Australian Government

The Treasury

ESTIMATES OF UNCERTAINTY AROUND BUDGET FORECASTS

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Treasury Working Paper[2]

2013–04

Date created: November 2013

Date modified: January 2014

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2 The views expressed in this paper are those of the authors and do not necessarily reflect those of the Australian Treasury or the Australian Government. This version of the paper incorporates a minor correction in the calculation of the central forecast and the outcome of payments affecting charts 5, 8 and B2 and page 15.

ISBN 978-0-642-74945-1

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January 2014

ABSTRACT

We use past forecast errors to construct confidence intervals around Australian Government Budget forecasts of key economic and fiscal variables. These confidence intervals provide an indication of the extent of uncertainty around the point estimate forecasts presented in the Budget.

JEL Classification Numbers: E17, H68
Keywords: Confidence intervals, forecast errors

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1. INTRODUCTION

Australian Government Budget documents present forecasts for key economic and fiscal variables. Estimates of uncertainty around such forecasts can help convey to readers a better appreciation of the risks associated with the economic and fiscal outlook. For example, they can help inform readers about how likely it is that outcomes will be close to the forecasts. This can be useful for informing government policy and public discourse more generally. For example, confidence intervals can highlight the amount of adjustment required to meet a budget target should particular risks materialise, throwing into sharper relief the trade-offs that government may face.

Estimates of forecast uncertainty can also improve the credibility and transparency of the forecasting process, key topics in the *Review of Treasury Macroeconomic and Revenue Forecasting* (Treasury Forecasting Review) (Treasury, 2012). Explicit estimates of uncertainty can aid in making clear that point forecasts may turn out to be incorrect and that forecasts may be more usefully considered as a range rather than a point estimate. Being explicit about inherent uncertainties may lead to fewer misunderstandings about the forecasts and what they represent.

A number of fiscal agencies provide estimates of uncertainty around their forecasts. This includes the US Congressional Budget Office (CBO), which publishes a fan chart of probabilities around its projections for the budget balance (as a share of GDP). The UK Office for Budget Responsibility (OBR), in its *Economic and Fiscal Outlook,* publishes measures of uncertainty around its central projections for real GDP growth, public sector net borrowing (as a share of GDP) and cyclically-adjusted budget balance (as a share of GDP). The New Zealand Treasury reports confidence intervals around its revenue forecasts and cyclically-adjusted budget balance forecasts as part of New Zealand Budget papers (New Zealand Treasury, 2013).[3] For Australia, the 2013 Pre-election Economic and Fiscal Outlook (PEFO) also presented confidence intervals around key aggregates; the first time this has been done.[4] Table 1 describes some measures of forecast uncertainty provided by a range of fiscal institutions.

3 In New Zealand, the Budget forecasts in the Economic and Fiscal Update are supplied to the Minister of Finance by the New Zealand Treasury, while the Australian Budget forecasts are produced by the Australian Government after receiving the advice of the Australian Treasury and Department of Finance.

4 The *Charter of Budget Honesty Act 1998* requires the Secretaries to the Treasury and the Department of Finance to release a PEFO prior to an election.

Table 1: Some measures of uncertainty published by fiscal institutions

Institution	Variables reported	Measure of uncertainty	Method of construction
Congressional Budget Office (US)	Budget balance.	10, 20, 30, …, 90 per cent confidence intervals.	Based on historical forecast errors, assuming normally distributed errors.
Office for Budget Responsibility (UK)	Real GDP growth, public sector net borrowing and cyclically-adjusted budget balance.	20, 40, 60, 80 per cent confidence intervals.	Based on historical forecast errors, assuming modified normal distribution.
NZ Treasury	Core crown tax revenue and cyclically-adjusted balance.	20, 40, 60, 80 per cent confidence intervals.	Based on historical forecast errors, assuming normally distributed errors.

Note: The approach adopted below uses root mean square errors of past forecast errors to construct confidence intervals in line with the NZ Treasury. More detailed information about what is reported can be found in the original sources.
Sources: CBO (2007a), CBO (2007b), OBR (2012), OBR (2013), New Zealand Treasury (2013), Parkyn (2010).

Publishing measures of uncertainty around economic forecasts is also common practice among central banks around the world. The Reserve Bank of Australia (RBA), the US Federal Reserve, the European Central Bank (ECB) and others report measures of uncertainty around their GDP and inflation forecasts (see Table 2 below). In the Australian context, confidence intervals around RBA forecasts have been published in an RBA discussion paper (Tulip and Wallace, 2012) and have been subsequently reported in the RBA *Statement on Monetary Policy*.

Table 2: Some measures of uncertainty published by monetary institutions

Institution	Variables reported	Measure of uncertainty	Method of construction
Reserve Bank of Australia	Real GDP growth and underlying CPI inflation. Unemployment rate and CPI inflation also reported in discussion paper.	70 and 90 per cent confidence intervals.	Based on historical forecast errors, assuming symmetric errors.
Bank of Canada	CPI inflation and core inflation.	50 and 90 per cent confidence intervals.	Combination of historical forecast errors and model errors, assuming normally distributed errors.
Bank of England (UK)	CPI inflation and level and growth of real GDP.	30, 60 and 90 per cent confidence intervals in some charts. Detail varies over time and within publication.	Based on forecast errors, modified for judgement.
Bank of Japan	GDP growth and CPI excluding fresh food.	Range and confidence intervals.	Based on forecast distributions of individual Policy Board members.
European Central Bank	Real GDP growth and its components and Harmonised Index of Consumer Prices inflation.	Range.	Twice the past mean absolute projection errors, with outliers excluded.
Federal Reserve (US)	Real GDP growth, unemployment rate and inflation.	Root mean square errors. Also participants' range of forecasts and judgement of risk and uncertainty.	Root mean square errors based on historical forecast errors. Also presents views of FOMC participants.
Sveriges Riksbank (Sweden)	Real GDP growth, CPI and core CPI inflation and re-purchase rate.	50, 75 and 90 per cent confidence intervals.	Based on past forecast errors, assuming normally distributed errors.
Norges Bank (Norway)	Policy interest rate, output gap and CPI and core CPI inflation.	30, 50, 70 and 90 per cent confidence intervals.	Based on model, assuming a normal distribution, constrained by zero lower bound for the policy interest rate.

Note: The approach adopted below uses root mean square errors of past forecast errors to construct confidence intervals in line with the Riksbank. More detailed information about what is reported can be found in the original sources.

Sources: Bank of Canada (2009), Bank of Canada (2013), Bank of England (2007), Bank of England (2013), Bank of Japan (2008), Bank of Japan (2013), ECB (2009), ECB (2013), Federal Open Market Committee (FOMC) (2012), Kjellberg and Villani (2010), Norges Bank (2013), Sveriges Riksbank (2007), Tulip and Wallace (2012).

In addition, some institutions, like the UK Office for Budget Responsibility and the European Central Bank, provide a comparison of forecasts from a number of institutions, making differences in views

between different forecasters more transparent. This potentially serves as a basis both for a better appreciation of the difficulties in forecasting and for discourse about why forecasts differ.

This paper presents estimates of uncertainty around key Budget parameters, similar to those developed by other institutions. After discussing the theory behind our approach in section 2 and data issues in section 3, we use recent forecast errors to construct confidence intervals around the 2013–14 Budget forecasts, presented in section 4. These confidence intervals highlight the important point that there has always existed a range of plausible alternative outcomes around any given point estimate.

2. THEORY

The appropriate method to construct measures of uncertainty around forecasts depends on the way the forecasts were generated.[5] As discussed in the Treasury Forecasting Review, there are a variety of approaches to modelling the economy. For example, one distinction between models is the trade-off between their coherence with economic theory and their coherence with economic data.

One approach could be to forecast using an economy-wide econometric model. In that case, it would be possible to use the model to generate measures of uncertainty around the forecast using statistics derived from that model. For example, suppose the forecasting model is:

$$AY_t = BX_t + e_t$$

where Y is the vector of macroeconomic and fiscal variables being forecast, X is the vector of other variables (such as historical data), A and B are matrices of parameters (which are estimated) and e is the vector of errors in the model.

