflation target, it would be unsurprising to find that the estimated coefficients sum to less than one.[12]

4.22 As described in the data section above, the model is estimated on the annualised quarterly inflation rate. To overcome the problem of seasonality in the data, the model includes three dummies to control for fixed seasonal effects (DQ1, DQ2 and DQ3) and, to allow for shifting seasonal effects over time, the fourth lag of the annualised quarterly inflation rate is also included.

4.23 As has been observed over the past year, changes in indirect taxes can have a relatively large one-off effect on the price level. These are controlled for directly, by including the change in the VAT rate as an explanatory variable.[13]

[11] The results for the most general specification are reported in Annex B, Table B.1, column 1.

[12] One way of thinking about the specification is that it allows inflation to be a weighted average of past inflation and the inflation target. The weight on past inflation is given by ($\alpha_1 + \alpha_2$) and the weight on the inflation target by ($1-\alpha_1-\alpha_2$). If the equation were estimated over a period in which the inflation target had been in place and had been unchanged, then the intercept term in the regression (α_0) would include the weighted contribution from the inflation target. In a sample period that predates formal inflation targeting the weight ($1-\alpha_1-\alpha_2$) would apply to an implicit target.

[13] Over the sample period the standard VAT rate was: 15% from 1981Q1 to 1991Q1, 17.5% from 1991Q2-Dec 2008, 15% from Dec 2008 – Dec 2009 and 17.5% from January 2010.

4.24 The preferred model specification described above has a reduced-form set up, where lags of the output gap and change in the output gap enter directly, and where there is no direct role for inflation expectations. In reality, there are intermediate channels by which the output gap influences inflation; excess demand in the goods market pushes up margins, excess demand in factor markets pushes up input prices (including wages), and expectations of higher future inflation feeds through to inflation today. Modelling each of these channels separately would require a multi-equation model. But to simplify the analysis, this study has opted for a simple single equation model. However, this should not be taken as meaning that inflation is a purely backward-looking process; one of the channels though which the output gap can influence inflation is through expectations. The importance of this channel is supported by the results reported in Table 5.C in Chapter 5, where the model is estimated including the Barclays Basix survey measure of inflation expectations.

Identification and potential endogeneity problems

4.25 Within this model, valid identification of the level effect of the output gap and the speed limit effect on inflation depends on both series being stationary. Statistical tests for stationarity were performed using an augmented Dickey Fuller test for all of the variables used in the analysis. This showed the variables used for analysis are stationary in the sample period from 1981Q1-2009Q4.[14]

4.26 Making valid inferences from the results of the preferred specification is also dependent on the assumption of the direction of causality between inflation and the output gap. If reverse causality exists from inflation to the output gap such that the output gap is endogenous, this may bias the results.[15] With the potential for both lags and forward-looking behaviour in endogenous variables, there are a large number of possible channels through which biases can emerge. For example, higher inflation could result in a higher output gap by reducing the real interest rate and boosting demand. Alternatively, higher inflation could result in a monetary policy response that weakens demand, raises the exchange rate and lowers import prices.

4.27 One way to check whether the results from estimating the preferred specification are being generated by endogeneity is to use instrumental variables. This technique utilises variables that are exogenous to both the dependent and explanatory variables in the preferred model, and which should in theory have a causal impact on the endogenous explanatory variables. The instrumental variables can be used to reduce any bias in the estimated coefficients that might arise from the endogenous response of the output gap and other explanatory variables to exogenous movements in CPI inflation.

4.28 The whole OECD area output gap may present a suitable instrument for the UK output gap. It may reasonably be considered as exogenous to the UK output gap and should also be correlated with the UK output gap, because external growth can cause UK growth through trade and financial market linkages. However, a possible flaw with this instrument is that changing the UK output gap is not the only way in which the foreign output gap could change UK inflation. A higher foreign output gap could also push up world prices, pushing up UK import prices and UK inflation. This effect can be controlled for by including import prices as an endogenous explanatory variable and adding world prices as an additional instrument for this variable.[16]

[14] The null of a unit root was rejected at the 1 per cent level for CPI inflation, at the 5 per cent level for import price inflation, and at the 10 per cent level for the output gap.

[15] Although note that potential endogeneity is not a problem if the equation is being used to forecast inflation conditional on a given path of the output gap.

[16] The instrumental variables estimation technique requires at least one instrument for each endogenous variable to make identification possible.

4.29 Although the results are not reported here, regressions using the level and change of the average OECD output gap, and world prices, as instruments for the level and change in the UK output gap and UK import prices, find positive and statistically significant effects from both the level and change in the UK output gap on the change in inflation. This offers support for the hypothesis that the output gap has a positive influence on the change in inflation, and that speed limit effects do exist.

5 Results

5.1 This chapter summarises the results from estimating the Phillips curve model above. First the basic specification is estimated over the sample period 1981Q1-2009Q4 and then additional explanatory variables are added to the model, including the sectoral change variable and the inflation expectations term. The analysis explores the robustness of the results to different output gap measures, inflation measures and time periods, and the evidence for asymmetries and non-linearities in the Phillips curve relationship is evaluated.

The basic specification

5.2 Table 5.A below summarises the results from estimating the preferred specification over the period 198Q1-2009Q4 on the annualised quarterly inflation rate for CPI all items, using the HM Treasury output gap.[1] The Table shows the coefficients of interest for our analysis; the full regression results are reported in Annex B, Table B.1 column 2.

Table 5.A: Regression results 1981-2009[2]

Dependent variable: CPI all items (annualised quarterly inflation rate)	**Coefficient**	**t-stat**[+]
π^{a}_{t-1} (annual inflation rate)	**0.40**	(3.03)**
π_{t-4} (annualised quarterly inflation rate)	**0.33**	(2.40)*
ΔGAP_{t-1} (one quarter change output gap)	**0.39**	(1.53)
ΔGAP_{t-2} (one quarter change output gap)	**0.30**	(1.11)
GAP_{t-5} (output gap)	**0.25**	(4.18)**
IMP^{a}_{t-1} (annual change import prices)	**0.13**	(3.53)**
Observations	**116**	
R-squared	**0.83**	
* significant at 5% level; ** significant at 1% level; [+] robust t-stat		
Source: HM Treasury calculations		

5.3 Both the level and the change in the output gap have the expected sign, with the level of the output gap significant at the 1 per cent level and the first lag of the change in the output gap significant only at the 15 per cent level and the second lag at the 30 per cent level. This suggests that the level of the output gap is an important driver of inflation, but that the evidence for the speed limit effect is more tentative, given that it is not possible to reject the hypothesis that the coefficients may be zero.

[1] Ordinary least squares estimation, applying robust standard errors to correct for general forms of heteroskedasticity.

[2] A range of standard diagnostic tests (Breusch-Godfrey LM test for autocorrelation, Dickey-Fuller test for unit root, and the Augmented Dickey Fuller test) reported the residuals were not autocorrelated and were stationary.

