Comparison of inflation and GDP forecasts

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Editor's note

In this paper we take a closer look at how our forecasts of inflation and GDP compare with those of other forecasters.

Depending on the set-up at each organisation there may not in fact be much continuity in the forecasting methodology over the sample period. This is of course also the case at the Reserve Bank, but developments in our forecasting methodology have been comparatively well documented.

Executive Summary

In this paper we examine the Reserve Bank's forecasting performance relative to that of 8 external forecasting agencies. Our forecasts of annual target CPI inflation and annual average growth in production-based GDP are examined.

Inflation forecast errors

In terms of bias, we find that:

- We have consistently and significantly under-estimated annual CPI target inflation 3 to 10 quarters ahead.
- The NZIER's forecasts of inflation 4 to 9 quarters ahead are unbiased and have significantly outperformed the Reserve Bank's forecasts.
- The National Bank of New Zealand forecasts of annual target inflation 8 to 10 quarters ahead are biased towards under-estimation. However, they are significantly less biased than the Reserve Bank forecasts.
- None of the other external forecasters examined performed significantly better or worse than the Reserve Bank in terms of bias.

When examining the size of our forecast errors, we find that compared to most external forecasters, the size of the Reserve Bank's forecast errors tends to be similar or slightly lower for short horizons (up to 3 quarters ahead) and similar or slightly higher for longer horizons. However, there is evidence that the National Bank of New Zealand and NZIER have made significantly smaller errors at some horizons.

GDPP growth forecast errors

The size of the Reserve Bank's forecast errors tends to be similar or lower than those made by external forecasters at all the forecast horizons considered.

In terms of bias, we find that:

- Our forecasts of annual average GDPP growth are unbiased up to 2 years ahead.
- No forecaster significantly outperforms, or performs worse than the Reserve Bank in terms of bias at any of the forecast horizons considered.

1 Introduction

This paper examine the Reserve Bank's quarterly forecasts of annual CPI inflation and GDP growth and compare our forecasting performance to that of 8 external forecasting agencies. Much of our data is taken from the database compiled by St Clair and Yates (2001).[1] Additional data for our study is taken from our forecasting banks and from the various publications produced by each of the surveyed forecasters.

The Reserve Bank's forecasting performance is compared to that of:

- ANZ Bank
- Business and Economic Research Limited (BERL)[2]
- The Bank of New Zealand (BNZ)
- Infometrics
- The National Bank of New Zealand (NBNZ)
- The New Zealand Institute of Economic Research (NZIER)
- The Treasury
- WestpacTrust

Forecasts of annual target inflation are examined. This is defined as underlying inflation until the September quarter 1997, CPIX for the December 1997 quarter until the June quarter 1999 and CPI inflation (excluding interest rates) thereafter.[3]

GDP growth is measured using the annual average percentage change (AAPC) in real production-based GDP (GDPP). GDPP forecast errors are calculated using revised data (ie GDPP as it is measured in the middle of the following year).[4]

Unlike previous research Reserve Bank research in this area, matching of observations is used when comparing our performance to that of individual external forecasters. This means that when constructing each of our data sets, we include observations only for those quarters where both the Reserve Bank and the external forecaster of interest prepared forecasts. When comparing the Reserve Bank to a number of forecasters simultaneously, we use sample periods over which all organisations prepared forecasts on a regular basis and all available observations. Both the use of matched observations and a shorter sample period reduces the number of observations in our samples but aims to ensure their comparability.

The Reserve Bank's forecasts of CPI inflation between June 1992 and June 2002 and its forecasts of GDPP growth between March 1993 and June 2002 are examined. When comparing the Reserve Bank's performance to external forecasters, the availability of data from individual external forecasters determines the appropriate sample period.

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1 St Clair and Yates (2001).

2 BERL's forecasts of AAPC growth in GDPP are not available.

3 This measure is chosen as it tends to be the measure most widely forecast by external forecasters. However, examining target inflation is potentially problematic. Changes in the target measure may introduce structural breaks into our forecast errors. However, two or more quarters ahead, the Reserve Bank's average inflation forecast errors have been consistently negative irrespective of regime changes.

4 Revised data is viewed as the most suitable outturn for assessing forecasting performance as it tends to be more reliable than first release data. Further, it tends to bear a closer relationship to forecast data than the most up to date data, especially in the presence of data revisions and level shifts. This is consistent the work of St Clair and Yates (2001) within the Reserve Bank, and the works of Zarnowitz and Braun (1992) and Batchelor (2001) externally. Our GDP forecasting performance using alternative outturns is examined in the memo "GDP forecast errors".

Forecast errors are defined as 'forecast minus actual'. Hence, a positive mean forecast error indicates a tendency to over-predict inflation (for example) while a negative one indicates a tendency to under-predict. Only actual outcomes (rather than using latest projections as assumed future 'actuals') are used when calculating forecast errors. We assess forecasting performance in terms of forecast bias (as measured by the mean forecast error) and by the size of forecast errors (as measured by the mean absolute forecast errors and the root mean forecast error).[5]

Caution is necessary when interpreting our findings, particularly when there are relatively few comparable observations.[6] The small number of observations available for some external forecasters reduces the power of our statistical tests. This makes it difficult to determine if there is a significant difference in forecasting performance, even if such differences should exist. Further, it tends to be easier to determine the presence of a statistically significant bias in larger samples. As a result there may be stronger evidence of bias in forecasts from those organisations that prepare forecasts more regularly when compared to those organisations that prepare forecasts infrequently, even if both sets of forecasts are in fact biased.

A further difficulty with short samples is that our sample period may not be long enough to capture longer-term cyclical patterns. As a result, our findings of bias may be heavily influenced by events specific to a particular sample period.

Finally, forecasts prepared for the same quarter but at different dates are not necessarily comparable. Those produced at later dates may incorporate additional information, potentially improving their forecasting ability. We have tried to ensure that we only compare forecasts that are prepared at similar dates.

The remainder of this note is structured as follows: In section 2 we compare the Reserve Bank's forecasts of target inflation to those made by external forecasters. In section 3 we compare forecasts of GDPP growth made by the Reserve Bank and external forecasting agencies. Section 4 concludes.

2 Comparison of the Reserve Bank's inflation forecast errors to external forecasters

2.1 Examination of the Reserve Bank's inflation forecast errors (June 1992 to June 2002)

Figure 2.1 and table 2.1 summarise our findings regarding the Reserve Bank's annual target CPI inflation forecast errors between June 1992 and June 2002.[7] On average we have not consistently under or over-estimated target inflation for the current quarter or 1 to 2 quarters ahead. We have, however, tended to under-estimate inflation 3 to 10 quarters ahead.[8] This bias is more pronounced for forecasts 5 to 10 quarters ahead. One year ahead the Reserve Bank's forecasts have been, on average, 0.52 percentage points lower than actual inflation.

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5 Details of how these statistics are calculated are presented here.

6 We have a maximum of 40 observations when comparing our inflation forecasts to those of external forecasters, and for GDPP forecasts a maximum of 31 observations.

7 "Inflation forecast errors: preliminary findings" examines our inflation forecasting performance more closely using quarterly data.

8 The mean (or median) forecast errors for these horizons are statistically different from zero at the 5 per cent significance level or better.

The 2 year ahead forecasts have on average been 0.8 percentage points lower than actual target inflation.