Once this model is estimated over historical data, estimates of uncertainty can be generated around the forecasts based on the errors. For example, draws could be taken from the estimated errors and each draw used to calculate a forecast. This would generate a distribution of forecasts that would give a measure of uncertainty around the central forecast under the assumption that the future will experience similar shocks to those experienced in the past and that the structure of the economy will be similar in the future. Some of the issues and details around such an approach, known as bootstrapping, are discussed in Berkowitz and Kilian (1996).

In practice, however, many forecasters, including the Treasury, draw upon a combination of modelling techniques and a range of other information, including judgement, to produce forecasts. The use of a combination of approaches to produce forecasts reflects the judgement that each method has its advantages and disadvantages. For example, an econometric model is an imperfect representation of the world, so it may be desirable to adjust a model-based forecast with judgement (see the discussion in Office for Budget Responsibility, 2011).

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5 An alternative approach would be to report subjective estimates of uncertainty. However, many studies have found these to be too low, often by large margins (see Tulip and Wallace, 2012).

In the absence of a single econometric model describing all key interlinkages between different aspects of the economy, it is not possible to use the above approach to provide reliable measures of uncertainty around the forecasts. This is because without a whole-of-economy model, which captures the relationships throughout the economy and the data-generating process of each variable, the impact of shocks on all forecast variables cannot be appropriately estimated.

However, to the extent that both the economy and the forecasting process used by a forecaster are similar to the past, uncertainty about a forecast can be assessed by the performance of similar forecasts in the past. Specifically, if the data-generating process for both the economy and forecasts is similar to the past, the forecast errors of the past will be a guide to future forecast errors. Reflecting this, a number of fiscal and monetary authorities have used their own historical forecast errors to derive measures of uncertainty (see Tables 1 and 2).

To construct confidence intervals (or prediction intervals) around the point estimate forecasts, we need to derive an estimate of the standard deviation of the forecast error.

For this, we calculate the root mean squared error (RMSE) for each forecast horizon:

$$RMSE_s = \sqrt{\frac{1}{n}\sum_{j=1}^{n}\left(y^f_{j+s} - y_{j+s}\right)^2}$$

where y^f is the forecast variable, y is the actual outcome and the summation is over all n observations at that forecast horizon, s.[6]

Assuming the forecast errors are normally distributed with zero mean, the past is representative of the future and the variable y is stationary, confidence intervals can be calculated around the central forecasts:

$$Confidence\ Interval = y^f_{t+s} \pm Z \times RMSE_s$$

where y^f_{t+s}*is* the central forecast and Z is the value of the relevant Z statistic for the confidence interval. For example, the 70 per cent confidence interval, used below, has a Z statistic of about 1.04, so the 70 per cent confidence interval is similar to the confidence interval of ± one standard deviation. Reporting the 70 and 90 per cent confidence intervals below gives a sense of the risks around the forecasts and follows the practice of the RBA.

When using the above approach for the forecasts of fiscal variables *as a share of GDP* (such as receipts as a share of GDP), the estimated confidence intervals will be affected by uncertainty in both the level of the fiscal variable (such as the level of receipts in dollar terms) and the level of nominal GDP. In the context of thinking about uncertainty around the level (or dollar value) of the fiscal variables, this can be misleading, as we will see shortly.

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6 In the analysis below for the Australian budget, the horizons are the financial year that is about to end and the two subsequent financial years. For the 2013-14 Budget delivered in May 2013, these correspond to 2012-13, 2013-14 and 2014-15.

An alternative method of calculating confidence intervals, which reflects uncertainty only in the level of the variable, is to normalise the forecast errors by the actual outcome of GDP. To be specific, if we assume

$$\frac{R^f_{t+s} - R_{t+s}}{GDP_{t+s}} \sim N(0, \sigma_s^2)$$

where R is receipts, GDP is nominal GDP and $\sim N(0, \sigma_s^2)$ means that errors are normally distributed with zero mean and constant variance, σ_s^2 (so we are assuming the error in the forecast of receipts as a share of GDP is stationary) then the confidence interval is calculated as

$$Confidence\ Interval = \frac{R^f_{t+s}}{GDP^f_{t+s}} \pm Z \times \sqrt{\frac{1}{n}\sum_{j=1}^{n}\left(\frac{R^f_{j+s} - R_{j+s}}{GDP_{j+s}}\right)^2} \quad (1)$$

where the term under the square root sign is the maximum likelihood estimator of σ_s^2. We refer to this as the *no-GDP-error approach*.

Taking account of the uncertainty about GDP in the confidence intervals around receipts (as a share of GDP) will tend to increase uncertainty (due to the variability of GDP), compared to the no-GDP-error approach which abstracts from GDP uncertainty, unless there is a positive relationship between errors in GDP forecasts and in receipt forecasts.

To explain this important point algebraically, the estimated variance of receipts as a share of GDP can be written as:

$$\begin{aligned}\frac{1}{n}\sum_{j=1}^{n}\left(\frac{R^f_{j+s}}{GDP^f_{j+s}} - \frac{R_{j+s}}{GDP_{j+s}}\right)^2 &= \frac{1}{n}\sum_{j=1}^{n}\left(\frac{R^f_{j+s} - R_{j+s}}{GDP_{j+s}}\right)^2 + \frac{1}{n}\sum_{j=1}^{n}\left(\frac{R^f_{j+s}}{GDP^f_{j+s}} - \frac{R^f_{j+s}}{GDP_{j+s}}\right)^2 \\ &+ \frac{1}{n}\sum_{j=1}^{n} 2\left(\frac{R^f_{j+s}}{GDP^f_{j+s}} - \frac{R^f_{j+s}}{GDP_{j+s}}\right)\left(\frac{R^f_{j+s} - R_{j+s}}{GDP_{j+s}}\right). \quad (2)\end{aligned}$$

So the estimated variance of receipts as a share of GDP (the left hand side of the equation) can be decomposed into three terms. The first is the estimate of the variance using the no-GDP-error approach, the second is always non-negative and is a function of uncertainty around GDP and the third term reflects how GDP and receipt forecast errors are related. If over-predictions of GDP are usually associated with over-predictions of receipts (and similarly for under-predictions) then this third term will be negative.

We will see below that the confidence intervals around receipts as a share of GDP using the no-GDP-error approach are larger than those which take account of uncertainty in nominal GDP, reflecting the strongly positive relationship observed between forecast errors for nominal GDP and for receipts.

To understand this point, consider the (extreme) scenario in which there are large errors in the forecasts for the levels of both receipts and GDP, but these errors are perfectly correlated so there is no error in the forecasts for the receipts-to-GDP ratio. In this case, there would be no confidence interval around the forecast ratio of receipts to GDP, which would clearly not be representative of the confidence intervals around the level of receipts. To generalise the point, small variances in the forecast errors of the receipts-to-GDP ratio can correspond to large forecast errors in the level of receipts when there are also large nominal GDP forecast errors. With the no-GDP-error approach (which does not allow for any error in the GDP forecast in the denominator of the receipts to GDP ratio), the error in the ratio is driven entirely by errors in forecasts for receipts, regardless of their causes (including GDP forecasting errors).

By contrast, the confidence intervals around payments as a share of GDP using the no-GDP-error approach are smaller than those which take account of uncertainty in nominal GDP, reflecting the negative relationship observed between forecast errors for nominal GDP and for payments.

The assumptions that the forecast errors are normally distributed with mean zero may not be exact, though it or similar assumptions are often made in generating confidence intervals (see Tables 1 and 2). Table A1 (in Appendix A) presents some summary statistics which shed light on the extent to which the assumptions are satisfied for the sample of historical forecast errors used in the calculations below (see below for information on how variables have been constructed and other details about the data).

Our analysis indicates that, in this sample, there are some signs of bias, with a tendency to under predict nominal GDP growth and over predict payments (Table A1). However this particular sample may be unrepresentative of the population or of future forecasts. Examining a longer sample suggests that Treasury's real GDP, nominal GDP and revenue forecasts exhibit little evidence of bias for the Budget year (Treasury, 2012). Moreover, even if there is systematic bias in our particular sample, forecasters are expected to learn and adjust their forecasts. So, any bias in errors is unlikely to persist.[7] Table A1 suggests that it is difficult to reject the hypothesis that the errors are normally distributed in our sample. This is consistent with the forecast error being the average of many miscellaneous factors and so by a central limit theorem the forecast errors should be approximately normally distributed.

