

# Trend Growth: Recent Developments and Prospects

April 2002



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# OVERVIEW

## INTRODUCTION

**1.1** The rate of trend (or potential) growth is the rate at which the output of the economy can grow, on a sustained basis, without putting upward or downward pressure on inflation. Many factors influence the observed rate of economic growth. Some, such as changes in confidence, demand conditions in the UK's trading partners, and the stance of monetary and fiscal policy, have temporary effects on economic growth. Other factors such as the growth of productivity and the rate of growth and structure of the population have long-lasting effects. It is the latter that are the focus of this analysis.

**1.2** This paper sets out the Treasury's view on the rate of trend growth over the recent past and presents the latest assessment of the neutral rate to be used for economic forecasts for the Budget 2002 projection period. This view is based upon a rigorous and detailed analysis which incorporates recently updated demographic projections, and for the first time, uses labour-force data from a single source – the Labour Force Survey (LFS). This allows an important improvement to the analysis by distinguishing the contribution to trend growth from average hours worked per person. It updates and extends the analysis set out in previous papers<sup>1</sup>.

**1.3** The analysis concludes that the neutral rate of trend growth over the period covered by the Budget 2002 projection is  $2\frac{3}{4}$  per cent. However, the public finance projections continue to be based on a cautious assumption of a  $\frac{1}{4}$  of a percentage point below the central forecast – that is an annual trend growth rate of  $2\frac{1}{2}$  per cent. As required by the *Code for Fiscal Stability*, the National Audit Office has audited the trend growth assumption for the public finance projections. The Comptroller and Auditor General has concluded that the assumption of  $2\frac{1}{2}$  per cent annual trend growth is 'reasonable and cautious' (NAO, 2002).

### Trend growth and fiscal policy

**1.4** Measures of trend growth play an important role in the conduct of fiscal policy. Accurate estimates of trend growth are necessary to:

- ensure that the public finances are placed on a sound and sustainable footing by taking account of the temporary impact of the economic cycle and by providing a robust assessment of the structural prospects for the public finances in the medium term; and
- provide an estimate of the spare capacity in the economy so that fiscal policy can play a role in supporting monetary policy over the economic cycle.

**1.5** In the past, optimistic expectations about the potential or trend growth of the economy have led to inappropriate policy decisions and added to macroeconomic instability. In order to take account of this forecast risk the Government deliberately uses a cautious assumption for trend growth for the public finance projections that is  $\frac{1}{4}$  of a percentage point lower than its neutral view. It is therefore important that the Government regularly reviews its central or neutral estimate of trend growth so that an appropriate degree of caution can be built into public finance projections.

<sup>1</sup> 'Fiscal Policy: Public Finances and the Cycle', HM Treasury, March 1999 and 'Trend growth: Prospects and Implications for Policy' HM Treasury, November 1999.

## METHODOLOGY

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**1.6** The neutral view of the prospects for trend growth is built up from judgements about when the economy was on-trend and from the analysis of what is driving the components of trend growth. The four components are:

- **labour productivity** is projected in line with the evidence of recent years. This implies trend productivity growth of 2.0 per cent;
- **average hours** worked are assumed to decline slightly, by 0.1 per cent a year, in line with the trend over the 1986 to 1997 cycle;
- **the trend employment rate** is projected to grow by 0.2 per cent a year (less than has been experienced in recent years) through a combination of a decline in the inactivity rate and modest further falls in the (Non-Accelerating Inflation Rate of Unemployment) NAIRU; and
- **the population of working age** projections are based on the Government Actuaries Department (GAD, 2001) assumptions. For the neutral case it is assumed that net migration will be similar to that of the last three years (equivalent to an average of GAD's principal and high migration projections). This implies a contribution to the trend rate of growth of 0.6 per cent a year over the Budget projection period, slightly less than over recent years.

**1.7** The projections for the components imply trend output growth of  $2\frac{3}{4}$  per cent over the Budget period. This underpins the mid-points of the Budget 2002 forecast ranges for the economy.

**1.8** The projections maintain the practice of not assuming a pick-up in productivity growth before it has happened, by basing the projection on past performance. Given that numerous Government policies are directed to achieving an increase in the rate of productivity growth, and the probability of Information Communication Technology (ICT) related gains there is good reason to expect a more favourable productivity outturn than that projected.

## COMPARISON WITH OTHER PROJECTIONS

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**1.9** In Section 4 of the paper the methodology and projections of the Treasury are assessed against external projections of trend growth in the UK. The main findings are:

- all the external estimates for UK trend growth going forward are in the range 2.5-2.8 per cent (see Table 1.1). Hence, they are close to the Treasury's view that trend growth will be  $2\frac{3}{4}$ ;
- alternative methods using statistical filters, such as the Hodrick-Prescott (H-P) filter, are unable to provide more than a rough guide for estimates of trend growth. The range of estimates produced by the H-P filter on reasonable assumptions is consistent with the Treasury's estimate of trend growth between 1997H1 and 2001Q3 of just over 2.6 per cent, and matches the European Commission's estimate using this method;

- most international organisations, such as the International Monetary Fund (IMF), Organisation for Economic Cooperation and Development (OECD) and the European Commission (EC), use a production function approach to estimate trend growth. Although firmly based in economic theory, this technique has the major drawback that most of critical data required are not available and have to be estimated. The IMF's estimate of trend growth is slightly above the Treasury's while the OECD's is slightly lower, due to different assumptions about potential employment (see Table 1.1). The EC's estimate for the recent past using a production function, at 2.7 per cent, is slightly higher than the Treasury's estimate over an equivalent period;

**Table 1.1: Estimates of trend growth for the UK (per cent, per annum)**

Organisation	Trend estimate/assumption
HM Treasury	2 <sup>3</sup> / <sub>4</sub>
IMF	2.8
OECD	2.5
EC <sup>a</sup>	2.7
EC <sup>b</sup>	2.6
NIESR	2.6
Oxford Economic Forecasting	2.5
Goldman Sachs	2.5

Notes:

HM Treasury for Budget 2002 projection period

IMF for the period 2001-2005

OECD for the period 2003-2006

EC<sup>a</sup> estimated from a production function for the period 1996-2000

EC<sup>b</sup> estimated from a H-P filter for the period 1996-2000

NIESR for the period 2003-2010

Oxford Economic Forecasting for the period 2000-2009

Goldman Sachs for the period 1998-

Sources: as for Table 4.1

- the main difference between the external estimates and that of the Treasury is that many of the external estimates imply relatively low rates of growth of potential employment. In part, this is because they assume growth of the working age population below that of the GAD projections published at the end of last year. On the other hand, most estimates that use production functions imply rather faster growth of labour productivity. This may reflect the production function approach automatically building in the implications of higher investment when projecting forward, whereas the Treasury approach simply projects labour productivity growth in line with recent trends.

## TREND GROWTH AND THE PUBLIC FINANCES

**1.10** The Budget 2002 public finance projections continue to be based on a deliberately cautious assumption for annual trend output growth that is  $\frac{1}{4}$  of a percentage point lower than the Government's neutral view, i.e. 2 $\frac{1}{2}$  per cent. Increasing the trend growth assumption for the fiscal policy projections in step with the increase in the Government's neutral view maintains the same  $\frac{1}{4}$  of a percentage point margin degree of caution as in previous projections, while also ensuring that the public finances remain reasonable and not excessively cautious, thus improving medium term planning of public spending.

## CONCLUSION

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**I.II** The conclusion of the paper is that recent evidence allows a reasonable judgement that a neutral estimate of trend output growth over the Budget period is  $2\frac{3}{4}$  per cent. This is also within the range of external estimates. Nevertheless, in order to maintain an adequate degree of caution in the public finance estimates, these will be based, as before, on a rate  $\frac{1}{4}$  of a percentage point below the neutral case, that is  $2\frac{1}{2}$  per cent.

## THE METHODOLOGY

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**2.1** The Treasury's methodology for estimating trend growth was set out in detail in 'Trend growth: Prospects and Implications for Policy'<sup>1</sup>. Output is measured excluding oil and gas<sup>2</sup> since, while the oil and gas sector significantly affects output, it has little impact on the sustainable level of employment, and so non-North Sea output is largely unaffected by North Sea output. Over past cycles, trend output growth is the annual average growth rate between points when the economy is judged to have been on-trend.

**2.2** On-trend points represent the dates where actual output is believed to have been at the trend level implying no change in the degree of inflationary pressure in the economy. On-trend points are estimated using a wide range of survey and other information<sup>3</sup>.

**2.3** Once the on-trend points are identified, the approach decomposes the change in trend output over the period resulting from changes in:

- trend labour productivity measured as output per hour worked<sup>4</sup>;
- trend average hours worked per person;
- the trend proportion of the working age population in employment (employment rate); and
- the working age population<sup>5</sup>.

**2.4** The main purpose of the decomposition is to make forward projections. Of course, many factors influence the trend rate of economic growth but arithmetically they can all be attributed to these four elements. For example, the impact of higher investment is likely primarily to affect labour productivity.

**2.5** Going forward, the projection for trend growth from the last on-trend point is built up from the projections of the components. As a general principle, trend productivity growth is projected in line with recent experience. This means the projections do not rely on any improvement in underlying productivity growth. In this sense the neutral estimate of trend growth is subject to upside risk.

## DATING 2001Q3 AS AN ON-TREND POINT

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**2.6** The economy was judged to be on-trend, on average, in the first half of 1997 (the average of the first and second quarters) and in mid-1999. The previous cycle was judged to have run from 1986Q2 up to the first half of 1997.

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<sup>1</sup> HM Treasury, November 1999.

<sup>2</sup> Gross Value Added in 1995 prices excluding oil and gas.

<sup>3</sup> Described in more detail in 'Fiscal Policy: Public Finances and the Cycle', HM Treasury, March 1999.

<sup>4</sup> Labour productivity can be further decomposed in to contributions from capital per worker and a residual termed total factor productivity. This is explained in detail in paragraph C.5 of Annex C.

<sup>5</sup> The combined contribution to trend growth of average hours, the employment rate and the population of working age can be described as the contribution from the growth in trend employment, as contrasted with the contribution from trend labour productivity.

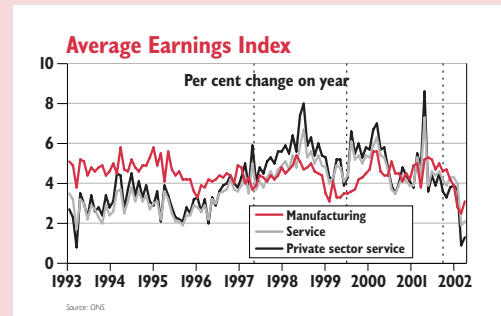
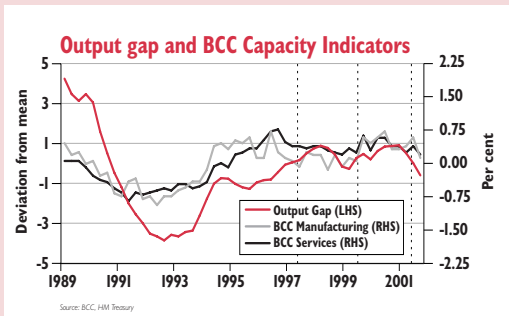
**2.7** The shortness of the 1997H1 to mid-1999 'cycle' (just 9 quarters) makes the corresponding estimated trend rate of growth, and the contributions of components, sensitive to revisions. A longer period would make the estimated trend rate of growth of the economy between the on-trend points more robust. Helpfully, it seems likely that the economy was on, or very near, trend in 2001Q3, completing a half-cycle begun in mid-1999. Taking 2001Q3 as an on-trend point allows us to use a longer period - 1997H1 to 2001Q3 - and to incorporate the latest information into the projections. Although there is a trade-off between reducing the sensitivity to revisions (by taking the longer period to 2001Q3) and being more certain about the on-trend points, on balance using the longer period is favoured here.

**2.8** In line with past practice the assessment of whether 2001Q3 was an on-trend point is based on a broad assessment of the available information, summarised in Box 2.1.

### Box 2.1: Summary of the evidence that 2001Q3 is an on-trend point

The charts below show how the output gap evolves on the assumption that 2001Q3 is an on-trend point. A wide range of evidence is used to verify this assessment. The data include surveys of capacity utilisation produced by the Confederation of British Industry (CBI) and British Chambers of Commerce (BCC).

Most of these indicate an on-trend point in the second half of 2001, but cannot clearly distinguish between Q3 and Q4. Moreover in recent years these surveys have tended to have a lower correlation with the output gap. The BCC capacity utilisation indicators for the manufacturing and service sectors remain above their long-run levels<sup>6</sup> but the services indicator is close to the levels observed at the on-trend points in mid-1999 and in 1997H1. The BCC indicators of difficulties in recruiting to manufacturing and services are also around the levels at the previous two on-trend points.



One of the clearest indicators in favour of Q3 is the growth in average earnings which fell to almost unprecedented levels (below 3 per cent overall) at the end of 2001, indicating that the economy was below trend at this point. This pattern is even more pronounced for private sector earnings in services, where the rate of growth fell to around 1 per cent. Another good indicator of the cyclical position of the economy is unit wage cost data. The most recent data suggests that 2001Q3 is comparable with previous on-trend points. Finally it should be remembered that since earnings data are based on annual increases and not current settlements, any turning points will tend to be lagged, thus adding further weight to the argument in favour of Q3.

<sup>6</sup> The long-run levels of the BCC indicators are not well-defined as the back-run of data is relatively short.

## DECOMPOSITION OF TREND GROWTH

**2.9** The trend growth decomposition is based on the following identity<sup>7</sup>:

$$\text{Output} = \text{Output per hour} \times \text{Average hours worked} \times \text{Employment rate} \times \text{Population}$$

Applying this decomposition to the data focusing on the contributions of the components to growth between on-trend points yields the results in Table 2.1.

**Table 2.1: Hours based decomposition of trend growth<sup>1</sup> (per cent)**

	Trend output per hour		Trend average	Trend employment	Population of working	Trend Output <sup>4</sup>
	Underlying <sup>2</sup>	Actual	hours <sup>3</sup>	rate <sup>3</sup>	age	
	(1)	(2)	(3)	(4)	(5)	(6)
<b>Over full economic cycles</b>						
1986Q2 to 1997H1	2.06	1.84	-0.14	0.45	0.35	2.51
1997H1 to mid-1999	1.91	1.55	-0.28	0.72	0.63	2.64
<b>Over the recent past</b>						
1997H1 to 2001Q3	2.14	1.96	-0.37	0.36	0.66	2.63

<sup>1</sup> Data definitions and sources are set out in Annex A

<sup>2</sup> The underlying productivity rate is the actual productivity rate adjusted for changes in the employment rate, ie assuming the employment rate had remained constant. Column (1) = column (2) + (1-a) × column (4), where a is the ratio of new to average worker productivity levels. The value of a is set at 50 per cent, consistent with econometric evidence and data on relative entry wages.

