Office for
Budget Responsibility

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How we present uncertainty

June 2012

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1 Introduction

1.1 In our *Economic and fiscal outlook* (*EFO*) publications we set out a central, or median, forecast. In other words, we believe at the time of making the forecast that the risks to it are balanced, such that the actual outcome is as likely to be above our expectations as below.

1.2 The chances of any economic or fiscal forecast being accurate in every dimension are infinitesimally small. This reflects uncertainty both about the outlook for the economy and about the performance of revenues and spending in any given state of the economy. Given these uncertainties, we probe the robustness of our central forecast in three ways:

- first, by looking at past forecast errors, which we illustrate through the use of fan charts;
- second, by seeing how our central fiscal forecast would change if we altered some of the key economic judgements that underpin it; and
- third, by looking at wider alternative economic scenarios.

1.3 This paper sets out these approaches in more detail, often in the context of the forecast presented in our March 2012 *EFO*. The principles are however applicable to future forecasts.

1.4 All of the approaches are inevitably more stylised than our central forecast. The past can only ever be an imperfect guide to the future, and forward-looking scenarios cannot hope to capture all the ways in which the economy or public finances might deviate from the central forecast. But whilst it is worth being aware of these limitations, it is just as important to consider the overall degree of uncertainty that these approaches suggest.

2 Fan charts

Introduction

2.1 The uncertainty about the outcome of a variable – for example GDP growth or public sector net borrowing – can be represented by a probability distribution, which attaches weights to the likelihood of a range of different outcomes. Fan charts bring together a series of these distributions, each relating to a particular period of time.

2.2 For both the economic and fiscal outlook, we believe that the risks around our central forecast are balanced, such that it is equally likely that the eventual outturns will come in above them as below them. But past experience and common sense suggest that these risks can be pronounced on both the upside and downside.

2.3 One way to illustrate this uncertainty is to draw lessons from the accuracy of previous official forecasts. This chapter provides an overview of past forecasting errors, which other than the most recent observation, relate to past Treasury forecasts. It also discusses how we use these to generate fan charts for key economic and fiscal variables, and in particular GDP growth, public sector net borrowing and the cyclically-adjusted current budget balance.

2.4 Taking on board the lessons is by no means an exact science. And more generally, the past can only ever be an imperfect guide to the future, particularly given that the models and methodologies used in the past will differ from our own. The approach does however recognise the great uncertainty surrounding all forecasts of the economy and public finances.

2.5 The final fan charts do not represent our assessment of specific risks to the central forecast. Neither can they fully capture the extreme range of potential outcomes. We would usually expect forecast errors to fall within a reasonable band around our central forecasts, and the fan charts capture this general degree of uncertainty reasonably well. However, on occasion, we would also expect substantial shocks to occur. It is not possible to build such events directly into our fan charts without introducing bands so wide as to make the illustration near meaningless.

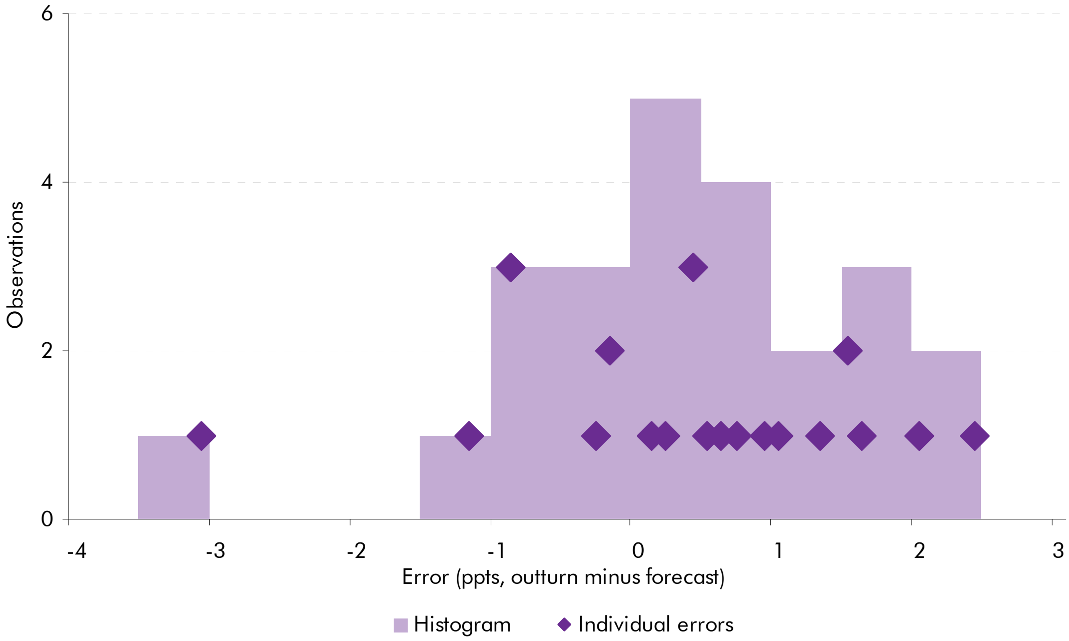
GDP

2.6 In the economy chapter of our *EFOs*, we present a fan chart for real GDP growth, giving a sense of the uncertainty around our central economic forecast. But it is of course only one amongst a much wider set of economic variables that we forecast.

Distribution of past forecast errors

2.7 The errors used to generate the fan chart are derived from official forecasts published from 1988 onwards.[1] Chart 2.1 illustrates the frequency distribution of these errors for in-year forecasts of GDP growth produced in official spring or summer forecasts. The chart plots the number of occasions that particular errors have occurred. But it is often clearer to group these observations into bands, in this case of ½ per cent, to form a histogram.

Chart 2.1: Spring/summer in-year GDP growth forecast errors



2.8 The errors have been concentrated fairly close to zero, with perhaps a marginal tendency to under forecast growth. The spread of errors is roughly even around that focal point.

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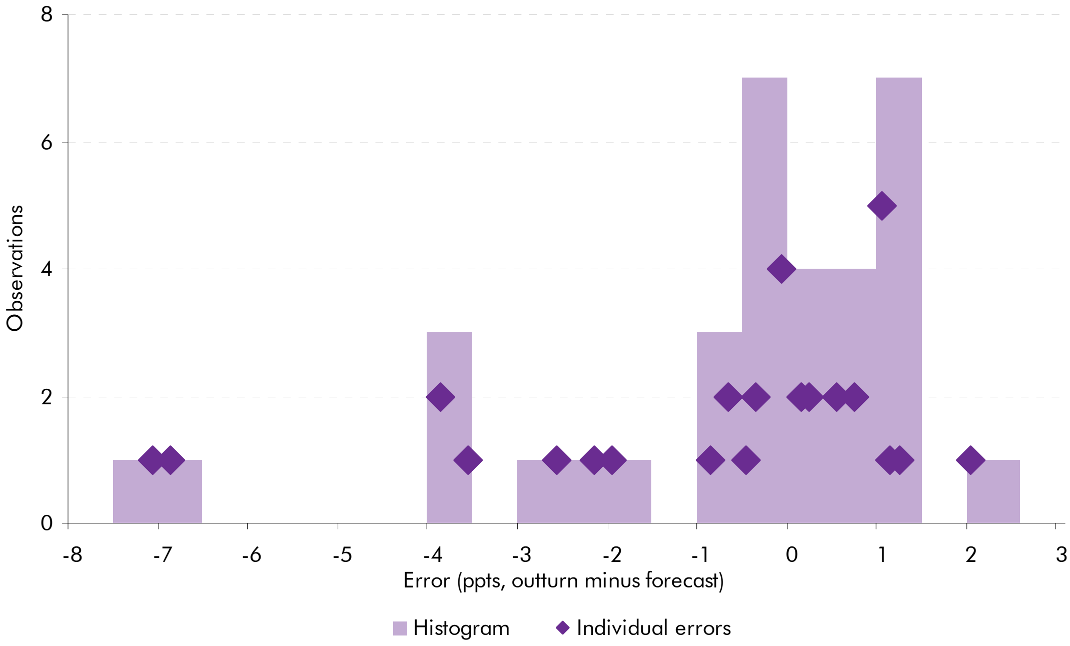
[1] These and earlier official forecasts are available on our website. Until 1998, the forecasts related to GDP at factor cost.

2.9 For forecasts of economic growth further into the future, the distribution of errors is not even. Whilst errors remain concentrated close to zero, forecast errors where the outturn has been lower than forecast tend to be larger than errors where outturn GDP growth has been higher than forecast. This reflects the distribution of actual growth, with the negative deviation from average growth rates experienced during recessions being much greater than the positive deviation during upswings. As recessions are by their nature difficult to forecast, this feature of the distribution of actual data carries over into the distribution of forecast errors.

2.10 Chart 2.2 illustrates this point using three year ahead GDP growth forecast errors. The profiles for other years are illustrated in Box 2.1. For periods further than a year ahead, we combine errors from spring/summer and autumn forecasts, allowing us to expand the sample of observations. Over a shorter horizon, the additional data available in autumn forecasts may affect the distribution of errors, but this would not be expected to affect periods further ahead.

Chart 2.2: Three year ahead GDP growth forecast errors



Box 2.1: Errors forecasting GDP growth (calendar year)

Chart A: Spring/summer in-year

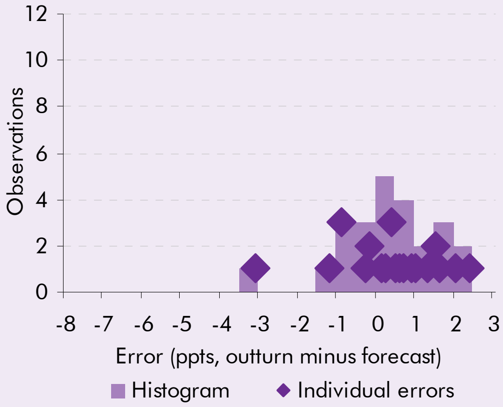


Chart B: Spring/summer year ahead

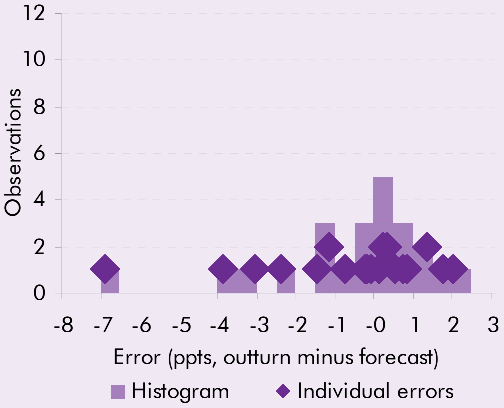


Chart C: Two years ahead

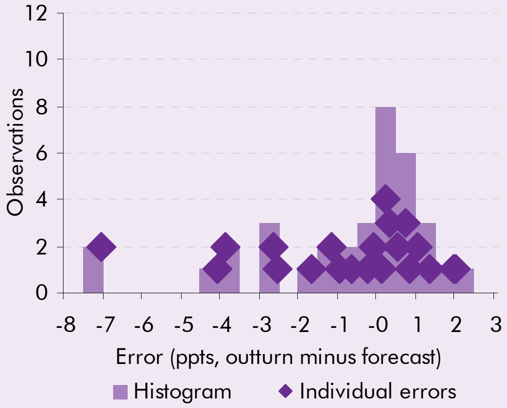


Chart D: Three years ahead

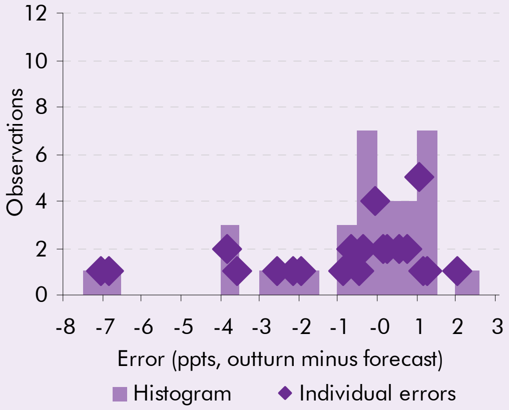
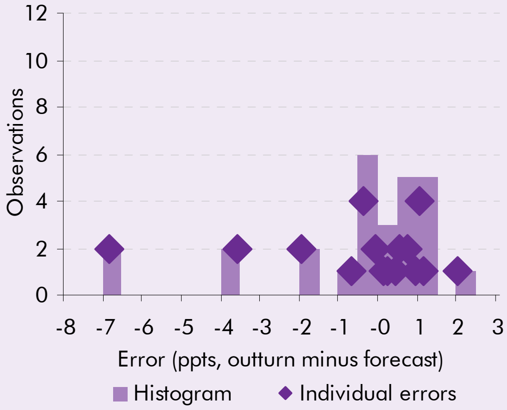


Chart E: Four years ahead



Constructing the distributions for the fan chart

2.11 The actual distribution of past errors is very erratic. So we do not replicate the precise shape, but instead attempt to generate a smooth picture that draws upon the main features of this distribution.