The assumption that the future is similar to the past is also important. While this is not testable, confidence intervals generated using this assumption provides a useful guide to likely risks around the forecasts.

7 Generally the amount of serial correlation in the errors is statistically insignificant, though there are some signs of serial correlation in our sample for the forecast errors for receipts as a share of GDP.

3. DATA

To calculate confidence intervals, we compare the Budget forecasts from the 1998-99 Budget onwards with current outcomes to generate historical forecasting errors.[8] Outcomes for nominal and real GDP are from the latest quarterly national accounts release for the June quarter 2013.

For the fiscal aggregates (receipts, payments and the underlying cash balance), there are some specific issues to bear in mind. First, the fiscal impact of all policy decisions made after a forecast was published have been added back to the relevant fiscal aggregate forecast to eliminate this potential source of error from the analysis. As a result, the root mean square errors for receipts, payments and the underlying cash balance do not reflect variations caused by subsequent policy changes. However changes in public debt interest as a result of policy decisions have not been removed from the data set.

Second, there was a change in the Budget reporting standard from cash to accrual in the 1999-2000 Budget. This change does not have a material impact on the underlying cash series. However, for many years in the sample, the Budget Papers published the effect of policy decisions only in accrual terms. As a result, we have constructed a composite series of policy decisions from records of cash and accrual measures, which has been used to adjust the relevant fiscal series.

Third, the potential for actual spending to exceed payment forecasts is taken into account through the Budget process. This is done through a provision made in the Contingency Reserve called the Conservative Bias Allowance (CBA). The CBA is an allowance for the tendency for expenses estimates of existing Government policy to be revised upwards in the forward years. This is of particular importance for demand driven programs where precise cost estimates are difficult to forecast. The allowance is calculated as a percentage of accrual expenditure and is unwound at each estimate update until it is removed completely when the year becomes the budget year. The reduction in the percentage over time reflects the fact that program estimates are progressively updated, thereby decreasing the bias. As such, the incorporation of the CBA into the budget updates is used to reduce bias and improve the accuracy of payment forecasts. (For further detail on the CBA see page 6–63 of the 2013–14 Australian Government Budget, Budget Strategy and Outlook.)

Fourth, abstracting from policy changes to construct confidence intervals around the fiscal variables does not encapsulate some cases where parameter variations have more in common with decisions of government, particularly concerning payment forecasts. For example, specific decisions to re-profile spending (due to changes in timing of projects) are captured as parameter variations. Similarly, the *Natural Disaster Relief and Recovery Arrangements* enable all new spending decisions relating to unprecedented natural disasters to be captured as parameter variations. We have abstracted only from

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8 In this analysis, the latest available estimate of the outcome is used as the measured outcome. Another approach could be to use a vintage of data close to when the forecasts were released. For example, Tulip and Wallace (2012) use GDP as reported in the fourth-published estimate (that is, released around four quarters after the event). Using later data vintages lessens issues around incomplete incorporation of source data but may increase issues from changing data definitions. However the use of forecast growth rates rather than levels in this paper should lessen the problems associated with changing data definitions (see footnote 12).

variations that have been reported for budgeting purposes as policy decisions, and have therefore included errors that in reality are not driven by parameter variations in isolation. Further, in line with longstanding convention and due to inherent difficulties in forecasting future impacts of natural disasters, estimates of the impact of disasters are not included beyond the Budget year. The forecast errors that arise as a result of this treatment have not been removed from the data.

Fifth, the underlying cash balance and receipts series have been constructed from each published Budget update and then payments have been derived as a residual. Note that underlying cash balance data exclude Future Fund earnings, while receipts data do not. To ensure the residual series (payments) is consistent with the reporting of payments in budget documentation, Future Fund earnings have been removed from the residual data.

Finally, the incorporation of GST receipts and payments in the 2008-09 Budget Papers saw significant changes to the Government's balance sheet as this was not considered a Commonwealth tax in Budgets prior to that year. Consequently, GST data have been removed from receipts and payments data to abstract from any forecasting error associated with this change.

Further details on the data can be found in Appendix A.

4. RESULTS

Real and Nominal GDP Forecasts

This section presents 70 and 90 per cent confidence intervals around key GDP forecasts from the 2013–14 Budget. For GDP forecasts, confidence intervals could be presented around forecasts of annual growth rates, average annualised growth rates or cumulative growth rates. While all three measures have merit, a key role of the GDP forecasts is as an input for producing revenue and expenses forecasts for the Budget. In this context, the forecast of the level of nominal GDP is particularly important. For this purpose, the average annualised GDP growth rate or the cumulative GDP growth rate is the more relevant summary statistic, since the level of GDP depends on cumulative growth over time. To get a good forecast of the level of GDP in 2013–14, the quality of the individual GDP growth forecasts in 2012–13 and 2013–14 is not in itself important, but rather the quality of the forecast of cumulative growth over the two years to 2013–14. (It is possible that a forecaster could incorrectly predict growth in both 2012–13 and 2013–14 but these errors may be offsetting such that the prediction of cumulative growth over the two years is accurate.) We have opted to report the average annualised growth rate (Charts 1 and 2) as it captures the effects of cumulative growth, while still giving a sense of what the annual growth rate would be. For Chart 3, we use the cumulative growth rate to calculate confidence intervals around the level of nominal GDP.[9]

Chart 1 presents point estimates and confidence intervals for the Budget forecast for average annualised real GDP growth. In the 2013–14 Budget, real GDP was expected to grow by 3 per cent in

9 Confidence intervals based on the average annual growth rate and cumulative growth yield very similar results for the level of nominal GDP, as would be expected.

2012–13 while average annualised growth over the three years to 2014-15 was also expected to be 3 per cent.[10] The observed outcome for 2012-13, which was not known when the 2013-14 Budget was delivered, is also noted on this and the following charts. The observed outcome for real GDP was close to the central forecast in the Budget.

Chart 1 suggests that, at the time when the 2013-14 Budget forecasts were published, there was a 70 per cent probability that the average annualised growth rate over the two years from 2011-12 to 2013-14 would lie between around 2 and 3¾ per cent.[11]

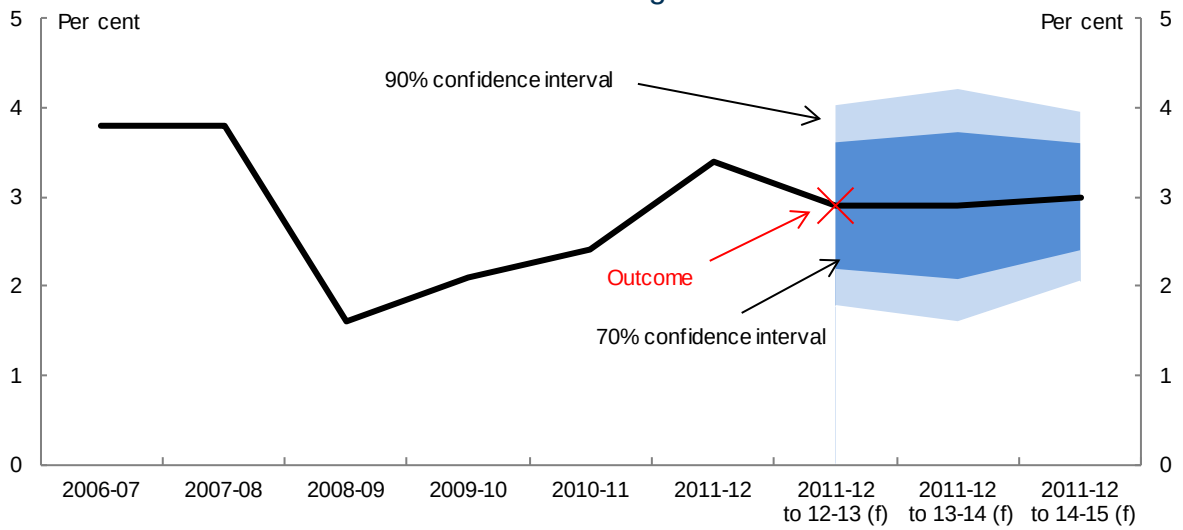
It is noticeable that the confidence intervals shrink in width for the 2014-15 year forecast. This occurs because reporting the average annualised growth rate moderates the impact of errors over longer horizons. By contrast, if confidence intervals were reported around the cumulative growth rates they would continue to widen.