<sup>3</sup> Lags between output and employment and between output and hours worked are allowed for. Employment is assumed to lag output by around three quarters (so on trend points for employment come three quarters after on-trend points for output). This assumption is supported by econometric evidence. Hours are easier to adjust and so the decomposition assumes that hours lag output by just one quarter.

<sup>4</sup> From columns (2), (3), (4) and (5). Figures independently rounded.

**2.10** Over the cycle and a half, 1997H1 to 2001Q3, the key points are:

- the estimated underlying rate of trend labour productivity growth (output per hour) was 2.1 per cent. This is slightly above the trend over the 1986Q2 to 1997H1 cycle;
- average hours worked fell by 0.37 per cent a year, much faster than in the earlier cycle;
- the contribution of employment growth was 0.36 per cent; and
- the contribution of working age population growth over recent years was 0.66 per cent on the basis of latest LFS and GAD estimates, though these will be subject to revisions following release of Census 2001 data in August 2002.

**2.11** These components sum to the estimated trend growth rate of just over 2.6 per cent for 1997H1 to 2001Q3.

<sup>7</sup> Full details of data sources and the precise definitions of concepts used are set out in Annex A.

## CONCLUSION

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**2.12** The Treasury's approach to estimating trend growth decomposes the change in trend output, as defined by on-trend points of the economic cycle, into its underlying determinants. The main purpose of this decomposition is to enable forward projections of the determinants and thus trend growth. On-trend points are assessed by a range of indicators, including survey evidence on capacity utilisation, and 2001Q3 is viewed as an on-trend point. Over the cycle and a half 1997H1 to 2001Q3, the trend growth of output has been just over 2.6 per cent.

### PROJECTING THE COMPONENTS OF FUTURE GROWTH

**3.1** Having identified recent trends in the key components that determine trend growth, it is necessary to examine how these will change over the next few years. This section looks at the future prospects for trend growth. This involves looking in turn at the following components:

- growth in labour productivity (on an hours basis);
- growth in average hours worked;
- growth in the employment rate; and
- growth in the population of working age.

**3.2** The section concludes with the Treasury's assessment of future trend growth based on the analysis of the trends in these components.

### GROWTH IN LABOUR PRODUCTIVITY

**3.3** The neutral estimate of the contribution of labour productivity growth to trend growth is based on an assessment of past trends (See Table 3.1). The Treasury's practice is that any increase in the productivity assumption has to be based on clear evidence of what has happened, rather than just an expectation of what might happen.

**Table 3.1: Trend labour productivity growth (per cent per annum)**

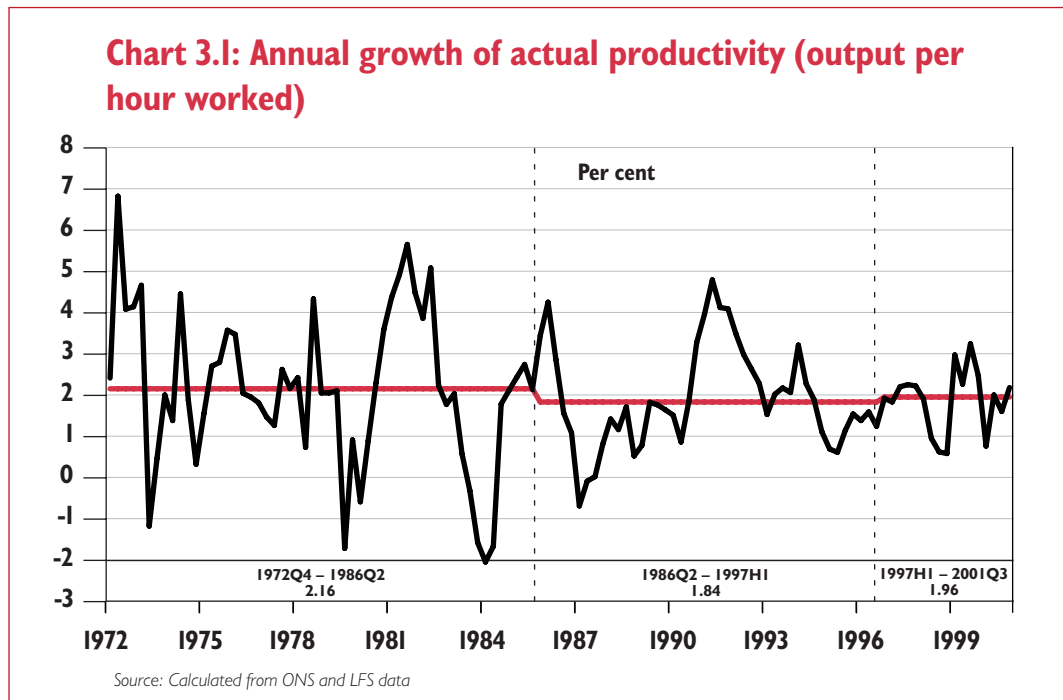
	Trend productivity growth (output per hour)	
	Underlying <sup>1</sup>	Actual
1986Q2 to 1997H1	2.06	1.84
1997H1 to mid-1999	1.91	1.55
mid-1999 to 2001Q3	2.39	2.40
1997H1 to 2001Q3	2.14	1.96

<sup>1</sup> The productivity rate that would have occurred if the employment rate had been constant. See notes to Table 2.1

Source: As for Table 2.1

**Output per hour** **3.4** Table 3.1 shows the growth of output per hour over recent cycles, and between the 1997H1 and 2001Q3 on-trend points. In this latest period actual trend growth in output per hour worked was just under 2 per cent. However, new employees tend to have lower than average productivity growth (related to 'learning effects' and the fact that marginal unskilled workers tend to have relatively low productivity), so when the employment rate is increasing this will tend to depress productivity growth. Making some allowance for this implies somewhat higher underlying productivity growth<sup>1</sup>, of around 2.1 per cent per year, reflecting the significant increase in the employment rate over this period.

<sup>1</sup> The underlying productivity rate is defined as the productivity rate that would occur if the employment rate had been held constant. See footnote 2 of Table 2.1 for further details.



**3.5** Going forward, the projections take the estimate of underlying productivity growth over the recent past and then adjust for the projected change in the employment rate to project actual productivity growth which is used to estimate trend growth. With the trend growth in the employment rate projected to be 0.2 per cent (See Paragraphs 3.27 onwards), this is expected to reduce actual productivity slightly relative to an underlying rate of 2.1 per cent. It is therefore assumed that actual trend productivity growth is 2.0 per cent.

**Sources of higher productivity**

**3.6** It is important to note that the productivity projections used in the calculations of trend growth assume that trend productivity itself is not affected by government policies whose impact is yet to be seen in the data. However, there are good reasons to anticipate some increase in trend productivity growth relative to the past:

- macroeconomic stability and investment;
- the Government's productivity agenda;
- the 'new economy'; and
- government policies to raise public sector productivity.

**Macroeconomic stability and investment**

**3.7** The new macroeconomic framework has resulted in a less volatile macroeconomic environment which is more conducive to investment and long-term planning in the economy<sup>2</sup>. In constant prices, annual business investment rose by 52 per cent from 1995 to 2000, reaching a record share of GDP in 2000 (14.2 per cent). While business investment growth has fallen back subsequently (as was anticipated), levels of investment remain high. The higher level of firms' investment spending might be expected to boost productivity going forward. But the extent of this is very uncertain, for instance investment in some areas, like Information Communications and Technology (ICT), might have rather short asset lives.

<sup>2</sup>The features of the UK's macroeconomic framework are set out in 'Reforming Britain's Economic and Financial Policy', HM Treasury (2002).

**The productivity agenda** 3.8 The Government's microeconomic reform agenda has at its centre the aim of overcoming market failures to improve the environment in which firms operate (see Box 3.1). The removal of these market failures should lead to an increase in productivity and help close the productivity gap with other countries. This productivity gap remains substantial implying plenty of scope for the UK to catch up<sup>3</sup>.

**Box 3.1: Government policies to raise the productivity growth rate**

The Government set out its comprehensive strategy for meeting the productivity challenge in "Productivity in the UK: The Evidence and the Government's Approach", which was published alongside the November 2000 Pre-Budget Report.

The Government's approach to improving the UK's long-term productivity performance rests on delivering macroeconomic stability and implementing microeconomic reforms to remove the barriers which prevent markets from functioning efficiently. These microeconomic reforms address historic weaknesses in five areas that affect the rate of productivity growth:

- strengthening competition to encourage firms to innovate, reduce costs and provide better quality goods and services to the consumer;
- promoting enterprise and innovation to unlock the potential of new technologies and working practices, supporting entrepreneurship, risk-taking and management in all communities across the country;
- improving the skills base to maximise the contribution of human capital to growth;
- encouraging investment to improve the UK's stock of physical capital in every sector and industry; and
- working directly to improve public services productivity.

**New economy** 3.9 In the US, rapid growth in ICT investment has been followed by a rise in productivity growth (see Box 3.2). In the UK, ICT investment accounted for over 15 per cent of total investment in 1999. While a similar pick-up in productivity as in the US might be expected, it has not been seen in the data so far.

<sup>3</sup>In 2000 GDP per hour worked in the USA was around 26 per cent higher than in the UK, in France around 23 per cent higher than in the UK, and in Germany around 22 per cent higher. Also in 2000, output per head was 38 per cent higher in the US compared to the UK, in France it was 18 per cent higher than in the UK, and in Germany 9 per cent higher than in the UK.

**Box 3.2: The new economy and productivity growth in the US**

In the late 1990s, the US saw a strong increase in the rate of trend productivity growth. US productivity growth averaged 2½ per cent per annum between 1996 and 2000, almost a percentage point higher than the average over the previous 25 years. Many attributed this to the increasing importance of ICT in the US economy with both production of high technology products, and their use in the wider economy.

Sentiment regarding the ‘new economy’ softened somewhat in 2001, as the US entered a downturn. In particular, concerns were raised that a US recession would unravel some of the gains in underlying productivity growth in the late 1990s and 2000. However, these fears seem to have been misplaced. Despite US GDP growth in 2001 slowing to a little over 1 per cent, productivity has still expanded by almost 2 per cent - with quarter on quarter annualised productivity growth of 5¼ per cent in the final quarter.

In the UK there are, thus far, no significant signs of a new economy driven pick-up in underlying productivity growth. Nevertheless ICT has become an increasingly important feature of the UK economy. For example, Kneller and Young (2001) find that the stock of computing equipment in the UK has grown at a similar rate to that seen in the US. The UK also generally fares well in international comparisons of ICT usage and production.

IMF (2001b) analysis suggests that UK productivity has indeed benefited from higher ICT *capital deepening*<sup>4</sup>, as well as higher *total factor productivity* (TFP) growth in the ICT producing industries. So far the UK has not replicated the US performance in terms of improvements to TFP outside of the high tech sector.

The US experience still offers hope that the UK will see greater productivity gains from ICT in the future. However, this will depend on firms continuing to invest substantially in ICT, given most high tech assets are subject to fast rates of depreciation and obsolescence.

**3.10** The Government’s policies to raise **public sector productivity** suggest another reason why productivity might turn out higher than expected (see Box 3.3). As well as being a substantial part of the economy in its own right, productivity within the public sector has a significant impact on productivity across the economy as a whole. However, some improvements in public sector productivity are unlikely to show up in official measures of whole economy productivity.

**Box 3.3: Public sector productivity**

The Government’s approach to increasing public sector productivity has three key strands:

- allocating resources effectively through improvements in the Government’s public spending framework;
- making the most of resources through Public Service Agreement (PSA) targets, improved lines of accountability and better use of incentives; and
- enhancing performance over time through the Civil Service reform programme, Departmental Investment Strategies to deliver improvements in the capital stock, the development of electronic delivery of public services, and steps to grant new freedoms and flexibilities to local public service managers.

<sup>4</sup>In addition Oulton estimates that some 56 per cent of capital deepening since 1989 has been accounted for by ICT – rising to 88 per cent if one isolates the more recent period from 1994 to 1998. Oulton 2001a.

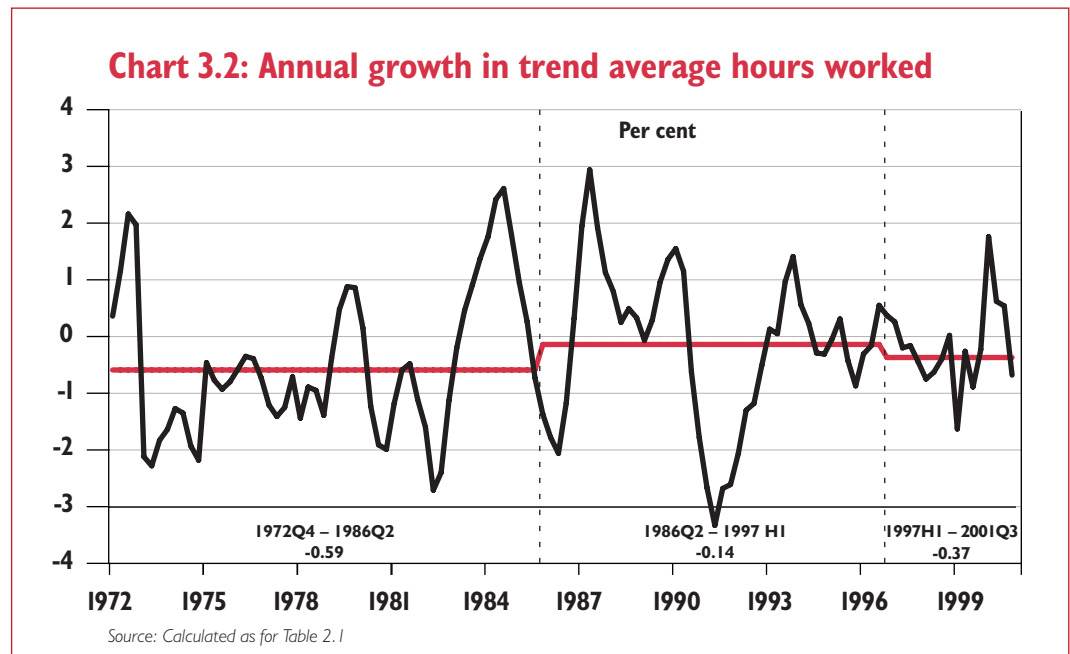
**3.11** Finally, the growth of public sector employment could have a negative impact on measured productivity growth since the level of labour productivity in the public sector is typically lower than in the private sector. So an increase in the share of public sector employment will tend to depress measured labour productivity growth. Again, this is probably partly a measurement issue as increases in public sector productivity are not necessarily reflected in measured output.