5.4 Both lagged inflation and import price inflation are important in explaining CPI inflation, with the expected signs. A statistical test rejects the hypothesis that the sum of the coefficients on lagged inflation equal one, and hence rejects the accelerationist model.[3] This is consistent with the monetary policy framework providing an anchor for inflation expectations. Although not reported here, the seasonal dummies and VAT change variables were significant and the coefficients have reasonable values. The detailed regression results are reported in Annex B, Table B.1.

5.5 An impulse response analysis using the coefficient reported above on annual import prices suggests that a one-off quarterly increase in import prices of 10 per cent will have the maximum impact on the annual rate of CPI inflation four quarters after the initial shock, adding nearly 0.4 percentage points to the annual rate of CPI inflation. Approximately half of this effect will feed through after two quarters. As the contemporaneous movement in sterling ERI and import prices have recently been highly (negatively) correlated, this suggests that the effect of changes in the sterling exchange rate will also pass through to consumer prices after around a year. Chapter 6 explores the estimated impact of the different components of the regression equation on recent inflation outturns further.

5.6 Table 5.B reports the results from estimating the basic specification with the addition of the 'sectoral change' variable to the model. The full results for this regression are reported in Annex B, Table B.1, column 3.

Table 5.B: Regression results 1981-2009 including 'sectoral change' variable

Dependent variable: CPI all items (annualised quarterly inflation rate)	**Coefficient**	**t-stat**$^{+}$
π^{a}_{t-1} (annual inflation rate)	0.38	(3.19)**
π_{t-4} (annualised quarterly inflation rate)	0.30	(2.44)*
ΔGAP_{t-1} (one quarter change output gap)	0.48	(1.78)
ΔGAP_{t-2} (one quarter change output gap)	0.27	(1.01)
GAP_{t-5} (output gap)	0.26	(4.13)**
IMP^{a}_{t-1} (annual change import prices)	0.13	(3.66)**
SD_sector (variation in sectoral growth contributions)	2.49	(1.76)
Observations	116	
R-squared	0.84	

* significant at 5% level; ** significant at 1% level; $^{+}$ robust t-stat

Source: HM Treasury calculations

5.7 The 'sectoral change' variable measures the standard deviation of sectoral contributions to whole economy growth and attempts to capture the potential impact of 'unbalanced' growth in generating speed limit effects on inflation, as described in Chapter 3. The coefficient on this variable is significant and positive at the 10 per cent level, suggesting that greater variation in the contributions of different sectors to growth may increase inflation. However, the possibility that speed limit effects are only generated by unbalanced growth does not appear to be supported by these results: the coefficients on the output gap change terms are broadly similar to the specification excluding the sectoral change variable and the coefficient on first lag in the change in the output gap is also larger and significant at the 10 per cent level when the sectoral change variable is included. Inclusion of the sectoral change variable has limited effects on the explanatory power of the regression and on the coefficients of the other variables in the regression.

[3] The accelerationist model is discussed in Chapter 4.

5.8 To add inflation expectations as directly observed from the Barclays Basix survey to the model, the sample is restricted to the period for which this series is available, 1986Q1-2009Q4. A summary of these results both including and excluding inflation expectations are reported in Table 5.C below (the full results are shown in columns 6-7 of Table B.1).

Table 5.C: Regression results 1986-2009 with inflation expectations

Dependent variable: CPI all items (annualised quarterly inflation rate)	**Coefficient**	**t-stat⁺**	**Coefficient**	**t-stat⁺**
π^{a}_{t-1} (annual inflation rate)	**0.34**	(2.48)*	**-0.01**	(0.05)
π_{t-4} (annualised quarterly inflation rate)	**0.22**	(1.85)	**0.25**	(2.38)*
ΔGAP_{t-1} (one quarter change output gap)	**0.58**	(1.73)	**0.23**	(0.66)
ΔGAP_{t-2} (one quarter change output gap)	**0.44**	(1.50)	**0.24**	(0.80)
GAP_{t-5} (output gap)	**0.36**	(3.97)**	**0.13**	(1.18)
IMP^{a}_{t-1} (annual change import prices)	**0.14**	(3.62)**	**0.11**	(3.11)**
π^{E}_{t+1} (expected annual inflation)			**0.55**	(3.27)**
Observations	**93**		**93**	
R-squared	**0.83**		**0.85**	

* significant at 5% level; ** significant at 1% level; ⁺ robust t-stat

Source: HM Treasury calculations

5.9 The results for the 1986Q1-2009Q4 sample excluding inflation expectations are very similar to the results reported in Table 5.A, although the output gap coefficients are slightly larger and more significant suggesting an enhanced role for the output gap level and change in explaining inflation over this period. This is also the case for the import price inflation coefficient. Furthermore, the lagged inflation term becomes less significant, suggesting that inflation expectations were more firmly anchored between 1986 and 2009 than had been the case between 1981and 1985.

5.10 Including the survey measure of inflation expectations causes the majority of the other explanatory variables of interest in the model to become insignificant. The inflation expectations term has a large degree of explanatory power in this model, almost to the exclusion of all other variables. This suggests that the output gap terms and lagged inflation are correlated with households' inflation expectations.

5.11 Comparison of the two regressions suggests that there is little to choose between modelling inflation as a function of the output gap (as in Table 5.A) or as a function of household inflation expectations. The analysis in the remainder of this paper uses the first approach, which allows inflation outturns and projections to be assessed in terms of developments in the output gap.

Output gap measures

5.12 The next section considers the sensitivity of the results to estimating the model on different measures of the output gap. The model was estimated using three different output gap measures; the HM Treasury output gap (repeating the results from Table 5.A above), the OECD output gap and the HP filter trend output gap. The different methods of construction for these output gap measures are described in Chapter 4. A summary of the results is shown in Table 5.D below (the full regression results are shown in columns 2, 4 and 5 of Table B.1).

Table 5.D: Regression results 1981-2009 using different output gap measures

Dependent variable: CPI all items (annualised quarterly inflation rate)	**HMT Output Gap**		**OECD Output Gap**		**HP Filter Output Gap**	
	Coeff.	**t-stat+**	**Coeff.**	**t-stat+**	**Coeff.**	**t-stat+**
π^{a}_{t-1} (annual inflation rate)	**0.40**	(3.03)**	**0.36**	(2.97)**	**0.33**	(2.49)*
π_{t-4} (annualised quarterly inflation rate)	**0.33**	(2.40)*	**0.33**	(2.52)*	**0.33**	(2.52)*
ΔGAP_{t-1} (one quarter change output gap)	**0.39**	(1.53)	**0.49**	(1.84)	**0.58**	(2.04)*
ΔGAP_{t-2} (one quarter change output gap)	**0.30**	(1.11)	**0.30**	(1.30)	**0.45**	(1.57)
GAP_{t-5} (output gap)	**0.25**	(4.18)**	**0.37**	(5.43)**	**0.58**	(4.92)**
IMP^{a}_{t-1} (annual change import prices)	**0.13**	(3.53)**	**0.13**	(3.77)**	**0.09**	(2.77)**
Observations	**116**		**116**		**116**	
R-squared	**0.83**		**0.85**		**0.84**	

* significant at 5% level; ** significant at 1% level; + robust t-stat

Source: HM Treasury calculations

5.13 The pattern of results is very similar across the different output gap measures, with both the level and change in the output gap having the expected sign and with the level more statistically significant than the change. However, the size and significance of the output gap coefficients increase when moving from the HM Treasury to the OECD to the HP measure of the gap.

