REVIEW OF TREASURY MACROECONOMIC AND REVENUE FORECASTING

December 2012

ISBN 978-0-642-74883-6

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Dr Martin Parkinson PSM
Secretary to the Treasury
Treasury Building
Langton Crescent, Parkes ACT 2600

Dear Dr Parkinson,

We have pleasure in presenting to you the Treasury Forecasting Review (attached). With the last major review completed in 2005, the intention of this Review is to undertake an up-to-date 'health check' of the Treasury's economic and revenue forecasting processes and associated performance. The Advisory Panel considers that those objectives have been achieved.

The report was prepared by the Secretariat established within the Treasury for that purpose. The Review does not include the 2012-13 Budget forecasts since outcomes for 2012-13 are not yet available. The Secretariat has authored the report and is responsible for the data, analysis and commentary in the report. The Advisory Panel has played an oversight role, including providing comments and suggestions to the Secretariat on the scope and content of the report.

In addition, the Advisory Panel has prepared the Executive Summary which includes a number of recommendations and suggestions for further improving the Treasury's forecasting processes going forward. The Advisory Panel considers that these suggestions may assist the Treasury in meeting the considerable forecasting challenges that arise during times of heightened economic uncertainty and volatility.

The members of the Advisory Panel would like to thank you for the opportunity of contributing to this Review. We would also like to thank the members of the Secretariat for their co-operative and unfailingly helpful approach throughout to the various discussions about forecasting methodologies, assessments of the quality of the forecasts and the governance arrangements for producing the forecasts, and for their willingness to either debate or take on board the Advisory Panel's suggestions.

The Advisory Panel considers that periodic reviews of the Treasury's forecasting methodology and record involving external advisers are to be commended and reflect positively on the Treasury.

Yours sincerely

Dr David Chessell (Chair)

Mr Peter Crone

Dr Malcolm Edey

Dr Lynne Williams

Advisory Panel to the Review of Treasury Macroeconomic and Revenue Forecasting

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Review of Treasury Macroeconomic and Revenue Forecasting

Background

Treasury's forecasting of the macroeconomy and revenues operates in an environment of continuous evaluation and development. The forecasts are regularly subjected to internal review and to external review as part of the quarterly Joint Economic Forecasting Group (JEFG) meetings with relevant agencies. However, from time to time, it is valuable to formally take stock of the Department's forecasting capability and performance. This was most recently done in 2005 for both macroeconomic and revenue forecasting, and it is timely to again take stock.

Scope

The review will assess the quality of Treasury forecasting of the macroeconomy and revenue by examining the appropriateness of forecasting methodologies and comparing forecast accuracy with other forecasters both in Australia and overseas.

Governance

The review will be undertaken by a team within Treasury, overseen by an independent external Reference Group with relevant expertise.

Timing

Three months.

Reporting

A summary of the Review will be published later in the year.

EXECUTIVE SUMMARY

Introduction

The past 10 years has been challenging for economic and revenue forecasting. Two major developments in particular stand out. The first relates to rapid rates of industrialisation in Asia, particularly in China, which increased worldwide demand for natural resources and, in turn, underpinned a sharp sustained rise in commodity prices and a mining investment boom (Mining Boom Mark I). The second relates to the impact of the global financial crisis and its aftermath on the Australian economy and taxation receipts and the emergence of a second phase of the mining boom (GFC and Mining Boom Mark II).

In common with many forecasters in Australia and overseas, Treasury has experienced mixed success forecasting over this period. In particular, the identification and prediction of major turning points in economic activity recently has been a failing of most forecasters around the world. Against this backdrop of a volatile economic environment, and the time that has passed since the previous review, Treasury decided that it was again timely to formally take stock of the Department's forecasting practices, capability and performance.

The Review has:

- assessed the quality of Treasury's macroeconomic and revenue forecasts by examining the appropriateness of forecasting methodologies and, data permitting, comparing forecast accuracy with other forecasters, both in Australia and overseas, over periods between 1990-91 and 2011-12; and

- prepared two case studies, which relate to the most recent challenges confronting forecasters, namely Mining Boom Mark I (2003-04 to 2007-08) and the GFC and Mining Boom Mark II (2008-09 to 2011-12).

A Secretariat was established within Treasury for this purpose, overseen by an independent external reference group.

Treasury's Macroeconomic and Revenue Forecasting Methodology

The Review's terms of reference require the quality of Treasury's forecasts to be assessed by first examining the appropriateness of forecasting methodologies. With this end in mind, a high-level survey of international forecasting practices has been prepared that provides a benchmark against which to assess Treasury's forecasting methodology. The Review has assessed Treasury's forecasting processes against the criteria that Treasury:

- draws upon the full range of information in preparing its forecasts;

- utilises this information efficiently by drawing upon models/technical tools appropriate to the forecasting task; and

- has governance arrangements in place that provide quality assurance of its forecasts and ensure continuous evaluation of its methodology.

The Review finds that Treasury has made a substantial investment in its macroeconomic and taxation revenue forecasting capability over an extended period, recognising the need for specialist expertise and techniques in these areas that takes considerable time and resources to build and maintain. As noted below, in recent years Treasury has overhauled the data and methodology used to forecast taxation revenue.

The Review finds that Treasury's macroeconomic forecasting approach draws upon the full range of information and modelling techniques used by comparable official agencies overseas. It also finds that the relative weight placed on the various macroeconomic forecasting methodologies — including structural econometric models and equations, business liaison and judgement — is broadly appropriate.

Similarly, the Review finds that, where information is available, Treasury's revenue forecasting methodology is comparable to those of official agencies overseas. Forecasts of taxation revenue are built up from forecasts of individual revenue heads, which are based on Treasury's macroeconomic forecasts of the relevant economic base, along with mapping models. The mapping models are accounting frameworks that adjust for the differences between taxable and economic bases (for example the difference between economic and taxable income for companies).

The Review has made recommendations that would enhance Treasury's existing forecasting methodology, as follows:

> Recommendation 1: Given the importance of information on economic conditions obtained from business liaison — and the capacity of this source to inform the forecasts — Treasury should investigate with the Reserve Bank of Australia more formal channels through which to exchange insights from their respective programs, such as during the quarterly joint forecasting rounds (without compromising the confidentiality of liaison contacts). Similarly, Treasury should also investigate whether further information can be drawn from the Australian Taxation Office's liaison with large corporate taxpayers for revenue forecasting purposes.
>
> Recommendation 2: A detailed assessment of the role, and appropriate type, of Treasury's macro econometric model was beyond the scope of this Review. However, the Review believes it is important to embed the redeveloped TRYM model into the economic forecasting process, both as a complement to the existing forecasting framework and to facilitate analysis of the impact of shocks to the domestic economy.
>
> Recommendation 3: Treasury should examine the feasibility of constructing a micro simulation model for forecasting personal income tax, as is the practice in the United States and United Kingdom.

The Review finds that Treasury has robust governance arrangements in place to quality assure its forecasts through a process of peer review. Treasury maintains an ongoing dialogue on the macroeconomic outlook with private sector forecasters, largely those employed in the financial sector. As part of the forecast round, Treasury's forecasts are first subject to internal review. They are then subject to the formal peer review of other government agencies. In particular, the macroeconomic outlook is discussed at the Joint Economic Forecasting Group (JEFG) meeting with representatives of the Reserve Bank of Australia, Australian Government central agencies and the Australian Bureau of Statistics. The revenue outlook is discussed at revenue conferences held with the Australian Taxation Office and the Australian Customs and Border Protection Service.

The Review also finds that Treasury's forecasting methodology operates in an environment of continuous internal evaluation and development, with forecast errors regularly reviewed, driving a quest for improvements in forecasting practices. In this regard, the Review notes that Treasury has employed an in-house technical specialist to ensure that its macroeconomic technical models/tools are at the cutting edge of macroeconomic forecasting practice, within the overall modelling strategy that Treasury has adopted.

2005 Review of Forecasting the Nominal Economy and Tax Revenue

The last major review of Treasury's forecasting performance was in 2005. It was commissioned in response to significant upward revisions to successive published forecasts of Australian Government taxation revenue over a number of years, which had drawn into question the quality of Treasury's forecasts at that time.

The major findings of the 2005 Review related to the revenue forecasts and revenue forecasting methodology and included that:

- the underestimation in Treasury's revenue forecasts appeared to reflect a series of conservative biases in the forecasting process that implied that forecast revenue growth was insufficiently sensitive to nominal GDP growth;
- Treasury had an inadequate understanding of the relationship between the nominal economy and taxation revenue; and
- Treasury's capacity to undertake meaningful analysis of taxation revenue had been severely hampered by underinvestment in taxation revenue data.

In response to these findings, Treasury's Executive Board established a team to implement the review's recommendations that were designed to overhaul the data and methodology used to forecast taxation revenue. The team subsequently made major investments in the quality of revenue data sets and forecasting methodology. Over time, these investments enabled the development of improved models of individual heads of revenue which, in turn, has seen Treasury place more weight on these models to generate revenue forecasts and less weight on econometric approaches to estimating aggregate revenue.

The Review finds that Treasury has largely implemented the other recommendations of the 2005 Review, which were designed to improve the professional interactions between the economic and revenue forecasters; to enhance the skill sets of the revenue forecasters; and to increase the emphasis given to the nominal economy in the macroeconomic forecasting area.

Strengthening the Governance of Treasury's Forecasting Processes

Notwithstanding the generally robust nature of existing practices, the Review has made some recommendations that would strengthen existing governance arrangements in order to improve the credibility and transparency of Treasury's forecasting processes. These recommendations would also bring these arrangements more in line with the practices of official agencies overseas.

The importance of credible and transparent forecasts in supporting public confidence has been highlighted by current global economic uncertainty. Publishing forecasting models, data, and technical assumptions in order to open them up to external scrutiny provides greater transparency. It also allows for feedback and testing of assumptions, leading to model improvements over time, as well as enhancing the credibility of the model's forecasts. These considerations lead the Review to recommend:

> Recommendation 4: Treasury should publish technical documentation that describes the data and the conceptual and econometric basis of models used for economic and revenue forecasting. A number of official agencies overseas have published technical documentation of their forecasting models.

Large forecasting errors can reduce the credibility of forecasts, particularly as they are viewed with the benefit of hindsight (which reveals information that was not available to the forecaster at the time

the forecasts were prepared). In this regard the Review notes that forecasting is an inherently difficult exercise and, on occasion, large forecasting errors are inevitable, especially at times of economic volatility. Regular public reviews of forecasting performance can help to provide perspective on forecast errors. They can also improve the transparency of the forecasting process. These considerations lead the Review to recommend:

> Recommendation 5: Treasury should include in the Budget papers a high level review of the economic forecast errors (nominal and real GDP) for the previous financial year, as a complement to the existing discussion of revenue forecasting errors.
>
> Recommendation 6: Reviews of Treasury's forecasting performance should be undertaken at least every five years to examine the causes of forecast errors and to help identify areas in which Treasury's forecasting methodology could be improved. These Reviews should be overseen by an independent external reference group.

Performance of the Nominal Economy Forecasts

The Review's terms of reference also require the quality of Treasury's forecasts to be assessed by comparing the accuracy of Treasury's forecasts with other forecasters, both in Australia and overseas. The Review has assessed Treasury's forecast performance against two desirable properties of forecasts:

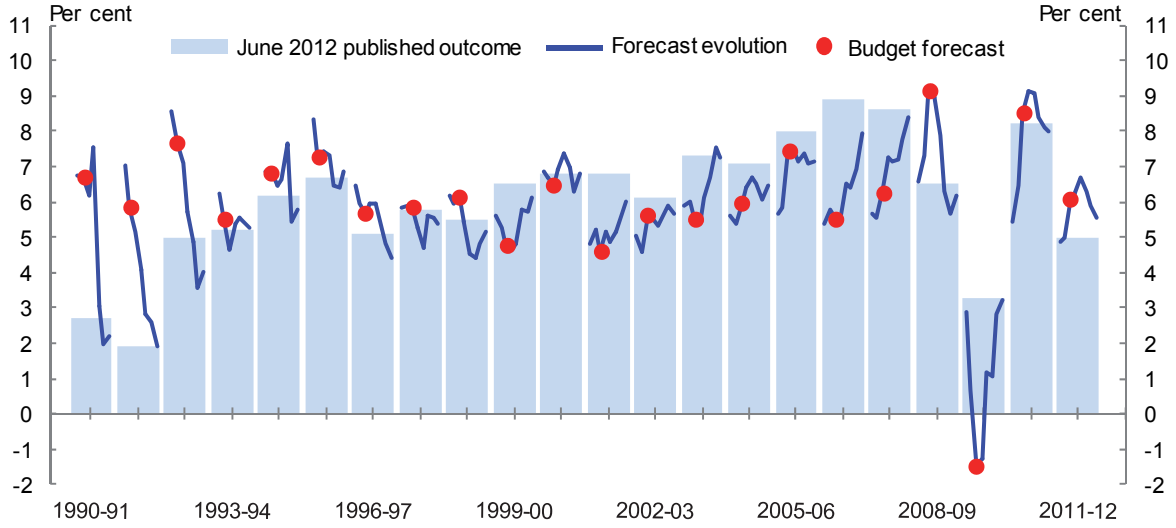
- the forecasts should be unbiased, that is to say the expected forecast error should be zero; and
- the forecasts should be accurate, that is the actual forecast errors should be minimised to the extent possible.

The Review finds that Budget forecasts of nominal GDP growth exhibit little evidence of bias over the past two decades, with the average Budget forecast error being insignificantly different from zero over this period. That said, an examination of the patterns in forecast errors reveals a more variable performance, with the forecast errors being correlated with the economic cycle (Figure 1). Hence, with the benefit of hindsight, Treasury has tended to underestimate growth during economic upswings and overestimate growth during economic downturns.[1] These have been broadly offsetting over the full sample.

This observation is not altogether surprising. 'It is in the nature of forecasting that errors will be larger around turning points in the economic cycle and smaller when the economy achieves stable, near-trend growth. Indeed, for most plausible stochastic processes driving GDP growth, optimal forecasts will exhibit the property that forecast errors are larger than average when growth outcomes turn out to be well-above or well-below trend'.[2]

[1] This may also reflect that Treasury can tend to remain too close to trend in forecasting growth, underestimating the size of peaks and troughs in the economic cycle.
[2] Gruen, D. and Stephan, D (2010), 'Forecasting in the Eye of the Storm', *Address to the NSW Economic Society*, 4 June.

Figure 1: Evolution of Nominal GDP Growth Forecasts



Note: In some years, the last forecast differs noticeably from the June 2012 published outcome. This is usually because of significant revisions to the estimated outcome between the first and most recent National Accounts releases.

The finding that Budget forecasts of nominal GDP growth exhibit little evidence of bias is in contrast with those of a recent study by Jeffrey Frankel of official government real growth rate (and budget balance) forecasts between 1985 and 2009 in 33 countries (including Australia).[3] That study found that official agency forecasts tended to have a positive average bias (that is, forecasts on average higher than outcomes); are more biased in booms; and are even more biased at the three-year horizon than at shorter horizons. The data for Australia indicate little evidence of bias in this regard compared with other countries.

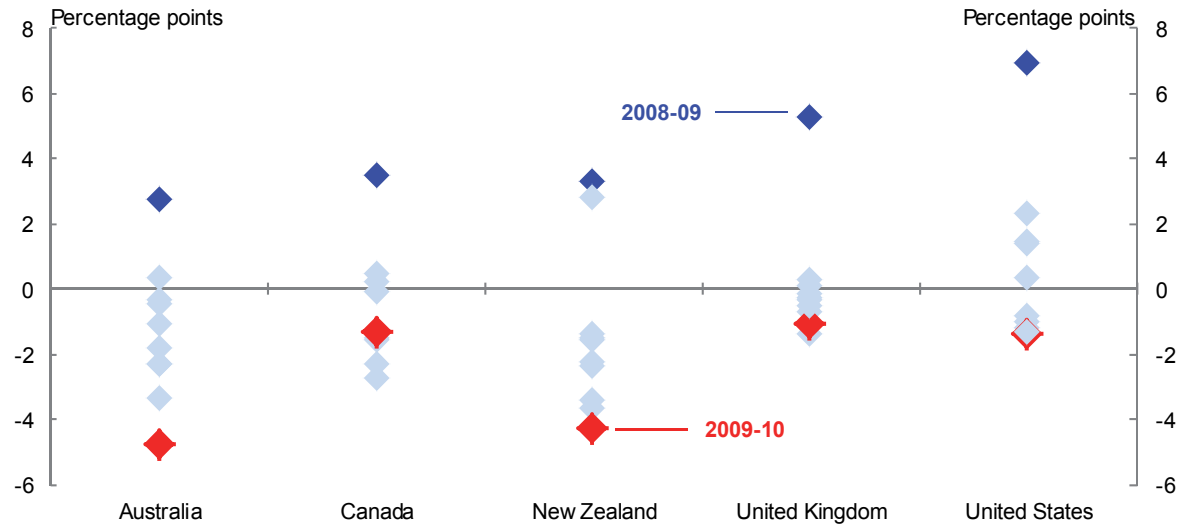
The Review also finds that Treasury's macroeconomic forecasts have been reasonably accurate. Over the past two decades, Budget forecasts of nominal economic growth have exhibited a mean absolute percentage error (MAPE) of 1.6 percentage points. Treasury's macroeconomic forecasting performance is comparable with that of other domestic forecasters. In fact, the overriding impression of the forecast errors of Treasury, the Reserve Bank and Deloitte-Access Economics (Access) is the similarity in the error patterns across agencies (with errors for each agency exhibiting significant variation across time). [4]

On the other hand, Treasury's forecasts are comparable with, or better than, those of official agencies overseas, although some caution is required in making cross country comparisons over a period as short as ten years, and given that official agencies prepare forecasts at different times in the year (Figure 2). Treasury's forecasts also compare favourably with statistical benchmarks generated by a naïve trend forecasting rule, which assumes that the series being forecast simply continues to grow at its recent average observed rate (one, three, five and ten-year moving averages of the forecast series were considered).

[3] Frankel, J. (2011), 'Over-optimism in Forecasts by Official Budget Agencies and its Implications', *Oxford Review of Economic Policy* 27(4), pp 536-562.

[4] The Review acknowledges the difficulty of drawing exact like-with-like forecast comparisons. The forecasting institutions run on different timetables, and forecasts made later will naturally have an advantage over those made earlier for a given reference period. For example, the timing of Treasury forecasts has tended to be optimised around the release of national accounts data, whereas for the RBA they are more likely to be optimised around the release of CPI data. This would contribute to the configuration of relative results for the two sets of forecasts. Results are likely to be sensitive to the choice of sub-periods.

Figure 2: International Comparison of Budget Forecast Errors across Official Agencies Nominal GDP Growth: 2001-02 to 2010-11



Note: Australia's Budget is published in early May, two months before of the start of the Budget financial year; the United Kingdom's Budget is published in March, a month before the start of its Budget financial year; Canada's Budget is generally published in February/March, within its Budget calendar year, New Zealand's Budget is published in May, two months before its Budget financial year; and the United States' Budget is published in February eight months before the start of its Budget financial year.

Within these general findings, however, Treasury's macroeconomic forecasts exhibit periods of high accuracy, interspersed with occasional periods with large outliers. In particular, Treasury overestimated nominal GDP growth in the early 1990s, as the recession at that time, and the related rapid re-establishment of low inflation, was not forecast. More recently, Treasury has also underestimated nominal economic growth during Mining Boom Mark I and large nominal economy forecast errors were generated during the GFC.

Experience suggests that these extreme events are particularly difficult to forecast. In these circumstances, large forecast errors may not necessarily indicate poor forecasting practice. Instead, they may reflect a more volatile and less predictable economic environment. Even if more resources were allocated to economic forecasting, it is not clear this would produce more accurate outcomes. In this regard, it is worth observing that all official agencies failed to forecast the onset of the GFC in 2008-09 and then appeared to overstate its effect on activity in 2009-10, albeit to a varying degree (Figure 2). Case studies have been prepared, outlined below, that discuss Treasury's forecasting performance in the face of the two major recent forecasting challenges, namely Mining Boom Mark I and the GFC and Mining Boom Mark II.

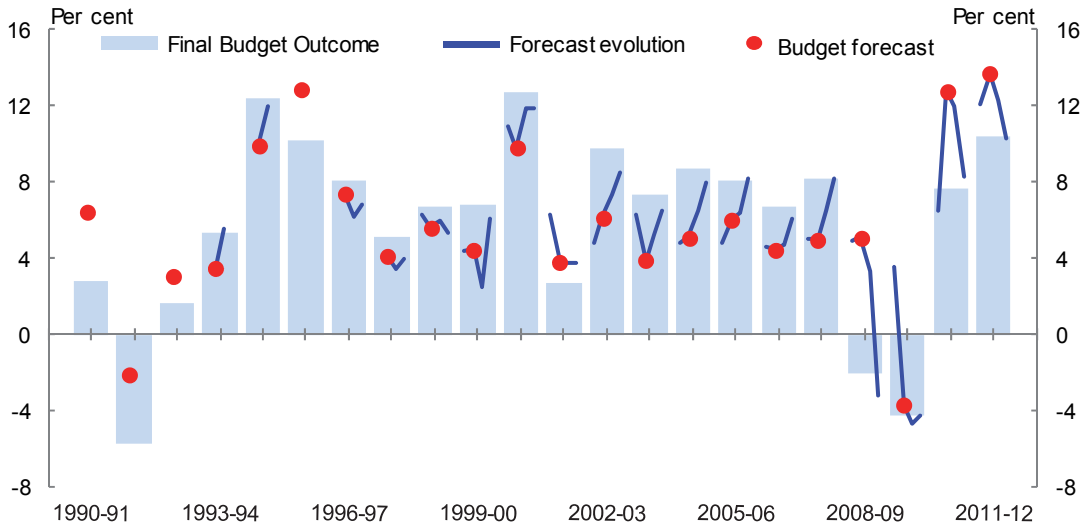
The Review has also found that Treasury's forecasts of GDP deflator growth are less accurate than those of real GDP growth. There were extended periods in the 1990s where Treasury's forecasts of GDP deflator growth were overestimated. In contrast, for periods in the 2000s outcomes were underestimated. In the 2000s, this substantially reflected the difficulty of forecasting commodity prices. These observations lead the Review to recommend that:

> Recommendation 7: Treasury should invest relatively more resources in understanding and forecasting GDP deflator growth and its components, in particular, commodity prices, and hence in nominal GDP growth.

Performance of the Taxation Revenue Forecasts

The Review finds that Budget forecasts of taxation revenue have also exhibited little evidence of bias over the past two decades, with the average Budget forecast error being insignificantly different from zero over this period. That said, as was the case with the macroeconomic forecasts, an examination of the patterns in forecast errors reveals sustained periods where Treasury has under and over-forecast revenue, with offsetting impacts over the full sample (Figure 3). In part, this has reflected patterns in the nominal economy forecast errors. While the 2005 Review found that the underestimation of taxation revenue in the first half of the past decade appeared to reflect a series of conservative biases in the forecasting process, methodological improvements appear to have removed these biases. Using the improved methodologies, remaining underestimation of revenue over that time period appears to reflect errors in forecasts of the nominal economy and asset prices, although as discussed in the case study on the GFC and Mining Boom Mark II, there are continuing issues with company tax revenue forecasts.

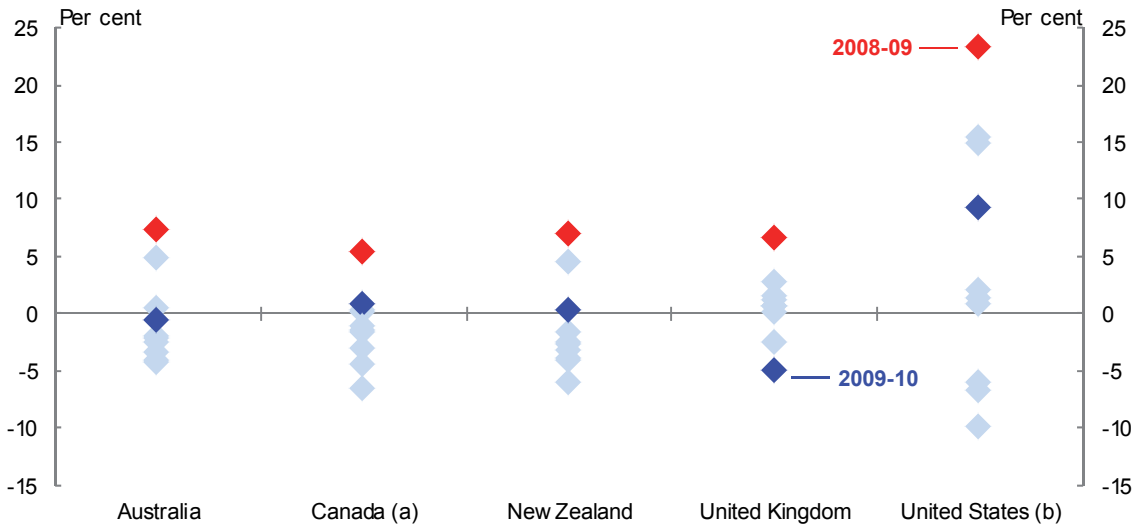
Figure 3: Evolution of Taxation Revenue Growth Forecasts



Taking into account the high degree of difficulty inherent in preparing revenue forecasts, the Review finds that those of Treasury are reasonably accurate. Over the past two decades Budget taxation revenue forecasts have exhibited a MAPE of 2.7 percentage points. This means that the average absolute Budget forecast error is around $8 billion (in 2011-12 dollars). Treasury's forecasting performance is comparable with that of Access, which is the only other domestic forecaster that has published a significant history of taxation revenue forecasts. As was apparent with the macroeconomic forecast comparison, the overriding impression of the forecast errors of Treasury and Access is the similarity in the error patterns across agencies (with errors for each agency exhibiting significant variation across time).

Treasury's revenue forecasts are comparable with, or better than, those of official agencies overseas over the past decade (Figure 4). Treasury's forecasts also display less bias than some official agencies over this period. It is worth observing that all official agencies overseas significantly over-predicted revenue for 2008-09, the year of the onset of the GFC. The pattern in 2009-10 is less clear: Australia, Canada and New Zealand made quite accurate forecasts, while the United Kingdom overestimated the impact of the GFC on taxation revenue and the United States underestimated its impact.

Figure 4: International Comparison of Budget Forecast Errors across Official Agencies Taxation Revenue: 2001-02 to 2010-11



(a) Canadian data exclude the 2002-03 Budget forecast, which are not available.
(b) Adjusted for post-Budget policy change.
Note: Australia's Budget is published in early May, two months before the Budget financial year; Canada's Budget generally published in February/March, around one month before the Budget financial year; New Zealand's Budget in May, two months before the Budget financial year; the United Kingdom's Budget in March, one month before the Budget financial year; and the United States' Budget in February, eight months before the Budget financial year.

Treasury's taxation revenue forecasts also outperform those generated by a naïve trend forecasting rule, which assumes that the series being forecast simply continues to grow at its recent average observed underlying rate (one, three, five and ten-year moving averages of the forecast series were considered).

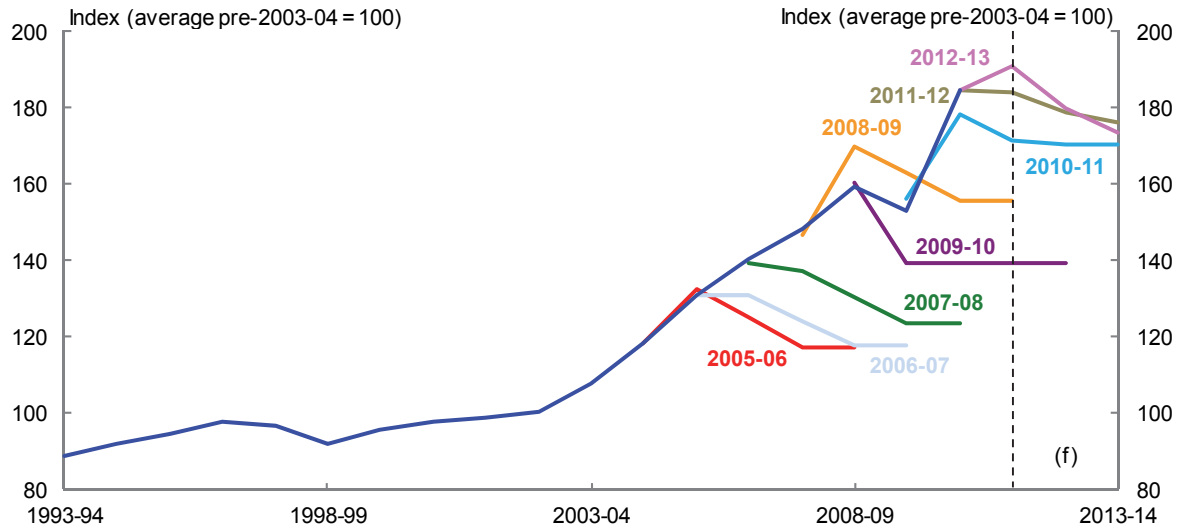
A major contributor to the errors in the taxation revenue forecasts are the errors in the macroeconomic forecasts. However, there are additional sources of error that reflect tax-specific factors, such as the timing of the receipt of revenue. As a consequence, the taxation revenue errors are generally larger than the macroeconomic errors. Over the past two decades, the MAPE for the Budget revenue growth forecasts has been around one percentage point higher than the MAPE for the Budget nominal GDP growth forecasts. That said, overall the taxation revenue forecast errors are reasonably well correlated with the nominal economy forecast errors.

The Review also finds that the heads of revenue with the largest forecast errors in recent years have been company tax and capital gains tax. Unsurprisingly, these are also two of the most volatile revenue heads, and they have been particularly challenging to forecast during the GFC and its aftermath. This is discussed in more detail in the case studies.

Case Study 1: Mining Boom Mark I

Rapid rates of industrialisation in Asia, particularly in China, increased worldwide demand for natural resources and, in turn, underpinned a sharp sustained rise in mining output prices through the mid-2000s, and a mining investment boom. In common with many other forecasters, Treasury underestimated the extent of the consequent increase in Australia's terms of trade through the mid-2000s, which led to the underestimation of nominal economic and taxation revenue outcomes (see Figure 5 and 1 and 3, above).

Figure 5: Budget Forecasts of Australia's Terms of Trade



Note: The figure plots the forecast level of the terms of trade against outcomes, with the forecast level derived from forecast growth rates of the terms of trade from successive Budgets, beginning with the 2005-06 Budget.

The Review finds that Treasury's terms of trade forecast errors largely reflected misjudgements of the evolution of the Chinese economy and the mining sector during this period, although, it would perhaps also be fair to conclude that Treasury had adopted a conservative approach to forecasting commodity prices over these years. The misjudgements contributed to commodity prices exceeding Treasury's expectations. The first of these was Treasury consistently underestimating economic growth in China, drawing heavily upon Consensus Economics forecasts, and hence the underlying strength of demand for iron ore and metallurgical coal. Chinese economic growth was underestimated on average by 2½ percentage points per annum over the period 2003 and 2007.

On the supply side, Treasury also overestimated the speed at which global mining production would respond to the rise in mining output prices. Treasury's assessment was based on mining companies' global projections for investment, production and export volumes, which consistently exceeded actual outcomes. In Australia this partly reflected infrastructure bottlenecks and the impact of natural disasters. This misjudgement saw Treasury's forecasts for export volumes consistently overstated over the period 2003-04 to 2008-09.

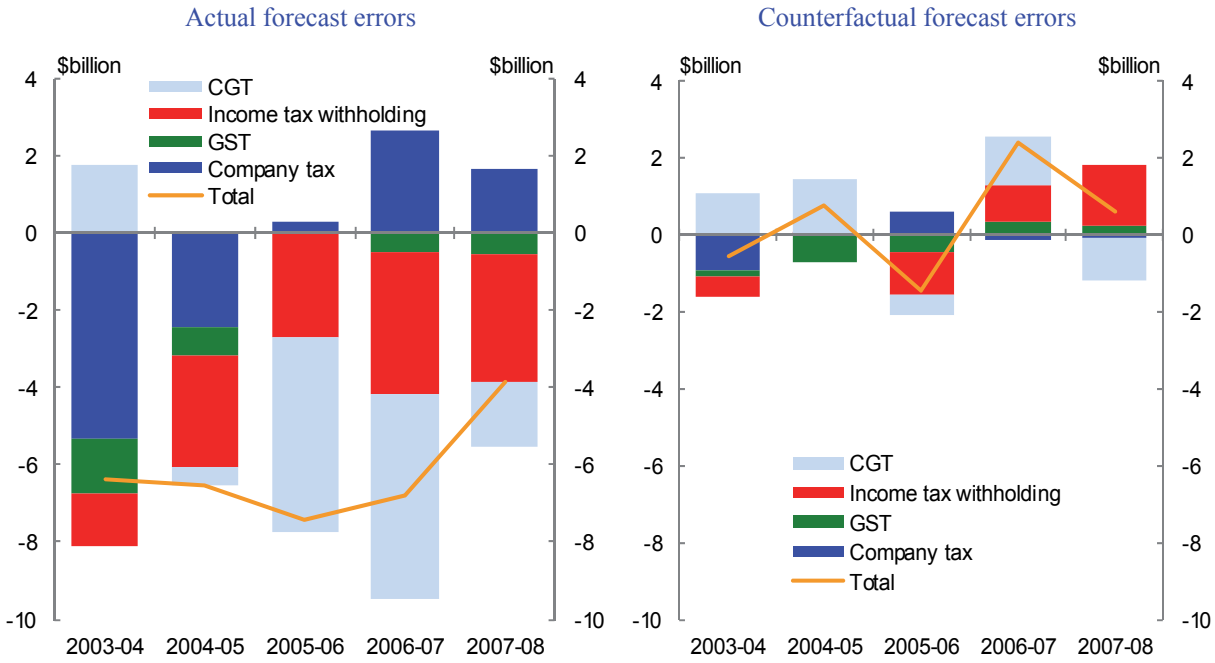
In response to these forecast errors, Treasury has substantially expanded its capability to forecast commodity prices and volumes by investing in a deeper understanding of the prospects for the Chinese and Indian economies, on the demand side, and developments among competing mining producers, on the supply side. In particular:

- as part of the JEFG process, a balance of payments subcommittee has been established to draw upon the expertise of the Bureau of Resources and Energy Economics to forecast the outlook for bulk commodities;
- a dedicated unit has been established within Treasury that focusses on the Chinese economy and Treasury representation in Asia has been enhanced by opening up a new post in India;
- Treasury's business liaison program has been refocused to place greater weight on the mining industry; and
- a major project is underway which uses detailed projections of commodity supply and demand to model the likely outlook for commodity prices through the medium-term.

The Review finds that Treasury also underestimated taxation revenue over this period. This reflected large forecast errors in the income tax withholding, company tax and capital gains tax revenue heads (Figure 6, left hand panel). To examine the extent to which these errors reflected forecast errors of nominal economic growth and outcomes for asset prices, a counterfactual exercise has been undertaken that prepared revenue forecasts over Mining Boom Mark 1 using actual, rather than forecast, nominal economic outcomes and asset prices.

On the basis of the counterfactual exercise, the Review finds that most of the revenue forecasting errors over this period could be attributed to errors in the nominal economy forecasts, rather than any systematic tendency to underestimate revenue during a boom period (Figure 6, right hand panel). While this provides some confidence in the integrity of the revenue forecasting methodology, this is not to downplay the inherent difficulty of forecasting revenue during this volatile period, and in particular the difficulty of forecasting sharp sustained rises in commodity prices and asset prices (such as house and equity prices).

Figure 6: Contribution to Budget Taxation Revenue Forecast Error by Major Head of Revenue



Note: The counterfactual exercise uses a more refined model for forecasting capital gains tax (CGT) than was available at the start of Mining Boom Mark I. The model was implemented from 2006-07, following a review of the CGT forecasting framework, which was undertaken due to the large forecasting error in CGT revenue in 2005-06.

Case Study 2: The Global Financial Crisis and Mining Boom Mark II

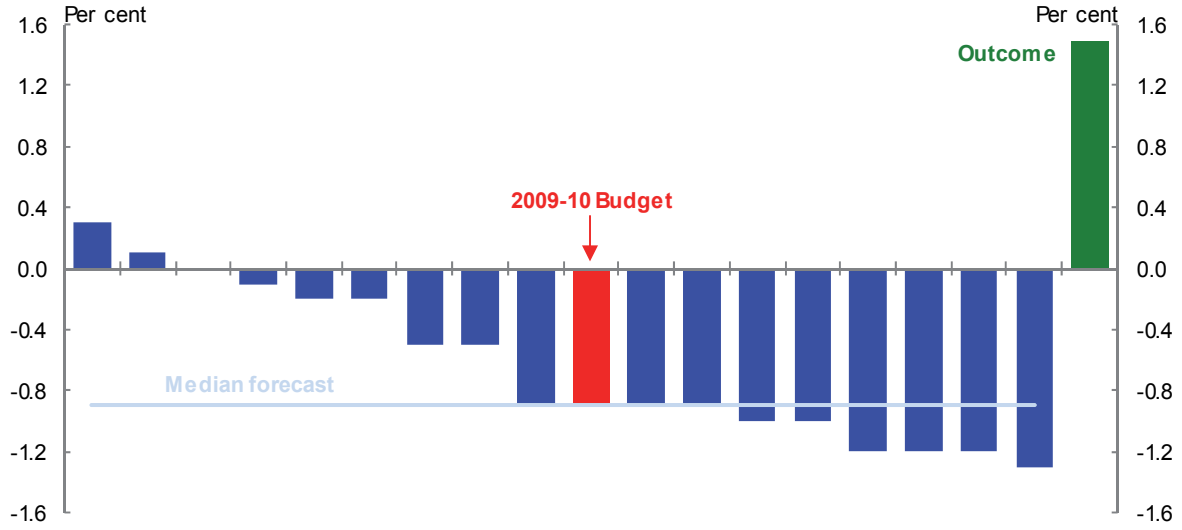
The world economy experienced a severe financial and economic shock in the second half of 2008. The Global Financial Crisis (GFC) began in 2007 with the US sub-prime crisis and the crisis intensified dramatically in September 2008 with the collapse of Lehman Brothers. During this period, financial conditions deteriorated rapidly, financial and real asset prices collapsed, and business and consumer confidence fell steeply. The GFC saw the world economy change course sharply from a five-year period of above-trend growth to the deepest recession since the Great Depression. As the impact of the GFC has subsided, Australia's terms of trade rebounded and reached a new record high in 2011-12, albeit against a backdrop of global uncertainty and more cautious households.

The Australian economy performed better than other advanced economies during the GFC. Although financial conditions were stressed, the financial system held up remarkably well; the economy slowed,

but did not fall into recession; and while unemployment rose, it did so by far less than in many other advanced economies. The strong performance of the Australian economy largely reflected the strength of the Australian financial system and public finances; the rapid deployment of fiscal stimulus measures; the first effects of a significant easing in monetary policy; and a pickup in demand from China which partly offset pronounced external weakness elsewhere. More broadly, it also reflected improved policy and institutional arrangements in Australia following a quarter century of reforms that have made the Australian economy much more resilient to external shocks.[5]

Treasury did not predict the degeneration of the US subprime crisis into the GFC in 2008-09 and subsequently overestimated the impact of the crisis on economic growth in 2009-10. This created large macroeconomic and revenue forecast errors (Figures 1 and 3, above). In particular, in the 2009-10 Budget, at the height of a period of significant global and domestic pessimism, Treasury forecast a recession in that year that did not eventuate. At the time, Treasury's forecast was around the median of the range of forecasts surveyed by Consensus Economics in mid-April (Figure 7). Treasury's forecast for a recession in 2009-10 was underpinned by a moderate expected decline in household consumption and a sharp decline in business investment and exports. In the event, household consumption continued to grow, and the contraction in business investment and exports in 2009-10 was considerably less than forecast.

Figure 7: Forecasts of Real GDP Growth in 2009 (as at April 2009)



Source: Consensus Economics (Survey date 14 April 2009), Treasury (Budget, 11 May 2009).

The Review finds that Treasury's forecasting error for economic growth in 2009-10 largely reflected misjudgements of the efficacy of Australia's policy response and the relatively early, and strong, recovery in economic growth in most of our major trading partners throughout 2009.[6]

Rapid and substantial monetary and fiscal policy stimulus played a critical role in increasing effective demand and the early recovery of consumer and business confidence in Australia. In particular, the stimulus appears to have been large enough and sufficiently rapid to convince consumers and businesses that the domestic slowdown would be relatively mild. This, in turn, led consumers and businesses to continue to spend and led businesses to cut workers' hours rather than laying them off,

[5] McDonald, T, and Morling, S, 2011, 'The Australian Economy and the Global Downturn, Part 1: Reasons for resilience', *Economic Roundup*, Issue 2, pp 1-31.
[6] Gruen, D, and Stephan, D (2010), 'Forecasting in the Eye of the Storm', *Address to the NSW Economic Society*, 4 June.

which in turn helped the economic slowdown to be relatively mild.[7] While the stimulus was explicitly factored into Treasury's forecasts, it was also a contributing factor to the 2009-10 Budget forecast errors.

The Australian economy also benefited from the earlier-than-expected, and stronger-than-expected, recovery in economic growth in most of our major trading partners throughout 2009, which in turn was driven by substantial macroeconomic policy stimulus in those countries. In particular, Chinese economic activity shifted into more commodity-intensive sectors, particularly infrastructure spending, associated with the Chinese government's stimulus packages. This supported the domestic outlook for exports and business investment.

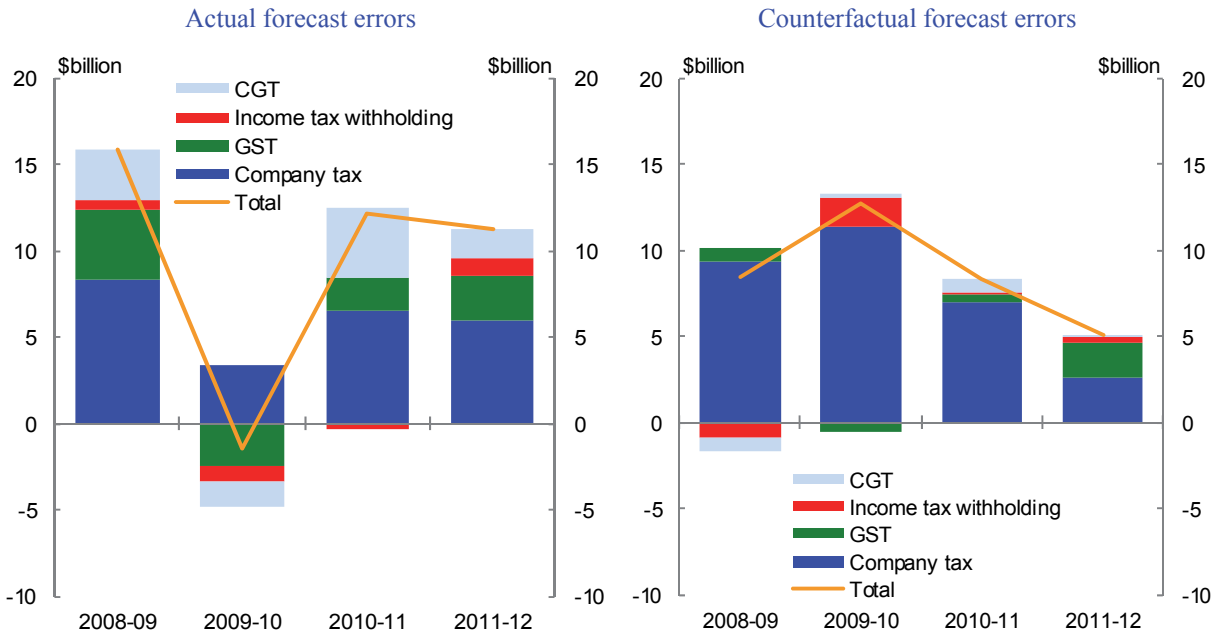
The Review observes that the large forecasting errors seen during the GFC highlight the fact that during such extreme events the evolution of the economy is fundamentally less predictable than at other times. As noted, above, a number of official agencies overseas had large forecasting errors during this period (Figure 2). That suggests a case for greater use of risk assessments around the central forecasts, rather than necessarily a major overhaul of forecasting procedures. This leads the Review to make the following recommendation.

> Recommendation 8: Scenario analysis is useful as a way of assessing the risks around the economic and revenue forecasts. Simulation models have an important role to play in this regard and further development of Treasury's suite of models may be required to deliver this capability, including in relation to the international economic outlook.

The Review finds that Treasury overestimated revenue growth during the GFC and Mining Boom Mark II. This reflects large forecast errors in the company tax, GST and CGT revenue heads (Figure 8, left hand panel). To examine the extent to which these errors reflected forecast errors in nominal economic growth, a further counterfactual exercise has been undertaken that uses actual, rather than forecast, nominal economic outcomes and asset prices to generate revenue forecasts over this period. The Review finds that the errors for most revenue heads are reduced significantly in the counterfactual (Figure 8, right hand panel). However, in contrast to the Mining Boom Mark I counterfactual, there are significant residual forecast errors in the company tax revenue head, indeed the company tax revenue errors are amplified in the first two years of the counterfactual.

[7] Treasury estimates that economic growth would have been negative for three consecutive quarters absent fiscal stimulus.