Chart 1 suggests that there is significant uncertainty around the Budget point estimate forecasts for real GDP growth. While not directly comparable (because the RBA confidence intervals are based on year-ended growth rates rather than year-average growth rates, as here), this is consistent with findings of Tulip and Wallace (2012) who conclude that there is a high level of uncertainty around RBA real GDP forecasts.

10 In the Budget, point estimates of these forecasts are reported rounded to the nearest quarter of a percentage point. Charts similar to Charts 1 and 2 were publishing in the 2013 PEFO, though they reported the PEFO forecasts of the Treasury and the Department of Finance and Deregulation.

11 The confidence intervals around the 2012–13 forecasts in this and subsequent charts are based on forecasts from the 1998–99 Budget to the 2013–14 Budget (16 observations), with the forecast from the 1998–99 Budget being for the financial year 1997–98. The confidence intervals for the 2013–14 forecasts are based on forecasts from the 1998–99 to 2012–13 Budgets (15 observations). Similarly, the 2014–15 confidence intervals are based on 14 observations. The sample periods reflect the availability of data on outcomes. The confidence intervals in this and the other graphs are broadly similar if they are calculated excluding 2008–09 and subsequent financial years which could have been effected by the global financial crisis.

Chart 1: Real GDP growth rate

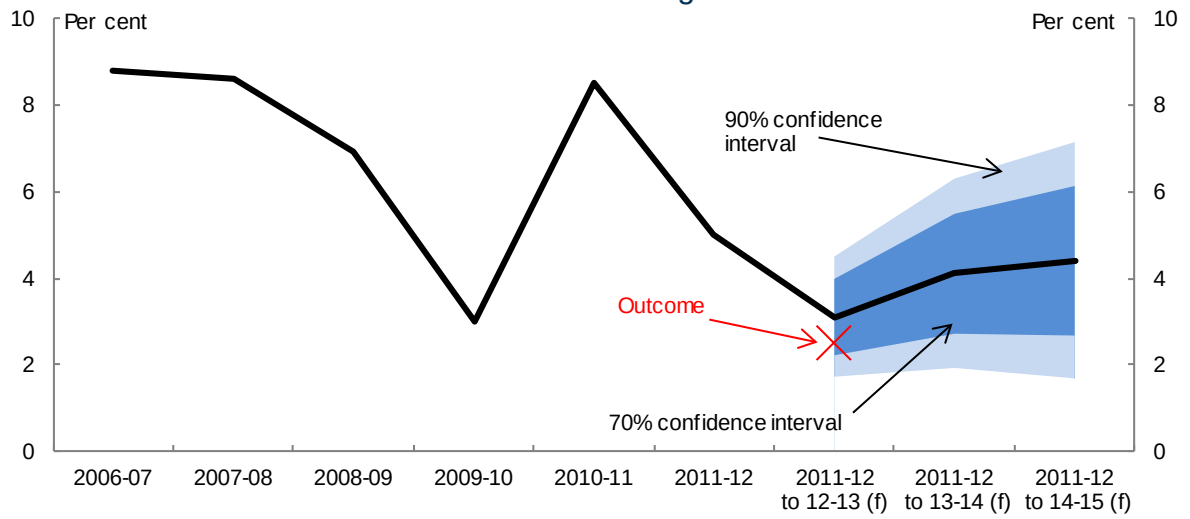


Note: The central line shows the outcomes and point estimate forecasts in the 2013-14 Budget. Annual growth is reported to 2011-12. Annualised average growth rates (from 2011-12) are reported from 2012-13 onwards. Confidence intervals are based on the root mean square errors of Budget percentage growth rate forecasts from the 1998-99 Budget onwards. (f) are forecasts. Before the 2009-10 Budget, a projection rather than a forecast was made for the year after the budget year. The chart reports seasonally adjusted financial year outcomes.
Source: ABS cat. No. 5206.0, Budget papers and Treasury.

In the 2013-14 Budget, nominal GDP growth was expected to weaken in 2012-13, with growth of around 3¼ per cent, before picking up in subsequent years, with annualised average growth of 4½ per cent in the three years to 2014-15 (Chart 2). As shown, the subsequently released outcome for 2012-13 was weaker than the Budget forecast, though it fell within the 70 per cent confidence interval.

At the time of the Budget, there was a 70 per cent probability that the average annualised growth rate over the two years from 2011-12 to 2013-14 would lie between 2¾ and 5½ per cent. The confidence intervals around the annualised average nominal GDP growth rate are significantly larger than those around the real GDP growth rate forecasts. This reflects the compounding nature of two sources of uncertainty; the uncertainty associated with the outlook for real GDP and the uncertainty associated with the outlook for prices or the GDP deflator. The forecasting of the GDP deflator was discussed in the Treasury Forecasting Review.

Chart 2: Nominal GDP growth rate

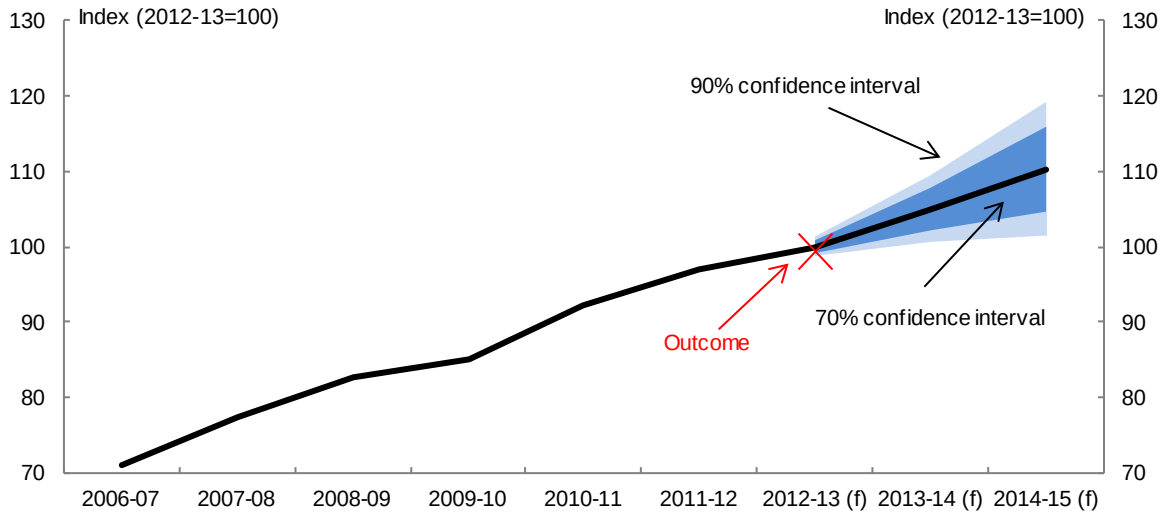


Note: See note to Chart 1.
Source: ABS cat. No. 5206.0, Budget papers and Treasury.

The level of nominal GDP is expected to continue to grow over the forecast period (Chart 3). The confidence intervals get wider over time, with a 70 per cent confidence interval of roughly $170 billion in 2014-15. This compares to a central forecast of nominal GDP of almost $1.7 trillion. The confidence interval gets wider because the root mean square error of the cumulative growth rate increases when predictions are made further into the future (that is, forecast errors tend to accumulate).

