



DEPARTMENT OF TREASURY

**FORECASTING ACCURACY
OF THE
ACT BUDGET ESTIMATES**

May 2008

1. Executive Summary

Every public or private organisation that produces projections or forecasts also evaluates their performance. Forecasts are evaluated to improve models that underpin these forecasts, and achieve better policy and planning outcomes.

Government agencies such as Commonwealth and State Treasuries produce forecasts of economic and fiscal variables that provide the basis for resource allocation in the annual budget process.

Treasuries also conduct reviews of their forecasts. For example, New Zealand Treasury regularly reviews performance of its forecasts¹. In Australia, the Western Australian Department of Treasury and Finance produced a comparison of forecasting performance by all states² that excluded ACT and Northern Territory from the comparison.

This paper evaluates ACT's forecasting performance of its revenue. The purpose of this study is to see if ACT Treasury forecast errors are within the reasonable limit of expectations or whether these errors are unreasonably large and require an improvement in the statistical models and process of producing these forecasts.

The paper analyses variances in revenue outcomes from the original forecasts for all States and the ACT. The results show that the ACT has better forecast performance than most of the smaller States. States, which consistently perform better than the ACT are New South Wales and Victoria.

¹ Treasury's Forecasting Performance, 25 November 2005, <http://www.treasury.gov.nz/forecasts/performance/>

² Review of Revenue Forecasting, March 2006, Department of Treasury and Finance, Government of Western Australia, http://www.dtf.wa.gov.au/cms/uploadedFiles/review_revenue_forecasting_march2006.pdf

2 Introduction

For Governments around the world, resource allocation is a balancing act – between programs and policies as well as between revenues and expenditures. While fiscal objectives and targets feature prominently in such considerations³, revenue forecasts become the defining parameter in a budget process.

In general, budget forecasts follow the process of converting forecasts of economic variables (such as GDP/GSP growth, employment, inflation etc.) into forecasts of fiscal variables. Besides the inaccuracies in economic forecasts being translated into inaccuracies in fiscal forecasts, the conversion process itself is based on statistical and regression methods that yield projections within certain tolerance bands and margins of error.

It should be no surprise that forecasts are not always accurate – they are essentially about predicting the future with incomplete information. Nevertheless, forecast inaccuracy, particularly consistent underestimation of revenues and budget surpluses, generally draws intense criticism.

While professional competence, and systems and processes of forecasting agencies feature prominently in such discussions, public policy issues related to forecast inaccuracy go well beyond any technical weaknesses in the forecasts⁴. Inaccurate forecasts are seen to hinder resource allocation choices and an informed debate on those choices⁵.

Such issues are not unique to the ACT or jurisdictions in Australia⁶, and forecast accuracy has been a matter of concern and subject of review internationally⁷. In general, the reasons for inaccuracies have been well analysed, and fall into the following categories:

- technical issues, such as data accuracy, forecasting methodology, process and agency structures;
- effects of fiscal objectives; and
- the economic cycle.

Forecasting agencies generally review and improve data and models on an ongoing basis, and issues identified in major reviews are generally marginal. Fiscal objectives and economic cycle on the other hand are considered to have more significant impact. In particular, it is well established that forecasts are generally too low in periods of high economic growth, and too high in periods of low economic growth⁸.

³ For example, an objective of *never having a deficit* will shape resource allocation differently from an objective of *achieving a balanced budget*. More specifically, targets on budget balance, however broad, together with revenue forecasts determine the expenditure envelop within which resources are allocated.

⁴ *Report of the Review of Canadian Federal Fiscal Forecasting Processes and Systems*; O'Neill T (2005).

⁵ Ibid.

⁶ See for example, *Ottawa's "Annual Fiscal Follies"*; Caledon Institute of Social Policy (2004). *The Accountability Act and the Parliamentary Budget Office*; Beaumier G A; Library of Parliament, Canada (2006) Department of Commerce Budget Statement; Office of Management and Budget; United States (2007).

⁷ *Review of the Forecasting Accuracy and Methods of the Department of Finance*; Ernst & Young (1994); *Report of the Review of Canadian Federal Fiscal Forecasting Processes and Systems*; O'Neill T (2005); *An Analysis of Tax Revenue Forecast Errors*; New Zealand Treasury Working Paper.

⁸ See for example, 2007-08 State of Intent, New Zealand Treasury; O'Neill Report into Canadian Forecasts (2005).

Forecasting Accuracy Comparison

In summary, it is not unreasonable to expect that forecasts should effectively be ‘wrong’ most of the time. In this sense ‘wrong’ means the forecasts would rarely be instructive about the precise level of a statistic at some point in the future; instead they provide useful information about the magnitude and direction of potential changes.