Figure 8: Contribution to Budget Taxation Revenue Forecast Error by Major Head of Revenue



The reasons for the company tax forecast errors are a matter of concern and continue to be investigated. They are likely to reflect in part the poor performance of the company tax forecasting model in cases where sectors of the economy are growing at very different rates, as was observed during the GFC and Mining Boom Mark II. This occurs in two ways:

- First, the company tax forecasting model does not distinguish between the different characteristics of different sectors, such as the capital intensive nature of the mining sector. In this regard, a significant driver of the weaker-than-expected outcomes for company tax was stronger-than-expected growth in depreciation deductions, relating to a surge in mining investment in response to the mining boom.

- Second, the company tax forecasting model does not take sufficient account of companies that operate on substituted accounting periods, in particular the large financial companies that operate on an accounting year ending in September and the large mining companies whose accounting year ends in December. This makes it more difficult to accurately estimate the timing of the receipt of cash payments of corporate tax on underlying corporate profits.

In response to the perceived source of these forecasting errors, Treasury is currently developing a three sector company tax model which splits the economy into mining, finance and insurance and other sectors. This approach better takes account of the different characteristics of these sectors for taxation purposes, for example, the capital-intensive nature of the mining sector, and the measurement of the income of the finance sector in the National Accounts. This approach also makes better allowance for substituted accounting periods.

Notwithstanding these developments, because of the difficulty Treasury has had forecasting revenue, in particular company tax revenue, but also capital gains tax revenue, the Review recommends that:

> Recommendation 9: Treasury should give further consideration to the appropriate balance between the top-down versus bottom-up approaches to forecasting revenue.
>
> Recommendation 10: Treasury, in conjunction with the ABS as necessary, should explore further ways of improving the current methodology for forecasting corporate tax, and also

consider alternatives to the current methodology, which could perhaps be used to complement existing approaches.

Recommendation 11: The technical specialist with deep financial market experience employed by Treasury should be tasked with improving the accuracy of the technical assumptions for equity and housing prices that are used to generate the capital gains tax revenue forecasts.

Conclusion

Macroeconomic and revenue forecasting is a core Treasury function. It informs Treasury's advice across a broad spectrum of policy areas. It is a complementary activity to policy formulation and costing.

There is a high degree of difficulty inherent in preparing forecasts. The economic environment has become more volatile recently and profound structural changes are occurring domestically and internationally that are making the forecasting task more difficult.

While the Review has made a number of recommendations for improvements to the forecasting process, the Review finds that Treasury approaches the forecasting task in a very professional manner and the forecasts it generates are broadly as accurate as those of both domestic forecasters and those generated by comparable agencies in countries with similar institutional arrangements as Australia.

RECOMMENDATIONS OF THE TREASURY FORECASTING REVIEW

The Review has made a number of recommendations, outlined below, to improve Treasury's forecasting methodology and process, while noting, as context, the need to ensure that resources are appropriately prioritised across the Department.

Recommendation 1: Given the importance of information on economic conditions obtained from business liaison — and the capacity of this source to inform the forecasts — Treasury should investigate with the Reserve Bank of Australia more formal channels through which to exchange insights from their respective programs, such as during the quarterly joint forecasting rounds (without compromising the confidentiality of liaison contacts). Similarly, Treasury should also investigate whether further information can be drawn from the Australian Taxation Office's liaison with large corporate taxpayers for revenue forecasting purposes.

Recommendation 2: A detailed assessment of the role, and appropriate type, of Treasury's macro econometric model was beyond the scope of this Review. However, the Review believes it is important to embed the redeveloped TRYM model into the economic forecasting process, both as a complement to the existing forecasting framework and to facilitate analysis of the impact of shocks to the domestic economy.

Recommendation 3: Treasury should examine the feasibility of constructing a micro simulation model for forecasting personal income tax, as is the practice in the United States and United Kingdom.

Recommendation 4: Treasury should publish technical documentation that describes the data and the conceptual and econometric basis of models used for economic and revenue forecasting. A number of official agencies overseas have published technical documentation of their forecasting models.

Recommendation 5: Treasury should include in the Budget papers a high level review of the economic forecast errors (nominal and real GDP) for the previous financial year, as a complement to the existing discussion of revenue forecasting errors.

Recommendation 6: Reviews of Treasury's forecasting performance should be undertaken at least every five years to examine the causes of forecast errors and to help identify areas in which Treasury's forecasting methodology could be improved. These Reviews should be overseen by an independent external reference group.

Recommendation 7: Treasury should invest relatively more resources in understanding and forecasting GDP deflator growth and its components, in particular, commodity prices, and hence in nominal GDP growth.

Recommendation 8: Scenario analysis is useful as a way of assessing the risks around the economic and revenue forecasts. Simulation models have an important role to play in this regard and further development of Treasury's suite of models may be required to deliver this capability, including in relation to the international economic outlook.

Recommendation 9: Treasury should give further consideration to the appropriate balance between the top-down versus bottom-up approaches to forecasting revenue.

Recommendation 10: Treasury, in conjunction with the ABS as necessary, should explore further ways of improving the current methodology for forecasting corporate tax, and also consider alternatives to the current methodology, which could perhaps be used to complement existing approaches.

Recommendation 11: The technical specialist with deep financial market experience employed by Treasury should be tasked with improving the accuracy of the technical assumptions for equity and housing prices that are used to generate the capital gains tax revenue forecasts.

SECTION 1: BACKGROUND

1.1: The challenges to preparing macroeconomic and revenue forecasts

Treasury is the principal economic advisory agency of the Australian Government. In this role, Treasury prepares macroeconomic and revenue forecasts as key inputs into the preparation of budget estimates of revenue and expenditure. The budget estimates provide a fiscal baseline against which new policy decisions can be taken by the Government, including policy decisions taken to meet its medium-term fiscal strategy. Treasury's medium term projections have taken on an enhanced role because of the requirement of the *Charter of Budget Honesty* for Governments to set fiscal policy within a sustainable medium-term framework.[1]

Treasury's macroeconomic forecasts are also used more broadly to assist in the framing of forward-looking macroeconomic policy advice.

Forecasting is an inherently difficult exercise. It is challenging to capture the salient features of a modern complex economy in a framework simple enough to be tractable. Unlike the physical sciences, the inability to conduct repeated experiments means that it is difficult to use economic data to disentangle quantitatively the impacts of different influences on the economy, particularly in the face of continual structural change. Human behaviour, in particular the influence of *animal spirits*, has elements that are inherently unpredictable. Economies are buffeted by shocks, which by their very nature are not foreseeable, for example economic disasters, such as droughts, and technological advances. Lags in data collection and survey error mean that forecasters are reliant upon their own informed assessment about the current state of the economy. It follows naturally that judgement plays an important role in the preparation of forecasts.

It is for these reasons that the discussion of the risks and uncertainties around central case point estimates is a fundamental part of any set of forecasts and a critical input into forward-looking macroeconomic policy deliberation. This element of forecasting practice can be downplayed in a review of forecasting performance which focuses on point estimates. Analysis of forecast errors can point to areas where forecasting methodology can be improved, but caution is required when using ex post evaluations of forecast accuracy to draw conclusions relating to the effectiveness of forecasts as inputs into the policy process. This would require an assessment of whether the broader presentation of the economic outlook affords a picture of likely developments that provides an adequate basis for policy decisions.

1.2: The 2005 Review of Forecasting the Nominal Economy and Taxation Revenue

As discussed, part of the process of improving forecasts is reviewing past forecasting performance, examining the reasons for forecasting errors and identifying areas where forecasting methodology can be improved.

Treasury's forecasting of the macroeconomy and revenue operates in an environment of continuous evaluation and development. The forecasts are regularly subjected to internal review, and to formal peer review by other government agencies as part of the quarterly Joint Economic Forecasting Group (JEFG) meetings. However, from time to time, it is also valuable to formally take stock of the Department's forecasting capability and performance.

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1 Clause 4 of the *Charter of Budget Honesty* requires that:

> 'The Government's fiscal policy is to be directed at maintaining the on-going economic prosperity and welfare of the people of Australia and is therefore to be set in a sustainable medium-term framework.'

The most recent major internal review of Treasury's forecasting performance was the Review of Forecasting the Nominal Economy and Taxation Revenue (the 2005 Review). It was commissioned in 2005 in response to significant upward revisions to successive published forecasts of Australian Government taxation revenue over a number of years, which had drawn into question the quality of Treasury's forecasts at the time.[2]

The major findings of the 2005 Review related to the revenue forecasts and revenue forecasting methodology and included that:

- the underestimation in the Treasury's revenue forecasts appeared to reflect a series of conservative biases in the revenue forecasting process, combined with technical assumptions that implied that forecast revenue growth was insufficiently sensitive to nominal GDP growth;
- Treasury had an inadequate understanding of the relationship between the nominal economy and taxation revenue; and
- Treasury's capacity to undertake meaningful analysis of taxation revenue had been severely hampered by underinvestment in taxation revenue data.

In response to these findings, Treasury's Executive Board established a dedicated team to implement the recommendations of the 2005 Review that were designed to overhaul the data and methodology used to forecast taxation revenue. The team subsequently made major investments in the quality of taxation revenue data sets and taxation revenue forecasting methodology over an eighteen month period.

The 2005 Review also made a number of recommendations designed to improve the professional interactions between the economic and revenue forecasters; to enhance the skill sets of the revenue forecasters; and to increase the emphasis given to the nominal economy forecasts in the economic forecasting area. The recommendations of the 2005 Review are at Attachment A, together with an assessment of progress made towards their implementation.

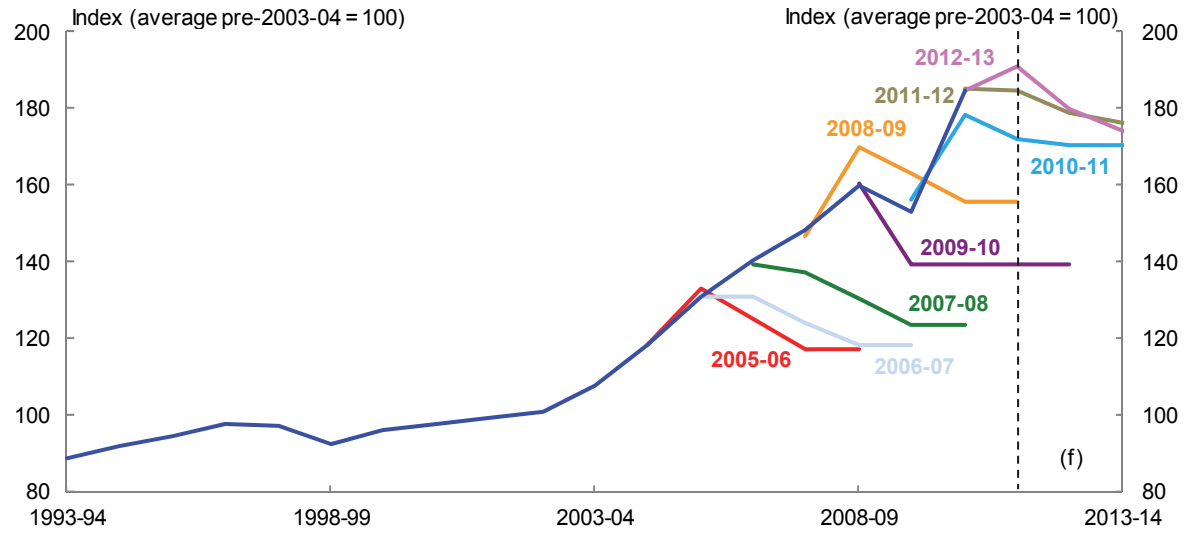
1.3: Recent forecasting challenges

The period since the 2005 Review has been challenging for both economic and revenue forecasting. Two major developments, in particular, stand out.

The first of these relates to rapid rates of industrialisation in Asia, particularly in China, which increased worldwide demand for natural resources and in turn, underpinned an investment boom and a sharp rise in output prices in the mining sector over an extended period. In common with other forecasters, Treasury underestimated the extent of the resultant terms of trade boom in Australia through the mid-2000s (see Figure 1.1), which led to the underestimation of nominal economic outcomes and taxation revenue.

2 The outcome of the review of macroeconomic forecasts was published in the *Economic Roundup*, Autumn, 2005. This follows on from the publication of key results of the 1996 evaluation of macroeconomic forecasting performance in the *Economic Roundup*, Autumn, 1996.

Figure 1.1: Budget Forecasts of Australia's Terms of Trade



Note: The figure plots the forecast level of the terms of trade against outcomes, with the forecast level derived from forecast growth rates of the terms of trade from successive Budgets, beginning with the 2005-06 Budget.

The second of these relates to the impact of the global financial crisis (GFC), and its aftermath, on the Australian economy and taxation receipts. In common with other forecasters, Treasury did not predict the onset of the GFC in 2008-09, and subsequently overestimated the impact of the GFC on economic growth in 2009-10. This created large macroeconomic and revenue forecast errors. In particular, in the 2009-10 Budget, at the height of a period of significant global and domestic pessimism, Treasury forecast a domestic recession in 2009-10 that did not eventuate. Treasury has also overestimated revenue growth in recent years, reflecting the lingering effects of the GFC. Even though Australia's nominal economy is now around 25 per cent larger than in 2007-08, tax receipts are only around 11 per cent higher, resulting in the tax-to-GDP ratio being 2.6 percentage points of GDP below its pre-GFC level (Figures 1.2 and 1.3).

Figure 1.2: Nominal GDP

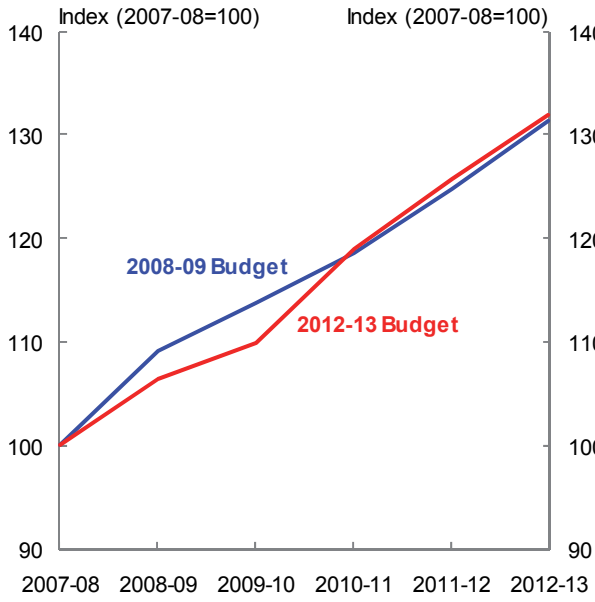
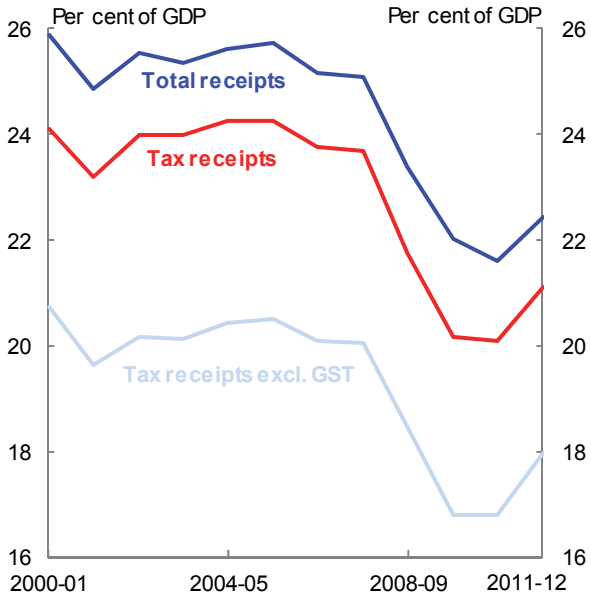


Figure 1.3: Tax to GDP ratio



1.4: The Review of Treasury Macroeconomic and Revenue Forecasting

Against this backdrop, and given the time that has passed since the last major review, Treasury decided that it was again time to undertake a review of its macroeconomic and revenue forecasting performance.

The Review of Treasury Macroeconomic and Revenue Forecasting (the Review) has been undertaken by a secretariat established within Treasury, and overseen by an independent external reference group (the Advisory Panel) made up of members with strong economic credentials.

The Terms of Reference for the Review require an assessment of the quality of Treasury's forecasting of the macroeconomy and taxation revenue by:

1. examining the appropriateness of forecasting methodologies and

2. comparing forecast accuracy with other forecasters, both in Australia and overseas.

In the view of the Review, to examine the appropriateness of forecasting methodologies requires an assessment of whether the Treasury:

- is drawing upon the full range of information in preparing its forecasts;

- is using this information efficiently by drawing upon models/technical tools appropriate to the forecasting task; and

- has appropriate governance structures in place to ensure that (i) Treasury's forecasts are subject to quality assurance and review (ii) its forecasting methodologies operate in an environment of continuous evaluation and development and (iii) Treasury has in place knowledge management systems, recognising the need for specialist expertise and technical tools in these areas that takes considerable time to build.

To aid in this assessment, a high level review of international forecasting practice has been prepared. This work forms the second section of this report.

Further, the Review ruled out of scope of the Terms of Reference matters relating to:

- the resourcing of the forecasting areas, including the number, technical capability and experience of staff. In part, this reflects the difficulty of the Review assessing the appropriateness of staff resourcing without an appreciation of the other demands on Treasury resources and the broader fiscal environment. This issue has been the subject of earlier internal reviews;

- any technical assessment of the models/technical tools being used by the forecasting areas, including their econometric and conceptual rigor. This issue has also been the subject of earlier internal reviews. Furthermore, Treasury has employed an in-house technical specialist to ensure that its macroeconomic technical models/tools are at the cutting edge of macroeconomic forecasting practice, within the overall modelling strategy that Treasury has adopted; and

- the accuracy of Treasury's taxation policy costings, noting that the 2005 Review found that errors in taxation policy costings did not make a material contribution to revenue forecast errors.

The interpretation of the second part of the terms of reference is more straightforward, requiring a quantitative assessment of Treasury's forecasting accuracy, and a comparison with forecasters in Australia and overseas. This work forms the third section of this report

In addition, case studies have been prepared that provide more qualitative analysis of Treasury's forecasting performance in relation to the key forecasting challenges faced over the last decade, including the lessons learned from these events. As foreshadowed earlier in this section, these forecasting challenges relate to the rapid industrialisation of China, and the associated terms of trade boom, and the GFC and its aftermath. The case studies form the fourth section of this report.

1.5: The role of the independent external reference group

The Advisory Panel has played an oversight role, including providing comments and suggestions to the Secretariat on the scope and content of the report. In addition, the Advisory Panel has prepared the Executive Summary which includes a number of recommendations and suggestions for further improving the Treasury's forecasting processes going forward.

The Secretariat has authored the report and is responsible for the data, analysis and commentary contained in the report.

SECTION 2: APPROPRIATENESS OF FORECASTING METHODOLOGY

2.1: International Forecasting Practices

Summary

A survey of comparable macroeconomic and revenue forecasting agencies reveals:

- there is no commonly-accepted standard practice in the production of macroeconomic and revenue forecasts;
- most agencies draw upon a combination of modelling techniques, consumer and business surveys, business liaison, expert opinion, and judgement to produce macroeconomic and revenue forecasts; and
- the differences across agencies lie in the modelling techniques, particularly, the type and role of the models employed in the forecasting process, and the weight given to each of these inputs.

Macroeconomic Forecasting Practices

A high-level survey of macroeconomic forecasting practices indicates that most official agencies draw upon a combination of modelling techniques, and a range of other information, including judgement, to produce macroeconomic forecasts. The benefits of this multi-dimensional approach to macroeconomic forecasting have recently been documented by the Office for Budget Responsibility (OBR) (2011)[1] and the Reserve Bank of Australia (RBA) (2010).[2]

It is common for forecasting agencies to maintain two forecasting systems (Pagan and Robertson, 2002).[3]

- The first focuses on the short-term forecasting horizon (up to, perhaps, six months) and uses indicator or spread sheet models and relies heavily upon judgement supplied by in-depth analysis of major sectors of the economy undertaken by sector specialists.
- The second focuses upon longer time horizons (greater than six months) and modelling the economy as a 'system' with the core forecasting technology typically either:
  - a relatively small economy-wide structural macro-econometric model; or
  - single structural econometric equations, with national account identities preserved within a spread sheet system, and consistency between the elements of the forecasts achieved by iteration between sector specialists.

The choice of core forecasting technology depends on the extent to which the forecasting agency has the need to undertake policy evaluation. In setting monetary policy, central banks will necessarily consider the impact of different policy stances against the central case forecasts. In contrast, fiscal policy is concerned with improving resource allocation, typically within a medium-term fiscal framework. In ordinary economic circumstances, discretionary fiscal policy is not concerned with stabilising the economic cycle. This distinction may account for the greater tendency for central banks to invest the significant resources necessary to develop and maintain state-of-the-art modelling

[1] OBR, 2011, 'Forecasting the Economy', *Briefing Paper No. 3*.
[2] Lowe, P. 2010, 'Forecasting in an Uncertain World', *Address to Australian Business Economists Annual Forecasting Conference Dinner*, Sydney, 8 December.
[3] Pagan, A. and Robertson, J. 2002, 'Forecasting for Policy', *A Companion to Economic Forecasting* edited by Michael P Clements and David F. Hendry.

capability that focuses on cyclical, rather than medium to longer term, economic fluctuations, that is, in comparison with Treasury and Finance Departments.

Modelling techniques

One distinction between models is the trade-off between their conceptual coherence with economic theory and their empirical coherence with economic data.[4] Economy-wide structural macro-econometric models draw heavily on economic theory to determine their specification, which facilitates their use for policy evaluation. Fukac and Pagan (2009)[5] distinguish between four generations of structural macro-econometric models, with dynamic stochastic general equilibrium models at the cutting edge of modelling practice and the greatest coherence with economic theory. In contrast, vector autoregression (VAR) models are economy-wide systems of equations that model the interrelationships between economic variables while imposing minimal assumptions about the underlying structure of the economy. They aim to provide good statistical representations of the interactions between variables over the available sample period. They are more widely used in near-term forecasting.

Located between these ends of the spectrum are structural macro-econometric models that use economic theory to tie down the long run (or steady state) path of the modelled economy, but allow the data to dictate the short-run dynamic adjustment path of the economy to the long run steady state. These models are the second and third generation of models according to the Fukac and Pagan taxonomy and can be used as the core forecasting technology, as well as to evaluate the impact of macroeconomic policy

Economy-wide structural macro-econometric models that play a central role in macroeconomic forecasting include the Bank of England Quarterly Model, the HM Treasury and UK Office of Budget Responsibility Macroeconomic model, the US Federal Reserve FRB/US model, and the New Zealand Treasury Model. These models require considerable resources in development and maintenance.

In addition to the core forecasting technology, forecasting agencies may also maintain auxiliary models, as inputs into the forecasting and policy advising process. These models may draw upon information sources that have been excluded from the core forecasting model. They can also be used to analyse issues that would be difficult to undertake within the core forecasting technology, for example, the economic impact of one-off events, such as weather-related phenomena.

Additional inputs into the forecasting process

While useful, pure forecasts generated by econometric models are generally supplemented by in depth analysis of major sectors of the economy, drawing upon a range of other information, to produce a final macroeconomic forecast. The reasons for this have been well-articulated by the OBR (2011),[6] who note that:

> ‘Producing forecasts has never been solely a matter of cranking the handle of an econometric model. Models are an imperfect representation of the world. They are necessary simplifications of reality. Forecasters are typically confronted with at least some key behavioural equations that do not explain the recent past well. The forecaster has first to try to identify the reasons for this, and then decide whether the unexplained element of behaviour — the equation ‘residual’ or ‘error’ — will stay the same, get bigger or get smaller.’

[4] Pagan, A. 2003, *Report on Modelling and Forecasting at the Bank of England*, January.
[5] Fukac, M. and Pagan, A. 2009, ‘Structural Macro-Econometric Modelling in a Policy Environment’, *Reserve Bank of New Zealand Discussion Paper*, 2009/16, December.
[6] OBR, 2011, op cit.

Five additional elements inform the macroeconomic forecasts of most agencies. The first three of these are particularly relevant for near-term forecasting horizons.

First are consumer and business surveys, which have been shown to be useful in identifying the likely direction of household spending, and business investment and hiring decisions, in the first few quarters of a forecast period. Surveys contain questions that are forward looking and are generally published in a timelier manner than official data.

Second is business liaison. Maintaining a regular dialogue with the business community is seen as extremely valuable for identifying emerging trends in the economy. Many agencies have established dedicated resources, usually involving staff based away from the head office in major cities, who regularly engage with the business community through one-on-one discussions. Information gained from these engagements is used to inform the final macroeconomic forecasts. Some agencies regularly publish their findings. Examples include the US Federal Reserve's Beige Book, the Bank of England's Agency Report, and the Bank of Canada's Business Outlook Survey. The importance of business liaison was recently highlighted by the RBA:

> 'Over recent years, a couple of examples stand out where this liaison has been particularly important. One was in helping us understand the implications of the much tighter credit conditions in 2008 and 2009. And the other has been helping us understand the scale and the timing of the pick-up in investment in the resources sector. In both cases, our liaison provided us with valuable information that was not available elsewhere and had a significant role in shaping our forecasts.'

Third, is partial economic data and leading indicators, such as the monthly building approval data in Australia, which can help to inform near-term forecasts of construction activity.

Fourth is expert opinion, such as advice from specialist agencies, for example the Australian Treasury draws upon expert advice from its Retirement Income Modelling unit to project the growth in working age population and expert advice from the Bureau of Resources and Energy Economics to inform the forecasts of non-rural commodities.

The fifth and least tangible input to macroeconomic forecasts is judgement, informed by experience and corporate memory.[7] The OBR cite work which suggests that the use of judgement generally improves the accuracy of the forecasts.[8] Indeed, all documentation by agencies on their approach to forecasting refers to the importance of judgement in shaping their forecasts.

Towards the end of the process, macroeconomic forecasts are typically subject to internal review by senior management. Some agencies including the New Zealand Treasury, the Congressional Budget Office (CBO), and the Canadian Ministry of Finance also subject their forecasts to peer review by an external panel of experts.

In short, most agencies draw upon a combination of modelling techniques, surveys, business liaison, expert opinion and judgement to produce macroeconomic forecasts. The differences across agencies lie in the modelling techniques and the weight given to each of the inputs.

Taxation Revenue Forecasting Practices

Countries tend to release only general and limited information on their revenue forecasting methodology and individual head of revenue models. This makes international comparisons more difficult than for macroeconomic forecasting.

[7] Onkal-Antay, D. Thomson, M. and Pollock, A, 2002, 'Judgemental Forecasting', *A Companion to Economic Forecasting* edited by Michael P Clements and David F. Hendry.
[8] OBR, 2011, op. cit.

Modelling techniques

Based on available information, most countries forecast taxation revenue using a 'bottom-up' approach, where individual heads of revenue are forecast and then aggregated to produce a total revenue forecast. This is the general approach taken in the United States, Canada and New Zealand.[9] Some regions forecast total taxation revenue and then disaggregate this figure into heads of revenue, for example Scotland[10], but this tends to be due to data limitations which constrain the use of a bottom-up approach.

In terms of methodology, the main technologies used in revenue forecasting are mapping models, single econometric equations and micro-simulation models. The range of forecasting technologies employed can vary from one head of revenue to another, as noted by the United Kingdom's OBR (2011):[11]

> 'forecasting models are specific to each individual tax and can take a variety of different forms such as econometric equations, micro-simulation models based on samples of individual tax records, projections in line with selected indicators [mapping] or just simply by judgement.'

Mapping models appear to be a widely used technology for countries where revenue forecasts are prepared in conjunction with macroeconomic forecasts. These models are largely accounting frameworks designed to account for the conceptual differences between a taxable base, which reflects taxation law principles, and an economic base, which reflects national accounting principles (for example the difference between economic and taxable income for companies).[12] Econometric techniques are not usually required as the elasticity of revenue to its taxable base is one for heads of revenue with a flat tax rate, as is the case for many taxes. The macroeconomic forecasts are used to grow the economic base, ensuring consistency between the macroeconomic and revenue outlooks. The New Zealand Treasury relies heavily on mapping technology to produce revenue forecasts.[13]

Mapping technologies tend to be supplemented by the use of econometric models to estimate tax revenue elasticities, for example, for progressive taxes, and in some instances by micro-simulation. Micro-simulation models operate at the level of the individual behavioural entity, such as a person, family, or firm. Such models simulate large representative populations of these low-level entities in order to draw conclusions that apply to higher levels of aggregation such as an entire country. This type of model is distinct from aggregate models whose explanatory variables already represent collective properties. Micro-simulation has been applied in the United States and United Kingdom to forecast personal income tax revenue, using large data sets to develop detailed micro-simulations.

Data limitations are a constraint on revenue forecasting methodology. In particular, there are typically long lags in receiving income tax return data, and items in individual tax returns tend to be aggregated, particularly for corporate tax payers, with the effect of concealing drivers of assessable income for revenue forecasting purposes.

Additional inputs into the forecasting process

As with macroeconomic forecasting, forecasts generated by revenue head models are supplemented by other information to produce a final taxation revenue forecast. The first of these is business liaison with companies, often undertaken by the revenue collection agency. The second, and least tangible input to revenue forecasts, is judgement, informed by experience.

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[9] O'Neil, T. *Review of Canadian Federal Fiscal Forecasting: Processes and Systems,* pg 40.
[10] *Scottish Tax Forecasts,* March, 2012.
[11] OBR, *Forecast Evaluation Report,* 2011, pg 32.
[12] NZ Treasury, *Treasury's Forecasting Performance 2011 Report,* pg 2.
[13] NZ Treasury, 'An Analysis of Tax Revenue Forecasting Errors*', Working Paper,* 07/02, pg 3.

2.2: Treasury's Approach to Macroeconomic Forecasting

Summary

- Treasury's forecasting approach draws upon the full range of modelling techniques and information used by comparable official agencies overseas, including structural macro econometric models and equations; spread sheet analysis and accounting frameworks; supplemented by survey data, business liaison, expert opinion and judgement.

- Broadly speaking, GDP forecasts are built up from forecasts of the components of the expenditure measure of GDP. Single structural econometric equations are the principal technical input to Treasury's macroeconomic forecasting approach, providing an empirical framework for forecasting key variables. National account identities are preserved within a spread sheet system (the National Accounts Forecasting Framework or NAFF), and consistency between the elements of the forecasts is achieved by iteration between sector specialists.

- Treasury's structural macro econometric model (TRYM) is effectively a one-sector, small-open-economy, neoclassical growth model. TRYM is currently under redevelopment, and upon completion will be used to produce macroeconomic forecasts and sensitivity analysis as an input into the NAFF-derived forecast. Treasury has taken the view that the substantial costs of developing and maintaining the latest generation of macroeconomic models could not be justified, in particular in terms of improved forecast accuracy.

- Business liaison information is an important input into the development of the forecasts. The information is used to inform judgement of the short-term forecasts and to identify key emerging trends in the economy. The program has been refocussed to target critical sectors on an ongoing basis, as well as sector-specific issues that arise in a particular forecast round.

- Macroeconomic forecasts are subject to internal review, ahead of formal peer review by other government agencies at the Joint Economic Forecasting Group (JEFG) meeting, where the forecasts are discussed with representatives from the RBA, Australian Government central agencies and the Australian Bureau of Statistics (ABS). Treasury also maintains an ongoing dialogue on the macroeconomic outlook with private sector forecasters.

- Treasury's forecasting methodologies operate in an environment of continuous internal evaluation and development. In recent years, Treasury has hired an in-house technical specialist to quality assure the rigour of its modelling techniques, and to ensure that they are at the cutting edge of forecasting practice, within the overall modelling strategy adopted by Treasury.

Context

Treasury is the principal economic advisory agency of the Australian Government. As part of this role, Treasury provides expert advice and analysis of domestic and international economic developments. The Domestic Economy Division (DED) is responsible for preparing the Australian Government's macroeconomic forecasts and briefing the Government on the current state of, and the outlook for, the domestic economy. DED has around 30 staff.

Treasury generally has two major forecasting rounds in the year. One is used as the basis for the Australian Government's forecasts published in the budget each May. Another forms the basis for the revised forecasts published in the *Mid-Year Economic and Fiscal Outlook* (MYEFO) in October-January. Two other rounds are also held, around June and December. As they come soon after the intensive forecasting for the budget and MYEFO respectively, these rounds tend to be less formal. Treasury also prepares an extensive commentary and analysis of economic developments to accompany the 'official forecasts, released in the Budget and MYEFO.

The range of Treasury's macroeconomic forecasting responsibilities reflects its role in the process of preparing budget estimates of taxation revenue and expenditure. Treasury is required to produce disaggregated nominal GDP forecasts to underpin taxation revenue estimates and labour market and CPI forecasts to underpin expenditure estimates. Forecasts are usually generated for the remainder of the current fiscal year, the budget year and the subsequent year, with projections prepared for the subsequent two years. Forecasts take into account cyclical variation in economic activity, whereas projections are based on long-term average growth rates and technical assumptions (for example, CPI growth is assumed to be 2½ per cent in the projection years, in line with the mid-point of the inflation target band).

The International Economy Division prepares the economic outlook for 19 countries (largely forecasts of GDP growth). These countries cover 77 per cent of global GDP on a PPP basis, and account for around 90 per cent of Australia's merchandise trade exports. For a few of the country forecasts, specifically the United States and China, a bottom-up framework examining each of the national accounts components is used to derive GDP forecasts. For all other countries, forecasts are developed at the aggregate level. The forecasts are compiled by looking at the latest economic data, the policy and external environment and the associated balance of risks, and applying judgment. These forecasts are strongly influenced by other reputable and timely forecasts, notably Consensus Economics' forecasts and the IMF World Economic Outlook.

Forecasting approach and process

Treasury's forecasting framework (the NAFF) is a large spread sheet system structured according to the methodological framework used by the ABS in producing national accounts' statistics. The system provides a comprehensive, detailed and consistent set of forecasts of the components of demand and output, the external accounts, the labour market, prices and wages. This framework has been used for many years.

Treasury's forecasting approach is structured around sectoral teams and is overseen by a central coordinating unit (the NAFF unit), containing around five staff. This unit manages the NAFF, oversees the forecasting process, ensures the quality and consistency of the sectoral team forecasts and produces forecasts of the economic series that underpin the Australian Government Budget. The NAFF unit is staffed by analysts with experience in one or more sectoral units.

The NAFF unit is also accountable for the technical assumptions that underpin Treasury's macroeconomic forecasts (for example, there are technical assumptions for interest rates, exchange rates and oil prices). These assumptions are reset at the start of each forecasting round. The usual assumption is that exchange rates and oil prices will remain around recent average levels, and that interest rates will evolve in line with market expectations. These assumptions are not always applied mechanically — for example, if the path for interest rates implied by market yields is diverging from the forecasts made by market economists, then weight may be given to both sources of information in arriving at a technical assumption. The assumptions are revisited throughout the forecasting round if there are significant movements in any of these variables.

Once the quarterly National Accounts have been released, sectoral teams produce forecasts for the components of the expenditure measure of GDP — that is, for consumption, private investment, government spending, exports and imports. These forecasts are aggregated in the NAFF to provide an estimate of GDP. It is also necessary to produce forecasts of the components of the income measure of GDP — such as compensation of employees and company gross operating surplus — in order to forecast taxation revenue. The NAFF unit has the main responsibility for generating these income forecasts. They are derived by decomposing the estimate of GDP (constructed from the expenditure forecasts), drawing upon the outlook for series, such as employment and wages. Interest and dividend income forecasts are also produced by the NAFF unit, which are used to forecast taxation revenue.

Forecasts produced by sectoral teams and the NAFF unit are prepared using a mix of:

- single structural econometric equations;
- partial and leading indicator data (for example, retail sales for private consumption and building approvals for dwelling investment);
- business surveys (for example, the ABS survey of capital expenditure intentions),
- business liaison information,
- information on general government expenditure received from Treasury's budget division, the Department of Finance and Deregulation (Finance) and State Treasuries; and
- information from specialist agencies such as the Bureau of Resources and Energy Economics (BREE) (on the outlook for non-rural commodities) and the Australian Bureau of Agricultural and Resource Economics and Sciences (on the outlook for rural commodities).

The weight placed on each of these inputs is informed by economic theory, evolving economic trends, liaison information and forecasting experience. These factors all inform the judgement applied to pure model-driven forecasts. The analysts discuss their forecasts with their colleagues and management before presenting them to a meeting of all economists within the DED, where they are subjected to rigorous review.

An iterative process is used to ensure consistency between the various elements of the forecasts (for example, employment is an important influence on consumption and hence GDP, but GDP also strongly influences employment). The individual sector forecasts are currently linked together using the NAFF, rather than in an econometric model, although Treasury's TRYM macroeconomic model has been used as a consistency check. The model has not been used in this capacity for the past two years due to its redevelopment which is detailed later in this section.

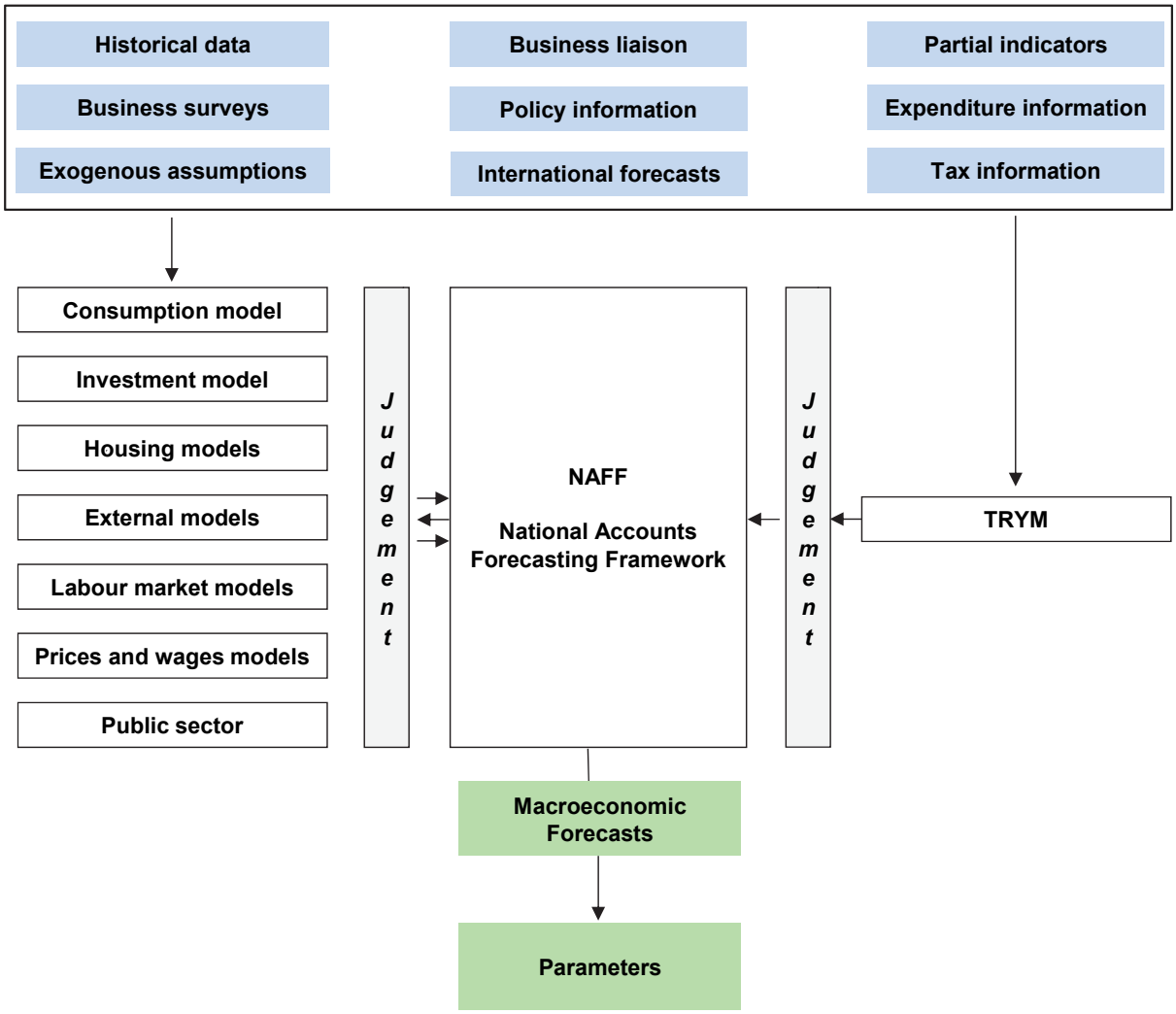
Treasury's macroeconomic forecasts are informed by discussions held at three formal committee meetings during each forecasting round: in particular;

- the international committee meeting to discuss the global outlook (comprising Treasury and the RBA);
- the public committee meeting to discuss the general government forecasts (comprising Treasury, the RBA, Finance and the ABS); and
- the balance of payments meeting to discuss the export forecasts, predominantly the outlook for non-rural commodity exports (comprising Treasury, the RBA, the ABS and BREE).

An internal quality test of the forecasts follows by presenting them to senior management within Treasury. They are then subject to formal peer assessment at the Joint Economic Forecasting Group (JEFG) meeting, which meets three times a year (but not during the June round), where the forecasts are discussed with representatives from the RBA, the Department of the Prime Minister and Cabinet, Finance and the ABS. Treasury also maintains an ongoing dialogue on the macroeconomic outlook with private sector forecasters, particularly those employed in financial markets.

A stylised schematic of the macroeconomic forecasting framework is provided in Figure 2.1, below.

Figure 2.1: Macroeconomic Forecasting Framework



Recent improvements to macroeconomic forecasting methodology

Treasury is continuously looking to improve forecasting methodology and processes to enhance the quality of its macroeconomic forecasts, the efficiency with which they are produced, and to incorporate the latest advances in forecasting technologies. In the current constrained budget environment this approach has even greater relevance. For the purposes of this review, it is important to highlight the following areas of recent focus.

Technical Adviser

Treasury established a dedicated technical advising role in DED in mid-2009. The Technical Adviser is in effect DED's Chief Knowledge Officer, and is responsible for administering knowledge management practices in the division, which includes:

- developing, an overall framework that guides, and actively promotes, macroeconomic technical skills development and training within, and beyond, DED;
- overseeing the documentation of forecasting methodology; and
- facilitating collaboration, coordination and communication within, and beyond, DED.

The Technical Adviser is an SES Band 1 with a PhD in economics, a research track-record (including publications in top general and field journals), post-graduate teaching experience, extensive peer-review experience, and over 10 years professional experience in a macroeconomic policy advising/forecasting role.

The knowledge management framework developed by the Technical Adviser is purpose-built to deliver effective development, dissemination and documentation of macroeconomic knowledge. Most elements have been in place for two years. This framework has allowed DED to move its training and econometrics and modelling to leading edge practices, which have been incorporated into producing the macroeconomic forecasts.

Attachment B provides more information on the role of the technical adviser.

Single-equation econometric models

As indicated above, single-equation econometric models are the principal input to Treasury's macroeconomic forecasting approach, providing an empirical framework for forecasting key variables. With assistance from the Technical Adviser, DED has been through a process over the past two years of refreshing, testing and documenting the suite of models used to produce macroeconomic forecasts. This has led to tangible improvements in the modelling of household consumption, new dwelling investment, elaborately transformed manufactured exports, services exports, endogenous imports and employment, wages and the CPI.

Treasury has also developed a coincident indicator which combines around 20 different economic data series to provide a timely summary measure of domestic economic activity. The coincident indicator is used as an input into the preparation of the near-term forecasts.

Business Liaison

Treasury's Business Liaison Program has maintained contact with organisations across Australia for over a decade and is an integral part of the forecasting process. Companies from major industry sectors participate in the program, ranging in size from large multinationals to smaller localised firms. As part of the JEFG process, Treasury also consults with the RBA and BREE on the key insights from their liaison programs, given the RBA runs a much larger program than Treasury, and the BREE's program is more targeted towards mining and energy sector companies.

The information collected from liaison is used to inform analyst judgement of their near-term forecasts and to test and identify key emerging trends in the economy.

There are two distinct purposes of the Treasury program. The first, and most substantive part of the program, is to develop a detailed understanding of the economic conditions being faced by business and their likely response to evolving economic conditions. The second is to gain information as a specific input into the macroeconomic forecasts, including for capital expenditure and export volumes.

Liaison rounds are conducted each quarter, approximately two weeks before the start of each forecasting round, with major rounds held in February and August, prior to the preparation of forecasts for the Budget and the MYEFO. The program is managed within DED with between 120 and 150 face-to-face interviews conducted each year.

The program was refocussed at the beginning of 2012 and divided into two streams, a core and a revolving stream. The core stream involves around 20 companies across a range of critical sectors of the economy, including miners, manufacturers, retailers and key suppliers of intermediate goods and services (such as law firms, recruitment firms, palette makers, and transport and logistics providers). It is intended that Treasury SES officers maintain contact with the same firms each quarter, with a

focus on relationship building and discussions around current activity and the outlook, as opposed to a set of structured questions.

The revolving stream is a new flexible component of the program. Prior to each forecasting round, key challenges and particularly important sectors of the economy are identified. Liaison contacts in those specific sectors or regions are then targeted to provide more qualitative information to inform the forecasts.