**Upside risks to productivity growth**

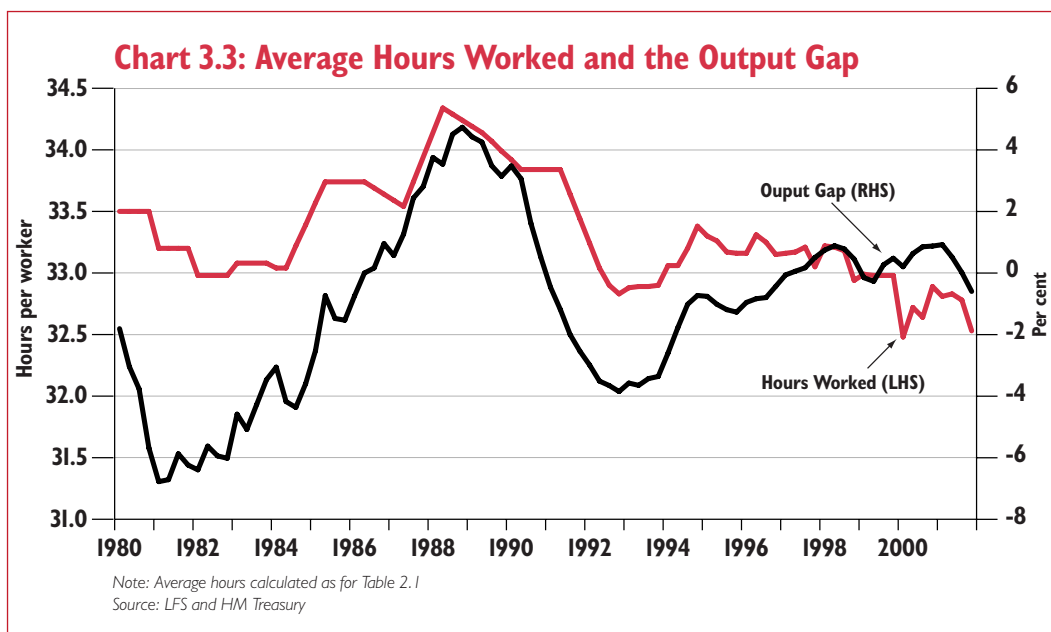
**3.12** The balance of risks on the productivity assumption is on the up side. However, in the interests of prudence there is no intention to change from the principle of assessing productivity trends over the past and projecting them forward without any allowance for possible productivity improvements. To do so would risk over-estimating productivity improvements as a result of new policies, a trap that has caught policy-makers in the past. Therefore, the projections assume underlying productivity of 2.1 per cent. With growth in the employment rate of 0.2 per cent, this implies actual trend productivity growth of 2 per cent.

### GROWTH IN AVERAGE HOURS WORKED

**3.13** This paper extends earlier Treasury analysis by distinguishing the contribution to trend growth arising from variations in hours worked. Average hours worked declined from the mid-1960s to 1982, and much of the fall through the 1960s and 1970s was probably associated with national collective agreements involving a move from a standard 48 to 40 hour week. Between the early 1980s and the mid-1990s the trend appears to have been broadly flat, with pro-cyclical variations around a level of about 33<sup>1</sup>/<sub>4</sub> hours a week. But the second half of the 1990s has shown a break with this pattern (see Chart 3.3). Average hours tended to decline despite the economy moving from below to above trend. This downward movement started from 1995, but signs of a somewhat sharper decline emerged from 1997. By 2000Q1 average weekly hours worked had fallen to about 32<sup>1</sup>/<sub>2</sub>, though since then they have fallen no further.



**3.14** Over the 1986Q2 to 1997H1 economic cycle, the rate of decline in average hours worked is estimated at just over 0.1 per cent a year. But between 1997H1 and 2001Q3 (both dates when the economy is judged to have been operating at its trend level) the estimated rate of decline is just under 0.4 per cent a year.



**3.15** It is not possible to explain fully why the number of hours worked declined from the mid-1990s, when the economy was close to trend. But it is likely that a number of one-off factors have accounted for a significant part of the decline.

**3.16** The decline is not a simple story of a shift in favour of part-time employment acting to drag the average hours worked down: indeed the share of part-time employment in total employment has been very stable since 1996 (See Table 3.2). Moreover, average hours worked by employees working part-time have risen, and the fall in overall average hours worked has been driven by a fall in full-time average hours (See Table 3.3).

**Table 3.2: Part-time employment (per cent of all employment, annual average)**

1995	1996	1997	1998	1999	2000	2001
24.4	24.9	24.8	24.7	24.8	25.0	24.9

Note: Classification of part time work is on the basis of individual responses to the LFS and so may differ slightly from classification by hours shown in Table 3.3  
Source: LFS

**Table 3.3: Distribution of employment by usual weekly hours of work (per cent of total employment)**

	≤30 hours	31-45 hours	≥45 hours	All
1995	24.4	49.7	25.9	100
1997	24.9	48.8	26.3	100
2001	25.1	50.8	24.1	100

Source: LFS

**3.17** There are a number of reasons why average hours worked may have fallen for various groups in recent years, including increased self employment, rising number of students, and reforms to the tax and benefit system. All these are discussed in more detail below.

**Self-employment 3.18** The self-employed tend to work above-average hours, LFS data indicate they worked over 5 hours more than average over 1999-2001. The number of self-employed has also fallen since 1997 (See Table 3.4) and the share in total employment fell by 1¼ percentage points between spring 1997 and spring 2000 but the share has stabilised since then.

**Table 3.4: Self-employment (per cent of all employment, spring quarters except 2001Q4)**

1995	1996	1997	1998	1999	2000	2001	2001Q4
12.9	12.5	12.5	12.1	11.7	11.3	11.3	11.3

Source: LFS

**3.19** Between 1997 and 2000 the share of self-employment in total construction industry employment fell from 44 per cent to 31 per cent, and this accounted for about half of the overall fall in self-employment. Notably the share of self-employment in both construction and total employment has stabilised since spring 2000 and since then average hours worked have been broadly stable.

**Students 3.20** Students tend to work relatively short hours and the rising share of 16-24 year-old students in total working age employment has contributed to the overall fall in average hours worked. This share increased by almost 1 percentage point between 1995 and 1998 and then stabilised (See Table 3.5). However, as already noted the average hours of part-timers as a whole rose, indicating that the effect of students was outweighed by increasing hours of non-students in part-time employment.

**Table 3.5: 16-24 year-old students<sup>1</sup> in employment a (per cent of total working age employment, annual averages)**

1995	1996	1997	1998	1999	2000	2001
2.7	3.0	3.4	3.5	3.5	3.5	3.5

<sup>1</sup> Those in full time education

Source: LFS

**Tax and benefit system 3.21** Tax and benefit reforms may have encouraged lower income earners to reduce their hours because they had to work fewer hours to maintain their living standards. Reform of employers' NICs may also have increased the incentive to employ two instead of one person for given hours.

**3.22** The Working Time Directive introduced in April 1999 will have tended to reduce average hours at the upper end of the hours distribution, though this was also happening before 1999 and it is unclear how far this has had just a reporting effect.

**3.23** Growth in services relative to the manufacturing and agricultural sectors will have tended to reduce average hours, though the decline in employment in these sectors is by no means a new development.

**Average hours in the future 3.24** Going forward, some of the factors identified which have tended to reduce average hours worked in the late 1990s are likely to have run their course. In particular, the reduction in construction industry self-employment appears to have come to an end, and the share of self-employment has stabilised since spring 2000. Moreover the effects of exceptionally strong employment growth and certain specific policy changes (such as the working time directive) are probably mainly through, and growth in the share of students in total employment has fallen back since 1999. In any case, it appears that average hours worked were no lower at the end of 2001 than in 2000Q1. Survey indicators of firms' demand for labour fell back in the second half of 2001 but, consistent with expectations that the slowdown in activity would be short-lived, LFS measures showed that firms responded mainly by reducing average hours per worker: total employment hardly fell, and then only over the summer. This suggests there may be an increase in average hours this year.

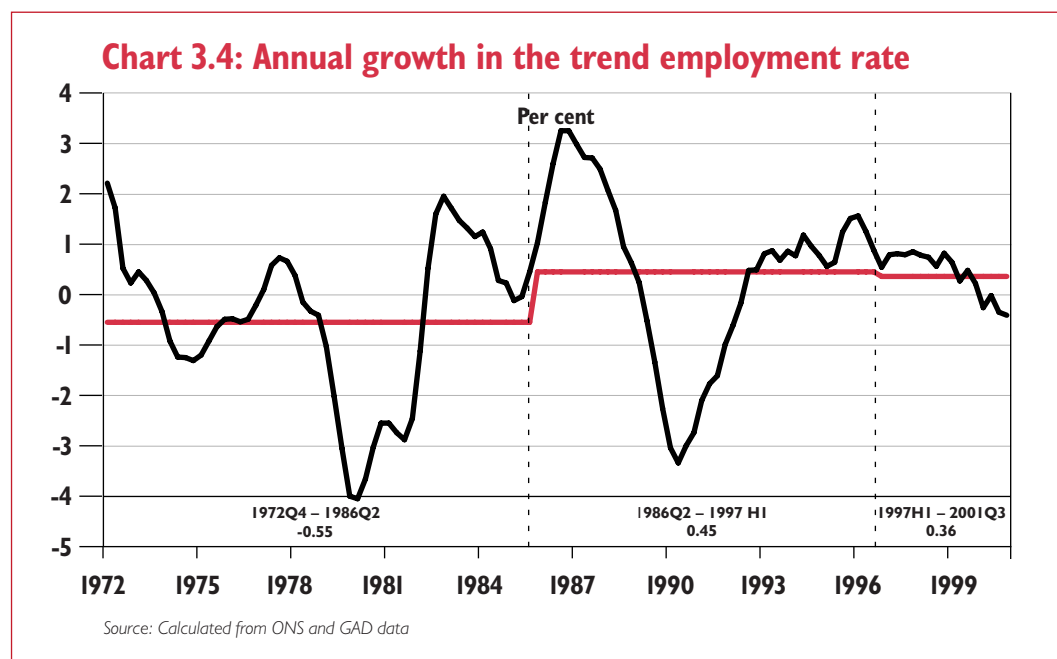
**3.25** Over the medium term, with only a modest further increase in the employment rate assumed (See Paragraphs 3.27 onwards), the assumptions imply a reversal to a broadly flat long-term trend in average hours worked. There is a case for assuming that average hours might increase from recent levels of just over 32½ hours a week. On this basis, a trend increase in average hours worked of 0.1 per cent a year over the next five years (implying a cumulative rise of less than 0.2 hours a week) could be justified. But this has to be set against the estimated weak downward trend of 0.1 per cent over the 1986 to 1997 cycle.

**Projected small decline in hours**

**3.26** Although a case can be made for assuming that average hours will be flat or even rising, the neutral projection for trend average hours implies they decline by 0.1 per cent a year from 2001Q3, in line with the trend over the 1986 to 1997 cycle.

## GROWTH IN THE EMPLOYMENT RATE

**3.27** Trends in the employment rate - the proportion of the population of working age in employment - need to be taken into account alongside the size of the working population and average hours in considering the total contribution to growth from labour. Clearly in the long run, the employment rate<sup>5</sup> will affect the level of output but not its growth rate. However, when the employment rate is changing it can contribute to the growth rate. Changes in the trend employment rate can be divided between those arising from a change in inactivity rates (or equivalently activity rates) and those arising from a change in the rate of unemployment that is consistent with stable inflation (the NAIRU).

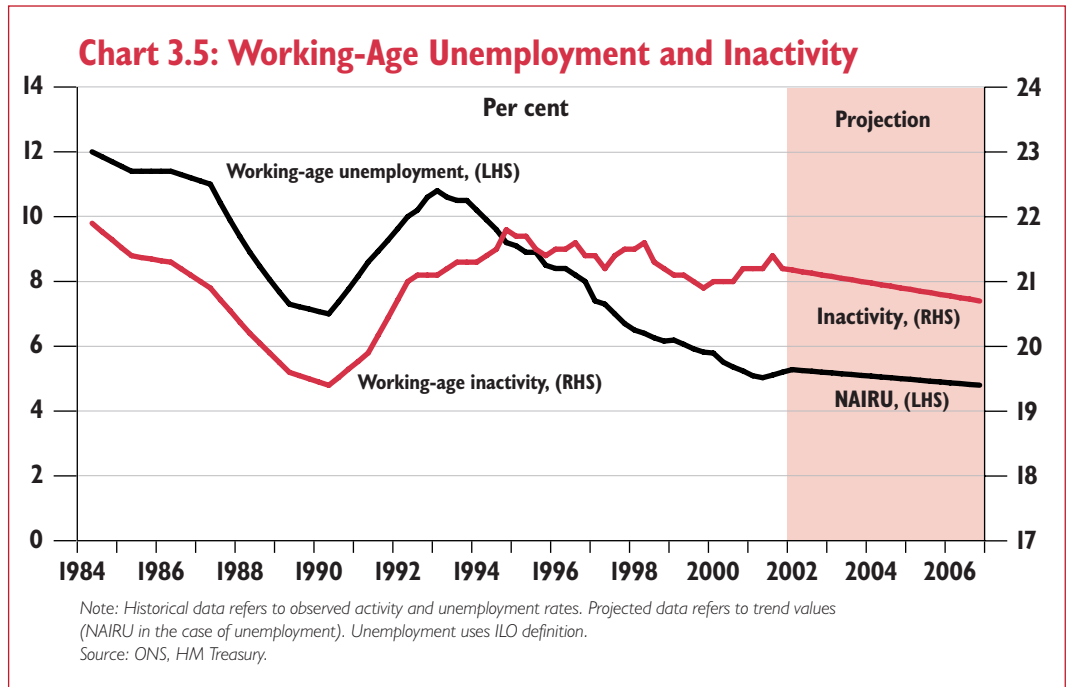


**Activity rates**

**3.28** The proportion of the working population that is inactive includes those who have left the labour market due to early retirement, or for long-term health reasons, those who are in full-time education (and not working) as well as those who simply choose not to work. The degree of attachment of inactive people to the labour market varies depending on the reason for their inactivity. Undoubtedly, many inactive people on benefits would like to work.

<sup>5</sup> The same of course applies for average hours worked.

**3.29** During the boom in the late 1980s inactivity rates tracked the proportion of the working age population who were unemployed by falling slightly, to just below 20 per cent. Initially, as the proportion of unemployed rose in the early 1990s, so did the inactivity rate. But, more recently during the long economic upturn there has been a much larger fall in the unemployment rate than the inactivity rate (See Chart 3.5). By 2001 unemployment as a proportion of the working age population had fallen to a low of 5.0 per cent, while inactivity was still a little over 22 per cent, little changed since 1993. In 2001, the number of inactive people of working age was around five times the number of unemployed people. Consequently, the potential contribution to the employment rate, from inactive people taking up employment, is high<sup>6</sup>.



**3.30** Activity rates for nearly all age and gender cohorts are both highly trended and cyclical. The Treasury's projections for the working age activity rate identify the trends in labour market activity rates for different age and gender cohorts and project them forward taking account of changes in the composition of the working age population - described in more detail in Annex B. The results show that while demographic trends are expected to depress the aggregate activity rate, as a result of changes in the structure of the working population structure towards cohorts with lower activity rates, these effects are small and are likely to be outweighed by the trend effects within cohorts. Overall, the projections imply an estimated trend increase in the working age activity rate of 0.1 percentage point a year (implying a trend reduction in inactivity of the same amount). Clearly, with reference to the historical evidence, an annual reduction of this order over the next five years would still leave the inactivity rate above the low-point of 1990 by some margin.