Figure 2.1
Mean forecast error and summary forecast statistics for Annual Target Inflation forecasts for the Reserve Bank (June 1992 to June 2002)

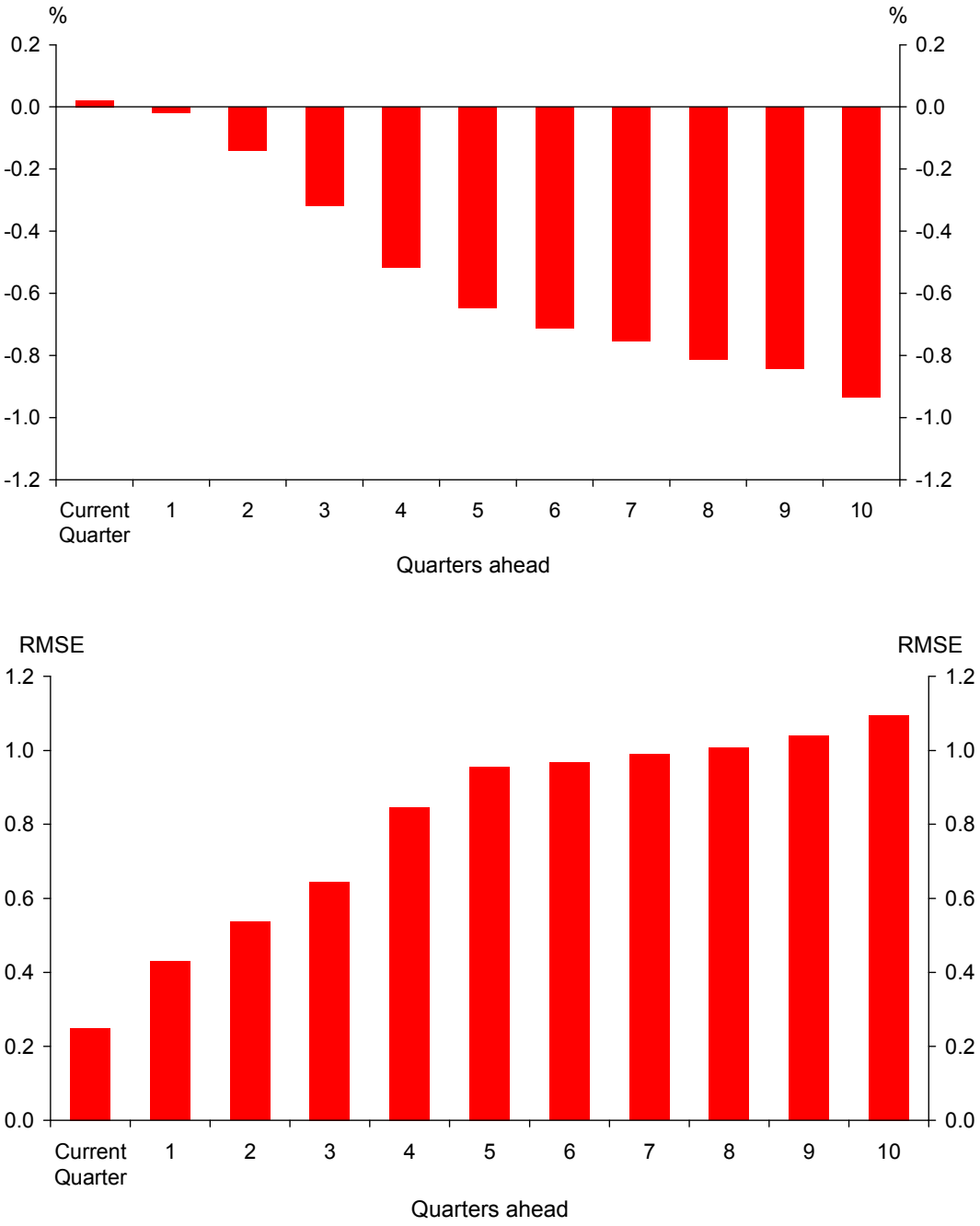


Table 2.1
Annual target inflation forecast errors statistics for the Reserve Bank (June 1992 to June 2002)

Quarters ahead	Mean Errors	RMSE	Observations
Current Quarter	0.02	0.25	41
1	-0.02	0.43	40
2	-0.14	0.54	39
3	-0.32***	0.65	38
4	-0.52***	0.85	37
5	-0.65***	0.96	36
6	-0.71***	0.97	34
7	-0.75***	0.99	32
8	-0.81***	1.01	30
9	-0.84***	1.04	28
10	-0.93***	1.10	22

Notes:
Asterisks indicate the significance with which the null hypothesis: Mean Error = 0 can be rejected:
*** = Significant at the 1 per cent level
** = Significant at the 5 per cent level
* = Significant at the 10 per cent level
Forecast errors for the 2, 3, 8 and 9 quarters ahead horizons are not normally distributed. For these horizons we test the null hypothesis: median forecast error = 0

2.2 Matched observation comparison of the Reserve Bank and external organisations inflation forecasting performance

We compare the Reserve Bank's target inflation forecasting performance to that of individual external forecasters using matched observations. We find that in terms of bias, the Reserve Bank's inflation forecasting performance is not significantly better or worse than most external forecasters. However, there are important differences between the bias in our forecasts and those from the NZIER and the National Bank of New Zealand (not coincidentally, the forecasters for whom we have the most data). The size of our forecast errors compared to those from most external forecasting agencies has tended to be similar or slightly lower for short horizons (up to 3 quarters ahead) and similar or slightly higher for longer horizons.

Appendix 1 contains summary statistics (including the mean error and RMSE) for our pairwise comparison of the Reserve Bank's target inflation forecasts relative to those of external forecasters. We discuss the NZIER and National Bank of New Zealand findings in more detail below.

2.2.1 Comparison of the Reserve Bank's target inflation forecast errors to the NZIER

Our sample period when comparing our forecasting performance to that of the NZIER is June 1995 to June 2002. On average, the NZIER has not significantly under- or over-estimated

target inflation up to 9 quarters ahead.[9] Over the same sample period the Reserve Bank has tended to under-predict target inflation 3 to 9 quarters ahead.[10]

Four to 9 quarters ahead, the Reserve Bank has tended to under-predict annual inflation by significantly more than the NZIER.[11] Over this sample period we have, on average, under-predicted annual inflation both 1 and 2 years ahead by 0.7 percentage points (this reflects a significant downwards bias in our forecasts). On average the NZIER under-estimated annual target inflation 1 year ahead by 0.25 percentage points and annual target inflation 2 years ahead by 0.03 percentage points. However, the NZIER's mean forecast errors for these horizons are not significantly different from zero, ie the forecasts are not significantly biased. Table 2.2 and figure 2.2 summarise our comparison of the Reserve Bank's target inflation forecast errors to those from the NZIER.

Table 2.2
Summary statistics for the Reserve Bank and NZIER target inflation forecasts (June 1995 to June 2002)

Quarters ahead	RBNZ			NZIER			Difference in mean forecast errors	Observations
	Mean Forecast error	MAE	RMSE	Mean Forecast error	MAE	RMSE		
Current quarter	0.06	0.19	0.28	0.00	0.33	0.42	0.06	28
1	0.02	0.37	0.50	-0.06	0.50	0.62	0.08	26
2	-0.17	0.42	0.63	-0.22	0.54	0.68	0.05	24
3	-0.40	0.59	0.77	-0.26	0.55	0.69	-0.15	23
4	-0.72	0.90	1.02	-0.25	0.61	0.73	-0.47**	21
5	-0.91	0.97	1.12	-0.15	0.52	0.69	-0.76***	19
6	-0.88	0.88	1.02	-0.05	0.30	0.40	-0.83***	16
7	-0.85	0.86	1.01	0.06	0.46	0.55	-0.92***	15
8	-0.73	0.73	0.88	-0.03	0.42	0.50	-0.70 ***	11
9	-0.70	0.70	0.91	-0.09	0.55	0.64	-0.61*	8