5.14 In terms of the size of the output gap coefficients, the observed pattern is likely to reflect the fact that the measurement of trend output using the HP filter tends to follow actual output more closely so the magnitude of the output gap tends to be smaller. Therefore, the magnitude of the output gap coefficients will be larger to offset this, essentially a scaling effect. This is supported by Chart 4.A which shows the three output gap measures generally following a similar pattern but with the HP gap having the lowest amplitude, the HM Treasury gap the largest and the OECD gap mostly in between the two.

5.15 Although there are differences between them, the consistent pattern of the results in this section is reassuring, and suggests that the output gap is a robust determinant of inflation.

CPI Services and Goods price inflation

5.16 This section considers the sensitivity of the results to estimating the model using different measures of inflation as the dependent variable. As CPI goods and services are only available from 1989, the results shown in Table 5.E below for the three inflation measures were all estimated on this period. The detailed regression results are reported in Table B.2, columns 8-10.

5.17 The results for all items CPI are similar to whole period results. Although the magnitude of the coefficient on the second lag of the change in the output gap is stronger than over the 1981-2009 period, it is not significant. There is an indication that external influences on inflation may have been stronger since 1989, with the import price inflation coefficient marginally higher. Lagged annual inflation and the fourth lag of the annualised quarterly change in inflation have less explanatory power, suggesting that inflation expectations were more firmly anchored between 1989 and 2009 than had been the case between 1981and 1988.

Table 5.E: Regression results 1989-2009 using different inflation measures

Dependent variable: (annualised quarterly inflation rate)	CPI all items		CPI goods		CPI services	
	Coeff.	t-stat+	Coeff.	t-stat+	Coeff.	t-stat+
π^{a}_{t-1} (annual inflation rate)	0.31	(2.25)*	0.48	(2.73)**	0.16	(1.19)
π_{t-4} (annualised quarterly inflation rate)	0.22	(1.79)	0.11	(0.70)	0.33	(3.26)**
ΔGAP_{t-1} (one quarter change output gap)	0.28	(0.62)	0.51	(1.02)	0.26	(0.39)
ΔGAP_{t-2} (one quarter change output gap)	0.53	(1.32)	0.31	(0.49)	0.35	(1.27)
GAP_{t-5} (output gap)	0.35	(3.37)**	0.25	(2.06)*	0.51	(3.93)**
IMP^{a}_{t-1} (annual change import prices)	0.15	(3.76)**	0.17	(3.15)**	0.11	(3.05)**
Observations	83		83		83	
R-squared	0.84		0.79		0.84	

* significant at 5% level; ** significant at 1% level; + robust t-stat

Source: HM Treasury calculations

5.18 Estimating the model on CPI goods and services inflation shows a number of interesting results. The coefficient on the output gap level is smaller and less significant for CPI goods than all items CPI, whereas the import price inflation coefficient is stronger, with the opposite being true for services CPI. This is in line with the prior reasoning that, as a high proportion of goods can be easily traded across borders, goods prices will be more determined by external influences and less by the domestic output gap than services prices.

5.19 The coefficients on the change in the output gap on inflation are higher for goods than for all items or services, but are not statistically significantly different from zero. Hence, while estimating on CPI inflation broadly disaggregated into a more domestic (services) and external (goods) component provides further support for the effect of the level of the output gap on inflation, it provides only very limited evidence for the existence of speed limit effects on inflation over this shorter time period.

5.20 The model was also estimated on CPI core goods inflation, although this is only available from 1997 (see Table B.2, column 12). As discussed further below, the effect of the output gap is largely insignificant across all inflation measures in the post-1997 period and also has a negative sign for core goods CPI. However, these results are of interest in considering the impact of import price inflation. The coefficient on import price inflation is slightly weaker for core goods than for all goods CPI over this period. However it is also significant at a longer lag, which may be because the core goods sub-component does not include items that are likely to respond more immediately to exchange rate movements, such as fuel and food.

Asymmetry & non-linearity

5.21 To test for evidence of asymmetries in the relationship between the output gap and inflation, the output gap terms were interacted with a dummy variable. The dummy variable equals 1 if the level of output gap is positive and 0 if the level of the output gap is zero or negative. This allows the model equation to isolate the effects of a positive output gap, captured in the interaction term coefficients presented in Table 5.F (the full results are shown in Table B.3, columns 17-18).

5.22 The coefficients on the interacted terms can be interpreted as the differences between the impact of a positive output gap and a negative output gap. These coefficients are all positive, which indicates that the effects of both the change and the level of the output gap on inflation are stronger when the output gap is positive. However, while the coefficients on terms in the (un-interacted) change in the output gap are positive, they are insignificant, suggesting weak

inflationary effects when the economy is at or below trend. Indeed, these coefficients can be set to zero, with limited effects on either the explanatory power of the regression or the coefficients on the other variables in the regression (Table 5.F, regression 2). Overall, these results provide evidence of an asymmetric relationship between the output gap and inflation, with changes in the output gap (or "speed limit" effects) boosting inflation only when output is above trend. By contrast, the regressions suggest that the magnitude of the response of inflation to the level of the output gap is the same regardless of whether output is above or below trend.

Table 5.F: Regression results 1981-2009 modelling asymmetries

Dependent variable: CPI all items (annualised quarterly inflation rate)		**Regression 1**		**Regression 2**	
		Coeff.	**t-stat⁺**	**Coeff.**	**t-stat⁺**
π^{a}_{t-1} (annual inflation rate)		**0.41**	(3.33)**	**0.47**	(3.81)**
π_{t-4} (annualised quarterly inflation rate)		**0.29**	(2.19)*	**0.25**	(2.00)*
ΔGAP_{t-1} (one quarter change output gap)		**0.07**	(0.17)		
ΔGAP_{t-2} (one quarter change output gap)		**0.13**	(0.38)		
GAP_{t-5} (output gap)		**0.17**	(1.39)	**0.22**	(3.88)**
$POS*\Delta GAP_{t-1}$ (one quarter change output gap when GAP >0)		**0.91**	(1.53)	**0.87**	(2.03)*
$POS*\Delta GAP_{t-2}$ (one quarter change output gap when GAP >0)		**0.61**	(1.18)	**0.69**	(1.79)
$POS*GAP_{t-5}$ (output gap when GAP >0)		**0.21**	(0.82)		
IMP^{a}_{t-1} (annual change import prices)		**0.12**	(3.17)**	**0.12**	(3.54)**
Observations		116		116	
R-squared		0.84		0.84	
Memo items: effective coefficients when the output gap is positive / negative					
ΔGAP_{t-1}	GAP is positive	0.98		0.87	
	Gap is negative	0.07		0.00	
ΔGAP_{t-2}	GAP is positive	0.74		0.69	
	Gap is negative	0.13		0.00	
GAPt-5	GAP is positive	0.37		0.22	
	Gap is negative	0.17		0.22	

* significant at 5% level; ** significant at 1% level; ⁺ robust t-stat

Source: HM Treasury calculations

5.23 Additional analysis was conducted to test for non-linearities in the relationship between the output gap and inflation. Nonlinear effects were modelled by creating dummies that were equal to 1 when the absolute level of the output gap was greater than 1,2, or 3 per cent. By interacting these dummies with the output gap terms, it should be possible to identify a non-linear effect of the output gap on inflation. Although one might expect the output gap to have a stronger impact on inflation as the absolute level of the gap increases, as discussed in Chapter 3, no robust results were found for the non-linear interaction terms.