2.12 A normal distribution is commonly used to achieve such a goal. This forms a classic bell shape around a central point, requiring two parameters: a mode and a standard deviation. The mode represents the most likely outcome, or peak, of the distribution. The standard deviation is a measure of the spread of outcomes, defining how widely they fall around this focal point. For the in-year forecast, we assume that errors are normally distributed. This is broadly consistent with the picture of past in-year forecast errors, as set out in Chart 2.1.

2.13 But as also discussed above, errors for medium-term economic growth have not been shaped in the same way, and instead have been skewed on the downside. The GDP fan chart displays this skew of risks. There is an equal chance that growth will be above or below our central view, but the expectation is that errors on the downside will be larger than errors on the upside.

2.14 To create the fan chart we have used a '2-piece normal' distribution.[2] This distribution effectively splices together halves of two separate normal distributions, both with the same mode, but with differing standard deviations. Chart 2.3 shows an illustrative example of how this distribution contrasts with the standard normal distribution.

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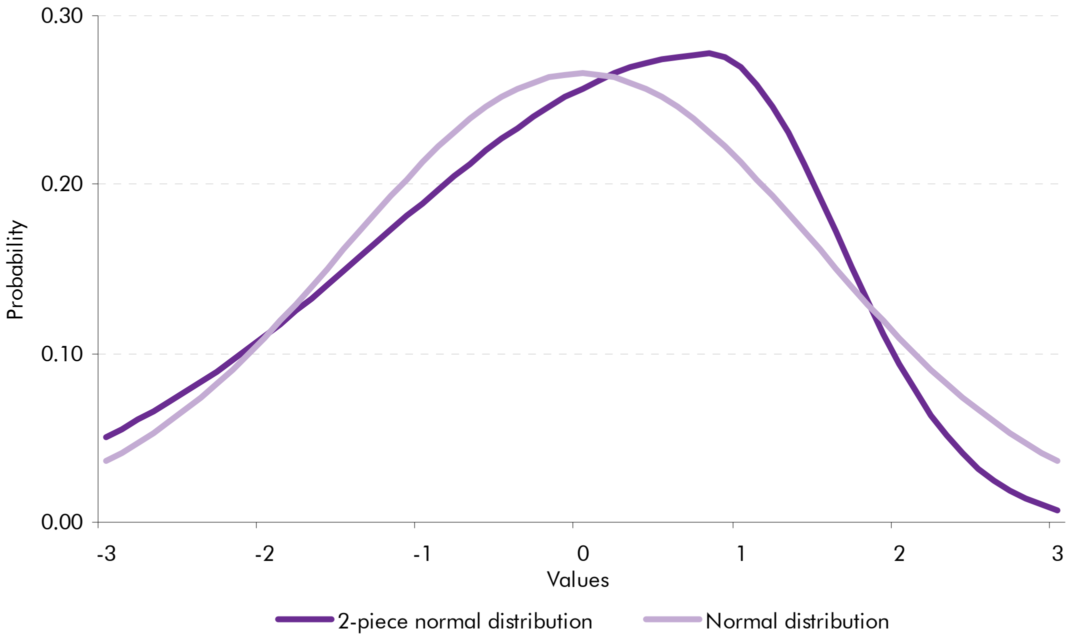
[2] See Johnson, Kotz and Balakrishnan (1994).

Chart 2.3: Illustrative comparison of the 2-piece and normal distributions



2.15 We could use other distributional forms, for example the skew-normal distribution.[3] But given the erratic nature of actual errors, we would not expect any noticeable gains by using any other well-defined distribution. The 2-piece normal distribution benefits from familiarity, as it is has been used by other institutions, including the Bank of England.[4] Its defining skew parameter is also reasonably straightforward to interpret.

2.16 The distribution is defined by three parameters: the mode and standard deviation, with the same interpretations as for the normal distribution, and a skew parameter. This additional third parameter determines the balance of risks, or the extent and degree to which risks are weighted to the upside or downside.

2.17 The true measure of the skew is a multiple of the difference between the mean, the average of all possible outcomes, and the mode of this distribution. We use this relationship to establish its values. Assuming the most frequent outcome in the past has been an error close to zero, which appears plausible given the evidence in Box 2.1, the skew is simply a multiple of the mean error.

2.18 We use the standard deviation of past forecast errors to illustrate the likely range of uncertainty, which determines the width of the fan chart. Together, the skew and the standard deviation define the shape of the distribution. The mode simply determines where this is concentrated along the broad spectrum of potential outcomes and is informed by our central median forecast.

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[3] See for example Chang, Lin, Pal and Chiang (2008).

[4] See Britton, Fisher and Whitley, Bank of England (1998).

2.19 Table 2.1 sets out the parameters of past errors that we use to derive our GDP fan chart. By comparing previous forecasts with the latest vintage of data, we are assuming that they have been computed on a comparable basis. That may not necessarily be the case. For example, changes to the way in which nominal GDP is deflated to calculate real GDP, introduced in *Blue Book 2011*, generally increases real GDP growth rates. However, this change was not anticipated in forecasts produced prior to that point.

Table 2.1: Parameters for GDP fan chart

	Calendar year				
	Current[1,2]	1[1]	2	3	4
Skew (mean - mode)	0.0	-0.5	-0.7	-0.7	-0.6
Standard deviation	1.2	2.0	2.2	2.2	2.2

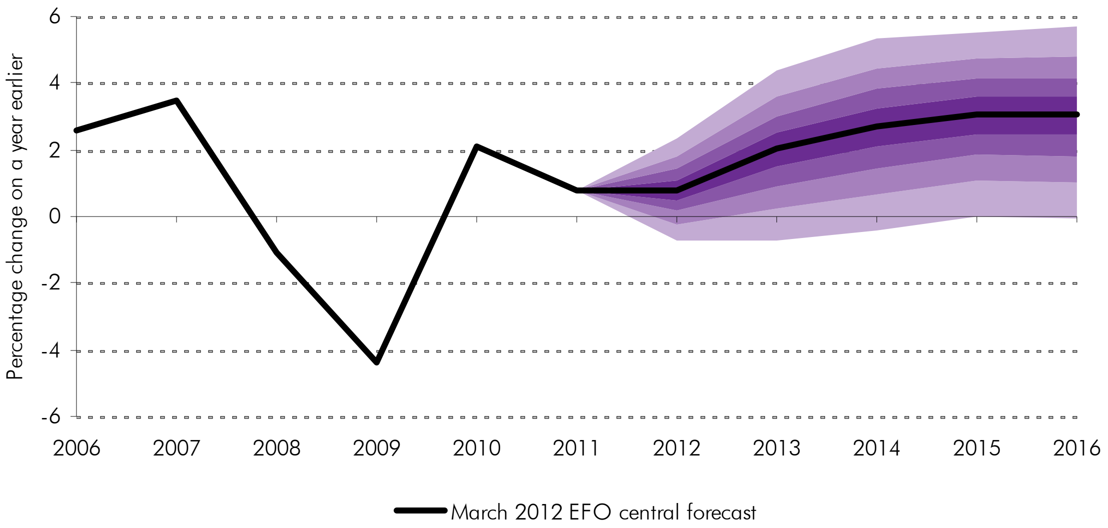
[1] Relate to spring/summer forecasts only.

[2] For the current year, where we assume a normal distribution, the mean error is not used to derive a skew.

Interpreting the fan chart

2.20 Chart 2.4 presents the March 2012 *EFO* growth forecast with the fan chart showing the probability of different outcomes based purely on past official forecasting errors. The solid black line shows our median forecast, with successive pairs of lighter shaded areas around it representing 10 per cent probability bands.

Chart 2.4: March 2012 *EFO* GDP fan chart

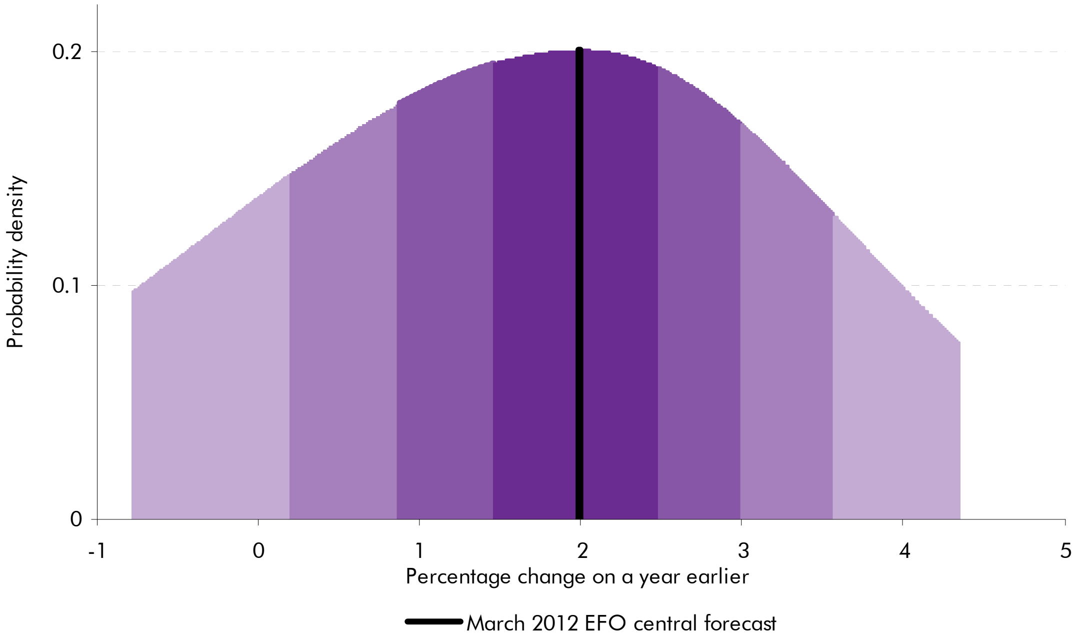


2.21 The chart suggests, purely based on the evidence of past forecast errors, that there is only a 20 per cent probability of growth being between ½ and 1 per cent in 2012 or between 1½ and 2½ per cent in 2013.

2.22 The fan chart is a collection of a number of distributions, with each relating to a particular year of the forecast. We can slice the fan chart into its corresponding pieces, with Chart 2.5 showing the implied probabilities for growth in 2013 as an example. The central forecast and the coloured bands are directly comparable to Chart 2.4. But the balance of risks is perhaps more evident in this picture. For example, the probability of being 2 percentage points below the central forecast, with zero growth, is noticeably above the probability of being 2 percentage points above, with growth of 4 per cent.