There are, however, boundaries of acceptable inaccuracy. This Paper does not offer an opinion on what precisely are acceptable boundaries. Rather, it analyses variances between ACT’s forecasts and actual results, and compares them with variances for other States in Australia.

The main purpose of this Paper is to identify if ACT’s forecasting performance is within the norms of variances across Australia. The Paper does not review or compare forecasting models or methods. This is undertaken on ongoing basis in the ACT Treasury. One particular statistic used in this Paper may implicitly provide an indication of the cumulative ‘value add’ of the forecasting models. This, however, should not be taken as a comparison of the forecasting models across States.

Section 3 of the Paper outlines the forecasting process in the ACT Treasury. Section 4 provides a brief discussion of the statistics used for forecast evaluation. Section 5 provides a discussion of the results. Section 6 provides conclusions.

3. Forecasting Process at the Treasury

The ACT Treasury often utilises the Australian Treasury forecasts of economic variables, such as the Consumer Price Index, Wage Price Index and GDP. For some economic variables, it uses its own statistical models.

Forecasts of fiscal variables are established through two groups; the Economic Forecasting Group based in Investment and Economics Division and the Revenue Forecasting Group which has representatives from core Divisions in the Treasury. The Economic Forecasting Group provides the forecasts of economic variables along with a range of supplementary information to the Revenue Forecasting Group.

These forecasts are discussed and examined in detail by the *Revenue Forecasting Group*, which comprises of executives and experts from different parts of the Treasury. The aim of this process is to eliminate any personal or logical bias that may be included in the forecasts.

Revenue Forecasting Group also helps in resolving issues that may arise during the cycle of the forecasting process. This includes provision of latest information and data to the forecasting team.

4. Forecast Evaluation

There are several statistical methods available to evaluate forecast performance. Table 1 below lists the commonly used measures. Mean Squared Error is the most widely used measure for its statistical properties.

Table 1: Statistical Techniques for Error Measurement

Technique	Abbrev	Measures
Mean Squared Error	MSE	The average of squared errors over the sample period
Mean Error	ME	The average dollar amount or percentage points by which forecasts differ from outcomes
Mean Percentage Error	MPE	The average of percentage errors by which forecasts differ from outcomes
Mean Absolute Error	MAE	The average of absolute dollar amount or percentage points by which a forecast differs from an outcome
Mean Absolute Percentage Error	MAPE	The average of absolute percentage amount by which forecasts differ from outcomes

All of these measures are subject to interpretation. For example, a simple dollar amount of mean or mean squared error would provide some useful information for a particular variable (or class of revenue), however, the mean percentage error means the relative errors can be compared across a number of variables (or revenue classes). Ignoring the sign of the error term by adopting absolute changes, one gets an idea of the magnitude of the errors generated by the forecasting techniques. While these tests provide useful information on the errors in forecasts, they will not provide commentary on the underlying forecast techniques⁹.

Instead of using Mean Squared Error (MSE), the analysis in this Paper uses Mean of the Percentage¹⁰ (MPE) and Absolute Percentage Errors (MAPE). This approach has the advantage that it provides more useful information than MSE, and due to the small sample size, forecast errors for each period can be presented in the percentage form. This approach is similar to that of the West Australian Treasury¹¹. When forecasts are made in terms of growth rates, forecast errors are expressed in terms of percentage point difference and evaluated using average and absolute average of the errors.

⁹ No matter what tool is used to forecast a set of relationships there will be some error. The appropriateness of the model cannot really be questioned because each model will generate a different range of errors and comparing two measures may lead to spurious decision making, in the sense that two errors may be identical, but for completely different reasons.

¹⁰ Mean percentage error is the average of the percentage differences between budget and actual outcomes. Mean percentage error distorts the forecasting performance in the presence of negative numbers (when errors are not random).

¹¹ Western Australian Treasury measures forecast accuracy in terms of forecast error relative to forecast (Budget estimate) rather than the actual or observed value as in MPE and MAPE.

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To ask the question whether the model being used is providing valuable information, a further test is used by constructing a 'Theil's U statistic' for each of the budget lines being interrogated. In essence, the U statistic compares the performance of a forecast against a naïve one step ahead forecast¹².

Statistical forms of these measures are summarised at **Appendix A**.

5. Results of the Forecast Accuracy Comparison

Two data sets are used in this analysis. One data set is based on the ABS publications and the other is based on the budget papers. The ABS data is the most consistent across States, but it is not provided in detail as in the budget papers.