It is difficult to make comparisons between the confidence intervals reported here and those reported by other institutions, in part because different institutions often report somewhat different variables. However Table 3.5 of the Treasury Forecasting Review suggests that the Reserve Bank of Australia's forecast accuracy for real GDP is similar to that of Treasury, implying that the uncertainty around its forecasts is similar to Treasury's. Also the UK Office for Budget Responsibility's estimates of uncertainty for annual real GDP growth, as reported in its March 2013 *Economic and Fiscal Outlook*, seem no smaller than those of Treasury (treating their current year forecast, made early in the year, as roughly equivalent to the Treasury's budget year forecast).

Chart 3: Nominal GDP



Note: The central line shows the outcomes and point estimate forecasts in the 2013-14 Budget. Confidence intervals for the levels are derived from the root mean square errors of Budget forecast errors of the cumulative growth rate from the 1998-99 Budget onwards (i.e. using the cumulative growth rate approach). (f) are forecasts. Before the 2009-10 Budget, a projection rather than a forecast was made for the year after the budget year. The chart reports seasonally adjusted financial year outcomes.
Source: ABS cat. No. 5206.0, Budget papers and Treasury.

Fiscal Forecasts

We now turn to confidence intervals around key fiscal forecasts from the 2013–14 Budget. The charts show confidence intervals around forecasts of fiscal variables as shares of GDP. Showing the fiscal variables relative to the size of the overall economy is in many ways more informative and easier to understand than the level of the fiscal variables over time.

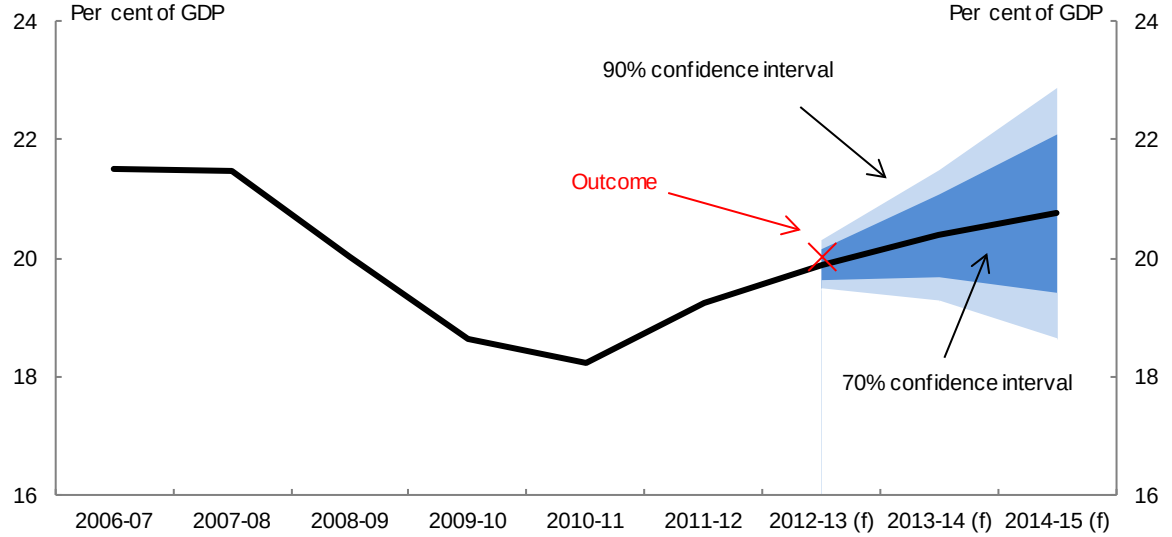
We present confidence intervals in two different ways. First, we present confidence intervals based on the errors in the forecasts of the fiscal variables as a share of GDP. As discussed above, this captures uncertainty in both the fiscal variable and GDP. However, if the key variables of interest are the levels (or dollar values) of receipts, payments and the underlying cash balance, then it is more informative to focus on confidence intervals that abstract from uncertainty about GDP, which are also presented below.

Confidence intervals incorporating both fiscal and GDP uncertainty

Charts 4, 5 and 6 report the Budget forecasts for receipts (excluding GST and including Future Fund earnings), payments (excluding GST) and the underlying cash balance (excluding Future Fund earnings). For these three charts, the confidence intervals have been calculated comparing the forecasts of the relevant fiscal variable as a share of GDP with the outcome. [12]

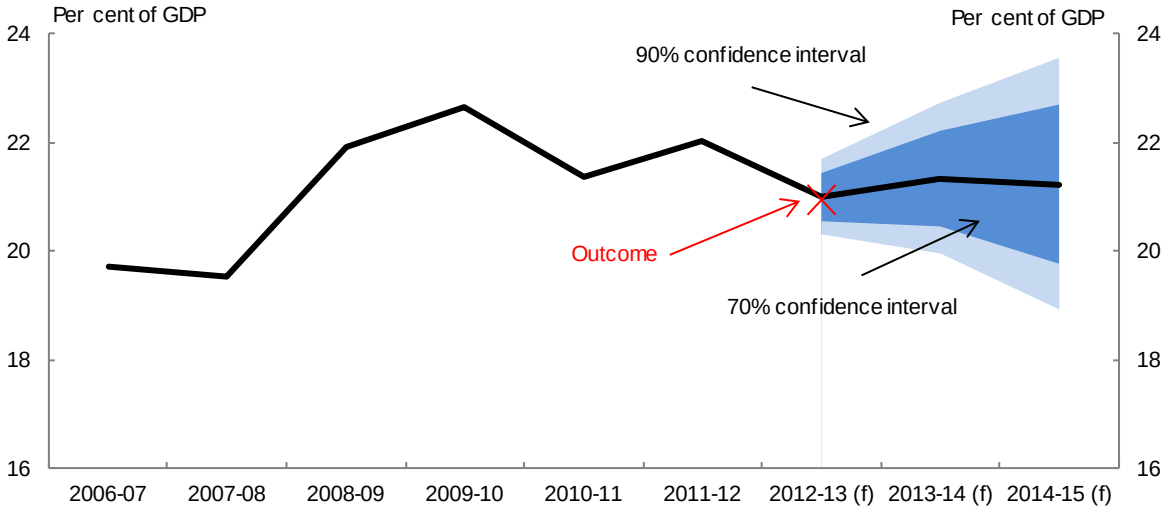
12 To calculate the forecast errors for the shares, an adjustment has been made to allow for historical revisions to GDP. This is particularly relevant because the September 2009 National Accounts moved to the new international standard (SNA08) which made several significant revisions to the GDP historical data.

Chart 4: Receipts (excluding GST) as a percentage of GDP



Note: The central line shows the outcomes and point estimate forecasts in the 2013-14 Budget. Confidence intervals use root mean squared errors (RMSE) for Budget forecasts from the 1998-99 Budget onwards. RMSE do not reflect forecast errors caused by policy decisions taken after the relevant Budget. (f) are forecasts. Before the 2009-10 Budget, a projection rather than a forecast was made for the year after the budget year. The outcome is based on information available at the time of the Final Budget Outcome.
Source: Budget papers and Treasury.

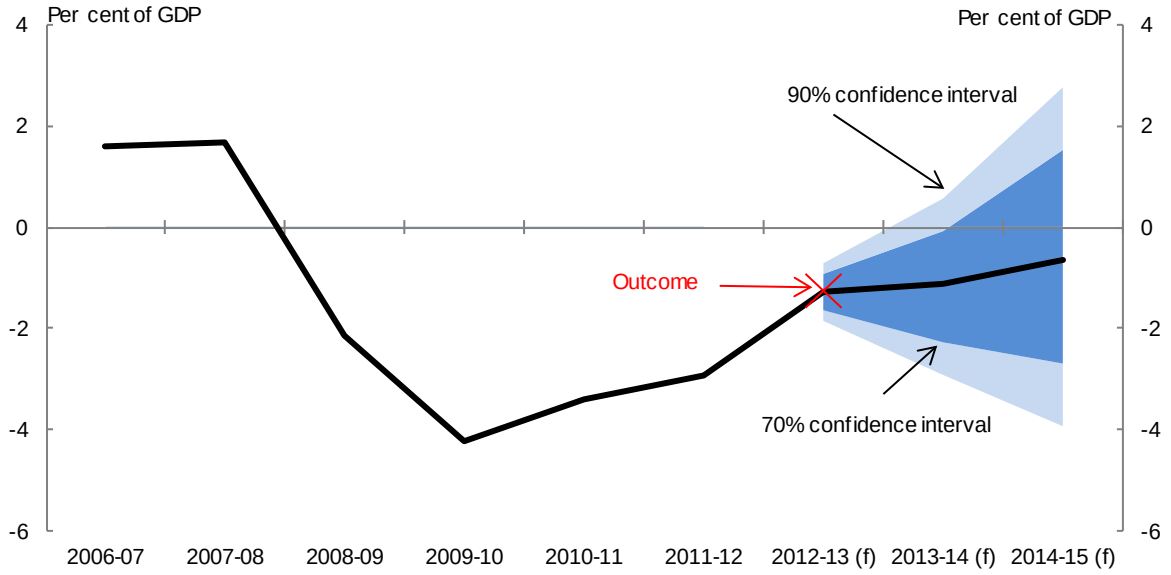
Chart 5: Payments (excluding GST) as a percentage of GDP



Note: See note to Chart 4.
Source: Budget papers and Treasury.