Stability of coefficients

5.24 As discussed in Chapter 3, there are good reasons for believing that the trade-off between inflation and the output gap may have been affected by changes in the monetary policy regime. This may cause the output gap coefficients in the model to change over time, particularly after the delegation of operational independence over monetary policy to the Bank of England in 1997.

5.25 To test for this, the model was estimated over the post-1997 period. These results are reported in Table B.2, columns 11-15. The regression results are harder to interpret over this period, with some of the output gap coefficients having the wrong sign and low statistical significance. The level and change in the output gap remain significant in the regression for services CPI inflation, but not for all items CPI or goods CPI. Although this could suggest that the output gap is less important for inflation in the post-1997 period, it could also reflect the fact that the variation in output and inflation over this period has been much more limited (up until the past two years). However, given the large standard errors on these coefficients, it is also not possible to reject the hypothesis that these coefficients are the same as the estimated values for the whole 1981Q1-2009Q4 period.

5.26 As an alternative test of the stability of coefficients over time, the model residuals for the 1981Q1-2009Q4 period were regressed on the explanatory variables over the pre- and post-1997 period. This approach confirmed that the differences in the coefficients over the sub-periods compared with the whole period were not statistically significant.

Summary of results

5.27 The results presented in this chapter support the conclusion that the level of the output gap has an important role in explaining inflation. This result is robust across a range of output gap measures and for the all items CPI, goods CPI and services CPI. Although this result is not robust to using CPI goods as the dependent variable, the results for this model point to a larger role for the external influence of import prices on inflation and can be informative for the forecast judgement on the pass through of sterling depreciation to consumer prices.

5.28 The equation modelling asymmetry in the output and inflation relationship provides some suggestion of an asymmetric relationship, with inflation responding more to changes in the output gap when output is above trend. Although speed limit effects are found to be insignificant when the output gap is negative, this does not rule out the possibility that inflation could be boosted if the current level of spare capacity were to be eroded rapidly, although it does suggest that the risk is low.

5.29 The results find strong empirical evidence of the influence of import prices on inflation with a one off shock to import prices lasting one quarter taking around one year to fully feed through to the annual rate of CPI inflation.

5.30 The inclusion of inflation expectations in the model causes the majority of the other explanatory variables of interest in the model to become insignificant. This suggests that the output gap terms and lagged inflation are correlated with households' inflation expectations.

5.31 In interpreting the results more generally, it is important to highlight that the main results are dependent on a long sample of observations being used for CPI all items and the sub-indices. This raises the question of how applicable the results are to the current period. However, there are difficulties with interpreting results estimated over shorter periods. In particular, inflation and the output gap have moved within a narrow range between 1997 and 2007, which makes it difficult to identify a strong effect from the output gap to inflation over this period. Nonetheless, it may be the case that the delegation of operational independence over monetary policy to the Bank of England in 1997 has reduced the effect of the output gap on inflation by anchoring inflation expectations more tightly to the inflation target, and this should

kept in mind when interpreting the results. The equations estimated over shorter samples (Table 5.C, 5.E) also suggest less persistence in the inflation process as the effect of lagged inflation terms become less important.

5.32 Bearing in mind these considerations, and that the results cannot be applied mechanistically to the current period, the following Chapter evaluates the ability of these results to explain recent inflation outcomes, and the implications for the future path of inflation.

6 Assessing developments in inflation

6.1 In this chapter two of the regressions reported in Chapter 5 are used to analyse recent and prospective developments in inflation. The regressions do not account for all of the determinants of inflation, including the important role that the credibility of the inflation target has in anchoring inflation expectations and outcomes.[1] As a result, the decompositions presented in this chapter should not be interpreted mechanistically. Nonetheless, they provide a perspective on the extent to which recent outturns and the projections contained in the Budget 2010 inflation forecast compare with past experience.

6.2 Inflation in the recent past has been shaped by a number of elements that feature in the regression specifications. Import prices have risen strongly, as a result both of developments in oil and commodity markets and from the depreciation of sterling since mid-2007. These inflationary pressures have been countered by the recession, which has generated a large output gap. In addition, the reduction in the VAT rate between December 2008 and December 2009 has affected the profile of inflation.

Inflation outcomes since 2007

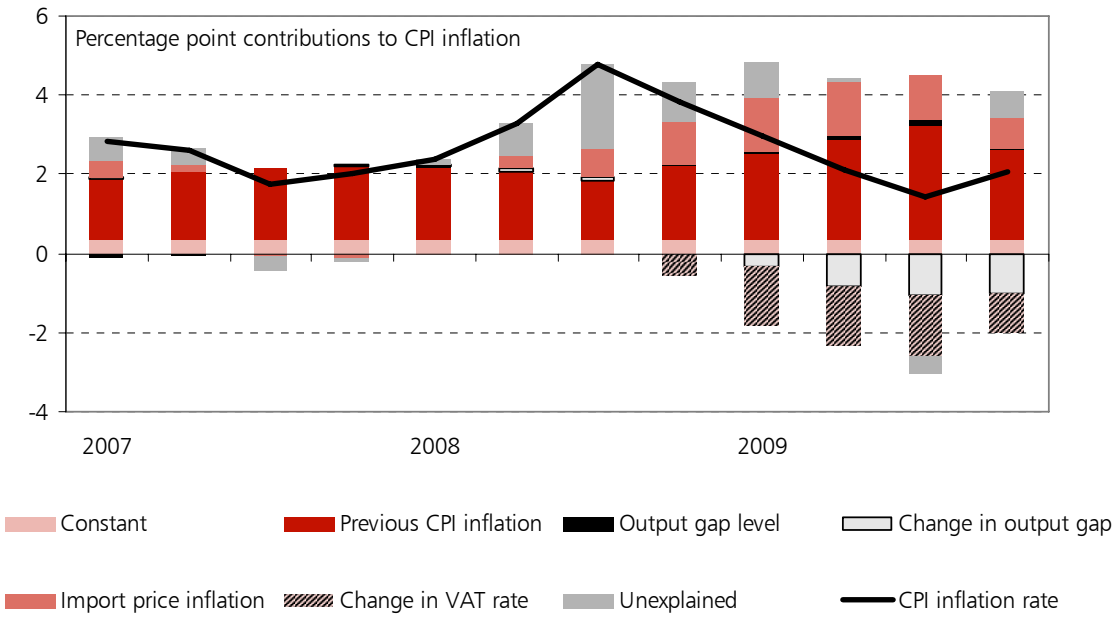
6.3 The regressions suggest that the output gap and import price inflation are major proximate influences on inflation. In common with many other economic variables, both of these elements were markedly more stable between 1998 and 2006 compared with the previous two decades.[2] However, both measures have become more volatile during the past three years. The regression equations can be used to estimate their impact on consumer price inflation over this period (Chart 6.A).[3]

