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Assessing forecast performance

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Assessing the accuracy of macroeconomic forecasts is critical to identifying opportunities to improve macroeconomic advice. For example, revealing and then removing bias – from either persistently under- or over-estimating economic activity – would allow a policymaker to better assess the state of the economy, improving monetary (and fiscal) policy. Policy might also be improved by incorporating the beliefs of forecasters with a good track record.

So it is perhaps not surprising that central banks often seek review of their own forecast performance, often against the forecasts of other agencies and private sector firms.² The Reserve Bank's past reviews include:

- McCaw and Ranchhod (2002) who found that the Reserve Bank significantly under-predicted inflation from December 1995 to September 2002 while forecasts of GDP growth were unbiased;
- Turner (2006) who found that during 2003 to 2005 the Reserve Bank's forecasts performed in line with the average

of Consensus forecasts, underpredicting growth in 2003 and 2004, and then overpredicting growth in 2005;

- Labbe and Pepper (2009) who compared the performance of the Reserve Bank to a range of external forecasts from March 2003 to December 2008 – the start of the fallout from the Global Financial Crisis (GFC). They found that external forecasters did reasonably well but the Reserve Bank of New Zealand outperformed others on forecasting GDP growth and the exchange rate. No forecaster predicted how far interest rates would fall after the GFC.

This report documents the performance of the Reserve Bank of New Zealand's forecasts during 2009 to 2015. The New Zealand Institute of Economic Research (NZIER) was asked to evaluate performance using the methodology in Labbe and Pepper (2009), as this allows for comparison of performance across the 2003 to 2008 period and the period since 2009.

Labbe and Pepper (2009) compare the Reserve Bank's performance to forecasts from independent forecasters (including private banks) collected by the Reserve Bank to help inform monetary policy deliberations over the sample period. Section 1 describes the forecasts – and forecasters – in more detail, while section 2 is a brief overview of macroeconomic conditions over the period.

¹ Dr Lees wrote this article while at NZIER, under a contract from the Reserve Bank of New Zealand. The data on which the study is based were provided by the Reserve Bank of New Zealand.

² See for example Andersson et al. (2007) on the Swedish central bank, European Central Bank (2013) on the ECB and the recent and extensive forecast review at the Bank of England (Independent Evaluation Office 2015). Other institutions also review forecast performance, including the New Zealand Treasury (Goh and Lawrence 2006), the IMF (Timmermann 2006) and the OECD (Pain et al. 2014).

We outline the methodology of evaluating forecast performance in section 3 before presenting key results in section 4. We restrict ourselves to brief concluding comments in section 5.

1 The forecasts

The sample of forecasters

The forecasts used in this assessment were collected by the Reserve Bank, from their own published forecasts and external forecasters for the period March 2009 to September 2015.

Most forecasters had access to a similar dataset when they reported forecasts to the Reserve Bank, 2-3 weeks before the Reserve Bank preparing the *Monetary Policy Statement*.

There are some exceptions. These include the NZIER who typically release forecasts in the weeks prior to the Reserve Bank's *Monetary Policy Statement*. The Treasury's forecasts are closely aligned to a six-monthly cycle determined by the Budget Economic and Fiscal Update and Half-yearly Economic and Fiscal Update reports, rather than a quarterly cycle.

Some forecasters do not provide a set of forecasts that spans the entire sample. We use a rule of thumb that forecasters need to have provided at least 10 forecasts. We also informally test whether differences in performance among forecasters might stem from differences in the number of forecasts submitted. Table 1 lists the 13 external forecasters that form our test sample.

Table 1
External forecasters

Forecaster	Number of one-year ahead inflation forecasts (out of 17)
First New Zealand Capital	13
Bank of New Zealand	17
UBS Warburg	17
Deutsche Bank	16
AMP	14
Goldman Sachs	14
ANZ	17
JP Morgan	16
Treasury	16
ASB	17
Westpac	17
Infometrics	17
NZIER	14

Source: RBNZ, NZIER.

We examine the performance of the 13 external forecasting agencies as well as the Reserve Bank. We also examine the median of the external forecasters and a weighted average, where external forecasts are combined with weights based on each forecaster's historical errors.

The motivation for this type of forecast combination comes from Bates and Granger (1969), who argue that it often leads to more accurate forecasts than a simple average. However, this alternative weighted average did not outperform the simple average and consequently it is not reported. This poor performance is perhaps due to the small sample size and low frequency of re-weighting.

The data

For historical reasons, assessment of macroeconomic forecasts in New Zealand has tended to ask for and report against actual observations for only the March quarter of each year. Using the standard nomenclature, this means that a “one-year ahead” forecast has varied from a one quarter ahead forecast of March data made in December to a full one-year ahead forecast made in March (see table 2). This is the approach taken in Labbe and Pepper (2009).³

Rather than continue to tie each forecast to a March year, in 2011 the Reserve Bank changed its survey, and began to ask external forecasters each quarter for one- and two-year ahead forecasts rather March year forecasts for the current and subsequent March years.