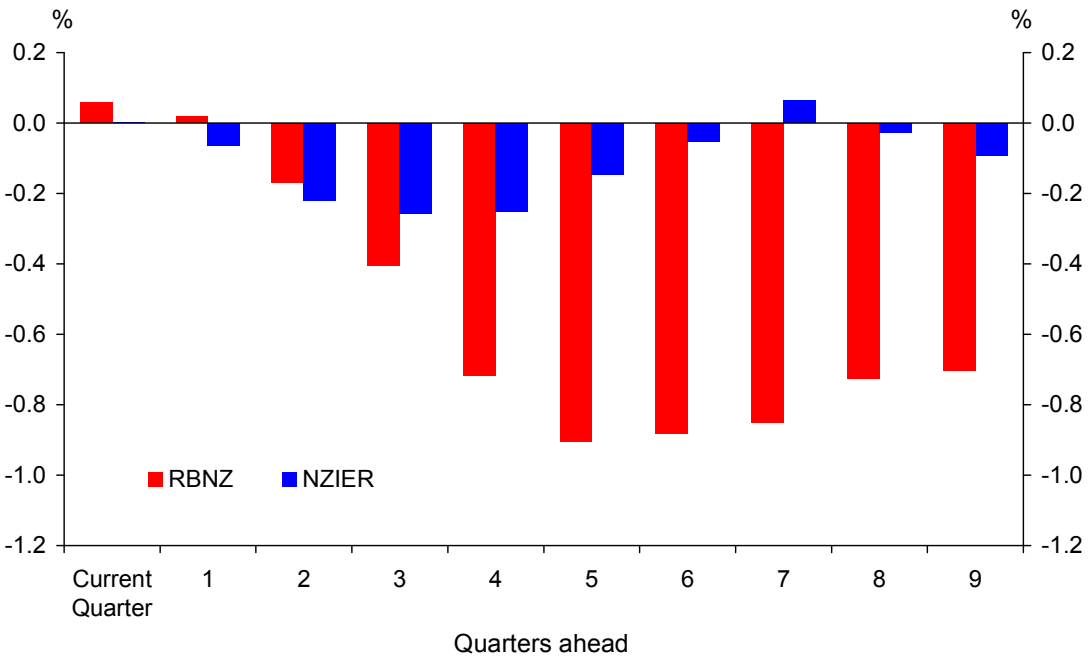
Notes:
Asterisks indicate the significance with which the null hypothesis:
Mean Forecast Error (Reserve Bank) = Mean Forecast Error (External forecaster) can be rejected.
*** = Significant at the 1 per cent level
** = Significant at the 5 per cent level
* = Significant at the 10 per cent level
Forecast errors for the current quarter and the 2 quarters ahead horizon are not normally distributed. For these horizons we test the null hypothesis: Median Forecast Error (Reserve Bank) = Median Forecast Error (External forecaster).

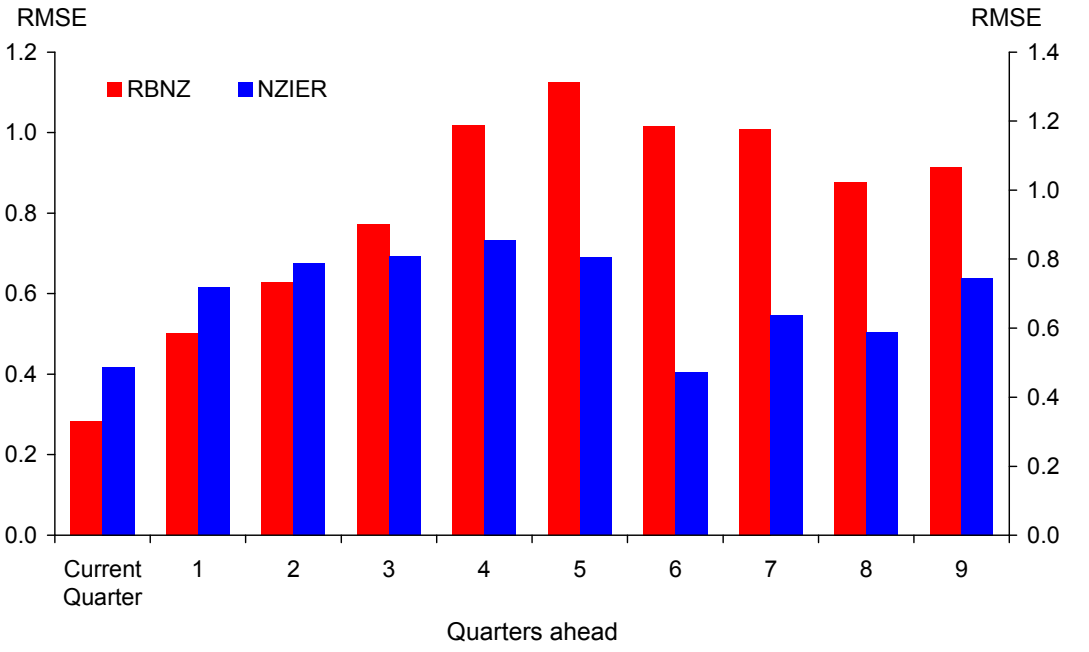
9 The NZIER's forecasts for horizons more than 9 quarters ahead were not examined due to an insufficient number of comparable observations.

10 The Reserve Bank's mean forecast errors for annual target inflation 3 to 9 quarters ahead are negative and statistically different from zero at the 5 per cent significance level or better. Our mean forecast error for annual target inflation 10 quarters head is statistically different from zero at the 10 per cent significance level.

11 As it happens, the biggest gap in the matched sample periods was for observations over 1997 and 1998. The Reserve Bank's forecast errors for this period were often towards over-estimation of inflation and hence, their exclusion from the sample increases the measured bias in the Reserve Bank's forecasts. We tested the robustness of our findings to including this data when calculating the Reserve Bank statistics. This made the measured bias for the Reserve Bank was around 0.15 per cent lower at the 4 quarter horizon. While the NZIER's forecasts for this horizon still have a lower mean and variance, the difference in bias was no longer significant at conventional levels. Findings for other quarters were robust to inclusion of the extra data.

Figure 2.2
Mean forecast errors and RMSEs for the Reserve Bank and NZIER forecasts of target inflation (June 1995 to June 2002)





These findings are robust to changes in the sample period. Five to 7 quarters ahead, we continue to observe a significant difference between the NZIER's mean forecast errors and our own when up to 8 observations (2 years of data) are excluded from either the beginning or the end of the sample. For the 2 year ahead horizon, a significant difference between the NZIER's mean forecast error and our own continues to be observed when up to 4 observations are excluded from either beginning or the end of the sample. Findings for the 1

year ahead horizon are robust to the exclusion of data from the start of the sample but not from the end.[12]

Note that the NZIER did not publish their forecasts of underlying inflation prior to Jun 1995. However, their forecasts of annual headline inflation back to June 1992 are available. When we compare these to the Reserve Bank's forecasts of annual headline inflation, we observe the same pattern that is present in the forecasts of target inflation over the shorter sample period.

The NZIER's forecasts for mid- to long-term horizons (6 or more quarters ahead) are noticeably different from our own. Since March 1997 target inflation has tended to lie in the upper half of the target range.[13] On average, the NZIER did not forecast inflation to fall as quickly as the Reserve Bank did. Their forecasts since March 1997 indicate show inflation tending to 1.5 per cent after approximately three years.[14] By way of contrast the Reserve Bank's forecast have shown inflation tending to 1.5 per cent after approximately 6 quarters. In recent periods however, our forecast have show inflation tended to 1.5 per cent after a longer period. The average inflation forecasts for both organisations since March 1997 are presented in table 2.3 and figure 2.3.

An important caveat to these results is that between May 1998 and September 2000, the NZIER's forecasts were published several weeks after the Reserve Bank's projections were finalised. This includes the Asian crisis period, during which the economic outlook was changing rapidly. However, even excluding this period, their forecasts are less biased than our own.