Treasury continues to look at innovative ways to connect with more businesses through existing networks and channels. For example, building on past work with Business Chambers to set up roundtables with a range of their members across diverse sectors and firms. And, drawing upon other Government agencies, such as Enterprise Connect, who regularly meet with business.

Recommendation 1:

Given the importance of information on economic conditions obtained from business liaison — and the capacity of this source to inform the forecasts — Treasury should investigate with the Reserve Bank of Australia more formal channels through which to exchange insights from their respective programs, such as during the quarterly joint forecasting rounds (without compromising the confidentiality of liaison contacts). Similarly, Treasury should also investigate whether further information can be drawn from the Australian Taxation Office's liaison with large corporate taxpayers for revenue forecasting purposes.

Treasury Macroeconomic Model (TRYM)

TRYM is effectively a one-sector, small-open-economy neoclassical growth model. DED has employed TRYM as a forecasting tool to varying degrees over the past 20 years. TRYM has been used primarily to provide a consistency check on the NAFF-derived forecast, with divergences at an aggregate and component level identified and analysed by the sectoral specialists. TRYM is also useful as a tool to run 'what if' scenarios where the model is shocked and the resulting output compared with a baseline.

Following a review in 2010, DED, in collaboration with the Macroeconomic Modelling Division, has undertaken a major redesign of TRYM, with a view to simplifying the computational environment and harmonising the data and assumptions. This work has progressed along a number of dimensions. A joint DED-ABS working group has been established to:

- transfer ownership to the ABS of numerous series currently constructed/inferred by Treasury for macroeconomic modelling purposes using ABS data; and

- regularly peer-reviewing Treasury's macroeconomic modelling and data construction.

Sectoral analysts in DED are responsible for the development and maintenance of TRYM's structural behavioural equations. On-going work is aimed at making TRYM consistent with 'best practice' structural vector auto-regression methods by removing all ad-hoc forward-looking elements.

At the conclusion of this redevelopment, TRYM will be used to produce macroeconomic forecasts and sensitivity analysis as an input into the NAFF. Treasury is aiming for the redeveloped TRYM to be fully operational for the Budget 2013 forecast round.

Further information on the TRYM model is provided at Attachment B.

Recommendation 2:

A detailed assessment of the role, and appropriate type, of Treasury's macro econometric model was beyond the scope of this Review. However, the Review believes it is important to embed the redeveloped TRYM model into the economic forecasting process, both as a complement to the existing forecasting framework and to facilitate analysis of the impact of shocks to the domestic economy.

Odysseus database

To undertake its forecasting and modelling work, DED uses a large number of economic time-series imported from many external sources. The Treasury data holdings contain over 80,000 time-series. At monthly and quarterly intervals, new time-series are retrieved and linked to historical data. The manual effort required to undertake this process and maintain data integrity was particularly onerous.

Given the core nature of this work, DED has made a significant investment in a comprehensive database management program, the Odysseus database. The development of this database followed an independent review into data management and information practices within DED that identified a number of problems associated with using Microsoft Excel as the data management, storage and analysis program. Many of the data management problems faced by DED related to the size and complexity of the time series being maintained, including the great number of links between Excel worksheets and workbooks. Most of the time-series data used in Treasury are provided in Excel format.

While mitigation strategies were put in place to deal with known risks, these strategies were resource intensive and relatively inefficient. The Odysseus database has reduced operational risks; improved data quality and integrity; provided more efficient mechanisms for data capture and processing; improved analytical capability and enabled analytical staff to spend more of their time on economic analysis instead of data checking.

2.3: Treasury's Approach to Revenue Forecasting

Summary

- Treasury revenue forecasting methodology is similar to comparable official agencies overseas. Forecasts of taxation revenue are built up from forecasts of individual revenue heads, which are based on Treasury's macroeconomic forecasts of the relevant economic base, and mapping models, which account for the differences between taxable and economic bases.

- Revenue forecasts are subject to internal review, ahead of formal peer review at revenue conferences held with the Australian Tax Office and Customs.

- Treasury overhauled its revenue forecasting methodology in response to the recommendations of the 2005 Review. The 2005 Review found that Treasury was underestimating revenue, in large part because Treasury had an inadequate understanding of the relationship between the nominal economy and revenue and, related to this,observation, Treasury had underinvested in taxation revenue data.

- Treasury is continually looking at ways to improve its forecasting methodology, including in response to forecast errors. It is currently investigating the use of micro simulation models to forecast individual income tax revenue.

Context

Treasury is responsible for preparing the Australian Government's taxation revenue forecasts. The Revenue Analysis Unit (RAU) has around 10 staff to perform this task, significantly less than the macroeconomic forecasting area, reflecting the revenue forecasting area's narrower forecasting focus and less onerous briefing work load.

Treasury prepares revenue forecasts twice a year, as well as the associated extensive commentary and analysis of revenue developments to accompany the Government's official forecasts, released at Budget and MYEFO. Forecasts are usually generated for the remainder of the current fiscal year, the budget year and the subsequent year, with projections prepared for the subsequent two years. Forecasts take into account cyclical variation in economic activity, whereas projections are based on long-term average growth rates.

The revenue forecasts are presented in the Budget documents on a cash basis. Under cash basis reporting, tax receipts are accounted for at the time a tax payment is received by the Australian Taxation Office (ATO). This is in contrast to the macroeconomic series which are reported in the National Accounts on an accrual basis, to reflect the time when the economic activity occurred. Timing adjustments are made to the economic base as part of the revenue forecasting process, in order to take into account the likely lag between the timing of the economic activity and the associated receipt of tax revenue by the ATO.

Forecasting Approach and Process

Similar to many countries, Treasury's revenue forecasts are generated using a 'bottom up' approach, where forecasts for individual revenue heads are prepared based on macroeconomic forecasts of the relevant economic base and then aggregated to produce a total revenue forecast. Treasury also maintains econometric approaches to estimating aggregate revenue. Over time, investments have enabled the development of improved models of individual heads of revenue which, in turn, has seen Treasury place more weight on these models to generate revenue forecasts and less weight on more aggregate approaches.

The revenue forecasting methodology can be best described as 'mapping', rather than modelling. This is because, firstly, the revenue head models are largely accounting frameworks, with an elasticity of one typically applied to forecasts of the taxable base (the reasons, for which, are discussed below). And, secondly, the macroeconomic forecasts supplied by DED are typically used to grow the taxable base without being subject to judgemental adjustment (also discussed further, below).

The revenue forecasting models are largely accounting frameworks designed to account for the conceptual differences between the taxable base, which reflects Taxation Law principles, and the economic base, forecast by DED, which reflects National Accounting principles. These differences are most pronounced for the income tax heads of revenue, in particular corporate income tax. For this head of revenue, gross operating surplus (GOS) is the relevant National Accounts measure of economic income. However, many adjustments need to be made to GOS to account for conceptual differences with taxable corporate profits before it can be used for revenue forecasting purposes. For example, corporate GOS is measured before deducting depreciation charges and debt-servicing interest expenses. It also excludes holding gains or losses in trading stock and realised capital gains or losses in the assets and liabilities of the corporate sector. For other revenue heads, such as excise, forecasts of the economic base supplied by DED can be used more directly, with less adjustment, because the taxable and economic bases are more closely aligned.

Econometric techniques are not usually required to uncover the quantitative relationships between a head of revenue and its taxable base. This is because, conceptually, the elasticity of revenue to its taxable base is one for revenue heads with a flat tax rate. This is the case for most Commonwealth

taxes. Intuitively, this means that taxation revenue increases by one per cent for each increase of one per cent in the taxable base. The main exception is Treasury's model for income tax withholding, which incorporates an elasticity which has been econometrically estimated, to capture the progressivity of the individuals' income tax system.

The revenue forecasting models generate forecasts on an income year or accrual basis. These forecasts need to be adjusted for the revenue head's payment arrangements to generate forecasts on a cash basis. The payment arrangements introduce a lag between the timing of the economic activity and the receipt of the associated revenue — for example, 60 per cent of corporate income tax is typically received in the year that the profit is generated, with the remaining 40 per cent received in the following year. Further adjustments are made to take into account any information on recent taxation collections provided by the ATO.

It follows from this approach to forecasting that the focus of Treasury's model development is improving its understanding of each taxable base. The models mimic, as closely as possible, the structure of the relevant income tax returns and payments systems. RAU works closely with the ATO to improve its technical understanding of the taxable bases and the tax payments system. It also works closely with DED to improve its understanding of the difference between the taxable and economic bases, and to identify and resolve instances where taxation receipts and economic data are providing conflicting signals about the state of the nominal economy. Several improvements to the information flows and knowledge transfer between these areas are described at Attachment C.

Once a new set of macroeconomic forecasts have been received, revenue head analysts prepare preliminary revenue forecasts on an accruals (income-year) basis by updating their models for the latest forecasts of the economic base. Adjustments may be made to individual components of the taxable base where additional information indicates that they are unlikely to grow in line with the forecast of the economic base provided by DED. The analyst then adjusts accruals (income year) forecasts for timing issues, to generate revenue forecasts on a cash basis. As mentioned, further adjustments are made to take into account any information on recent tax collections from the ATO.

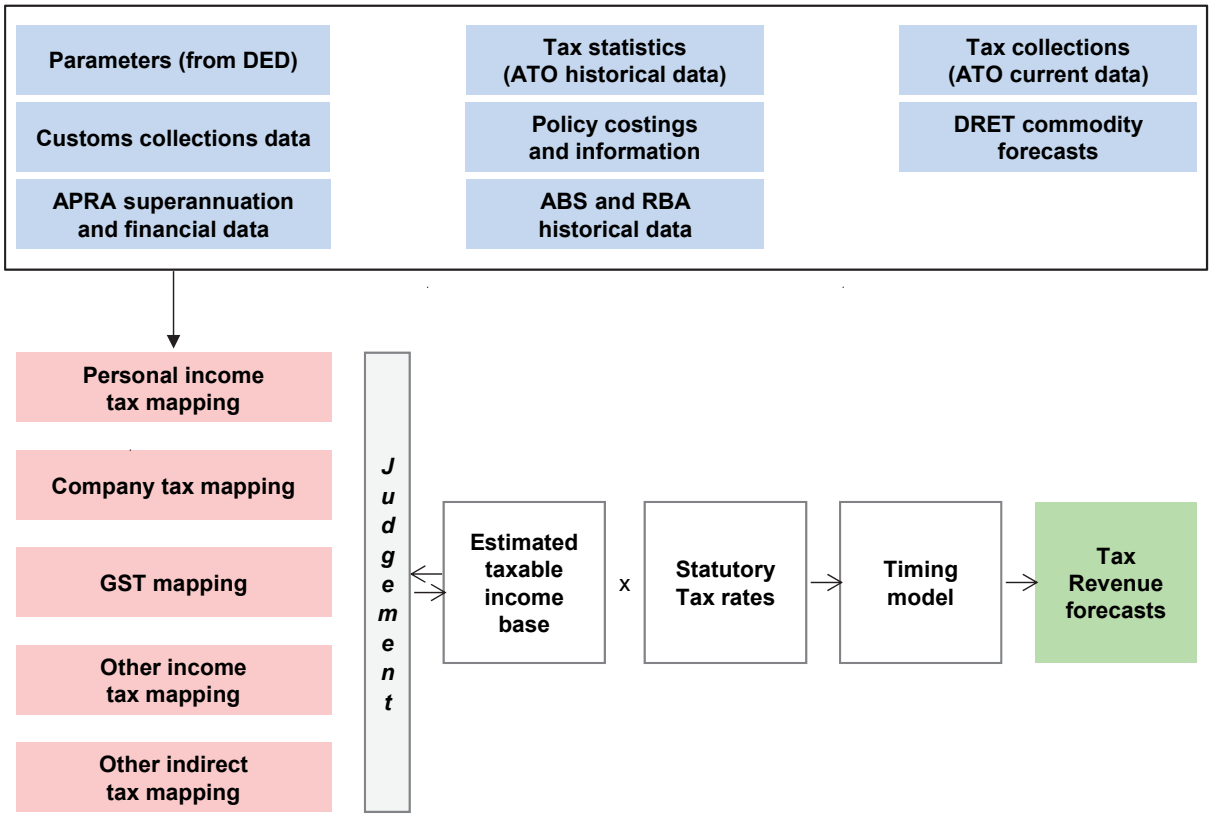
The cash tax revenue forecasts are then adjusted for the estimated impact of government policy decisions, court decisions and ATO compliance activity, to produce a forecast for each head of revenue.

The analysts discuss their forecasts with their colleagues and management. The forecasts are also subject to formal peer review at revenue conferences held with the ATO and Customs.

Judgement is employed in Treasury's revenue forecasting process generally to deal with issues where there are little data or historical precedent — for example, the likely profile of the recovery in capital gains tax receipts following the global financial crisis. The main reason for this approach is to prevent inconsistencies between the macroeconomic and revenue forecasts, which could result in the Budget presenting one view on the nominal economy and a conflicting view on taxation revenue. It would also reduce the transparency of the forecasting process.

A stylised schematic of the revenue forecasting framework is provided in Figure 2.2, below. It shows the external data inputs into the forecasting process (highlighted in blue), the major categories of head of revenue mapping model (highlighted in red) and the forecast outputs (highlighted in green).

Figure 2.2: Revenue Forecasting Framework



Data limitations are a constraint on the modelling techniques and tools that can be employed in revenue forecasting. They include:

- the long lags in receiving detailed income tax return data (the main detailed publication, 'Taxation Statistics', is published with a lag of close to two years, in order to allow the majority of taxpayers to be captured in the data);
- the aggregated nature of items in tax returns, particularly for corporate tax payers, with the effect of reducing information on drivers of assessable income for revenue forecasting purposes; and
- data completeness issues — for example, each edition of Taxation Statistics is based on tax returns lodged up until a certain date, so the data needs to be scaled up to attempt to account for all eventual taxpayers (including those likely to lodge beyond that date).

To assist in overcoming these data limitations, Treasury utilises a variety of sources of unpublished partial data in the revenue forecasting process, including:

- monthly tax collection outcomes from the ATO;
- matched tax return data (the ATO extrapolates tax revenue outcomes for the current year by comparing a sample of taxpayers who have already lodged against these taxpayer's returns from the previous year);
- advanced release of information from Taxation Statistics;
- Business Activity Statement data;

- ATO business liaison information. The ATO advise Treasury of 'one off' noteworthy information they receive from their business liaison teams. The advice is largely commercial-in-confidence in nature, relating to the expected timing and value of specific companies taxation liabilities; and

- Australian Prudential Regulation Authority (APRA) data on superannuation funds; and Customs duty collection reports.

A more detailed description of the revenue forecasting process and governance is at Attachment C.

2005 Forecasting Review

The most recent major internal review of Treasury's forecasting performance was the 2005 Review. It was commissioned in response to significant upward revisions to successive published forecasts of Australian Government taxation revenue over a number of years, which had drawn into question the quality of Treasury's forecasts at the time.

The major findings of the 2005 Review related to the revenue forecasts and revenue forecasting methodology and included that:

- the underestimation in the Treasury's revenue forecasts appeared to reflect a series of conservative biases in the revenue forecasting process, combined with technical assumptions that implied that forecast revenue growth was insufficiently sensitive to nominal GDP growth;

- Treasury had an inadequate understanding of the relationship between the nominal economy and taxation revenue; and

- Treasury's capacity to undertake meaningful analysis of taxation revenue had been severely hampered by underinvestment in taxation revenue data.

In response to these findings, Treasury's Executive Board established a dedicated team to implement the recommendations of the Review that were designed to overhaul the data and methodology used to forecast taxation revenue. The team subsequently made major investments in the quality of data sets and forecasting methodology over an eighteen month period, with the assistance of the ABS and the ATO. This work underpinned the construction of the new income tax revenue head mapping models. This included constructing, and scaling, time series of income tax return data and preparing an accounting mapping between taxable income and economic income (in practice, between data published in Taxation Statistics and the National Accounts). The team also carefully prepared models of income tax payment arrangements.

The 2005 Review also made a number of other recommendations designed to improve macroeconomic and revenue forecasting methodology. These recommendations are at Attachment A, together with an assessment of progress made towards their implementation.

Recent Improvements to Revenue Forecasting Methodology

The work of the implementation team has been continued by RAU. The mapping models are now designed to mirror the tax payments system as closely as possible — for example, the personal income tax model includes each of the income and expense items (wages and salaries, dividends, interest income, work related expenses etc) that feed into the taxable income base.

Some recent improvements to the main mapping models are detailed below:

Improving the model alignment with the economic base

Examination of some revenue head models has found that the data was of insufficient quality to justify the level of disaggregation. The general approach, now taken, is to forecast at the level of the broad head of revenue, rather than at greater levels of disaggregation. This is guided by the principle that the forecast accuracy of total revenue depends on the forecast accuracy of the broad revenue heads, not on the breakdown or 'splits' of particular revenue heads into sub components of revenue, which are of only residual interest. The splits can then be estimated based on recent trends or other information.

For example, total alcohol excise is now modelled, with the forecast then split into the sub components of alcohol excise, such as beer excise. This approach has had the effect of improving the model alignment with the economic base. For example, beer excise has no discernible historical relationship with total private consumption of alcohol — the economic base forecast by DED. A higher level of aggregation has also been applied to the modelling of tobacco excise.

The superannuation and capital gains tax models have also been rebuilt based on the balance sheet for the relevant tax entity, rather than a flow of income approach. This more closely mirrors the process by which capital gains are generated. It allows for capital losses to be calculated separately and taken into account in calculating the taxable income base.

Improvements to data sources

Some of the head of revenue models have been improved through the use of data from additional or better sources. For example, the superannuation model has been enhanced using data from APRA, which cover around two-thirds of Australia's superannuation funds, and are timelier than Taxation Statistics (as at July 2012, APRA data are available for 2010-11, compared with 2009-10 for Taxation Statistics). In addition, the capital gains tax model has also been enhanced by making better use of asset price data from the RBA, the ABS and the ASX.

Use of micro simulation techniques

RAU is currently exploring the use of micro-simulation techniques in personal income tax models. While data limitations had previously constrained the use of micro-simulation techniques, arrangements have now been put in place to allow RAU to access detailed confidentialised personal income tax data from the ATO, with appropriate safeguards in place. Some other countries, including the United States, employ micro-simulation techniques in their personal income tax revenue forecasting.

Micro simulation models operate at the level of the individual behavioural entity, such as a person, family, or firm. Such models simulate large representative populations of these low-level entities in order to draw conclusions that apply to higher levels of aggregation such as an entire country. This type of model is distinct from aggregate models whose explanatory variables already represent collective properties. Certain types of modelling problems are best dealt with using micro simulation, whereas for others an aggregate approach is more appropriate.

In particular, the application of micro-simulation techniques to personal income tax may improve the revenue forecasts by helping to identify and forecast characteristics of the taxpayer population that are changing over time. Some examples are provided below.

- The distribution of various forms of income varies markedly. For example, interest and dividend income is generally earned by those facing higher income tax scales, whereas pension income is generally earned by those at the lower end. Being able to apply different rates to different income items would provide more robust forecasts.

- Dis-equiproportional growth in income distributions could be explicitly factored into the analysis and forecasts, rather than indirectly, via econometric techniques.

- The impact of population ageing on personal income tax revenue could be better quantified.

Recommendation 3:

Treasury should examine the feasibility of constructing a micro simulation model for forecasting personal income tax, as is the practice in the United States and United Kingdom.

2.4: Strengthening the Governance of Treasury's Forecasting Processes

Notwithstanding the generally robust nature of existing practices, the Review has made some recommendations that would strengthen existing governance arrangements in order to improve the credibility and transparency of Treasury's forecasting processes. These recommendations would also bring these arrangements more in line with the practices of official agencies overseas.

The importance of credible and transparent forecasts in supporting public confidence has been highlighted by current global economic uncertainty. Publishing forecasting models, data, and technical assumptions in order to open them up to external scrutiny provides greater transparency. It also allows for feedback and testing of assumptions, leading to model improvements over time, as well as enhancing the credibility of the model's forecasts.

These considerations lead the Review to recommend:

Recommendation 4:

Treasury should publish technical documentation that describes the data and the conceptual and econometric basis of models used for economic and revenue forecasting. A number of official agencies overseas have published technical documentation of their forecasting models.

Large forecasting errors can reduce the credibility of forecasts, particularly as they are viewed with the benefit of hindsight (which reveals information that was not available to the forecaster at the time the forecasts were prepared). In this regard the Review notes that forecasting is an inherently difficult exercise and, on occasion, large forecasting errors are inevitable, especially at times of economic volatility. Regular public reviews of forecasting performance can help to provide perspective on forecast errors. They can also improve the transparency of the forecasting process.

These considerations lead the Review to recommend:

Recommendation 5:

Treasury should include in the Budget papers a high level review of the economic forecast errors (nominal and real GDP) for the previous financial year, as a complement to the existing discussion of revenue forecasting errors.

Recommendation 6:

Reviews of Treasury's forecasting performance should be undertaken at least every five years to examine the causes of forecast errors and to help identify areas in which Treasury's forecasting methodology could be improved. These Reviews should be overseen by an independent external reference group.

SECTION 3: QUALITY AND ACCURACY OF FORECAST PERFORMANCE

3.1: Approach to Forecasting Assessment

Summary

- The Review has assessed Treasury's forecast performance against two desirable properties of forecasts. First, the forecasts should be unbiased, that is the expected forecast error should be zero. And, second, the forecasts should be accurate, that is the actual forecast errors should be minimised to the extent possible.

- To provide a benchmark against which to assess accuracy, Treasury's forecast performance is compared to that of other domestic forecasters and official agencies overseas and also to the performance of naive forecasting rules, based on the past trend behaviour of the forecast series.

Description of the data

The Review has focused its assessment of Treasury's macroeconomic forecasts on those series which are most important for revenue forecasting. These series include nominal GDP and the major components of the income measure of nominal GDP, in particular compensation of employees and gross operating surplus. The nominal GDP forecasts are constructed from the real GDP and GDP deflator forecasts, and therefore these series, and the terms of trade, are also assessed. In terms of Treasury's revenue forecasts, the Review has assessed the performance of aggregate taxation revenue and the major heads of revenue. All the analysis presented for revenue is on a cash basis because this is the only method of recognition of revenue that has data back to 1990-91.

The forecasts are assessed over the period 1990-91 to 2011-12, data permitting. The start date for the assessment period was chosen because it coincides with a major structural break in the economy, reflecting the transition of Australia to a low-inflation environment. The forecasts are also assessed over four distinct economic sub-periods that reveal patterns in forecast errors that are obscured over the full sample. These sub periods are: 1990-91 to 1993-94, which includes the early 1990s recession; 1994-95 to 2002-03, which covers a period of relatively stable growth; 2003-04 to 2007-08, which covers the first mining boom; and 2008-09 to 2011-12, which includes the global financial crisis, and the emergence of a second phase of the mining boom.

In principle, the macroeconomic forecast performance could be measured against the ABS's first, or most recent, published outcomes, which are from the June quarter 2012 National Accounts release (at the time of the preparation of this report). The measure of forecast performance depends importantly on the choice of benchmark due to ABS revisions. The Review has compared Treasury forecasts with the most recent estimated outcomes for two reasons. First, the most recent estimated outcomes represent the ABS's current best estimates of the true outcomes. And, second, Treasury's revenue mapping models use the most recent estimates of the nominal economy in order to forecast taxation revenue and hence it is these estimates that are most important for revenue forecasting purposes.[1]

Measures of forecasting performance

There are many approaches to measuring forecast performance. The Review bases its assessment of Treasury's forecast performance upon two desirable properties of forecasts. First, the forecasts should be unbiased, that is the expected forecast error should be zero. And, second, the forecasts should be

1 One disadvantage of this approach is that ABS revisions can reflect changes in the definitions of series, including as the result of the adoption of more recent international benchmarks for national accounting statistics.

accurate, that is the actual forecast errors should be minimised to the extent possible.[2] It draws upon metrics that have been commonly used in such analysis, and are easy to interpret. These metrics are the mean error and the mean absolute error (or in percentage points, the mean absolute percentage error).

The *mean* error measures the *bias* of the forecasts. A positive (negative) number indicates that, on average, the forecast has tended to be higher (lower) than the outcome. All other things equal, a figure closer to zero indicates a better forecasting performance. The *mean absolute* error measures the *accuracy* of the forecasts, as it measures the average distance between the forecast and the outcome, which is the size of the typical error. All other things equal, a smaller number indicates a better forecasting performance.

Formally, the metrics are calculated as:

$$\text{Mean error} = \frac{\sum_{i=0}^{n-1}(f_{t-i}^{*} - f_{t-i})}{n}, \text{ and Mean absolute percentage error} = \frac{\sum_{i=0}^{n-1}|(f_{t-i}^{*} - f_{t-i})|}{n},$$

where: f_t^* and f_t are the forecast and actual growth rates for the series being assessed.

The main alternative metric of forecasting performance is the root-mean-squared-error, which places greater weight on large forecast errors. Most studies, such as Zarnowitz (1991)[3] for the United States and Holden and Peel (1988)[4] for the United Kingdom, find that conclusions are insensitive to the choice of measure.

As with any statistical assessment of forecast performance there are limitations in the interpretation of these metrics. In particular, a small sample size reduces the reliability of sample averages as a few large errors can have an unduly large influence. Hence it is necessary to base conclusions on tests of statistical significance. These measures also need to be interpreted in light of the average growth rate of the series being forecast — a 1 percentage point mean error (or bias) in annual growth forecasts for a series that grows on average by 40 per cent per annum is a very different performance to the same mean error in a series that grows on average by 2 per cent.

Forecast comparisons and their limitations

To provide a benchmark against which to assess accuracy, Treasury's forecasts are compared with those of selected domestic and official agencies overseas. In terms of domestic forecasters, Treasury's macroeconomic forecasts are compared with those produced by the Reserve Bank of Australia (RBA), Deloitte-Access Economics (Access) and Consensus Economics. Its revenue forecasts are compared with those produced by Access. Both sets of forecasts are compared to those produced by official agencies in the United States, Canada, the United Kingdom and New Zealand. Treasury's forecasts are also compared with those generated by a naive forecasting rule, which assumes that the series being forecast simply continues to grow at its recent average observed rate (one, three, five and ten year moving averages of the forecast series were considered).

Forecast comparisons provide insight although they need to be carefully interpreted. In particular, different agencies tend to finalise their forecasts at different times. A forecast prepared at a later time is likely to have an information advantage. This could reflect the receipt of additional official statistics or knowledge of a new macroeconomic development, for example consider the difference between the

2 The serial correlation of the forecast errors and the success rate in identifying the direction of changes in GDP growth are also considered, although the Review has not reported on these metrics in detail.

3 Zarnowitz, V. 1991, 'Has macro-forecasting failed?', *NBER working papers*, no 3867.

4 Holden, K. and Peel, D. 1988, 'A comparison of some inflation, growth and unemployment forecasts', *Journal of Economic Studies*, 15(5), pp. 5-21.

macroeconomic outlook the month before, and the month after, the collapse of Lehman Brothers in September 2008. Forecast comparisons are also sensitive to the chosen sample period.

Challenges to preparing forecasts

Forecasting errors are inevitable, even with the most rigorous forecasting framework and procedures. Forecasting is an inherently difficult exercise and errors arise from many sources. Models — which describe behavioural economic relationships — are always simplifications of the modern complex economy. Coefficient estimates — which provide an assessment of the strength of economic relationships — may be imprecise, particularly in the face of continual structural change. Exogenous assumptions, such as the exchange rate, or the international economic outlook, might turn out to be wrong. More often than not, there are shocks to the economy which were not anticipated at the time of the forecasts. The official statistics are also subject to revision.

Many of these forecasting errors are unavoidable. That said, a forecasting methodology that draws upon the range of available information, and processes that information efficiently, should help to minimise forecasting errors.

3.2: Treasury's Macroeconomic Forecasting Performance

Summary of macroeconomic forecasting performance

- Treasury's forecasts of nominal GDP growth exhibit little evidence of bias over the past two decades; although, with the benefit of hindsight, forecast errors have been correlated with the economic cycle. Hence, Treasury has tended to underestimate growth during economic upswings and overestimate growth during economic downturns.

- Treasury's macroeconomic forecasts have been reasonably accurate. Treasury's forecast performance has been comparable with that of other domestic forecasters. Its forecasts are comparable with, or better than, those of official agencies overseas. They also compare favourably with statistical benchmarks generated by a naïve trend forecasting rule.

- Within these general findings, however, Treasury's forecasts exhibit periods of quite high accuracy, interspersed with occasional periods of large outliers.

- Treasury's forecasts of GDP deflator growth are less accurate than those of real GDP growth. In particular, there were extended periods in the 1990s where outcomes were overestimated and in the 2000s where outcomes were underestimated. In recent years, this has substantially reflected the difficulty of forecasting commodity prices.

Nominal GDP

Treasury's forecasts of nominal GDP growth exhibit little evidence of bias over the past two decades, with the mean Budget forecast error being insignificantly different from zero (Table 3.1). Over this period, Treasury's forecasts have been reasonably accurate, exhibiting a mean absolute percentage error (MAPE) of 1.6 percentage points across Budget forecast rounds.

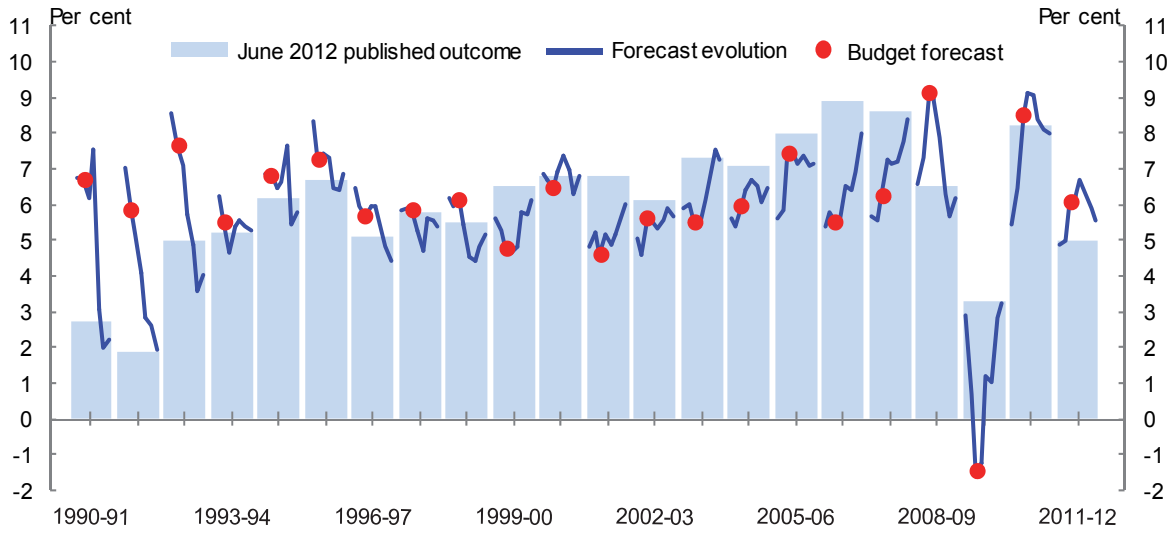
Table 3.1: Performance of Nominal GDP Growth Forecasts against Most Recent Estimated Outcomes

	1990-91 to 2011-12		1990-91 to 1993-94		1994-95 to 2002-03		2003-04 to 2007-08		2008-09 to 2011-12	
	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points
All forecast rounds	-0.3	1.2	1.4	1.7	-0.3	0.7	-1.5	1.5	-0.2	1.3
Budget (a)	-0.1	1.6	2.7	2.7	-0.2	0.8	-1.8	1.8	-0.2	2.2
MYEFO (b)	0.0	1.3	2.0	2.0	-0.4	1.0	-1.3	1.3	0.5	1.5

(a) March forecast round for the financial year starting in the July of the same year. Budget forecast from 1996-97.
(b) September forecast round for the financial year which started two months earlier. MYEFO forecast from 1998-99.

That said, an examination of the patterns in forecast errors in Table 3.1, and Figure 3.1, reveals a more variable performance across economic sub periods, with the forecast errors being correlated with the economic cycle, with the benefit of hindsight. In particular, Treasury overestimated nominal GDP growth in the early 1990s (1990-91 to 1993-94), as the recession at that time was not forecast, nor was the speed of the transition to a low inflation environment. It also underestimated nominal GDP growth during Mining Boom Mark I (2003-04 to 2007-08), with broadly offsetting effects over the full sample.

Figure 3.1: Evolution of Nominal GDP Growth Forecasts



The patterns in forecast errors in recent years reflect the challenges of forecasting two major economic developments. The first of these relates to the rapid rates of industrialisation in Asia, particularly in China, which increased worldwide demand for natural resources (Mining Boom Mark I). Treasury underestimated the extent of the resultant sharp and sustained rise in commodity prices through the mid-2000s, which led to an underestimation of Australia's terms of trade and, in turn, nominal economic outcomes.

The second relates to the impact of the global financial crisis (GFC), and its aftermath, on the Australian economy. Treasury did not predict the onset of the GFC in 2008-09, and subsequently overestimated its effect on growth in 2009-10. This saw large forecast errors generated in 2008-09 and 2009-10. In particular, in the 2009-10 Budget, at the height of a period of significant global and domestic pessimism, Treasury forecast a recession in 2009-10 that did not eventuate.

These episodes are discussed in more detail in Section 4. These patterns in forecast errors are apparent in subsequent figures and tables, below.

Real GDP

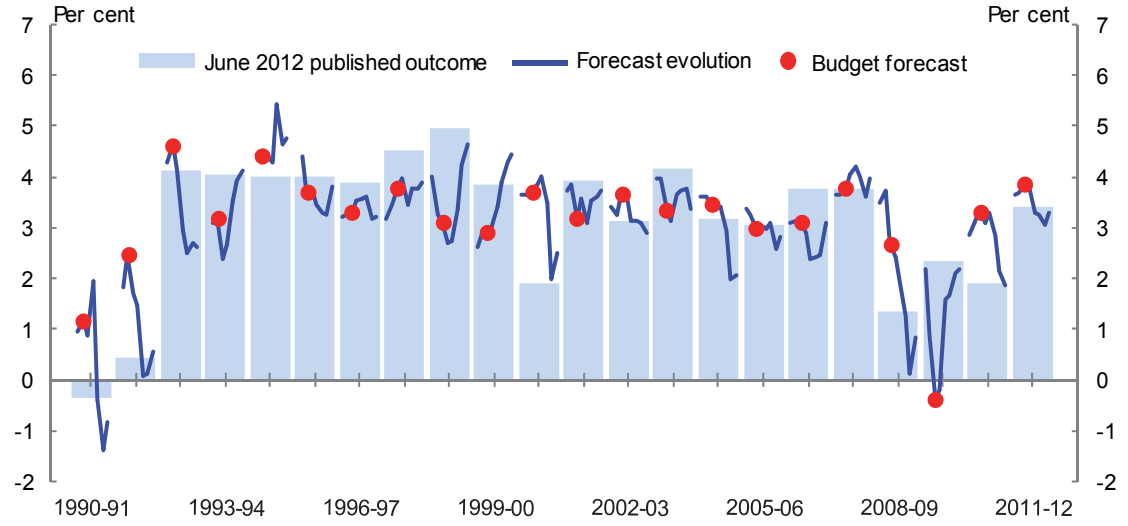
Treasury's forecasts of real GDP growth also exhibit little evidence of bias, with the mean Budget forecast error being insignificantly different from zero (Table 3.2 and Figure 3.2). Its real GDP growth forecasts have been quite accurate, with the MAPE generally remaining within a range of ½ to 1 percentage point. Treasury's forecasting performance has been less accurate in recent years than over the full sample period, reflecting greater volatility in real GDP growth as a result of the impact of the GFC, and its aftermath, on the Australian economy.

Table 3.2: Performance of Real GDP Growth Forecasts against Most Recent Estimated Outcomes

	1990-91 to 2011-12		1990-91 to 1993-94		1994-95 to 2002-03		2003-04 to 2007-08		2008-09 to 2011-12	
	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points
All forecast rounds	-0.1	0.7	0.0	0.9	-0.2	0.7	-0.3	0.5	0.1	0.9
Budget (a)	0.0	0.9	0.8	1.2	-0.3	0.9	-0.2	0.4	0.1	1.5
MYEFO (b)	-0.1	0.9	0.2	1.5	-0.3	0.9	-0.3	0.5	0.3	0.7

(a) March forecast round for the financial year starting in the July of the same year. Budget forecast from 1996-97.
(b) September forecast round for the financial year which started two months earlier. MYEFO forecast from 1998-99.

Figure 3.2: Evolution of Real GDP Growth Forecasts



These findings contrast with those of a recent study by Frankel (2011) of official government real growth rate (and budget balance) forecasts between 1985 and 2009 in 33 countries. That study found that official agency forecasts tended to have a positive average bias; are more biased in booms (and are even more biased at the three-year horizon than at shorter horizons). The data for Australia indicate little bias in all these respects compared with other countries.

The different volatility of the various expenditure components of GDP makes some easier to forecast than others (Table 3.3). Not surprisingly, Treasury's forecasts of the most volatile expenditure components tend to be the least accurate, with the largest MAPEs. Treasury has had the greatest difficulty in accurately forecasting business and dwelling investment, with the former, as an import-intensive component of GDP, also having an impact on the accuracy of the imports' forecasts.

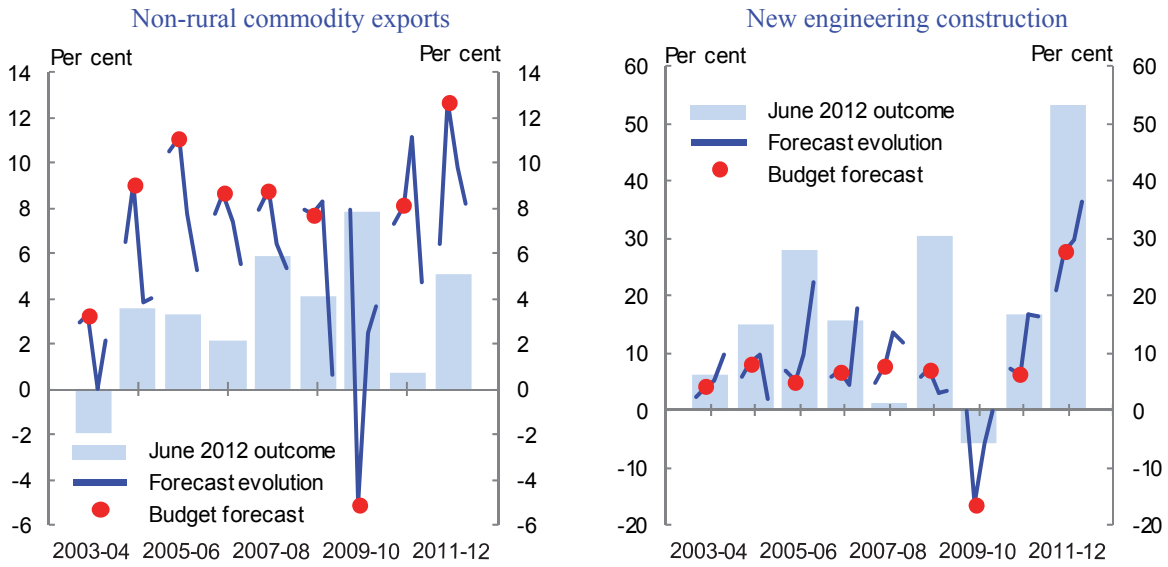
Table 3.3: Performance of GDP Expenditure Component Growth Forecasts (1998-99 to 2011-12, All Forecast Rounds)

	Mean error % points	MAPE % points	Standard deviation of series(a)	Share of economy(b) %
Household Consumption	-0.1	0.8	1.3	56
Public Final Demand	-0.2	0.9	1.6	19
Exports	1.2	2.7	5.7	20
Imports	-1.1	3.5	3.0	-21
Business Investment	-2.4	4.7	8.1	15
Dwelling Investment	-0.5	4.9	9.6	6
GDP	-0.1	0.7	1.0	100

(a)Standard deviation of series growth rates, from 1998-99 to 2011-12.
(b)Average share of economy, from 1998-99 to 2011-12.

An examination of the mean forecasting errors of the expenditure components of GDP indicates that Treasury has overestimated exports growth in recent years, and underestimated business investment and, in turn, imports growth. In particular, since the beginning of Mining Boom Mark I, Treasury has consistently overestimated growth in non-rural commodity exports (Figure 3.3). These forecasts are heavily influenced by mining company's stated targets, which have consistently exceeded actual outcomes, in part due to the impact of natural disasters and infrastructure bottlenecks. Treasury has also been overly pessimistic forecasting business investment, particularly the mining-boom related surge in engineering construction (Figure 3.3).

Figure 3.3: Evolution of Non-rural Commodity Exports and Engineering Construction Growth Forecasts



GDP deflator

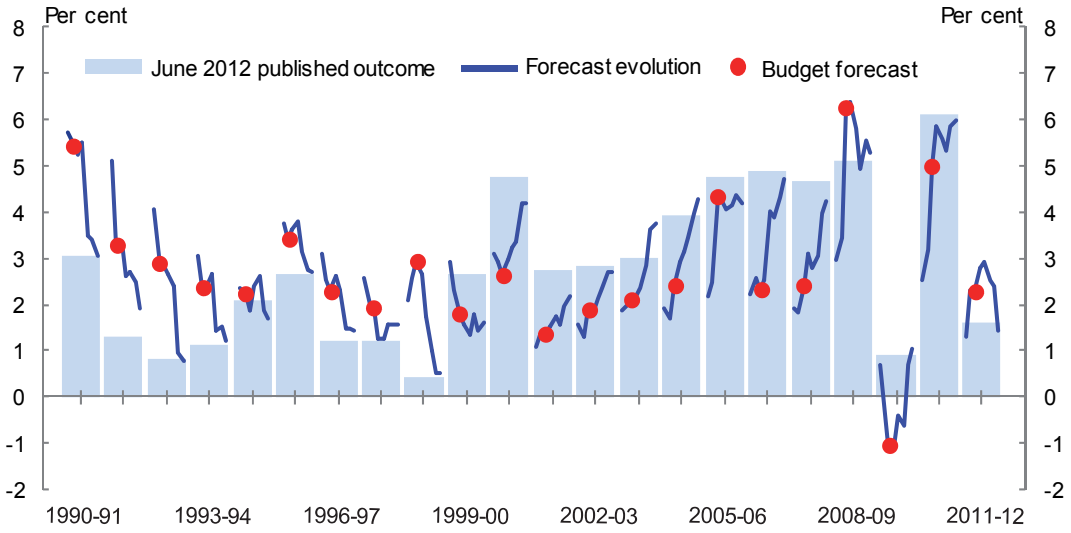
Treasury's forecasts of GDP deflator growth have been less accurate than Treasury's forecasts of real GDP growth. In particular, GDP deflator growth was consistently overestimated in the 1990s, although the size of the forecast error fell on average through the decade (Table 3.4 and Figure 3.4). As discussed, this reflects the recession in the early 1990s, which was not forecast, nor was the durability of the transition to a low-inflation environment. In contrast, over the period from the early 2000s through to the GFC, GDP deflator growth was consistently underestimated, as discussed, due to Treasury underestimating the extent and duration of the sharp rise in Australia's terms of trade as a result of Mining Boom Mark I. These episodes have had broadly offsetting impacts on the mean forecast error over the full sample

Table 3.4: Performance of GDP Deflator Growth Forecasts against Most Recent Estimated Outcomes

	1990-91 to 2011-12		1990-91 to 1993-94		1994-95 to 2002-03		2003-04 to 2007-08		2008-09 to 2011-12	
	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points
All forecast rounds	-0.1	1.1	1.4	1.4	-0.1	0.9	-1.1	1.2	-0.4	1.1
Budget (a)	-0.1	1.4	1.9	1.9	0.0	1.2	-1.5	1.5	-0.3	1.2
MYEFO (b)	0.1	1.1	1.8	1.8	-0.1	0.9	-1.0	1.0	0.1	1.0

(a) March forecast round for the financial year starting in the July of the same year. Budget forecast from 1996-97.
(b) September forecast round for the financial year which started two months earlier. MYEFO forecast from 1998-99.

Figure 3.4: Evolution of the GDP Deflator Growth Forecasts



These observations lead the Review to recommend that:

Recommendation 7:

Treasury should invest relatively more resources in understanding and forecasting GDP deflator growth and its components, in particular, commodity prices, and hence in nominal GDP growth.

Comparison with other domestic forecasters

Treasury's forecasting performance is compared with that of Access and the RBA in Table 3.5 at various forecasting horizons. As discussed in Section 3.1, the Review acknowledges the difficulty of drawing exact like-with-like forecast comparisons. Forecasting institutions run on different timetables, and forecasts made later will naturally have an advantage over those made earlier for a given reference period. For example, the timing of Treasury forecasts has tended to be optimised around the release of National Accounts data, whereas for the RBA they are more likely to be optimised around the release of CPI data. This would contribute to the configuration of relative results for the two sets of forecasts. Results are likely to be sensitive to the choice of sub-periods. To help to reduce informational advantages relating to the timing of the preparation of forecasts, the results for the RBA and Access in Table 3.5 are based on forecasts containing the same National Accounts information as Treasury's forecasts.