For example, GDP was revised to consider research and development as capital formation rather than as a business expense. The effects of the revisions were to increase the historical level of nominal GDP by between 1.5 and 3 per cent. Hence a ratio to GDP forecast on the previous basis cannot be compared to an outcome on the current basis. Growth rates were largely unaffected by the revision. Therefore, forecasts of nominal GDP growth have been applied to the historical GDP series (as at the June quarter national accounts release) to generate forecast shares that allow comparisons between forecasts and outcomes on a more comparable basis.

Chart 6: Underlying cash balance as a percentage of GDP



Note: See note to Chart 4.
Source: Budget Papers and Treasury.

The confidence intervals are substantial and widen over time. They suggest that, at the time of the 2013-14 Budget, there was a 70 per cent probability that receipts would lie between 19.7 and 21.1 per cent of GDP, payments between 20.5 and 22.2 per cent of GDP and the underlying cash balance between -2.2 and 0.0 per cent of GDP in 2013-14 (Charts 4, 5 and 6).

As previously discussed, these confidence intervals reflect uncertainty about both the level of the fiscal variable (the numerator of the share) and nominal GDP (the denominator of the share). The above charts may suggest that the historical errors around forecasts of the level of payments are greater than for receipts. In reality, however, historical errors around payment forecasts (in level terms) are substantially smaller than those of receipts.

This potential misconception arises because the confidence intervals shown above are strongly influenced by the correlation between the forecast errors of the fiscal variables and nominal GDP (as highlighted in equation (2) above). This issue is discussed further below and results are presented that do not reflect this correlation.

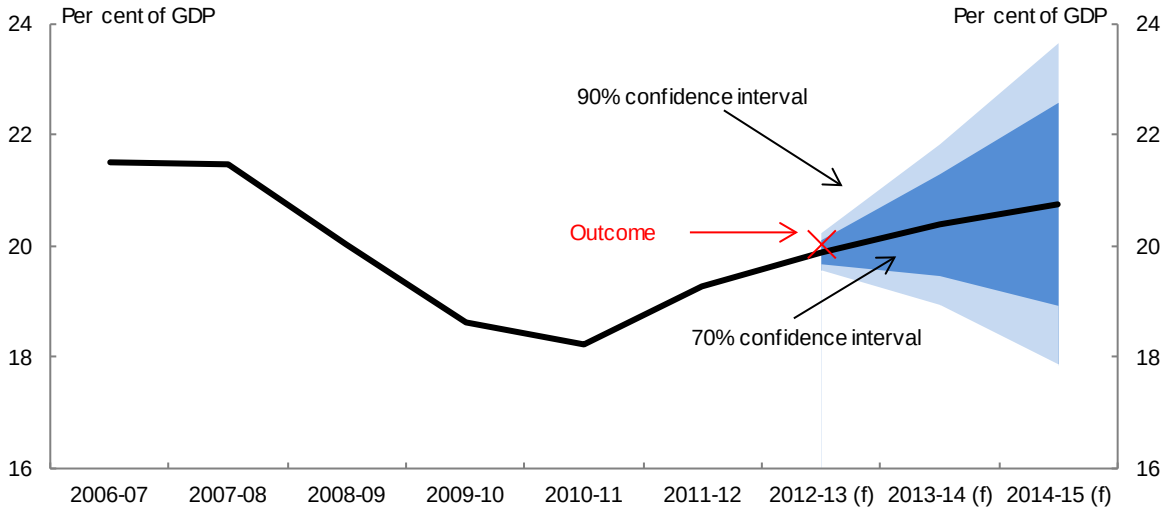
Confidence intervals incorporating fiscal uncertainty only

As discussed in section 2, an alternative approach, which takes account of uncertainty only in the fiscal variable, is the no-GDP-error approach. Charts 7, 8 and 9 report receipts, payments and the underlying cash balance as shares of GDP but with confidence intervals based on the no-GDP-error approach (see equation (1) above).

Charts 7-9 suggest that there is substantial uncertainty around the fiscal forecasts and this uncertainty grows over time. They suggest that, at the time of the 2013-14 Budget, the widths of 70 per cent confidence intervals for forecasts in 2014-15 were roughly $60 billion for receipts, $20 billion for payments and $70 billion for the underlying cash balance. (We get similar results when using an alternative approach described in Appendix B.)

The 70 per cent confidence intervals for the underlying cash balance are wider than for both receipts and payments (see Charts 7-9) reflecting the forecast errors for receipts and payments tend to be negatively correlated. (The correlation coefficients between the forecast errors for the cumulative growth rates for receipts and payments are around -0.2 for the 2013-14 forecast year and -0.3 for 2014-15.) To understand this point, suppose the underlying cash balance was initially forecast to be zero and then there were forecast errors for both receipts and payments equal to ½ a per cent of GDP. If these errors were in the same direction, they would cancel each other out, with no impact on the underlying cash balance. However, if the forecast errors were in opposite directions, the forecast error for the underlying cash balance would be 1 per cent of GDP (around $17 billion in 2014-15).

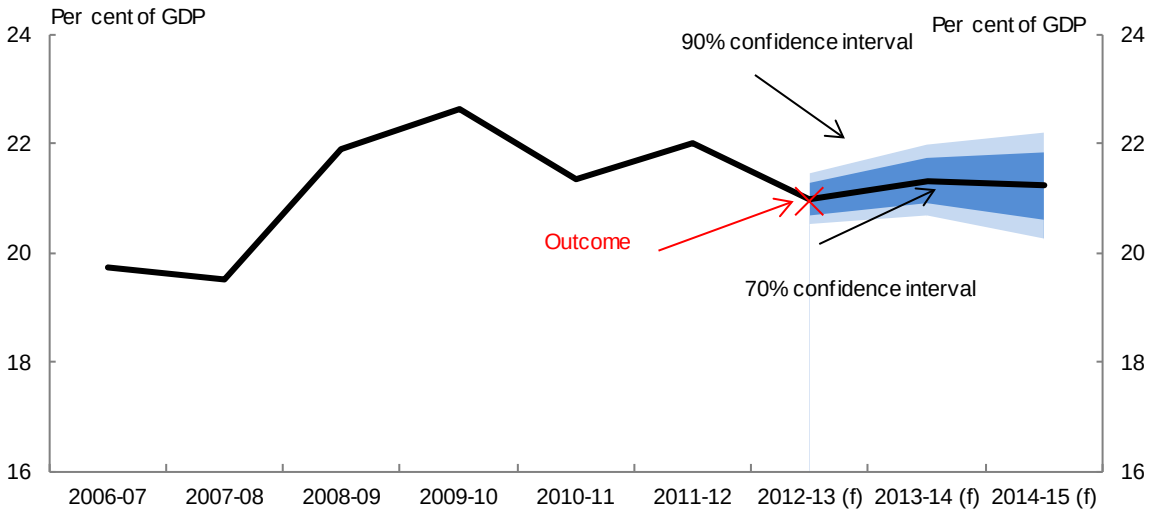
Chart 7: Receipts (excluding GST) as a percentage of GDP
(no-GDP-error approach)



Note: The central line shows the outcomes and point estimate forecasts in the 2013-14 Budget. Confidence intervals use root mean squared errors (RMSE) for Budget forecasts from the 1998-99 Budget onwards. RMSE do not reflect forecast errors caused by policy decisions taken after the relevant Budget. Confidence intervals do not reflect uncertainty about nominal GDP. (f) are forecasts. Before the 2009-10 Budget, a projection rather than a forecast was made for the year after the budget year. The outcome is based on information available at the time of the Final Budget Outcome.
Source: Budget papers and Treasury.