Table 2.3
Average CPI inflation forecasts for the Reserve Bank and the NZIER March 1997 to June 2002

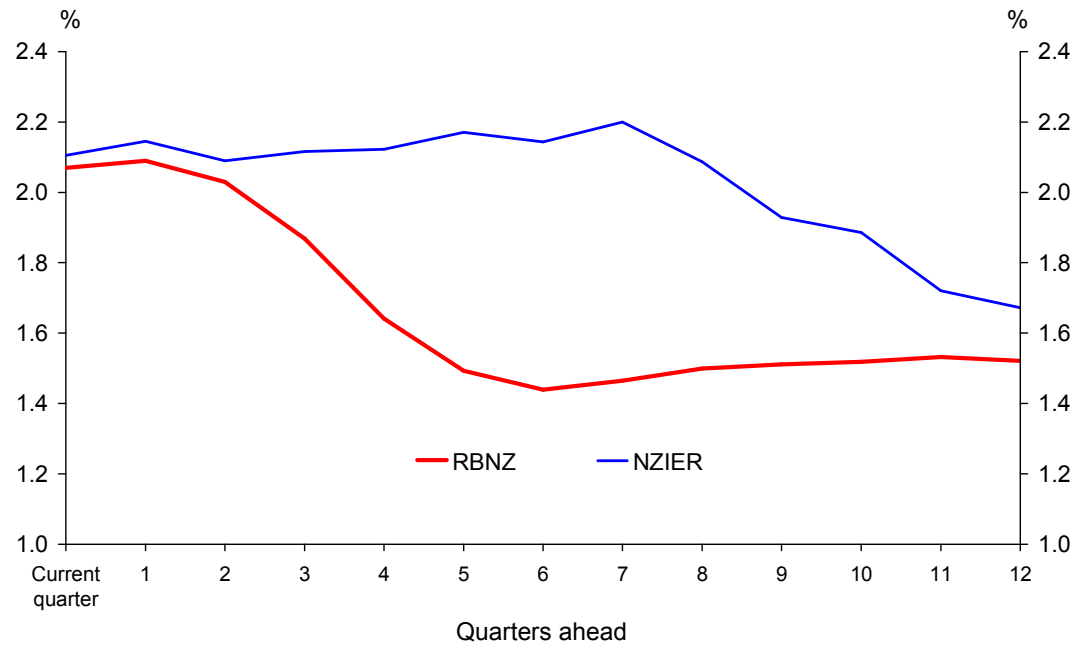
Quarters ahead	Forecaster		Difference
	RBNZ	NZIER	
Current quarter	2.07	2.10	-0.04
1	2.09	2.15	-0.06
2	2.03	2.09	-0.06
3	1.87	2.12	-0.25
4	1.64	2.12	-0.48
5	1.49	2.17	-0.68
6	1.44	2.14	-0.71
7	1.46	2.20	-0.74
8	1.50	2.09	-0.60
9	1.51	1.93	-0.45
10	1.52	1.89	-0.40
11	1.53	1.72	-0.21
12	1.52	1.67	-0.16

[12] For the 1 year ahead horizon we continue to find a significant difference between our forecast errors and those of NZIER when up to eight observations are excluded from the start of the sample period. However the presence of a significant difference between the two forecasters for this forecast horizon is only robust to the exclusion of 1 observation from the end of the sample period.

[13] Between March 1997 and June 2002 this was an annual rate of inflation between 0 and 3 per cent.

[14] NZIER's average forecast for inflation 12 quarters ahead since March 1997 has been 1.68 per cent.

Figure 2.3
Average target inflation forecasts for the Reserve Bank and the NZIER March 1997 to June 2002



2.2.2 Comparison of the Reserve Bank's inflation forecast errors to the National Bank of New Zealand

Summary statistics for our comparison with the National Bank of New Zealand are presented in table 2.4. When comparing our forecasting performance to that of the National Bank of New Zealand our sample period is September 1992 to June 2002. Both the Reserve Bank and the National Bank of New Zealand have tended to significantly under-predict inflation 3 to 10 quarters ahead.[15] However, 8 to 10 quarters ahead, the Reserve Bank has tended to under-predict inflation by significantly more than the National Bank of New Zealand. The Reserve Bank has, on average, under-predicted annual inflation 8 to 10 quarters ahead by approximately 0.8 percentage points. On average, the National Bank of New Zealand has tended to under predict inflation for these horizons by between 0.45 and 0.50 percentage points.[16]

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15 The forecast errors from both organisations for these forecast horizons are statistically different from zero at the 5 per cent significance level or better and, on average, are negative. The National Bank has also tended to under-predict inflation 2 quarters ahead, (the mean forecast error for this horizon is statistically different from zero at the 5 per cent significance level) but their mean error for this horizon is relatively small.

16 The findings of a significant difference between our forecast errors and those from the National Bank at the 8 and 10 quarter ahead horizons are robust to the exclusion of data from both the start and end of the sample period. Findings for the 9 quarter ahead horizons are robust to the exclusion of data from the start of the sample period but not the end.

Table 2.4
Summary statistics for the Reserve Bank and the National Bank of New Zealand forecasts of target inflation (September 1992 to June 2002)

Quarters ahead	RBNZ			NBNZ			Difference in mean forecast errors	Observations
	Mean Forecast error	MAE	RMSE	Mean Forecast error	MAE	RMSE		
Current quarter	0.03	0.17	0.25	0.00	0.17	0.23	0.03	40
1	-0.02	0.31	0.43	-0.11	0.31	0.40	0.09	39
2	-0.15	0.36	0.54	-0.28	0.44	0.56	0.13	38
3	-0.33	0.47	0.65	-0.48	0.56	0.72	0.15	37
4	-0.54	0.71	0.86	-0.61	0.67	0.84	0.08	36
5	-0.66	0.81	0.97	-0.65	0.72	0.87	-0.01	35
6	-0.72	0.81	0.98	-0.62	0.68	0.84	-0.10	33
7	-0.77	0.83	1.00	-0.55	0.62	0.81	-0.23	31
8	-0.83	0.84	1.02	-0.50	0.60	0.75	-0.34*	29
9	-0.82	0.82	1.01	-0.45	0.58	0.70	-0.38*	26
10	-0.87	0.87	1.00	-0.49	0.55	0.73	-0.38**	17

Notes:
Asterisks indicate the significance with which the null hypothesis:
Mean Forecast Error (Reserve Bank) = Mean Forecast Error (External forecaster) can be rejected.
*** = Significant at the 1 per cent level
** = Significant at the 5 per cent level
* = Significant at the 10 per cent level
Forecast errors for the current quarter and 2, 3, 8 and 9 quarters ahead horizons are not normally distributed. For these horizons we test the null hypothesis: Median Forecast Error (Reserve Bank) = Median Forecast Error (External forecaster).

2.2.3 Size of forecast errors

When compared to external forecasters, the size of the Reserve Bank's forecast errors for annual target inflation (as measured by MAE and RMSE) generally tends to be similar or slightly lower for short horizons (up to 3 quarters ahead). For longer horizons, the size of our forecast errors tends to be similar or slightly larger than those made by external forecasters.

Notable exceptions to this pattern are the NZIER and the National Bank of New Zealand. Four to 7 quarters ahead the NZIER's forecast errors for annual target inflation have, on average, been significantly smaller than the Reserve Bank's forecast errors.[17] Also, the National Bank's forecast errors 7 to 10 quarters ahead have, on average, been significantly smaller than the Reserve Bank's forecast errors.[18] Again, we note that the sample size when examining some external forecasters is too small for meaningful comparisons to be made. When comparing our forecasts to those from the National Bank of New Zealand or the NZIER we have a relatively large number of observations, allowing for a more precise analysis.

2.3 Comparison of the Reserve Bank's forecast errors to multiple forecasters

We also compare the Reserve Bank's forecasts simultaneously to those the five external forecasters with the most observations over the period June 1995 to June 2002.[19] The forecasters examined are ANZ, BERL, Infometrics, the National Bank of New Zealand and NZIER. Caution is needed with such an analysis as we have relatively few observations from some forecasters at some horizons. This can be misleading when considering accuracy of one

17 The sample period is June 1995 to June 2002. Findings are significant at the 5 per cent level or better.
18 The sample period is September 1992 to June 2002. Findings are significant at the 10 per cent level or better.
19 This shorter sample period is used to ensure the comparability of forecasts from each organisation.

set of forecaster relative to another. We find that up to 3 quarters ahead the performance of all the forecasters (in terms of bias and size of forecast errors) is very similar. However 4 to 8 quarters ahead the NZIER outperforms the Reserve Bank on both of these criteria. Eight to 10 quarters ahead, the Reserve Bank is outperformed by the National Bank of New Zealand on these criteria. The differences are more pronounced for longer forecast horizons.