[1] In addition, the estimated coefficient on the change on VAT has been over-written to a value of 2.4, which is consistent with ONS estimates that a full pass-through of the change in the VAT rate would add around 1.5 percentage points to the inflation rate. The imposed coefficient is lower than, but not statistically significantly different from, the regression coefficient (3.1). However, this coefficient is likely to be estimated imprecisely as there are only four observations in the sample period in which the VAT rate changed.

[2] Between 1998 and 2006 the standard deviation of the output gap was 0.7 percentage points and 3.4 percentage points for import price inflation. Between 1976 and 2009, these figures were 2.6 and 6.1 percentage points, respectively.

[3] The regression results from estimating the preferred equation over the period up to 2007 are reported in Table B.3. These are very similar to the results for the whole period.

Chart 6.A: Contributions to CPI inflation outcomes since 2007



CPI inflation measured as change on year earlier.
This decomposition is derived from the regression reported in Table 5.A, with the coefficient on the change in VAT imposed at 2.4, which implicitly assumes 100 per cent pass through.

Source: HM Treasury

6.4 Inflation outcomes in 2007 are explained well by the regression. The estimated output gap was close to zero during 2006 and 2007, import price inflation was moderate, and past inflation had been close to target. The regression predicts that inflation should have stayed close to target, and this turned out to be the case.[4]

6.5 The following year was more eventful. CPI inflation rose sharply, peaking at 4.9 per cent in the third quarter. Import prices were boosted by the depreciation in the exchange rate, which fell by around 25 per cent between July 2007 and January 2009, and by increases in oil and commodity prices during the first half of 2008. According to the regression, the increase in import prices should have raised consumer price inflation by 1.1 percentage points by the fourth quarter of 2008. The onset of the recession meant that output fell sharply in the second half of 2008. However, the lags in the regression equation imply that this would have had little impact on inflation until the following year.

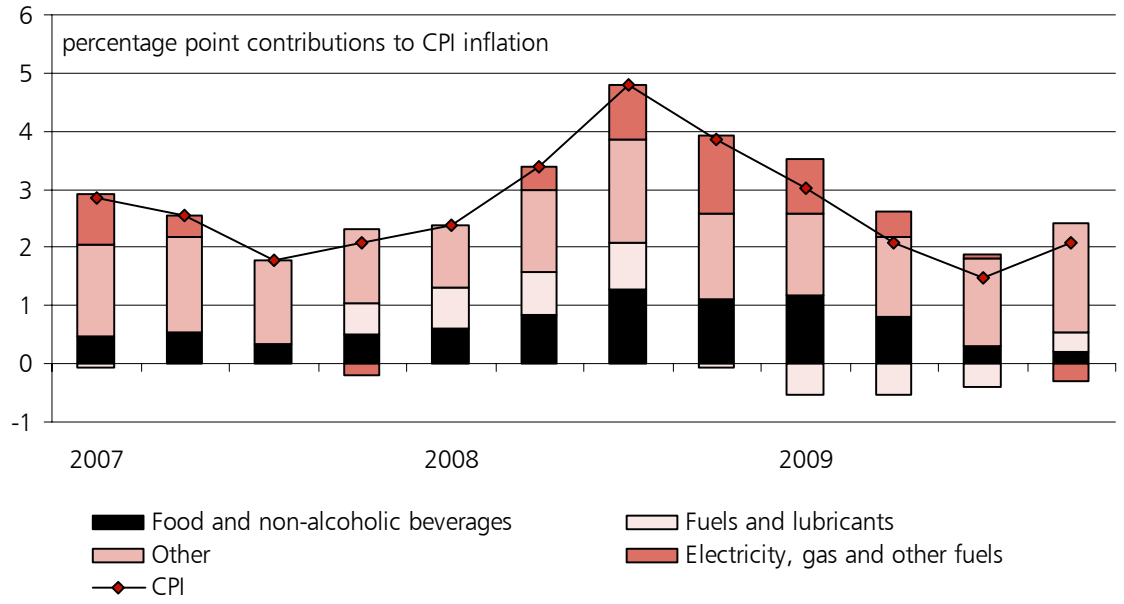
6.6 Nonetheless, the regression failed to account fully for the pick-up in inflation in 2008. In particular, the unexplained element reached 2.1 percentage points in the third quarter of the year. This can be explained partly by the unusually strong contribution to CPI inflation in this quarter from food, oil and energy prices (Chart 6.B), none of which are independently identified

[4] Over this period the variables in the regression were close to notional steady-state values. A steady-state could be characterised by the level and change in the output gap at zero, consumer price inflation at 2 per cent and import prices growing at close to 2 per cent. In this case, past consumer price inflation would contribute 1.5 percentage points to the predicted inflation rate, import price inflation would contribute 0.2 percentage points and the constant 0.3 percentage points. An alternative analysis could decompose the past inflation component into elements examining the impact of earlier movements in the output gap, inflation, VAT and unexplained "shocks".

in the regression equation, but where the pass through to consumer price inflation is likely to be rapid.[5]

6.7 CPI inflation fell markedly during 2009. The regression equation explains most of this decline. Import price inflation continued to put upward pressure on CPI inflation, but this was more than offset by the deflationary pressures from the rapid widening in the output gap in 2008 Q4 and 2009Q1 and from the reduction in the VAT rate at the end of 2008. As the estimated output gap did not open up until late 2008, the effects from its level (distinct from its change) on inflation were small in 2009, as the regression implies it takes five quarters for the level of the output gap to affect inflation.