2.23 We only show the central 80 per cent of the distribution. On occasion, we would expect the final growth outcome to lie outside the range illustrated in our fan charts.

Chart 2.5: March 2012 *EFO* probability projections for 2013 GDP

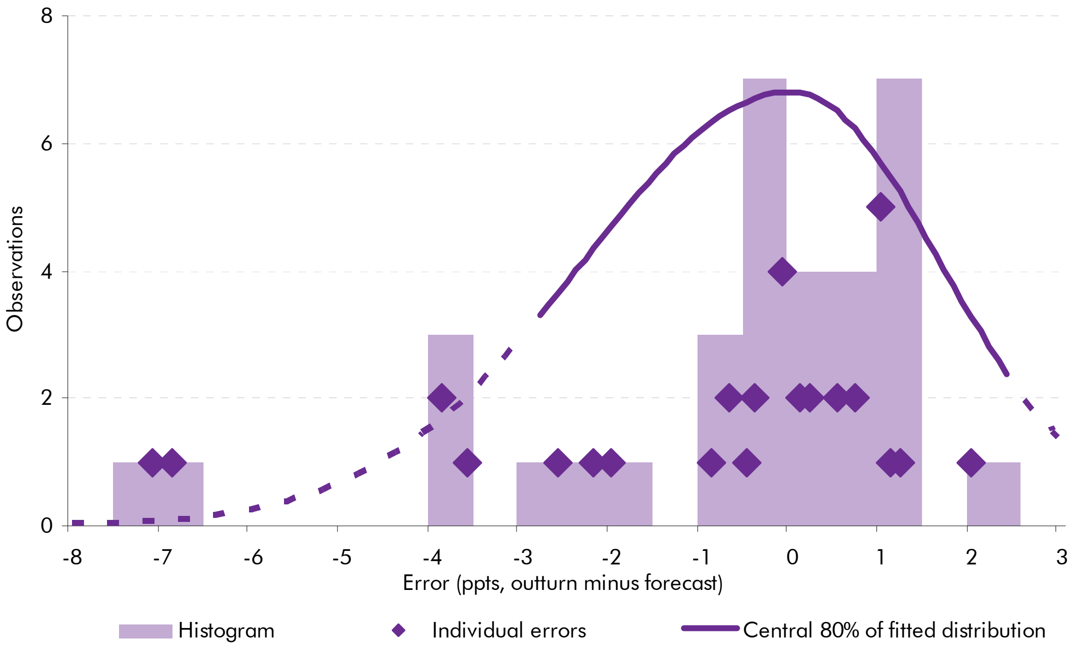


2.24 Chart 2.6 returns to the original forecast errors three years ahead, set out above, and illustrates how these relate to the assumed distribution of outcomes that we are applying to our forecasts over that horizon. It also shows what the 2-piece normal distribution would imply for outcomes beyond the central 80 per cent.

2.25 As can be seen, the actual tail of negative outcomes is fatter than our assumed distribution would otherwise imply. On occasion, we would expect substantial shocks to occur, such as the 2008-09 recession, and under such circumstances the entire distribution of potential outcomes would shift significantly lower. But it is impossible to judge if or when that would be and we cannot build such events directly into our fan charts without introducing bands so wide as to make the illustration near meaningless.

2.26 By including the larger errors in our calculation of the standard deviation, we may also be overstating the degree of uncertainty in more 'normal' times. Of course, without the benefit of hindsight, it is not possible to identify what are normal or unusual periods.

Chart 2.6: Three year ahead GDP growth forecast errors and the fitted distribution



Public sector net borrowing

Distribution of past forecast errors

2.27 The public sector net borrowing (PSNB) fan chart is also generated using errors relating to forecasts published from 1988 onwards.[5] Box 2.2 sets out how these evolve as the forecast horizon gets longer.[6] As for GDP growth, we combine errors from spring/summer and autumn forecasts for periods further than a year ahead.

2.28 The spread of errors rapidly expands as the forecast horizon moves towards two years, and more gradually thereafter. This is a similar story as for GDP growth, although the spread is generally wider throughout. That is not surprising, given that as well as uncertainty around the economic outlook, there is also uncertainty around the level of receipts and spending given the state of the economy.

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[5] These and earlier official forecasts are available on our website. Until 1998, the forecasts related to the public sector borrowing requirement, which is now more familiarly known as the public sector net cash requirement.

[6] For forecasts produced from April onwards, 'in-year' is assumed to relate to the previous fiscal year, ending in March of that calendar year.

Box 2.2: Errors forecasting PSNB/GDP

Chart A: Spring/summer in-year

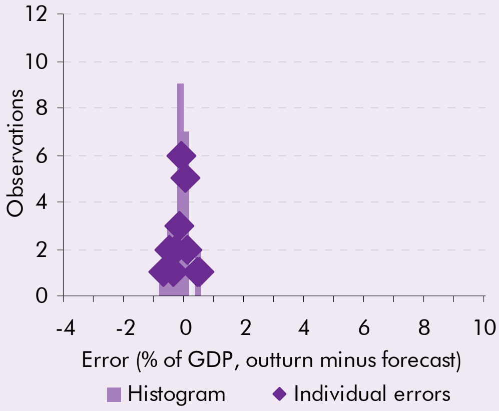


Chart B: Spring/summer year ahead

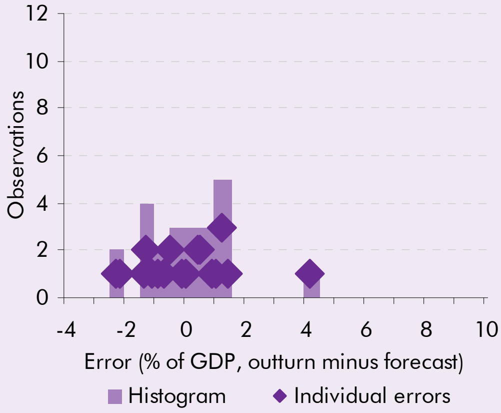


Chart C: Two years ahead

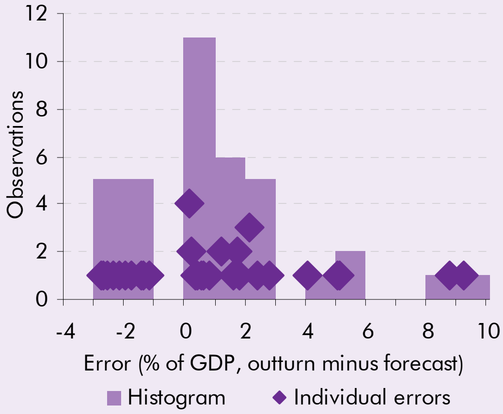


Chart D: Three years ahead

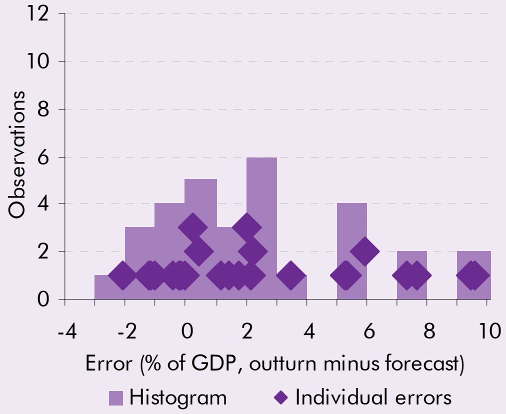


Chart: E Four years ahead

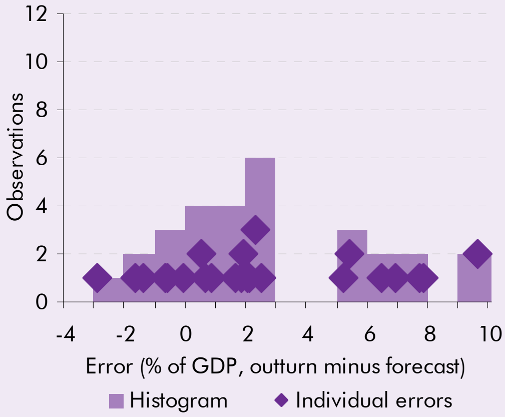
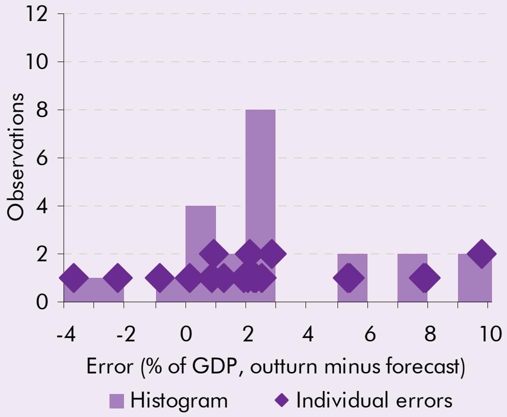
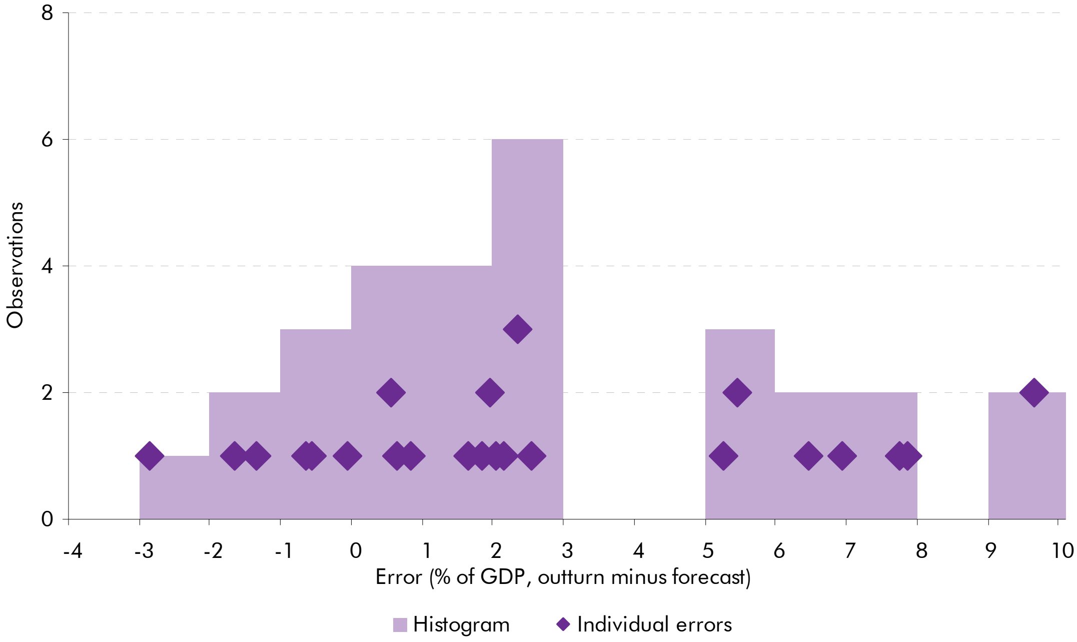


Chart F: Five years ahead



2.29 However, there are two other features that distinguish the series from the GDP growth errors: the average forecast error increases over time, being clearly above zero in later years; and the errors are more evenly spread, with there being less evidence of a skew. Chart 2.7 illustrates this issue using the frequency distribution of errors for four year ahead PSNB forecasts.

Chart 2.7: Four year ahead PSNB forecast errors



2.30 PSNB forecasting errors will to some extent reflect economic activity in all the preceding years of the forecast, whilst the GDP errors relate to one year only. This may at least partially explain the difference in average errors over time. Whereas the most likely error for GDP growth may be close to zero in all years, the effects on borrowing of weakness in any given year may persist in later periods. In contrast, weak growth in one year may be followed by similarly weak growth a year later, or be the platform for stronger growth.