2.4 Comparison with previous research

Previous research within the Reserve Bank by St Clair and Yates (2001) compared our target inflation forecasting performance to that of the NZIER, the National Bank of New Zealand and a number of other external forecasters. Their sample period was June 1992 to June 2000. In contrast to our own work, St Clair and Yates work used all available data from each forecaster when making comparisons among organisations (rather than a matched observation or sample period approach) and focused mainly on RMSE, allowing forecasters to be ranked according to the size of their forecast errors.[20] This methodology indicated that the Reserve Bank's performance was similar to that of most external forecasting agencies. However, the findings of our new research for the NZIER (ie that of a significant difference between the forecast errors of the Reserve Bank and those of the NZIER) are in fact evident in St Clair and Yates' data.[21] Because of their focus and methodology this difference was not obvious, and consequently, was not noted in their report. Our finding of a significant difference between the National Bank's forecast errors and those from the Reserve Bank is not present when our methodology issue on St Clair and Yates' original data set. This difference in findings is likely to reflect the additional data that is available to us, making it easier to determine if a significant difference exists.

3 Comparison of the Reserve Bank's GDPP growth forecast errors to external forecasters

3.1 Examination of the Reserve Bank's GDPP errors (March 1993 to June 2002)

Our findings for the Reserve Bank's forecasts of GDPP using 'revised' data (ie GDPP as it stands in the middle of the following year) are summarised in figure 3.1 and table 3.1.[22] We examine forecasts of annual average GDP growth, as this is the most widely published measure. However, it should be borne in mind that calculating quarterly forecast errors using annual or annual average measures may be problematic due to the existence of overlapping observations. The effect of overlapping observations is to carry forecasting errors forward. For example, if an unexpected shock occurs that causes GDP to be lower than expected in the March 2000 quarter, this will be reflected in the forecast errors for annual GDP growth for the year to March 2000, June 2000, August 2000 and December 2000 (and in the forecast errors for annual average growth for a further four quarters). Hence focusing on quarterly forecasts of annual inflation or annual-average GDP growth may introduce serial correlation into forecast errors.

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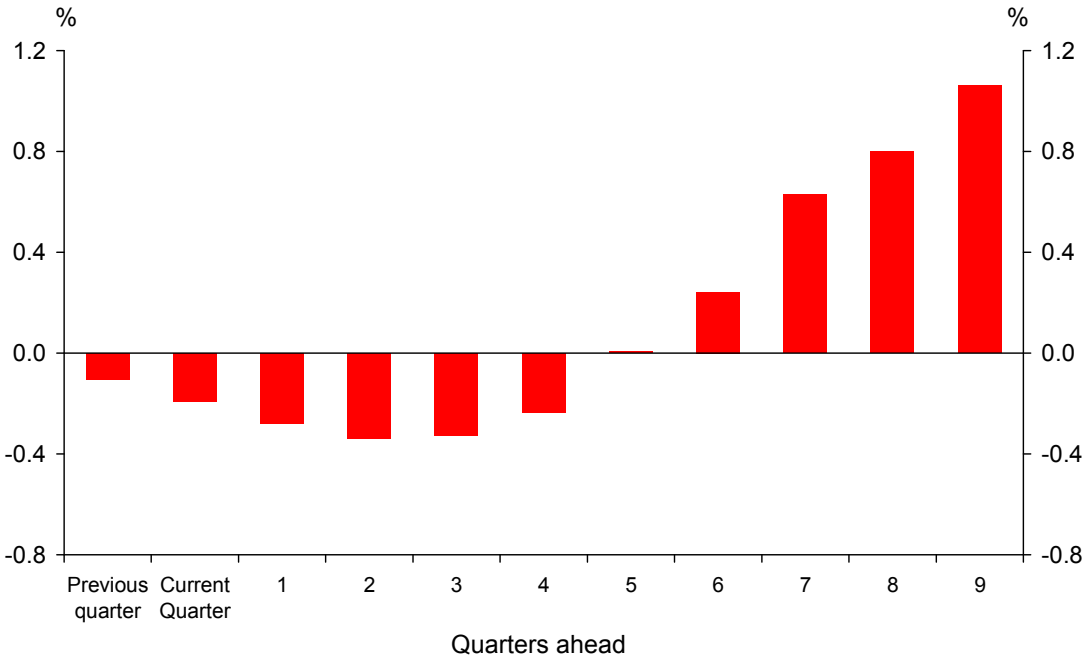
20 St Clair and Yates averaged RMSEs over several horizons in order to rank forecasters.

21 We re-examined St Clair and Yates data using paired observations. The findings were similar to those reported in this paper.

22 Due to the long lags before GDP is published, the quarter *prior* to the publication of our forecasts and the current quarter are both viewed as a forecasting quarters.

The Reserve Bank has not tended to consistently under- or over-predict the annual average percentage change in GDPP up to two years ahead. We have tended to significantly over-predict the AAPC in GDPP 9-quarters ahead.[23] We note that previous Reserve Bank research has found evidence of a bias in our mid-term forecasts of GDPP growth. The differences between the findings presented here and those from previous research are likely to reflect differing sample periods and methodologies.[24]

Figure 3.1
Mean forecast error and summary forecast statistics GDPP growth forecast errors (AAPC) for the Reserve Bank (March 1993 to June 2001)



[23] The mean forecast error for our 9 quarter ahead forecasts is statistically different from zero at the 5 per cent significance level.

[24] "GDP forecast errors" examined forecasts between December 1994 and March 2002 using quarterly data and several vintages of outturns. This work suggests the presence of a positive bias in our forecasts of medium-term quarterly GDP growth.

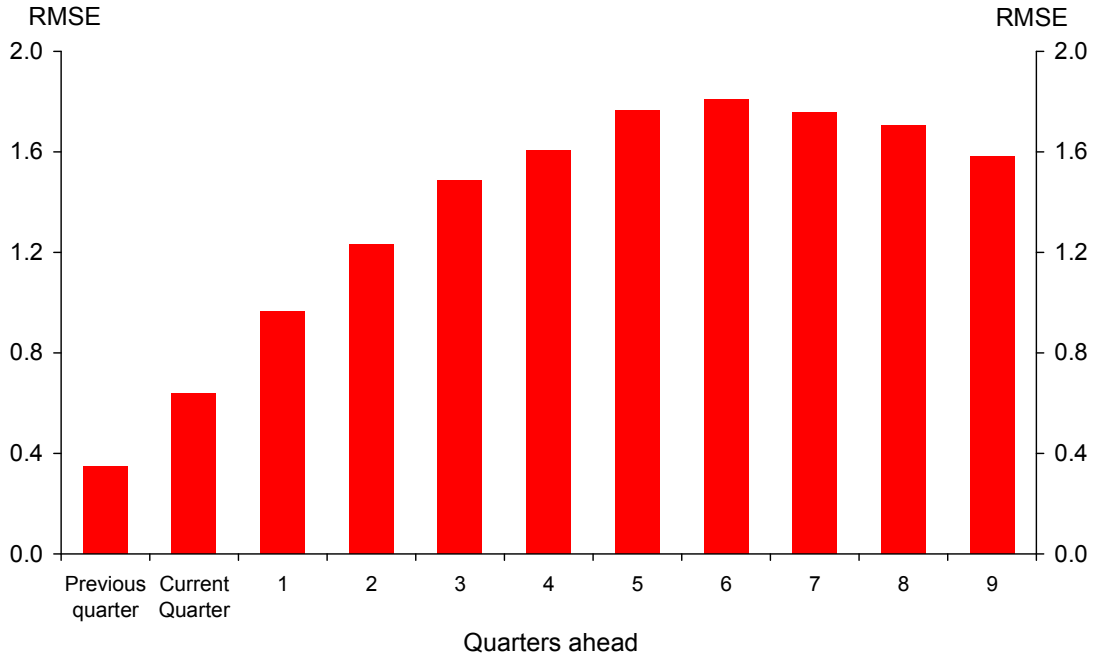


Table 3.1
GDPP growth forecast errors statistics (AAPC) for the Reserve Bank (March 1993 to June 2001)

Quarters ahead	Mean Errors	RMSE	Observations
Previous Quarter	-0.10	0.35	31
Current Quarter	-0.19	0.64	30
1	-0.28	0.97	29
2	-0.34	1.23	28
3	-0.33	1.49	27
4	-0.23	1.61	26
5	0.01	1.77	25
6	0.24	1.81	24
7	0.63	1.76	22
8	0.80	1.71	21
9	1.06**	1.58	18

Notes:
Asterisks indicate the significance with which the null hypothesis: Mean Error = 0 can be rejected:
*** = Significant at the 1 per cent level
** = Significant at the 5 per cent level
* = Significant at the 10 per cent level

3.2 Comparison of the Reserve Bank GDPP forecasting performance to external forecasters

Summary statistics (including the mean error and RMSE) comparing the Reserve Bank's forecast errors for annual average GDPP growth to those from external forecasters are presented in appendix 2.