Treasury's forecasting performance for the core macroeconomic series have been comparable with that of Access and the RBA over the past two decades (Table 5). The differences in forecasting

accuracy across agencies are small and not statistically significant at the 10 per cent level.[5] That is to say, the differences could not be distinguished from random noise. Consistent with this finding, the ranking of forecasters varies across macroeconomic series and forecasting rounds. The variation in rank suggests that comparisons of relative forecast accuracy will be sensitive to the sample period. Due to data limitations, RBA forecasts for the GDP deflator, nominal GDP and the terms of trade are only available since 2000, and so are not shown in the table. Over this shorter sample, RBA forecast accuracy was not significantly different to that of Treasury.

Table 3.5: Performance of Access, the RBA and Treasury Forecasts (MAPE)

To end of financial year:	MYEFO 7 quarters	Budget 5 quarters	MYEFO 3 quarters	Budget 1 quarter	Average forecasts
1993-94 to 2011-12					
Real GDP					
Access	0.8	0.9	0.8	0.5	0.7
RBA	1.0	0.9	0.7	0.4	0.8
Treasury	0.7	0.9	0.8	0.5	0.7
1996-97 to 2011-12					
CPI (tty)					
RBA	1.1	1.0	0.6	0.1	0.7
Treasury	0.9	1.1	0.8	0.3	0.7
GDP deflator					
Access	1.8	1.5	0.8	0.6	1.2
Treasury	1.7	1.4	1.0	0.5	1.1
Nominal GDP					
Access	1.7	1.6	1.0	0.7	1.3
Treasury	1.3	1.5	1.3	0.7	1.2
Terms of trade					
Access	7.3	6.7	4.3	1.8	5.0
Treasury	5.4	4.4	2.7	1.0	3.4

Note: the differences in the results between agencies are statistically insignificant.

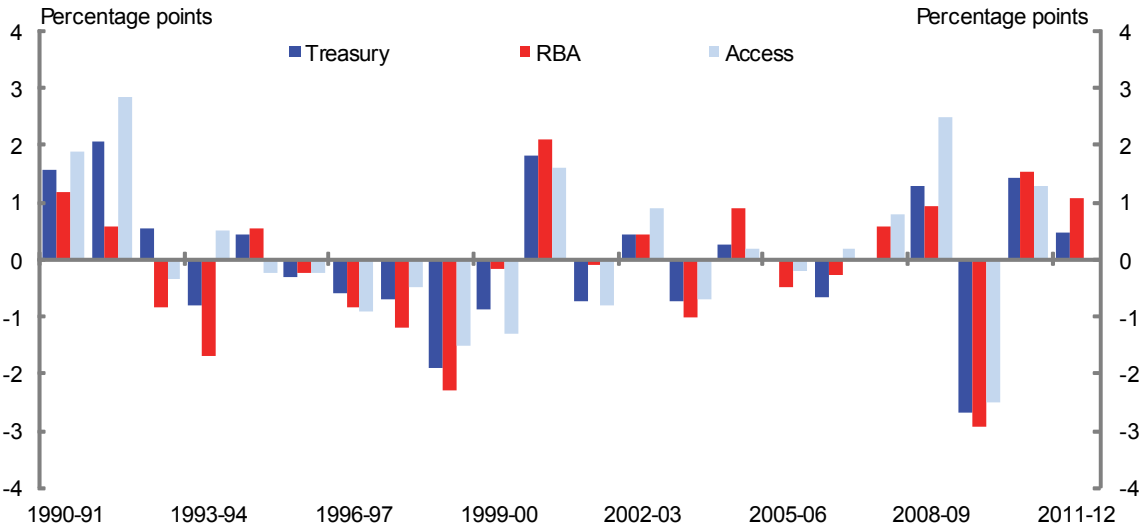
This assessment is supported by examination of the patterns of forecast errors across agencies. Figure 3.5 shows the patterns in forecast errors across agencies for real GDP growth for the Budget forecast round (five quarters before the end of the financial year). The striking feature of this chart is the similarity of the forecast errors, with the small variation across agencies contrasting with the significant variation in errors across time. It may also be interesting to note that the ranking of forecasters has no persistence but changes almost every year, consistent with the large random element in measures of forecast accuracy.

The patterns in forecast errors across agencies for nominal GDP growth and terms of trade growth for the Budget forecast round are shown in Figures 3.14 and 3.15 in the Appendix to this section.

5 The statistical significance between forecasts was econometrically tested using a Diebold-Mariano test. In general, the test requires the forecast errors of two forecasts $\{y_{it}\}_{t=1}^{T}$ and $\{y_{jt}\}_{t=1}^{T}$ for a key variable $\{y_t\}_{t=1}^{T}$. These errors are typically denoted as $\{e_{it}\}_{t=1}^{T}$ and $\{e_{jt}\}_{t=1}^{T}$. An absolute loss function $d_t = |e_{it}| - |e_{jt}|$ is then constructed and regressed against a constant, with the null hypothesis of equal forecast accuracy (or zero loss) tested using the Diebold-Mariano test statistic.

DM statistic $= \overline{d_t} \Big/ \sqrt{\text{var}\left(\frac{\overline{d_t}}{T}\right)}$, where $\overline{d_t}$ is the sample mean loss differential.

Figure 3.5: Comparison of Budget Forecast Errors for Real GDP Growth



It is noteworthy that the MAPEs for Treasury's MYEFO forecasts (seven quarters before the end of the forecast year) tend to be smaller than those for the Budget forecasts (five quarter before the end of the financial year), despite the latter having more information. This is because the Budget data include a large error relating to the forecast of a domestic recession in 2009-10 due to the GFC, which did not eventuate. The corresponding forecast at MYEFO (two quarters earlier) did not forecast a recession in 2009-10.

The performance of Treasury's forecasts of real GDP growth is also comparable to those of Consensus Economics (see Table 3.6).

Table 3.6: Performance of Consensus, the RBA and Treasury Forecasts for Real GDP growth: 2000 to 2011: Calendar Year: MAPE

To end of calendar year:	Budget 7 quarters	MYEFO 5 quarters	Budget 3 quarters	MYEFO 1 quarter	Average forecasts
Real GDP					
Consensus	0.70	0.72	0.81	0.59	0.70
RBA	1.42	0.78	0.84	0.56	0.90
Treasury	0.87	0.66	0.67	0.49	0.67

Note: the differences in the results between agencies are statistically insignificant.

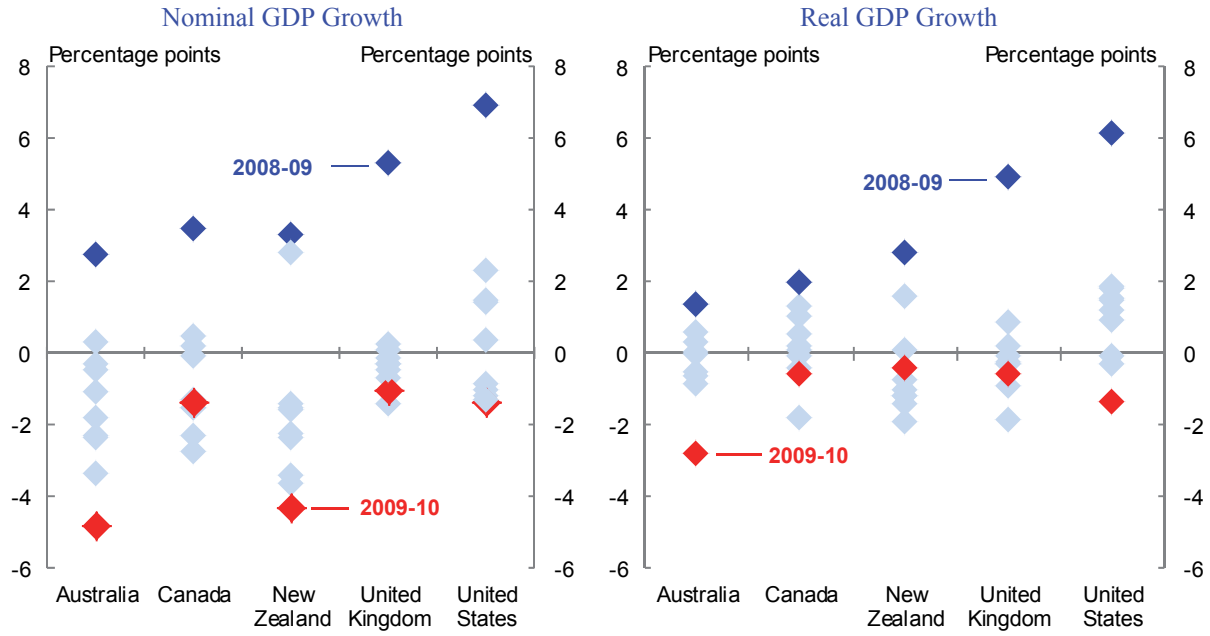
Comparison with official agencies overseas

Treasury's forecast performance has been comparable with, or better than, the performance of official agencies overseas over the past decade, although some caution is required in making cross country comparisons over a period as short as ten years, and given that official agencies prepare forecasts at different times in the year (Figure 3.6). In particular, Australia's official forecasts of nominal GDP growth outperform those of New Zealand, but are statistically insignificant from those of Canada, the United Kingdom and the United States. Australia's official forecasts of real GDP growth are statistically insignificant different from those of Canada, New Zealand, the United Kingdom and the United States.

It is interesting to note that all official agencies missed the onset of the GFC and tended to overstate its effect on activity in 2009-10, albeit to varying degrees (Figure 3.6). As a result, all official

agencies tended to overestimate economic growth outcomes in 2008-09 and underestimate outcomes in 2009-10.

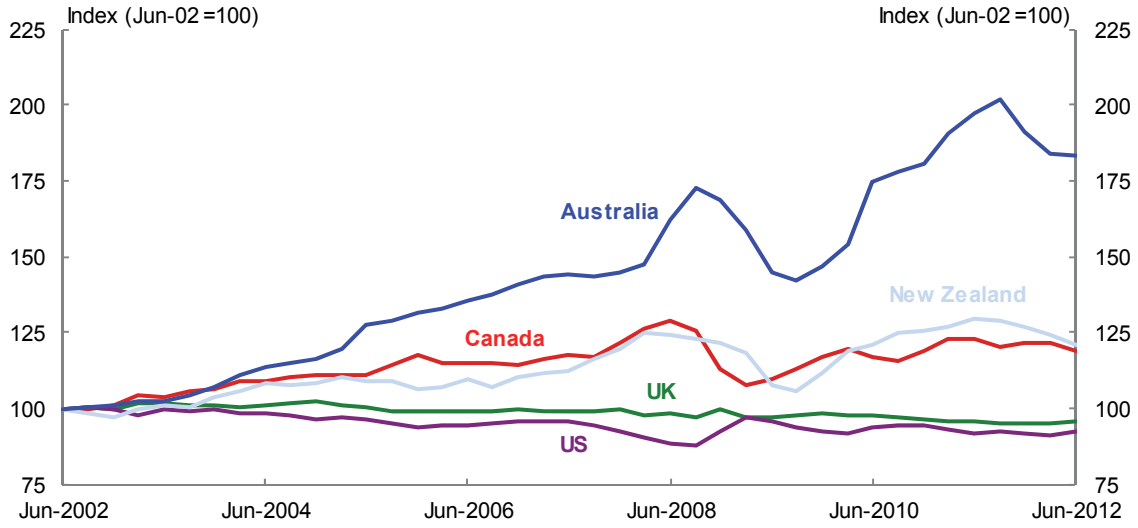
Figure 3.6: International Comparison of Budget Forecast Errors across Official Agencies: 2001-02 to 2010-11



Australia's Budget is published in early May, two months before of the start of the Budget financial year; the United Kingdom's Budget is published in March, one-month before the start of its Budget March year; Canada's Budget is published between January and March, within its Budget calendar year, New Zealand's Budget is published in May, two months before the start of its Budget June year; and the United States' Budget is published in February eight months before the start of its Budget September year.

It is also worth noting that over this period domestic forecasters faced a dramatic rise in Australia's terms of trade of almost 200 per cent, which, as discussed, has contributed to the nominal GDP growth forecast errors. This is in stark contrast to the experience of the other countries surveyed (Figure 3.7). This would have contributed to the configuration of the relative results for the international forecast comparison, as would the relative severity of the impact of the GFC on the domestic economies of the countries surveyed (Figure 3.6).

Figure 3.7: Terms of Trade, by Country



Comparison with naïve trend forecasts

Treasury's real and nominal GDP growth forecasts tend to outperform trend estimates for the Budget forecast round (one quarter out from the start of the financial year) (Table 3.7). An examination of the data over sub periods reveals, perhaps unsurprisingly, that it is more difficult to outperform trend estimates during periods of relative economic stability. In contrast, during periods of economic volatility, forecasters can more rapidly incorporate information reflecting a changing environment, for example, the transition to the low inflation environment in the early 1990's, than backward-looking trend forecasts.

Table 3.7: Performance of Treasury Budget Forecasts and Naïve Trend Forecasts against Most Recent Estimated Outcomes (1990-91 to 2011-12)

	Nominal GDP		GDP Deflator		Real GDP	
	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points
Budget (a)	0.0	1.6	0.0	1.4	0.0	0.9
Trend forecasts 1 yr	0.5	2.2	0.3	1.7	0.1	1.4*
Trend forecasts 3 yr	0.8	2.2	0.5	1.6	0.2	1.3*
Trend forecasts 5 yr	1.0	2.2	0.6	1.5	0.3	1.3*
Trend forecasts 10 yr	1.4	2.7*	1.1	1.8	0.3	1.1

(a) March forecast round for the financial year starting in the July of the same year. Budget forecast from 1996-97.
*Trend MAPEs significantly differ from Budget at the 10% level.

3.3: Treasury's Revenue Forecasting Performance

Summary of revenue forecasting performance

- Treasury's taxation revenue forecasts have exhibited little evidence of bias over the full sample, although this conceals sustained periods where Treasury has under, or over, forecast revenue, with broadly offsetting effects overall, as was found with the macroeconomic forecasts.

- Taking into account the high degree of difficulty inherent in preparing revenue forecasts, Treasury's forecasts are on the whole reasonably accurate. They are comparable with those of

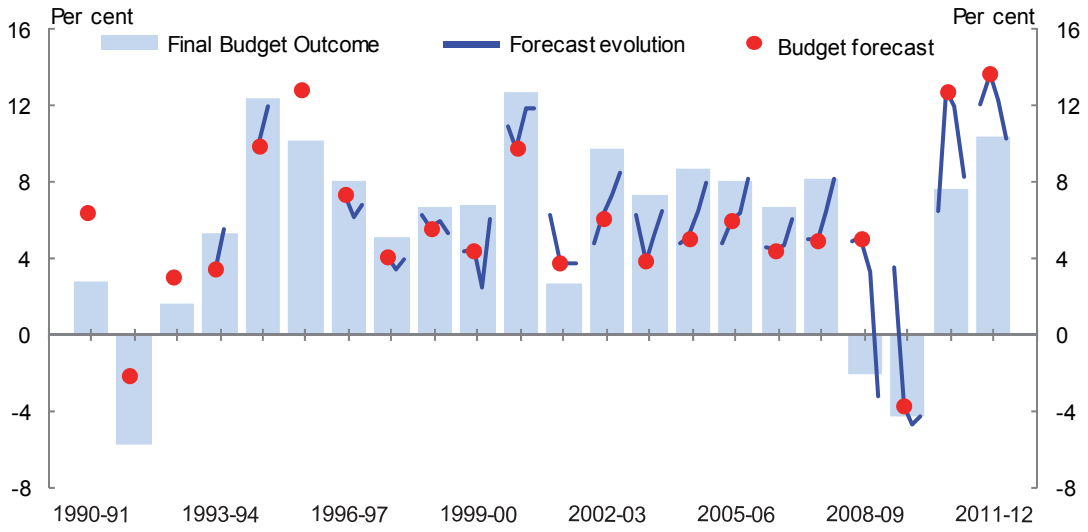
Access and are comparable with, or better than, those of official agencies overseas. They easily outperform statistical benchmarks.

- The heads of revenue with the largest forecast errors in recent years have been company tax and capital gains tax. These are two of the most volatile heads of revenue, and they have been particularly challenging to forecast in the aftermath of the GFC.

Taxation Revenue

Treasury's forecasts of taxation revenue growth have exhibited little evidence of bias over the past two decades, with the average Budget forecast error being insignificantly different from zero over this period. Taking into account the high degree of difficulty inherent in preparing revenue forecasts, Treasury's forecasts are on the whole reasonably accurate (Figure 3.8 and Table 3.8). However, within this timeframe, there have been periods when revenue has been persistently underestimated (in particular, the period from the early 2000s until the GFC) and periods where revenue has been persistently overestimated (the early-1990s recession, and the recent period since the GFC).

Figure 3.8: Evolution of Taxation Revenue Growth Forecasts



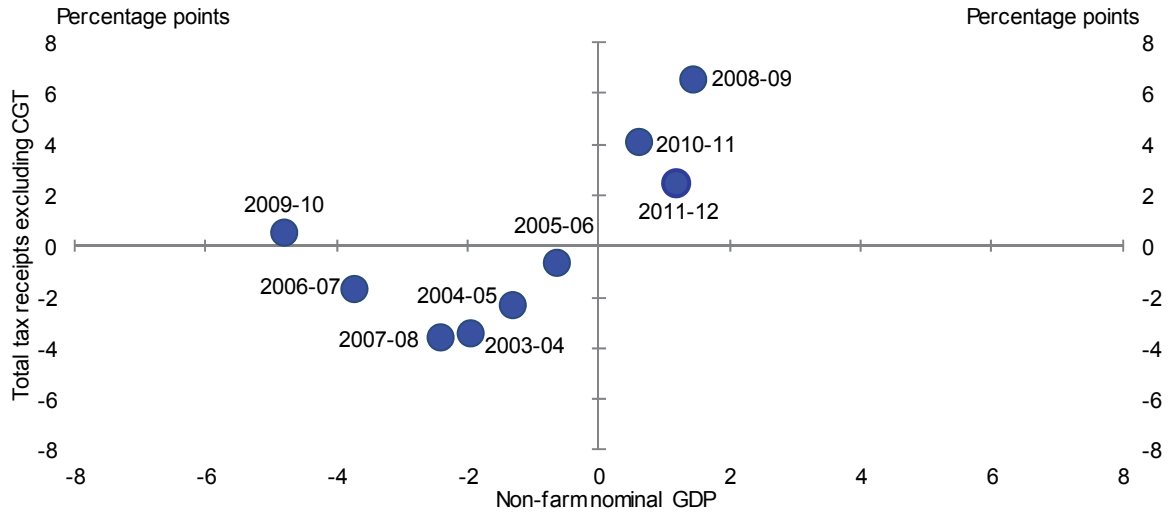
A major contributor to the errors in the taxation revenue forecasts have been the errors in the macroeconomic forecasts. However, there are additional sources of error that reflect taxation-specific factors, such as errors in assumptions made about the timing of the receipt of taxation revenue. As a consequence, the revenue forecast errors are generally larger than those of the macroeconomic forecasts. Over the past 22 years of Budget forecasts, the MAPE for the taxation revenue forecasts has been around 1 percentage point higher than the MAPE for the nominal GDP forecasts (Table 3.8). That said, overall, the revenue forecast errors have been reasonably well correlated with the nominal economy forecast errors, with a correlation coefficient of 0.6 observed over the past decade, although there are some notable outliers (Figure 3.9).

Table 3.8: Performance of Taxation Revenue and Nominal GDP Forecasts

	1990-91 to 2011-12		1990-91 to 1993-94		1994-95 to 2002-03		2003-04 to 2007-08		2008-09 to 2011-12	
	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points
Budget forecasts (a)										
Nominal GDP	-0.1	1.6	2.7	2.7	-0.2	0.8	-1.8	1.8	-0.2	2.2
Total Tax Revenue	-0.1	2.7	1.7	2.6	-1.2	2.0	-2.9	2.9	4.0	4.0
MYEFO forecasts (b)										
Nominal GDP	0.0	1.3	2.0	2.0	-0.4	1.0	-1.3	1.3	0.5	1.5
Total Tax Revenue	N/A	N/A	N/A	N/A	-1.5	1.8	-1.9	1.9	2.8	3.0

(a) Budget forecast for the financial year which starts in July (two months later). In 1990-91 to 1993-94 and 1996-97 the Budget was published in August and so it is the Budget forecast for the financial year which had started one month earlier.
(b) MYEFO forecast for the financial year which started in July (around four months earlier) and is available from 1996-97. Prior to 1996-97, the September round forecast is used for Nominal GDP (no taxation revenue forecasts are available).

Figure 3.9: Correlation between Budget Forecast Errors for Growth in Nominal GDP and Taxation Revenue

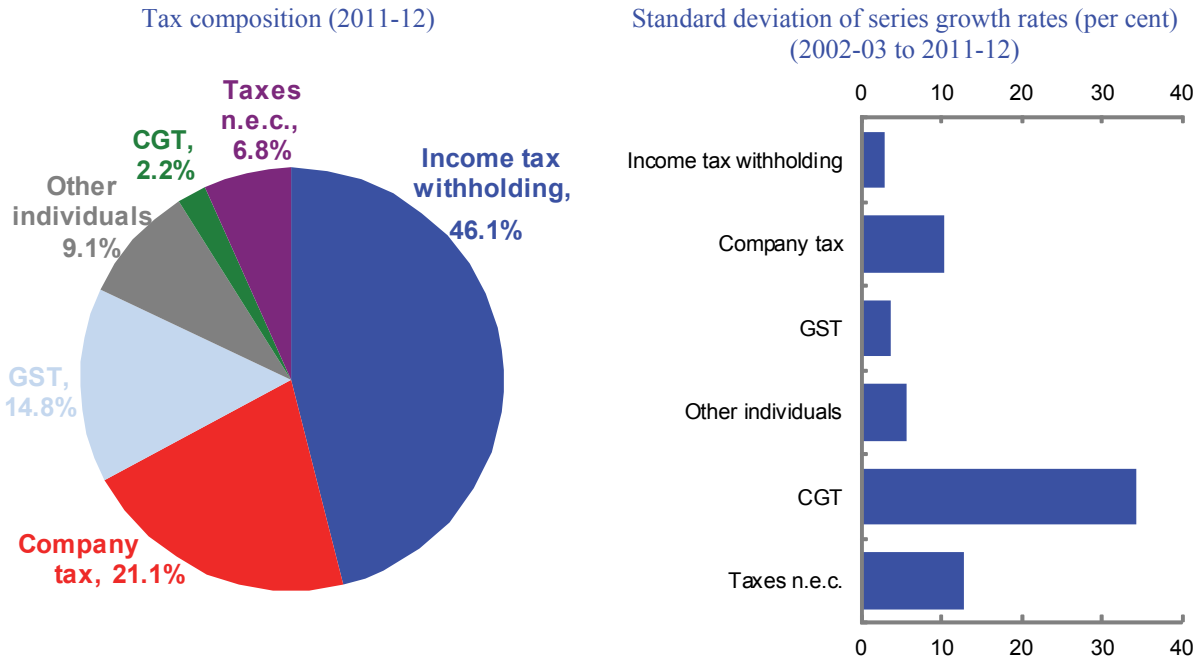


Forecast Errors by Head of Revenue

It can be revealing to break down the total taxation revenue forecast error into contributions from individual heads of revenue in order to better understand the source of the forecast error.

The contribution of an individual head of revenue to the overall taxation revenue forecast error depends upon its share of the tax base (its relative importance), and the error in the forecasts for that head of revenue. The left-hand panel of Figure 3.10 shows the shares of the tax base for each of the main heads of revenue, while the right-hand panel shows the standard deviation of the historical growth rates for each head of revenue. Those with a larger standard deviation are more volatile and will often be more difficult to forecast.

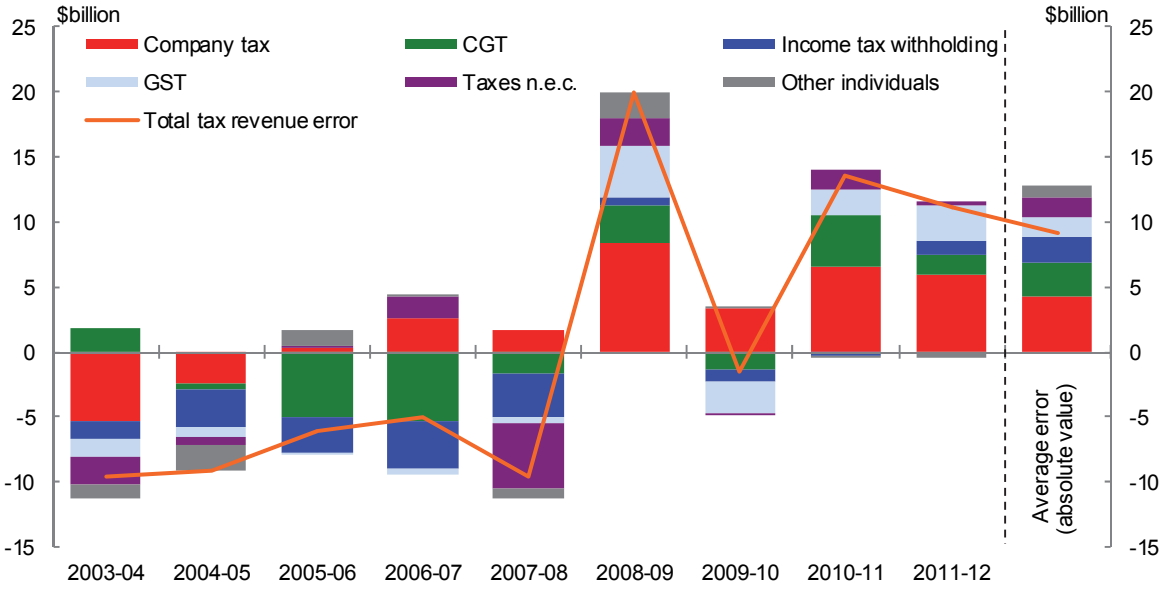
Figure 3.10: Australian Government Heads of Revenue: Descriptive Statistics



Note: Taxes n.e.c. includes superannuation taxes; petroleum resource rent tax, fringe benefits tax, excise and customs duty and miscellaneous indirect taxes.

The contributions of the major head of revenues to the total Budget taxation revenue forecast error since the start of Mining Boom Mark I are shown in Figure 3.11.

Figure 3.11: Contribution to Revenue Error by Head of Revenue (Budget forecasts, 2003-04 to 2011-12)



As expected, the largest sources of forecast error come from the more volatile heads of revenue, namely company tax and capital gains tax. In particular, the severity of the fall in company tax receipts following the onset of the GFC was not predicted (receipts fell by 12.1 per cent in 2009-10, compared with a forecast fall of only 2.4 per cent). The rebound in company tax receipts since the

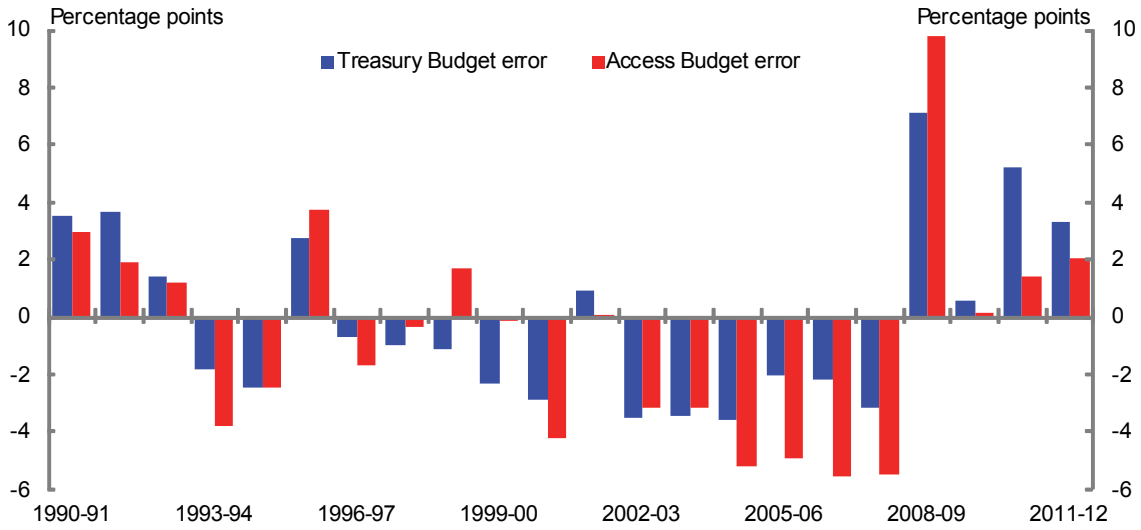
GFC has also failed to meet expectations. The reasons for these errors are explored further in Section 4 of the report, and include higher-than-expected depreciation and royalty deductions associated with the mining boom.

The capital gains tax errors reflect the underestimation of asset price growth during Mining Boom Mark I followed by the general overestimation of asset price growth since the GFC. Capital gains tax revenue has been particularly volatile over this period, with annual outcomes ranging from growth of 60 per cent in 2004-05 to a contraction of 43 per cent in 2009-10. Capital gains tax revenue has been held down by the significant realisation of capital losses incurred during the GFC. These issues are explored further in Section 4.

Comparison with other domestic forecasters and official agencies overseas

Deloitte Access Economics ('Access') is the only other forecaster of the Australian economy that has published a history of taxation revenue forecasts that is sufficiently long for the purposes of forecast comparison. Treasury's forecasts of taxation revenue have been comparable with those of Access Economics over the past two decades. The differences in forecasting accuracy between Treasury and Access are small and were found not to be statistically significant (at the 10 per cent level). This assessment is supported by an examination of the patterns in forecast errors across agencies in Figure 3.12. A feature of Figure 3.12 is the similarity of the forecast errors, with the small variation across agencies contrasting with the significant variation in errors across time, as was found with the macroeconomic forecast comparison.

Figure 3.12: Treasury and Access Budget Forecasts of Taxation Revenue Growth

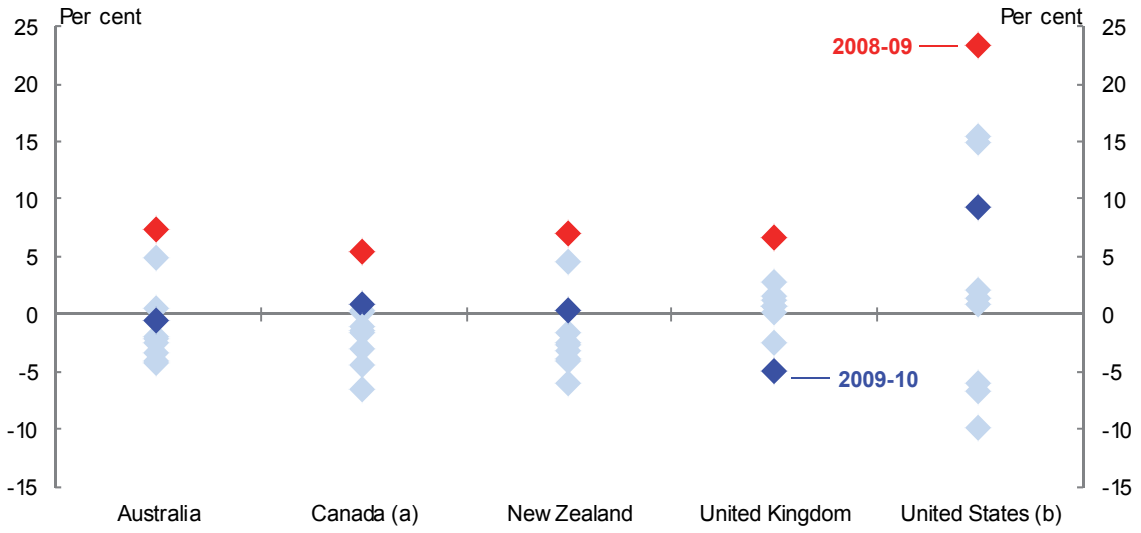


Note: Access forecasts are on an accrual (not cash) basis from 1999-00, and are compared with Final Budget Outcomes on an accrual basis. Access forecasts are generally taken from the May *Budget Monitor* (for Budget), which is typically published around one week ahead of the Budget. Adjustments have been made to Access' forecasts to help to reduce Treasury's information advantage. First, Access does not have information about new policy measures in the relevant update. Access' forecasts have been modified for the policy costings used by Treasury in the relevant update. Second, Access does not have the most up-to-date tax collections information at the time it prepares its revenue forecasts. For example, at Budget, Treasury knows tax collections for the current year up to the end of April. Access will be working off tax collections data from at least one month earlier. There are often significant errors in Access' estimates for the current (base) year. In order to abstract from the base year errors potentially related to different access to information, the comparison has been prepared on a growth rate basis. In fact, the errors for the base year estimates are not correlated with the errors for the Budget year forecasts — the correlation coefficient between the current year errors and Budget year errors (in per cent of level) is 0.04. Nevertheless, the comparison has been prepared in this way to reduce the possibility that the results are driven by Treasury's information advantage.

Compared with the forecasts of official agencies overseas, Treasury's forecasts display less bias than a number of the surveyed agencies over the past decade and, in terms of accuracy, Treasury's

forecasts are comparable with, or better than, those of the surveyed agencies (Figure 3.13). In particular Australian Government Budget forecasts display less bias than those made by official agencies in Canada, New Zealand and the United States. The differences in forecasting accuracy between Australia and official agencies overseas were found not to be statistically significant at the 10 per cent level, except for the United States.

Figure 3.13: International Comparison of Budget Forecast Errors across Official Agencies: Taxation Revenue Growth: 2001-02 to 2010-11



(a) Canada excludes 2002-03 as the data is not available. (b) Adjusted for post-Budget changes to policies.
Note: There is a lag between the publication of budget forecasts and the commencement of each countries respective fiscal year. Australia, Canada and New Zealand have a two month lag; the United Kingdom a one month lag; and the United States (as discussed above) an eight month lag.

That said, it should be noted that the United States' Budget forecasts are made further in advance of the beginning of the financial year than in other countries, which may reduce forecast accuracy. In particular, the United States' Budget forecasts are published around eight months prior to the beginning of the financial year, compared with one to two months for the other countries surveyed. Taxation revenue growth has also been more volatile in the United States than in the other countries surveyed, which also makes it harder to forecast.

Unsurprisingly, all international agencies significantly over-predicted taxation revenue growth during 2008-09, the year of the onset of the GFC (Figure 3.13). The pattern in 2009-10 is less clear. Australia, Canada and New Zealand made quite accurate forecasts, while the United Kingdom overestimated the impact of the GFC on taxation revenue and the United States underestimated its impact.

Comparison with naïve trend forecasts

Treasury's taxation revenue forecasts outperform trend estimates for the Budget forecast round (one quarter out from the start of the financial year) (Table 3.9). The differences in the MAPEs between naïve trend forecasts and Treasury's forecasts are all statistically significant. Underlying (policy adjusted) taxation revenue series are used for this analysis, which remove the advantage that Treasury's forecasts would otherwise have over the trend forecasts relating to the impact of new policy on the outcomes, as well as the construction of the trend estimates For example, the Treasury forecasts would factor in the introduction of the GST in 2000-01, whereas naïve forecasts based on trends in headline taxation revenue would not capture this new policy. Subsequent to the introduction of the GST, naïve trend forecasts based upon headline taxation revenue would be biased upwards reflecting the introduction of the GST.

Table 3.9: Performance of Treasury Budget Forecasts and Naïve Trend Forecasts against Estimated Underlying Taxation Revenue Growth Outcomes (1990-91 to 2011-12)

	Underlying Taxation Revenue	
	Mean error % points	Mean Absolute Percentage Error % points
Budget	-0.1	2.4
Trend forecasts 1 yr	-0.2	4.9
Trend forecasts 3 yr	0.8	4.8
Trend forecasts 5 yr	0.8	4.7
Trend forecasts 10 yr	1.9	4.2

Note: Trend is defined as the one, three, five and 10 year moving average annual growth rate in underlying taxation revenue. Underlying taxation revenue growth is calculated by adjusting headline revenue for changes to policy between years.

Treasury's forecasts tend to perform better than trend estimates during periods of economic volatility, particularly during the two downturns in taxation revenue (the early 1990's recession and the GFC). This is because Treasury's forecasters can more rapidly incorporate information relating to these downturns, and the subsequent bounce back in taxation revenue during the recovery phase, than backward-looking trend estimates.

APPENDIX: MACROECONOMIC FORECAST COMPARISON WITH OTHER DOMESTIC FORECASTERS

Figure 3.14: Comparison of Budget Forecast Errors for Nominal GDP Growth

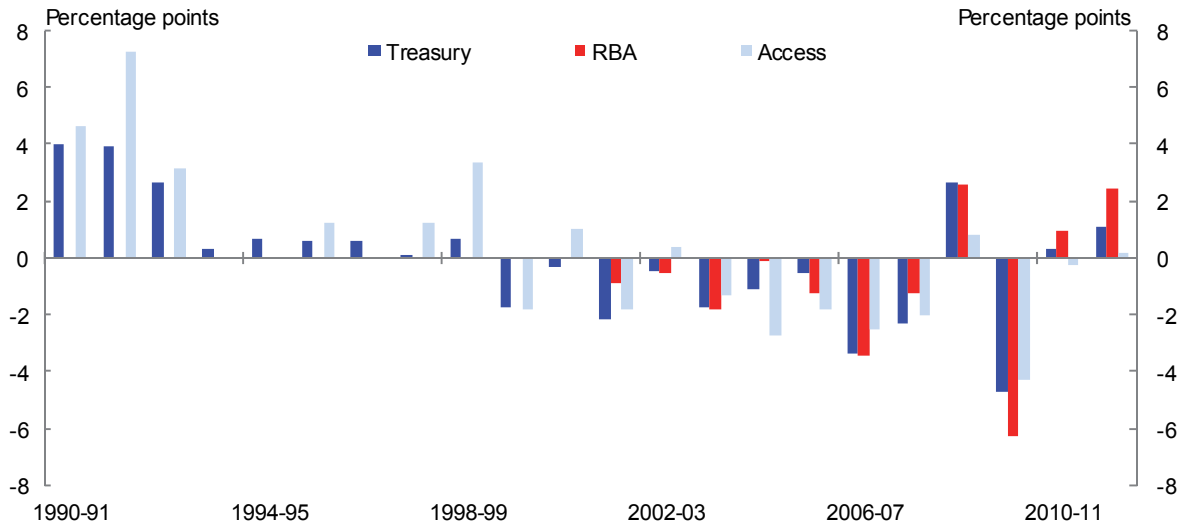
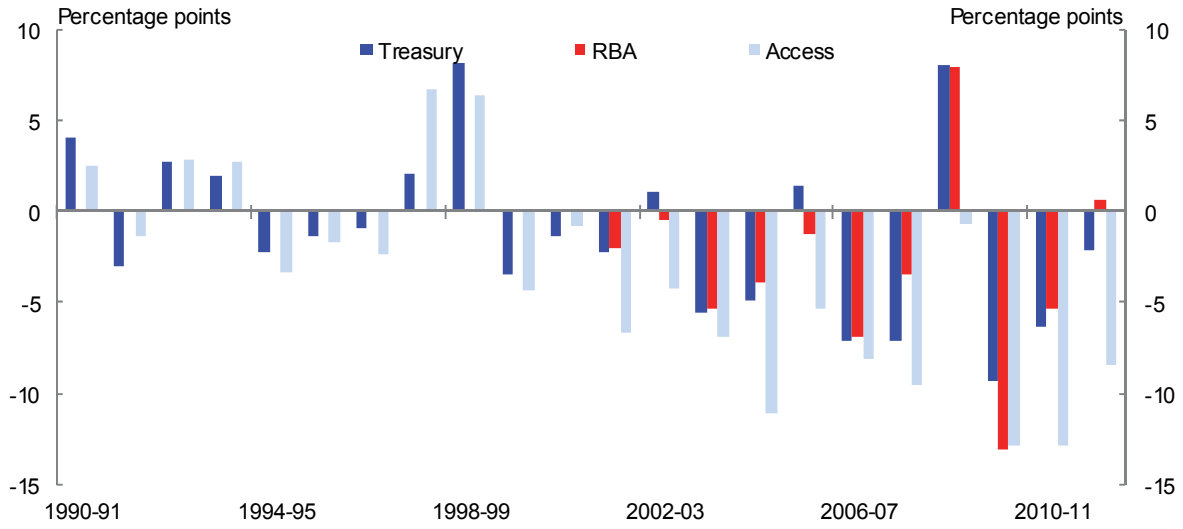


Figure 3.15: Comparison of Budget Forecast Errors for Terms of Trade Growth



SECTION 4: CASE STUDIES

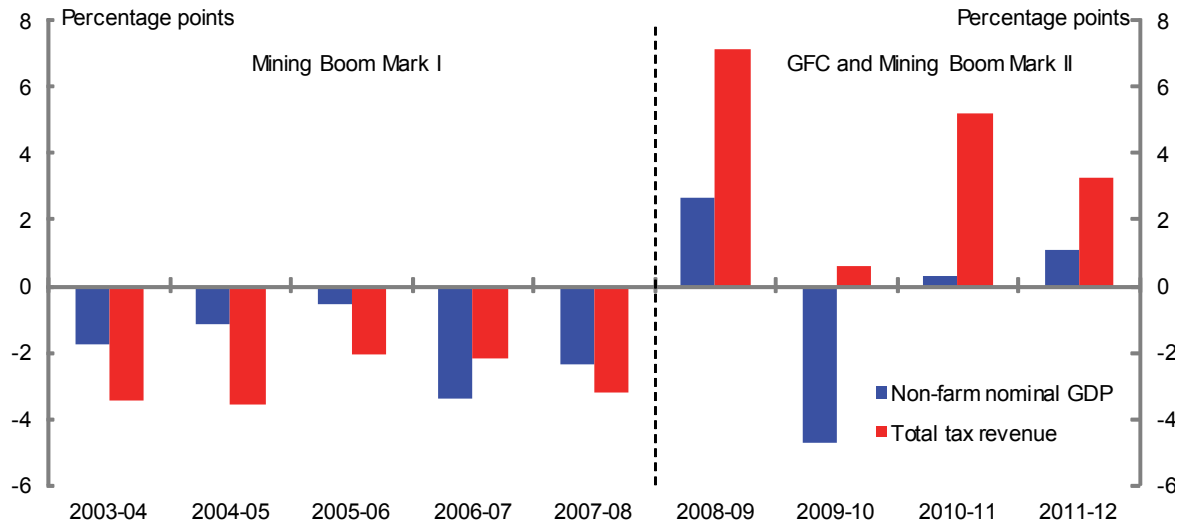
4.1: Introduction

This section presents case studies of Treasury's forecasting performance. The case studies relate to the most recent challenges confronting forecasters, namely Mining Boom Mark I (2003-04 to 2007-08) and the global financial crisis (GFC) and Mining Boom Mark II (2008-09 to 2011-12).

Treasury underestimated the extent of the rise in the terms of trade during Mining Boom Mark I, which led to the underestimation of nominal economic outcomes and, in turn, taxation revenue, over the period. In contrast, during the GFC and Mining Boom Mark II, taxation revenue growth has generally been overestimated, with taxation receipts having struggled to recover from their post-crisis lows, as accumulated losses continued to flow through the tax system.

The Budget forecast errors (forecast minus actuals) over these periods for nominal GDP and taxation revenue growth are shown in Figure 4.1, below.

Figure 4.1: Budget Forecast Errors for Nominal GDP and Taxation Revenue Growth



As part of Treasury's process of continuous internal evaluation, these forecasting errors have resulted in several improvements to economic and revenue forecasting methodology and process.

4.2: Mining Boom Mark I

Summary

- In common with many other forecasters, Treasury underestimated the extent of the rise in Australia's terms of trade during Mining Boom Mark I, which led to the underestimation of nominal economic outcomes. This reflected misjudgement of both demand and supply-side developments in the mining sector.

- On the demand side, economic growth in China consistently exceeded forecasts over this period, on average by around 2½ percentage points per annum. As a result, the demand for steel and, in turn, iron ore and metallurgical coal, was underestimated.

- Treasury also overestimated the speed at which global mining production would respond to the rise in mining output prices. Treasury's assessment was largely based on the mining companies' global

projections for production and export volumes, which consistently exceeded actual outcomes. In Australia this partly reflected infrastructure bottlenecks and the impact of natural disasters.

- In response to these forecast errors, Treasury has progressed several initiatives designed to enhance its capability to forecast commodity prices and volumes. As part of the JEFG process, a balance of payments subcommittee has been established to focus specifically on the outlook for bulk commodities, comprising Treasury, the RBA, BREE and the ABS. Treasury's business liaison program has been refocused to place greater weight on the mining industry. A major project is also underway which uses detailed projections of commodity supply and demand to model the outlook for commodity prices through the medium-term.

- Taxation revenue outcomes were also underestimated, largely reflecting the underestimation of the strength of the nominal economy during this period. Counterfactual analysis finds that the revenue forecast errors would have been small if the actual economic outcomes had been known at the time that the revenue forecasts were being prepared.

- Capital gains tax (CGT) was a major source of forecast error during Mining Boom Mark I, in large part, due to the underestimation of the sharp rise in asset prices over the period.

- In response to these forecast errors, Treasury overhauled its forecasting models to take better account of the volatile nature of this head of revenue. CGT is now explicitly forecast in a stock model (rather than being grown in line with other heads of revenue), which better allows for periods of rapid asset price growth and the accumulation of capital gains and losses.