Chart 6.B: Actual contributions to CPI inflation 2007-2009



Source: Office for National Statistics

Inflation projections

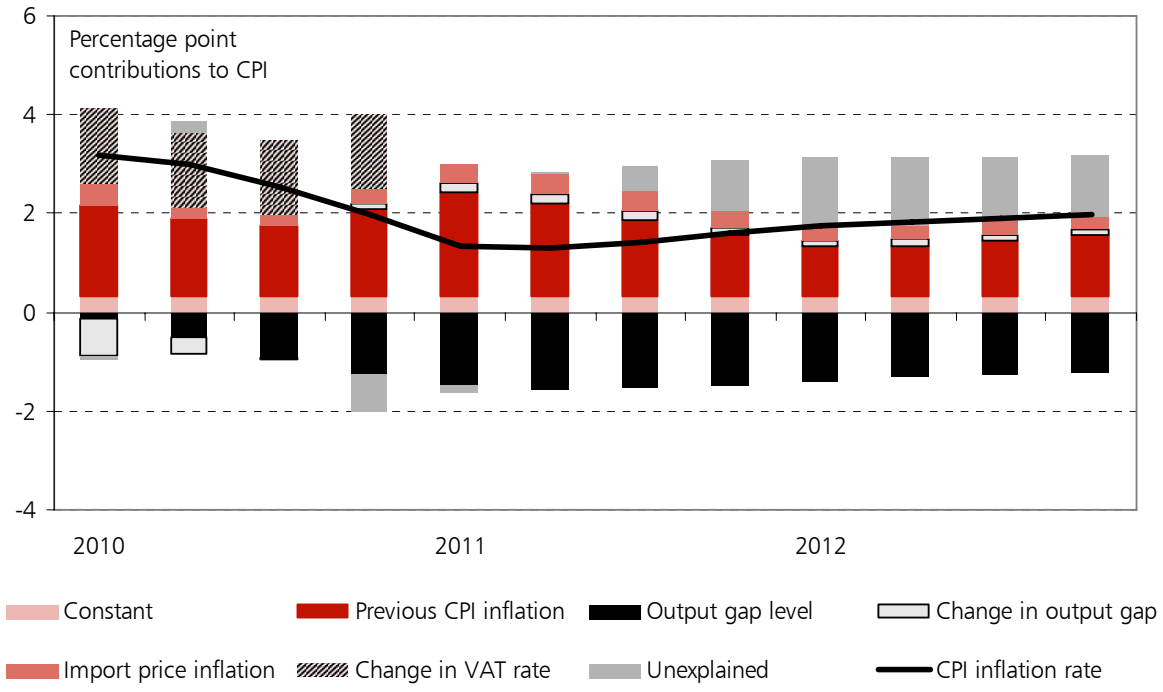
6.8 The regression equations can also be used to evaluate projections for inflation in the period ahead, and different variants can be used to illustrate the sensitivity of this analysis to different assumptions about both the size of the output gap and the impact that the output gap has on inflation outcomes.

6.9 Import price inflation is projected to remain moderate over the forecast period, implying that consumer price inflation will be predominantly shaped by domestic price pressures. Import price inflation peaked at around 14 per cent in the third quarter of 2008, but had subsided to 2 per cent by the end of 2009, reflecting the moderation in world prices and greater stability the sterling Exchange Rate Index. The restoration of the standard rate of VAT to 17.5 per cent at the start of the year would add around 1.5 percentage points to the inflation rate during 2010 if passed through in full (Chart 6.C).[6]

[5] However, in a specification where oil prices and non-oil imported goods prices were modelled separately, the coefficient on oil price inflation was insignificant. This could imply that the extent of pass-through from oil prices to consumer price inflation may vary depending on the wider economic context.

[6] This effect has been imposed, see footnote 1.

Chart 6.C: Contributions to CPI inflation projections



CPI inflation measured as change on year earlier.
This decomposition is derived from the regression reported in Table 5.A, with the coefficient on the change in VAT imposed at 2.4, which implicitly assumes 100 per cent pass through.

Source: HM Treasury

6.10 The output gap should exert persistent downward pressure on CPI inflation, according to the regressions. The Treasury projects the output gap to take some years to close during the next several years from over –6 per cent at the end of 2009 to around –3½ per cent in the second half of 2012. However, unlike in 2009, the effects from the output gap in the period ahead arise mainly from the impact of the (lagged) level of the output gap rather than from its change. The relatively slow pace at which the output gap is projected to close means that the upward pressure from the change in the output gap (or 'speed limit') terms in the regression is limited.

6.11 In assessing inflation prospects, an important judgement relates to whether inflation outcomes will be pulled down as much as is implied by the regression results. The Treasury's Budget 2010 projections show CPI inflation falling below 1½ per cent in early 2011 and rising gradually back to the 2 per cent target by the end of 2012. This recovery in inflation is faster than the regression coefficients imply. As a result there is a persistently positive unexplained (by the regression) contribution to the inflation projection in the second half of 2011 and throughout 2012. This is because the projections are informed by a judgement that the inflation target will provide a stronger anchor for inflation outcomes than implied by the historical relationship between the output gap and inflation.

6.12 The Budget 2010 projections can also be analysed with reference to the regression that allows for asymmetric effects from the output gap terms onto inflation, depending on whether the output gap is negative or positive. Regression 2 in Table 5.F implies that the coefficients on the change in the output gap terms could be zero when the output gap is negative. This regression also implies that the coefficient on the output gap level could be a little smaller than indicated by the regression reported in Table 5.A. If applied to the Budget projections, this implies that the output gap exerts somewhat less downward pressure on inflation in the years ahead (Table 6.A, column 3 compared with column 2). A corollary is that the positive "unexplained" component implicit in the Budget projections for inflation is also smaller.

Table 6.A: Estimated contributions of level of the output gap to CPI inflation, percentage points

	Regression with symmetric output gap terms	Regression with asymmetric output gap terms	Regression with symmetric output gap terms, smaller initial output gap that closes faster	Regression with asymmetric output gap terms, smaller initial output gap that closes faster
2010 Q4	-1.3	-1.1	-0.9	-0.8
2011 Q4	-1.5	-1.3	-0.9	-0.8
2012 Q4	-1.2	-1.0	-0.5	-0.5

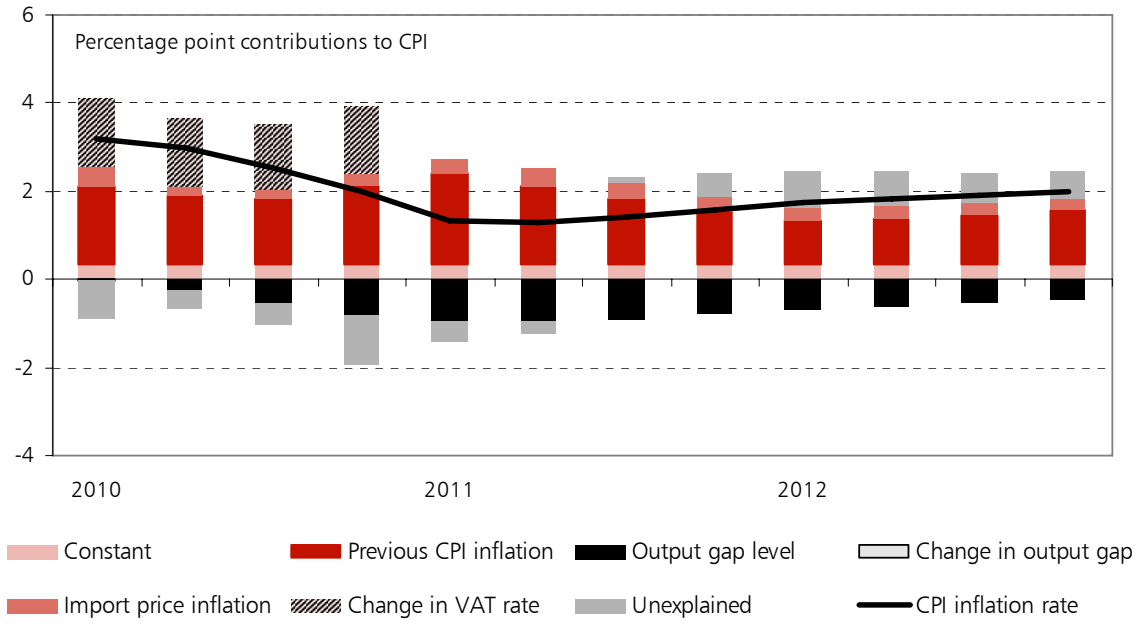
Results in columns 2 and 4 are derived from the regression reported in Table 5.A and in columns 3 and 5 from regression 2 in Table 5.F.
Results in columns 2 and 3 are derived using the output gap profile in the Budget 2010 forecast, in which the output gap closes from around –6 per cent in 2010 Q1 to around –3 per cent by the end of 2012.
Results in columns 4 and 5 use an output gap profile that closes from around –4 per cent in 2010 Q1 to zero by the end of 2012.