We have chosen to use the set of one-year ahead forecasts each quarter from December 2011, augmented with the full one-year ahead forecasts made in the March 2009, 2010 and 2011 quarters. That gives us a maximum of 17 observations on each forecaster against which we compare the Reserve Bank’s forecast performance.

We examine performance for the same variables as Labbe and Pepper (2009): one- and two-year ahead forecasts for real GDP growth (annual average percentage change), inflation (annual percentage change in the Consumers’ Price Index (CPI)), interest rates (annual average of the 90-day rate) and the exchange rate (annual average of the Trade Weighted Index (TWI)). These four key variables are listed in the Policy Targets Agreement and could be considered critical for understanding the dynamics of the New Zealand economy.

³ Similar issues pervade other comparisons of macroeconomic forecasts. For example, Bauer et al. (2003) test the performance of blue-chip forecasters in the US that report against calendar years each quarter.

Table 2
Horizons used in historical forecast comparisons

GDP growth example

Date forecast made	One-year ahead outturn	Actual forecast horizon	Two-year ahead outturn	Actual forecast horizon
Mar-09	Mar-10	4 quarters	Mar-11	8 quarters
Jun-09	Mar-10	3 quarters	Mar-11	7 quarters
Sep-09	Mar-10	2 quarters	Mar-11	6 quarters
Dec-09	Mar-10	1 quarters	Mar-11	5 quarters
Mar-10	Mar-11	4 quarters	Mar-12	8 quarters

Source: NZIER

2 Recent economic conditions

Figures 1-4 show the evolution of the key macroeconomic variables. The shaded grey area denotes the time period over which we assess the forecasts.

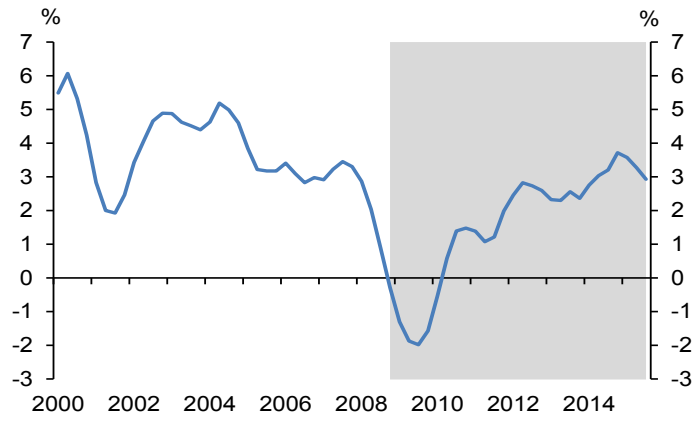
One of the key features of this review period – March 2009 to September 2015 – is the marked decline in inflation (see figure 2) despite no pronounced fall in economic growth (see figure 1).

Across the period, an increase in GST had a material impact on annual inflation. For example, inflation spiked at 5.3 percent in June 2011, but if the impact of GST is stripped out, the annual rate was 3.3 percent.⁴

Interest rates were relatively low and flat over the sample period, not just in New Zealand, but across the globe. Over the period, the Official Cash

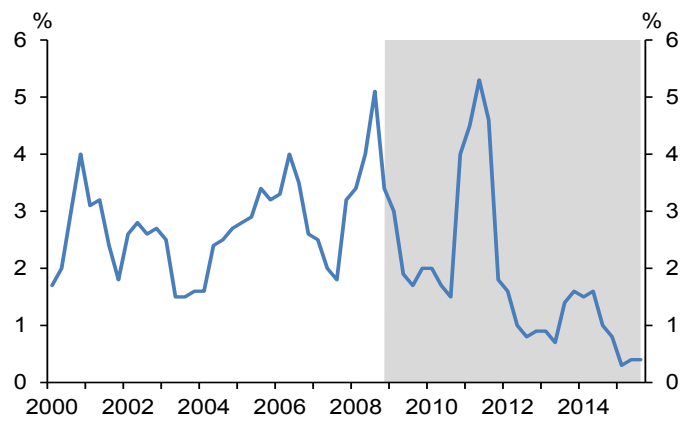
⁴ See Statistics New Zealand (2011), Consumer price index release for June 2011.