**NAIRU 3.31** Variations in the NAIRU need to be allowed for because they affect the level of the employment rate that is sustainable without changing the degree of inflationary pressure in the economy. For example, a decline in the NAIRU would imply the actual level of unemployment could fall by the same amount as the fall in the NAIRU. Hence the employment rate could rise by an equivalent amount without increasing inflation.

<sup>6</sup> See "The changing welfare state: employment opportunity for all", HM Treasury and Department for Work and Pensions, 2001 for details of the Government's policy to help the inactive into work.

**3.32** The Treasury estimates that the NAIRU is currently close to 5<sup>1</sup>/<sub>4</sub> per cent<sup>7</sup>. The projection for the NAIRU is for a decline of 0.05 percentage points per annum. This would imply only a very modest further reduction in the NAIRU over the next five years and certainly a lot less than has been seen in the recent past. Over the 1997-1999 cycle it is estimated that the NAIRU fell by something around 0.7 percentage points, implying a contribution to trend growth of over 0.35 per cent a year and accounting for about half the increase in the employment rate over this period.

**3.33** The projections for the inactivity rate and the NAIRU imply a trend increase in the employment rate of 0.2 per cent a year - rather less than what has been experienced from 1997H1 to 2001Q3 (See Table 3.6). One reason for this is that the projections do not include an explicit assessment of the impact of Government labour market policies although these policies will have helped account for some of the rise in employment rates in the recent past. Government policies to help the unemployed back to work, encourage those detached from the labour market back in to it, and increase the skills of the lowest skilled workers could boost the employment rate further. But the size of such effects are difficult to judge (See Box 3.4).

**Table 3.6: Trend growth in the employment rate (per cent)**

Economic cycle	Growth in employment rate
1986Q2 to 1997H1	0.45
1997H1 to mid-1999	0.72
1997H1 to 2001Q3	0.36

Source: HM Treasury

<sup>7</sup>These estimates are obtained by working back from the on-trend points, and allowing for lags between output and employment. Owing to the lags between output and employment there is not yet the data to do the same calculation for 1997H1-2001Q3. However, the decline in unemployment and apparent closeness of the economy to trend since 1999 suggest further declines of the NAIRU of the order of 0.2 percentage points annually. The forecast of a decline of only 0.05 percentage points over the next five years is therefore very conservative.

**Box 3.4: The Government's policies to raise the employment rate**

Since 1997, the Government has introduced a large number of reforms to tackle worklessness and improve the functioning of the labour market. The Government's long-term employment goal is that, by the end of the decade, there will be a higher proportion of people in work than ever before.

Macroeconomic stability is a prerequisite for achieving this aim. But stability alone is not enough, it must be supported by flexible working practices and by responsive employment policies to ensure that the labour market is able to adapt without generating higher structural unemployment.

To advance its long-term goal the Government is implementing a broad-based microeconomic strategy<sup>8</sup>. The main elements are:

- **Welfare to Work policies** that help unemployed people search and compete effectively for jobs, and help re-attach the long-term unemployed and economically inactive to the labour market;
- **reforms to the tax and benefit system to make work pay**, by tackling unemployment and poverty traps. These include the introduction of the Working Families' Tax Credit (WFTC), reforms to national insurance contributions (NICS) and income tax. In the next stage of the reform the Government will introduce a new Working Tax Credit; and
- **help with the return to work**, by removing barriers to work and ensuring that people are financially secure when moving from welfare to work.

**3.34** Overall, the projections imply a trend increase in the employment rate of 0.2 per cent per annum, coming from a combination of lower inactivity rates (as trend activity rates within age cohorts are projected to continue to increase), and further modest falls in the NAIRU.

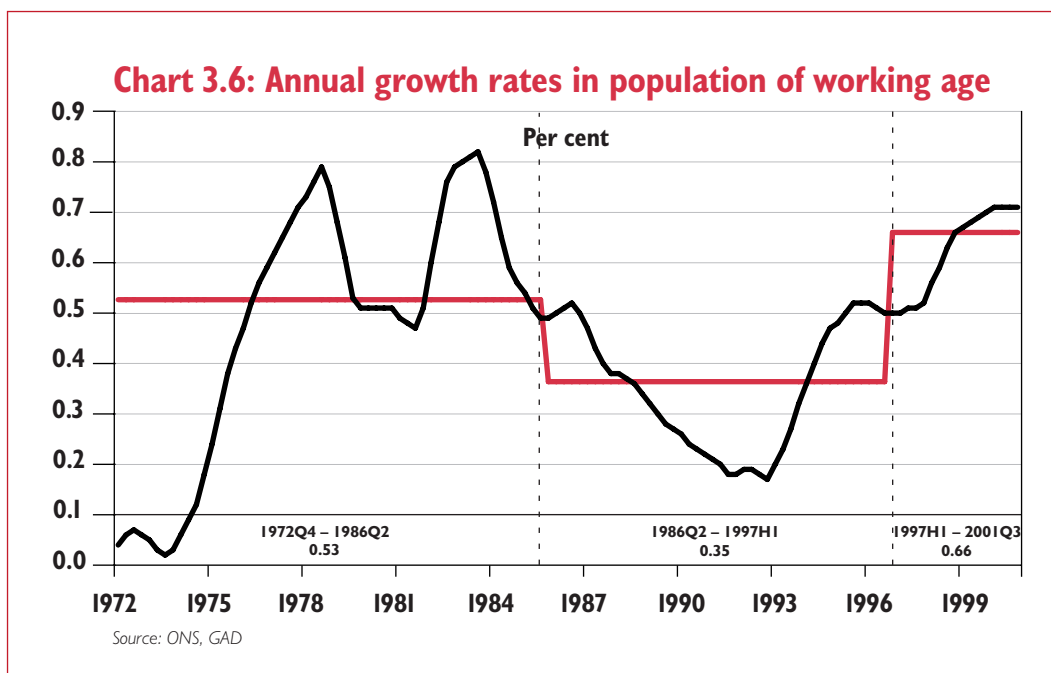
## GROWTH IN POPULATION OF WORKING AGE

**3.35** The projections for the population of working age are based on the population estimates and projections made by the Government Actuary's Department (GAD)<sup>9</sup>. While other projections of population growth are available, the GAD projections are considered to be the most authoritative<sup>10</sup>. The latest GAD projections were published in November 2001. They are based on estimated outturns for 2000 and by comparison with earlier GAD projections the latest projections include a significant upward revision for net inward legal migration to the United Kingdom. In August 2002, the 2001 Census results will be published and will provide a more solid picture of recent demographic trends, including legal migration.

<sup>8</sup> See the "Changing welfare state: employment opportunity for all", published by HM Treasury and DWP in November 2001 for details of the government's strategy for extending employment opportunities to all those who are out of work.

<sup>9</sup> *2000-based Population Projections for the United Kingdom and constituent countries*, GAD, 15 November 2001 and available from [www.gad.gov.uk](http://www.gad.gov.uk).

<sup>10</sup> The GAD projections are made by an inter-departmental working group, which draws on the relevant expertise in the Government departments concerned.

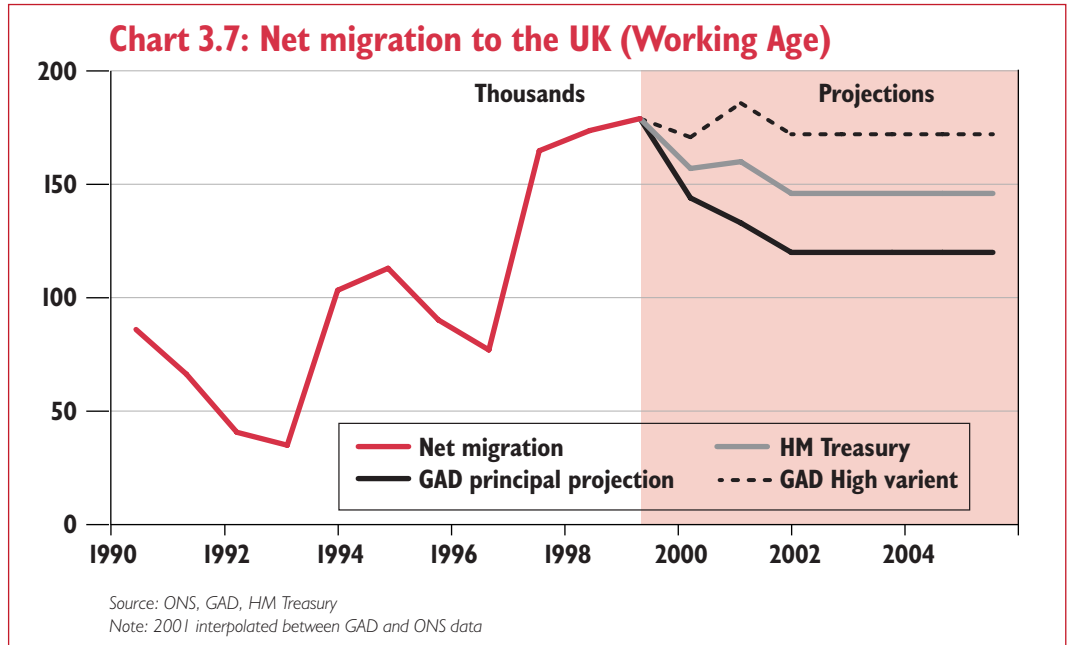


**3.36** Within projections of population growth, and net migration apart, the numbers in each age group for those of working age over the next ten years are likely to be well-estimated, as the number of children that will enter the work force and the number of people that will come up for retirement depend only on death rates of people who have already been born. The main uncertainty over the projections concern the assumptions on net migration.

**Net migration 3.37** Net migration is partly a policy variable. The design of the immigration regime will affect both the number and the activity rates of immigrants. However, immigration to the UK is not entirely a policy variable. Immigrants from other EU countries comprise over a quarter of the total and they are outside the immigration regime. It is likely that net migration from EU countries will be related to opportunities to work, the economic cycle and higher education opportunities.

**3.38** The GAD's principal projection assumes net migration to the UK of 135,000 people per year from 2003 onwards, revised up from 95,000 in the 1998-based projection. On average GAD projections show around 90 per cent of net inward migration is accounted for by people of working age (about 120,000 people per year from 2003 on) and net migration accounts for around 60 per cent of the projected increase in the working age population over 2002-2006.

**3.39** The GAD have also published high and low variants for migration around the principal projection. The high variant implies net migration of people of working age of about 170,000, some 50,000 people per year more than in the principal projection. The GAD's principal projections appear excessively cautious in the light of recent experience, indeed there are signs of a possible upward trend in net migration (See Chart 3.7). Therefore in the neutral case, the Treasury projections assume a level of net migration half-way between the GAD's principal and high migration scenarios. This is also close to the average level of the last three years' data (1997-1999), although rather less than what has been seen over the last two years (which would be equivalent to the GAD's high migration scenario). The detailed assumptions are set out in Table 3.7.



**Table 3.7: Projections of net migration of the population of working age (thousands)**

	2001	2002	2003	2004	2005	2006
GAD (principal)	144	133	120	120	120	120
GAD (high migration)	171	186	172	172	172	172
HM Treasury projection <sup>2</sup>	157	160	146	146	146	146

Source: GAD (2001) projections

<sup>2</sup> The HM Treasury projection is half-way between the GAD's principal and high migration scenarios

**3.40** In terms of trend growth of the population of working age, the Treasury's projection implies growth of 0.6 per cent over the Budget period – slightly less than was experienced over 1997H1 to 2001Q3. This is a bit less than 0.1 per cent per annum above the GAD's principal projection (Table 3.8). Clearly, if the GAD's high migration scenario were realised, higher growth of around 0.7 per cent would be observed.

**Table 3.8: Trend growth projections for the population of working age (over 2002–2006, per cent change)**

	Trend growth
GAD (principal)	0.55
GAD (high migration)	0.69
HM Treasury	0.62

Source: GAD, HM Treasury

**3.41** Beyond the horizon of the Treasury's projections for trend growth, the GAD projections imply a slowdown in the rate of growth of the population of working age for several years. This is related to the particular demographics affecting this period, rather than assumptions about net migration. The growth in the population of working age is then projected to increase again as the increase in the female retirement age from 60 to 65 years is gradually phased in over 2010 to 2020.

**3.42** The projections for trend growth are based on the GAD projections of the population of working age. The Treasury's projections assume net migration will be half-way between the GAD's principal projection and their high migration projection. This projection reflects recent outturns and is roughly equivalent to projecting the same level of net migration as over the last three years' data. **This implies a contribution to the trend rate of growth from the population of working age of 0.6 per cent over the Budget projection period which is slightly less than what was observed over 1997H1 to 2001Q3. If the GAD's high migration scenario were realised, the contribution would be about 0.7 per cent. Even this would be an understatement if the recent trend increase in net migration were projected forward.**

## CONCLUSION : THE PROSPECTS FOR TREND GROWTH

**3.43** The projections for trend growth are built up from the projections of the four components discussed above:

- **growth in labour productivity** (measured as output per hour): quantitatively this is the most important assumption. It is an assumption the Treasury is particularly cautious about, in particular in not scoring productivity advances before they happen. In line with this practice, trend underlying productivity growth of 2.1 per cent is assumed (compared with nearly 2.4 per cent achieved over mid-1999 to 2001Q3). Together with the employment rate assumption this implies actual trend productivity growth of 2.0 per cent;
- **growth in average hours:** average hours have fallen at an unusually rapid rate in the last few years. Some of the factors identified as having driven this reduction appear to have run their course. Going forward, although a good case can be made for assuming average hours are flat at their current level, the Treasury projections imply that trend average hours will decline in line with the trend over the 1986 to 1997 cycle;
- **growth in the employment rate:** the analysis of trends in activity rates combined with the assumption of modest further falls in the NAIRU suggest a contribution from trend growth in the employment rate of 0.2 per cent. This is less than was experienced from 1997H1 to 2001Q3; and
- **growth in the population of working age:** the projections are based on the GAD (2001) projections. A key uncertainty is the level of net migration. For the neutral case it is assumed that net migration will be half-way between GAD's principal projection and their high projection. This reflects the average outturn of the last three years' data. It implies a contribution to the trend rate of growth from the population of working age of 0.6 per cent, slightly less than what was recorded over 1997H1 to 2001Q3. It is also less than would be forecast on the basis of the last two years' migration data (a figure around the GAD's high migration projection), which would result in a contribution to trend growth of around 0.7 per cent a year.