Source: HM Treasury

6.13 The projections for inflation also depend on the projected path of the output gap. The projections presented until now have been based on the Budget 2010 profile. As discussed in Chapter 2, there is significant uncertainty about the size of the output gap.

6.14 Table 6.A considers the case where the output gap is just over -4 per cent in 2010 Q1, and then closes faster (by 0.5 percentage points per annum) than in the Budget profile. This implies that the output gap closes by the end of 2012. The regressions imply that this would exert less downward pressure on inflation in the years ahead than implied by the Budget projection (Table 6.A, columns 4 and 5). And this in turn reduces the magnitude of the "unexplained" element of the Budget projections for CPI inflation (Chart 6.D, which illustrates the scenario reported in Table 6.A, column 5).

Chart 6.D: Contributions to CPI inflation projections under alternative scenarios



This decomposition is derived from:
a). regression 2 reported in Table 5.F, with the coefficient on the change in VAT imposed at 2.4, which implicitly assumes 100 per cent passthrough.
b). an output gap profile that assumes that the output gap is smaller in 2010Q1 and then closes more rapidly, by 0.5 percentage points per annum, than in the forecast.

Source: HM Treasury

6.15 In summary, the regression results suggest that there is likely to be sustained disinflationary pressure over the next few years that can be attributed to a persistent negative output gap. By contrast, the boost to inflation from higher import prices is expected to be much weaker than during the past two years.

6.16 An important uncertainty concerns how firmly inflation expectations will be anchored by the inflation target. The Budget 2010 projections assume that the disinflationary pressures from a large output gap are partly mitigated by the credibility of the monetary policy framework. The track record of the MPC in keeping inflation close to target, and in preventing the development of a deflationary spiral during 2009, may have reinforced the framework's capacity to anchor expectations.

6.17 If the economy were to recover more rapidly than anticipated then the disinflationary impulse from the output gap would be correspondingly weaker, but would still be expected to remain a major influence on inflation prospects over the next two to three years.

A Variable definitions

	Description	Definition	Variables	Start	End	Source
π_t	Quarterly inflation annualised	$\log(CPI_t/CPI_{t-1})*400$	CPI all items	1976Q1	2009Q4	ONS
			CPI goods	1989Q1	2009Q4	ONS
			CPI service	1989Q1	2009Q4	ONS
			CPI core goods	1997Q1	2009Q4	ONS
π^a_t	Annual inflation	$\log(CPI_t/CPI_{t-4})*100$	CPI all items	1976Q1	2009Q4	ONS
			CPI goods	1989Q1	2009Q4	ONS
			CPI service	1989Q1	2009Q4	ONS
			CPI core goods	1997Q1	2009Q4	ONS
GAP_t	Output gap	Level output gap	HMT Output gap	1955Q1	2009Q4	HM Treasury
			OECD Output Gap	1970Q4	2009Q4	OECD, EO86
			HP Output Gap	1955Q1	2009Q4	HM Treasury
ΔGAP_t	One quarter change in output gap	$GAP_t - GAP_{t-1}$	HMT Output gap	1955Q1	2009Q4	HM Treasury
			OECD Output Gap	1970Q4	2009Q4	OECD, EO86
			HP Output Gap	1955Q1	2009Q4	HM Treasury
IMP^a_t	Annual change in log import price deflator (National Accounts)	$\log(IMP_t/IMP_{t-4})*100$	-	1956Q1	2009Q4	ONS
IMP_t	Annualised quarterly log change import price deflator (National Accounts)	$\log(IMP_t/IMP_{t-1})*400$	-	1956Q1	2009Q4	ONS
ΔVAT_t	One quarter change in VAT rate	$VAT_t - VAT_{t-1}$	-	1973Q2	2009Q4	HMRC
DQ1	Dummy	DQ1=1 if period is Q1	-			-
DQ2	Dummy	DQ2=1 if period is Q2	-			-
DQ3	Dummy	DQ3=1 if period is Q3	-			-
π^E_{t+1}	Annual Inflation Expectations	Barclays Basix 1 yr ahead inflation expectations	-	1986Q4	2009Q4	Barclays Capital
SD_sector	Measure of variation in sectoral contributions to growth	Standard deviation of sectoral contributions to growth	-	1955Q1	2009Q4	ONS, HM Treasury calculations
POS	Dummy	POS=1 if GAP >0	-	1955Q1	2009Q4	-