It is worth noting that the different ways of characterising uncertainty around the fiscal variables lead to significantly different measures of uncertainty. For example, the reported confidence intervals for receipts as a share of GDP in 2013-14 and 2014-15 are *wider* in Chart 7 (based on the no-GDP-error approach) than Chart 4 (based on share of GDP forecasts). This is because forecast errors in GDP are strongly positively correlated with forecast errors in receipts, with a correlation coefficient between the forecast errors for the cumulative growth rates for receipts and nominal GDP of 0.6 for both the 2013-14 and 2014-15 forecast horizons. As a consequence, the impact on the forecast error of the ratio of receipts to GDP from these two sources is offsetting.

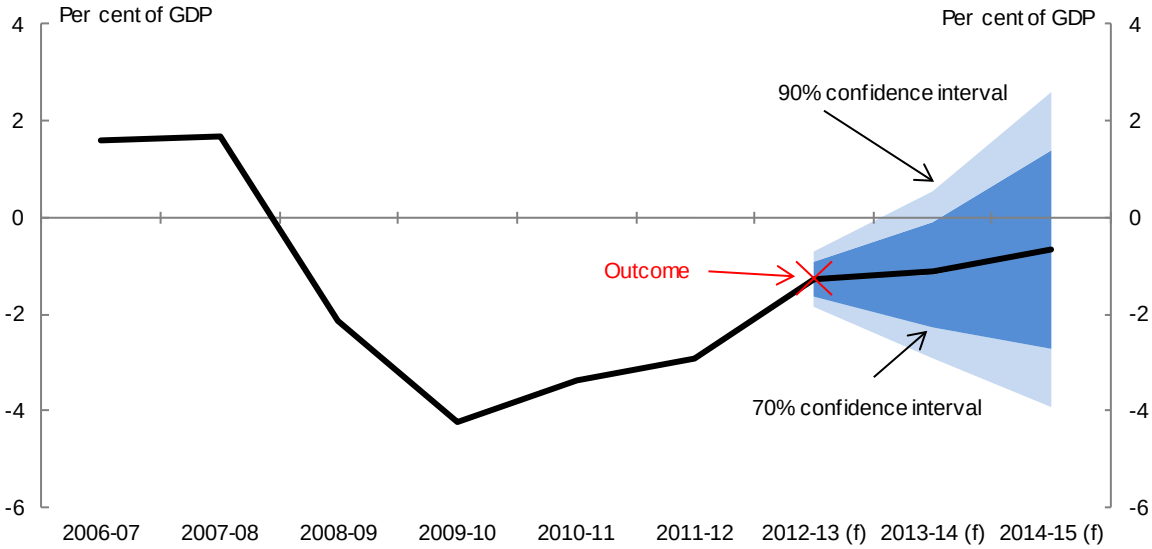
Chart 8: Payments (excluding GST) as a percentage of GDP (no-GDP-error approach)



Note: See note to Chart 7.
Source: Budget papers and Treasury.

The confidence intervals for payments are *smaller* in Chart 8 (based on the no-GDP-error approach) than Chart 5 (based on share of GDP forecasts). This reflects a negative correlation between the forecast errors of payments and nominal GDP, with a correlation coefficient between the cumulative growth rate forecast errors of payments and nominal GDP of roughly -0.5 for both the 2013-14 and 2014-15 forecast horizons. As a consequence, the impact on forecast errors of payments as a share of GDP from these two sources is not offsetting as was the case for receipts.

Chart 9: Underlying cash balance as a percentage of GDP (no-GDP-error approach)



Note: See note to Chart 7.
Source: Budget papers and Treasury.

The confidence intervals around the underlying cash balance as a share of GDP are similar based on either the share of GDP forecast errors (Chart 6) or no-GDP-error approach (Chart 9).

We have seen that the different ways of estimating uncertainty around the fiscal variables sometimes leads to significantly different measures of uncertainty. When the variable of interest is the level (or dollar value) of receipts, payments or the underlying cash balance, it is more appropriate to focus on confidence intervals that reflect uncertainty around these levels. The no-GDP-error approach provides a way of doing this.

Measures of uncertainty around fiscal variables are not common. However the CBO, when calculating confidence intervals around the primary surplus, uses a procedure based on normalised forecast errors (in the spirit of our no-GDP-error approach), though they normalise relative to revenue rather than GDP (CBO, 2007b).

For the underlying cash balance (as a share of GDP) in Charts 6 and 9, the width of Treasury's 70 per cent confidence interval for the budget year is around 2.2 percentage points. This compares to the US Congressional Budget Office's equivalent confidence interval around the budget balance of about 1.7 percentage points for the current year (although the forecast horizon is different with the CBO often forecasting for the year that has already begun rather than the year about to begin). For the subsequent year, the width of the Treasury confidence interval is a little over 4 percentage points compared to the CBO estimate of around 3 percentage points (CBO, 2007b). The UK Office for Budget Responsibility reports confidence intervals for the cyclically-adjusted budget balance which is appropriate for their purposes (as the UK Charter for Budget Responsibility defines the fiscal mandate in terms of this measure), though this makes it difficult to compare to Australia's underlying cash balance measure.

5. CONCLUSION

Confidence intervals provide a guide to the degree of uncertainty around forecasts. We have presented confidence intervals around key budget forecasts, which suggest that rather than focusing on precise point estimates, a more nuanced discussion would acknowledge that uncertainty is an unavoidable feature of forecasts, with confidence intervals spanning a wide range of outcomes. This is particularly true of the nominal macroeconomic and fiscal variables, for which uncertainty increases as the forecast horizon lengthens.

Reporting confidence intervals provides a way of improving the understanding of the uncertainty inherent in forecasting. Reporting confidence intervals complements existing approaches to convey uncertainty including the discussion of risks to the forecasts and sensitivity analysis provided in the Budget as well as analysis of ways to improve forecasting performance, such as that in the Treasury Forecasting Review.

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APPENDIX A: DATA

DATA SOURCES

Budget forecasts used to construct historical forecasting errors have been sourced from Budget Papers from the 1998–99 Budget through to the 2013–14 Budget.

Actual fiscal outcomes used to compare against Budget estimates have been sourced from Final Budget Outcome documents spanning 1998–99 to the latest published outcome. Fiscal variables relative to GDP are calculated using original (non-seasonally adjusted) series with adjustments to allow for revisions in data concepts (see footnote 12). Note that for all the data and analysis in this paper, receipts exclude GST and include Future Fund earnings, payments exclude GST and the underlying cash balance excludes Future Fund earnings. Hence receipts less payments measured in this way will not exactly equal the underlying cash balance.

For nominal and real GDP, the forecasts are compared to seasonally adjusted financial year average outcomes of the following series:

Australian Bureau of Statistics, 2013. Table 1—Key National Accounts: Seasonally Adjusted Gross Domestic Product: Chain Volume Measure. *National Accounts: National Income, Expenditure and Product, June Quarter 2013. ABS Catalogue 5206.0.* Australian Bureau of Statistics: Canberra. 4/9/2013.

Australian Bureau of Statistics, 2013. Table 1—Key National Accounts: Seasonally Adjusted Gross Domestic Product: Current prices. *National Accounts: National Income, Expenditure and Product, June Quarter 2013. ABS Catalogue 5206.0.* Australian Bureau of Statistics: Canberra. 4/9/2013.

Table A1 summarises some features of the forecast errors which were described in the main text.