Figure 1
GDP growth
(annual average percent change)



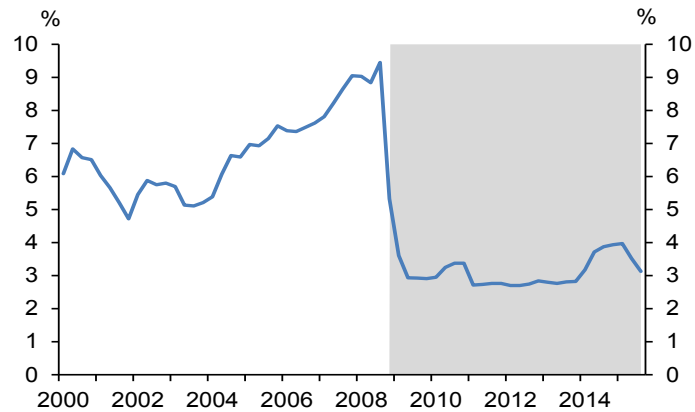
Source: Statistics New Zealand.

Figure 2
CPI inflation
(annual)



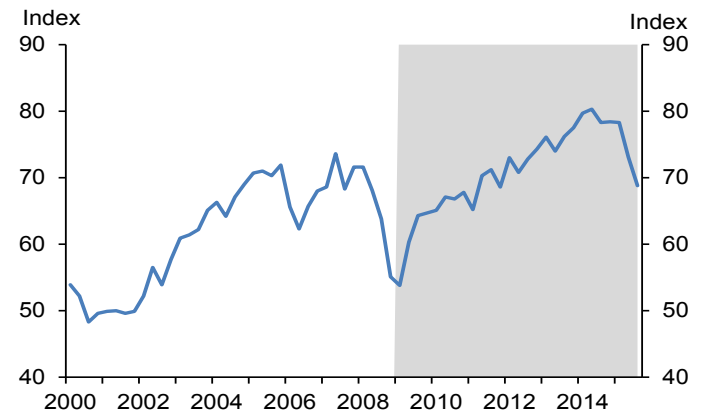
Source: Thomson Reuters.

Figure 3
90-day interest rate



Source: Thomson Reuters.

Figure 4
Nominal TWI



Source: Thomson Reuters.

Rate (OCR) was much lower than historically, translating into materially lower short-term interest rates. The OCR was lowered to 2.5 percent following the GFC but was raised twice in June and July of 2010.

The OCR was again lowered to 2.5 percent in March 2011, after the second major earthquake in Christchurch. The Reserve Bank said at the time:

We expect that the current monetary policy accommodation will need to be removed once the rebuilding phase materialises. This will take some time. For now we have acted pre-emptively in reducing the OCR to lessen the economic impact of the earthquake and guard against the risk of this impact becoming especially severe.

Governor Alan Bollard, Policy Assessment, March 2011 Monetary Policy Statement

The Christchurch earthquakes destroyed substantial residential, commercial and government infrastructure. Understanding the impact of the earthquake and the likely rebuild profile exercised macroeconomic forecasters across the period.⁵

Our analysis also includes a second period where the OCR was increased in 2014, and then reduced from June 2015.

The nominal exchange rate tended to drift up with an economy that performed better than many after the GFC. The New Zealand dollar trade-weighted index (TWI) reached a peak of 81.9 in July 2014 (using monthly data) but subsequently fell relatively sharply when the prices of some New Zealand commodities, dairy in particular, declined quickly.

⁵ See Wood, Noy and Parker (2016) for more on the economic effects of the earthquakes.

3 Methodology

There are a number of alternative methods for evaluating point forecasts such as the set of forecasts outlined in section 2. Ideally, forecast evaluation should penalise inaccurate forecasts based on how the forecasts are used.⁶ For example, under-predicting government revenue – that then requires raising debt or increasing taxes to meet current expenditure – might be more costly than over-predicting government revenue.⁷ In principle, evaluation criteria or a loss function that maps forecast errors into costs for the forecaster should reflect these characteristics.

In the case of the Reserve Bank, monetary policy needs to keep future inflation between 1 and 3 percent on average over the medium term. Within that target and time horizon, the 2012 Policy Targets Agreement also requires focussing on keeping future average inflation close to the 2 percent midpoint of the target band.

In that context, we think the Reserve Bank's forecast loss function can be approximated by a symmetric loss function. Such a loss function equally penalises upside surprises in macroeconomic variables – such as an increase in the exchange rate or economic growth relative to forecast – and downside surprises. Moreover, there are material reputational effects that accrue from forecast accuracy that support applying a symmetric loss function.

⁶ See Elliott and Timmermann (2008) for example.

⁷ See Krol (2013) for example.

We use the Root Mean-Squared Error (RMSE) to measure forecast accuracy – the size of forecast errors – that is:

$$RMSE = \sqrt{\frac{\sum_{i=1}^n (y_i^f - y_i)^2}{n}}$$

where y_i^f is the forecast and y_i is the actual value of the macroeconomic variable, while n is the number of forecasts for evaluation.