Our pairwise comparison of forecasters indicates that no forecaster performs significantly better or worse than the Reserve Bank in terms of bias at any of the forecast horizons considered. However, as with our examination on inflation forecast errors, the limited number of observations available for some forecasters makes it difficult to determine whether a significant difference exists between organisations.

When compared to most external forecasters, the size of the Reserve Bank's forecast errors tends to be similar or lower at all the forecast horizons considered. We note that 6 to 8 quarters ahead the size of our forecast errors (as measured by MAE) has been significantly smaller than those from the Treasury.[25] However, there is no significant difference between the mean errors from the Reserve Bank and the Treasury at any horizon.[26]

We also compare the Reserve Bank's forecast errors simultaneously to those from the National Bank of New Zealand, the NZIER and the Treasury over the sample period December 1994 to June 2002. Again we stress that caution is needed when interpreting these findings due to the limited number of observations from some forecasters at particular horizons. In terms of bias the Reserve Bank performs well at all horizons when compared to external forecasters. When we consider the size of our forecast errors, we find that the Reserve Bank's performance is similar to that of the median external forecaster at each horizon (however, we note that the forecasts from the National Bank of New Zealand contain a similar level of bias to our own, but their forecast errors tend to be smaller in the medium term).

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[25] This is for the sample period December 1994 to June 2002. Data used comparison when comparing the Treasury to the Reserve Bank differs from that published by the Treasury. The data used was obtained from the Treasury and is of a higher frequency than that which was published. The Treasury has not significantly under- or over predicted growth at any of the horizons considered.

[26] Forecasts of GDPP growth from the Treasury are not significantly biased at any of the horizons considered.

4 Conclusion

Consistent with our other research, we find that the Reserve Bank has tended to under-estimate annual target CPI inflation 3 to 10 quarters ahead. Our comparison of our inflation forecasting performance with that of external agencies is severely hampered by small sample sizes. However, our analysis indicates that, while our performance is not significantly different from that of most forecasting agencies, we have been outperformed (in terms of bias and size of forecast errors) by the NZIER and, to a lesser extent, the National Bank of New Zealand, at several forecasting horizons.

With regards to forecasts of GDPP growth, the Reserve Bank's forecasting performance is not significantly different from most of the forecasting agencies surveyed.

References

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Appendix 1: Comparison of the Reserve Bank's annual target inflation forecast errors to external forecasters: summary statistics

The tables below present summary statistics for the forecasting performance of the Reserve Bank relative to individual forecasting agencies. These figures are calculated using a matched observation approach. This means that when constructing each data set we only include observations for those quarters when both the Reserve Bank and forecaster of interest produced forecasts. These tables only compare individual forecasters to the Reserve Bank and should not be used to make comparisons between forecasting agencies.

Caution is needed when interpreting the findings. In many cases there are relatively few comparable observations. In such cases, the findings may be highly susceptible to distortions due to events specific to particular sample periods. As a result, summary statistics based on a limited number of observations may not accurately represent forecasters' general performances.

Note that the dates refer to indicate to the final month of the relevant quarter, not the dates at which forecasts were prepared.

Table A1.1
Summary statistics for the Reserve Bank and the ANZ (September 1994 to March 2002)

Quarters ahead	RBNZ			ANZ			Difference in mean forecast errors	Observations
	Mean Forecast error	MAE	RMSE	Mean Forecast error	MAE	RMSE		
Current quarter	0.08	0.17	0.23	0.11	0.24	0.31	-0.03	16
1	0.19	0.38	0.46	0.19	0.44	0.54	0.01	16
2	0.04	0.31	0.37	0.16	0.50	0.59	-0.12	15
3	-0.16	0.44	0.61	0.19	0.52	0.63	-0.36	16
4	-0.33	0.68	0.81	0.03	0.58	0.65	-0.36	15
5	-0.53	0.87	1.05	-0.05	0.76	0.90	-0.47	14
6	-0.45	0.74	1.01	-0.24	0.67	0.98	-0.22	10

Notes:
Asterisks indicate the significance with which the null hypothesis:
Mean Forecast Error (Reserve Bank) = Mean Forecast Error (External forecaster) can be rejected.
*** = Significant at the 1 per cent level
** = Significant at the 5 per cent level
* = Significant at the 10 per cent level

Table A1.2
Summary statistics for the Reserve Bank and BERL (September 1995 to June 2002)

Quarters ahead	RBNZ			BERL			Difference in mean forecast errors	Observations
	Mean Forecast error	MAE	RMSE	Mean Forecast error	MAE	RMSE		
Current quarter	0.02	0.18	0.25	-0.10	0.29	0.34	0.12	21
1	-0.05	0.33	0.49	-0.18	0.39	0.49	0.12	20
2	-0.13	0.41	0.62	-0.27	0.51	0.67	0.14	18
3	-0.22	0.53	0.66	-0.24	0.51	0.65	0.01	17
4	-0.36	0.71	0.80	-0.29	0.49	0.68	-0.07	17
5	-0.50	0.73	0.85	-0.27	0.48	0.66	-0.23	14
6	-1.01	1.01	1.23	-0.51	0.69	0.93	-0.50	9

Notes:
Asterisks indicate the significance with which the null hypothesis:
Mean Forecast Error (Reserve Bank) = Mean Forecast Error (External forecaster) can be rejected.

*** = Significant at the 1 per cent level
** = Significant at the 5 per cent level
* = Significant at the 10 per cent level
Forecast errors for the 2 quarter ahead horizon are not normally distributed. For this horizon we test the null hypothesis: Median Forecast Error (Reserve Bank) = Median Forecast Error (External forecaster).

Due to changes in the measurement of the CPI, we exclude BERL's published forecasts for September 1999, December 1999 and March 2000 from our examination of target CPI. This is done to ensure that only comparable series are included in our analysis.

Table A1.3
Summary statistics for the Reserve Bank and the Bank of New Zealand (September 1997 to June 2002)

Quarters ahead	RBNZ			BNZ			Difference in mean forecast errors	Observations
	Mean Forecast error	MAE	RMSE	Mean Forecast error	MAE	RMSE		
Current quarter	0.25	0.29	0.42	0.09	0.31	0.39	0.16	8
1	0.25	0.51	0.63	-0.05	0.36	0.58	0.30	9
2	-0.20	0.48	0.80	-0.29	0.57	0.66	0.09	8
3	-0.61	0.76	1.06	-0.60	0.74	0.89	-0.01	7
4	-0.51	0.96	1.17	-0.68	0.86	1.10	0.17	6

Notes:
Asterisks indicate the significance with which the null hypothesis:
Mean Forecast Error (Reserve Bank) = Mean Forecast Error (External forecaster) can be rejected.
*** = Significant at the 1 per cent level
** = Significant at the 5 per cent level
* = Significant at the 10 per cent level

Table A1.4
Summary statistics for the Reserve Bank and Infometrics (March 1993 to June 2002)

Quarters ahead	RBNZ			Infometrics			Difference in mean forecast errors	Observations
	Mean Forecast error	MAE	RMSE	Mean Forecast error	MAE	RMSE		
Current quarter	0.04	0.18	0.22	0.10	0.22	0.32	-0.07	25
1	-0.04	0.33	0.43	0.01	0.29	0.40	-0.05	25
2	-0.21	0.42	0.64	-0.08	0.47	0.61	-0.13	23
3	-0.32	0.51	0.73	-0.10	0.56	0.74	-0.23	24
4	-0.47	0.68	0.81	-0.22	0.64	0.82	-0.25	24
5	-0.61	0.77	0.88	-0.42	0.71	0.87	-0.18	23
6	-0.68	0.80	0.97	-0.56	0.84	1.02	-0.12	23
7	-0.75	0.84	1.02	-0.77	1.02	1.31	0.03	21
8	-0.95	0.96	1.17	-1.00	1.15	1.49	0.05	16
9	-0.99	0.99	1.15	-1.01	1.22	1.55	0.02	9

Notes:
Asterisks indicate the significance with which the null hypothesis:
Mean Forecast Error (Reserve Bank) = Mean Forecast Error (External forecaster) can be rejected.
*** = Significant at the 1 per cent level
** = Significant at the 5 per cent level
* = Significant at the 10 per cent level
Forecast errors for the 2 quarter ahead horizon are not normally distributed. For this horizon we test the null hypothesis: Median Forecast Error (Reserve Bank) = Median Forecast Error (External forecaster).