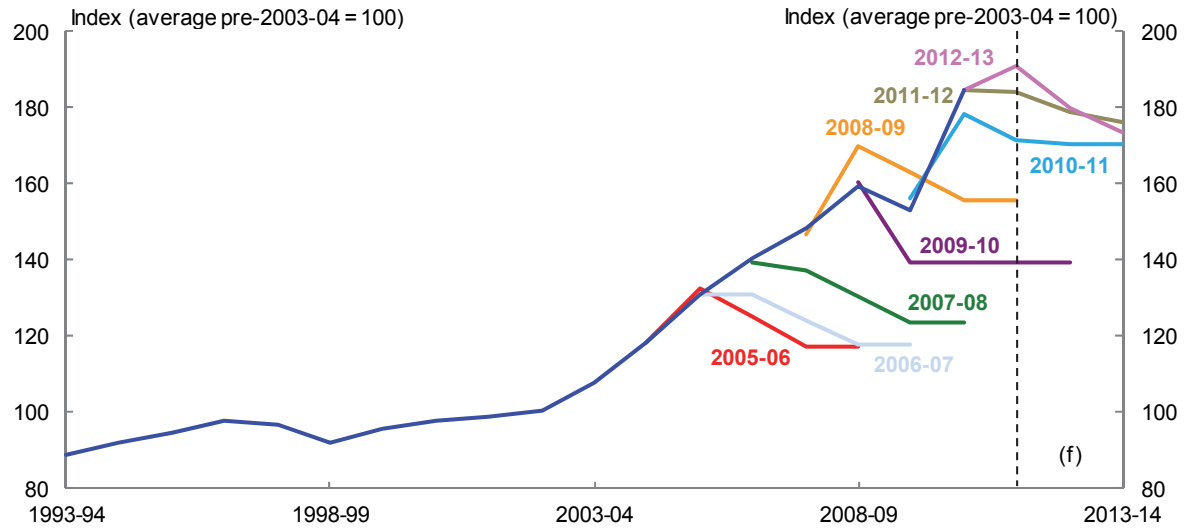
Background

The first phase of the mining boom spanned the five-year period to 2007-08, with rapid rates of industrialisation in Asia, particularly in China, increasing worldwide demand for natural resources and in turn, underpinning an investment boom and a sharp sustained rise in output prices in the mining sector. As a result, Australia's terms of trade rose by almost 50 per cent from early 2004 until the onset of the GFC in 2008. The economy began to approach capacity constraints around 2006 and 2007, with unemployment heading down towards 4 per cent — a rate not seen since the early–1970s. Monetary policy was tightened to address inflationary pressures, with inflation peaking at 5 per cent in mid-2008.

Macroeconomic forecasting performance

In common with many other forecasters, a feature of Treasury's macroeconomic forecasts during Mining Boom Mark I was the underestimation of the sharp rise in Australia's terms of trade, and in turn nominal GDP growth, over the period. The main driver of the rise in the terms of trade, and hence the main driver of Treasury's forecast error, was a sustained increase in iron ore and coal prices. Both demand and supply-side surprises explain the forecast errors. Figure 4.2 highlights the consistent underestimation of the rise in the terms of trade over successive Budgets.

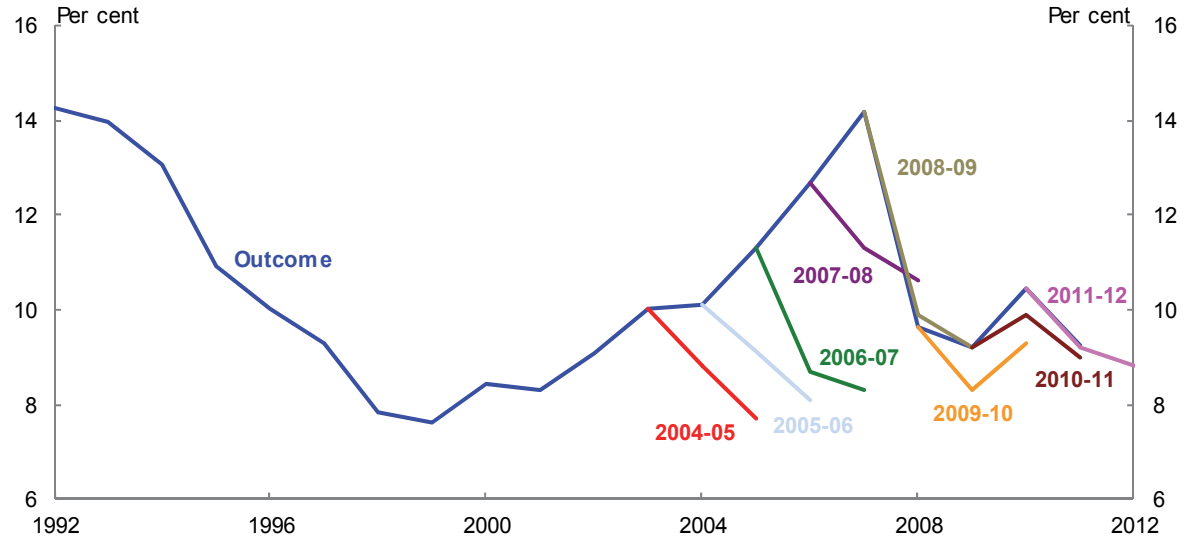
Figure 4.2: Budget Forecasts of Australia's Terms of Trade



Note: The figure plots the forecast level of the terms of trade against outcomes, with the forecast level derived from forecast growth rates of the terms of trade from successive Budgets beginning with the 2005-06 Budget.

On the demand side, forecasters consistently underestimated economic growth in China and other emerging economies and hence underestimated the demand for steel and in turn iron ore and metallurgical coal. This pattern was observed over the period of the first mining boom, with forecasts of the Chinese economy only recently becoming more accurate. Over the period 2003 to 2007, the average forecast error was 2½ percentage points per annum. Figure 4.3 shows the Consensus Economics two-year forecasts for Chinese real GDP growth against outcomes.

Figure 4.3: Consensus Economics Two-year Forecasts for Chinese Real GDP growth

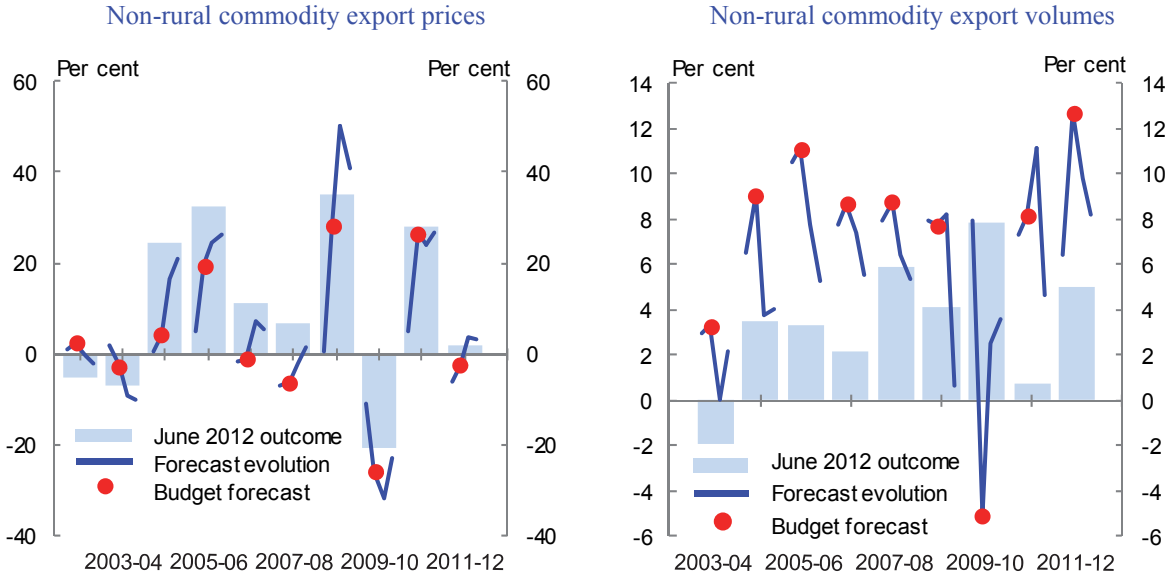


Source: Consensus Economics and Treasury estimates

On the supply side, despite strong growth in mining investment in response to the sharp rise in commodity prices, growth in mining production and in turn export volumes was consistently slower than expected. As early as the 2005-06 Budget, the expectation was that production would quickly catch-up with forecast demand. The expected supply response was based on what was perceived at the time to be a conservative assessment of mining companies' global projections for production and export volumes, which consistently exceeded actual outcomes. In Australia this has partly reflected

infrastructure bottlenecks and the impact of natural disasters. Figure 4.4 shows that non-rural commodity export volume forecasts have been consistently overstated, with the error largely due to overestimation of iron ore and coal export volumes.

Figure 4.4: Evolution of Non-Rural Commodity Export Price and Volume Growth Forecasts



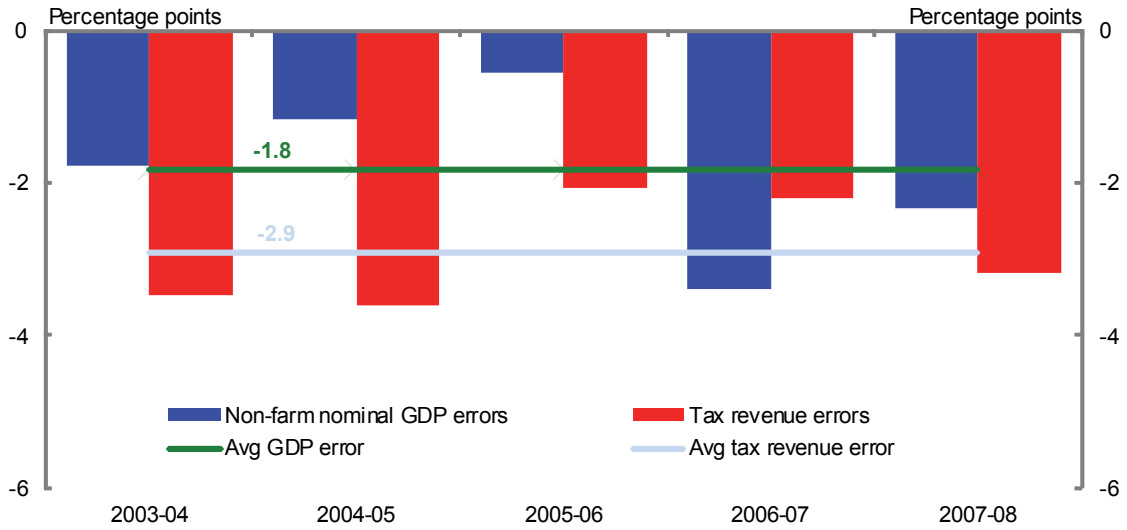
As a result of this experience Treasury has progressed several initiatives to build a deeper understanding of developments in China and other emerging market economies and the links these developments have with Australia. In particular:

- a dedicated unit has been established within Treasury that focusses on the Chinese economy and Treasury representation in Asia has been enhanced by opening up a new post in India;
- there has been a greater focus on developing resource industry contacts as part of Treasury's business liaison program;
- a BOP subcommittee meeting has been incorporated into the JEFG process, drawing upon the expertise of the Bureau of Resources and Energy Economics to forecast the outlook for bulk commodities;
- more resources have been devoted to forecasting non-rural commodity production, export volumes and prices; and
- a major project is currently underway using industry data to develop a methodology for projecting bulk non-rural commodity export prices based on a medium-term supply and demand framework, supplemented by a comparison with projections by BREE, Consensus and private sector providers.

Revenue forecasting performance

As observed with Treasury's nominal economy growth forecasts, taxation revenue growth was also underestimated during Mining Boom Mark I. In particular, nominal economic growth was underestimated by an average of 1.8 percentage points per annum, compared with an average forecast error of 2.9 percentage points for taxation revenue growth (Figure 4.5).

Figure 4.5: Budget Forecast Errors for Growth in Nominal GDP and Taxation Revenue



In the case of taxation revenue forecast errors, it is useful to distinguish between those that reflect errors in the macroeconomic forecasts and those that reflect other sources of error. The latter might include:

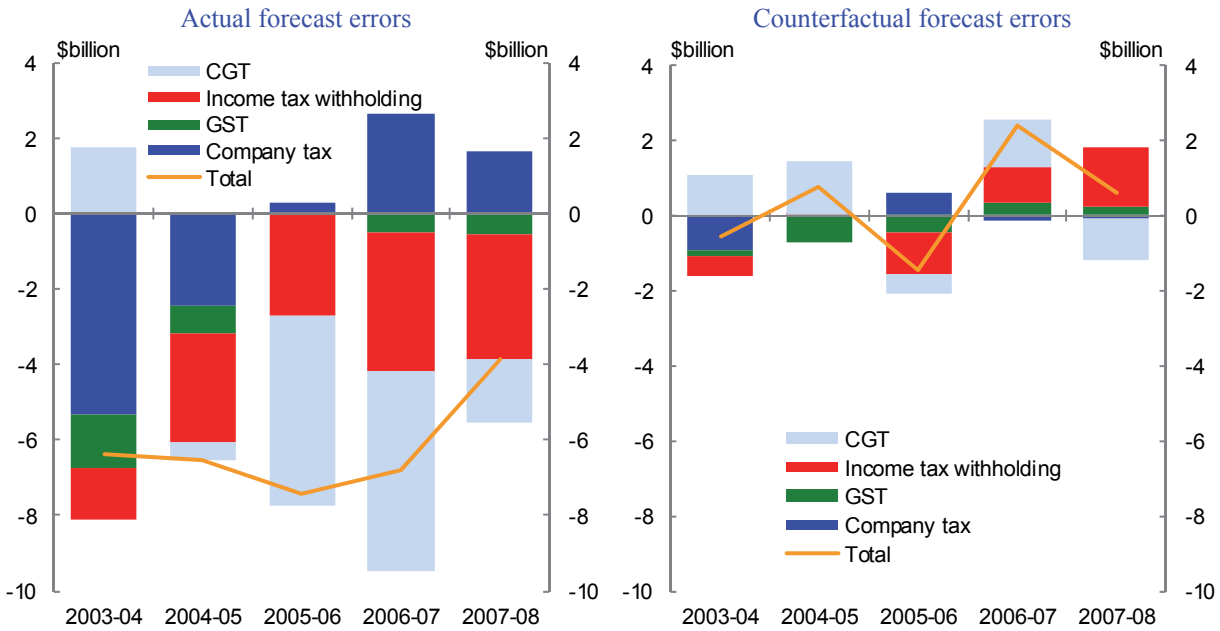
- error in items that are within scope of the tax base, but not the economic base[1];
- error in estimates of taxation revenue elasticities[2];
- error in estimates of the timing of the receipt of taxation revenue; and
- miscellaneous factors, such as errors in Budget policy costings, post-Budget policy decisions and court decisions relating to tax law interpretation.

A counterfactual exercise has been undertaken to decompose taxation revenue forecast errors into those that reflect macroeconomic forecast errors and those that reflect other sources of error. The results of this exercise are detailed in Figure 4.6, below. The left-hand panel of Figure 4.6 shows the actual forecast errors over Mining Boom Mark I. The right-hand panel shows the results of a counterfactual exercise, which estimates the revenue forecast errors that would have occurred if actual economic outcomes had been known at the time that the forecasts were being prepared. The presence of significant revenue forecast error in the counterfactual would suggest scope to improve revenue forecasting methodology.

The counterfactual exercise assumes in particular that the outcomes for compensation of employees (the income tax withholding economic base), consumption subject to GST (the GST economic base) and gross operating surplus (the corporate tax economic base) are known. In the case of capital gains tax, it is assumed that actual asset price outcomes are known (that is, share prices and house prices). Not all heads of revenue have been included in this exercise, although the four heads of revenue considered comprise around 85 per cent of taxation revenue and on average account for around 80 per cent of the forecast error over the case study period.

1 For example, the company tax base includes deductions for depreciation and current year losses, which are not part of gross operating surplus (the associated economic base).
2 This is largely an issue for income tax withholding. In contrast, the elasticities of the other heads of revenue to their taxable bases should be one, by definition, as they have flat tax rates.

Figure 4.6: Contribution to Budget Revenue Forecast Error by Head of Revenue



The counterfactual exercise finds that most of the taxation revenue forecasting error during Mining Boom Mark I can be attributed to errors in the nominal economy forecasts. The average actual revenue forecast error during Mining Boom Mark I was (an underestimate of) $6.2 billion, whereas the average estimated forecast error under the counterfactual exercise is (an overestimate of) $0.3 billion. This suggests that the revenue forecast error reflects the underestimation of the strength of the nominal economy during Mining Boom Mark I, rather than any systematic tendency to underestimate revenue over this period.

The sections, below, discuss the errors in each of the major heads of revenue over this period.

Income Tax Withholding

Income tax withholding is the largest tax revenue head, comprising over 45 per cent of total taxation revenue. The relevant economic base for income tax withholding is compensation of employees, which measures the total wage bill of the economy (and can be split into the total number of employees multiplied by the average wage). The correlation between the growth in income tax withholding and the growth in compensation of employees over the past decade (2002-03 to 2011-12) has been 0.87, indicating a good relationship.[3]

Figure 4.7 below shows the forecast errors for compensation of employees during Mining Boom Mark I. The strength in employment growth was consistently underestimated during this period, as was average wages growth, albeit to a lesser extent. The forecast errors are significantly reduced when the actual employment and wages outcomes are applied to the income tax withholding model (as shown in the right-hand panel of Figure 4.6, above), indicating that there was minimal forecasting error beyond the underestimation of the strength of the labour market over this period.

3 The correlation coefficient has been calculated after adjusting income tax withholding for tax policy changes (largely personal income tax cuts). Tax policy changes are costed and taken into account separately in the forecasting process.

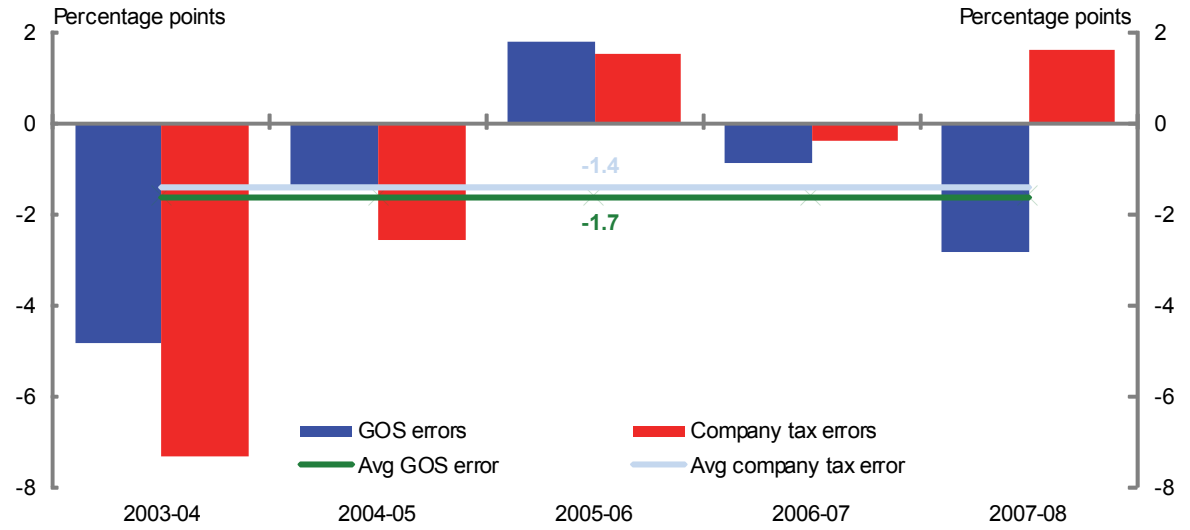
Figure 4.7: Budget Forecast Errors for Growth in Compensation of Employees and Income Tax Withholding

Company tax

Company tax is the second largest revenue head, comprising over 20 per cent of total revenue. The main component of the economic base for company tax is gross operating surplus (GOS). The correlation between the growth in company tax and the growth in GOS over the past decade has been 0.26, indicating that the relationship between the two series is not particularly strong. This is due to the conceptual differences between corporate taxable income and GOS, and the lag between the timing of the economic activity and the associated receipt of taxation revenue, which are discussed further in Section 4.3.

Figure 4.8 shows the Budget forecast errors for GOS and company tax (excluding CGT). The strength of GOS was generally underestimated during Mining Boom Mark I, which led to the underestimation of company tax.

Figure 4.8: Budget Forecast Errors for Growth in Gross Operating Surplus and Company Tax



The company tax forecast errors are significantly reduced when the actual GOS outcomes are applied to the company tax model, (as shown in the right-hand panel of Figure 4.6, above).

Goods and Services Tax

The goods and services tax (GST) comprises around 15 per cent of total taxation revenue. The primary economic base for GST is consumption subject to GST. The correlation between growth in GST and consumption subject to GST over the past decade has been 0.75, indicating a good relationship between the two series.

GST was not a significant source of forecast error during Mining Boom Mark I*;* however, the head of revenue was typically underestimated (as shown in the left-hand panel of Figure 4.6, above). When actual outcomes for consumption subject to GST are applied to the GST model, the forecast errors are reduced (as shown in the right-hand panel of Figure 4.6 above) and display less bias. This indicates that there was minimal error in the GST forecasts over this period beyond a slight underestimation of the strength of consumption subject to GST.

Capital gains tax

Capital gains tax (CGT) is a relatively small, but very volatile, head of revenue. This reflects volatility in asset prices and variability in both realisation rates (since CGT is only payable when assets are sold) and also the extent to which capital losses are offset against capital gains. Over the period of the case study, the annual growth rate of CGT has varied from a rise of 60 per cent in 2004-05 to a fall of 43 per cent in 2009-10, resulting in CGT being a large source of forecast error.

The stock of accrued capital gains accelerated rapidly during Mining Boom Mark I, with asset values rising at a historically rapid rate. Over this period, CGT was significantly underestimated, particularly in 2005-06 and 2006-07 (as shown in the left-hand panel of Figure 4.6).

The CGT forecast errors are significantly reduced when the actual outcomes for equity and house prices are applied to the current CGT model, (as shown in the right-hand panel of Figure 4.6 above) and the bias in the forecast errors disappears. Treasury does not forecast these asset prices, but instead adopts the technical assumption that asset prices grow in line with nominal GDP growth. The counterfactual exercise shows that if the technical assumption had accurately predicted asset prices, the current CGT model would not have systematically underestimated revenue over this period.

Capital gains tax model improvements

As a result of Treasury's forecasting experience during Mining Boom Mark I, the CGT models have been overhauled. The development has been an ongoing process, with the first improvements implemented in 2006-07, following the sharp rise in CGT revenue in 2005-06.

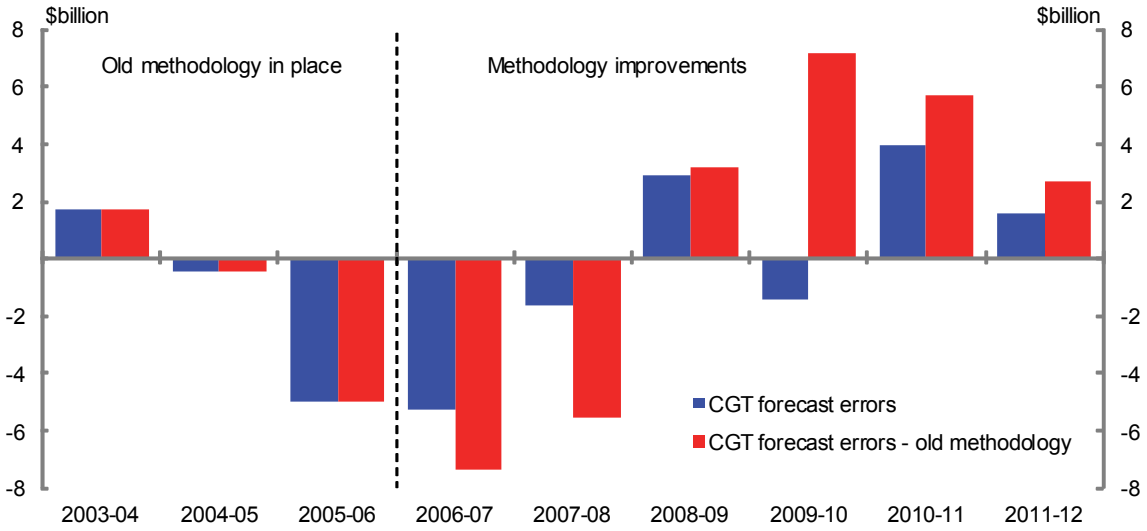
There are three broad types of CGT taxpayers — individuals, companies and superannuation funds. The previous methodology did not separately model CGT for individuals and companies. It effectively assumed that CGT collections would grow in line with the associated taxpayer revenue stream; for example CGT paid by companies would grow in line with company tax. CGT paid by superannuation funds was forecast using a simple model based on recent trends and judgement.

The new CGT models are structured to mirror the balance sheet of relevant taxpayers, by tracking the stock of assets subject to CGT and their price movements. Figure 4.25 (Appendix A) provides an overview of the model for CGT paid by superannuation funds, by way of an example.

The changes to the CGT modelling framework have improved forecast performance. Figure 4.9 shows the forecast errors for CGT over the recent period, compared with the errors that would have been generated using the old CGT forecasting methodology for individuals and companies (which was in place until 2006-07). The average absolute forecast error for CGT since 2006-07 has been $2.8 billion

per annum. However, if the old methodology had been in place the average absolute forecast error would have been much larger at $5.3 billion per annum.

Figure 4.9: Capital Gains Tax Forecast Errors



4.3: Global Financial Crisis and Mining Boom Mark II

Summary

- In common with many other forecasters, Treasury did not predict the degeneration of the US subprime crisis into the GFC in 2008-09 and subsequently overestimated the impact of the crisis on economic growth in 2009-10.
- Treasury's forecasting error for economic growth in 2009-10 largely reflected misjudgements of the efficacy of Australia's policy response and the relatively early, and strong, recovery in economic growth in most of our major trading partners throughout 2009.
- One lesson from this experience is the importance of having in-house expertise to understand the operation of financial markets and their linkages with the real economy. To this end the Treasury has employed a technical specialist with deep financial markets experience and created a dedicated unit for this purpose.
- Taxation revenue outcomes were consistently overestimated during this period, despite the nominal economic forecast errors being close to zero on average. Counterfactual analysis finds that even if the economic outcomes had been known at the time the forecasts were being prepared, revenue would still have been overestimated, primarily reflecting company tax errors.
- In response to the perceived source of these taxation revenue forecasting errors, Treasury is currently developing a three sector company tax model that takes better account of the different characteristics of these sectors for taxation purposes, for example, the capital-intensive nature of the mining sector, and the measurement of finance sector income in the National Accounts.

Background

The world economy experienced a severe financial and economic shock in the second half of 2008. The Global Financial Crisis (GFC) began in 2007 with the US sub-prime crisis and the crisis intensified dramatically in September 2008 with the collapse of Lehman Brothers. During this period, financial conditions deteriorated rapidly, financial and real asset prices collapsed, and business and

consumer confidence fell steeply. The GFC saw the world economy change course sharply from a five-year period of above-trend growth to the deepest recession since the Great Depression.

The Australian economy performed better than other advanced economies during the GFC. Although financial conditions were stressed, the financial system held up remarkably well; the economy slowed, but did not fall into recession; and while unemployment rose, it did so by far less than in many other advanced economies. The strong performance of the Australian economy largely reflected the strength of the Australian financial system and public finances; the rapid deployment of fiscal stimulus measures; the first effects of a significant easing in monetary policy; and a pickup in demand from China which partly offset pronounced external weakness elsewhere. More broadly, it also reflected improved policy and institutional arrangements in Australia following a quarter century of reforms that have made the Australian economy much more resilient to external shocks.[4]

As the impact of the GFC subsided, Australia's terms of trade rebounded, with the emergence of a second phase of the mining boom, and reached a new record high in late 2011 (Mining Boom Mark II). In contrast to Mining Boom Mark I, the second phase occurred against a backdrop of global uncertainty and balance sheet consolidation by the corporate and household sectors, reflected in a significant decline in credit growth. Sectors aligned with mineral resources have grown strongly, while there has been pressure on some domestic manufacturing and trade-exposed sectors from the high level of the Australian dollar over this period.

Economic forecasting performance

In common with other forecasters, Treasury did not predict the degeneration of the US subprime crisis into the GFC in 2008-09 and subsequently overestimated the impact of the crisis on the nominal economy in 2009-10.

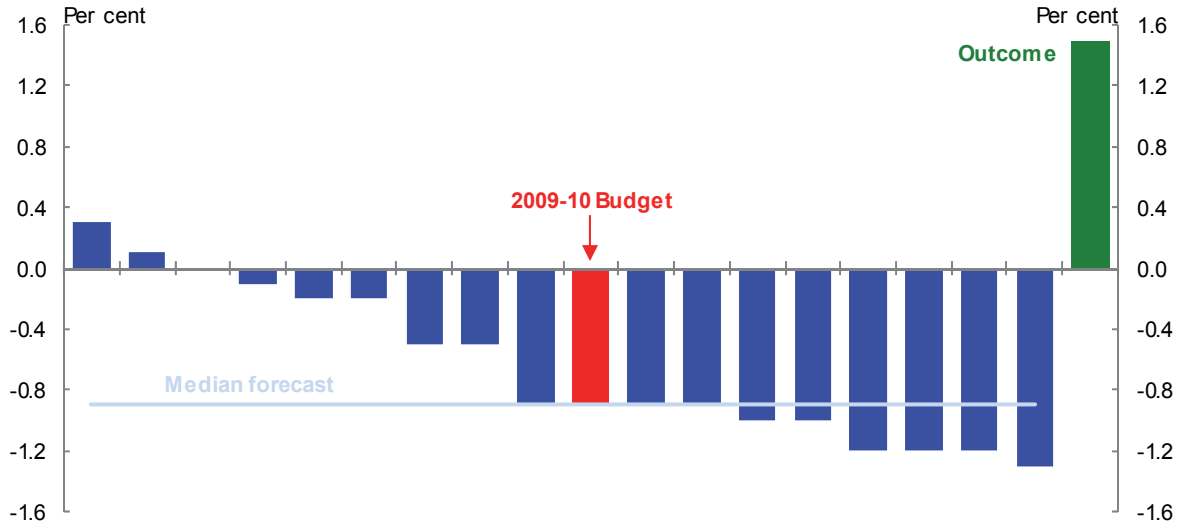
The impact of the GFC on Australia was expected to be severe, with the 2009-10 Budget, prepared in May 2009, the first in history to forecast a contraction in both real and nominal GDP. Gruen (2010) notes that at the time the 2009-10 Budget forecasts were being prepared the international context was dire, with forecasters making significant downgrades to global growth and global trade. For example, as the global outlook deteriorated, the IMF downgraded its forecasts for 2009 global GDP growth by 4.3 percentage points between October 2008 and April 2009. Over the same period, it downgraded its forecasts for advanced economy growth by 4.3 percentage points and for global trade volumes by over 15 percentage points. In line with these forecasters, Treasury significantly downgraded its forecasts for global growth and correspondingly Australian goods and services export volumes, using the IMF and OECD forecasts from their inter-country trade models as a guide.

Domestic indicators were also bleak (Gruen, 2010). At the time the 2009-10 Budget forecasts were being prepared, the latest comprehensive reading on the economy, the December quarter 2008 National Accounts, which was released in early March 2009, showed a contraction of 0.5 per cent. At the time, this was the weakest quarter — indeed the first negative quarter — since the December quarter 2000. With subsequent revisions to the National Accounts, that quarter now stands as the weakest since March 1983. The unemployment rate had also risen sharply from 4.1 per cent in August 2008 to 5.7 per cent in March 2009.

By the time the Budget forecasts were finalised in April 2009, the average Consensus forecast was predicting a contraction in Australia's real economy in 2009 of around 0.6 per cent. As Figure 4.10 shows, the Budget forecast for a contraction of 0.9 per cent was around the median of the range of forecasts surveyed by Consensus in mid-April.

4 McDonald, T, and Morling, S, 2011, 'The Australian Economy and the Global Downturn, Part 1: Reasons for resilience', *Economic Roundup*, Issue 2, pp 1-31.

Figure 4.10: Forecasts for Australian real GDP growth in 2009, as at April 2009



Source: Consensus Economics (Survey date 14 April 2009), Treasury (Budget, 11 May 2009).

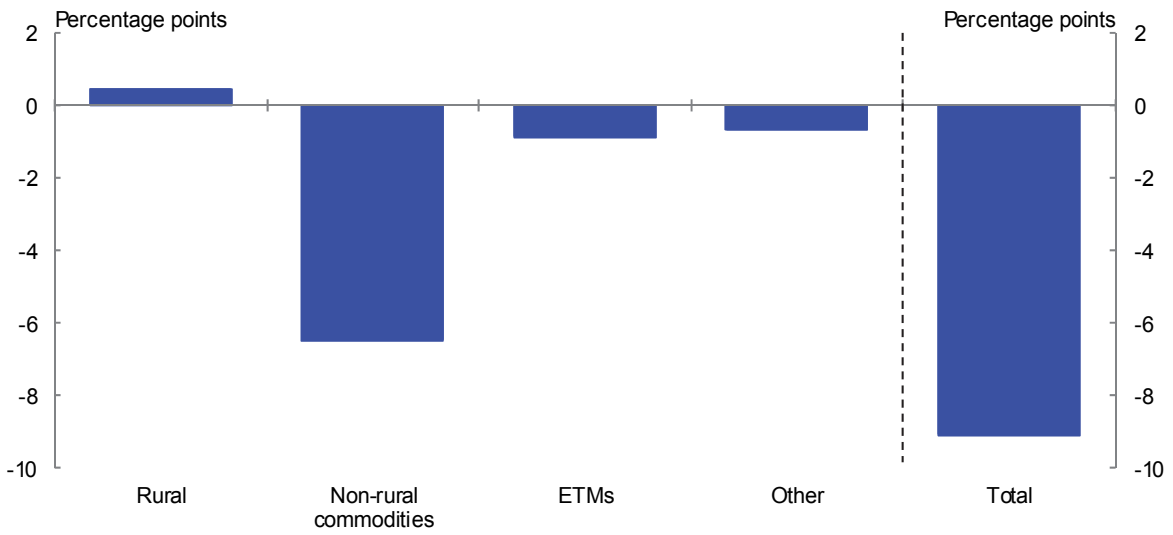
Although the real economy did experience a significant slowdown in 2009-10, it performed significantly better than Treasury expected, largely reflecting misjudgements of the efficacy of Australia's policy response and the relatively early, and strong, recovery in economic growth in most of our major trading partners throughout 2009.[5]

The largest contributions to the 2009-10 Budget forecast error for real GDP growth were from household consumption, exports and business investment. Household consumption was forecast to decline moderately in 2009-10. In the event, it grew by 2.5 per cent. As noted in Gruen (2010), expansionary monetary and fiscal policy appears to have been large enough and quick enough to convince consumers and businesses that the domestic slowdown would be relatively mild. In turn this supported confidence and led consumers and businesses to continue to spend. While the stimulus was explicitly factored into Treasury's forecasts, it was also a contributing factor to the 2009-10 forecast errors.

The 2009-10 Budget forecast exports to contract sharply, by 4 per cent, in 2009-10. In the event, the outcomes were significantly better than forecast. The outlook for exports was heavily influenced by expert views on the scale of the global downturn at the time that the forecasts were being prepared. Within the export forecast error, the main contribution was from non-rural commodity exports, with smaller contributions from exports of elaborately transformed manufactures and other goods and services (Figure 4.11). Relative to the 2009-10 Budget forecasts, non-rural commodity exports performed significantly better than expected, with volumes exceeding forecasts by a significant margin.

5 Gruen, D, and Stephan, D (2010), 'Forecasting in the Eye of the Storm', *Address to the NSW Economic Society*, 4 June.

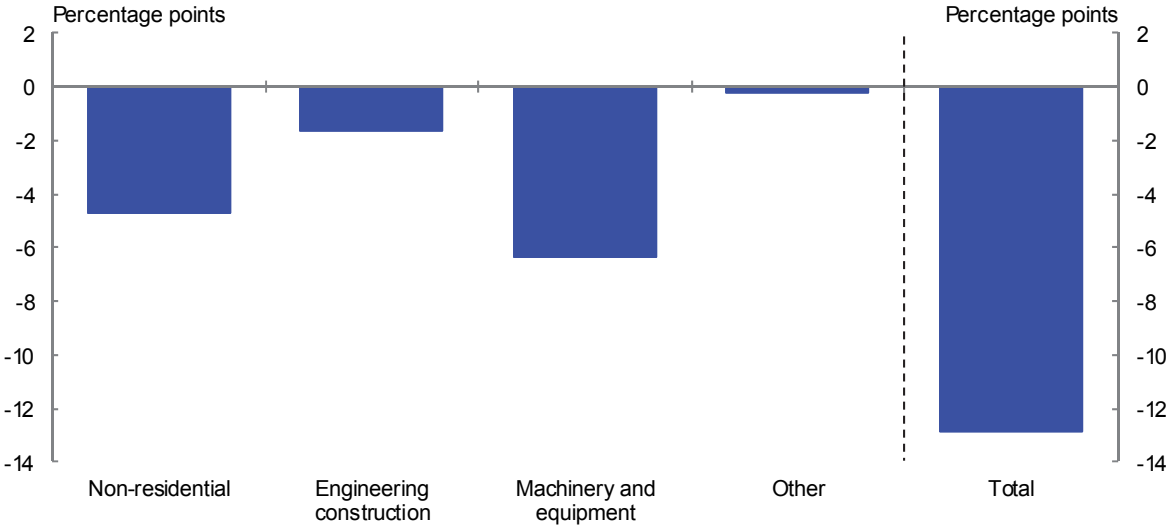
Figure 4.11: Contribution to Budget Forecast Errors for Exports in 2009-10, by Component



The better-than-expected outcome for exports largely reflected the better-than-expected performance of non-Japan Asia, particularly China. Chinese economic activity shifted into more commodity-intensive sectors, particularly infrastructure spending associated with the Chinese government's stimulus packages. There was also substitution away from Chinese domestic production and towards imports, as lower commodity prices resulted in the closure of some relatively high-cost Chinese production.

Business investment made the largest contribution to the 2009-10 Budget forecast error. Although, business investment contracted in 2009-10, the actual contraction was considerably less than forecast. As Figure 4.12 indicates, all components of business investment fell by less than expected, with machinery and equipment and non-residential construction finding greater-than-expected support from the macroeconomic stimulus, and engineering construction benefiting from a rebound in the outlook for resource commodities reflecting the stronger-than-expected growth performance of non-Japan Asia, particularly China.

Figure 4.12: Contribution to Budget Forecast Errors for Business Investment in 2009-10, by Component



One lesson from this experience was the importance of having in-house expertise to understand the operation of financial markets, advances in financial market products and the linkages between

financial markets and the real economy. To this end, Treasury has employed a technical specialist with deep financial markets experience and created a dedicated unit for this task.

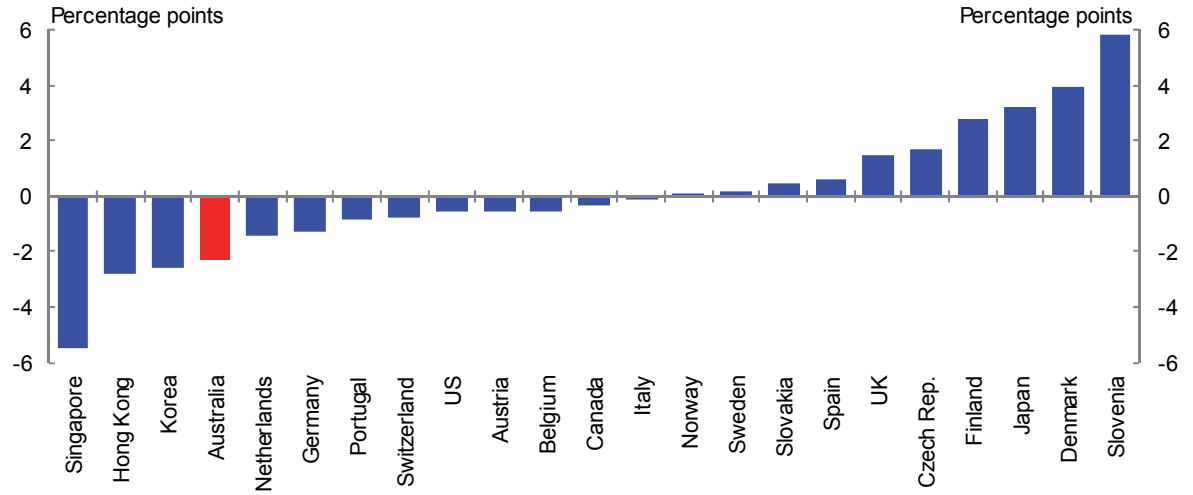
The Review observes that the large forecasting errors seen during the GFC highlight the fact that during such extreme events the evolution of the economy is fundamentally less predictable than at other times. A large number of official agencies overseas also had large forecasting errors during this period (Figure 4.13). That suggests a case for greater use of risk assessments around the central forecasts, rather than necessarily a major overhaul of forecasting procedures.

This leads the Review to make the following recommendation:

Recommendation 8:

Scenario analysis is useful as a way of assessing the risks around the economic and revenue forecasts. Simulation models have an important role to play in this regard and further development of Treasury's suite of models may be required to deliver this capability, including in relation to the international economic outlook.

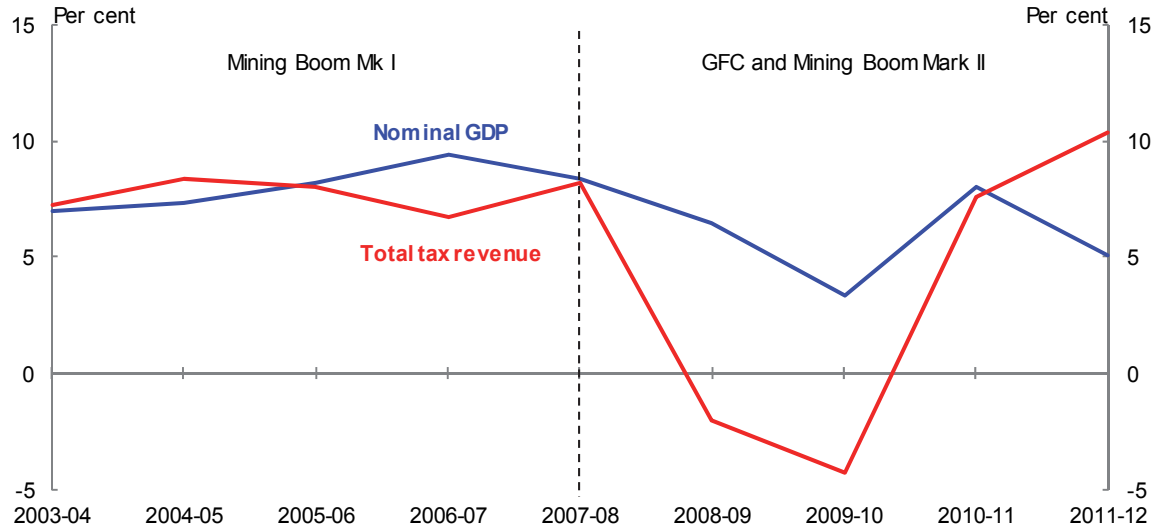
Figure 4.13: Forecast Errors for Real GDP Growth for Calendar Year 2009, by Selected Official Agencies Overseas



Revenue forecasting performance

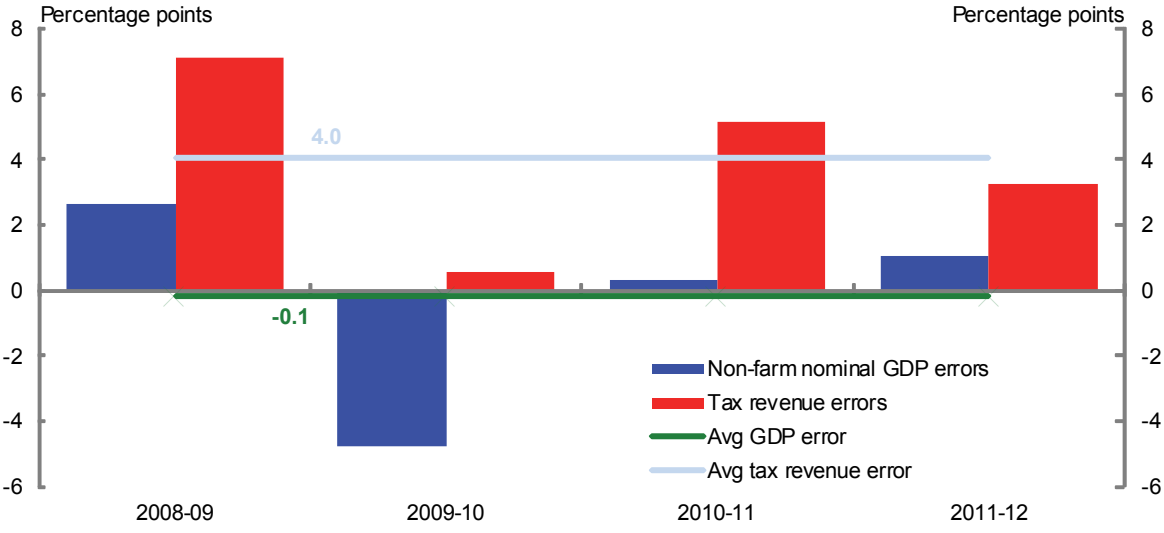
The outcomes for the nominal economy and taxation revenue diverged significantly during the GFC, largely reflecting the impact of accumulated losses on taxable incomes. During the GFC, taxation revenue fell by 6¼ per cent over 2008-09 and 2009-10, while nominal GDP continued to grow in year-average terms (Figure 4.14). This resulted in a large decline in the tax-to-GDP ratio.