**Table 3.9: The Treasury's decomposition of trend growth<sup>1</sup> (per cent growth)**

	Trend output per hour		Trend average hours (3)	Trend employment rate (4)	Population of working age (5)	Trend Output <sup>3</sup> (6)
	Underlying <sup>2</sup> (1)	Actual (2)				
<b>Over full economic cycles</b>						
1986Q2 to 1997H1	2.06	1.84	-0.14	0.45	0.35	2.51
1997H1 to mid-1999	1.91	1.55	-0.28	0.72	0.63	2.64
<b>Over the recent past</b>						
1997H1 to 2001Q3	2.14	1.96	-0.37	0.36	0.66	2.63
<b>Projection</b>						
2001Q4 to 2006Q4	2.1	2.0	-0.1	0.2	0.6	2 <sup>3</sup> / <sub>4</sub>

<sup>1</sup> Data definitions and sources are set out in Annex A.

<sup>2</sup> The underlying productivity rate is the actual productivity rate adjusted for changes in the employment rate, ie assuming the employment rate had remained constant. Column (1)=column (2)+(1-a) x column (4), where a is the ratio of new to average worker productivity levels, set at 50 per cent.

<sup>3</sup> From columns (2) to (5)

### Projection of trend growth

3.44 The implications for trend growth are summarised in Table 3.9. In terms of the Treasury's economic forecasts the analysis implies that the neutral trend growth assumption which anchors the economic forecast should be 2<sup>3</sup>/<sub>4</sub> per cent for the Budget 2002 projection period. As noted earlier, in the interests of caution, the Treasury will continue to use for the purposes of the public finance projections a trend growth estimate <sup>1</sup>/<sub>4</sub> of a percentage point below the projected neutral rate. So the public finance projections will be based on the assumption of 2<sup>1</sup>/<sub>2</sub> per cent trend growth over the same period.



## INTRODUCTION

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**4.1** The previous two sections set out the evidence and methodology underlying the Treasury's projection of trend growth of  $2\frac{3}{4}$  per cent per year over the Budget projection period. The Treasury approach is based on identifying on-trend points and then estimating the trend growth rate assuming trend growth is constant between on-trend points. Projections of trend growth looking forward are then built up from the analysis of the components – labour productivity, average hours, the employment rate and the population of working age.

**4.2** However, the Treasury's method for estimating trend growth is only one of several methods that could be used. Other methods include the use of statistical filtering techniques, or methods based on economic models, such as production functions. This section takes a closer look at how various institutions have used these methods to derive estimates for trend growth in the UK<sup>1</sup>. It shows that the results from these different methods depend fundamentally upon the assumptions on which they are based and it discusses the main assumptions which need to be made in each method. It concludes that all the external estimates for trend growth are in the range 2.5–2.8 per cent, close to the Treasury's view that trend growth will be  $2\frac{3}{4}$  per cent over the Budget period.

## ALTERNATIVE ESTIMATES OF TREND GROWTH

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**4.3** A number of international and other organisations make estimates for the trend rate of growth in the UK. Table 4.1 presents a summary of recent estimates. Three things are immediately apparent:

- all of the estimates are very close and within a band of 2.4-2.9 per cent, and range from 2.5-2.8 per cent a year going forward;
- a large number of institutions rely on a production function based approach; and
- the estimates are dated and relate to particular periods.

**4.4** The Treasury's neutral estimate of  $2\frac{3}{4}$  per cent trend growth is within the range of the external estimates going forward. However, the different projections in Table 4.1 are based on different methods of estimation from the Treasury method. The different results shown in the table are driven by the models employed and the underlying assumptions made in those models. But there is no evidence that a particular method tends to deliver high or low estimates of trend growth.

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<sup>1</sup> See "Potential output growth and output gaps: concept, use and estimates" published in the ECB Monthly Bulletin, October 2000, for a full discussion of the different methods of estimating potential output.

**Table 4.1: Estimates of trend growth for the UK (per cent, per annum)**

Organisation	Trend estimate/assumption	Comment
HM Treasury	2.63	Backward looking
	2 <sup>3</sup> / <sub>4</sub>	Budget projection
IMF	2001–2005: 2.8	Production function based
	1995–2002: 2.4	Production function based
OECD	2003–2006: 2.5	Production function based
	1996–2000: 2.7	Production function based
EC	1996–2000: 2.6	H-P Filter
	2003–2010: 2.6	Model based
NIESR	2003–2010: 2.6	Model based
	1990–1999: 2.37	Production function based
Oxford Economic Forecasting	2000–2009: 2.53	Production function based
	1994–1998: 2.9	On-trend extrapolation
Goldman Sachs	1998– : 2.5	On-trend extrapolation

Sources:

IMF 2001b

OECD 2001b

EC: McMorrow and Roeger 2001

National Institute Economic Review 2002

Oxford Economic Forecasting 2002

Walton and Binsbengen 2002

## Trend growth estimates from statistical filters

**4.5** Statistical filtering techniques are a common method used to determine trend growth because they are relatively simple to apply and easily replicated<sup>2</sup>. They are used both to estimate trend growth itself and to smooth variables used in production function estimates. Such approaches work by fitting a trend through the series for actual output.

**4.6** A very simple approach is to assume that there is a deterministic linear trend, i.e. that the trend component of output is just a linear function of time. This implies there is a constant trend rate of growth and it is the approach the Treasury method applies between on-trend points<sup>3</sup>. Another widely used approach is to apply the Hodrick-Prescott (H-P) filter.

**4.7** The H-P filter is used by the European Commission to calculate trend output as the basis for their estimates of the output gap as published in their regular forecasts<sup>4</sup>. They also publish estimates based on a production function approach and increasing attention is paid to this approach now (discussed further from Paragraph 4.21).

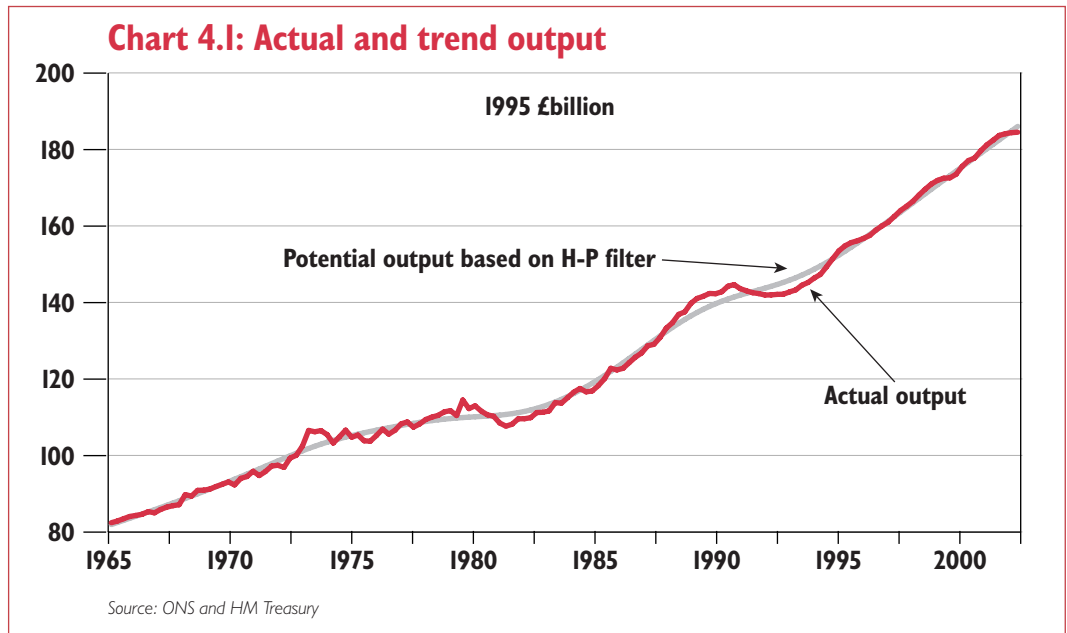
**4.8** As a check on the Treasury's estimates of trend growth, trend output was derived using the H-P filter by filtering actual non-oil GVA over the period 1965Q1 to 2001Q4 and including a forecast to 2007Q1 on the end of the historical data<sup>5</sup>. The trend level of output implied by the H-P filter is plotted along with actual output in Chart 4.1.

<sup>2</sup> For more detail see 'Trend extraction: A Practitioners Guide' by Mike Wickens with discussion by D Quah and K Wallis (GES working paper no 125) March 1995

<sup>3</sup> Since the on-trend points are not themselves identified by using this approach, trend growth rates can differ between on-trend points (for further details see section 3).

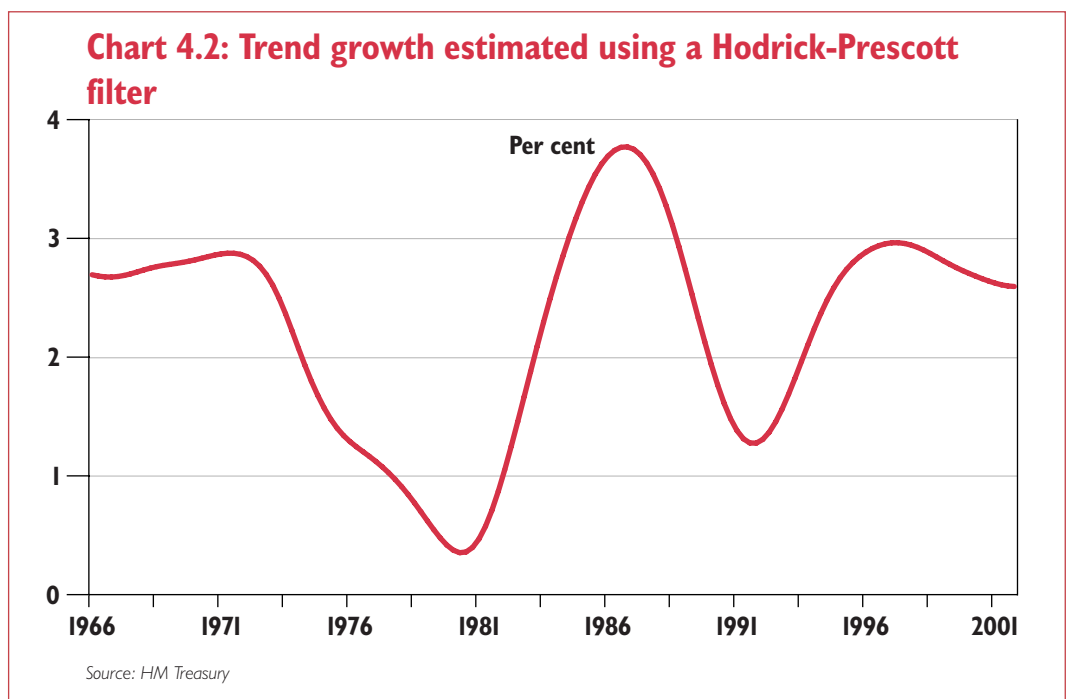
<sup>4</sup> European Commission, European Economy, Autumn 2001 forecasts for 2001-2003 in Supplement A Economic Trends No 10/11-October/November 2001.

<sup>5</sup> The key parameter in the estimation, lambda, was set at the conventional value of 1600. For further discussion of this point and some sensitivity analysis see Annex D.



**4.9** Chart 4.1 illustrates that while the estimate of trend output is much ‘smoother’ than for actual output, it varies over time, flatter in some periods and steeper in others. The fact that the estimated trend varies over time is what makes the H-P filter different from a deterministic trend estimated over the whole sample period. However, a *series* of deterministic trends estimated over sub-periods (e.g. representing the on-trend points as in the Treasury approach) would also give varying estimates of trend growth within a long sample period such as this, reflecting periods when growth was lower and higher than the full sample average.

**4.10** The implied trend growth rate for the H-P filter is presented in Chart 4.2. The variability of the series reflects the filter’s dependency on the data and smoothness constraint imposed. According to the H-P filter applied, trend growth reached a localised peak in mid-1997 of just under 3 per cent. Since then the estimated trend growth rate has steadily declined to its current rate of around 2.6 per cent.



**4.11** However the estimate of trend growth in Chart 4.2 is but one of a whole range of estimates the H-P filter could deliver, between a constant growth rate and the actual output series, depending on the value set for lambda. In addition the estimate of the trend growth curve will be significantly influenced by the last available data and any forecast data (this is known as the end-point problem). These problems are discussed in more detail in Annex D.

### Production function estimates of trend growth

#### Production function method

**4.12** The production function approach is widely used by international organisations – the IMF, the OECD and the EC<sup>6</sup> – to estimate trend (or potential) output. One key advantage is that it provides a clear link between output and its determinants and so it can be used to estimate future trend growth based on forecasts of the components. It can also be used to estimate the impact of structural change on trend growth based on an assessment of the impact of the change in the determinants.

**4.13** The production function approach relates the level of output (GDP) to the level of technology and the inputs that are used to produce it. While in principle the technique could handle any number of inputs, the estimates of trend growth from the IMF, the OECD and the EC, consider only two inputs, labour and capital. There are many different possible functional forms for the production function, but the most widely used is the Cobb-Douglas production function. The Cobb-Douglas production function has a number of desirable properties and it is straightforward to estimate. It divides productivity into labour, capital and a residual, representing technical progress, known as Total Factor Productivity (TFP). See Annex C for a detailed discussion of the methodology.

#### IMF approach

**4.14** Each year the IMF conduct an Article IV examination of the UK. In 2001 the IMF published a paper on their estimates of UK trend growth alongside the Article IV staff paper. Table 4.2 shows the IMF's estimates based on a production function which uses whole economy capital stock and distinguishes between ICT capital and other capital (see Annex C for further discussion). The estimate of trend growth of 2.8 per cent per annum for 2001-2005 is slightly higher than the Treasury's estimate of  $2\frac{3}{4}$  per cent per annum over the Budget period.

**Table 4.2: The IMF estimates of trend growth and its components (per cent, per annum)**

	Potential GDP	Growth in capital stock		Growth in	Growth in
	growth	non-ICT	ICT	labour supply	TFP
2001-2005	2.8	2.75–2.25	17	0.6–0.5	0.9

Source: IMF Article IV 2001b

**4.15** The IMF projections for the capital stock are based on investment forecasts, whereas they project TFP growth in line with its growth in recent cycles. The IMF's implied estimate of labour productivity growth per employee is higher than the analogous concept in the Treasury's work, at about  $2\frac{1}{4}$  per cent. The IMF's projection of ICT investment growth of 17 per cent might seem high, but this has to be set against evidence that between 1979 and 1999, ICT capital services grew at over 22 per cent annually while the rest of the capital stock only grew at 2.5 per cent annually<sup>7</sup>.

<sup>6</sup> Also used by the Bank of England (2000).

<sup>7</sup> Oulton 2001a.

**4.16** In spirit the IMF's approach to the labour input is close to the Treasury's, although there are a number of differences in practice. The estimate for potential employment is calculated from the working age population and estimates of the NAIRU. This formulation does not allow for variations in the inactivity rate which is projected to fall in the Treasury projections. In addition the IMF assume the NAIRU is constant, while the Treasury project a modest further fall. So effectively the IMF projections imply no further increase in the employment rate.