The analysis period is six financial years 2001-02 to 2006-07. This is the period over which consistent and comparable information both from the ABS and the States' Budget papers was available. Coincidentally, this is also the period of continued economic growth, with forecast inaccuracies across all the States. At the time of completing this Paper, audited financial results for 2007-08 were not available.

The results¹³ are provided in **Appendix B**.

Results based on ABS¹⁴ data are presented in Table B1. The results show that the ACT forecasts of:

- *Total Own Source Revenue* are second best across all States;
- *Taxation Revenue* are median among all States after New South Wales, Victoria and Western Australia; and
- *Current Grants and Subsidies* are best across all States.

In summary, the ACT has above average forecast performance in two of the three revenue categories.

The budget estimates or forecasts of conveyance duty produced by the ACT Treasury are compared with actual outcomes in Table B2. The table also includes results from other states for comparison. One year ahead (or forward) budget estimates are used as forecasts.

As expected, the accuracy of forecasts across all states is low for conveyance duty in comparison to other revenue forecasts. This is because from year to year conveyance duty, which is largely a function of the highly unpredictable housing market, is extremely volatile.

The results also show that the ACT's forecast errors over the last six years are, with two exceptions, higher than the average of all States. However, the average error is around median and within the

¹² A naïve one step ahead forecast would be similar to saying, for example, that last years employee expenses will be the same this year. By running this test one asks whether the forecast method employed historically is valuable enough to retain. More succinctly it asks whether the investment in forecasting is worth the cost?

¹³ Results are based on the formula used by the Western Australian Treasury, as discussed before. This formula provides forecast errors in conventional percentage form which is easy to understand by a lay person.

¹⁴ BUDGET ESTIMATES: ABS Cat. No. 5501.0.55.001 Government Financial Estimates, Australia Electronic Delivery - 2006-07, and ACTUAL ESTIMATES: ABS Cat. No. 5512.0 Government Finance Statistics, Australia, 2005-06.

Forecasting Accuracy Comparison

acceptable limit (i.e. it is not an outlier). It should be noted that the ACT housing market was significantly affected by the 2003 Bushfires which destroyed about 500 homes.

Theil's U statistic is widely used to evaluate forecasts. Theil's statistic can be used in two ways. Firstly, to see how much two series (e.g. actuals and forecasts) are closer to each other¹⁵, and secondly whether forecasts produced by a model perform better than the naïve forecasts¹⁶.

Theil's U statistics for the ABS data are presented in Table B3. Results for Theil's U₁, which is a relative measure, show that ACT forecasts perform better than Tasmania, Western Australia and Queensland. The New South Wales and Victorian forecasts perform better because of their diverse economies, which make these States less dependent on a few revenue sources.

Theil's U₂ statistics show that (a) ACT forecasts perform better than naïve forecasts, and (b) in relative terms, ACT forecasts are second best after New South Wales. Taxation revenue is most difficult to forecast. Except for New South Wales, Queensland and the ACT, all other States perform either worse than or nearly equal to the naïve forecasts. In this case, the ACT has the third best performance.

To see how the use of economic forecasts affects revenue forecasts, a comparison of State GSP and Consumer Price Index forecast performance is provided in Table B4. The results show that economic forecasts have a high degree of volatility and inaccuracy that may affect revenue forecasts. However, there does not appear to be any relationship between the economic and revenue forecast errors. It may be due to weak dependency of revenue forecasts on the economic parameters.

It is worth noting that some States consistently over estimate their GSP, and with few exception, all States under estimate their Inflation forecasts.

6. Conclusion

The accuracy of the ACT revenue estimates is comparable with other states particularly NSW and Victoria.

Consistent under estimation¹⁷ across all jurisdictions is mainly due to continued economic and labour market growth in the last six years. The strong housing market has also resulted in significantly higher than expected conveyance duty revenues over this period. When housing market showed weakness in NSW, forecast bias for conveyance duty and taxation revenue was negative (over estimated).

¹⁵ Measured in terms of Theil's U₁. The U₁ statistic is bounded between 0 and 1. Values closer to 0 indicate greater forecasting accuracy.

¹⁶ Measured in terms of Theil's U₂. The U₂ statistic will take the value 1 under the naïve forecasting method. Values less than 1 indicate greater forecasting accuracy than the naïve forecasts, values greater than 1 indicate the opposite.

¹⁷ Reflected by positive numbers.