Table A1.5
Summary statistics for the Reserve Bank and the National Bank of New Zealand (September 1992 to June 2002)

Quarters ahead	RBNZ			NBNZ			Difference in mean forecast errors	Observations
	Mean Forecast error	MAE	RMSE	Mean Forecast error	MAE	RMSE		
Current quarter	0.03	0.17	0.25	0.00	0.17	0.23	0.03	40
1	-0.02	0.31	0.43	-0.11	0.31	0.40	0.09	39
2	-0.15	0.36	0.54	-0.28	0.44	0.56	0.13	38
3	-0.33	0.47	0.65	-0.48	0.56	0.72	0.15	37
4	-0.54	0.71	0.86	-0.61	0.67	0.84	0.08	36
5	-0.66	0.81	0.97	-0.65	0.72	0.87	-0.01	35
6	-0.72	0.81	0.98	-0.62	0.68	0.84	-0.10	33
7	-0.77	0.83	1.00	-0.55	0.62	0.81	-0.23	31
8	-0.83	0.84	1.02	-0.50	0.60	0.75	-0.34*	29
9	-0.82	0.82	1.01	-0.45	0.58	0.70	-0.38*	26
10	-0.87	0.87	1.00	-0.49	0.55	0.73	-0.38**	17

Notes:
Asterisks indicate the significance with which the null hypothesis:
Mean Forecast Error (Reserve Bank) = Mean Forecast Error (External forecaster) can be rejected.
*** = Significant at the 1 per cent level
** = Significant at the 5 per cent level
* = Significant at the 10 per cent level
Forecast errors for the current quarter and 2, 3, 8 and 9 quarters ahead horizons are not normally distributed. For these horizons we test the null hypothesis: Median Forecast Error (Reserve Bank) = Median Forecast Error (External forecaster).

Table A1.6
Summary statistics for the Reserve Bank and the NZIER (June 1995 to June 2002)

Quarters ahead	RBNZ			NZIER			Difference in mean forecast errors	Observations
	Mean Forecast error	MAE	RMSE	Mean Forecast error	MAE	RMSE		
Current quarter	0.06	0.19	0.28	0.00	0.33	0.42	0.06	28
1	0.02	0.37	0.50	-0.06	0.50	0.62	0.08	26
2	-0.17	0.42	0.63	-0.22	0.54	0.68	0.05	24
3	-0.40	0.59	0.77	-0.26	0.55	0.69	-0.15	23
4	-0.72	0.90	1.02	-0.25	0.61	0.73	-0.47**	21
5	-0.91	0.97	1.12	-0.15	0.52	0.69	-0.76***	19
6	-0.88	0.88	1.02	-0.05	0.30	0.40	-0.83***	16
7	-0.85	0.86	1.01	0.06	0.46	0.55	-0.92***	15
8	-0.73	0.73	0.88	-0.03	0.42	0.50	-0.70 ***	11
9	-0.70	0.70	0.91	-0.09	0.55	0.64	-0.61*	8

Notes:
Asterisks indicate the significance with which the null hypothesis:
Mean Forecast Error (Reserve Bank) = Mean Forecast Error (External forecaster) can be rejected.
*** = Significant at the 1 per cent level
** = Significant at the 5 per cent level
* = Significant at the 10 per cent level
Forecast errors for the current quarter and 2 quarters ahead horizon are not normally distributed. For these horizons we test the null hypothesis: Median Forecast Error (Reserve Bank) = Median Forecast Error (External forecaster).

Table A1.7
Summary statistics for the Reserve Bank and the Treasury (June 1994 to June 2002)

Quarters ahead	RBNZ			Treasury			Difference in mean forecast errors	Observations
	Mean Forecast error	MAE	RMSE	Mean Forecast error	MAE	RMSE		
Current quarter	-0.02	0.17	0.22	0.14	0.44	0.51	-0.16	4
1	0.06	0.49	0.62	0.13	0.48	0.54	-0.06	10
2	-0.77	0.89	1.18	-0.50	0.62	0.74	-0.28	5
3	-0.72	0.77	1.07	-0.72	0.72	0.96	0.00	7
4	-0.83	1.28	1.31	-0.56	0.85	0.89	-0.27	4
5	-0.76	0.84	0.95	-0.48	0.68	0.79	-0.28	9

Notes:
Asterisks indicate the significance with which the null hypothesis:
Mean Forecast Error (Reserve Bank) = Mean Forecast Error (External forecaster) can be rejected.
*** = Significant at the 1 per cent level
** = Significant at the 5 per cent level
* = Significant at the 10 per cent level

Table A1.8
Summary statistics for the Reserve Bank and Westpac (September 1995 to June 2002)

Quarters ahead	RBNZ			Westpac			Difference in mean forecast errors	Observations
	Mean Forecast error	MAE	RMSE	Mean Forecast error	MAE	RMSE		
Current quarter	0.13	0.16	0.19	0.16	0.19	0.23	-0.03	7
1	0.36	0.42	0.54	0.20	0.48	0.55	0.16	7
2	-0.03	0.28	0.34	-0.02	0.21	0.27	0.00	7
3	-0.33	0.51	0.70	-0.14	0.43	0.51	-0.19	6
4	-0.55	0.85	0.94	-0.18	0.63	0.74	-0.37	6

Notes:
Asterisks indicate the significance with which the null hypothesis:
Mean Forecast Error (Reserve Bank) = Mean Forecast Error (External forecaster) can be rejected.
*** = Significant at the 1 per cent level
** = Significant at the 5 per cent level
* = Significant at the 10 per cent level

Appendix 2: Comparison of the Reserve Bank's GDPP growth (AAPC) forecast errors to external forecasters: summary statistics

The tables below present summary statistics for the annual average GDPP growth forecasting performance of the Reserve Bank relative to individual forecasting agencies. These figures are calculated using a matched observations approach. This means that when constructing each data set we include only observations for those quarters when both the Reserve Bank and forecaster of interest produced forecasts. These tables only compare individual forecasters to the Reserve Bank and should not be used to make comparisons between external forecasting agencies.

Caution is needed when interpreting the findings. In many cases there are relatively few comparable observations. In such cases, the findings may be highly susceptible to distortions due to events specific to particular sample periods. As a result, summary statistics based on a limited number of observations may not accurately represent forecasters' general performances.

Note that the dates referred to indicate to the final month of the relevant quarter, not the dates at which forecasts were prepared. Revised GDPP data (GDPP as it was measured in the following year) was used to calculate forecast errors. As a result, the latest quarter for which we have data is June 2001.