We also test for bias using the mean of the forecast errors (MFE):

$$MFE = \frac{\sum_{i=1}^n (y_i^f - y_i)}{n}$$

Table 3
Stylised example of bias and RMSE for two hypothetical cases
Inflation

	Forecaster number one				Forecaster number two			
Year	Forecast	Target	Error	Error ²	Forecast	Target	Error	Error ²
2012	2	2	0	0	1	2	-1	1
2013	2	2	0	0	1	2	-1	1
2014	5	2	3	9	1	2	-1	1
Sum Error			3				-3	
Bias			1				-1	
Sum. Error ²				9				3
Ave. Error ²				3				1
RMSE				1.732				1

Source: NZIER

Erratum: This corrects the figures in Forecaster No. 2 error column.

This benchmark is widely used and is consistent with previous evaluation of the Reserve Bank's forecast performance. One effect of using the RMSE criterion is that large forecast errors are weighted relatively heavily. Table 3 shows a stylised calculation of bias and RMSE for two hypothetical forecasters. Note that the RMSE returns a larger value for the case of a forecaster that makes a single large error compared to a forecaster that makes a sequence of smaller errors.

It is worth noting we are working with a relatively small sample – essentially five years of forecasts. Normally, to evaluate the significance of any forecast performance, we would use the Diebold and Mariano statistic.⁸ However, here we have a very small sample which means we would reject the null hypothesis of equal forecast accuracy too frequently (see Harvey, Leybourne, and Newbold (1997) and Clark (1999)). As such we refrain from testing for the statistical significance of forecasting performance.

8 See Diebold and Mariano (1995).

Finally, we calculate an aggregate measure of forecast performance. Our measure equally weights performance across inflation, economic growth, the exchange rate and interest rates. Since forecasting the exchange rate is materially more difficult than forecasting other variables, we weight each forecaster's performance on each variable relative to the average RMSE recorded on a variable-by-variable basis. Alternative weighting schemes, such as weighting inflation more highly than other variables, return different rankings.

4 Results

We report results for both the one-year and two-year ahead forecasts that compare external forecasters to the Reserve Bank's forecasts for GDP growth, inflation, interest rates and the nominal exchange rate. We present the results in figures 5 to 12 and we represent the same information in tables 4 to 7 in the appendix. We use letters to denote the forecasters, retaining the convention across all our charts.

GDP growth

Tracking growth in output is central to managing the economy. Figure 5 ranks macroeconomic forecasters according to their one-year ahead forecast performance. The red bars show forecaster 'B' was the most accurate forecaster at the one-year ahead horizon and the Reserve Bank was fourth relative to the other forecasters and ahead of the median forecast. Forecasting performance declines at the two-year horizon (light blue bars). Forecaster 'B' has materially fewer forecasts than others in

the sample so some of this good performance is likely to be linked to the period in question. Figure 6 shows mean forecast errors. There is no evidence of bias in the Reserve Bank's one-year ahead forecasts but the mean two-year ahead error is relatively high at 0.48.

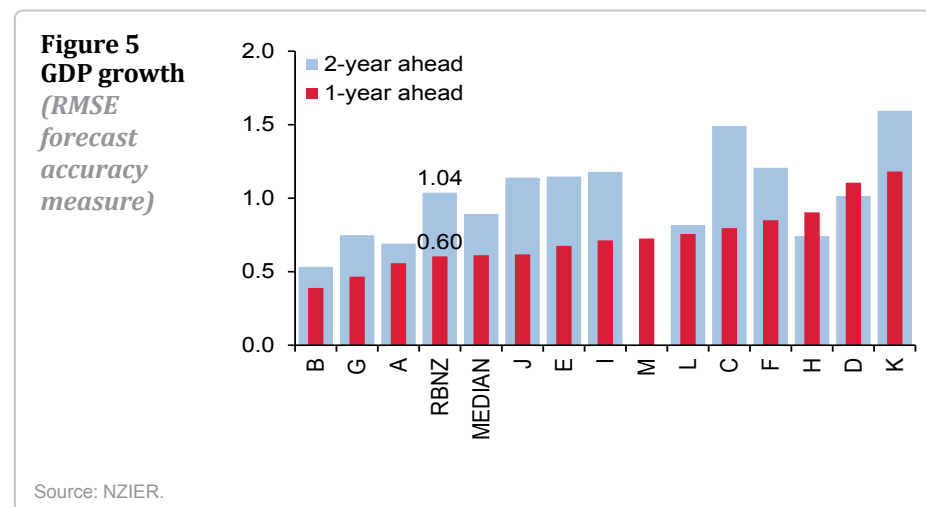
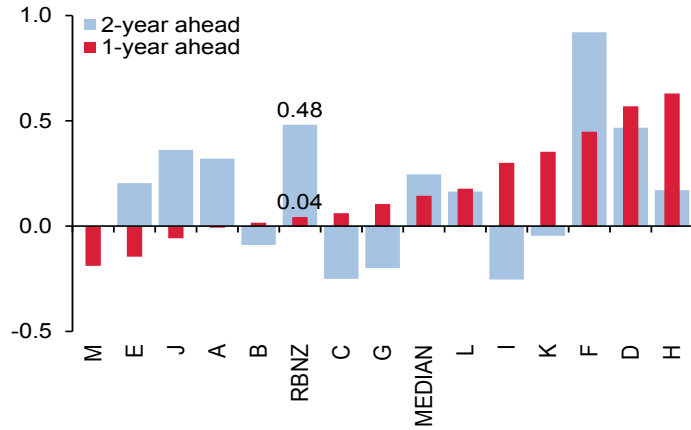
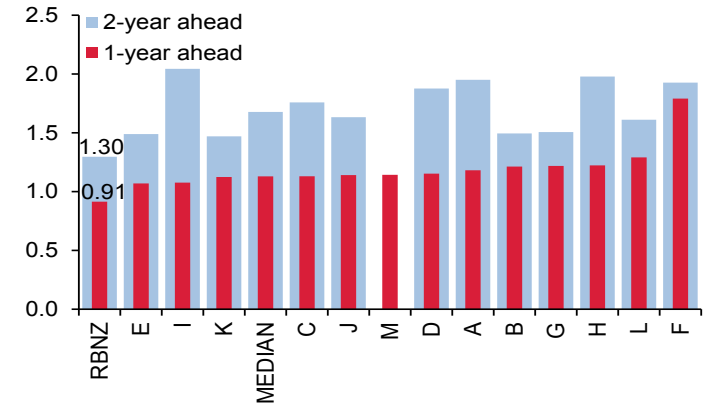