Figure 4.14: Nominal GDP Growth versus Taxation Revenue Growth



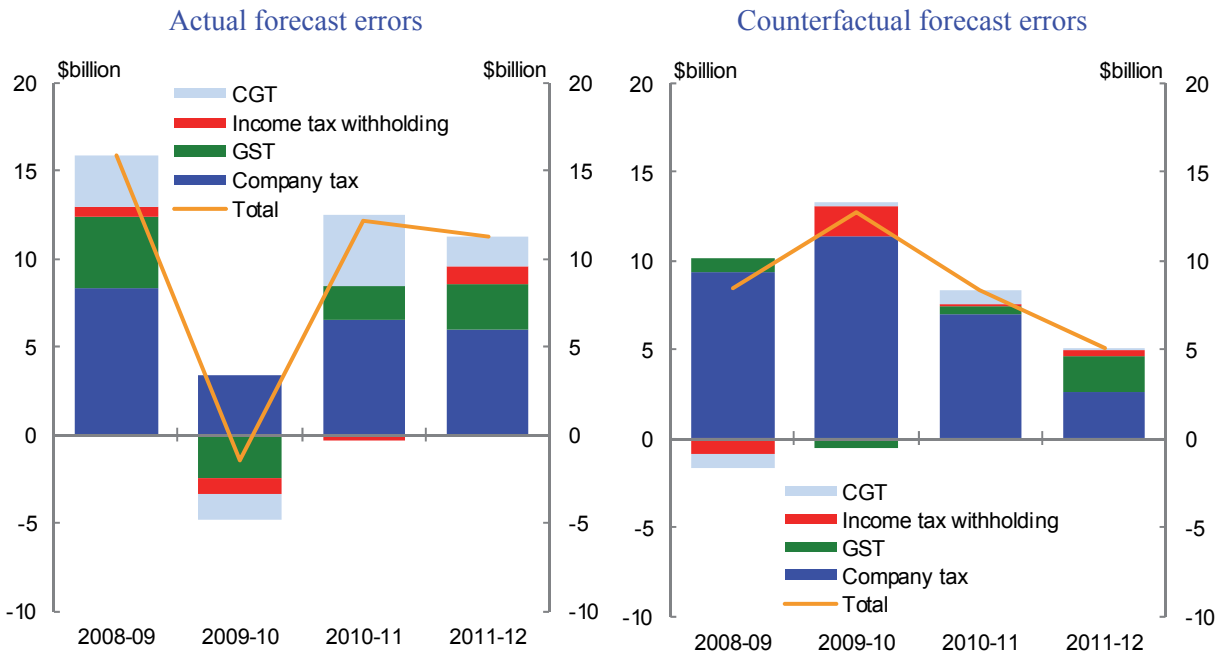
Treasury's forecast errors for the nominal economy and taxation revenue also diverged significantly during the GFC and Mining Boom Mark II. As shown in Figure 4.15, below, the Budget forecasts of nominal economic growth were underestimated by an average of 0.1 percentage points over this period, while taxation revenue growth was overestimated by an average of 4.0 percentage points.

Figure 4.15: Budget Forecast Errors for Growth in Nominal GDP and Taxation Revenue



The counterfactual exercise undertaken for Mining Boom Mark I has been repeated for this case study, with the results detailed in Figure 4.16. The left-hand panel of Figure 4.16 shows the actual revenue forecast errors and the right-hand panel shows estimates of the forecast errors that would have occurred if economic outcomes had been known at the time the forecasts were being prepared. The errors for most heads of revenue are reduced significantly in the counterfactual. However, in contrast to the Mining Boom Mark I analysis, the overestimation bias in the revenue forecasts does not disappear in the counterfactual. This is due to company tax overestimation errors, which actually materially increase in the first two years of the counterfactual. This finding will be examined in more detail, below.

Figure 4.16: Contribution to Budget Revenue Forecast Error by Head of Revenue

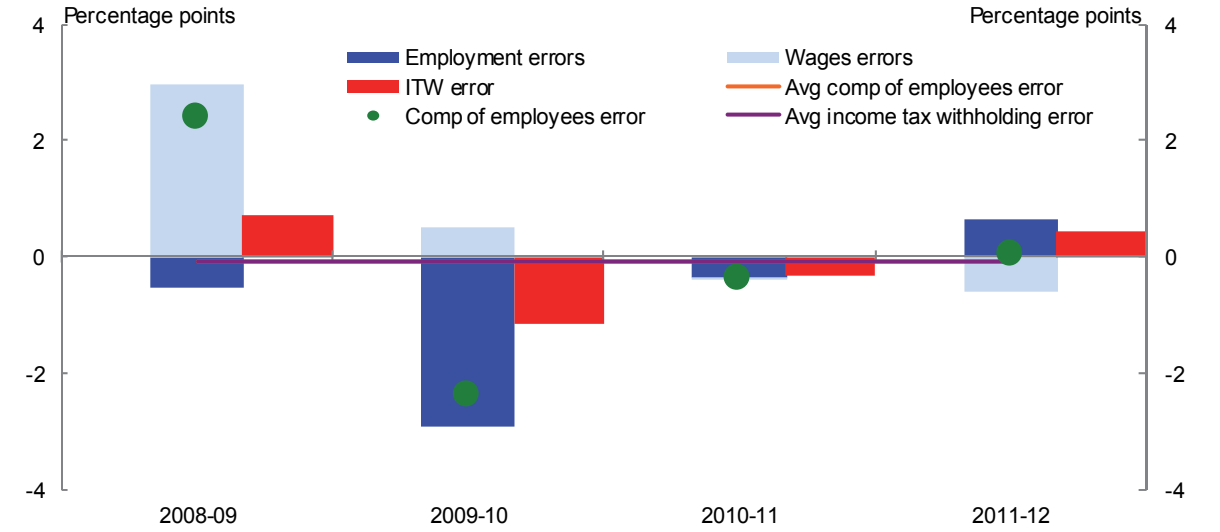


The sections, below, discuss the errors in each of the major heads of revenue in turn over this period.

Income Tax Withholding

Income tax withholding was a relatively small source of error during the GFC and Mining Boom Mark II. The average error over this period for the forecasts of both income tax withholding and compensation of employees was just -0.1 of a percentage point. When the actual outcomes for compensation of employees are applied to the income tax withholding model, the forecast errors for income tax withholding are broadly unchanged (as shown in the right-hand panel of Figure 4.16).

Figure 4.17: Budget Forecast Errors for Growth in Compensation of Employees and Income Tax Withholding

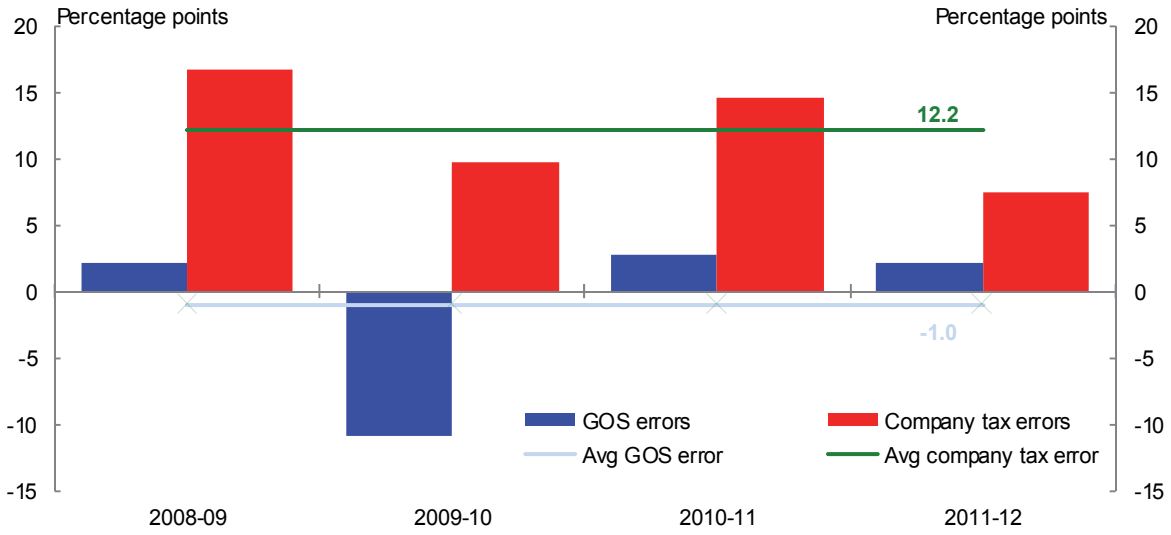


Company Tax

Company tax made the largest contribution to the overall revenue forecast error in each of the years since the GFC (left hand panel of Figure 4.16). Company tax revenue is generally a significant source

of forecast error as it is a relatively large, and volatile, head of revenue. This section discusses some factors that made company tax revenue forecasting difficult over this period. Figure 4.18, below, shows the forecast errors for GOS and company tax during the GFC and Mining Boom Mark II period. GOS was underestimated by an average of 1.0 percentage points per annum over this period, whereas company tax was overestimated by an average of 12.2 percentage points per annum.

Figure 4.18: Budget Forecast Errors for Growth in GOS and Company Tax

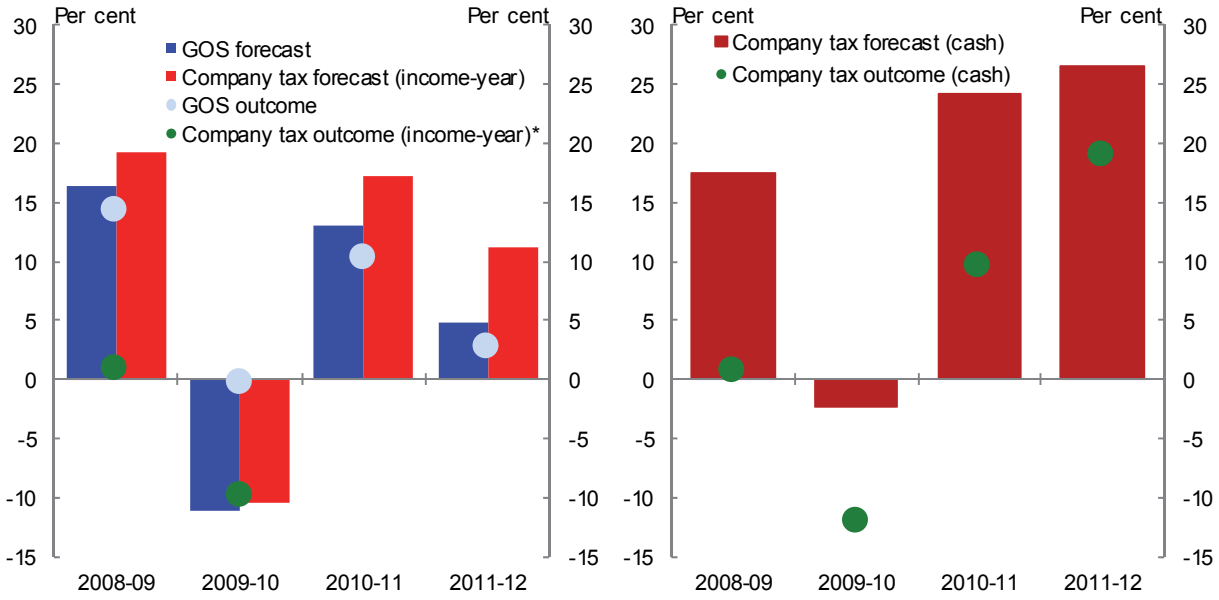


The relationship between GOS and company tax is complex. First, there are many conceptual differences between GOS and corporate taxable income. For example, corporate GOS is measured before deducting depreciation charges and debt-servicing interest expenses, and excludes holding gains or losses in trading stock and realised capital gains or losses in the assets and liabilities of the corporate sector. These conceptual differences are taken into account when translating forecasts of GOS (blue bars in the left-hand panel of Figure 4.19) into forecasts of company tax on an income-year basis (red bars in the left-hand panel of Figure 4.19).

Second, there are significant timing differences between these series that reflect the lag between the earning of economic profits and the receipt of the associated tax revenue. This means that company tax forecasts on an income year basis (red bars in the left-hand panel of Figure 4.19, below) need to be translated into company tax forecasts on a cash basis (red bars in the right-hand panel of Figure 4.19), which introduces a further potential source of forecast error.

Figure 4.24 in the appendix to this section provides more detail about the company tax model.

Figure 4.19: Company Tax Growth: Forecasts and Outcomes — Income-year and Cash

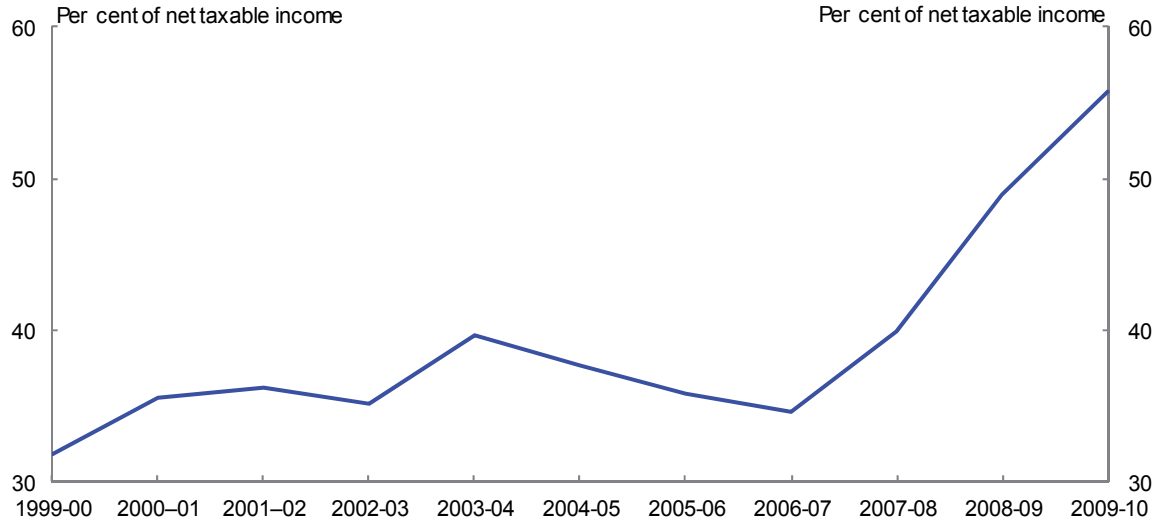


Note: Income-year company tax outcomes for 2010-11 or 2011-12 are not yet available.

In both 2008-09 and 2009-10, the company tax forecast on an income-year basis was closely aligned with the GOS forecast (the red and blue bars in the left-hand panel of Figure 4.19). However, the outcomes for the two series diverged significantly (the green and blue dots in the left-hand panel of Figure 4.19). GOS grew in total by 13.9 per cent over these two years, whereas company tax (income-year) fell in total by 8.9 per cent.

A major contributing factor to the weak outcome for company tax was high depreciation deductions (see Figure 4.20 below), relating to the huge increase in capital investment as part of the mining boom, and higher royalty expenses (also related to increased mining activity). As mentioned, GOS is measured gross of depreciation expenses. At the time, depreciation expenses were forecast separately in the company tax model based on historical trends. The methodology for forecasting depreciation deductions has been improved in light of this experience, and now utilises the investment forecasts produced by the macroeconomic forecasters.

Figure 4.20: Depreciation and Other Investment-related Deductions



Note: Deductions include depreciation, rents and royalties, research and development, mining exploration, capital expenditure, capital allowances and industry payments.

In addition, the timing adjustments made to the income-year forecast for 2009-10 proved to be inaccurate (as shown in the right-hand panel of Figure 4.19). Company tax was expected to fall by less on a cash, than on an income-year, basis, due to backwards-looking elements in the company tax payment system. In the event, company tax fell by around the same amount in 2009-10 on both a cash and income year basis. In fact, the company tax forecast for the 2009-10 income-year for a fall of around 10 per cent turned out to be reasonably accurate (left-hand panel of Figure 4.19), even though the cash forecasts for 2009-10 and 2010-11 were inaccurate. This, again, indicates problems with the assumptions made in relation to the timing of cash payments of company tax.

The majority of company tax is paid in quarterly instalments, based on an instalment rate derived from the most recently assessed tax return. This was expected to lead to overpayments of company tax on a cash basis in 2009-10, since it was a year of declining taxable profits. However, as companies became aware that the quarterly instalment payments that they were making in 2009-10 were likely to overestimate their yearly tax liability, they elected to vary down their instalments payments (to a greater extent than was anticipated in the forecasts).

Company tax revenue growth was also overestimated in 2010-11 and, to a lesser extent, in 2011-12. The reasons behind these forecast errors will be difficult to discern until tax return data are available for these income years[6]. In both years, the company tax growth rates were adjusted upwards in translating from income-year to cash forecasts. This is based on the typical pattern of company tax payments after a downturn, where instalments rates are varied upwards as profits recover[7].

The counterfactual exercise finds that the forecast errors do not improve when the GOS outcomes are applied to the current company tax model (as shown in the right-hand panel of Figure 4.16, above). In particular, the overestimation of company tax increases in 2009-10, due to the GOS outcome being significantly higher than forecast, with flow-on implications for the 2010-11 forecast error, due to the lags in the company tax payment system.

Figure 4.21, below, shows the historical mismatch between estimates of company tax (income-year) based upon GOS and actual company tax (income-year) outcomes. This shows that even when all of the economic and tax schedule data are known, it is not possible to completely reconcile the actual company tax outcomes with GOS. That said, the relationship was stable over the five-year period between 2003-04 and 2007-08. In recent years the relationship appears to have deteriorated.

Figure 4.21: Actual Company Tax Collections versus Company Tax Calculated from GOS

Note: The ratio is set equal to one in 2003-04.

6 The Taxation Statistics are released with a significant lag, with the 2009-10 edition being released on 1 May 2012.
7 See the box on page 5-22 of the 2012-13 Budget Paper No 1 for further discussion of this issue.

It is possible that future revisions to the GOS outcomes may improve the relationship between GOS and company tax in recent years. In the past, GOS has been revised significantly: for example, the outcome for growth in GOS in 2008-09 was revised upwards from 6.8 per cent, as first published, to 14.2 per cent (as at the June 2012 National Accounts). As they stand, the current GOS outcomes for 2008-09 and 2009-10 are particularly difficult to reconcile with the company tax outcomes through the GFC.

Significant work has been undertaken to improve the company tax model in response to the forecast errors that have been observed in recent years. In particular, Treasury is developing a three sector company tax model which splits the economy into mining, finance and insurance and other sectors. This should allow the model to take better account of the different characteristics of these sectors, such as:

- the greater role of the mining sector in the Australian economy and its capital-intensive nature;
- the measurement of the income of the finance sector in the National Accounts; and
- substituted accounting periods, which makes it more difficult to accurately estimate the timing of the receipt of cash payments of corporate tax. In particular many large financial companies operate on an accounting year ending in September and many large mining companies operate on an accounting year ending in December.

Notwithstanding these developments, due to the difficulty that Treasury has had forecasting revenue, in particular company tax revenue, the Review recommends that:

Recommendation 9:

Treasury should give further consideration to the appropriate balance between the top-down versus bottom-up approaches to forecasting revenue.

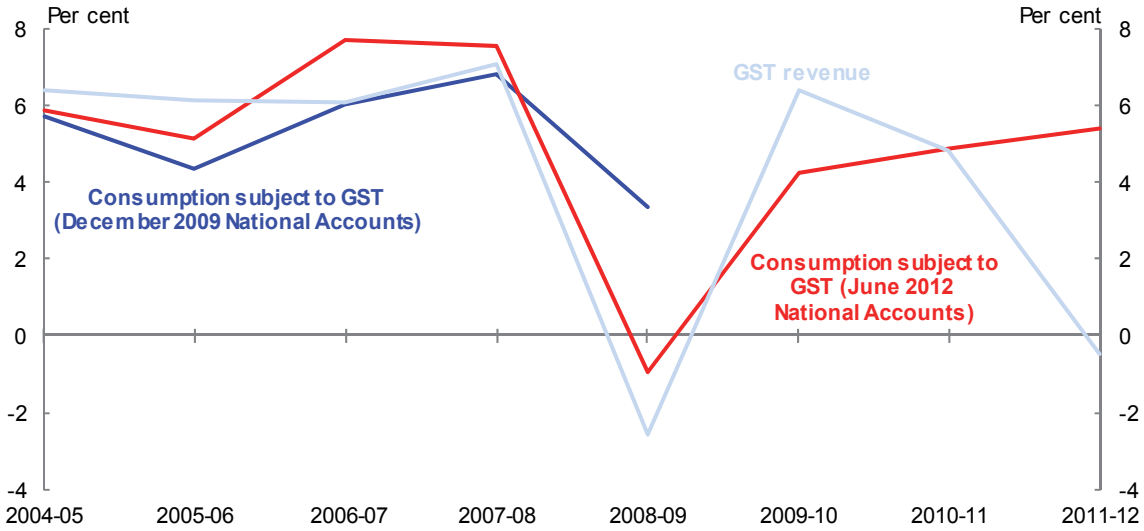
Recommendation 10:

Treasury, in conjunction with the ABS as necessary, should explore further ways of improving the current methodology for forecasting corporate tax, and also consider alternatives to the current methodology, which could perhaps be used to complement existing approaches.

GST

During the GFC period, the outcomes for GST revenue diverged significantly from the outcomes for its main economic base (consumption subject to GST), which presented challenges for forecasting. GST revenue fell in 2008-09, following the onset of the GFC (the light blue line in Figure 4.22). At the time, growth in consumption subject to GST fell only marginally (the blue line). This series has since been revised (the red line) and now better tracks GST revenue growth during 2008-09. However, a large discrepancy opened up again in 2011-12 between GST revenue and consumption subject to GST growth, with the National Accounts data again indicating a stronger economy than would be suggested by the GST revenue data.

Figure 4.22: GST and Consumption Subject to GST

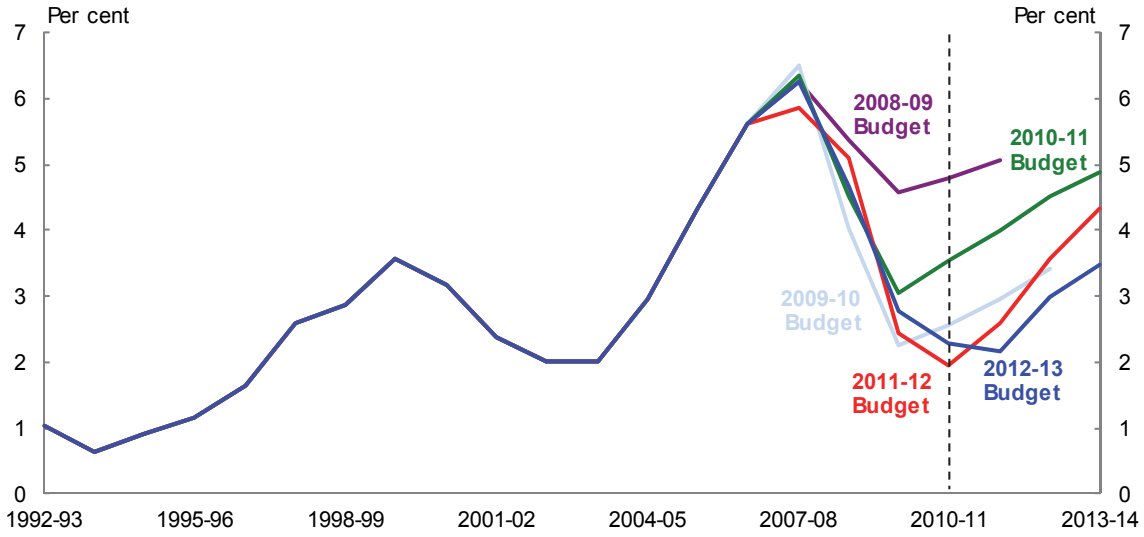


When the consumption subject to GST outcomes are applied to the GST model, the forecast errors reduce significantly (as shown in the right-hand panel of Figure 4.16 above, the green bars), except in 2011-12. The consumption subject to GST outcome for 2011-12 may be revised in the future, as the ABS reconciles the National Accounts consumption data with the ATO tax collections data.

Capital gains tax

The extent of the run-up in CGT revenue during Mining Boom Mark I was unanticipated, as was the extent of the drop-off following the GFC. As shown in Figure 4.23 below, CGT peaked as a share of revenue in 2007-08 at 6.3 per cent of revenue in that year. The stock market began to decline in December 2007 and by 2010-11 CGT comprised only 2.3 per cent of taxation revenue.

Figure 4.23: Evolution of Capital Gains Tax Forecasts (as a Percentage of Taxation Revenue)



The CGT forecast errors reduce significantly when actual asset price outcomes are applied to the current model, (as shown in the right-hand panel of Figure 4.16, the light blue bars), indicating that if asset prices had been known at the time the forecasts were being prepared, the current CGT model would not have generally overestimated revenue over this period.

This observation leads the Review to recommend that:

Recommendation 11:

The technical specialist with deep financial market experience employed by Treasury should be tasked with improving the accuracy of the technical assumptions for equity and housing prices that are used to generate the capital gains tax revenue forecasts.

APPENDIX A: REVENUE FORECASTING MODELS

Current Company Tax Model (Figure 4.24)

Of the National Accounts variables forecast by DED, company tax is most closely related to gross operating surplus (GOS), which is a measure of company profits. However, the relationship is far from simple. There are many conceptual differences between GOS and corporate taxable income, including depreciation, the treatment of losses, net interest income and capital allowances. There are also significant timing differences between profits being earned and the receipt of the associated tax revenue. As a rule-of-thumb, around 60 per cent of company tax is received in the year the profit is generated, with the remaining 40 per cent received in the following year. This means that at times when profits are varying significantly from year-to-year, as occurred over the GFC period, incorrect assumptions around timing can be a major source of forecast error.

Part A, of Figure 4.24, below, shows the steps undertaken to translate from GOS (economic income on a National Accounts basis) to gross operating profit/loss subject to tax (economic income on a tax basis). Part B shows how deductions and other items are subtracted, and the average tax rate is applied, to generate company tax on an income-year basis (the forecasts for which are shown in the left-hand panel of Figure 4.19, the blue bars). Part C shows how timing adjustments are applied, and government policy measures are taken into account, to generate company tax on a cash basis (the forecasts for which are shown in the right-hand panel of Figure 4.19, the red bars).

Capital Gains Tax Forecasting Model — Superannuation Funds (Figure 4.25)

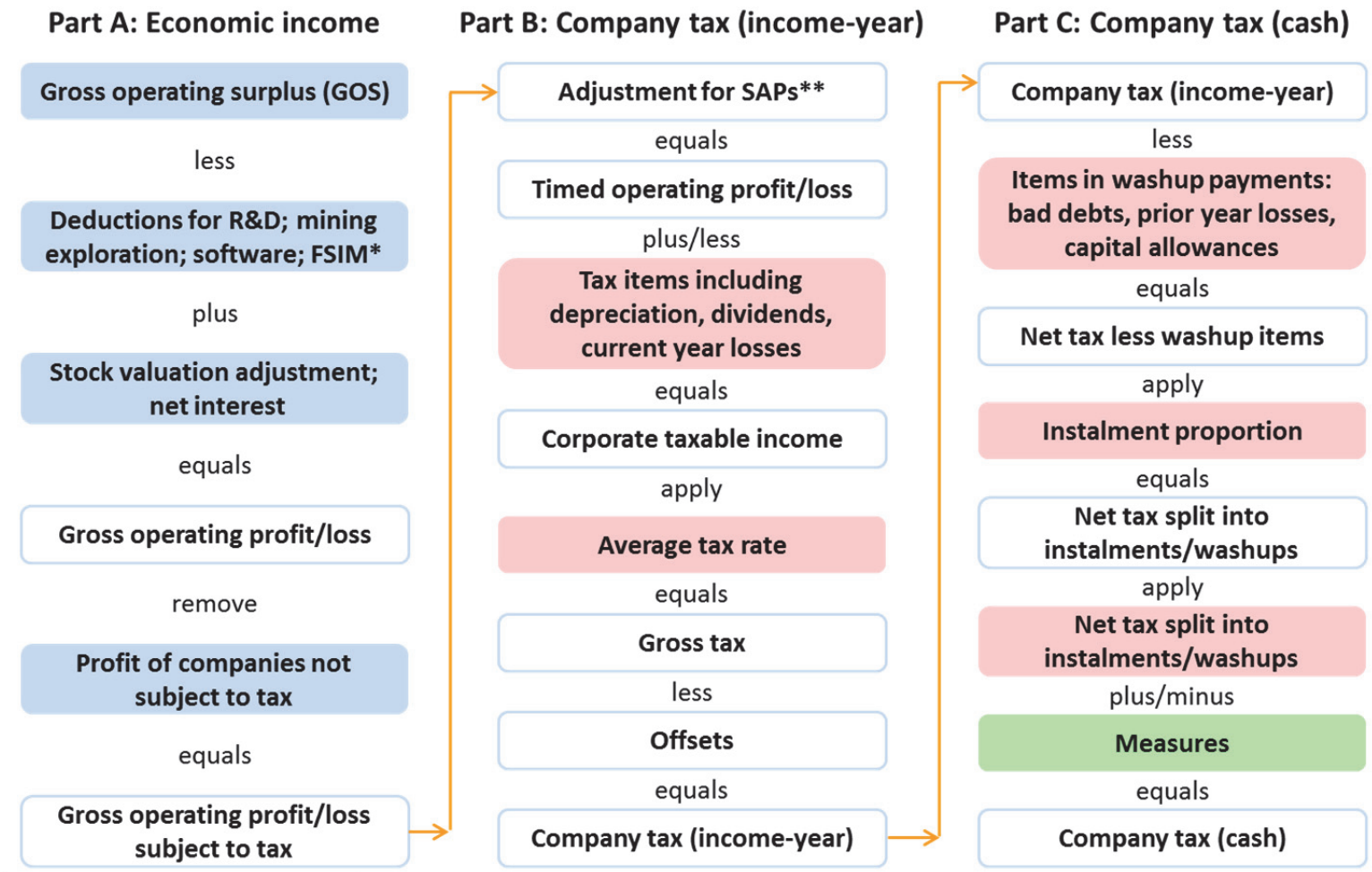
Broadly, the first step in forecasting CGT payable by superannuation funds is to estimate the stock of unrealised gains and losses, as at the end of the previous year. Unpublished APRA and ATO data are used to assist in this process. Since these data are generally released with a lag, modelled estimates of capital gains and losses are used to build the stock from the last available data point.

The second step is to forecast the current year capital gains. Unpublished APRA data is used to estimate the level and mix of assets held by superannuation funds, and data on year-to-date price movements in the ASX 200 and house prices are used to calculate asset price growth in the current year. Beyond the current year, all asset prices are assumed to grow in line with nominal GDP. Current year losses are assumed to be a certain fraction of current year gains, based on recent historical averages.

A realisation rate is then applied to the capital gains (and an application rate to the losses), to account for the fact that the assets may not be sold in the current year and that losses from previous years may be applied to the current year. The realisation rate is based on recent historical averages, unpublished data from the ATO and judgement.

The final steps are to apply the CGT discount, and then multiply the net capital gain by the effective tax rate (15 per cent in the case of superannuation funds) to calculate a CGT forecast.

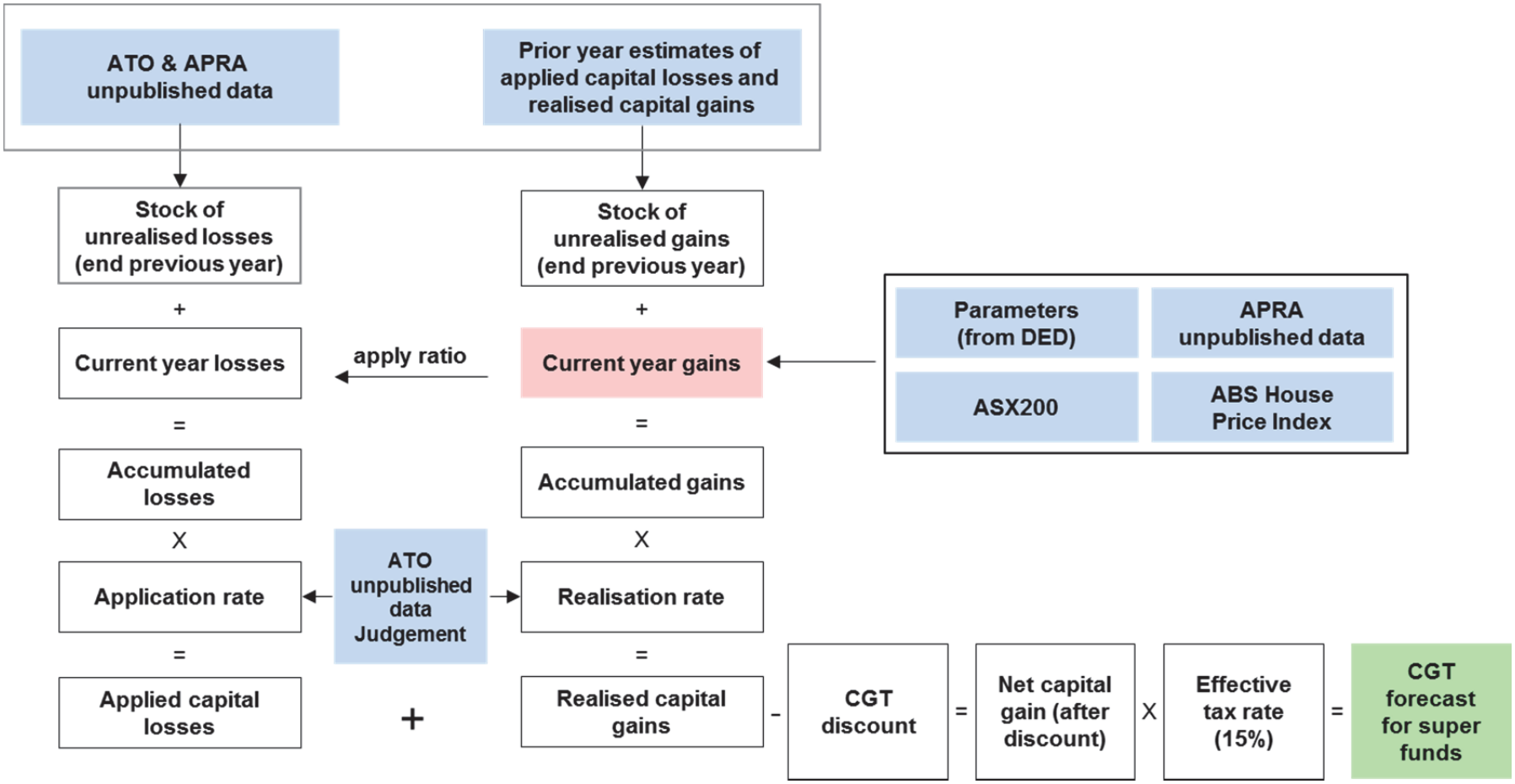
Figure 4.24: Current Company Tax Model



Key
Blue = economic parameter
Red = based on historical ATO data
Green = Treasury costings
White = calculation

Notes
*These items are not separately forecast by DED, and are generally grown in line with GOS.
**Adjustment to account for companies with Substituted Accounting Periods. For example, the 2007-08 tax data will include some companies on a 2007 calendar year accounting period, so this adjustment attempts to translate the data for all companies to a 2007-08 financial year basis.

Figure 4.25: Capital Gains Tax Forecasting Model — Superannuation Funds



ATTACHMENT A: RECOMMENDATIONS OF THE 2005 FORECASTING REVIEW

Conservative Bias in the Nominal Economy or Taxation Revenue Forecasts	
Recommendation(s) The Executive Board should provide direction as to: • whether there should be any conservative biases in Treasury's forecasts; • if so, the extent of the biases, and where they should be incorporated — in the economic or revenue forecasts (or both); and • whether any conservative bias should be made public (as with the Contingency Reserve provided for in the expense estimates).	**Implementation** The Executive Board decided to maintain longstanding practice not to incorporate conservative biases in Treasury's forecasts.
Revenue Forecasting: Taxation Data	
Recommendation(s) Treasury and the Australian Taxation Office (ATO) should review the data needed to forecast taxation revenue. These data would include:	**Implementation**
• measures-adjusted series, on a consistent accounting basis, for aggregate revenue and its associated revenue heads; and	Implemented
• complete histories of taxation return data at an aggregate level (and by industry for corporate and unincorporated taxation return data, with the industry data aggregated, where necessary, to protect the confidentiality of individual taxpayers).	Implemented
Processes should be put in place for ongoing maintenance of revenue databases, including the regular post implementation review of policy measure costings.	Implemented for revenue databases
The Executive Board should give consideration to the publishing of this revenue data for the purposes of transparency and fostering academic research.	Not implemented. Recommendation of the 2012 Review.
To implement these recommendations, a new team should be established with the aim of significantly improving the quality of the taxation revenue data. The new team would consist of about four people and be led by an EL2. In order to make significant progress, it is thought that the new team may need to be off-line for perhaps a year.	Implemented

Revenue Forecasting: Skill Sets of Revenue Forecasters	
Recommendation(s)	**Implementation**
Analysts should be swapped between the Domestic Economy Division (DED) and Tax Analysis Division (TAD) on a systematic basis, say one person per year in each direction, which, given the special circumstances, should be considered outside the bulk round process. Consideration should be given to the possibility of similar exchange arrangements (possibly on a temporary basis) between TAD and the Revenue Analysis Branch of the ATO.	There have been a number of movements of staff between DED and TAD.
TAD should commence developing a training program to improve the analytical skills of analysts, which could be implemented as the revenue data sets become available.	Implementation in progress
Revenue Forecasting: Forecasting Methodology	
Recommendation(s)	**Implementation**
Reinvigorate the parameter reviews by: • providing greater management backing to improve the quality of outcomes: • the reviews should be made formally cross group, with teams guided by a steering committee of senior managers from each group; • inviting the ATO to formally participate in the parameter reviews; and • moving staffing resources off-line to ensure that higher priority outputs do not distract analysts.	Implemented
TAD should review its revenue head models with a view to ensuring that they are consistent with the estimated longer-run elasticity of taxation revenue with respect to nominal GDP of 1.2. Consideration should also be given to incorporating short-run dynamics into these models to make them consistent with a short-run aggregate revenue elasticity of around 1.7.	Implemented
The estimated underlying aggregate revenue models should be used to benchmark Treasury's revenue forecasts. When these forecasts are put together, some weight should be placed on the predictions of the aggregate estimated models in all forecast years, but particularly for revenue forecasts in the projection years.	Implemented

Revenue Forecasting: Relationship between the Costings and Revenue Forecasting Areas	
Recommendation(s)	**Implementation**
Consideration should be given to ways to improve the interaction between the revenue forecasting and costing areas. Plans for collocation on the same floor will help and should proceed apace. One possible restructure for TAD would be along team lines, to maximise synergies between the costings and revenue forecasting functions.	
• Under this proposal, teams would be created on a head of revenue basis, with responsibility for costing of policy measures and revenue forecasts associated with that head of revenue. Teams would report to different managers tasked with responsibility for forecasting revenue and costing policy measures.	Not implemented
Revenue policy measures should be costed on a more comprehensive basis. For example, discussions with TAD indicate that it should be possible to provide costings, perhaps in the form of a range rather than a point estimate, for many measures currently deemed unquantifiable.	Not implemented
Budget Documentation: Adequacy of Budget Documentation of the Economic and Revenue Forecasts	
Recommendation(s)	**Implementation**
The Budget discussion of the economic forecasts should cover nominal GDP, and possibly include some discussion of the components of the GDP deflator and the components of nominal GDP most relevant to forecasting revenue — the taxation parameters.	Implemented
The Budget discussion of the revenue forecasts should place greater emphasis on economic and other drivers.	Implemented
• Ideally, empirical estimates of elasticities for aggregate revenue (and, if possible, for the major revenue heads) should be included in the Budget discussion, along with analysis of why revenue forecasts differ from those implied by the elasticities.	
The 2005-06 Budget Papers should include more detailed analysis of the relationship between revenue and the nominal economy, to provide an intellectual framework for subsequent years.	Implemented
The Budget, FBO and MYEFO should attempt to reconcile variations in revenue forecasts with variations in the forecast growth of the nominal economy, as well as in policy costings and other factors.	Implemented

Economic Forecasting: Allocation of Resources on Domestic Economy Forecasting	
Recommendation(s)	**Implementation**
Greater emphasis should be given to the nominal economy forecasts by senior forecasters, including adopting a more holistic approach to preparing forecasts of the real and nominal sides of the economy. This would be expected to lead to some additional investment into aspects of the nominal economy forecasts, and should include the development of an econometrically estimated equation for the GDP deflator, but need not involve significant additional resources.	Implemented. That said, the 2012 Review recommends that Treasury should invest relatively more resources in forecasting GDP deflator growth and its components, in particular, commodity prices.
Greater management backing should be provided to the parameter review process which will, as a by-product, improve the allocation of resources devoted to producing the economic parameters.	Implemented
Links between Revenue and Economic Forecasting: Communication between TAD & DED	
Recommendation(s)	**Implementation**
The General Managers of TAD and DED should consider ways to increase information flows between the two divisions through, for example, a joint seminar series.	Implemented
TAD analysts should attend relevant DED sectoral meetings and DED analysts should attend relevant discussions of revenue head forecasts.	Implemented
The JEFG Revenue Sub Committee should be given a seat at the JEFG meeting, with the contribution of the sub-committee to JEFG evolving as the understanding of the analytical relationship between revenue collections and the macro-economy improves.	Implemented
Links between Revenue and Economic Forecasting: Relationship between Treasury and the Australian Office of Financial Management	
Recommendation(s)	**Implementation**
The AOFM should be provided with a copy of revenue briefings to the Treasurer to better assist them in their function of cash management.	Implemented
Treasury should investigate whether the AOFM's transactions data sources would assist analysis.	Not Implemented
Links between Revenue and Economic Forecasting: The Integration of the Economic and Revenue Forecasts	
Recommendation(s)	**Implementation**
Senior forecasters in RAU and DED should meet prior to the finalisation of the revenue forecasts to discuss the balance and interaction of risks surrounding the economic and revenue forecasts, in order to reach a consistent treatment.	Implemented

ATTACHMENT B: FURTHER DETAIL OF MACROECONOMIC FORECASTING PRACTICES

B.1 Outline of macroeconomic forecasting timeline and public presentation

PROCESS TIMELINE	PURPOSE	GOVERNANCE
1. Business Liaison	• Provide qualitative information, inform and test judgements.	• Divisional meeting to identify key themes prior to discussions. • Divisional meeting to discuss results. • Write up of discussions. • Key findings published in Economic Roundup.
2. BOP Subcommittee Meeting	• Discuss preliminary non-rural commodity forecasts drawing on expertise of BREE and RBA liaison.	RBA, BREE, divisional executive and analysts.
3. ABS Data Meeting	• Discuss forthcoming National Accounts and recent data issues.	• ABS, divisional executive and analysts.
4. International JEFG Meeting	Discuss international forecasts.	• RBA, International divisional executive and analysts, DED representative.
5. Context Setting Meeting	• Identify key issues for the forecasting round. • Discuss technical assumptions. • Discuss the general international and domestic outlook, key drivers and risks.	• Executive Director, macroeconomic group executive, divisional analysts.
6. 1st Sector Meetings	• Broad assessment of the sectoral outlook. • Developments since last round — issues and risks. • Areas of focus and further work for the round.	• Divisional executive and analysts.
Receive National Accounts data		
7. 2nd Sector Meetings	• Discuss detailed sectoral forecasts.	• Divisional executive and analysts

8. Public Subcommittee Meeting	• Share information on the outlook for the public sector, drawing on expertise of Finance.	• Finance, ABS, RBA, divisional executive and analysts.
9. TRYM Run	• Check on the sectoral forecasts.	• Principal Technical Adviser, analysts.
10. Divisional Manager's Meeting	• Discuss and critique the forecasts, analysing changes made to sectoral forecasts.	• Divisional executive.
11. Macroeconomic Group Executive Meeting	• Discuss and critique the forecasts.	• Macroeconomic Group Executive
Draft Treasury Forecasts		
12. JEFG Meeting	• Discuss and critique the forecasts. • Compare Treasury forecasts with RBA and PM&C forecasts.	• JEFG members — RBA, Finance, PM&C, ABS and Treasury.
Final JEFG Forecasts		
13. JEFG Report	• Write up of final JEFG forecasts. Sent to JEFG participants for comment and the Treasurer for information.	• JEFG members — RBA, Finance, PM&C, ABS and Treasury.
14. Parameter Meeting	• Parameters are inputs into forecasting taxation revenue and government expenses. • This meeting presents the draft parameters to the main users, and critiques the parameters.	• Tax Analysis Division, Budget Policy Division, Finance, ATO, divisional executive and analysts.
Final Parameters		
15. JEFG Debrief		• Divisional executive and analysts.
16. Model Development Meetings		• Divisional executive and analysts

B.2 Role of the Technical Principal Adviser and model development

Treasury established a dedicated technical advising role in DED in mid-2009. The Technical Adviser is effectively DED's Chief Knowledge Officer as such is responsible for administering knowledge management practices in the division, which includes such things as:

- developing an overall framework that guides macroeconomic technical skills development and training;

- actively promoting macroeconomic technical skills development and training within and beyond the division;
- overseeing the documentation of macroeconomic forecasting developments; and
- facilitating collaboration, coordination and communication within and beyond the division.