APPENDIX A: STATISTICAL FORM OF MEASURES

1. Definition of Variables

- a = actual end of year outcome
- f = forecast outcomes
- t = time reference [i.e. t is now, $(t-1)$ is last year, $(t+1)$ is next year] usually reported as a subscript reference (e.g. $t, t-1$)
- e = error defined as $(a - f)$
- n = the number of time periods; and
- \sum means 'the sum of' or 'Total'.

1. Mean Squared Error

The formula used to calculate the mean squared error is:

$$MSE = \frac{1}{n} \sum_{t=1}^n (a_t - f_t)^2$$

2. Mean Percentage Error

The formula used to calculate the mean percentage error is:

$$MPE = \frac{1}{n} \sum_{t=1}^n \frac{(a_t - f_t)}{a_t} \times 100$$

3. Mean Absolute Error

The formula used to calculate the mean absolute error is:

$$MAE = \frac{1}{n} \sum_{t=1}^n |(a_t - f_t)|$$

4. Mean Absolute Percentage Error

The formula used to calculate the mean absolute percentage error is:

$$MAPE = \frac{1}{n} \sum_{t=1}^n \frac{|(a_t - f_t)|}{a_t} \times 100$$

5. Theil's U Statistic

The formulas used to calculate Theil's U statistics are:

$$U1 = \frac{\sqrt{\sum_{t=1}^n (a_t - f_t)^2}}{\sqrt{\sum_{t=1}^n a_t^2 + \sum_{t=1}^n f_t^2}}, \quad U2 = \frac{\sqrt{\sum_{t=1}^{n-1} \left(\frac{f_{t+1} - a_{t+1}}{a_t} \right)^2}}{\sqrt{\sum_{t=1}^{n-1} \left(\frac{a_{t+1} - a_t}{a_t} \right)^2}}$$

To interpret the U statistics the general guide is:

- U1 is bound between 0 and 1, with values closer to 0 indicating greater forecasting accuracy.
- if $U2 = 1$, there is no difference between a naïve forecast and the technique used
- if $U2 < 1$ the technique is better than a naïve forecast; and
- if $U2 > 1$ the technique is no better than a naïve forecast.

Forecasting Accuracy Comparison

APPENDIX B: SUMMARY OF RESULTS

TABLE B1: Forecast Errors (ABS Data) – ACT and other States

Taxation Revenue								
	NSW	VIC	QLD	WA	SA	TAS	ACT	All States MAPE
	%	%	%	%	%	%	%	%
2001-02	-1.1	2.0	0.3	0.9	-0.7	5.0	-2.5	1.8
2002-03	10.1	7.3	14.0	11.4	8.1	17.5	15.7	12.0
2003-04	5.7	6.9	17.9	13.9	16.3	18.4	16.9	13.7
2004-05	-1.2	1.4	9.7	5.8	15.4	13.0	-4.3	7.3
2005-06	-2.2	5.6	8.1	4.1	30.0	5.1	0.8	8.0
2006-07	3.9	6.7	7.8	5.3	12.5	2.7	13.6	7.5
MPE	2.6	5.0	9.6	6.9	13.6	10.3	6.7	7.8
MAPE	4.0	5.0	9.6	6.9	13.8	10.3	9.0	8.4

Current Grants and Subsidies								
	NSW	VIC	QLD	WA	SA	TAS	ACT	All States MAPE
	%	%	%	%	%	%	%	%
2001-02	0.1	0.0	2.2	0.7	-0.2	1.2	0.0	0.6
2002-03	2.5	2.7	7.4	1.5	5.6	1.5	1.6	3.3
2003-04	1.9	3.1	5.8	3.8	3.7	6.7	4.2	4.2
2004-05	3.0	3.1	3.8	3.1	9.4	5.6	3.7	4.5
2005-06	2.2	1.5	2.2	2.4	3.5	0.0	0.3	1.7
2006-07	1.3	2.3	3.0	2.1	-0.1	-0.1	0.4	1.3
MPE	1.8	2.1	4.1	2.2	3.6	2.5	1.7	2.6
MAPE	1.8	2.1	4.1	2.2	3.7	2.5	1.7	2.6

Total Own Source Revenue								
	NSW	VIC	QLD	WA	SA	TAS	ACT	All States MAPE
	%	%	%	%	%	%	%	%
2001-02	3.7	2.4	-2.5	3.5	0.6	3.6	-5.4	3.1
2002-03	6.8	7.0	0.4	6.0	5.4	5.8	7.9	5.6
2003-04	4.6	7.1	17.9	8.7	8.3	7.9	-0.6	7.9
2004-05	2.5	3.0	15.0	6.0	16.8	9.3	0.4	7.6
2005-06	1.8	4.4	13.1	5.2	14.0	5.0	9.6	7.6
2006-07	5.0	7.5	10.0	4.4	5.7	4.7	6.3	6.2
MPE	4.1	5.2	9.0	5.6	8.5	6.0	3.0	5.9
MAPE	4.1	5.2	9.8	5.6	8.5	6.0	5.0	6.3