Figure 6
GDP growth
(MFE forecast bias measure)



Source: NZIER.

Figure 7
Annual CPI inflation
(RMSE forecast accuracy measure)



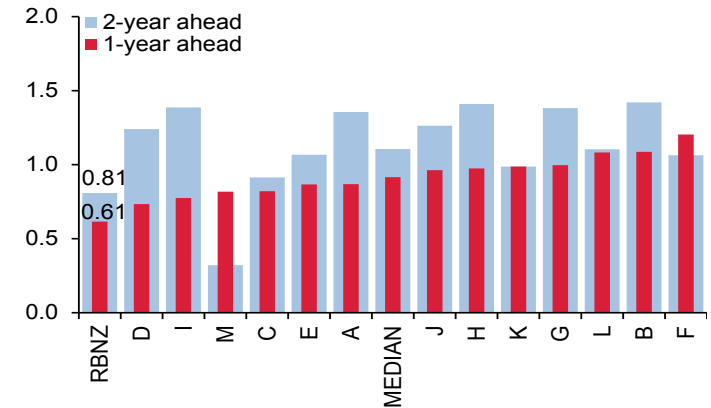
Source: NZIER.

Inflation

Figure 7 shows the Reserve Bank returned the best forecast performance over the period with regard to inflation. On the one-year ahead method, the RMSE for the Reserve Bank was 0.91 while the next best forecaster recorded a score of 1.07. The Reserve Bank also performed relatively well on the two-year ahead measure.

All forecasters over-estimated the amount of inflation in the economy, but the bias for the Reserve Bank was slightly lower than other forecasters.

Figure 8
Annual CPI inflation
(MFE forecast bias measure)



Source: NZIER.

Exchange rate

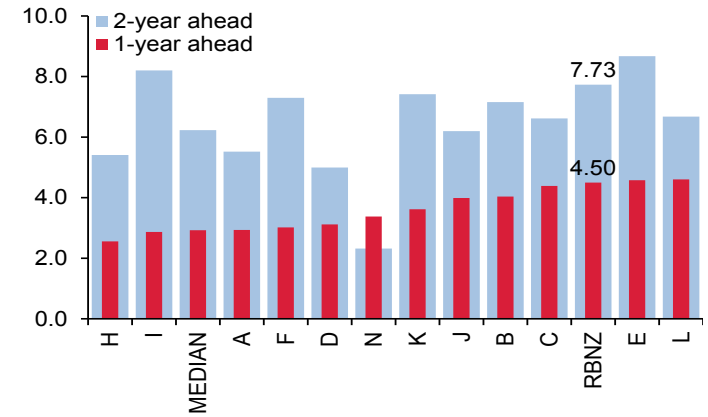
A long history of research has shown the exchange rate to be extremely difficult to forecast. Typically even very simple models, such as using last period's exchange rate value, prove impossible for macroeconomic forecasters to beat (see Kilian and Taylor 2003 on this point). So the materially worse performance of all forecasters on the exchange rate than on other variables is perhaps to be expected.

The Reserve Bank does relatively poorly compared to other macroeconomic forecasters and is 10th of 12 forecasters over the period. Given the Reserve Bank topped the exchange rate forecasting performance in the five-year period to 2008 in the Labbe and Pepper (2009) study, it would be worth looking closely at any changes – if any – in the way the exchange rate is forecast.