A candidate for this Treasury role was recruited via a 'specialist round' held mid-2010. The role is currently filled by a Principal Adviser (SES Band 1) with a PhD in economics, a research track-record (including publications in top general and field journals), post-graduate teaching experience, extensive peer-review experience, and over 10 years professional experience in a policy advising/forecasting role.

The knowledge management framework developed by the Technical Adviser is purpose-built to deliver effective documentation, dissemination and development of macroeconomic knowledge. Most elements have been in place for two years. This framework has allowed DED to move its training and econometrics and modelling to leading edge practices which have been incorporated into producing the macroeconomic forecasts. One example has been the input-output analysis which disaggregates the economic forecasts into mining; mining-related; and non-mining.

Documentation

DED's knowledge management framework recognises that gaining and maintaining knowledge at both an individual and organisational level is best achieved via informative documentation that is always 'up-to-date'. DED's system aims to achieve the latter goal via 'live' documents that are easy to update using current analysis and strict adherence to a minimal style template. The required content of all supporting documentation is decided at the inception of a project by the analysts undertaking the project in collaboration with their manager and the TA. The typical document takes the form of a technical working paper with the following structure:

- introduction, including a brief review of related research;
- proposed theoretical framework;
- data analysis exploring prima facie evidence in favour of the proposed theory;
- empirical strategy (for example econometric method);
- limitations of approach;
- work yet to be done; and
- reference material, including details of data sources and computational code.

Computational programs (for example EViews and SAS) and excel files also serve as important elements of the documentation process. DED requires all computation analysis be supported by written programs. Analysts are guided in the development of these programs by exemplars/templates that specify the basic problem solving algorithm, useful syntax and required remarks/comments.

DED has also improved the accessibility of all primary and supporting documentation by organising its research files into a small set of broad subject folders that contain all current and archive research projects falling under respective subject heading. Strict version control of forecasting files is ensured by restricting development work to these research folders, which are physically distinct from the folders used in the forecasting process. Once a framework/model has been vetted it is then employed in the

forecasting process, which essentially involves a physical copy of the computational files being placed in the appropriate forecasting folder.

Dissemination

DED's knowledge management system places considerable emphasis on effective dissemination of knowledge. Working towards this end, the TA runs a series of seminar programs that discuss 'best practice' data handling, estimation and forecasting.

Graduates and new-comers to MEG who are likely to work with data and/or develop an empirical model are required to attend a four-hour session on programming in EViews, which covers a host of general data-handling and programming topics. These sessions are structured so that by the end of session attendees have constructed their own exemplars/templates for future work. The training module was developed in-house by the TA and has recently been rolled-out to the rest of Treasury as a department-wide training option.

DED spreads the ownership of forecasting model/framework knowledge and mitigates key-person risk by rotating analysts through the division's five units. In the lead up to each forecasting round rotating analysts undertake a full review of their newly inherited forecasting models/frameworks. An important component of the review is a presentation of the model/framework at the weekly MEG Macroeconomic Theory and Application Seminar (MTAS). This seminar is conducted along the lines of a weekly academic seminar program and is open to all of Treasury staff. DED attendees are expected to comment on each other's models, with the stipulation that comments must be constructive (that is suggest a solution to an identified problem). This review process ensures all forecasting models/frameworks are evaluated at least once during an annual budget cycle.

In addition to the annual review cycle, analysts working on a new framework are expected to workshop their development proposal and present their final results at the MTAS to ensure appropriate guidance, vetting and knowledge transfer.

The MTAS is also used as vehicle to deliver training on macroeconomic modelling techniques. These seminars are typically run as a series of one hour lectures by the TA with detailed lecture notes and sample data/programs provided to participants a week in advance. While the emphasis is on practical modelling tools, the seminar has also been used to deliver advance techniques widely used in the modelling of macroeconomic data for forecasting purposes such as frequency domain filtering, non-parametric econometrics and state-space/unobserved component techniques.

Development

DED's knowledge development system aims to improve the division's capability by building on the capability of individual analysts. Working towards this goal, the TA liaises with analysts, managers and division/group executives to identify gaps in DED's current or future briefing/forecasting capability. Once a gap is identified the TA works with the responsible manager and analysts on a development proposal. The TA's primary responsibility in this process is in helping to establish an analytical framework that is both feasible and defensible.

All development proposals are workshopped at a quarterly research meeting (attended by DED and MEG executives), which is held as soon as possible after the completion of a forecast round. The main purpose of the meeting is to vet proposals and where necessary to help managers prioritise tasks/projects. It is the responsibility of the manager (in their role as project manager) to defend the purpose, analytical strategy and resourcing requirements of each project at the research meeting.

All development projects given the go-ahead are supported by the following mechanisms:

- the TA meets with managers and/or analysts on a regular basis (for example weekly) to assess progress against the project plan and to help troubleshoot problems;
- the TA works with managers and/or analysts to identify training requirements. Training is typically delivered on a division-wide basis by the TA at the MTAS, with specific training needs handled on a one-on-one basis (that is TA works directly with analysts). DED's training needs have been greatly simplified by limiting analysts to a small set of best-practice analytical tools:
- xxcel for bottoms-up or one-off data analysis;
- EViews for econometric estimation and forecasting/simulation;
- MATLAB for tasks that cannot be done using Eviews; and
- the TA works with managers and/or analysts to identify opportunities to enhance DED's central database and programming knowledge.

B.3 Treasury Macroeconomic (TRYM) Model redesign

Treasury has maintained a macro-econometric model since the 1970. The first Treasury model, constructed in conjunction with the Commonwealth Bureau of Census and Statistics (forerunner of the Australian Bureau of Statistics), was the National Income Forecasting (NIF) model; presented in Higgins (1970). The NIF model went through a considerable evolution, up to NIF-10, before a revamp as NIF-88; see Higgins and Fitzgerald (1973), Treasury (1981, 1984) and Simes and Horn (1988). NIF-88 was described at the time as a medium-sized model, with 97 behavioural equations.

A new stream of modelling was commenced in Treasury around 1991. The Treasury Macroeconomic Model (TRYM) is smaller (25 estimated behavioural equations), with more emphasis on a theoretical basis for equations and their long-run properties. Most equations are specified in an error correction model format which makes a clear distinction between short- and long-run properties. Some subsets of equations were estimated as a system; Taplin et al (1993).

TRYM is effectively a one-sector, small-open-economy neoclassical growth model so the long-run growth path of the model is tied down by productivity and labour force growth assumptions. These assumptions are exogenous to the model over the forecast period, so just like the NAFF the future path of these variables is based entirely on judgement. At the same, the techniques used to estimate macro-econometric models ignore high frequency movements of the data, so model based forecasts are effectively simulations of the transition from the current cyclical deviation embodied in the data to the long-run assumed growth path.

DED has employed TRYM as a forecasting tool to varying degrees over the last 20 years. TRYM has been used primarily as a consistency check on the NAFF derived forecast. From a practical standpoint this involves running TRYM conditionally (that is imposing the NAFF forecasts for a feasible set of variables) and backing-out the adjustment factors that would be necessary for the model to generate the imposed path. Large adjustment factors suggest strong disagreement between the TRYM and NAFF.

A review of the TRYM forecasting process conducted by DED's TA in mid-2010 identified fundamental differences in TRYM and NAFF frameworks:

- in TRYM productivity is exogenous while in the NAFF productivity is endogenous, which led to large and persistent residuals in labour demand (employment), GDP deflator and capital demand (investment equations) over the forecast/projection period; and

- owing to the cumbersome TSP programming environment used to simulate TRYM as well as its aggregate nature, many NAFF variables used in conditional forecasting runs were inconsistent with the TRYM definition.

Following the review DED, in collaboration with MMD, has undertaken a major redesign of TRYM with a view to simplifying the computational environment and harmonising the data and assumptions used in the NAFF and TRYM. This work has progressed along a number of dimensions:

- the existing TSP based estimation and simulation approaches have been transferred to a more user-friendly EViews platform;

- all data construction methods have been reviewed to ensure full knowledge of the source of all historic data and consistency with NAFF definitions;

- to avoid wasting precious model development resources to maintaining out-dated data and analytical frameworks, Treasury has terminated the public release of TRYM and its associated database via the ABS;

- a joint DED-ABS working group has been established to (1) transfer the ownership to the ABS of numerous variables currently constructed/inferred by Treasury for macro modelling purposes using ABS data and (2) regular peer-review Treasury macro modelling/data assumptions; and

- sectoral analysts in DED are responsible for the development and maintenance of TRYM's structural behavioural equations.

ATTACHMENT C: FURTHER DETAIL OF REVENUE FORECASTING PRACTICES

C.1. Relationships between revenue and economic areas

Revenue forecasts in the Treasury are produced by Revenue Analysis Unit (RAU), which is part of Tax Analysis Division. RAU is a unit of around 10 analysts. Economic forecasts in the Treasury are produced by Domestic Economy Division (DED), which has over 30 analysts.

The greater size of DED partly reflects the larger number of forecast variables that DED are required to produce, and the task of interpreting the numerous available sources of information on the economy (such as ABS data, business liaison and partial indicators). In addition, the briefing requirements are more significant, as DED is required to brief the government on all major economic releases and to prepare presentations for senior Treasury officials and the Treasurer on economic issues.

Relationship between RAU and DED

It is important to maintain good relationships and knowledge transfer between the economic and revenue forecasting areas of the Treasury. DED provides the economic parameter forecasts which feed into RAU's head of revenue mapping models (discussed later in this Attachment), so it is crucial that RAU understands the conceptual scope of the economic parameters and how the parameter forecasts have been derived. RAU receives information on tax collections from the ATO, which provides an alternative perspective on the nominal economy that is generally more up-to-date than the official National Accounts data, and so it is important that DED receives and understands this information.

The 2005 Review highlighted scope to improve the information flows and knowledge transfer between the economic and revenue forecasting areas within Treasury. Several process improvements have been made as a result of this Review, and these are briefly outlined below.

During the major forecasting periods RAU and DED regularly meet to discuss recent developments in the economy and revenue. In particular, as part of the Budget and MYEFO rounds, there is now a formal economic parameter meeting at which DED presents the draft parameters to the main users (RAU, Budget Policy Division, Finance and the ATO), giving RAU an opportunity to critique the economic parameters before they are finalised. Analysts from RAU now also attend the DED second sector meetings, at which detailed sectoral forecasts are discussed, in order to provide RAU with a greater understanding of the factors driving the economic parameter forecasts. The manager of RAU now also attends the Joint Economic Forecasting Group (JEFG) meeting, at which the economic forecasts are discussed and critiqued by participants including the Reserve Bank of Australia, the Department of Finance, the Department of Prime Minister and Cabinet and the Australian Bureau of Statistics.

DED and RAU now also work more closely together to identify and explore areas where the economic parameters and revenue collections appear misaligned. For example, during the global financial crisis, the economic parameter for consumption subject to GST continued to grow strongly, while actual GST collections received by the ATO were very weak. DED and RAU worked together to explore possible reasons for the misalignment, to reach a common view on what the data were signalling about the nominal economy.

Written information is now also exchanged more frequently between the two areas. DED's economic notes on major data releases are now circulated to RAU, and RAU now produces revenue notes on recent ATO tax collections data which are circulated to DED (and within Tax Analysis Division).

Another recommendation of the 2005 Review was to encourage greater transfer of analysts between DED and RAU, in order to share knowledge and skills. Whilst it was decided not to institute a formal transfer program, internal transfers between the two areas are encouraged, and around ten current Treasury employees have worked across both areas during their careers.

Relationship between RAU and the Australian Taxation Office

The Australian Tax Office (ATO) is an important source of information for RAU. The two major sources of data RAU receives from the ATO are:

- taxation statistics — official data on previous year's tax collections, released with a lag of close to two years in order to capture the majority of tax lodgements (the latest Taxation Statistics for 2009-10 was released in March 2012); and

- current tax collections — confidential data on recent tax collections, provided with a lag of as little as a few days. These are taken from sources including income tax returns, Business Activity Statements and excise clearances.

The ATO also assists RAU with technical information around areas such as:

- understanding the scope of the taxable income bases;

- understanding the tax payments system, including issues such as timing of payments, treatment of tax debts and tax collections;

- information on the likely impact of recent tax law court cases on tax collections;

- information on ATO compliance activities; and

- information from ATO liaison with major companies.

RAU consults with the ATO frequently both during and outside the major forecasting periods, in order to gather this information and to exchange views on the likely outlook for tax revenue. A formal revenue conference is also held in each of the two major forecasting rounds between RAU, the ATO and the Australian Customs and Border Protection Service (Customs), in order to critique RAU's preliminary revenue forecasts.

C.2. Revenue forecasting process and governance

Table C.2 provides a stylised timeline for the typical revenue forecasting process during a Budget forecasting round.

Table C.2: Revenue Forecasting Timeline for a Budget Round

TIMELINE	PURPOSE	GOVERNANCE
1. Prepare updated revenue forecasts for ERC	• Prepare updated revenue forecasts to guide discussion at the Expenditure Review Committee • Updates are generated by applying a 'rule of thumb' to the MYEFO revenue forecasts, based on economic and taxation data and policy decisions since this time.	• Tax Analysis Division executive and analysts.
Expenditure Review Committee		
2. Model preparation	• Assess model structure and performance prior to receiving Budget round inputs. • Prepare models to receive new data inputs.	• Revenue Analysis Unit executive and analysts.
Receive draft Budget parameters		
3. Parameter Meeting	• Domestic Economy Division presents the draft Budget parameters to the main users, including RAU, who critique the parameters.	• Domestic Economy Division, Budget Policy Division, Finance, ATO, Revenue Analysis Unit executive and analysts.
Receive final Budget parameters. Generate preliminary revenue forecasts.		
4. Forecast assessment meetings	• Discuss and critique the preliminary revenue forecasts.	• Revenue Analysis Unit executive and analysts.
5. Revenue Conferences	• Discuss and critique the preliminary revenue forecasts.	• ATO, Customs, Revenue Analysis Unit executive and analysts.
Baseline revenue forecasts		
6. Manager's meeting	• Discuss and critique the baseline revenue forecasts.	• Tax Analysis Division executive.
7. Incorporate new measures and parameter variations	• Incorporate the impact of any late stage Government policy measures on the revenue forecasts. • Incorporate the impact of any late release data on the revenue forecasts, for example the Consumer Price Index.	• Domestic Economy Division, Tax Analysis Division executive and analysts.
Final revenue forecasts		
8. Post-Budget assessment	• Discuss issues which arose during the Budget process and actions which need to be taken.	• Revenue Analysis Unit executive and analysts.

C.3. Head of revenue mapping models

The table below shows the main head of revenue mapping models used by RAU. It details: the head of revenue; the conceptual taxable income base (that is the income base upon which the tax is actually levied); the associated economic parameter(s) provided by DED to RAU and which feed into the revenue forecasts; whether there are significant timing issues involved in translating the accrual revenue forecasts into cash receipts forecasts; and the broad forecasting methodology used in the mapping model.

Table C.3: Head of revenue Mapping Models

Head of revenue	Conceptual taxable income base	Associated economic parameter(s)	Significant timing issues?*	Broad forecasting methodology
Income Tax Withholding	The income derived from work by wage and salary earners	Compensation of employees (wages)	No	Econometric model where income tax withholding is forecast using the parameter and a progressivity factor.
Other Individuals	Personal income items (that is interest, dividends, capital gains) excluding salary and wages	Gross mixed income; other business income; and property income parameters	Yes	Map the relevant parameter growth rate directly to tax return item growth rate for each individual item, and then aggregate.
Fringe Benefits Tax	The taxable value of non-cash benefits provided to employees	Compensation of employees (wages)	No	Map parameter growth rate directly to revenue growth rate.
Super funds	Super fund contributions and super fund earnings on investments.	Compensation of employees (wages); and Nominal GDP growth	Yes	For super fund contributions, map the parameter growth rate (wages) directly to tax return item growth rate. For super fund earnings, map the parameter growth rate (nominal GDP) directly to asset price growth rate. Assumptions are made about realisation rates of capital gains and losses.
Companies	Taxable profit of the corporate sector	Gross Operating Surplus	Yes	For most items, map parameter growth rates directly to tax return item growth rates. For some items such as foreign income, apply recent historical trends.
PRRT	Taxable profit on petroleum production	Exchange rate; commodity prices.	Yes	Map parameter growth rate directly to revenue growth rate.

Head of revenue	Conceptual taxable income base	Associated economic parameter(s)	Significant timing issues?*	Broad forecasting methodology
GST	Taxable consumption and dwelling investment and associated ownership transfer costs (for example real estate agent fees)	Dwelling investment; consumption subject to GST; and ownership transfer costs	No	Map an aggregated parameter growth rate directly to revenue growth rate.
Alcohol Excise and Customs	Commercial alcohol production and importation	The volume of private consumption of alcohol	No	Map parameter growth rate directly to revenue growth rate.
Tobacco Excise and Customs	Tobacco production and importation	The volume of private consumption of cigarettes	No	Map parameter growth rate directly to revenue growth rate.
Fuel Excise	Fuel production and importation	The volume of private consumption of automotive fuel; real GDP (for diesel)	No	Map the relevant parameter growth rate directly to revenue growth rate for each individual item, and then aggregate.
Luxury Car Tax	The value of luxury cars	The value of total motor vehicle sales (cars & station wagons)	No	Map parameter growth rate directly to revenue growth rate.
Capital Gains Tax	Realised changes in the value of assets (which are subject to CGT)	Nominal GDP growth	No	Map parameter growth rate directly to asset price growth rate. Assumptions are made about realisation rates of capital gains and losses.

* If there are 'significant timing issues' it is necessary to significantly adjust the accrual tax revenue forecasts, to generate tax receipts forecasts on a cash basis.

ATTACHMENT D: MACROECONOMIC FORECASTING PERFORMANCE

This attachment extends the analysis in Section 3 of the performance of Treasury's macroeconomic forecasts over the past two decades.

Choice of ABS data benchmark: first published or most recent outcomes

A summary of Treasury's forecasting performance for forecasts of year-average nominal GDP growth against the first-published outcomes and estimates of the most recent, outcomes (the June quarter 2012 National Accounts) are shown in Tables D.1 and D.2 respectively.[1]

Table D.1: Performance of nominal GDP growth forecasts against first published outcomes

	1990-91 to 2011-12		1990-91 to 1993-94		1994-95 to 2002-03		2003-04 to 2007-08		2008-09 to 2011-12	
	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points
All forecast rounds	0.1	1.2	2.2	2.2	0.1	0.7	-1.0	1.1	-0.3	1.4
Budget (a)	0.3	1.7	3.5	3.5	0.1	0.9	-1.4	1.4	-0.6	2.2
MYEFO (b)	0.3	1.4	2.7	2.7	-0.1	0.9	-0.9	0.9	0.1	1.5

(a) March forecast round for the financial year starting in the July of the same year. Budget forecast from 1996-97.
(b) September forecast round for the financial year which started two months earlier. MYEFO forecast from 1998-99.

Table D.2: Performance of nominal GDP growth forecasts against most recent estimated outcomes

	1990-91 to 2011-12		1990-91 to 1993-94		1994-95 to 2002-03		2003-04 to 2007-08		2008-09 to 2011-12	
	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points
All forecast rounds	-0.3	1.2	1.4	1.7	-0.3	0.7	-1.5	1.5	-0.2	1.3
Budget (a)	-0.1	1.6	2.7	2.7	-0.2	0.8	-1.8	1.8	-0.2	2.2
MYEFO (b)	0.0	1.3	2.0	2.0	-0.4	1.0	-1.3	1.3	0.5	1.5

(a) March forecast round for the financial year starting in the July of the same year. Budget forecast from 1996-97.
(b) September forecast round for the financial year which started two months earlier. MYEFO forecast from 1998-99.

The mean error in the forecasts depends importantly on whether the forecasts are compared with the first-published outcomes or with the most recent estimated outcomes. On average over the full sample, Treasury's nominal GDP growth forecasts are broadly in line with the first-published outcomes, but around ¼ of a percentage point lower than the most recent estimated outcomes. The differences arise because the ABS has revised up estimated year-average nominal GDP growth outcomes over time, largely due to upward revisions to growth in real GDP, rather than the GDP deflator.

All subsequent tables and charts compare the economic forecasts with the most recent estimated outcomes. This is for two reasons. Firstly, the most recent estimated outcomes presumably represent the ABS's current best estimates of the true outcomes. And, secondly, Treasury's revenue mapping models use the most recent estimates of the nominal economy in order to forecast tax revenue.[2]

Terms of trade

Treasury's forecasting performance for growth in the terms of trade against the most recent estimated outcomes is shown in Table D.3 and Figure D.1.

1 The June quarter 2012 release was the most recent data when the analysis in this attachment was prepared.
2 One disadvantage of this approach is that ABS revisions can reflect changes in the definitions of series, including as the result of the adoption of the latest international benchmarks for national accounting statistics.

The large size of the absolute errors in Treasury's forecasts of the terms of trade is a reflection of the difficulty in forecasting commodity prices. The forecasts have tended to underestimate growth in the terms of trade since the early years of the 2000s, and particularly during the first mining boom. The absolute error has been largest over the period post the GFC, reflecting heightened volatility in global prices of coal and iron ore.

Table D.3: Performance of terms of trade growth forecasts

	1990-91 to 2011-12		1990-91 to 1993-94		1994-95 to 2002-03		2003-04 to 2007-08		2008-09 to 2011-12	
	Mean error	MAPE	Mean error	MAPE	Mean error	MAPE	Mean error	MAPE	Mean error	MAPE
	% points	% points	% points	% points	% points	% points	% points	% points	% points	% points
All forecast rounds	-1.1	2.7	1.2	1.8	0.3	1.7	-3.8	3.9	-3.0	5.0
Budget (a)	-1.2	3.9	1.4	2.9	0.0	2.5	-4.7	5.2	-2.4	6.4
MYEFO (b)	-0.7	2.3	1.8	1.9	0.1	1.5	-3.3	3.3	-2.0	3.5

(a) March forecast round for the financial year starting in the July of the same year. Budget forecast from 1996-97.
(b) September forecast round for the financial year which started two months earlier. MYEFO forecast from 1998-99.

Figure D.1: Evolution of terms of trade growth forecasts

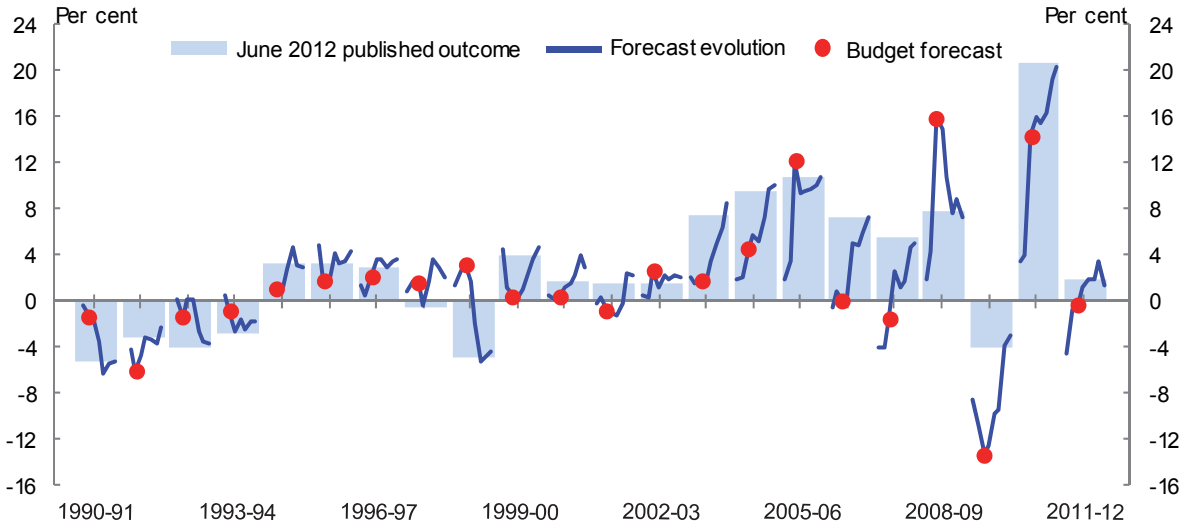


Figure D.1 suggests that the direction of change in the terms of trade is usually forecast correctly, although the size of the change has been typically underestimated.

Correlation of the forecast errors

As nominal GDP is the product of real GDP and the GDP deflator, a strong positive correlation between nominal GDP and these two components should be observed.[3]

Table D.4 shows correlation coefficients between Budget forecast errors for nominal GDP growth and a selection of its main components over the period 1996-97 to 2011-12. For each variable, the forecast error is the difference between the Budget forecast and its estimated outcome from the June quarter 2012 National Accounts release.

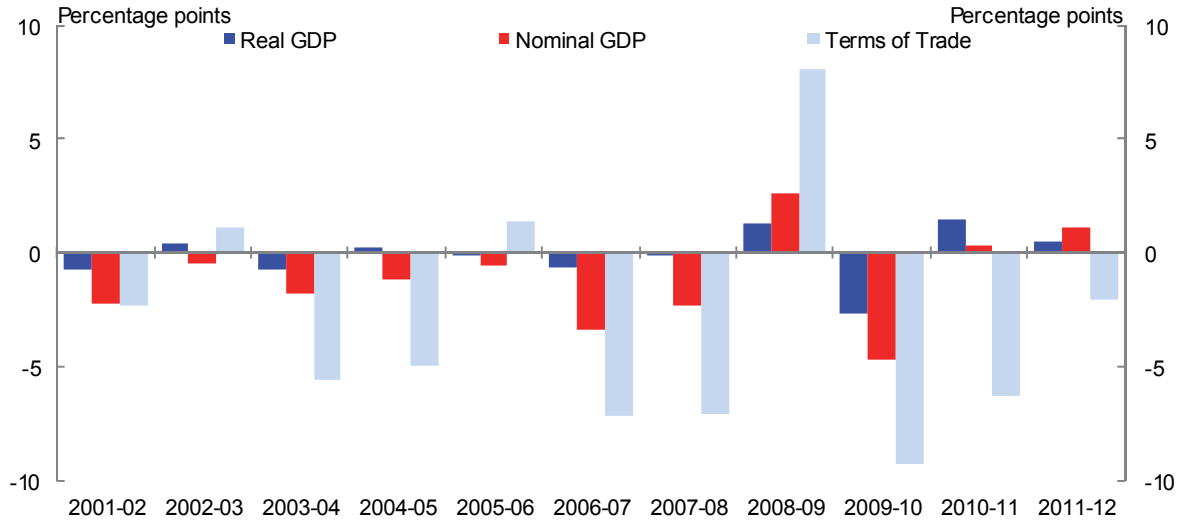
3 The correlation between nominal GDP and real GDP is fairly straightforward. In the absence of price changes, a rise in real GDP leads to a rise in nominal GDP. As a result, positive (or negative) forecast errors in real GDP are correlated with positive (or negative) forecast errors in nominal GDP. Similarly, in the absence of any changes to real output, a positive shock to prices will lead to a positive shock to nominal GDP.

Table D.4: Correlation coefficients between Budget forecast errors, 1996-97 to 2011-12

	Nominal GDP	Real GDP	GDP deflator	Consumption deflator	Terms of trade
Nominal GDP	1.0				
Real GDP	0.6	1.0			
GDP deflator	0.8	-0.1	1.0		
Household consumption deflator	0.6	0.0	0.7	1.0	
Terms of trade	0.8	0.2	0.8	0.5	1.0

Consistent with expectations, the correlations found in Table D.4 indicate nominal GDP growth forecast errors are strongly correlated with price growth forecast errors (growth in the GDP deflator and the terms of trade) and, to a lesser extent, real GDP growth forecast errors. Figure D.2 summarises the forecast errors for nominal and real GDP and the terms of trade.

Figure D.2: Summary of Treasury Forecast Errors



Expenditure components of real GDP

Treasury adopts a sectoral team based approach to forecasting, with aggregate GDP forecasts built from components of the expenditure measure of GDP. The relative volatility of the various expenditure components makes some expenditure components easier to forecast than others. For example.

Figure D.3 illustrates the volatility of annual dwelling and business investment growth compared with the relative stability of household consumption growth.

Figure D.3: Growth in Household Consumption, Dwelling and business Investment

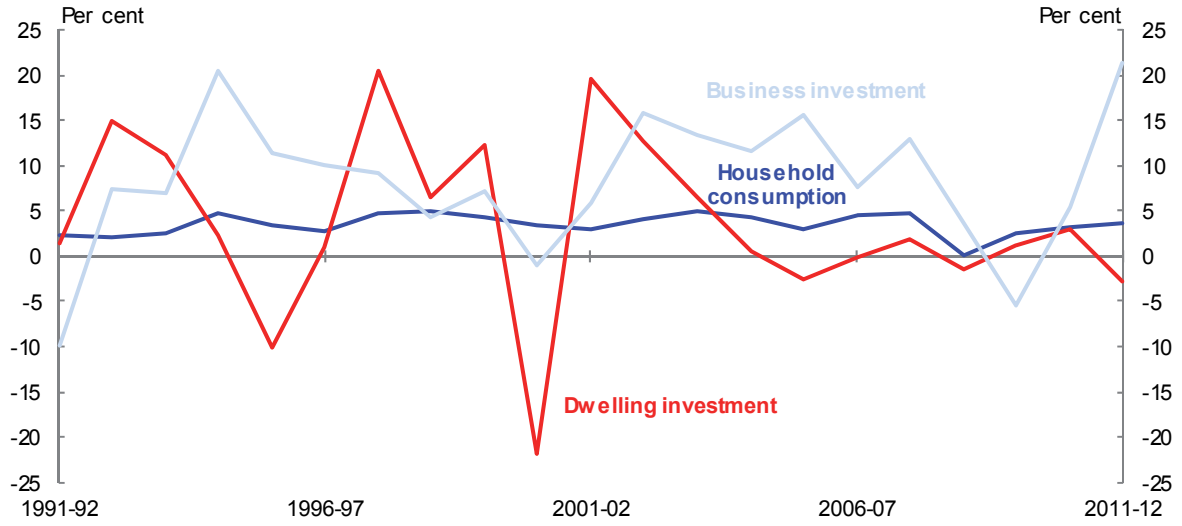


Table D.5 below shows the mean error and mean absolute percentage error (MAPE), standard deviation, and share of the economy (relative importance) of the components of GDP(E) over the period 1998-99 to 2011-12. As expected, forecasts for the most volatile expenditure series tend to have the largest forecast error. The results also indicate that Treasury has been too optimistic forecasting exports growth and too pessimistic forecasting business investment growth and correspondingly imports growth.

Table D.5: Performance of GDP expenditure component forecasts (1998-99 to 2011-12, all forecast rounds)

	Mean error % points	MAPE % points	Standard deviation of series(a)	Share of economy(b) %
Household Consumption	-0.1	0.8	1.3	56
Public Final Demand	-0.2	0.9	1.6	19
Exports	1.2	2.7	5.7	20
Imports	-1.1	3.5	3.0	-21
Business Investment	-2.4	4.7	8.1	15
Dwelling Investment	-0.5	4.9	9.6	6
GDP	-0.1	0.7	1.0	100

(a)Standard deviation of series growth rates, from 1998-99 to 2011-12
(b)Average share of economy, from 1998-99 to 2011-12

Income components of GDP

To provide macroeconomic series for forecasting tax revenue, it is necessary to split nominal GDP into its various income components, in particular, compensation of employees, profits earned by companies, and profits earned by unincorporated businesses.

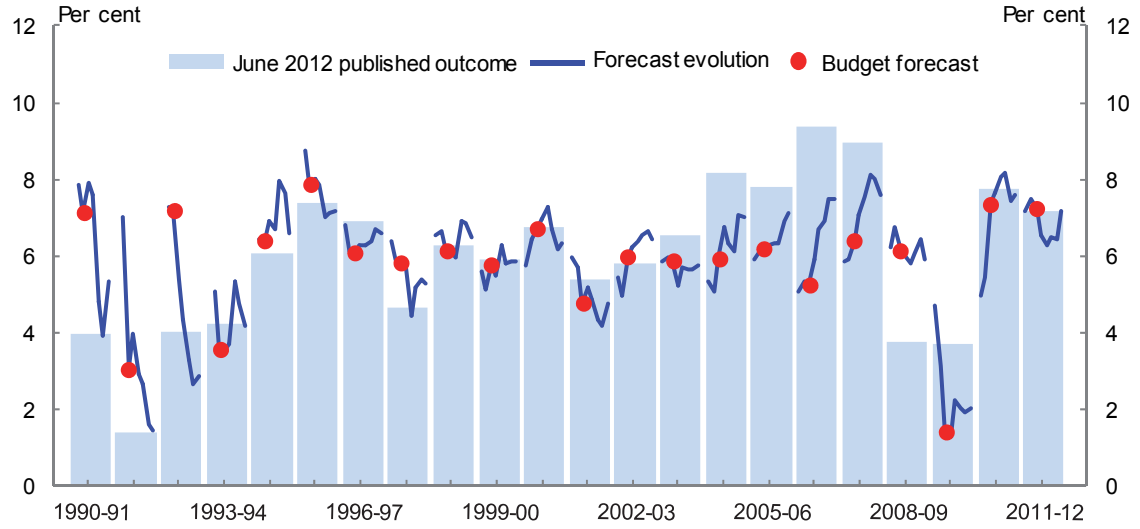
The largest income component is compensation of employees, which measures wages and other payments made to employees. Table D.6 and Figure D.4 show Treasury's forecasting performance for this series. The forecasts show the same pattern of overestimation common to the forecasts of nominal GDP growth in the early years of the forecasts. Forecast accuracy improved considerably after 1994-95, before deteriorating again during Mining Boom Mark I and then improving again over the post-GFC period.

Table D.6: Performance of forecasts of growth in compensation of employees against most recent estimated outcomes

	1990-91 to 2011-12		1990-91 to 1993-94		1994-95 to 2002-03		2003-04 to 2007-08		2008-09 to 2011-12	
	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points
All forecast rounds	-0.2	1.2	1.3	1.6	0.1	0.5	-1.8	1.8	0.0	1.4
Budget (a)	-0.2	1.3	1.9	2.2	0.1	0.4	-2.2	2.2	0.0	1.3
MYEFO (b)	-0.1	1.1	1.3	1.5	0.1	0.5	-1.7	1.7	0.0	1.2

(a) March forecast round for the financial year starting in the July of the same year. Budget forecast from 1996-97.
(b) September forecast round for the financial year which started two months earlier. MYEFO forecast from 1998-99.

Figure D.4: Evolution of compensation of employee's growth forecasts



Errors in nominal GDP growth forecasts that are not reflected in forecast errors of growth in compensation of employees manifest themselves in forecast errors of growth in the other components of income, in particular gross operating surplus and gross mixed income. Growth in compensation of employees is relatively more stable than growth in either gross operating surplus or gross mixed income.

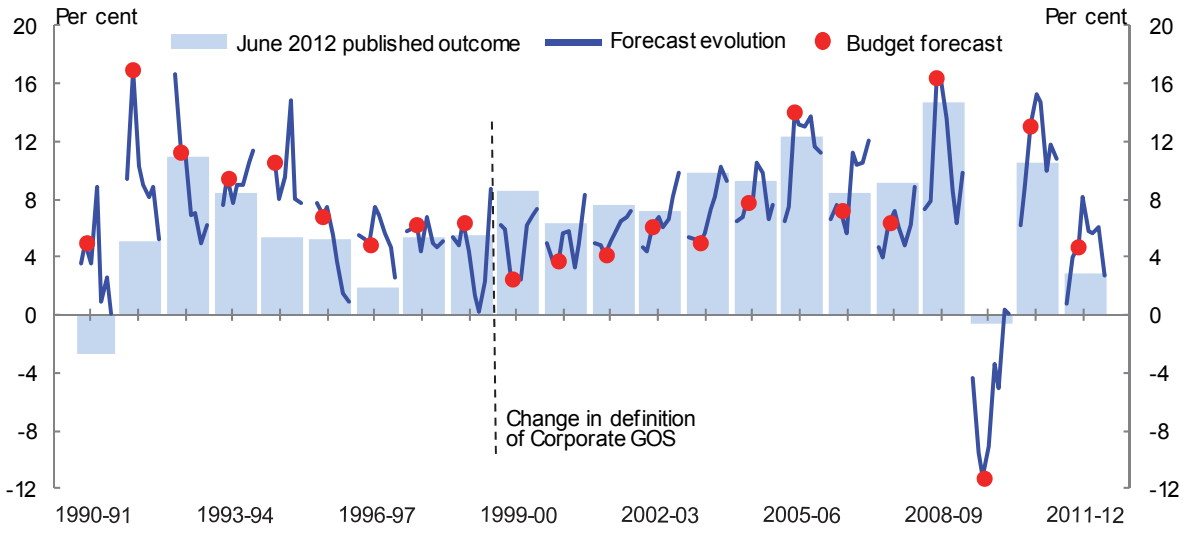
Table D.7 and Figure D.5 shows the forecasting performance for corporate gross operating surplus (GOS), which is the sum of GOS for non-financial private companies, financial private companies and public trading enterprises.

Table D.7: Performance of forecasts for growth in corporate GOS against most recent estimated outcomes

	1990-91 to 2011-12		1990-91 to 1993-94		1994-95 to 2002-03		2003-04 to 2007-08		2008-09 to 2011-12	
	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points
All forecast rounds	-0.3	2.9	2.4	3.9	-0.1	2.5	-1.5	2.4	-1.5	3.9
Budget (a)	0.3	3.4	5.2	5.2	-0.2	2.7	-1.7	2.4	-1.1	4.2
MYEFO (b)	0.5	3.0	2.9	4.9	-0.3	2.8	-0.2	2.0	0.8	2.7

(a) March forecast round for the financial year starting in the July of the same year. Budget forecast from 1996-97.
(b) September forecast round for the financial year which started two months earlier. MYEFO forecast from 1998-99.

Figure D.5: Evolution of corporate GOS growth forecasts



Note: The definition for private financial corporation gross operating surplus was changed from the 1998-99 national accounts onwards, creating a break in series that forecasts cannot be compared across.

Over the past 22 years, Treasury has underestimated corporate gross operating profits on average by around ¼ of a percentage point when compared with recent published outcomes, with a mean absolute percentage error of around 3 percentage points. The size of the underestimation has increased since the start of Mining Boom Mark I. Over the post-GFC period, the negative bias has fallen slightly; however, there has been a continued increase in the mean absolute percentage error, which largely reflects the very large forecast error in 2009-10.

Serial correlation of aggregate forecasts

Revisions to Treasury's forecasts do not display serial correlation. As Table D.8 shows, the average serial correlations of revisions to the forecast aggregates are close to zero across the full sample period. This indicates that the revisions to Treasury's forecasts are unpredictable. In other words, revisions to Treasury forecasts between rounds occur as a result of (completely) incorporating new information.

Table D.8: Serial correlation of forecast revisions (1990-91 to 2011-12)

	1990-91 to 2011-12	1990-91 to 1993-94	1994-95 to 2002-03	2003-04 to 2007-08	2008-09 to 2011-12
Nominal GDP	0.0	-0.2	-0.1	-0.1	0.4
Real GDP	0.0	0.2	-0.2	-0.1	0.1
GDP deflator	-0.1	-0.5	0.0	0.0	0.2
Terms of trade	0.0	-0.1	0.1	-0.1	0.1

Identifying directional changes in forecasts

Table D.9 summarises Treasury's performance in correctly identifying accelerating (decelerating) year-on-year growth for the key economic aggregates. Acceleration (or deceleration) in growth is defined as a year-on-year change in growth in excess of ½ of a percentage point.

The results in Table D.9 indicate that Treasury is generally successful in identifying the direction of changes in the key aggregate forecasts. With the exception of the GDP deflator (where forecasts have been less accurate), changes in growth have been correctly predicted around 60 to 75 per cent of the time over the past 20 years.

Table D.9: Correctly predict acceleration (1992-93 to 2011-12)

	Actual rate of acceleration (deceleration)	Predicted share of acceleration (deceleration)	Percentage correctly predicted
Nominal GDP	55	55	60
Real GDP	65	75	70
GDP deflator	60	80	40
Terms of trade	80	95	75

ATTACHMENT E: REVENUE FORECASTING PERFORMANCE

E.1: Revenue Forecasting Performance

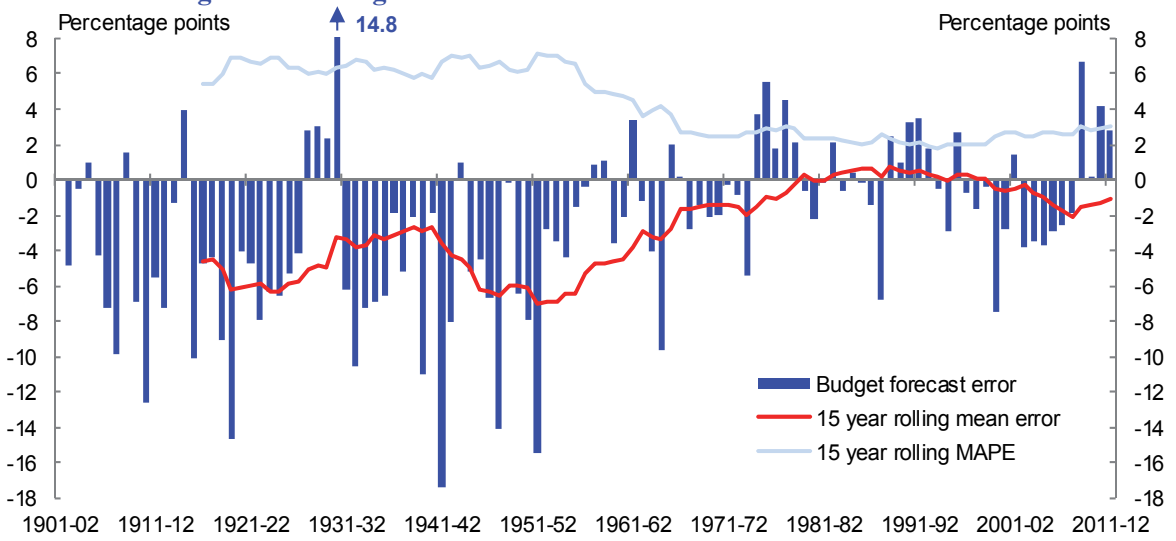
Introduction

This attachment extends the analysis in Section 3 of the performance of Treasury's forecasts of tax revenue. It first looks briefly over the entire revenue forecasting history since Federation (110 years) for general trends in forecasting performance. It then takes a more detailed look at the revenue forecasting performance over the past two decades, consistent with the time period chosen for the analysis of the economic forecasting performance.

Long run analysis (1901-02 to 2011-12)

Figure E.1 below shows the forecast error (f* — f) for each Budget forecast of total revenue since 1901-02 (the bars), as well as the 15-year rolling mean absolute percentage error (MAPE, the light blue line) and the 15-year rolling mean error (the red line).[1]

Figure E.1: Budget Forecast Errors For Growth In Total Revenue



As can be seen from Figure E.1, the forecasts have become more accurate (lower MAPE) and less biased (smaller mean error) over the second half of the past century. The rolling average MAPE has fallen from around 7 percentage points to around 2 percentage points, indicating a substantial improvement in accuracy. The MAPE has risen again to around 3 percentage points in recent years, with the 2008-09 Budget forecast for 2008-09 being particularly inaccurate, overstating actual revenue by around 7 percentage points, the largest overstatement since 1930-31. This forecast was made before the GFC, which had a very significant negative impact on tax revenue in 2008-09. The issues surrounding revenue forecasting during the GFC are discussed in more detail in Section 4 of this report.

In terms of bias, the forecasts were on average nearly 5 percentage points below the actual outcomes up until the start of the 1960's, indicating a conservative tendency to significantly underestimate government revenue. Since the 1960's, the forecasts have shown only a slight conservative bias, underestimating revenue by ½ of a percentage point on average.

1 Total revenue includes both tax and non-tax revenue (for example, government revenue from dividends and sales of goods and services), whereas the rest of this report only considers tax revenue. Data for tax revenue has not been collated separately from non-tax revenue for some of the very early Budget documents.

Recent Revenue Forecasting Performance

A summary of Treasury's performance over the past two decades for forecasts of tax revenue against Final Budget Outcomes[2] are shown in Tables E.1 and E.2. A comparison of Treasury forecasts with those of Access Economics, as well as those of official agencies overseas, is presented below.