Source: BUDGET ESTIMATES: ABS Cat. No. 5501.0.55.001 Government Financial Estimates, Australia Electronic Delivery - 2006-07, and ACTUAL ESTIMATES: ABS Cat. No. 5512.0 Government Finance Statistics, Australia, 2005-06

Forecasting Accuracy Comparison

TABLE B2: Forecast Errors (based on Budget Papers) – ACT and other States

Conveyance Duty								
	NSW	VIC	QLD	WA	SA	TAS	ACT	All States MAPE
	%	%	%	%	%	%	%	%
2001-02	45.1	63.9	55.5	24.4	78.6	51.3	88.9	58.2
2002-03	35.2	33.1	52.7	27.7	81.4	87.8	59.4	53.9
2003-04	16.1	31.8	50.0	43.4	69.4	98.1	59.4	52.6
2004-05	-8.7	4.5	21.3	44.0	24.0	30.6	-15.8	21.3
2005-06	-3.3	28.7	24.1	90.2	23.9	1.9	4.7	25.3
2006-07	28.2	22.1	20.3	24.0	24.2	15.5	37.0	24.5
MPE	18.8	30.7	37.3	42.3	50.2	47.5	38.9	38.0
MAPE	22.8	30.7	37.3	42.3	50.2	47.5	44.2	39.3

Source: State and Territory Budget Papers and Annual Reports

TABLE B3: Theil's U Statistics based on ABS Data

	NSW	VIC	QLD	SA	WA	TAS	ACT
Theil's U1							
Taxation Revenue	0.02	0.03	0.05	0.04	0.08	0.05	0.05
Current Grants and Subsidies	0.01	0.01	0.02	0.01	0.02	0.02	0.01
Total Revenue	0.02	0.03	0.06	0.03	0.05	0.03	0.03
Theil's U2							
Taxation Revenue	0.81	0.96	0.83	0.94	1.10	1.55	0.86
Current Grants and Subsidies	0.29	0.32	0.48	0.37	0.61	0.56	0.35
Total Revenue	0.75	0.85	0.97	0.90	1.06	1.11	0.81

Forecasting Accuracy Comparison

TABLE B4: Forecast Errors ¹⁸ of State Economic Variables (based on Budget Papers)

Gross State Product								All States
	NSW	VIC	QLD	WA	SA	TAS	ACT	MAE
Percentage Points								
2001-02	-0.4	2.2	1.4	1.7	1.2	1.0	0.9	1.2
2002-03	-1.3	-0.9	1.6	0.2	-2.2	0.5	-0.5	1.0
2003-04	-1.3	0.0	0.9	3.0	1.8	-0.2	-1.2	1.2
2004-05	-2.2	-1.0	-0.2	-1.8	0.1	0.9	1.0	1.0
2005-06	-1.4	-0.3	0.2	0.4	-0.3	-0.2	1.6	0.6
2006-07	-0.7	-0.6	0.7	1.1	-1.7	-1.4	2.5	1.2
ME	-1.2	-0.1	0.8	0.8	-0.2	0.1	0.7	0.1
MAE	1.2	0.8	0.8	1.4	1.2	0.7	1.3	1.0

Consumer Price Index								All States
	NSW	VIC	QLD	WA	SA	TAS	ACT	MAE
Percentage Points								
2001-02	0.8	0.8	0.2	0.0	0.8	0.0	0.0	0.4
2002-03	0.3	1.1	0.5	-0.3	1.3	0.6	-0.2	0.6
2003-04	-0.2	0.0	0.4	-0.4	0.0	0.2	0.7	0.3
2004-05	0.3	0.0	0.1	0.0	0.3	0.9	0.0	0.2
2005-06	0.0	0.4	0.4	1.8	0.5	0.5	1.4	0.7
2006-07	0.0	0.2	0.6	0.9	-0.7	-0.3	0.2	0.4
ME	0.2	0.4	0.3	0.3	0.4	0.3	0.4	0.3
MAE	0.3	0.4	0.3	0.6	0.6	0.4	0.4	0.4

Source: State and Territory Budget Papers

¹⁸ Defined as 'Actual – Budget Estimate' and presented in percentage points. A positive number indicates under estimation of the economic parameters.