Given it is extremely difficult to forecast the exchange rate, small differences in information about the current level of the exchange rate – even if only a small number of days – might cloud interpretation of the results. For example, if it takes a week for the Reserve Bank to collect external forecasts and then finalise a forecast, that time period may be sufficient to improve relative performance.

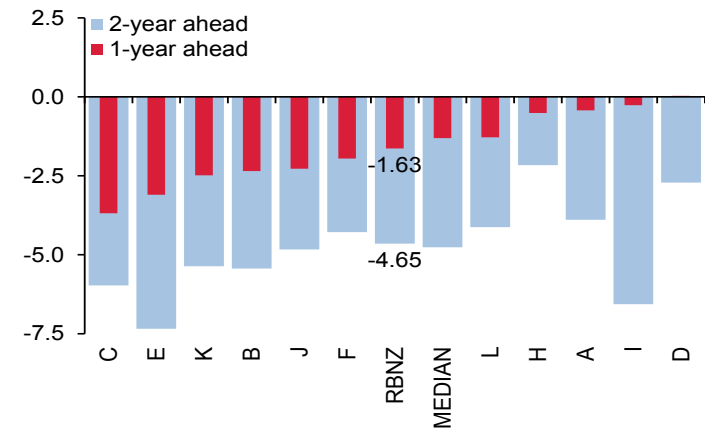
Figure 10 shows that all forecasters under-estimated the exchange rate, persistently expecting an exchange rate depreciation that never arrived. This pattern is also observed from 2003 to 2008. All forecasters might find that adopting alternative exchange rate models would prove more useful for forecasting purposes.

Figure 9
Nominal TWI
(RMSE forecast accuracy measure)



Source: NZIER.

Figure 10
Nominal TWI
(MFE forecast bias measure)

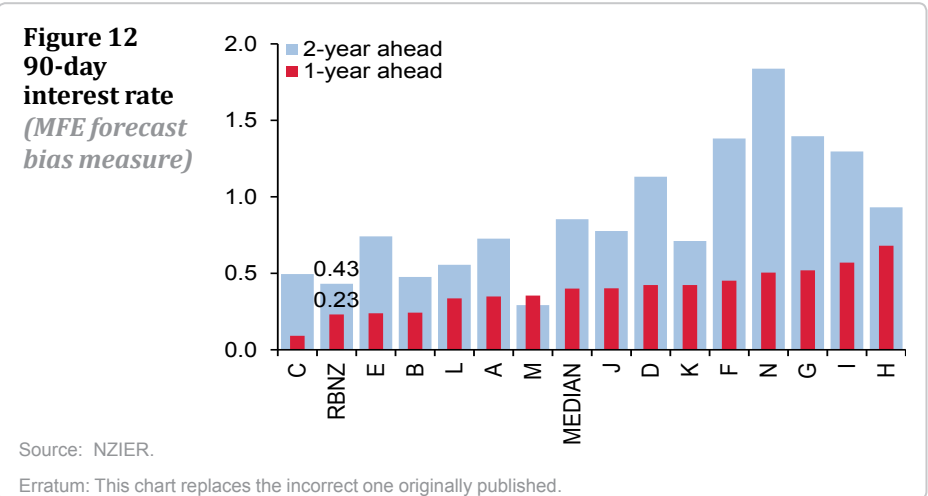
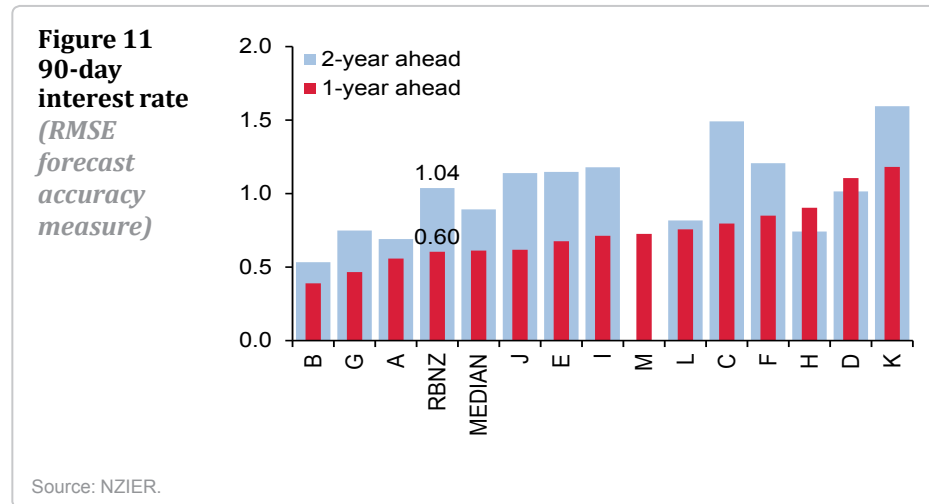


Source: NZIER.