B Regression results

Table B.1: Detailed regression results for Tables 5.A, 5.B, 5.C and 5.D

Column no.	1	2	3	4	5	6	7
Estimation period	1981-2009					1986-2009	
Dependent variable (π_t)	CPI All	CPI All	CPI All	CPI All	CPI All	CPI All	CPI All
Output gap	HMT	HMT	HMT	OECD	HP	HMT	HMT
π^a_{t-1}	0.40 (2.74)**	0.40 (3.03)**	0.38 (3.19)**	0.36 (2.97)**	0.33 (2.49)*	0.34 (2.48)*	-0.01 (0.05)
π_{t-4}	0.33 (2.36)*	0.33 (2.40)*	0.30 (2.44)*	0.33 (2.52)*	0.33 (2.52)*	0.22 (1.85)	0.25 (2.38)*
ΔGAP_{t-1}	0.38 (1.37)	0.39 (1.53)	0.48 (1.78)	0.49 (1.84)	0.58 (2.04)*	0.58 (1.73)	0.23 (0.66)
ΔGAP_{t-2}	0.26 (0.82)	0.30 (1.11)	0.27 (1.01)	0.30 (1.30)	0.45 (1.57)	0.44 (1.50)	0.24 (0.80)
ΔGAP_{t-3}	-0.03 (0.08)						
ΔGAP_{t-4}	0.00 (0.01)						
GAP_{t-5}	0.24 (3.79)**	0.25 (4.18)**	0.26 (4.13)**	0.37 (5.43)**	0.58 (4.92)**	0.36 (3.97)**	0.13 (1.18)
ΔVAT	2.96 (6.13)**	3.09 (6.74)**	3.16 (7.95)**	3.06 (6.67)**	3.14 (7.78)**	3.25 (5.03)**	3.13 (4.24)**
DQ1	-1.13 (3.05)**	-1.15 (3.25)**	-1.23 (3.49)**	-1.18 (3.39)**	-1.14 (3.24)**	-1.53 (3.47)**	-1.44 (3.52)**
DQ2	1.92 (3.29)**	1.88 (3.56)**	1.93 (3.78)**	1.86 (3.70)**	1.86 (3.60)**	1.91 (3.90)**	1.83 (3.97)**
DQ3	-1.22 (3.07)**	-1.27 (3.24)**	-1.32 (3.41)**	-1.26 (3.29)**	-1.26 (3.25)**	-1.43 (3.39)**	-1.44 (3.66)**
IMP^a_{t-1}		0.13 (3.53)**	0.13 (3.66)**	0.13 (3.77)**	0.09 (2.77)**	0.14 (3.62)**	0.11 (3.11)**
π^E_{t+1}							0.55 (3.27)**
SD_Sector			2.49 (1.76)				
IMP_{t-1}	0.02 (1.12)						
IMP_{t-2}	0.06 (2.59)*						
IMP_{t-3}	0.02 (0.60)						
IMP_{t-4}	0.02 (0.81)						
Constant	0.75 (2.20)*	0.79 (2.45)*	0.30 (0.63)	0.72 (2.33)*	0.90 (2.84)**	1.30 (3.55)**	0.10 (0.19)
Observations	116	116	116	116	116	93	93
R-squared	0.84	0.83	0.84	0.85	0.84	0.83	0.85
Absolute value of robust t statistics in parentheses * significant at 5%; ** significant at 1%							

Table B.2: Detailed regression results for Table 5.E and additional results for 1997-2009

	8	9	10	11	12	13	14	15
Estimation period	1989-2009			1997-2009				
Dependent variable (π_t)	**CPI All**	**Goods**	**Services**	**CPI All**	**Core Goods**	**Core**	**Goods**	**Services**
Output gap	**HMT**	**HMT**	**HMT**	**HMT**	**HMT**	**HMT**	**HMT**	**HMT**
π^a_{t-1}	0.31	0.48	0.16	0.47	0.26	0.19	0.62	0.12
	(2.25)*	(2.73)**	(1.19)	(1.05)	(1.03)	(0.51)	(1.63)	(0.30)
π_{t-4}	0.22	0.11	0.33	-0.10	0.34	0.30	-0.11	-0.06
	(1.79)	(0.70)	(3.26)**	(0.45)	(2.80)**	(1.88)	(0.57)	(0.37)
ΔGAP_{t-1}	0.28	0.51	0.26	0.44	-0.80	-0.05	0.48	0.76
	(0.62)	(1.02)	(0.39)	(1.05)	(1.87)	(0.13)	(0.83)	(2.72)**
ΔGAP_{t-2}	0.53	0.31	0.35	-0.28	-1.15	-0.44	-0.82	0.11
	(1.32)	(0.49)	(1.27)	(0.72)	(2.26)*	(1.40)	(1.70)	(0.45)
GAP_{t-5}	0.35	0.25	0.51	-0.27	-0.79	-0.08	-0.76	0.49
	(3.37)**	(2.06)*	(3.93)**	(0.99)	(2.08)*	(0.32)	(1.86)	(2.23)*
IMP^a_{t-1}	0.15	0.17	0.11	0.11	0.12^{++}	0.05	0.15	0.03
	(3.76)**	(3.15)**	(3.05)**	(2.41)*	(2.41)*	(1.30)	(2.20)*	(0.82)
ΔVAT	3.38	3.47	3.47	2.25	3.17	1.40	3.72	0.08
	(5.72)**	(6.19)**	(3.11)**	(2.29)*	(2.17)*	(2.50)*	(2.24)*	(0.16)
DQ1	-1.56	-3.12	0.10	-2.57	-5.23	-2.56	-4.63	-0.14
	(3.19)**	(3.64)**	(0.27)	(3.95)**	(4.49)**	(3.54)**	(4.51)**	(0.41)
DQ2	1.92	1.74	2.13	2.33	-0.47	0.83	1.67	2.88
	(3.81)**	(2.59)*	(3.76)**	(3.01)**	(0.85)	(1.82)	(1.85)	(5.32)**
DQ3	-1.36	-3.38	0.68	-1.42	-4.41	-1.31	-4.28	1.93
	(3.08)**	(4.04)**	(2.01)*	(2.78)**	(4.23)**	(2.75)**	(4.21)**	(3.86)**
Constant	1.31	1.60	1.34	1.63	1.87	1.42	2.17	2.24
	(3.51)**	(3.35)**	(2.79)**	(2.86)**	(2.54)*	(2.40)*	(4.03)**	(1.81)
Observations	83	83	83	51	51	51	51	51
R-squared	0.84	0.79	0.84	0.74	0.92	0.85	0.74	0.73
Absolute value of robust t statistics in parentheses					NB: $^{++}$3lags			
* significant at 5%; ** significant at 1%								

Table B.3: Detailed regression results for Table 5.F and additional results for 1981-2007

	16	17	18
Estimation period	**1981-2007**	**1981-2009**	
Dependent variable (π_t)	**CPI All**	**CPI All**	**CPI All**
Output gap	**HMT**	**HMT**	**HMT**
π^a_{t-1}	0.39 (2.71)**	0.41 (3.33)**	0.47 (3.81)**
π_{t-4}	0.35 (2.36)*	0.29 (2.19)*	0.25 (2.00)*
ΔGAP_{t-1}	0.34 (1.14)	0.07 (0.17)	
ΔGAP_{t-2}	0.36 (1.03)	0.13 (0.38)	
GAP_{t-5}	0.24 (3.89)**	0.17 (1.39)	0.22 (3.88)**
$POS*\Delta GAP_{t-1}$		0.91 (1.53)	0.87 (2.03)*
$POS*\Delta GAP_{t-2}$		0.61 (1.18)	0.69 (1.79)
$POS*GAP_{t-5}$		0.21 (0.82)	
IMP^a_{t-1}	0.12 (3.38)**	0.12 (3.17)**	0.12 (3.54)**
ΔVAT	3.22 (7.40)**	3.28 (7.13)**	3.45 (7.86)**
DQ1	-1.24 (3.42)**	-1.28 (3.58)**	-1.31 (3.83)**
DQ2	1.76 (3.27)**	1.95 (3.67)**	2.06 (4.19)**
DQ3	-1.41 (3.42)**	-1.36 (3.49)**	-1.41 (3.68)**
Constant	0.77 (2.62)*	0.74 (2.36)*	0.81 (2.66)**
Observations	108	116	116
R-squared	0.85	0.84	0.84
Absolute value of robust t statistics in parentheses			
* significant at 5%; ** significant at 1%			

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