Table A2.1
Summary statistics for the Reserve Bank and the ANZ (December 1994 to June 2001)

Quarters ahead	RBNZ			ANZ			Difference in mean forecast errors	Observations
	Mean Forecast error	MAE	RMSE	Mean Forecast error	MAE	RMSE		
Previous quarter	0.01	0.38	0.43	0.00	0.38	0.42	0.01	7
Current quarter	-0.19	0.57	0.65	-0.21	0.53	0.64	0.02	7
1	-0.35	0.93	1.10	-0.29	0.81	1.14	-0.05	6
2	-0.36	0.70	0.85	-0.50	0.77	0.95	0.14	7
3	0.23	1.14	1.41	0.10	1.15	1.37	0.13	6
4	0.34	1.15	1.42	0.35	0.96	1.29	-0.01	6

Notes:
Asterisks indicate the significance with which the null hypothesis:
Mean Forecast Error (Reserve Bank) = Mean Forecast Error (External forecaster) can be rejected.
*** = Significant at the 1 per cent level
** = Significant at the 5 per cent level
* = Significant at the 10 per cent level

Table A2.2
Summary statistics for the Reserve Bank and the Bank of New Zealand (June 1993 to March 2001)

Quarters ahead	RBNZ			BNZ			Difference in mean forecast errors	Observations
	Mean Forecast error	MAE	RMSE	Mean Forecast error	MAE	RMSE		
Previous quarter	-0.19	0.25	0.33	-0.30	0.36	0.42	0.11	11
Current quarter	-0.26	0.51	0.62	-0.61	0.70	0.79	0.35	9
1	-0.24	0.94	1.16	-0.87	0.89	1.10	0.63	10
2	0.07	0.82	1.06	-0.54	0.97	1.13	0.61	8
3	-0.48	1.19	1.45	-0.49	1.30	1.57	0.01	10
4	-0.08	0.94	1.31	0.36	1.34	1.58	-0.43	8
5	-0.19	1.37	1.92	-0.06	1.40	1.77	-0.13	8
6	0.14	1.06	1.57	1.32	1.43	1.93	-1.18	6
7	0.01	1.18	1.88	0.35	1.75	2.21	-0.34	8

Notes:
Asterisks indicate the significance with which the null hypothesis:
Mean Forecast Error (Reserve Bank) = Mean Forecast Error (External forecaster) can be rejected.
*** = Significant at the 1 per cent level
** = Significant at the 5 per cent level
* = Significant at the 10 per cent level

Table A2.3
Summary statistics for the Reserve Bank and Infometrics (December 1996 to June 2001)

Quarters ahead	RBNZ			Infometrics			Difference in mean forecast errors	Observations
	Mean Forecast error	MAE	RMSE	Mean Forecast error	MAE	RMSE		
Previous quarter	-0.11	0.33	0.36	-0.37	0.58	0.60	0.26	5
Current quarter	-0.39	0.61	0.68	-0.59	0.84	0.97	0.21	5
1	-0.78	0.98	1.16	-0.57	1.04	1.19	-0.20	5
2	-	-	-	-	-	-	-	-
3	0.60	1.45	1.68	0.51	0.87	1.27	0.09	4
4	0.72	1.52	1.71	0.71	1.73	2.04	0.01	4

Notes:
Asterisks indicate the significance with which the null hypothesis:
Mean Forecast Error (Reserve Bank) = Mean Forecast Error (External forecaster) can be rejected.
*** = Significant at the 1 per cent level
** = Significant at the 5 per cent level
* = Significant at the 10 per cent level

Table A2.4
Summary statistics for the Reserve Bank and the National Bank of New Zealand (December 1993 to June 2001)

Quarters ahead	RBNZ			NBNZ			Difference in mean forecast errors	Observations
	Mean Forecast error	MAE	RMSE	Mean Forecast error	MAE	RMSE		
Previous quarter	-0.15	0.28	0.33	-0.11	0.31	0.37	-0.04	17
Current quarter	-0.18	0.58	0.68	-0.14	0.52	0.65	-0.04	17
1	-0.32	0.79	0.99	-0.27	0.76	0.95	-0.05	16
2	-0.40	0.98	1.20	-0.22	0.79	0.98	-0.18	14
3	-0.55	0.87	1.12	-0.20	0.57	0.67	-0.35	12
4	-0.26	1.06	1.32	0.13	0.80	1.01	-0.39	12
5	0.00	1.03	1.39	0.46	1.00	1.29	-0.46	10
6	0.44	0.95	1.52	0.64	1.09	1.46	-0.20	8

Notes:
Asterisks indicate the significance with which the null hypothesis:
Mean Forecast Error (Reserve Bank) = Mean Forecast Error (External forecaster) can be rejected.
*** = Significant at the 1 per cent level
** = Significant at the 5 per cent level
* = Significant at the 10 per cent level

Table A2.5
Summary statistics for the Reserve Bank and the NZIER (September 1993 to June 2001)

Quarters ahead	RBNZ			NZIER			Difference in mean forecast errors	Observations
	Mean Forecast error	MAE	RMSE	Mean Forecast error	MAE	RMSE		
Previous quarter	-0.10	0.28	0.35	-0.15	0.36	0.42	0.05	31
Current quarter	-0.19	0.54	0.64	-0.31	0.55	0.65	0.11	30
1	-0.28	0.77	0.97	-0.45	0.75	0.95	0.17	29
2	-0.34	1.01	1.23	-0.49	0.93	1.22	0.15	28
3	-0.33	1.17	1.49	-0.33	1.02	1.35	0.01	27
4	-0.23	1.28	1.61	-0.06	1.24	1.54	-0.17	26
5	0.01	1.35	1.77	0.20	1.41	1.73	-0.20	25
6	0.24	1.31	1.81	0.44	1.60	1.95	-0.20	24
7	0.63	1.19	1.76	0.80	1.68	2.09	-0.17	22
8	0.68	1.20	1.65	0.70	1.67	2.13	-0.01	18
9	0.78	1.18	1.39	0.75	1.43	1.87	0.03	12

Notes:
Asterisks indicate the significance with which the null hypothesis:
Mean Forecast Error (Reserve Bank) = Mean Forecast Error (External forecaster) can be rejected.
*** = Significant at the 1 per cent level
** = Significant at the 5 per cent level
* = Significant at the 10 per cent level

Table A2.6
Summary statistics for the Reserve Bank and the Treasury (December 1994 to June 2001)

Quarters ahead	RBNZ			Treasury			Difference in mean forecast errors	Observations
	Mean Forecast error	MAE	RMSE	Mean Forecast error	MAE	RMSE		
Previous quarter	-0.10	0.28	0.32	-0.15	0.31	0.34	0.05	16
Current quarter	-0.10	0.51	0.64	-0.17	0.46	0.61	0.07	15
1	-0.20	0.71	0.91	-0.22	0.64	0.90	0.02	15
2	-0.13	0.97	1.16	-0.05	0.93	1.26	-0.08	14
3	-0.03	1.01	1.26	0.22	1.09	1.44	-0.25	14
4	-0.01	0.99	1.31	0.48	1.38	1.78	-0.49	13
5	0.29	1.06	1.37	0.77	1.65	1.95	-0.48	13
6	0.41	1.01	1.45	0.97	1.91	2.25	-0.56	12
7	0.71	1.08	1.49	1.10	2.07	2.33	-0.38	12
8	0.93	1.14	1.56	1.18	2.04	2.38	-0.25	11
9	1.10	1.34	1.57	1.28	1.82	2.24	-0.17	11

Notes:
Asterisks indicate the significance with which the null hypothesis:
Mean Forecast Error (Reserve Bank) = Mean Forecast Error (External forecaster) can be rejected.
*** = Significant at the 1 per cent level
** = Significant at the 5 per cent level
* = Significant at the 10 per cent level

Data used comparison when comparing the Treasury to the Reserve Bank differs from that published by the Treasury. The data used was obtained from the Treasury and is of a higher frequency than that which was published.

Table A2.7
Summary statistics for the Reserve Bank and Westpac (March 1995 to June 2001)

Quarters ahead	RBNZ			Westpac			Difference in mean forecast errors	Observations
	Mean Forecast error	MAE	RMSE	Mean Forecast error	MAE	RMSE		
Previous quarter	-0.13	0.29	0.32	-0.16	0.31	0.32	0.03	7
Current quarter	-0.30	0.57	0.63	-0.28	0.56	0.61	-0.01	7
1	-0.71	0.88	1.07	-0.66	0.77	0.98	-0.06	6
2	-0.38	0.57	0.76	-0.41	0.84	1.04	0.03	6
3	0.29	1.08	1.39	0.03	1.00	1.27	0.26	6
4	0.39	1.21	1.45	0.64	1.25	1.49	-0.25	6

Notes:
Asterisks indicate the significance with which the null hypothesis:
Mean Forecast Error (Reserve Bank) = Mean Forecast Error (External forecaster) can be rejected.
*** = Significant at the 1 per cent level
** = Significant at the 5 per cent level
* = Significant at the 10 per cent level