2.31 Intuitively, a skew in the distribution of real GDP growth would be expected to feed into PSNB errors at some stage. The distributions of errors do not refute that argument, but neither do they display overwhelming evidence for it.

2.32 The pattern may reflect marginally different outcomes in nominal GDP, which more directly determines PSNB. Shocks that lead to weaker-than-expected real GDP growth, but also higher-than-expected inflation, may lead to nominal GDP and PSNB remaining closer to forecast and so being less skewed (although such a shock would likely lead to errors in other parts of the forecast, such as the labour market, that would also raise PSNB). Box 2.3 sets out the errors in forecasting nominal GDP growth. These are generally more evenly clustered than for real GDP growth, but also have a number of extreme downside errors.

2.33 Subsequent policy announcements that affect PSNB, but cannot have been foreseen at the time of the original forecast, will also affect the pattern of errors. Policy changes that correct deviations in fiscal outcomes from forecast will lead to smaller observed errors, which may partly explain why PSNB errors appear less skewed. Conversely, any policy loosening might be expected to lead to larger errors. As our forecasts are produced on the basis of unchanged policy, stripping out such effects would provide errors on a more comparable basis.

2.34 However, it is not straightforward to produce a policy-adjusted series over a sufficient period to inform the fan chart. In particular, data separating changes in spending due to forecasting errors and changes in policy are not readily available. There is more accessible information on changes in tax policy, as costings are provided at each Budget, although the original costings may incorporate their own errors or span a shorter period than the overall borrowing forecast horizon.

2.35 The effect of adjusting for tax policy changes on the distribution of errors appears to be minimal. It is difficult to draw strong conclusions from this, as the effect of incorporating spending policy changes may be more significant. In the interests of transparency, we have chosen to base the fan charts on the unadjusted series of errors highlighted above. That may imply that the range of uncertainty in our forecast of unchanged policies is greater than we illustrate below.

Box 2.3: Errors forecasting nominal GDP growth (fiscal years)

Chart A: Spring/summer in-year

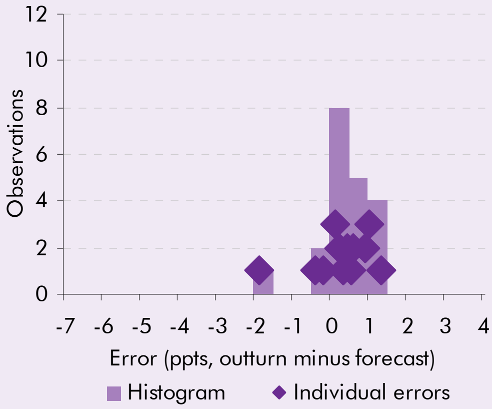


Chart B: Spring/summer year ahead

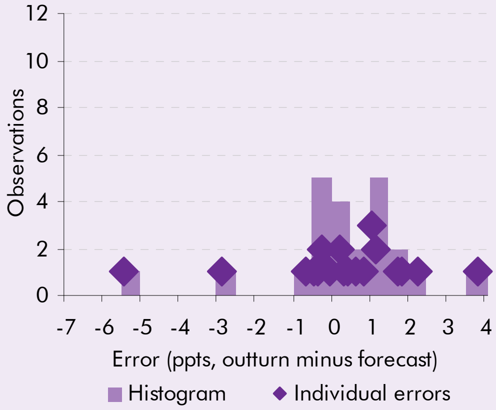


Chart C: Two years ahead

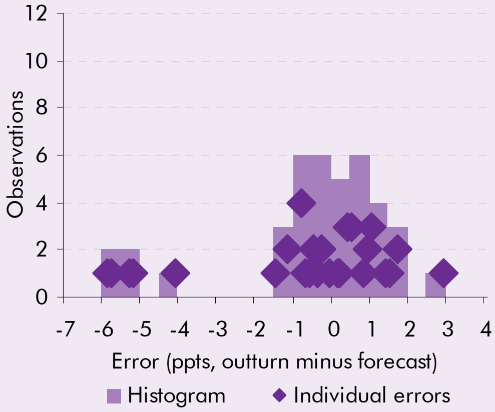


Chart D: Three years ahead

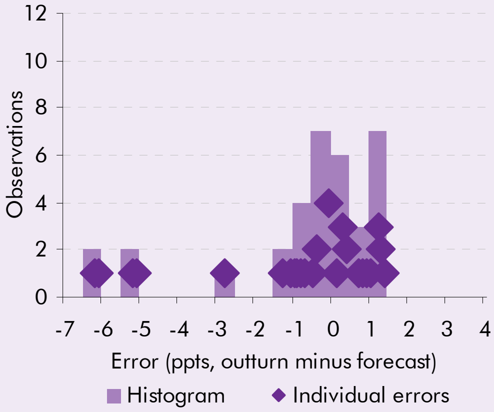


Chart: E Four years ahead

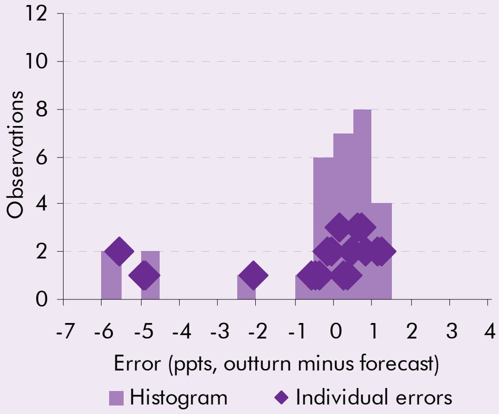
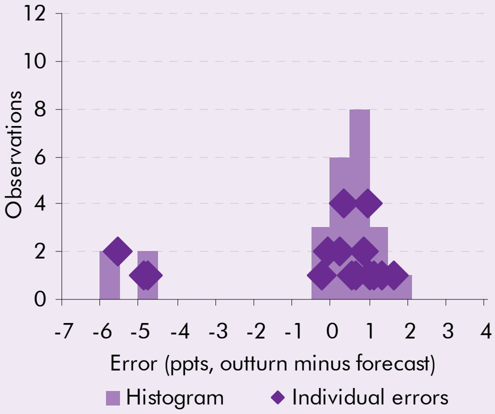


Chart F: Five years ahead



Constructing the distributions for the fan chart

2.36 In the past, as we were not able to confirm a skew in the distribution of past errors around the fiscal forecast, we assumed a symmetrical distribution. However, that presents a potential inconsistency with the GDP fan chart. Given the close link between borrowing and the economy, one might expect risks to PSNB to also be skewed. A glance at past PSNB errors would also suggest the balance of risk is towards more negative outcomes (higher borrowing), which fits in with what we would otherwise expect. Therefore, to ensure a coherent picture across the piece, we now skew the PSNB fan chart.

2.37 It is not possible to use the PSNB forecast errors directly, as we do for GDP growth, because it is not clear what the historical modal error has been. It is however possible to tie up our view of uncertainty around potential borrowing outcomes with uncertainty around growth using a ready reckoner that links changes to GDP to PSNB.[7] In particular, the ready reckoner assumes that a 1 per cent change in GDP will result in a 0.5 per cent of GDP change in PSNB in the first year, and a full 0.7 per cent of GDP change in PSNB after two years. The background to this ready reckoner and its limits are discussed in Chapter 3.

2.38 We use the ready reckoner to derive a modal PSNB projection, given the modal path of GDP growth implied in Chart 2.4. These paths do not reflect our subjective view of the most likely outcome, but instead are the implied projections if one were to assume that past errors provided an accurate guide to future uncertainty, and that this guide could be perfectly mapped by a 2-piece normal distribution.

2.39 As for the GDP fan chart, we use the standard deviation of past errors. But the skew is implicitly derived through the difference between our central median forecast and the implied modal PSNB projection, rather than past errors. Table 2.2 sets out the parameters that we use to derive our PSNB fan chart.

Table 2.2: Parameters for PSNB fan chart

	Fiscal year					
	Current[1]	1[1]	2	3	4	5
Skew (mean - mode)	0.0	0.0	0.2	0.7	1.1	1.5
Standard deviation	0.3	1.4	2.8	3.2	3.4	3.5

[1] Relate to spring/summer forecasts only.

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[7] For alternative approaches, see for example Blix and Sellin, Riksbank (1998) or Cronin and Dowd, Central Bank of Ireland (2011).

2.40 When moving from GDP to PSNB, we assume that the calendar year modal GDP growth figures directly translate into a modal fiscal year GDP profile over time. The effect of the calendar to fiscal year switch is minimal.[8] More substantively, annual errors are likely to be correlated. So for example, annual modal growth may be 3½ per cent for 2015 and 2016, but the most likely outcome will not be successive growth rates of 3½ per cent in both 2015 and 2016. Ideally, we would use a GDP levels fan chart, which would avoid this issue. However, we are unable to easily compile one. The forecast errors we use span different horizons, and so we cannot produce a consistent series.

2.41 All else equal, the skews we impose for our PSNB fan chart would therefore overstate the balance of risks. However, this approach does not capture any potential skew in modelling receipts and spending given the state of the economy. In more normal times, these errors in the fiscal forecast tend to dominate any error in the underlying economic forecast. We might expect that if the economy were significantly weaker than expected, that we would also overstate receipts or understate spending by a disproportionate amount.

2.42 HM Treasury's *End of year fiscal reports* split out the contributions to year-ahead PSNB forecasting errors due to: errors in the underlying economic determinants; errors in forecasting receipts and spending given the actual economic data; and unanticipated policy or classification decisions. We repeated a similar exercise in our 2011 *Forecast evaluation report*, when analysing our June Budget 2010 forecast for 2010-11. Chart 2.8 sets out the split as originally reported. It will not reflect the latest vintages of outturn data, but shows that the types of errors for any given year have typically been in the same direction.

2.43 It is not possible to identify how much of the error due to economic determinants reflected any error in forecasting GDP growth specifically. However, there is evidence that large errors due to an error in forecasting the economy are compounded by errors elsewhere.

2.44 In many cases, these would reflect errors in projecting the effective tax rate, over and above errors in forecasting the underlying economic base. This may, for example, reflect cyclical movements in tax evasion, or losses set against corporation tax payments, as well as changes in consumption or working patterns.

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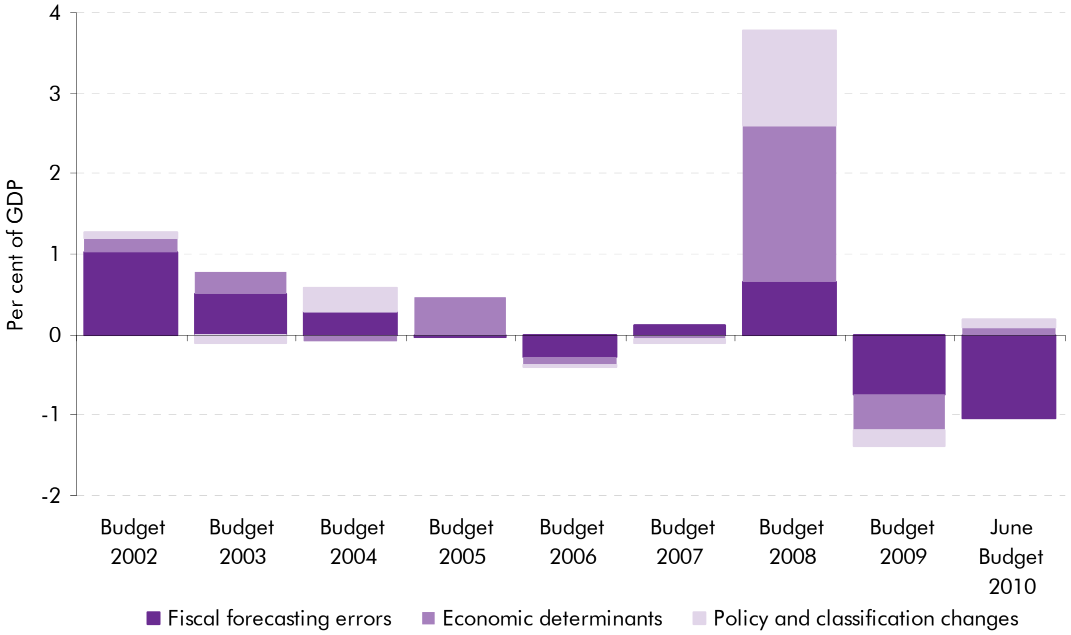
[8] Fiscal years span 9 months of one calendar year and then 3 months of another. For simplicity, we assume uncertainty over growth in the fiscal year matches uncertainty in the initial calendar year. So for example, there is the same degree of uncertainty around 2012-13 as there is for 2012.