Table A1: Summary statistics of forecast errors

Forecast error	Bias (forecast - actual)	Serial correlation	Normality
Real GDP (average annual growth rate in percent)			
Year about to end	-0.4**	-0.1	1.2
Budget year	-0.3	-0.3	0.4
Subsequent year	-0.1	-0.3	1.3
Nominal GDP (average annual growth rate in percent)			
Year about to end	-0.6**	0.4	0.1
Budget year	-0.7*	-0.1	0.1
Subsequent year	-1.0*	-0.1	0.2
Receipts (as share of GDP in percent)			
Year about to end	0.1	-0.2	1.1
Budget year	0.1	0.5*	1.1
Subsequent year	-0.2	0.7**	0.7
Payments (as share of GDP in percent)			
Year about to end	0.4**	0.3	0.4
Budget year	0.5*	0.2	0.4
Subsequent year	0.8*	0.1	1.1
Underlying cash balance (as share of GDP in percent)			
Year about to end	-0.3**	0.1	0.5
Budget year	-0.5	0.3	1.7
Subsequent year	-0.9	0.4	1.5
Receipts (no-GDP-error approach — level error as a percentage of GDP)			
Year about to end	0.0	-0.2	1.4
Budget year	-0.2	0.4	0.9
Subsequent year	-0.7	0.4	2.0
Payments (no-GDP-error approach — level error as a percentage of GDP)			
Year about to end	0.2**	0.3	3.5
Budget year	0.2*	0.4	1.3
Subsequent year	0.1	0.5	1.0
Underlying cash balance (no-GDP-error approach — level error as a percentage of GDP)			
Year about to end	-0.3**	0.1	0.5
Budget year	-0.4	0.4	1.6
Subsequent year	-0.8	0.4	1.4

Note: Bias is the average forecast error (expressed as forecast less actual so a positive number indicates overprediction), where significance is tested using White heteroskedasticity-consistent standard errors. Serial correlation is the first order autocorrelation of the mean-corrected forecast errors with the statistical significance based on the Ljung-Box Q-statistic for first order autocorrelation. For normality, the Jarque-Bera statistic (which has a chi-squared distribution with 2 degrees of freedom under normally distributed errors) is reported for the forecast errors. The sample is based on forecasts from the 1998-99 Budget onwards (see footnote 11). * indicates statistical significance at the 5 per cent level and ** at the 1 per cent level.
Source: Treasury.

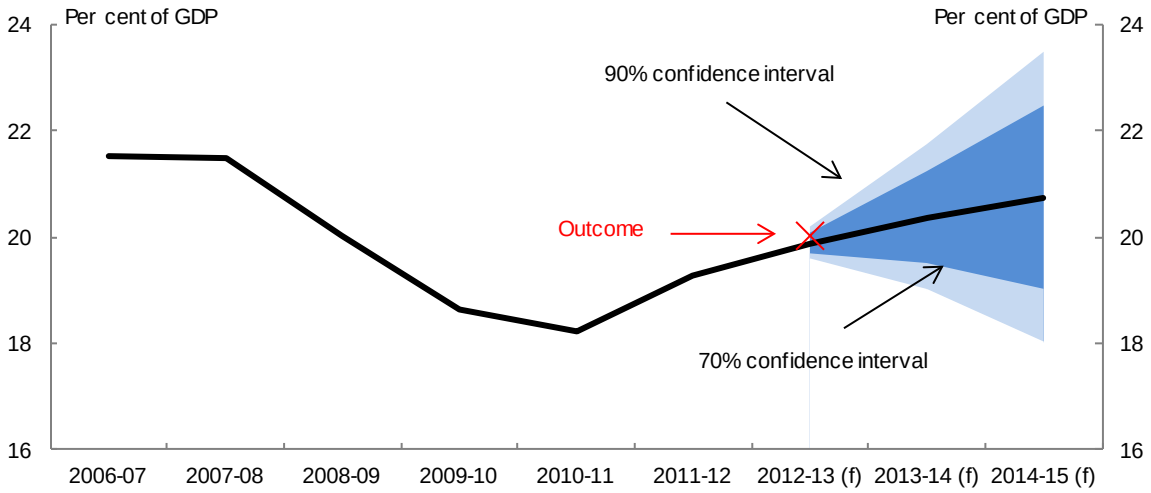
APPENDIX B: ALTERNATIVE TO NO-GDP-ERROR APPROACH

There is more than one way to calculate confidence intervals which reflect uncertainty in the level of fiscal variable but not in nominal GDP. Apart from the no-GDP-error approach used above, an alternative is to base the confidence intervals on the root mean squared errors of the cumulative growth rate forecasts of the level of the fiscal variables. Using this approach, the root mean squared errors are used to first derive confidence intervals around the cumulative growth rates of the fiscal variables (similar to what was done in Charts 1 and 2) and then these confidence intervals can be used to calculate confidence intervals for the levels of the fiscal variables and hence confidence intervals for the fiscal variables as a share of GDP (by dividing the confidence intervals for the levels by the forecast for nominal GDP). This cumulative growth rate approach can be used for receipts and payments but it is problematic to use for the underlying cash balance, as the growth rate and forecast errors will be large if the underlying cash balance is close to zero.[13]

The results using this cumulative growth rate approach (Charts B1 and B2) are similar to those based on the no-GDP-error approach (Charts 7 and 8). They suggest that, at the time of the 2013-14 Budget, the widths of the 70 per cent confidence intervals for forecasts for 2014-15 were roughly $60 billion for receipts and $20 billion for payments.

13 The cumulative growth rate approach is similar to that used by the New Zealand Treasury for calculating confidence intervals around revenues. New Zealand Treasury uses forecast errors as a percentage of actual revenue (Parkyn, 2010) while we use forecast errors in cumulative growth rates. The two approaches are approximately equivalent in the absence of revisions to the historical data. (They would be exactly equivalent in the absence of revisions if our results were based on the log differences rather than the growth rates.)

Chart B1: Receipts (excluding GST) as a percentage of GDP (Cumulative growth rate approach)



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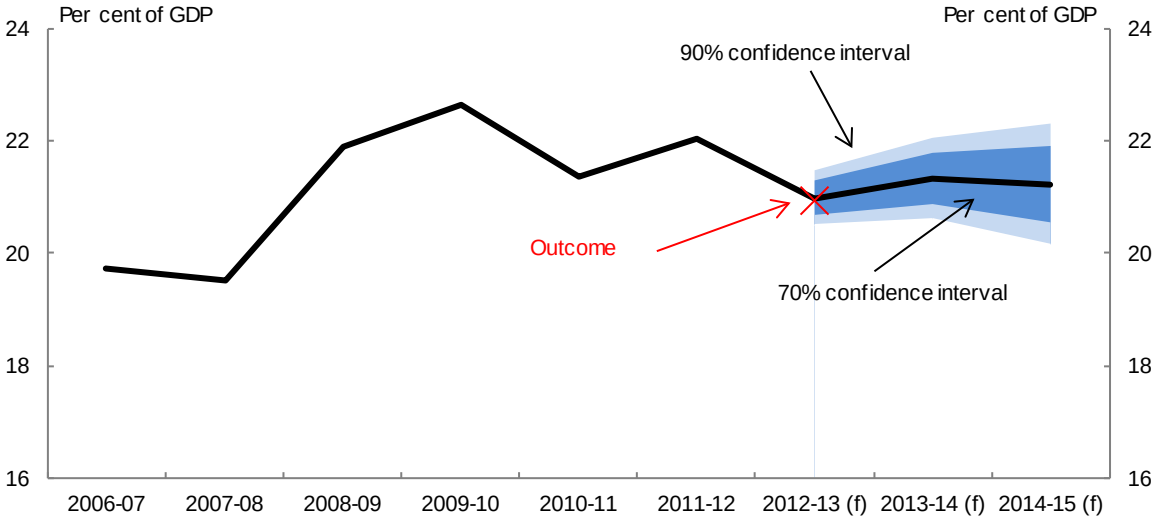
Source: Budget papers and Treasury.

Chart B2: Payments (excluding GST) as a percentage of GDP (Cumulative growth rate approach)



Note: See note to Chart B1.
Source: Budget papers and Treasury.