**OECD approach 4.17** The OECD's view of the prospects for trend growth is shown in Table 4.3. Their estimate is for growth of 2.5 per cent in 2003-2006, a little below the Treasury's estimate of  $2\frac{3}{4}$  per cent.

**Table 4.3: The OECD estimates of trend growth and its components (per cent, per annum)**

	Potential GDP growth	Potential labour productivity growth <sup>1</sup>	Potential employment growth	Composition of potential employment <sup>2</sup>		
				Trend participation	Working age population	Fall in NAIRU
1995-2002	2.4	1.8	0.6	0.1	0.4	0.1
2003-2006	2.5	2.0	0.5	0.1	0.3	0.0

<sup>1</sup> Output per employee

<sup>2</sup> Percentage point contributions to potential employment growth

Source: OECD 2001b

**4.18** The OECD's production function strips out the government sector so as to isolate potential growth in the business sector. The value added in the government sector is then added to this to derive potential growth for the whole economy. The OECD therefore take actual business sector capital input (excluding housing) to measure the capital stock.

**4.19** The OECD estimate for labour productivity growth over 2003-2006, at 2 per cent, is the same as the Treasury's once allowance is made for the different definitions.

**4.20** The OECD's measure of labour input (on a heads basis) is similar to the Treasury's, although there are a number of differences in detail. The OECD's measure starts from the population of working age, allows for variations in participation rates and for variations in the employment rate related to the change in the NAIRU. Overall, the OECD estimates for employment growth are slightly lower than the Treasury's. Their projection for the contribution from the growth in the working age population is below the GAD's principal projection, i.e. even before allowing for the likelihood of higher net migration. This accounts for most of the difference between the OECD's and Treasury's trend growth estimates. The assumptions on trend participation and the NAIRU are only slightly different.

**EC approach 4.21** As noted, the European Commission (EC) use both the H-P filter and a production function to estimate trend output in the forecasts they publish of the output gap. However, recently greater attention has shifted to the production function approach. While the functional form is Cobb-Douglas, the EC's implementation differs in detail from the IMF and OECD. The EC's estimates are shown in Table 4.4. The EC estimate of trend growth is 2.7 per cent for 1996-2000 (the only period explicitly reported). This is slightly higher than the Treasury's estimate of just over 2.6 per cent for the period 1997-2001.

**Table 4.4: The EC Production function estimates of trend growth and its contributions (per cent, per annum)**

	Potential GDP growth	Growth in capital stock	Components Growth in labour supply	Growth in TFP
1996-2000	2.7	0.8	0.5	1.4

Source: EC: McMorrow and Roeger 2001

**4.22** Comparing labour productivity, the EC approach shows contributions from the growth in the capital stock and TFP summing to 2.2 per cent. Making allowance for the different definitions again, this estimate is above the Treasury's estimate of labour productivity growth over 1997-2001. It is also above the Treasury's Budget projection, though close to the IMF's projections. The contributions of TFP and the growth in the capital stock differ notably between the EC and IMF approaches, however, the capital stock playing a more prominent role in the IMF approach and TFP growth being 0.5 percentage points higher in the EC approach.

**4.23** A feature of the EC approach is that it avoids relying on a filtered residual from the production function to estimate TFP. Instead it builds up the estimate of TFP by combining estimates of labour and capital efficiency. Capital efficiency is related to the mean age of the capital stock while labour efficiency is estimated with a deterministic trend (allowing for the possibility of trend breaks). Using this approach could have a significant impact on the projections since TFP no longer has to be projected in line with its past values and it becomes an additional independent input. However, calculations presented by the EC (for EU15 and US) over the past comparing their approach with a more standard approach, show only small differences.

**4.24** The contribution from labour is less in the EC's approach than the Treasury's estimate for 1997 to 2001 (from Table 2.1, columns 4 and 5). The EC's labour input measure is obtained by first applying a H-P filter to the participation rate series. This is then multiplied by the population of working age to get a smoothed labour force series. Subtracting the estimated NAIRU from this yields the EC's estimate of potential employment.

**4.25** The EC work represents work in progress. The authors report plans to update it and extend it in a number of directions and ongoing work is being carried forward in conjunction with the Economic Policy Committee (EPC) which reported to the meeting of the European Finance Ministers in November 2001<sup>8</sup>.

**Other estimates** **4.26** The other external estimates in Table 4.1 include the National Institute, Oxford Economic Forecasting and Goldman Sachs. The **National Institute's approach** is based on a macro-model and takes account of influences that can be easily predicted such as population changes. Over the longer term it expects growth to average around 2.6 per cent, including an assumption of labour productivity growth of  $2\frac{1}{4}$  per cent – above the Treasury's projection. This in turn implies a rather lower contribution from employment growth. Even assuming a constant employment rate (instead of a small further rise as in the Treasury projections), GAD's (2001) principal projections would imply a higher contribution from employment growth in the period up to 2006.

<sup>8</sup>The Council noted in particular that: 'As recommended in the EPC's report, the Commission was preparing to use the evaluation method based on production function as from the 2002-2003 financial year, in parallel with the evaluation system currently in force. The Council also asked the EPC to continue examining evaluation methods so as to refine the "production function approach" and to submit its findings to the Council next year'. Press release, number 13474/01 (Presse 401), of the 2382nd Council meeting - ECOFIN held on 6 November 2001.

**4.27** Table 4.5 presents **Oxford Economic Forecasting's (OEF)** estimates of potential GDP and its components. Their estimate of trend growth going forward is 2.53 per cent, with a contribution from labour productivity of 2 per cent, similar to the Treasury's projection. The estimates are derived from a standard production function, assuming the labour input factor share of 0.65. They also assume the NAIRU is stable at 4<sup>1</sup>/<sub>2</sub> per cent (on a claimant count basis), unemployment is currently below this but it is expected to converge on the NAIRU by 2004. The contribution from growth in employment, for a given NAIRU, is a bit lower than in the Treasury's projection.

**Table 4.5: OEF's estimate of trend growth and its components (per cent, per annum)**

	Potential GDP growth	Growth in capital stock	Growth in employment at NAIRU	Growth in TFP
1990–1999	2.37	2.06	0.41	1.39
2000–2009	2.53	2.14	0.52	1.45

Source: OEF, 2002

**4.28** **Goldman Sachs'** technique is similar to the Treasury's. They use coincident indicators to establish on-trend points in a cycle, and then deterministic linear trends between the on-trend points are used to estimate trend growth. They estimate the recent on-trend points to have been 1990Q4, 1994Q2 and 1998Q3. Between the first of these periods they calculate trend was 1.8 per cent p.a., rising to 2.9 per cent p.a. in the mid-1990s and 2.5 per cent p.a. since 1998.

## CONCLUSION

**4.29** This section examined various ways of estimating trend growth with a view to assessing external projections of trend growth in the UK. The conclusion is that H-P filters are unable to provide more than a rough guide for estimates of trend growth, and they will be subject to significant end-point/forecasting problems which substantially limit their usefulness to policy-makers.

**4.30** The most respected international organisations, namely the IMF, OECD and the EC, all use production functions. This technique is not without its drawbacks, but it is firmly based in economic theory. The IMF's estimate is very close to the Treasury's, the OECD's is slightly lower. The EC's estimate for the past is slightly higher than the Treasury's estimate over an equivalent period. The other institutions who have recently published estimates of trend growth include the National Institute, OEF and Goldman Sachs whose projections are all in the range 2.5-2.6 per cent.

**4.31** Looking at the approaches in more detail, a number of the external estimates of trend growth imply relatively low rates of growth of potential employment. In part, this is because the assumptions for the projections of the population of working age are below those the GAD published at the end of last year. On the other hand, it is notable that most estimates that use production functions imply rather faster growth of labour productivity than in the Treasury's projections. This may reflect the fact that the production function approach automatically builds in the implications of higher investment when projecting forward, whereas the Treasury approach simply projects labour productivity growth in line with recent trends.

**4.32** In conclusion, all the external estimates for trend growth (Table 4.1) going forward from 2003 are in the range 2.5-2.8 per cent, close to the Treasury's view that trend growth will be 2<sup>3</sup>/<sub>4</sub> per cent.



**A.1** The data definitions and sources underpinning the analysis in Table 2.1 are set out below. All data refer to the UK and are seasonally adjusted unless specified otherwise. Where possible National Statistics data series identifiers are shown in brackets.

## **Trend Growth**

**A.2** Non-oil output is defined as Gross Value Added at constant basic prices (ABMM) less the output of the extraction of oil and gas (CKZO). The trend level of output is interpolated between identified on-trend points.

## **Productivity (output per hour worked)**

**A.3** Defined as non-oil output, divided by total actual weekly hours worked (YBUS) scaled in the ratio of total employment (MGRZ) to working-age employment (YBSE) from the Labour Force Survey (LFS).

## **Underlying Productivity**

**A.4** This gauges the growth in productivity once changes in employment have been taken into account i.e. productivity growth with constant employment. If new entrants to employment have different productivity rates to existing workers we would expect the average level of productivity to be affected. Underlying productivity growth is derived by adding to actual productivity growth the growth in the employment rate multiplied by the ratio of the productivity of new workers to average productivity.

## **Population of working age (household basis)**

**A.5** UK household population aged 16-59/64 from the LFS (YBTF). Prior to 1992 quarterly data were obtained by linking this LFS data to mid-year estimates of UK working-age resident population produced by National Statistics. Projections are based on the 2000-base projections of population produced by the Government Actuaries Department (GAD), published in November 2001.

## **Working-age employment**

**A.6** All persons in employment aged 16-59/64 (YBSE) from the LFS. Prior to 1992 quarterly data was constructed by aligning annual data that refers to the spring quarter, to Q2, and then interpolating missing quarters in line with the quarterly growth rates in the workforce jobs series (DYDC).

### Average hours worked by people of working age

**A.7** From 1992Q2 the data come directly from the LFS, and are calculated as the estimate of total actual weekly hours worked by people of working age divided by working-age employment. It is assumed that average hours worked by people of working age are the same as for those of all in employment. From 1984 to 1992 the LFS Historical Supplement (1997) includes data for average actual weekly hours of work for all in employment in Great Britain. This series was therefore used to backcast the UK series from 1992Q2 after aligning the spring quarter to correct for the small timing difference. Missing calendar quarter figures back to 1984 were then interpolated from the annual Q2 figures. Prior to 1984 annual data were derived by using Mary O'Mahony's series (MoM) for annual average hours worked per person engaged ('Britain's Relative Productivity Performance', NIESR 2001) to backcast the LFS data.

## Employment rate projection

**B.1** The Treasury assessment of trend growth decomposes growth in output between growth in productivity, average hours worked, the working-age employment rate, and the working-age population. In considering prospects for growth in the working-age employment rate this annex focuses in particular on projections of the activity rate i.e. labour market participation.

**B.2** Growth in the employment rate can be divided between changes in the unemployment rate and changes in the inactivity rate (broadly those persons of working age who are neither employed nor seeking employment). The decomposition is as follows.

If  $E$ ,  $I$ ,  $A$  and  $P$  are levels of employment, inactive population, active population and working age population respectively and  $e$ ,  $i$ ,  $a$  and  $u$  are employment, inactivity, activity and unemployment rates then the following identities hold:

$$e = \frac{E}{P}, i = \frac{I}{P} \text{ and } u = \frac{U}{A} \quad (1)$$

$$P = E + U + I \quad (2)$$

$$e + u(1-i) + i = 1 \quad (3)$$

$$\text{so } e = 1 - u - i + ui \quad (4)$$

$$\text{then } \Delta e = -\Delta u - \Delta i + \Delta(ui) \quad (5)$$

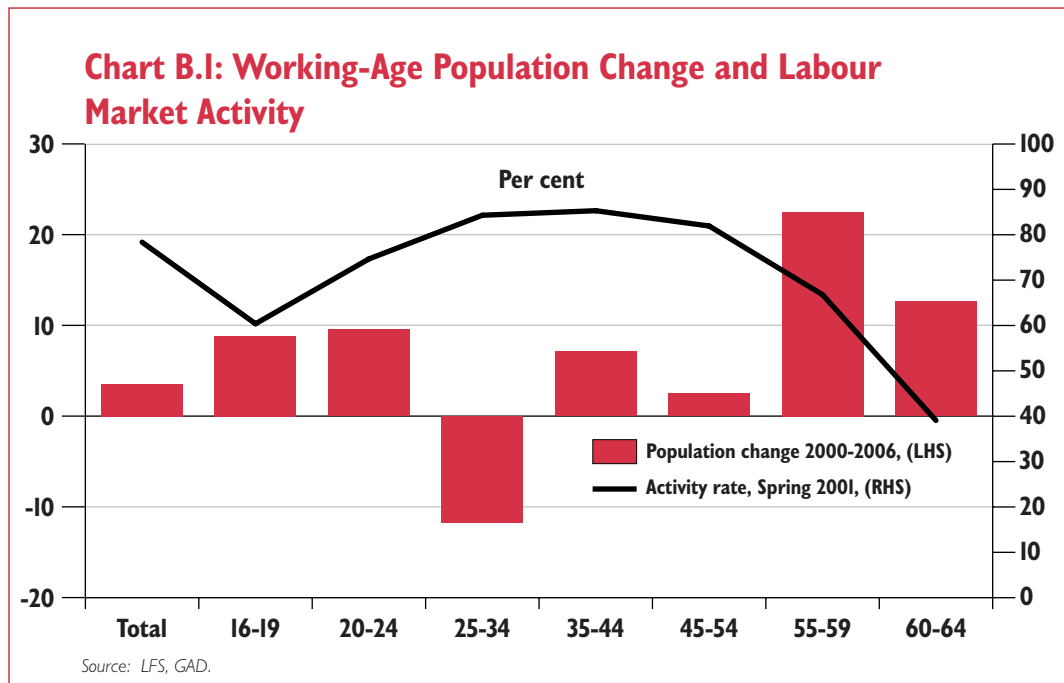
$$\frac{\Delta e}{e} = \frac{1}{e} (-\Delta u - \Delta i + \Delta(ui)) \quad (6)$$

where  $\frac{\Delta e}{e}$  is the rate of growth of the employment rate, which is the term that enters the trend growth calculation.

Using this formula the trend rate of growth in the working-age employment rate can be calculated from falls in the trend rate of unemployment (NAIRU) and declines in the trend rate of inactivity. Since direct estimates of the NAIRU, which is not directly observable, are notoriously difficult to make, the projection of the NAIRU is based on a cautious judgement of recent trends and observed wage pressures. However, it is somewhat easier to model trends in activity rates since, at a disaggregate level, they are both highly trended and pro-cyclical.