Chart 2.8: Decomposition of year ahead PSNB errors



Interpreting the fan chart

2.45 Chart 2.9 presents the March 2012 *EFO* PSNB forecast with the fan chart showing the probability of different outcomes based on the approach described above. The solid black line shows our median forecast, with successive pairs of lighter shaded areas around it representing 10 per cent probability bands. Chart 2.10 illustrates the degree of uncertainty around the 2016-17 forecast in particular.

2.46 PSNB is expected to fall as a share of GDP in 2012-13, reflecting the transfer of assets once Royal Mail's historic pension fund moves to the public sector. But there is significant uncertainty over the path thereafter. By 2016-17, there is only around a one in five probability that borrowing will be within 1 per cent of GDP of our central forecast.

Chart 2.9: March 2012 *EFO* PSNB fan chart

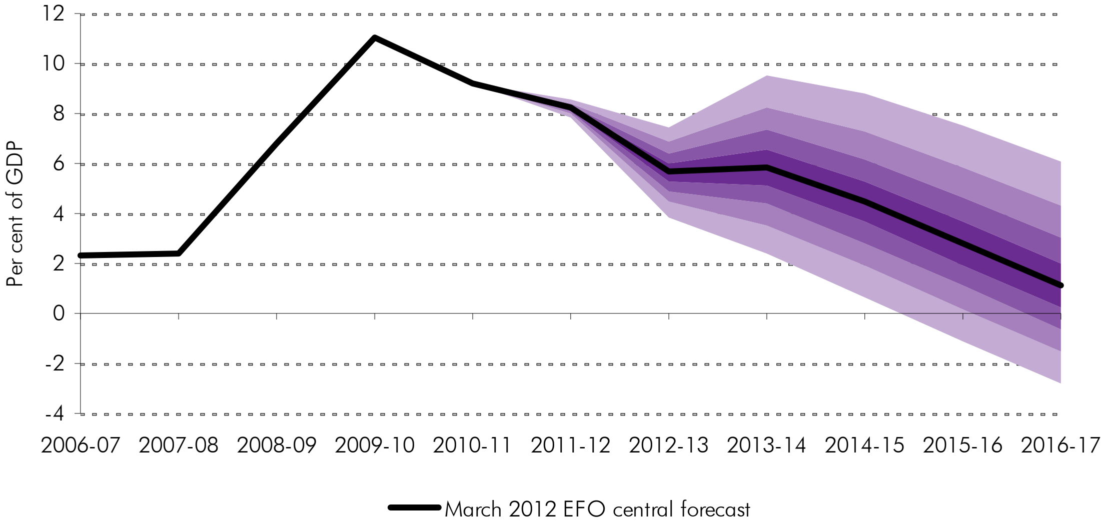
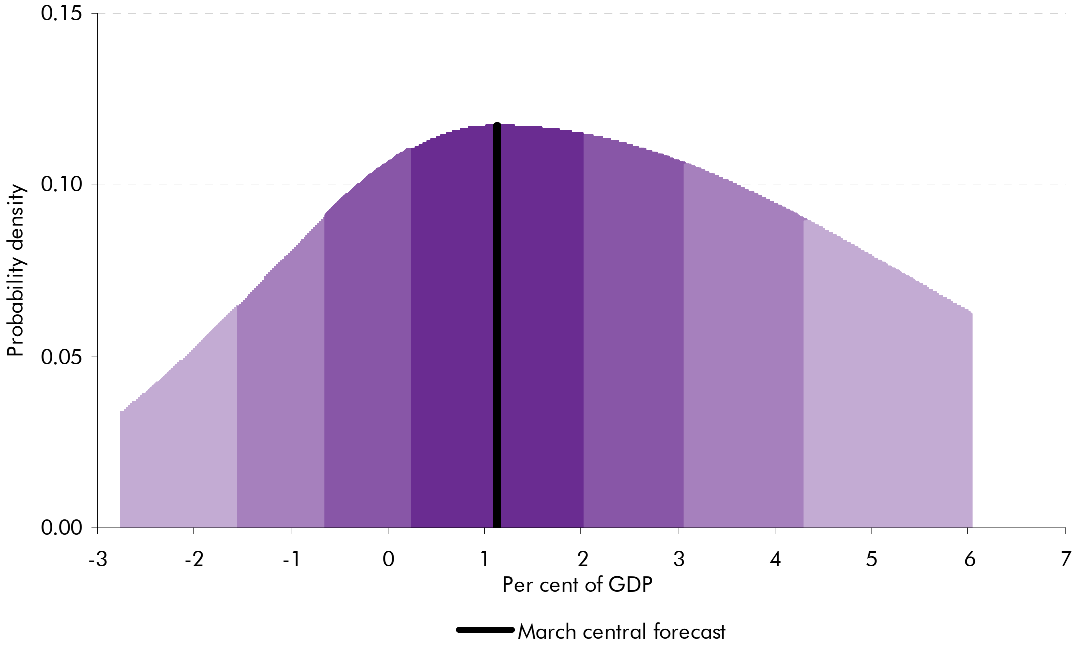
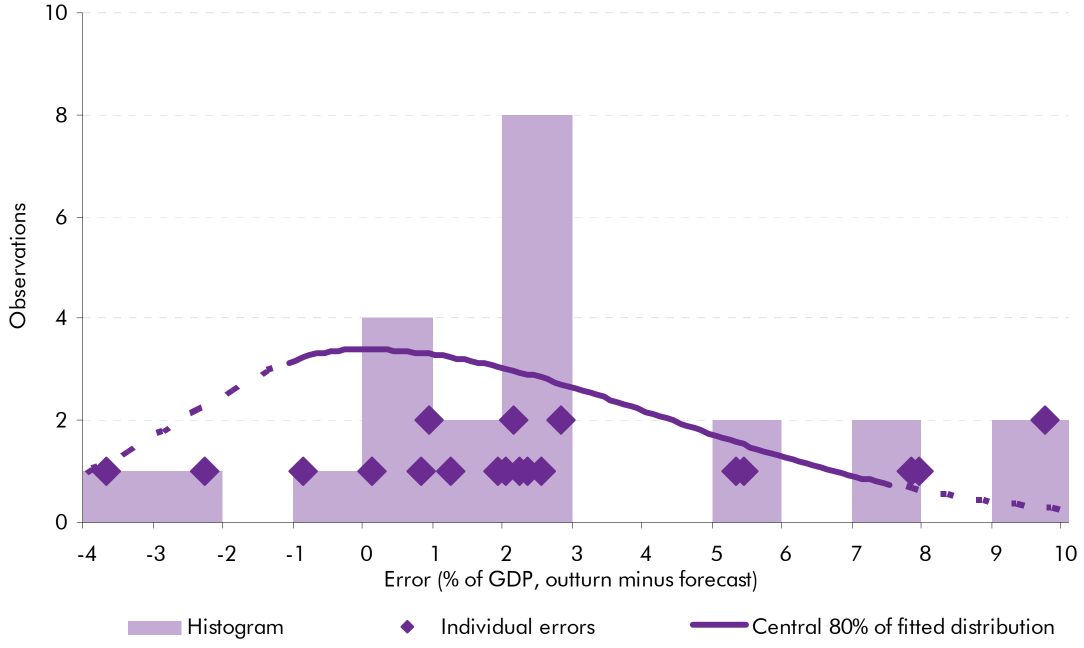


Chart 2.10: March 2012 *EFO* probability projections for PSNB in 2016-17



2.47 Chart 2.11 illustrates how the assumed distribution of outcomes in 2016-17 relates to past errors over a similar horizon. We only take on board the shape of the distribution and not the average error. Whereas in the past, errors have been significantly positive and above zero, we judge that it is reasonable to assume that in the future the median error will be zero, as we have sought to balance risks on the upside and the downside. The chart reinforces the point that we would, on some occasions, expect the final outcome to lie outside the bounds illustrated in our fan chart.

Chart 2.11: Five year ahead PSNB forecast errors and the fitted distribution



Assessing the Government's fiscal targets

2.48 In the June 2010 Budget the Coalition Government set itself a medium-term fiscal mandate and a supplementary target:

- to balance the cyclically-adjusted current budget (CACB) by the end of a rolling five-year period; and
- to see public sector net debt (PSND) falling as a share of GDP in 2015-16.

2.49 Our fan charts do not affect our judgements whether the Government has a greater than 50 per cent probability of meetings its targets. This is determined simply by asking whether our central, median, forecast shows the CACB in balance five years ahead, and public sector net debt falling as a share of GDP in 2015-16.

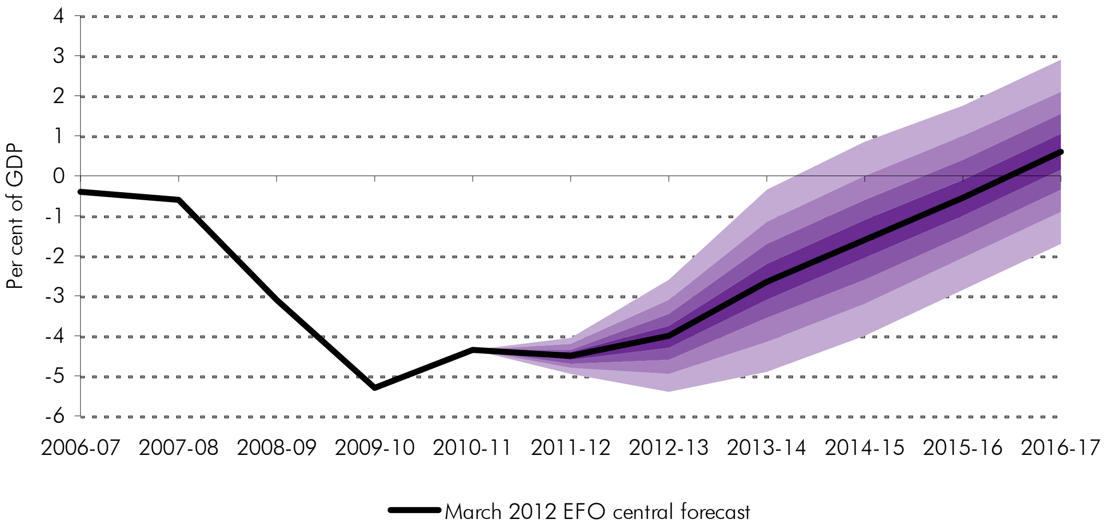
2.50 The CACB is the surplus on the current budget adjusted to remove the estimated effect of the economic cycle, in other words, the surplus we would see if the output gap was zero. We use a CACB fan chart to assess the margin between the Government meeting and missing its fiscal mandate.

2.51 As neither the output gap nor the effect on the current budget can be observed directly, we have no official outturn data by which to assess past forecasts against. Instead, we compare forecasts against our own estimates, and the corresponding errors are shown in Box 2.4.