Interest rates

Even though the Reserve Bank sets the OCR, Goodhart and Lim (2011) show the Reserve Bank’s projection for the 90-day interest rate may differ from the actual outcome. The Reserve Bank’s interest rate projection represents the monetary policy path required for the Bank to achieve its inflation objective, based on information available at the time. As such, the interest rate projection may be revised in response to an ever-evolving macroeconomic outlook, which results in forecast errors.

Figure 11 shows that the Reserve Bank performed relatively well, outperforming most forecasters and the median forecast. Figure 12 reveals that all the forecasters expected interest rates to move higher and return to historical norms, and were surprised when this did not occur.

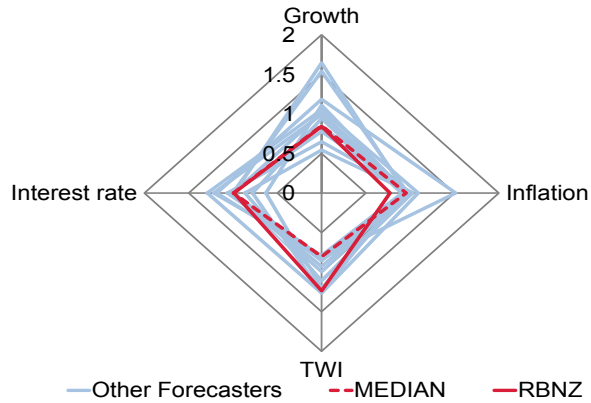


Our combined measure

To construct a combined measure that could be used to assess performance across all four measures, we normalise forecast performance to 1 across each of the four variables, ranking forecast performance relative to the average for each variable. Then we simply sum across each variable (GDP growth, inflation, the exchange rate and the interest rate), effectively weighting performance on each variable equally – a strong assumption given the primacy attached to inflation in the Policy Targets Agreement, which could suggest putting more weight on inflation.

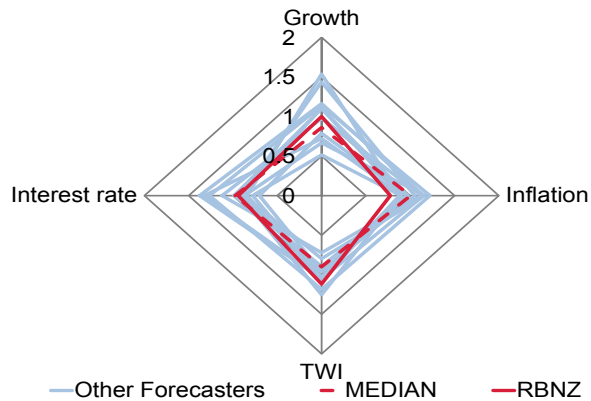
Figures 13 and 14 capture our measure for the one-year and two-year ahead forecasts respectively. The solid red line shows the average Reserve Bank performance relative to the other forecasters. Points closer to the middle of diagram – such as the Reserve Bank’s performance on one-year ahead inflation – show better performance.

Figure 13
1-year ahead
forecast
performance
(normalised
RMSE)



Source: NZIER.

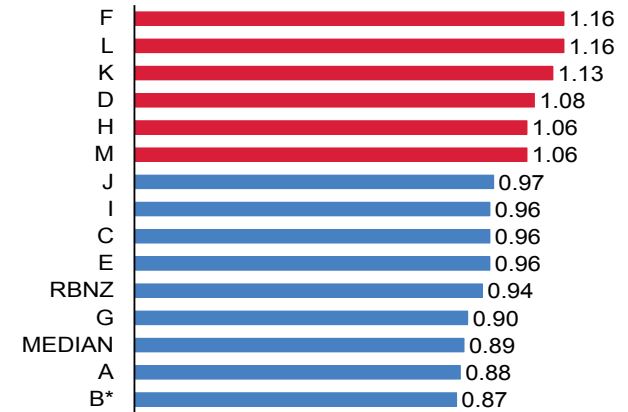
Figure 14
2-year ahead
forecast
performance
(normalised
RMSE)



Source: NZIER.

We graph our summary performance for one-year ahead and two-year ahead measures in figures 15 and 16. The Reserve Bank is the fourth-best forecaster at the one-year ahead horizon according to our measure. At the two-year ahead horizon, relative performance deteriorates a little and the Reserve Bank places fifth in the field of forecasters.⁹ The results for both time horizons are summarised in a scatter plot in figure 17. The median of the macroeconomic forecasts outperformed the Reserve Bank forecast at the one-year ahead horizon, but share similar forecast performance at the two-year ahead horizon.