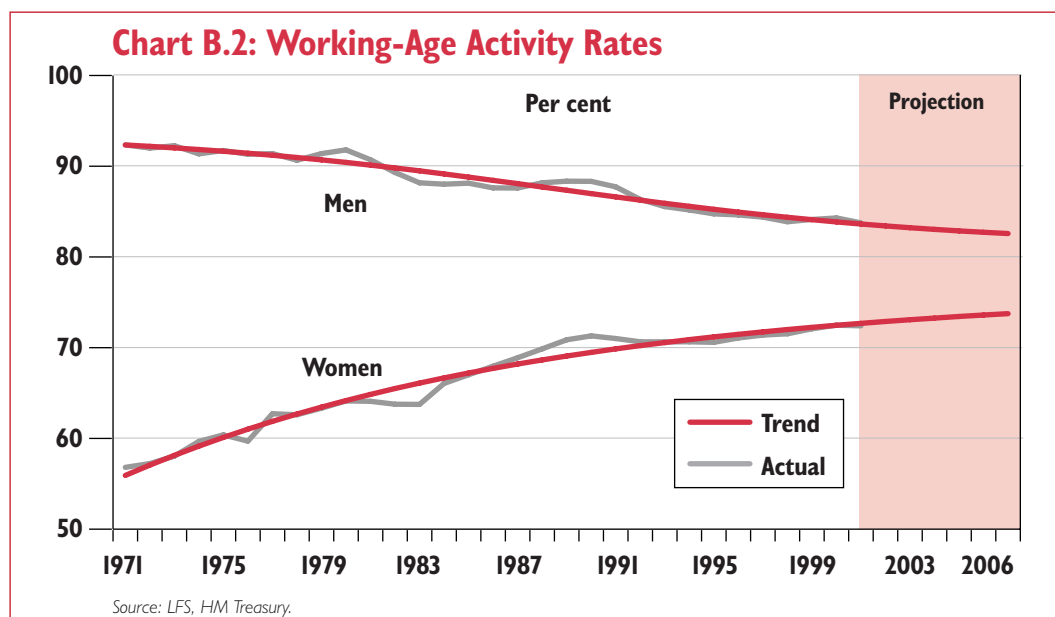
**Activity rates B.3** Overall, labour market activity rates are the result of a combination of complex demographic, social and economic trends. Different age groups have different participation rates in the labour market, with those aged 25-45 having the highest participation rates (see chart B.1). Equally, men have historically had higher participation rates than women, although as will be seen below, the participation rates for men and women of working age are converging. Economic activity rates are also clearly influenced by the economic cycle, participation in higher and further education, patterns in household formation and child bearing.

**B.4** In addition to these trends there will be changes in the structure of the population that will influence overall activity rates. For example, as can be seen in Chart B.1 below, one of the most important changes over the coming years will be a decline in the population aged 25-34 (a high activity cohort) and a rise in the population aged 55-59 (a low activity cohort). All other things being equal demographic change would tend to depress the working-age activity rate by around 0.6 percentage points between 2001 and 2006.



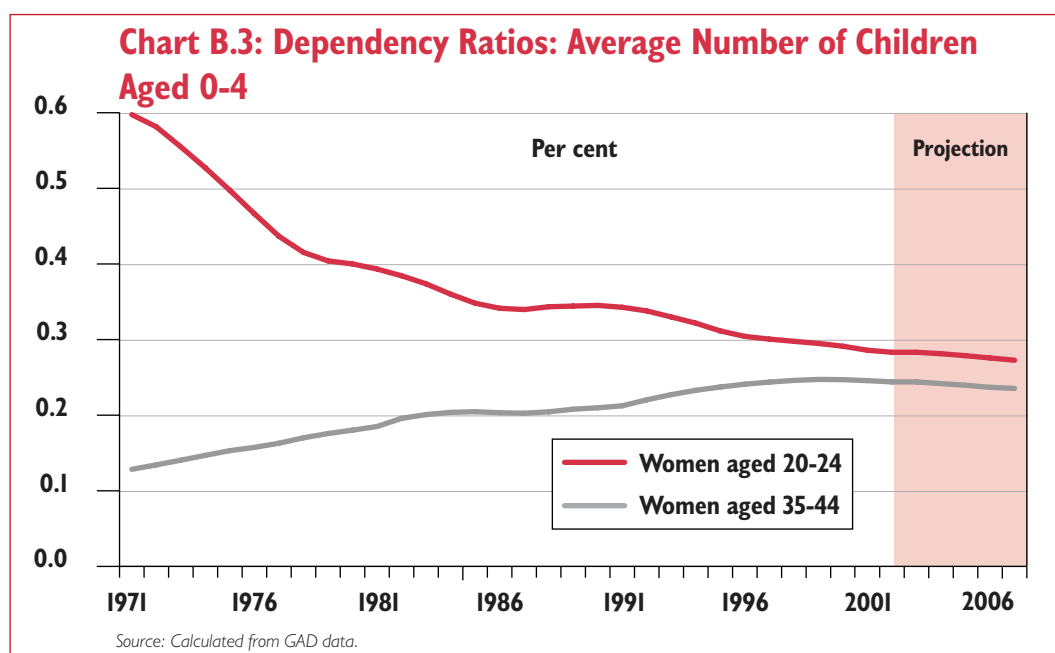
**B.5** Hence, in considering prospects for working-age activity rates, all of these factors above should, as far as possible, be taken into account. To do this the working-age population was split into 17 separate cohorts identified by age, gender and, for those aged 16-19 and 20-24 years, participation in education. With annual data on the population and labour force, by cohort, available for the years 1971 to 2001. Activity rates for the majority of cohorts are clearly trended, though often in a highly non-linear way, and also partly cyclical. For each cohort a non-linear trend<sup>1</sup> was estimated numerically by minimising the sum of squares from the actual activity rate. The advantage of such an approach is that not only will it capture any general trends but also, more importantly, any asymptotic trends present in the data. By implication the residuals from such trends are partly explained by cyclical effects, and, in estimating a fuller model, this influence was captured by the Treasury estimate of the output gap.

<sup>1</sup> Long-term linear trends cannot easily be used for bounded ratios such as activity rates without resulting in impossible or extremely implausible results. The general form of the trend function used was:  $a_0 + a_1 / (1 - e^{(a_2 + a_3 t)}) + a_4$ , where  $a_0$  to  $a_4$  are the parameters to be estimated.

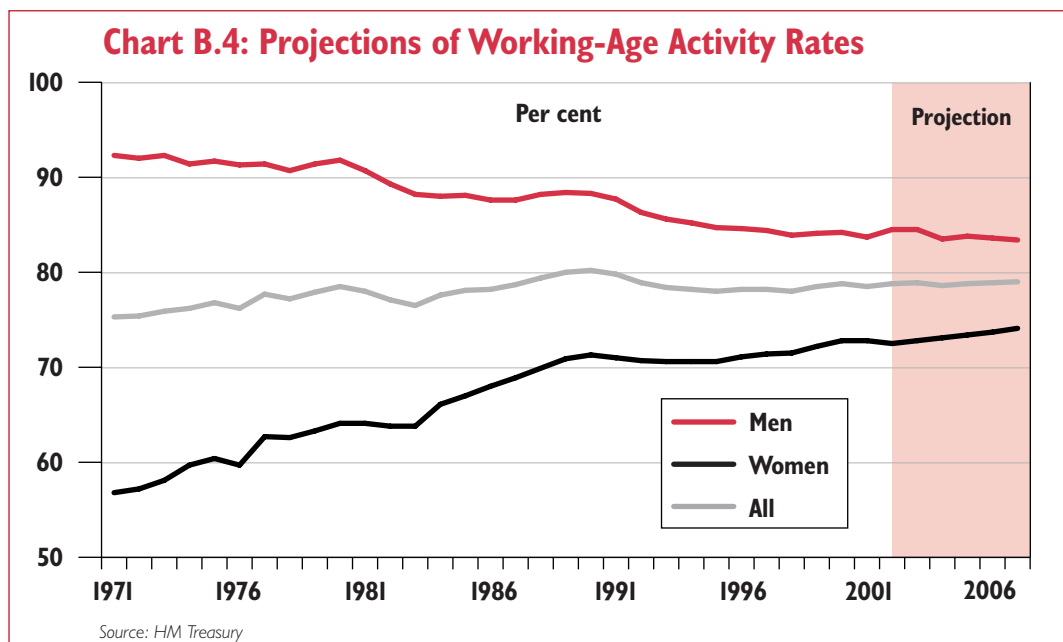


**B.6** The results confirm that participation rates for the majority of cohorts are both highly trended and also partly cyclical. These effects can also be observed directly in aggregate. For example, working-age male participation rates have shown a significant downward trend, having fallen from an estimated 92.3 per cent in 1971 to 83.8 per cent in 2001, while female participation rates have risen from 56.8 to 72.4 per cent over the same period (see Chart B.2). Rising participation rates for women are partly driven by the trends for women to have both fewer children and to have children later in life.

**B.7** The tendency for women to have fewer children later in life is illustrated in Chart B.3 below, there has been a sharp decline in the average number of children aged 0-4 for women aged 20-24. Moreover, while there has been an increase in this dependency ratio for women aged 35-44 it is less marked than the fall for the younger age cohort. Going forward dependency ratios for children aged 0-4 for female cohorts aged 16-19, 20-24, 25-34 and 35-44 are projected to decline, and while the dependency ratio of children aged 5-9 for women aged 20-24 is projected to show a slight increase, it is projected to fall for women aged 25-34 and 35-44. Overall, trends in child bearing for women are, all other things being equal, likely to support higher participation rates for women of working age.



**B.8** For each cohort, activity rates were then modelled as a function of their trend, the output gap, and for women dependency ratios - all three variables were correctly signed and highly significant. Other researchers have found comparable results using a similar approach<sup>2</sup>. For the projections, the trends, derived in sample, were extended forward and combined the projections with Treasury forecasts of the output gap along with projections of dependency ratios consistent with the GAD (2001) 2000-base principal projections. An aggregate forecast was obtained by applying forecast activity rates to population projections halfway between the GAD (2001) 2000-base principal projection and the high migration variant projection. Projections of student numbers were made broadly in line with the Department for Education and Skills targets for higher and further education. The results show that although demographic effects (particularly the increase in the population in the low activity cohorts prior to retirement) tended to depress the projected working-age activity rate, such effects were relatively small and outweighed by the trend effects within cohorts that tended to raise the activity rate. Chart B.4 shows the combined result of these effects.



**B.9** While the working-age participation rate for men is projected to decline fractionally this is more than offset by a rise in the working-age participation rate for women. With the net effect that the overall working-age activity rate is projected to show a modest increase of around 0.1 percentage points per annum over the period 2001 to 2006. Combined with the estimate of an annual fall in the NAIRU of 0.05 percentage points, and applying equation (6) yields a projected annual employment growth rate of 0.2 per cent.

**B.10** In conclusion the contribution to trend growth, in our neutral case assumption, from the growth in the employment rate is projected to be 0.2 per cent a year on average, well below the estimated recent trend rate of just under 0.4 per cent since 1997. Arguably, given the recent trend, this may be a cautious assumption, more so given the convention of not scoring any effects to allow for the impact of policy measures introduced by the present Government. For example, the reforms to the tax and benefit system introduced by the Government since 1997 designed to make work pay are likely to promote a significant increase in employment from groups in the labour market with high rates of unemployment or inactivity.

<sup>2</sup> Cutler and Turnbull 2001.

# ANNEX C: PRODUCTION FUNCTION ESTIMATES OF TREND GROWTH

## METHODOLOGY

**C.1** The production function approach relates the level of output to the level of technology and the inputs that are used to produce it. While in principle the technique could handle any number of inputs, in most estimations two inputs, labour and capital are considered. The most widely used is the Cobb-Douglas production function. The Cobb-Douglas production function has a number of desirable properties and it is straightforward to estimate.

### Cobb-Douglas function

**C.2** The Cobb-Douglas production function relates output to inputs of labour and capital as follows:

$$Y_t = A_t N_t^\alpha K_t^{(1-\alpha)} \quad (1)$$

$Y_t$  is output (GDP or GVA),  $N_t$  is total employment and  $K_t$  is capital input. Alpha ( $\alpha$ ) is the elasticity of output with regard to labour. So if labour increases by 1 per cent and capital is held constant, output increases  $\alpha$  per cent. The assumption of constant returns to scale<sup>1</sup> means that if labour and capital both increase by 1 per cent then output will increase by 1 per cent.  $A_t$  represents the efficiency with which capital and labour can be used to produce output. It is generally known as 'total factor productivity' (TFP), and captures the effects of technical progress. Unlike employment and the capital stock, TFP is unobservable. It is normally estimated as the residual after selecting a value for alpha, and calculating the contributions of labour and capital to output. One immediate consequence of this is that any errors in estimating the contributions of labour and capital, will affect the estimate of TFP.

**C.3** With the additional assumption that the marginal products of labour and capital are equated with the wage rate and the profit rate respectively (as under perfect competition),  $\alpha$  is simply the share of output going to labour (in the form of wages), and  $1-\alpha$  is the profit share. This also gives the intuitive result that the level of output is a geometric weighted average of the contributions from labour and capital (where the weights are just their shares in national income) together with the exogenous efficiency in which these inputs are combined (TFP).

**C.4** Equation (1) defines actual output. The trend, or 'potential' level of output can be determined by substituting trend values of the inputs and assuming that TFP is at its trend level. Using asterisks to denote trend values:

$$Y_t^* = A_t^* N_t^*{}^\alpha K_t^*{}^{(1-\alpha)} \quad (1^*)$$

This introduces a significant new problem, namely that the trend values of the labour and capital inputs are not directly observable. The studies considered in section 4 deal with this in more or less the same way. They all assume that the actual capital input can be taken as a measure of the trend capital input and so the deviations in output from its trend level can be largely explained by deviations in the labour input from its trend level. This means that any errors in the estimate of the NAIRU will feed into the derived estimates of trend TFP.

<sup>1</sup> In terms of equation (1) constant returns to scale depends on the exponents on the labour and capital inputs summing to unity.

**C.5** Finally, it is worth noting that dividing the production function by the labour input gives an expression for the trend rate of productivity in terms of TFP and the capital-labour ratio:

$$Y_t/N_t = A_t (K_t/N_t)^{(1-\alpha)} \quad (2)$$

This means that the Treasury's methodology can be interpreted as a variant of the production function technique in which the effects of changes in capital intensity are not considered explicitly but are subsumed in labour productivity growth. The Treasury's approach of projecting trend growth based on labour productivity is justified if labour productivity growth is stable relative to the capital-labour ratio and TFP growth. Further, by concentrating on the analysis of on-trend points, the Treasury's approach sidesteps the considerable problems of estimating the entire history of the trend levels of the factor inputs and the associated problems of estimating the history of the NAIRU.

## PRACTICAL PROBLEMS OF IMPLEMENTATION

**C.6** While the Cobb-Douglas production function is less of a statistical black box than statistical filtering techniques, like the H-P filter, its estimation nevertheless raises practical problems. These take two main forms:

- estimation problems; and
- the end-point/forecasting problem.

**Estimation problems** **C.7** As discussed above, estimation of potential output requires inputs of:

- potential employment;
- potential capital;
- trend TFP; and
- estimates of factor shares.