2.52 CACB forecasts have only been produced since 1998.[9] The sample of errors is therefore significantly smaller than for GDP or PSNB. GDP growth and PSNB errors will largely relate to errors in forecasting the cyclical position of the economy. As the CACB should not move with the economic cycle, we would not expect the same pattern of errors to be repeated for the CACB. We therefore continue to assume that risks around the median CACB forecast are distributed symmetrically.

2.53 As shown in Charts 2.12 and 2.13, the margin between the Government meeting and missing its fiscal mandate is dwarfed by the uncertainty that surrounds the forecast over that time horizon.

Chart 2.12: March 2012 *EFO* CACB fan chart



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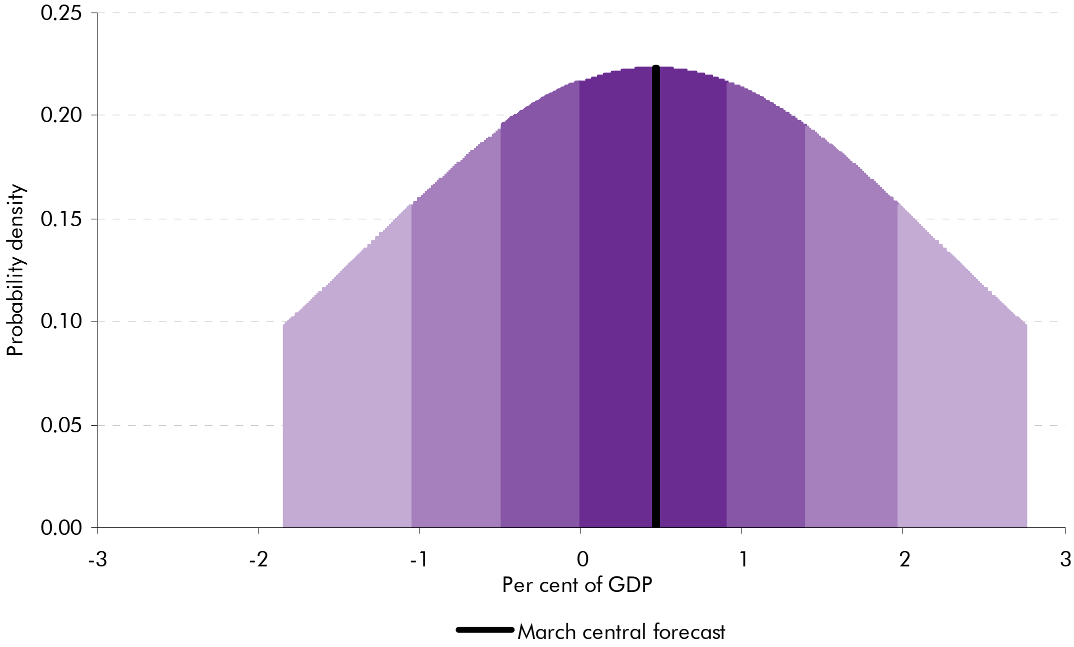
[9] The forecasts used are available on our website.

Chart 2.13: March 2012 *EFO* probability projections for CACB in 2016-17



2.54 Unfortunately, one cannot easily estimate the probability of achieving the supplementary target, which is to see PSND falling in 2015-16, given that we do not have a joint distribution that would allow us to apply the same technique. The change in PSND would partly be a function of the level of public sector net borrowing in 2015-16, which we capture in our PSNB fan chart, but also nominal GDP growth in that year and the level of public sector net debt in 2014-15.

Box 2.4: Errors forecasting CACB/GDP (fiscal years)

Chart A: Spring/summer in-year

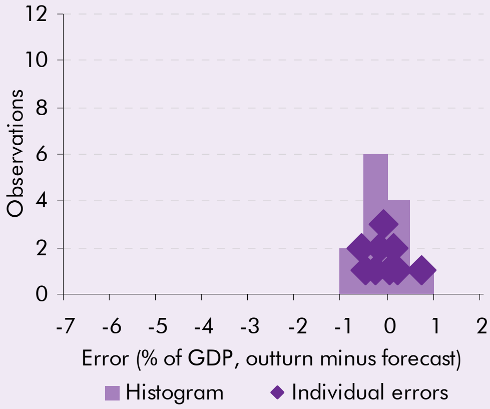


Chart B: Spring/summer year ahead

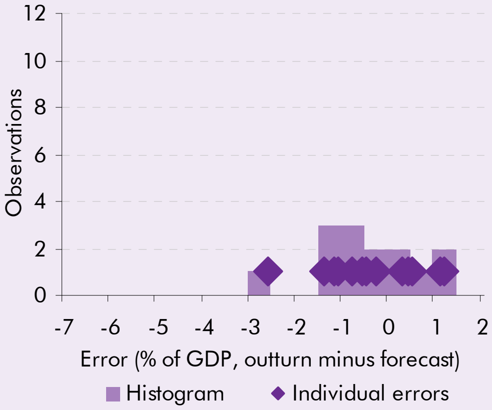


Chart C: Two years ahead

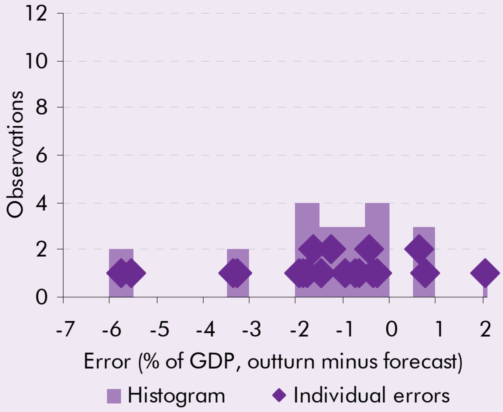


Chart D: Three years ahead

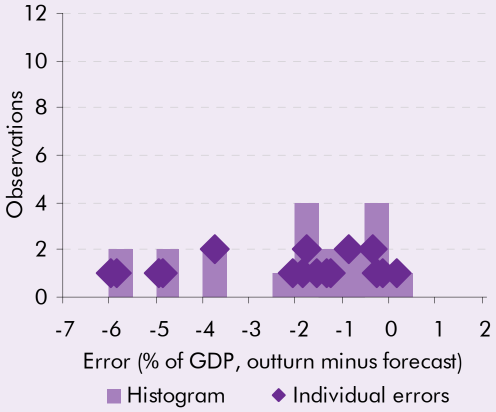


Chart E: Four years ahead

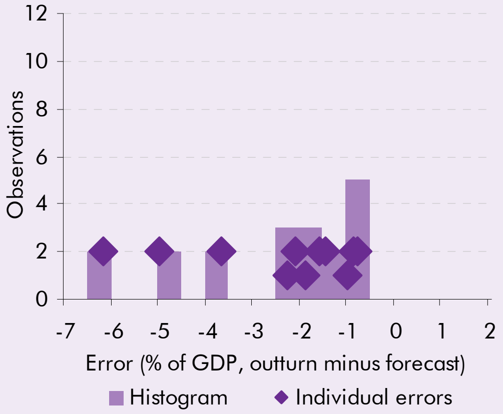
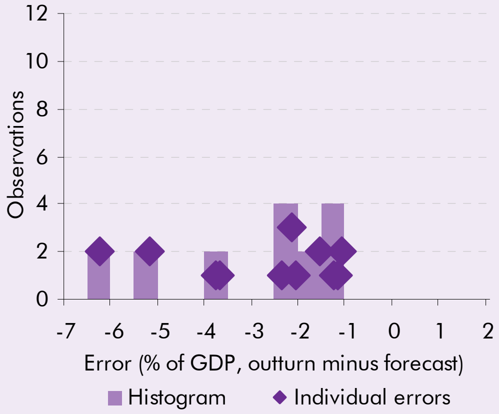


Chart F: Five years ahead



Other approaches

Methodology

2.55 The approaches set out above use past errors in a fixed and objective manner. We could alternatively choose to continue with the same broad framework, but set the parameters more flexibly, by choosing values that reflect our judgement at the time of each forecast. Although we reserve the right to do so, in such a case it may be difficult to explain how parameters have been chosen.

2.56 Nevertheless, there are other ways to producing a fan chart in an objective fashion. One option would be to consider a range of survey or market indicators.[10] We regularly illustrate a comparison against external forecasts within our *EFOs*. However, the range of survey responses is not necessarily a good guide to uncertainty, as it measures the dispersion of central opinions, whilst each forecaster will in fact have their own expected distribution around their stated forecast. Although market options data, for example for equity prices, may give a better sense of uncertainty, it is not straightforward to indicate what these imply for economic and fiscal outcomes.

2.57 Another option would be to generate stochastic simulations. Within this, the same model is repeatedly run with different draws from the error distribution and the outcomes aggregated in one chart. In practice, the fan chart would reflect the assumed distribution of the error term, which may not be particularly transparent. An additional layer of complexity would also be added, as the economic and fiscal forecasts are not produced by a single deterministic model. Over time, reconciling the two would be difficult.

Presentation

2.58 Our fan chart is centred on the median forecast, with bands either side, each representing 10 per cent of the probability distribution. We could instead centre the chart on the implied modal forecast, bringing the presentation more in line with the Bank of England's. For the charts in the Bank's *Inflation Reports*, rather than percentiles, bands are formulated in pairs, with each pair containing a band above and below the mode. Combined, the pair reflects a constant proportion of the distribution. With an unequal distribution of risk, one of the bands will be wider than the other and no particular band can be read off the chart by itself.

2.59 However, presenting the chart in this form would not be an effective way of presenting our particular set of forecasts. It would not be clear from such a chart what our central, median forecast actually was. It would also place disproportionate emphasis on a modal profile that would not reflect our view at the time.

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[10] See Elekdag and Kannan, IMF (2009).

3 Sensitivities and scenarios

Introduction

3.1 As discussed in Chapter 2, it is very difficult to produce a full subjective probability distribution of potential outcomes, given the huge variety of determining factors. However, to recognise the uncertainty in our forecast we can go further than using the lessons of past forecasting errors.

3.2 We do this by illustrating ways in which the economy might diverge from our central forecast and what the fiscal consequences might be. In particular, we alter a number of key economic judgements in isolation, but also look at wider alternative economic scenarios.

3.3 Our briefing papers *Forecasting the public finances* and *Forecasting the economy*, set out our approach to producing the central forecasts. For practical reasons, we do not undertake complete forecast runs for each variant, but instead use ready reckoners and simplifying assumptions to generate illustrative estimates. This chapter discusses the approaches used in more detail.

Key sensitivities

3.4 In Chapter 5 of our *EFOs*, where we assess the Government's prospects of meeting its fiscal targets, we regularly report on the sensitivity of our judgement to changes in four key parameters:

- the level of potential output, captured by the size of the output gap;
- the speed with which the output gap closes (i.e. the pace of the recovery);
- possible errors on our cyclical adjustment coefficients; and
- the interest rates that the Government has to pay on its debt.

Cyclical-adjustment ready reckoners

3.5 To consider the effect of any particular change in the size of the output gap, and/or the pace at which it closes, we first derive an alternative GDP growth profile consistent with that variant. We then apply ready reckoners, to move from the implied changes in the level of actual GDP over time, to changes in PSNB and the current surplus.

3.6 These ready reckoners are discussed in detail in our working paper, which estimates the sensitivity of borrowing to changes in the output gap.[1] It attaches coefficients of 0.5 on the current year's output gap and 0.2 on the previous year's output gap. In effect, if growth was 1 per cent weaker than expected, these would suggest borrowing would be 0.5 per cent of GDP higher in the first year, and a full 0.7 per cent of GDP higher after two years.