Table E.1: Performance of forecasts of growth in tax revenue against Final Budget Outcomes (percentage points)

	1990-91 to 2011-12		1990-91 to 1993-94		1994-95 to 2002-03		2003-04 to 2007-08		2008-09 to 2011-12	
	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points
All forecasts	-0.3	1.8	0.9	1.3	-1.1	1.6	-1.7	1.8	2.2	2.5
Budget forecasts (a)	-0.1	2.7	1.7	2.6	-1.2	2.0	-2.9	2.9	4.0	4.0
MYEFO forecasts (b)	N/A	N/A	N/A	N/A	-1.5	1.8	-1.9	1.9	2.8	3.0
Within year forecasts (c)	-0.4	0.6	0.0	0.0	-0.7	0.9	-0.4	0.5	-0.2	0.5

(a) Budget forecast for the financial year which starts in July (two months later). In 1990-91 to 1993-94 and 1996-97 the Budget was published in August and so it is the Budget forecast for the financial year which had started one month earlier.
(b) MYEFO forecast for the financial year which started in July (four months earlier). Available from 1996-97.
(c) Budget forecast for the financial year which started the previous July (ten months earlier). In 1990-91 to 1993-94 and 1996-97 the Budget was published in August and so it is the Final Budget Outcome.

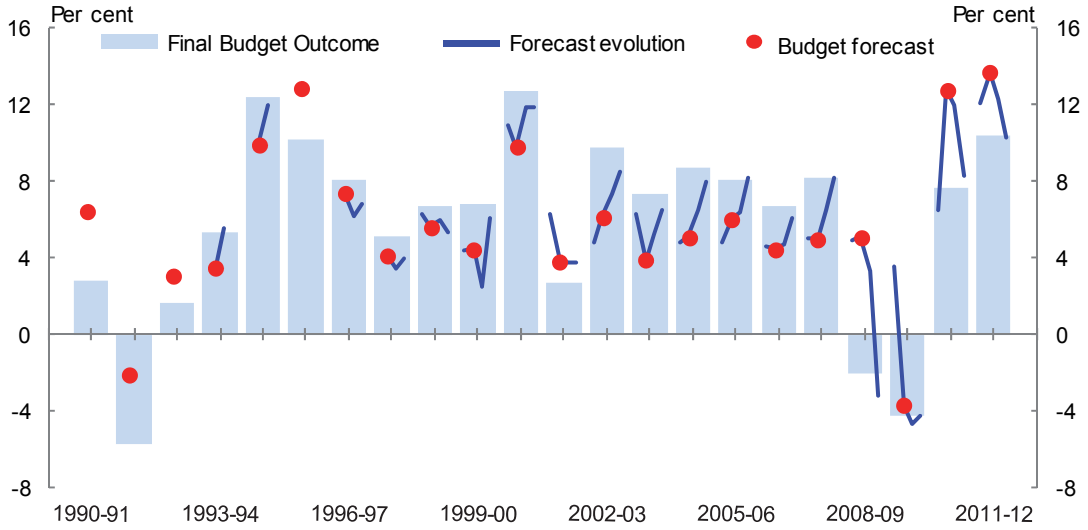
As would be expected, the accuracy of the forecasts generally improves as the forecast horizon shortens. The MAPE for Budget forecasts of the coming financial year (made two months prior to the start of the relevant financial year) is 2.7 percentage points. In contrast, the MAPE for Budget forecasts of the current financial year (made around ten months after the start of the relevant financial year) is 0.6 of a percentage point. This is due to the fact that more accurate information on revenue and economic activity becomes available as the forecast horizon shortens.

Over the full sample, Treasury's forecasts of tax revenue growth have only a minor negative bias, being on average only 0.3 of a percentage point below the outcomes. This figure has not been found to be statistically different from zero. However, within the sample there are two time periods during which tax revenue was generally overestimated — the early 1990's recession, and the recent period since the GFC — and one phase during which tax revenue was generally underestimated — the period of continuous economic expansion from 1994-95 to 2007-08.

Figure E.2 below shows the evolution of Treasury's forecasts for taxation revenue growth over the past 22 years, and the Final Budget Outcomes.

2 The Final Budget Outcome is the first published outcome for the relevant year – for example, the Final Budget Outcome for 1998-99 was published in September 1999. First published outcomes are used rather than most recent published outcomes because changes to the definition of tax revenue over time can alter the historical growth rates. For example, the first published outcome for tax revenue growth in 1998-99 was 6.8 per cent, but the most recent published outcome is 5.7 per cent due to certain fees and fines being reclassified from tax to non-tax revenue.

Figure E.2: Evolution of Taxation Revenue Forecasts



Moving from annual growth rates to levels of annual revenue in dollars (Table E.2), Treasury's taxation revenue forecasts are, on average, $1.1 billion below Final Budget Outcomes (or 0.4 per cent of total 2011-12 tax revenue) while the Budget forecasts are, on average, $0.4 billion below outcomes (or 0.1 per cent of total 2011-12 tax revenue).

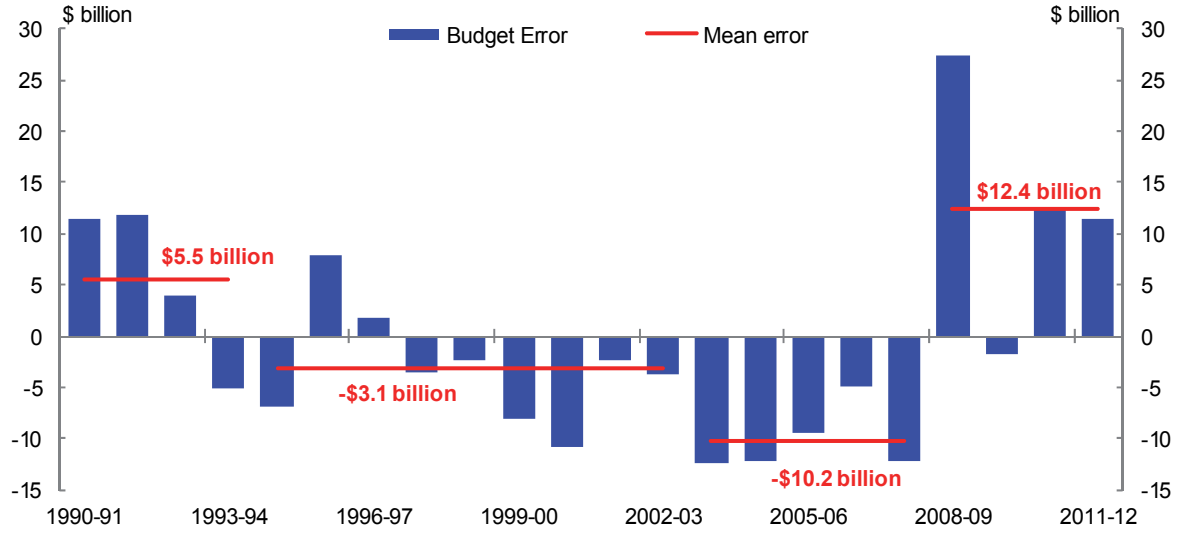
Table E.2: Performance of forecasts of tax revenue levels against Final Budget Outcomes (normalised to 2011-12 values, $billion*)

	1990-91 to 2011-12		1990-91 to 1993-94		1994-95 to 2002-03		2003-04 to 2007-08		2008-09 to 2011-12	
	Mean error $bn	MAE $bn	Mean error $bn	MAE $bn	Mean error $bn	MAE $bn	Mean error $bn	MAE $bn	Mean error $bn	MAE $bn
All forecasts (a)	-1.1	5.5	4.1	4.1	-3.2	4.6	-6.0	6.0	6.7	7.9
Budget forecasts (b)	-0.4	8.4	5.5	8.1	-3.1	5.3	-10.2	10.2	12.4	13.2
MYEFO forecasts (c)	NA	NA	NA	NA	-4.8	5.8	-6.3	6.3	8.4	9.1
Within year forecasts (d)	-1.3	1.8	0.1	0.1	-2.1	2.9	-1.3	1.5	-0.6	1.5

*Normalised using nominal GDP growth, to calculate the level of tax revenue error if the nominal economy had been at its 2011-12 size for the whole period.
(a) Includes the Budget forecasts, MYEFO forecasts, and Budget within year forecasts.
(b) Budget forecast for the financial year which starts in July (two months later). In 1990-91 to 1993-94 and 1996-97 the Budget was published in August and so it is the Budget forecast for the financial year which had started one month earlier.
(c) MYEFO forecast for the financial year which started in July (four months earlier). Available from 1996-97.
(d) Budget forecast for the financial year which started the previous July (ten months earlier). In 1990-91 to 1993-94 and 1996-97 the Budget was published in August and so it is the Final Budget Outcome.

Figure E.3 shows the Budget error in billions of dollars for each year, and the mean error in each of the four sub periods.

Figure E.3: Errors in Budget Forecasts of the Level of Tax Revenue (normalised to 2011-12 values, $billion*)



* Normalised using nominal GDP growth, to calculate the level of tax revenue error if the nominal economy had been at its 2011-12 size for the whole period.

E.2: Comparisons with other Forecasters

Access Economics

Comparisons of Treasury total tax revenue forecasts with those of Access Economics from their *Budget Monitor* publication are presented in Table E.3 below.

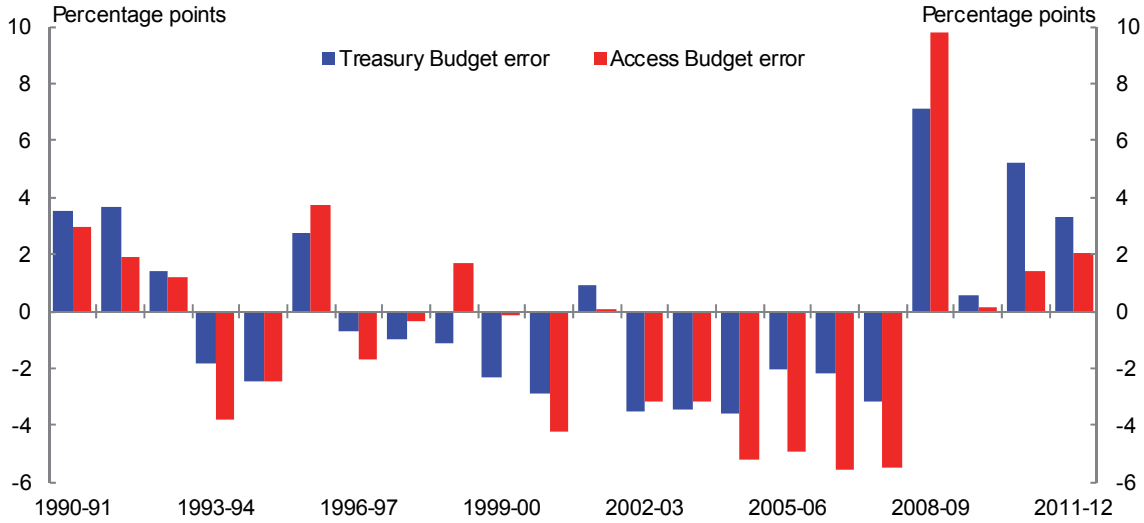
Table E.3: Performance of Treasury and Access forecasts of revenue growth against Final Budget Outcomes (percentage points)

	1990-91 to 2011-12		1990-91 to 1993-94		1994-95 to 2002-03		2003-04 to 2007-08		2008-09 to 2011-12	
	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points	Mean error % points	MAPE % points
All forecasts (a)										
Treasury	-0.3	1.8	0.9	1.3	-1.1	1.6	-1.7	1.8	2.2	2.5
Access	-0.4	2.2	0.5	2.0	-0.8	1.5	-2.4	2.8	2.7	2.9
Budget forecasts (b)										
Treasury	-0.1	2.7	1.7	2.6	-1.2	2.0	-2.9	2.9	4.0	4.0
Access	-0.7	3.0	0.6	2.5	-0.7	1.9	-4.9	4.9	3.4	3.4
MYEFO forecasts (c)										
Treasury	N/A	N/A	N/A	N/A	-1.5	1.8	-1.9	1.9	2.8	3.0
Access	N/A	N/A	N/A	N/A	-0.6	1.2	-2.5	2.5	3.7	3.7
Budget within year forecasts (d)										
Treasury	-0.4	0.6	0.0	0.0	-0.7	0.9	-0.4	0.5	-0.2	0.5
Access	-0.2	1.1	0.0	0.0	-1.0	1.1	0.2	1.0	1.0	1.6

Note: Access forecasts are on an accrual (not cash) basis from 1999-00, and are compared with Final Budget Outcomes on an accrual basis. Access forecasts are generally taken from the May Budget Monitor (for Budget) and the November Budget Monitor (for MYEFO), which are usually released around a week in advance of the Budget and MYEFO publications.
(a) Includes the Budget forecasts, MYEFO forecasts, and Budget within year forecasts.
(b) Budget forecast for the financial year which starts in July (two months later). In 1990-91 to 1993-94 and 1996-97 the Budget was published in August and so it is the Budget forecast for the financial year which had started one month earlier.
(c) MYEFO forecast for the financial year which started in July (four months earlier). Available from 1996-97.
(d) Budget forecast for the financial year which started the previous July (ten months earlier). In 1990-91 to 1993-94 and 1996-97 the Budget was published in August and so it is the Final Budget Outcome (this applies to Treasury and Access).

Treasury's Budget forecasts of tax revenue have been comparable to those of Access Economics over the past 22 years. The differences in forecasting accuracy between Treasury and Access are small and were found not to be statistically significant at the 10 per cent level. In this regard, it is worth noting that Access Economics publish their forecasts around a week in advance of the Budget, and have access only to the tax policy information that is made publicly available at this time. An adjustment is made to Access' forecasts to allow for Budget costings of policy measures in an attempt to remove the information advantage that Treasury forecast would otherwise have over Access in relation to new policy measures announced in the Budget. Figure E.4, below, shows the Budget forecast errors of the two organisations for each of the past 22 years.

Figure E.4: Treasury and Access Economics Errors for Budget Forecasts of the Growth of Tax Revenue



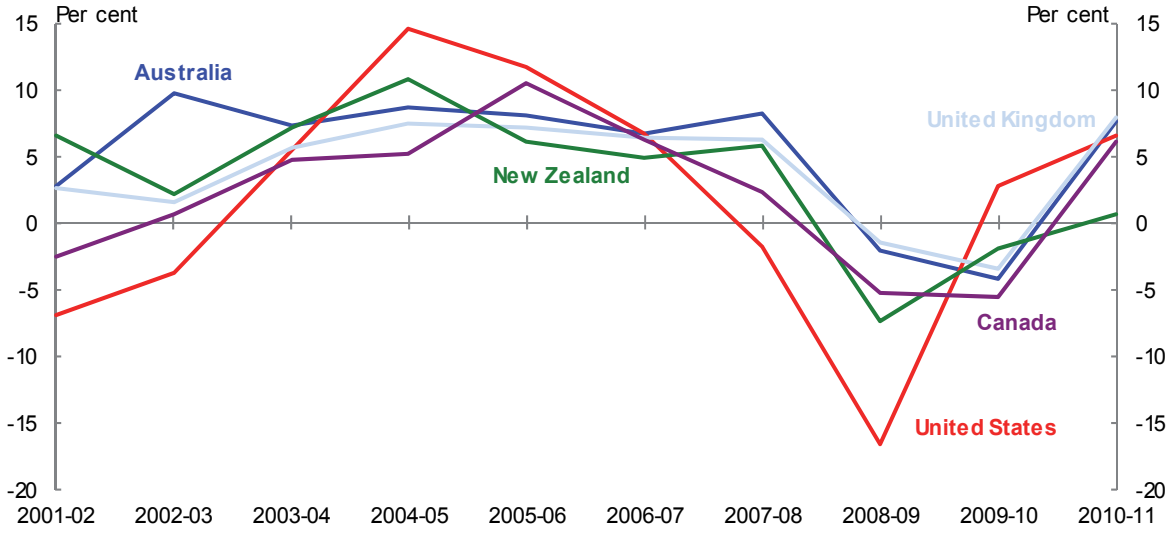
Note: Access forecasts are on an accrual (not cash) basis from 1999-00. They are generally taken from the May *Budget Monitor* (for Budget) and the November *Budget Monitor* (for MYEFO), which are usually released around a week in advance of these publications.

Official Agencies Overseas

This section compares the performance of Treasury total tax revenue forecasts with the forecasts prepared by official agencies overseas — HM Treasury (United Kingdom), Department of Finance Canada, New Zealand Treasury, the Office of Management and Budget (United States). These countries have broadly similar tax systems to Australia.

Figure E.5 below shows the outcomes for tax revenue growth in each country over the past decade. Tax revenue growth in Australia has been quite similar to the other countries over this period, with the exception of the United States, where growth has been more variable. All countries experienced falling tax revenue during the GFC due to the adverse economic impacts on production, consumption, profits and employment.

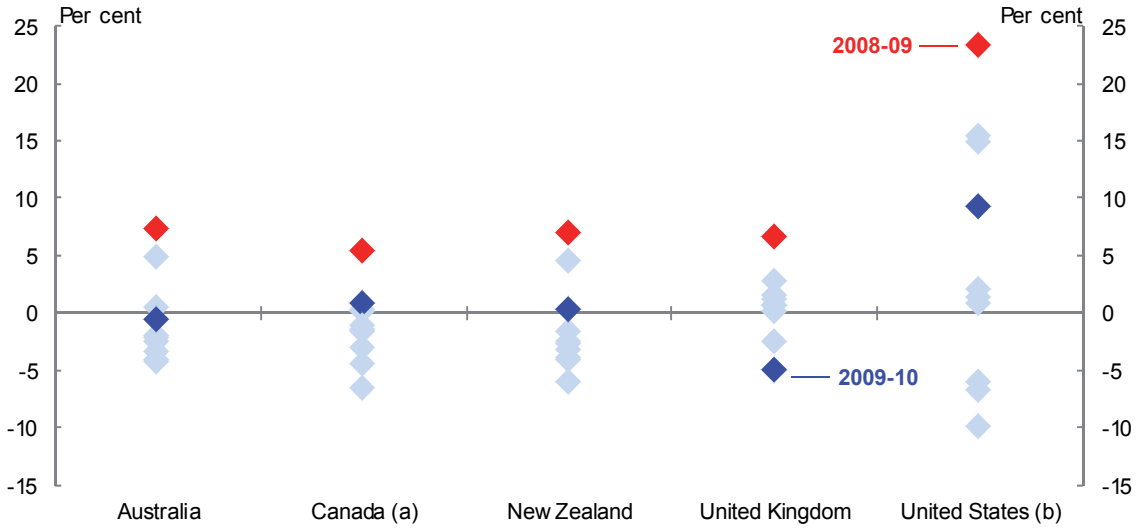
Figure E.5: Annual Tax Revenue Growth by Country



Different institutional environments in which the revenue forecasts are prepared may have implications for forecast accuracy. For example, the United States may be at a particular disadvantage as their Budget is released relatively far in advance of the start of the fiscal year (around eight to 10 months prior), and the legislature has the power to alter any of the tax policies set out in the Budget. In contrast, in the other countries we examine, Budgets are released relatively close to the start of the fiscal year (two months or less prior), and the legislature has limited power to adjust tax policies, unless they wish to reject the entire Budget. Our results for the United States attempt to adjust for any forecast disadvantage due to the impact of post-Budget changes to tax policies.

Figure E.6 shows the forecast errors (f* — f) for growth in tax revenue across the five agencies, over the past decade. The red diamonds are the errors observed for 2008-09 or equivalent financial year for each country — these errors highlight the universal difficulties experienced in forecasting at this time. The revenue forecasting performance of the Australian Treasury is comparable to that of official agencies in the United Kingdom, Canada and New Zealand. The United States forecast performance is much worse, with errors almost three times as great.

Figure E.6: International tax revenue forecast errors (2001-02 to 2010-11)



(a) Data for Canada excludes 2002-03, as no Budget is available for this year.
(b) Total revenue forecasts, including tax and other miscellaneous revenue. Adjusted for post-Budget changes to policies.

Table E.4 below shows summary statistics for forecast performance for each country over the past decade. The United Kingdom forecasts have been the most accurate, with a MAPE of around 2 per cent, with Australia, Canada and New Zealand displaying similar levels of forecast accuracy with MAPEs of between 2½ to 3½ per cent. The United States forecasts are far more inaccurate, with a MAPE of around 9 per cent. The differences in forecasting accuracy between Australia and official agencies overseas were found not to be statistically significant at the 10 per cent level, except for the United States.

In terms of bias, the Canadian and New Zealand forecasts show some negative bias, with an average error of around -1¼ to -1½ per cent, whereas the Australian forecasts have displayed a smaller negative bias of around -¾ per cent over this period. The United Kingdom forecasts have a slight positive bias of around ½ of a per cent, and the United States forecasts have a substantial positive bias of around 4½ per cent.

Table E.4: International performance of tax revenue forecasts against outcomes (2001-02 to 2010-11)

	Mean error %	MAPE %	Standard deviation (actual growth rates)	Correlation coefficient with Australia (actual growth rates)
Australia	-0.7	3.2	4.8	1.0
Canada (a)	-1.4	2.5	5.3	0.8
New Zealand	-1.2	3.6	5.2	0.7
United Kingdom	0.6	2.1	4.0	0.8
United States (b)	4.4	8.9	9.3	0.5

(a) Data for Canada excludes 2002-03, as no Budget is available for this year.
(b) Forecasts for total on-Budget revenue, including tax and other miscellaneous revenue. Adjusted for post-Budget changes to policies.

Trend estimate forecast comparison

This section compares the performance of Treasury's Budget tax revenue forecasts with those from a simple trend approach. All data have been adjusted to remove tax policy changes,[3] creating underlying tax revenue series and forecasts. These adjustments attempt to remove the policy advantage that Treasury's forecasts would otherwise have over the trend forecasts (for example, the Treasury forecasts would factor in the introduction of the GST in 2000-01, whereas the trend forecast would not).

For the purposes of this analysis, 'trend' is defined as the average annual growth rate over the previous X years for which an outcome is available, consistent with the approach taken in the economic section of this report. For example, the 3 year trend estimate in 2011-12 is the average of tax revenue growth in 2007-08, 2008-09 and 2009-10.[4] The trend results are compared with Treasury's Budget forecasts.

Figure E.7 below shows the outcome for underlying tax revenue growth compared with the Budget forecasts and the 10-year trend. The Budget forecasts are clearly much better at capturing the cyclical influences on tax revenue growth than using a trend approach. In particular, they capture the two major downturns in tax revenue in 1991-92 and 2009-10 and the subsequent recoveries.

3 It is worth noting that the adjustments are based on Treasury's policy costings which are also subject to error.
4 2010-11 is not included as the outcome would not have been available at the time of the 2011-12 Budget.

Figure E.7: Budget and Trend Estimates Versus Actual Tax Revenue Growth (growth rates, underlying)

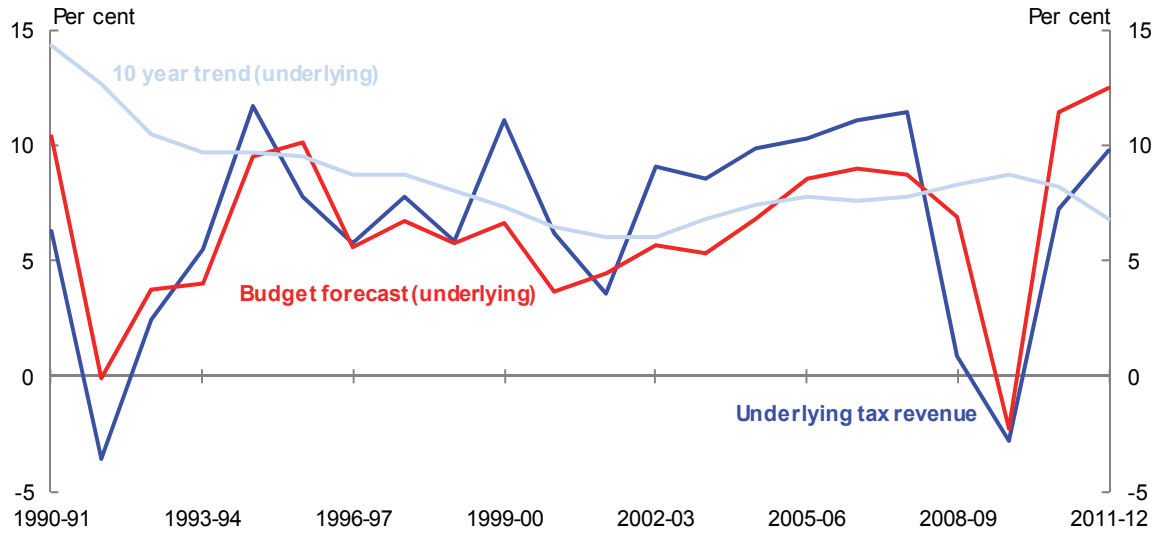


Table E.5 shows the performance of Budget forecasts against trend estimates of varying lengths.

Table E.5: Performance of Budget forecasts of growth in tax revenue against trend estimates (underlying)

	1990-91 to 2011-12		1990-91 to 1993-94		1994-95 to 2002-03		2003-04 to 2007-08		2008-09 to 2011-12	
	Mean error	MAPE	Mean error	MAPE	Mean error	MAPE	Mean error	MAPE	Mean error	MAPE
	% points	% points	% points	% points	% points	% points	% points	% points	% points	% points
Budget forecasts	-0.1	2.4	1.8	2.6	-1.2	1.9	-2.6	2.6	3.3	3.3
1 yr trend	-0.2	4.9	2.3	6.8	-1.0	3.1	-2.0	2.0	1.4	10.8
3 yr trend	0.8	4.8	5.9	7.8	-1.2	3.6	-2.4	2.4	4.3	7.6
5 yr trend	0.8	4.7	8.1	8.1	-1.2	2.4	-4.5	4.5	4.9	6.7
10 yr trend	1.9	4.2	9.1	9.1	0.2	2.1	-2.8	2.8	4.2	5.7

Over the full sample, Treasury's forecasts of tax revenue growth are more accurate than the trend estimates. Treasury forecasts have a lower MAPE for the period as a whole, and for three of the four sub-periods. The one and three year trend estimates are more accurate over the 'Mining Boom Mark I' period from 2003-04 to 2007-08, a period over which tax revenue was consistently underestimated by Treasury.

The trend estimates do particularly badly in terms of accuracy over the two recession and recovery periods, from 1990-91 to 1993-94 and from 2008-09 to 2011-12. Treasury's forecasts predict these downturns and the bounce back in tax revenue during the recovery phase, whereas the backward-looking trend estimates do not.

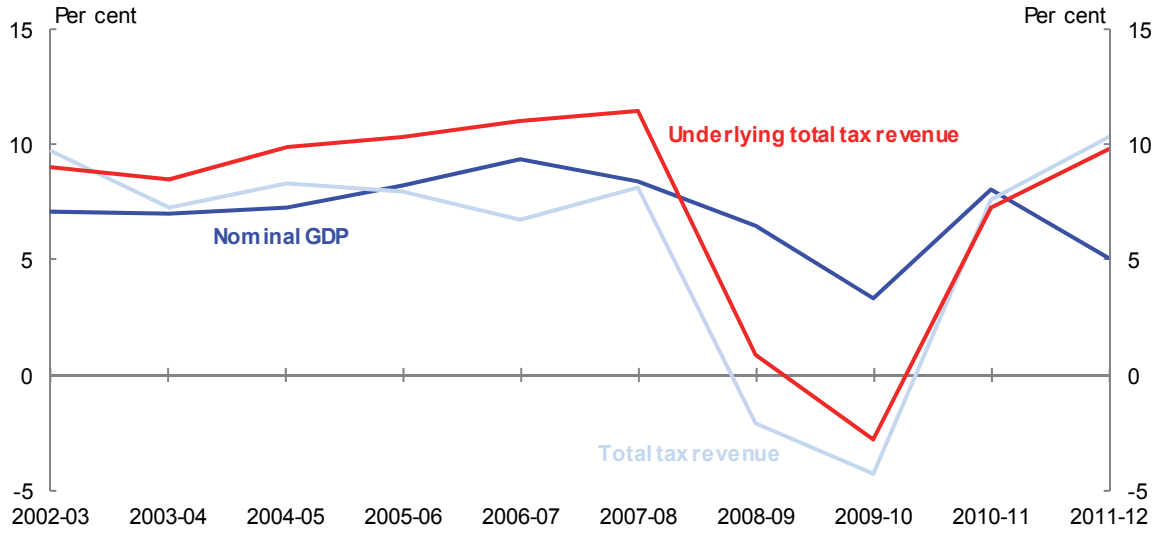
E.3: Relationship between Revenue Errors and Nominal Economy Errors

This section examines the correlations between the forecast errors for tax revenue and the nominal economy (or economic base), over the past decade.

There is not an exact relationship between the overall growth of the nominal economy and growth in total tax revenue. The historical relationship between economic and tax growth over the past decade is shown in Figure E.8 below. The correlation coefficient between these two series is 0.55. One reason why the series will not track exactly is that revenue collections will be impacted by tax policy changes

— for example, a reduction in a tax rate or a broadening of a tax base. The red line below shows underlying tax revenue growth (adjusting for tax policy changes), and it does map slightly better with economic growth than the grey line (which is not adjusted for policy changes), with a correlation coefficient of 0.73. However, there are still obviously other sources of differences between economic and tax growth, including timing differences, which are discussed further below.

Figure E.8: Nominal GDP growth versus tax revenue growth (annual average)



In terms of a particular head of revenue (such as company tax), there are several reasons why growth in the head of revenue may not track closely with growth in the corresponding economic base. These include:

- Policy decisions which lead to variations in the growth of the head of revenue.
- Timing differences between economic activity and the receipt of the associated tax revenue.
- Differences in scope between the tax base for the head of revenue, and the associated economic base. For example, fringe benefits tax is levied on the value of fringe benefits provided to employees, but the closest economic base is a wages measure (see Table C.3 in Attachment C for a description of the main head of revenue mapping models).
- Miscellaneous factors such as changes in compliance activities of the ATO.

Table E.6 below shows the major heads of revenue and the primary associated economic base. It also notes how much of the total tax base each head of revenue comprises, and the correlation between the head of revenue and its associated economic base.

All of the remaining analysis in this Attachment excludes capital gains tax (CGT), whereas CGT is included in the rest of the report. The economic bases do not include capital gains. CGT is forecast separately using a stock model which incorporates assumptions regarding the timing of gain realisation and loss utilisation.

Table E.6: Major heads of revenue

	Income tax withholding (c)	Company tax	GST	Other individuals	Total tax revenue
Share of tax base (%) (a)	47.1	21.1	15.1	9.1	
Associated economic base	Compensation of employees	Corporate gross operating surplus	Consumption subject to GST	Gross mixed income	Non-farm nominal GDP
Correlation coefficient between series (b)	0.87	0.26	0.75	0.05	0.44

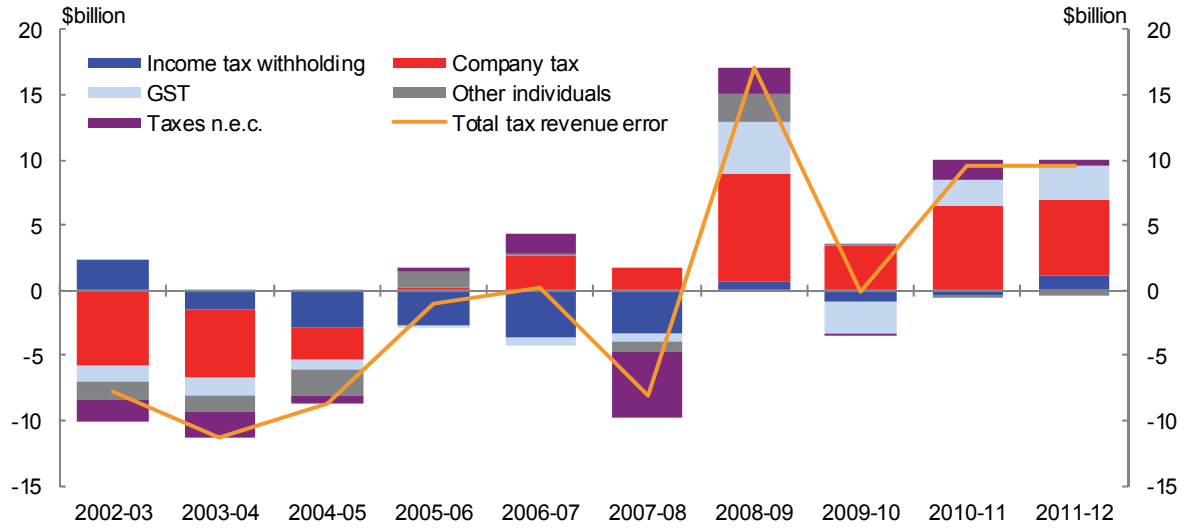
Note: All numbers exclude capital gains tax.
(a) In 2011-12.
(b) Correlation between growth rates in revenue and associated economic base, between 2002-03 and 2011-12. GST calculations start from 2003-04, as 2002-03 was a transitional year when revenue accelerated due to increased compliance and education.
(c) Income tax withholding has been adjusted for tax policy measures in calculating the correlation coefficient.

As can be seen from Table E.6, the individual economic bases do not map perfectly with the major heads of revenue. In particular, the economic bases used as an input in forecasting company tax and other individuals tax do not have a good relationship with these revenue heads, with correlation coefficients of 0.26 and 0.05. This is one source of difficulty in translating the economic bases into tax revenue forecasts. There are also several other potential sources of revenue forecast error, such as:

- forecast errors in the economic base;
- errors in tax policy costings;
- errors in tax revenue timing estimates; and
- miscellaneous factors such as post-Budget policy decisions and court decisions relating to tax law interpretation.

The contribution of an individual head of revenue to the overall tax revenue forecast error will depend upon its share of the tax base (its relative importance), and the error in the forecasts for that head of revenue. Figure E.9 shows the contributions of the major heads of revenue to the total Budget tax revenue forecast error, over the past decade.

Figure E.9: Contribution to total tax revenue error by head of revenue (Budget forecasts)



The main contributors to total tax revenue error over the past decade have been company tax, income tax withholding and GST. The company tax contribution reflects larger percentage forecast errors, while the income tax withholding contribution reflects smaller percentage forecast errors which are amplified due to its relative importance (since it comprises nearly 50 per cent of the tax base). Section 4 of the Report discusses in greater detail some of the main forecast errors by head of revenue since the start of 'Mining Boom Mark I' (2003-04).

Table E.7 below looks at the relationships between the major pairs of tax head of revenues and associated economic bases. It shows the mean error and MAPE for each of these pairs — in general, the error on the head of revenue should be at least as high as the economic base error, since this error is just one of many potential sources of revenue error (other sources of error have been briefly outlined above — tax policy costing error, timing error etc). The standard deviation of each series is also shown, with a higher number indicating a more volatile series which is more difficult to forecast.

The correlation between the historical growth for each pair is also shown (which was also reported in Table E.6), as is the correlation between the Budget forecast errors. The forecast errors should generally be well correlated, except where there are significant differences in timing or scope between the head of revenue and the economic base which need to be adjusted for in the head of revenue model (for example, in the case of company tax and other individuals tax). Appendix A of Section 4 of the Report shows the significant adjustments that take place to the Corporate GOS economic base in order to generate the company tax forecasts.

Table E.7: Relationship between errors in the economic base and taxation revenue (Budget forecasts)

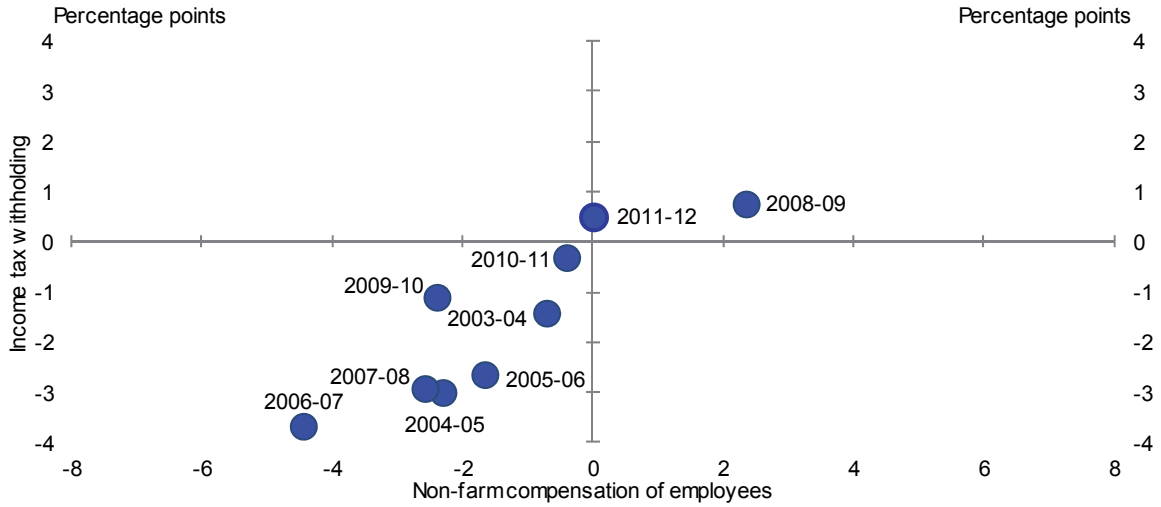
	2002-03 to 2011-12				
	Mean error % points	MAPE % points	Standard deviation of series (a)	Correlation coefficient between series growth	Correlation coefficient between forecast errors
Compensation of Employees	-1.2	1.7	2.0		
Income tax withholding (b)	-1.3	1.8	2.8	0.87	0.85
Corporate GOS	-1.3	3.1	4.3		
Company tax	2.3	8.0	10.3	0.26	0.18
Consumption subject to GST (c)	-0.3	1.9	1.5		
GST Revenue	0.2	3.8	3.6	0.75	0.80
Gross mixed income	0.0	3.2	3.5		
Other individuals tax	-2.2	2.8	5.6	0.05	0.25
Non-farm nominal GDP	-1.3	1.9	1.7		
Total tax receipts	-0.2	2.9	4.2	0.44	0.62

Note: All numbers exclude capital gains tax.
(a) Standard deviation of series growth rates, from 2002-03 to 2011-12.
(b) Income tax withholding has been adjusted for tax policy measures in calculating the correlation coefficient.
(c) GST calculations start a year later, in 2003-04, as 2002-03 was a transitional year when GST revenue accelerated due to increased compliance and education.

In the case of the largest head of revenue, income tax withholding, the majority of the forecast error over the past decade has been driven by error in the associated economic base (compensation of employees). The correlation coefficient between the two error series is 0.85, indicating that there are not significant timing or scope differences between income tax withholding and compensation of employees. In addition, the two series have very similar mean errors and MAPEs over this period, indicating that there is not much additional revenue forecasting error beyond the economic base error.

Figure E.10 below shows the forecast errors between income tax withholding and the associated economic base. Most of the errors fall in the top right quadrant (the errors on both forecasts are positive) or the bottom left quadrant (the errors on both forecasts are negative).

Figure E.10: Budget forecast errors on compensation of employees and income tax withholding growth



In contrast, the error in the second largest head of revenue, company tax, has only been weakly correlated with the error in its corresponding economic base, gross operating surplus (correlation coefficient of 0.18).

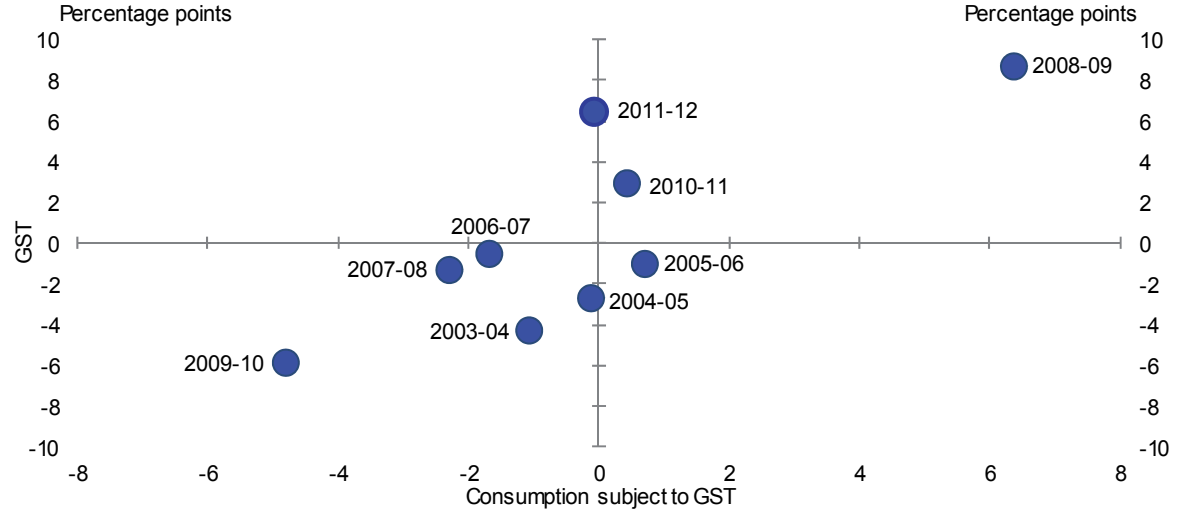
Figure E.11 shows the forecast errors between company tax and gross operating surplus. Several of the recent errors on company tax have been positive (in the top left and right quadrants), with the mean error on company tax revenue forecasts being 2.3 percentage points over the past ten years. This overestimation of company tax revenue has been driven by factors including longer than usual lags in the recovery of company tax payments following the GFC, and an increasing share of the economy being accounted for by the mining sector, which currently has a relatively low corporate tax-to-GOS ratio.

The relationship between company tax and gross operating surplus is complex. Although the correlation coefficient between the errors is low, this is in a large part due to two factors. Firstly, the outlier 2009-10 result, which is difficult to explain, has a significant effect. Without this data point, the correlation coefficient is 0.65. Secondly, the lag between the economic activity (as measured by GOS) and company tax caused by the company tax payments system, means that the relationship should not be expected to be exact. The timing model for company tax attempts to account for this lag, and is described in more detail in Section 4 of this Report.

Figure E.11: Budget forecast errors on gross operating surplus and company tax

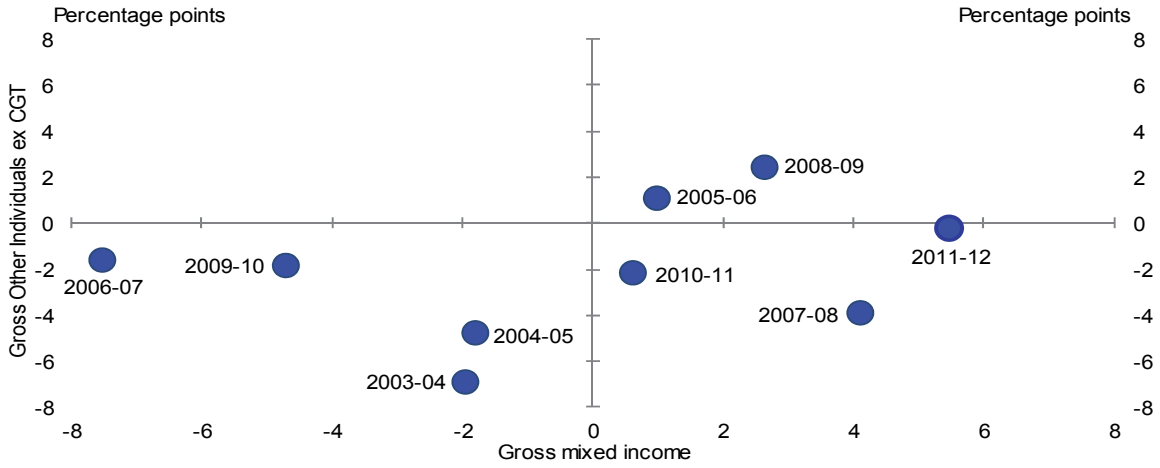
The third largest head of revenue, GST, has a reasonably good historical relationship with its main economic base (consumption subject to GST), indicating that the series have similar scope. The forecast errors are also reasonably well correlated (correlation coefficient of 0.80), as shown in Figure E.12, with a notable exception in 2011-12 when there was a large forecast error on GST collections and almost zero error on the economic base. This was due to the growth outcomes for these series diverging significantly, with GST collections falling by 0.5 per cent while the economic base grew by 5.4 per cent. This issue is discussed further in Section 4 of this Report.

Figure E.12: Budget forecast errors on consumption subject to GST and GST



The final and smallest individual head of revenue which we examine, other individuals taxes, comprises a variety of items including taxes on interest, dividends and small business income. Partly because of the diversity of this head of revenue, it is difficult to find a corresponding economic base. The main economic base used, gross mixed income, does not map particularly well with the head of revenue in history (correlation coefficient of 0.05). Other smaller economic bases are also utilised in the other individual's taxes model, including other business income and property income economic bases such as interest and rent. Figure E.13 shows the forecast errors are also not well correlated with the economic base (correlation coefficient of 0.25).

Figure E.13: Budget forecast errors on gross mixed income and other individuals tax



Overall, the total tax revenue errors are reasonably well correlated with the error on the forecast for the nominal economy (correlation coefficient of 0.62), as shown in Figure E.14 below.

Figure E.14: Budget forecast errors on nominal GDP (non-farm) and total tax revenue