It is a feature of most studies that any errors of definition and estimation will be reflected in errors in actual (and thus trend) TFP.

**C.8** Estimates of potential employment are generally derived from estimates of the NAIRU<sup>2</sup>, which is also unobservable. But there is little agreement about how NAIRU estimates should be obtained, or what precisely its history is. Studies also differ in the extent to which they allow the participation rate to change over time.

**C.9** Actual capital stock data is used by the IMF, OECD and EC studies as the measure of the input of trend or potential capital. Typically it is not smoothed or de-trended because it is thought to contain only a small cyclical element. But it does introduce a complication concerning the measurement of capital input. Some studies use capital stock data i.e. the sum of past gross investment less depreciation (in the case of net capital stock), or less retirements (in the case of gross capital stock). However, these are wealth measures of capital, weighting together different types of capital by their asset prices, while what is really required for production function analysis is a flow measure of the productive input from capital i.e. capital services<sup>3</sup>. It is often assumed that capital services are proportional to the asset value measure of capital stock, but when the average life of the stock is changing (as with recent changes in composition towards shorter-life ICT assets), then this assumption is likely to be misleading.

<sup>2</sup>Since  $e^* = WPa^*(1-u^*)$  where  $e^*$  is trend employment,  $WP$  is population of working age,  $a^*$  is trend activity, and  $u^*$  is the NAIRU.

<sup>3</sup>See for example Oulton 2001b.

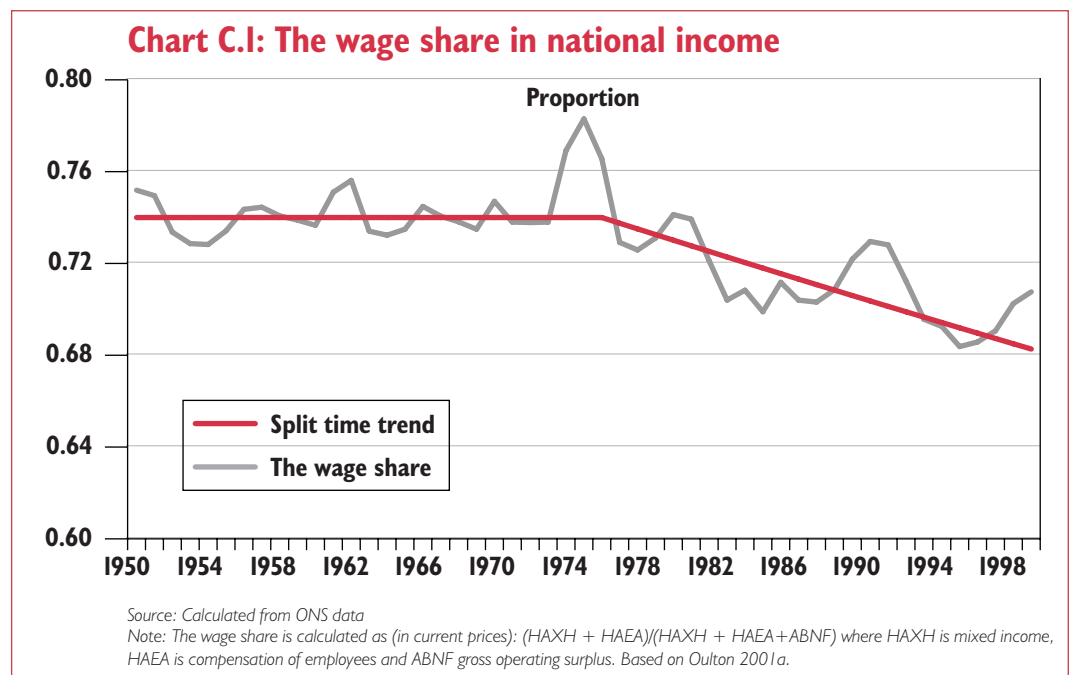
**C.I0** The IMF has examined the impact of the New Economy by distinguishing the effects of ICT capital from more traditional forms of capital<sup>5</sup>. This is done by splitting out the two types of capital as follows:

$$Y_t = A_t N_t^\alpha (K_{ICT} K_O)^{(1-\alpha)} \quad (3)$$

**C.I1** The advantage of splitting the capital stock in this way is that one can obtain a measure of capital that is closer to capital services. This is particularly important for the ICT sector which would have a relatively low share in a measure of the capital stock (about 5 per cent) but a higher share in a capital services measure (about 15 per cent of profits are generated by ICT)<sup>6</sup>. The separate identification of ICT investment also allows specific questions related to ICT to be addressed and the contribution ICT capital makes to growth to be examined explicitly. Studies also differ in the coverage of the capital stock. The IMF and EC use whole economy capital stock. The OECD use only the business sector capital stock.

**C.I2** Trend TFP growth is normally inferred as the residual from equation (1) after smoothing, for example by the H-P filter. The IMF and OECD studies both do this. While this provides a measure for TFP growth, it leaves unanswered the question of what determines TFP growth. The EC attempt to explain part of TFP in terms of changes in the average age of the capital stock.

**C.I3** To estimate alpha, data are readily available from the National Accounts for the share of wages in total income. Direct estimation of alpha can lead to very different estimates from the labour share as measured by the share of national income. This may just reflect the fact that perfect competition does not hold. In practice, most studies use the sample averages of the wage share. However, as chart C.1 shows, the shares on this measure are actually trended with the labour share falling after the late 1970s (and, conversely, the profit share rising). This can have a significant effect on the decomposition of trend output growth, especially changing the estimated TFP. The IMF and the EC differ slightly in their estimates of alpha. For the OECD study the exact labour share is not published.



<sup>5</sup> The “New Economy” in the United Kingdom, IMF 2001a.

<sup>6</sup> Oulton 2001a

**The end-point forecasting problem**

**C.14** It is common practice to use statistical filters to smooth several of the components of equation (1), particularly to obtain estimates of potential employment (or the NAIRU) and trend TFP. The IMF, OECD and EC all use a filter in some part of their estimation. Most forward-looking smoothing techniques (Annex D discusses the much-used H-P filter) have an ‘end point problem’ in the sense that they run out of data towards the end of the sample and the estimated ‘trend’ is dependent on forecasts of the components of trend output. Forecasting factors such as investment (to derive the evolution of the capital input) is notoriously difficult and adds more room for judgement to the process. Producing forecasts of trend growth exacerbates this problem, requiring judgements on the components far into the future.

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**CONCLUSION**

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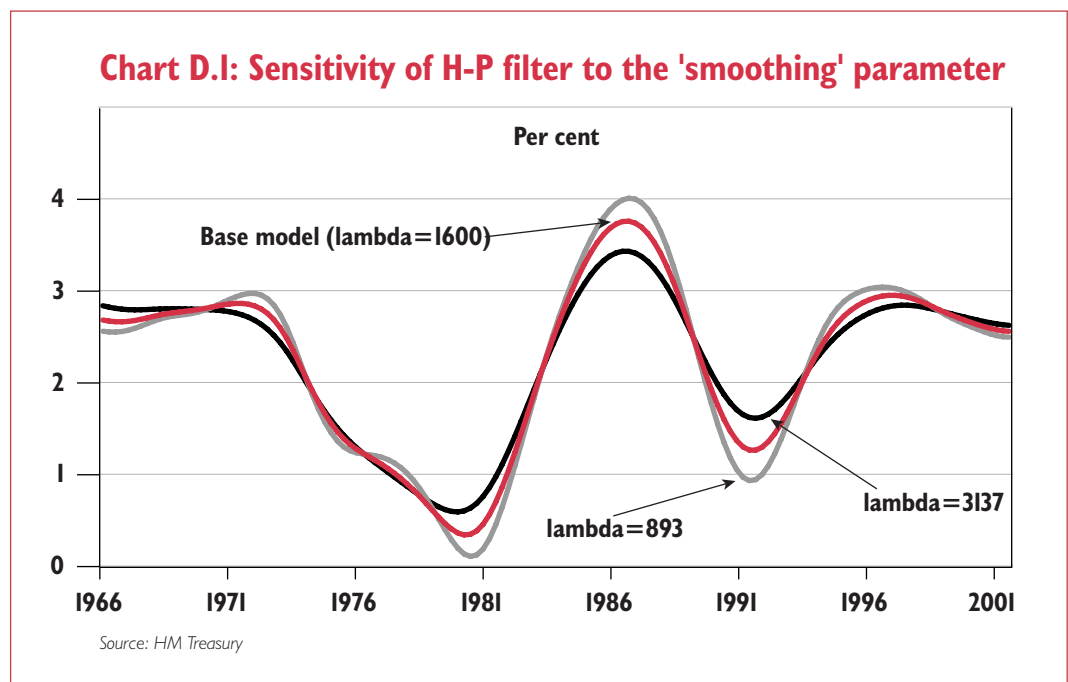
**C.15** The production function approach to estimating trend growth has a number of attractive features. It provides a clear link between output and its determinants, enabling estimates of trend growth to be based on forecasts of the components. It can also help estimate the impact of structural change on trend growth. However, while a number of international institutions adopt the production function approach, there are a number of practical problems with implementation. In particular the underlying determinants (potential employment and potential capital) are unobservable and have to be estimated. Assumptions made to estimate the potential capital stock could be especially significant in light of the development of the ICT sector.

## ANNEX D: HODRICK-PRESCOTT FILTER ESTIMATES OF TREND GROWTH

**D.1** The H-P filter estimates trends by minimising the difference between an observed series and its trend subject to a smoothness constraint, involving a parameter commonly known as 'lambda'. The greater the degree of smoothness imposed, the closer the trend path will be to a straight line (i.e. the deterministic trend approach). The lower the degree of smoothness then the closer 'trend' series will be to the observed one. Obviously, the interest is in applying a value for lambda between the extremes of infinity and zero which delivers a reasonably smooth trend. In practice, the smoothness parameter is chosen arbitrarily and most studies use the value for lambda set in Hodrick-Prescott's (1980) original paper<sup>1</sup>.

**D.2** In this annex simulations are repeated using alternative values for lambda. In the absence of a well-defined theory for choosing lambda, the arbitrariness of the resulting estimates of trend growth is a serious shortcoming of the filtering method.

**D.3** To illustrate the effects of the choice of lambda, trend output was estimated for the UK for the period 1966 to 2001. The central estimate uses a value of lambda of 1600 (the conventional figure), while alternative values of 3137 and 893 were used to show the effect on the trend growth estimate<sup>2</sup>. Applied to the UK data the different values imply estimates of trend growth ranging between 2.54 per cent and 2.66 per cent for the most recent period.



<sup>1</sup>i.e. lambda = 1600; for quarterly data.

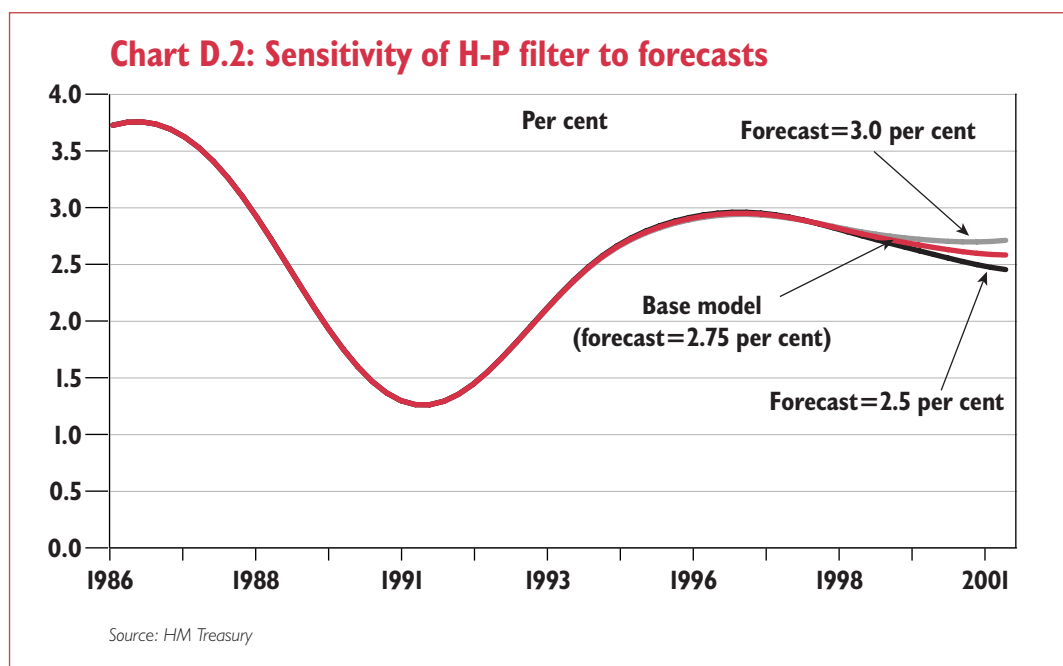
<sup>2</sup>The alternative values for lambda are taken from calculations by Ross and Ubide 2001.

**D.4** The choice of lambda is not the only problem with using H-P filters to estimate trend growth:

- it takes no account of information from other data series than output in identifying the trend and cyclical components of growth. For example, changes in inflation might help to identify whether output was above or below trend. Multivariate statistical techniques can be used to overcome this problem, although this comes at the cost of being less straightforward to implement;
- it cannot detect structural breaks in trends, but rather spreads the effect of any break over periods both before and after the break. This may generate misleading estimates of trend output; and
- it has been shown the H-P filter can induce spurious cyclical patterns into the data when there are none<sup>3</sup>.

**D.5** Another key problem is that the H-P filter is not very reliable at estimating trend output at the end of the sample, as it is unduly influenced by the last data points. This limits its usefulness for policy-makers as the recent past is the part of the sample that is of most interest. A common approach to deal with this problem is to add forecasts of output to the historical data. But this just turns the end-point problem into a forecast error problem. Moreover, the forecasts themselves may be dependent upon an assumed trend growth rate (at least when forecasting into the medium term) which leads to an element of circularity.

**D.6** The sensitivity of the estimates of trend growth for the current period to the forecasts of actual non-oil GVA growth is demonstrated in Chart D.2. Chart D.2 shows the implications of assuming three different paths for the forecasts of output beyond the end of 2001 – with growth of  $2\frac{1}{2}$ ,  $2\frac{3}{4}$  and 3 per cent over the medium term. The result is striking: the series begin to diverge well before the forecast period when the actual growth rates diverge. By 2001Q4, the implied trend growth rates range from 2.5 to 2.7 per cent per annum – a significant difference in this context.



<sup>3</sup>Harvey and Jaeger 1993

## CONCLUSION

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**D.7** The H-P filter is best used as a rough check on estimates of trend growth. The range of estimates produced by the H-P filter on reasonable assumptions is consistent with the Treasury's analysis in section 2 which estimates trend growth over 1997H1-2001Q3 of 2.6 per cent. This also matches the EC's estimate referred to in Table 4.1.



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