3.7 Using the coefficients requires the assumption that future economic cycles will repeat the same patterns as the average cycle in the past. Although that is unlikely to be the case, for simple illustrative purposes, we assume that it is.

3.8 The smaller the output gap, the larger the proportion of the deficit that is structural (and therefore impervious to economic recovery) and the less margin the Government has against its fiscal mandate. Conversely if potential output is higher relative to actual output, less of the deficit is structural and the Government has more margin against its mandate. Closing the output gap at a different pace will result in a change in cyclical borrowing, affecting the Government's prospects of meeting its supplementary target, but has little effect on the structural balance.

Cyclical adjustment coefficients

3.9 We also represent the sensitivity to the cyclically-adjusted fiscal balances of using different cyclical adjustment coefficients. These coefficients do not affect the headline current budget or net borrowing, but instead determine how much of it is structural. A lower coefficient would suggest that borrowing is less sensitive to changes in the output gap and would therefore remain higher as the output gap closes over time. More detailed analysis of the coefficients and the uncertainty around them is set out in our working paper *Cyclically adjusting the public finances*.

Debt interest ready reckoners

3.10 To assess the sensitivity to changes in the interest rate that the Government has to pay on its debt, we ready reckon the effect of 50 basis point movements in the effective conventional gilt rate. We only capture the direct effect on debt interest costs, and not any indirect effect on the economy and therefore other tax and spending items.

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[1] See Helgadottir et al, OBR (2012).

3.11 The ready reckoners we apply for this calculation are consistent with the model we use to forecast debt interest costs in our central forecast. The impact is dependent on a number of factors that are subject to change, in particular the profile of debt. As these factors move between forecasts, we revise the ready reckoners accordingly and publish them on our website, alongside other supplementary material to the forecast. The latest figures can be seen in Table 3.1.

Table 3.1: Debt interest ready reckoners

	£ billion				
	2012-13	2013-14	2014-15	2015-16	2016-17
1ppt increases in gilt rates	0.9	2.6	4.4	6.0	7.5
1ppt increase in short rates	1.0	1.0	1.0	1.0	1.0
1ppt increase in RPI inflation	2.8	3.4	4.2	5.2	6.2
£5 billion increase in CGNCR	0.1	0.2	0.4	0.6	0.8

Note: all increases are assumed to continue throughout the forecast period.

3.12 The effect of a persistent increase in the effective gilt rate gradually builds over time as higher rates only apply to new debt issuance, and the UK has a relatively long average debt maturity for conventional gilts.

3.13 Around two-thirds of debt interest payments over the forecast period are on conventional gilts, with most of the remainder on index-linked gilts. Positive RPI inflation raises the amount the Government is committed to paying on index-linked gilts, and this commitment is recognised in borrowing and net debt each year, but the actual cash payments will not occur until redemption of the gilt which may be many years in the future.

Scenarios

Approach to producing scenarios

3.14 Although the cyclical adjustment coefficients discussed above provide a useful benchmark, the actual sensitivity of our central fiscal forecast to an economic shock would be dependent on a number of wider factors, including the impact on inflation and the composition of GDP, as well as labour and asset market trends, which may not move in line with the typical economic cycle. We produce economic scenarios to illustrate the fiscal implications of varying some of these factors.

3.15 Given a particular scenario, we produce a bottom-up projection for borrowing, by applying ready reckoners that are informed by the models used to forecast each tax and spending component. We also align the numbers to the Government's stated policy assumption for total spending beyond the current Spending Review. Finally, we infer what the profile for the output gap implies for the cyclically-adjusted balances.

3.16 The scenarios are heavily dependent on judgement. The ready reckoners only show the direct impacts of determinant changes and not any indirect effects which may outweigh these. We attempt to capture those wider considerations within the broader scenario.

3.17 As an example, our 'temporary oil price spike' scenario discussed in the March 2012 *EFO*, sets out how the direct effect of higher oil prices on the public finances is likely to be positive, as higher oil and gas revenues more than offset a reduction in fuel duty. But the degree to which this is the case is very sensitive to the assumed levels of oil and gas production. The indirect effects on inflation and output are also likely to more than offset any apparent direct gains.

Tax and spending ready reckoners

3.18 Our briefing paper *Forecasting the public finances*, sets out the economic determinants that affect each of the main categories of receipts and spending. The scenarios offer only a broad-brush illustration and focus on a much narrower set of determinants than we project in our central forecast.

3.19 In our briefing paper *Forecasting the economy*, we set out three simple rules we often use to produce stylised economic scenarios: the Taylor rule, linking interest rates to inflation and the output gap; a simple aggregate demand equation, relating interest rates and output; and Okun's law, defining the relationship between output and employment. A forthcoming working paper will discuss these and alternative equations in the context of a small macroeconomic model of the economy.

3.20 In the following sections, we illustrate the key ways in which we would expect these main categories – inflation, interest rates, output and the labour market – to affect receipts and spending. We also discuss the sensitivity to assets, including property, equities and oil. Finally, we provide a summary of the broad quantitative effects, consistent with our March 2012 forecast numbers. The ready reckoners are in themselves highly stylised and are only infrequently updated, so will generally not be fully aligned with the latest forecasts.

Inflation

3.21 While most economic forecasts focus on the outlook for real (i.e. inflation-adjusted) GDP, nominal GDP is more important for the public finances forecast.

3.22 The cyclical adjustment ready reckoners do not make a distinction between real and nominal activity. That would suggest a 1 per cent rise in the GDP deflator would reduce borrowing by 0.7 per cent of GDP after two years. Such an outcome would however be dependent on departmental spending remaining fixed in nominal terms and the tax base rising in line with higher inflation.

3.23 We currently assume that nominal departmental spending remains fixed in line with the 2010 Spending Review allocations up to and including 2014-15. Higher-than-expected inflation would however imply larger real cuts over this period.

3.24 The Government's stated policy assumption beyond 2014-15 is based on real-terms growth in total spending over the current Spending Review period. Additional inflation over that period would therefore imply lower growth in cash spending from 2015-16. But higher inflation after 2014-15 would increase total spending over that period.

3.25 The impact on nominal receipts would be dependent on how higher inflation fed through to nominal activity. Our scenarios generally assume a simple Taylor rule relating interest rates to inflation and the output gap. Tighter monetary policy as a result would be expected to reduce real GDP growth, partially offsetting the positive effect of inflation on nominal activity.

3.26 The behavioural effects of businesses and households would be the overriding factor, and this would to a large extent depend on the initial source of the inflation shock. In the 'persistent inflation' scenario described in our March 2011 *EFO*, higher inflation feeds through into higher wage settlements and consumption. We discuss the importance of this particular composition further below, but the net effect is a notable increase in receipts. Conversely, in our 'temporary oil price spike' scenario set out in the March 2012 *EFO*, the impact of higher consumer prices on nominal activity is largely offset by movements in the terms of trade, as the price of imports rises by more than the price of exports.

3.27 Inflation also has a direct effect on the public finances through its impact on the uprating of income tax and national insurance contributions (NICs) thresholds, as well as a number of benefits and other taxes. Changes are usually pegged to a particular inflation measure, although for some years rates may be frozen or determined by explicit policy.

3.28 The direct effect on receipts is relatively small, although it varies over time and includes a number of offsetting factors. Indirect taxes, in particular fuel duty, alcohol and tobacco, generally rise in line with estimates of the current year's (September) RPI inflation. Business rates are also linked to RPI inflation, with the impact arising in the following year.

3.29 The indexation of income tax and NICs thresholds are also based on a mix of RPI and CPI inflation in the preceding year. All else equal, a higher threshold would lead to less income being taxed at a higher rate, so higher inflation reduces income tax and NICs receipts. In total, we would expect taxes to be higher in the first year, but marginally lower in later years, once the effects on business rates and income tax & NICs feed through.

3.30 The direct effect on spending would be to raise benefits, tax credits and public service pensions, linked to CPI inflation, with a one year lag. Higher RPI inflation would also lead to a much larger increase in payments relating to index-linked gilts.

3.31 Higher inflation (through the GDP deflator), by raising nominal GDP, would also lower the public sector net debt to GDP ratio. However, persistently higher inflation would also likely push up conventional gilt rates and further increase the cost of servicing debt.

Interest rates

3.32 For the central forecast, we assume that interest rates move in line with market expectations. Our scenarios assume that any deviation in the output gap or inflation relative to our central forecast leads to a change in Bank Rate consistent with a simple Taylor rule. The degree to which this feeds through to the market and gilt yield curves, and then the interest rates faced by businesses and households, is dependent on judgement. The 'persistent tight credit conditions' scenario in our November 2011 *EFO*, assumed that funding spreads would remain elevated for longer.

3.33 There is an obvious direct relationship between changes in interest rates and central government debt interest costs. But these direct costs are somewhat offset by additional receipts.

3.34 An increase in savings rates would increase income tax on personal savings income, some of which would be received through self-assessment the following year. There is a smaller net effect on corporation tax, as businesses would pay additional tax on their interest income, but also potentially deduct greater amounts from their tax payments, as interest costs are tax deductible. Central government and local authorities would also receive additional income on their reserves and holdings of financial assets.

3.35 The net direct impact of a change in interest rates would be dependent on its effect on the shape of the yield curve. The direct effect of changes focussed towards the short end of the yield curve might be expected to be broadly neutral, once additional receipts, higher interest payments on treasury bills and the direct read across to gilt rates (to the extent that long-term interest rates reflect expectations of short-term movements over time) are accounted for. In Chapter 5 of our *EFOs*, and discussed above, we consider the other extreme, where only gilt rates move.

3.36 The overall effect would also reflect changes in the stocks (savings and debt) that these interest rates are applied to, as well as their effect on the broader economy. We would expect higher interest rates to have a negative effect, although, to the extent that these were a consequence of a stronger recovery, or a beneficial increase in risk appetite, the broader effect on the public finances would likely be more positive.

Expenditure composition of growth

3.37 As well as the level of output, the composition of nominal GDP is important for the fiscal forecast, as individual tax bases are often specific to a particular form of expenditure or income.

3.38 Changes in consumption have a discernible impact on the public finances. Around 70 per cent of VAT receipts are derived from household consumption, and these move largely one-for-one with changes in nominal consumer spending.

3.39 Receipts are also affected by changes in the composition of consumption, as different types of spending attract different VAT rates. In particular, domestic fuel and power attract a reduced rate of 5 per cent and most food is zero-rated. Overall, just over half of household spending is taxed at the standard 20 per cent rate, so a 1 percentage point change in this standard-rated share has a similar effect as a 2 per cent change in consumption. Consumption trends will also affect other indirect taxes, and in particular alcohol duties.

3.40 Changes in other expenditure components of GDP generally have only a small impact on receipts and spending. Higher nominal business investment would marginally reduce corporation tax payments as capital allowances rise. That is not to say that increases in business investment have a negative effect on the public finances, as there will also be indirect effects through higher incomes, which would be taxed separately and likely more than offset this direct effect.

3.41 More broadly, we use GDP as a proxy for total demand where the effect on receipts may not be confined to a particular type of spending. For example, fuel duty and air passenger duty will be affected by both households' and businesses' spending.

3.42 Our central forecast assumes a rebalancing of demand away from consumption and towards investment and net exports. In our November 2010 *EFO*, we illustrated a 'delayed rebalancing' scenario, showing an improved outlook for the public finances over a five-year time horizon, as revenue-rich consumption remained higher as a share of total spending. However, to the extent that higher borrowing in this scenario allowed households to exchange consumption tomorrow for consumption today, a reversal of these positive fiscal influences could have been expected further down the line.

Income composition of growth

3.43 Incomes represent a much larger tax base relative to expenditure. Labour income in particular accounts for around three quarters of domestic income and it is also more heavily taxed than profits. Income tax and NICs comprise around 45 per cent of total receipts, so a decline in the labour share would be expected to depress total receipts relative to GDP.

3.44 Staggered income tax and NICs thresholds mean that receipts rise (and fall) by relatively more than changes in labour income; a 1 per cent rise in income would be expected to increase income tax and NICs receipts by around 1¼ per cent.[2]

3.45 Corporation tax liabilities are dependent on income, primarily trading profits, but also deductions, such as capital allowances and trading losses. Holding deductions constant, corporation tax liabilities are geared to changes in income, with a 1 per cent rise in non-oil profits increasing corporation tax by around 1½ per cent.

3.46 However, the sensitivity over our current forecast period is lower than this, and closer to 1¼ per cent, as the pool of losses that companies are able to offset against their corporate tax liabilities has increased following the recession. For some companies, stronger-than expected profits would bring forward the moment at which they would again be liable to pay corporation tax, rather than have an immediate effect on their tax payments. This is particularly the case for some financial companies and our central forecast is currently less sensitive to changes in financial company profits than it would otherwise have been in the past.

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[2] This assumes the rise in income can be half explained by a rise in average earnings, and half by an increase in employment. We discuss the sensitivity to these further below.

Labour market

3.47 Our economic scenarios generally assume a simple Okun's law relationship between changes in the output gap and unemployment. A 1 percentage point widening in the output gap relative to our central forecast is assumed to increase the unemployment rate by around half a percentage point.

3.48 The 'higher structural unemployment' scenario presented in our November 2011 *EFO*, illustrated the consequences of assuming an alternative split of employment and earnings growth given our central output gap forecast. In this scenario, total wages and salaries were unchanged and the net effect on borrowing was small.

3.49 Income tax receipts are more geared towards earnings than employment, given staggered income tax thresholds. This distinction is smaller for national insurance contributions, as a lower employee NICs rate is applied to earnings above the upper earnings limit. A 1 per cent rise in average earnings would increase income tax and NICs receipts by a little less than 1½ per cent. In comparison, there is a one-for-one relationship with employment and tax on employment income.[3]

3.50 The 'Triple Guarantee' ensures that the State Pension rises by the higher of 2.5 per cent, CPI inflation or average earnings growth, which is usually average earnings. Pension Credit is also uprated in line with average earnings. Partially offsetting these, an increase in earnings would also reduce spending on tax credits and child benefit, as the entitlement to these tapers away as incomes rise.

3.51 For our scenarios, we assume that the claimant count rises in absolute terms in line with the ILO measure of unemployment. An increase in the claimant count leads to a one-for-one increase in spending on Jobseekers' Allowance and directly related benefits. On average, higher unemployment also marginally increases tax credits expenditure, even though entitlement to working tax credits is withdrawn.

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[3] Our self-assessment forecast does not currently make an explicit distinction between changes in income relating to higher earnings and an increase in the number of self employed.

Assets

Property market

3.52 Our scenarios typically assume that, relative to our central forecast, differences in house prices can be explained by differences in earnings. Receipts are much less sensitive to changes in commercial property prices and we do not generally capture the implications of movements in these.

3.53 Property prices have a direct effect on stamp duty land tax (SDLT) receipts. As higher price bands attract increasing rates of SDLT for the entire price of the property, a 1 per cent increase in residential prices raises SDLT receipts by over 1½ per cent. Property prices also affect the value of assets subject to inheritance tax and capital gains tax.

3.54 Residential property transactions are a key determinant of our forecast for SDLT receipts, as well as affecting capital gains tax receipts. Transactions are currently expected to recover towards a level consistent with the average historical duration of home ownership. Our scenarios often involve a judgement as to what alternative paths for growth and credit conditions would imply for this recovery.

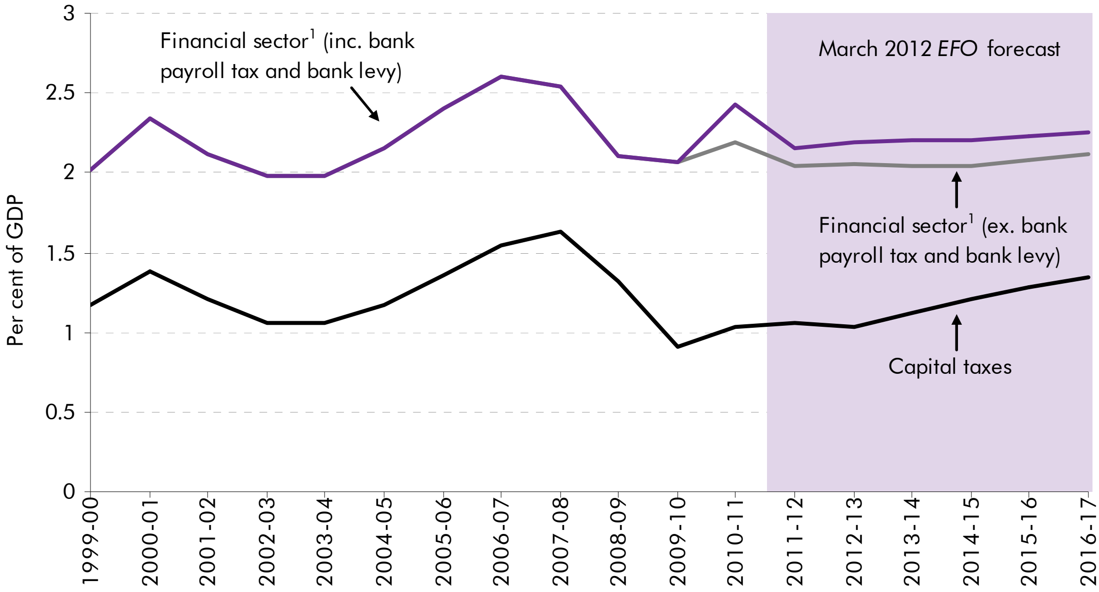
Equity prices

3.55 Our central forecast assumes that equity prices move in line with nominal GDP and our scenarios are usually based on the same assumption. Equity prices have a direct effect on our forecasts for capital taxes, and corporation tax from the life assurance sector.

3.56 Stamp duty on shares moves one-for-one with changes in equity prices (and also with the volume of transactions). Inheritance tax is slightly more geared to changes in prices, as tax is only liable on the value of assets above the inheritance tax threshold. More significantly, capital gains tax is very sensitive to price swings, as the tax is only due on the profit on sale of the asset, and not its overall value. The current forecast assumes that a 1 per cent increase in equity prices raises capital gains tax on the sale of financial assets (representing more than two-thirds of total capital gains tax receipts) by around 2½ per cent. The return on financial investments is also a key determinant of the life assurance sector's corporation tax liabilities.

3.57 Equity prices will also indirectly affect personal and corporation taxes relating to the financial sector, which as Chart 3.1 shows are greater than capital tax receipts (and only a subset of these will relate to equities). Our central forecast is for capital taxes to rise as a share of GDP as the equity and property markets continue to recover. However, the recovery in financial sector receipts is expected to be more subdued, as losses are carried forward and regulatory changes constrain the medium-term recovery. Our scenarios usually maintain the same profile as a share of GDP.

Chart 3.1: Financial sector and capital tax receipts



[1] Financial sector receipts include: PAYE income tax and NICs; corporation tax paid by the sector; bank levy; and bank payroll tax. Beyond 2011-12 the PAYE component is a stylised extrapolation rather than a detailed forecast. Stuck VAT in the financial sector and insurance premium tax are not included.

Source: ONS, HMRC, OBR

Oil and gas

3.58 Our central forecast assumes that oil prices move in line with the prices implied by futures markets. We do not generally revise this assumption for our scenarios, although we illustrated the effect of an alternative path in our 'temporary oil price spike' scenario in our March 2012 *EFO*.

3.59 Oil prices directly affect UK oil and gas revenues. Higher prices also reduce the demand for fuel and therefore fuel duty, which is charged on the number of litres consumed, although demand for fuel is relatively inelastic. Price movements will therefore increase VAT receipts, if spending on fuel (subject to the standard rate of VAT) displaces spending on other items that are either zero-rated or subject to a reduced rate of VAT.

3.60 In our latest central forecast we expect gas prices to follow the same trend as oil prices but with a six month lag, although these prices have decoupled in the past. The amounts raised by higher oil and gas prices would be affected by the levels of production and related capital expenditure. We do not alter these in our scenarios, but in the recent past, rises in oil prices in the mid-2000s and in 2011 have been associated with a sharp increase in capital expenditure.

Summary

3.61 Table 3.2 provides ballpark figures for the typical impact of changes in economic variables on receipts and spending. These are specific to the March 2012 *EFO* forecast and we would expect these to become outdated over time, as policy and our forecast continue to evolve. They also do not cover the full set of economic determinants that feed into the fiscal forecasting models.

3.62 However, taken together they provide the platform to allow us to assess the fiscal implications of the economic sensitivities and scenarios that we present. The figures only show the direct effects on borrowing, and as some of our scenarios show, these direct effects can be more than outweighed by related indirect effects. We also might expect, as tentatively suggested by Chart 2.8 above, that alternative economic scenarios would trigger additional modelling errors that are not fully captured.

Table 3.2: Summary of ready-reckoners

Determinant	Direct impact on fiscal position of 1 per cent increase, unless otherwise stated[1, 2]	Affected receipts or spending categories
GDP	0.5% of GDP in first year, rising to 0.7% of GDP after two years	Public sector net borrowing
Inflation		
GDP deflator	Up to and including 2014-15: 0.1% of GDP After 2014-15: -0.4% of GDP	Total spending in 2015-16 and 2016-17
RPI/CPI[3]	In-year £½ billion; -£¼ billion thereafter	Indirect taxes, business rates, IT & NICs
CPI[3]	-£1¾ billion with a one year lag	Benefits, tax credits, public sector pensions
RPI	-£3 billion to -£6 billion	Debt interest
Interest rates (1ppt)		
Gilt rates	-£2½ billion to -£7½ billion	Debt interest
Short rates	-£1 billion	Debt interest
Savings rates	£1 billion (>£¼ billion lags a year)	Tax on savings income, self-assessment
Interest on govt. assets	£1 billion	Interest receipts
Nominal GDP expenditure		
Consumption	£¾ billion	VAT on consumption
Consumption SRS (1ppt)[4]	£1½ billion	VAT on consumption
Business investment	-£50 million	Corporation tax
Wider spending	£¼ billion	Indirect taxes
GDP income		
Wages & salaries	£2¾ billion to £3½ billion (1¼% of the tax base)	PAYE income tax & NICs
Self employment income	£¼ billion, with a one year lag	Self-assessment
PNFC trading profits	£½ billion	Indust. & comm. CT
Financial profits	<£100m	Financial sector CT
Labour market		
Average earnings	£3¼ billion to £4 billion (1½% of the tax base)	PAYE income tax & NICs
	-£1 billion	Benefits and tax credits
Employment	£2¼ billion to £3 billion (1% of the tax base)	PAYE income tax & NICs
Unemployment (0.1m)	-£¾ billion	Benefits and tax credits
Assets		
House prices	£100 million to £200 million	Capital taxes
Property transactions	£50 million to £100 million	Capital taxes
Equity prices	£200 million	Capital taxes
Oil prices (£10 a barrel)	£2 billion	Oil and gas revenues
	-£¼ billion	Fuel duty

[1] These are ballpark figures that are specific to the March 2012 *EFO* forecast. The actual effects will differ over time, as policy and our forecast continue to evolve. The preceeding text discusses issues related to each ready reckoner in more detail.

[2] A positive figure represents an improvement in the fiscal position.

[3] Impact of a 1% increase in the price level.

[4] Standard rated share; share of nominal household consumer spending subject to the standard rate of VAT.

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