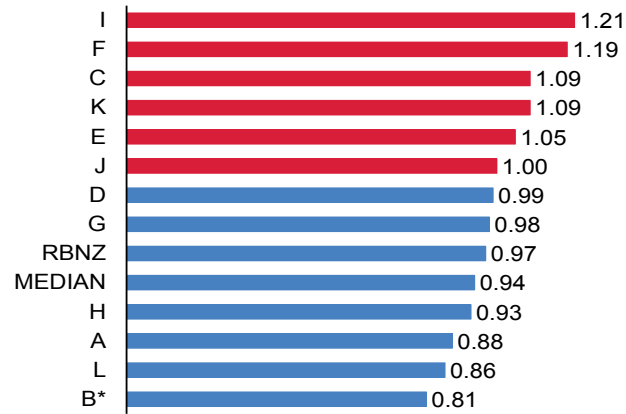
Figure 15
Summary
measure of
1-year ahead
forecast
performance
(normalised
RMSE)



Source: NZIER

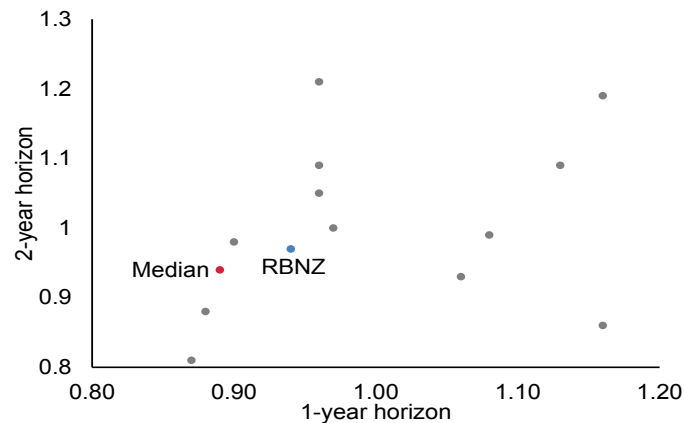
⁹ One forecaster (forecaster 'B') passes our rule for inclusion in the sample – at least 10 observations from a possible 17, but submitted slightly fewer forecasts than others. Using the median forecast as a guide to the relative ease of forecasting at different times, this difference leads to no material advantage in terms of inflation, in contrast, GDP growth appears harder to predict for the subsample (four quarters) not submitted by this forecaster.

Figure 16
Summary
measure of
2-year ahead
forecast
performance
(normalised
RMSE)



Source: NZIER.

Figure 17
Normalised
forecast
performance
on all
variables
(based on
RMSE)



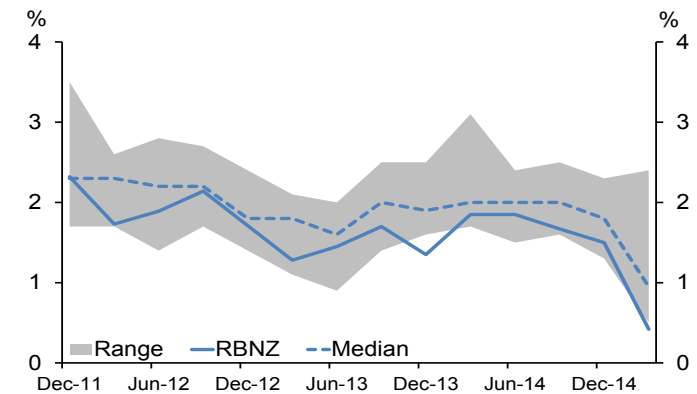
Source: NZIER.

When do the forecasts differ?

Understanding what we can learn from relative forecast performance requires identifying the periods where the Reserve Bank forecasts diverged from those of the other macroeconomic forecasters. We show periods of divergence by plotting the Reserve Bank's forecasts for each variable against the range of forecasts and the median forecast in figures 18-21.

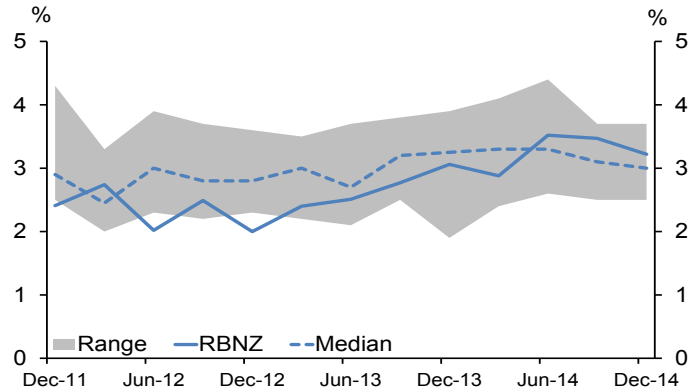
Much of the time, the forecasts are relatively similar. However, the Reserve Bank's forecast for inflation is a little lower than the median across the forecast period. There are other differences, including a period towards the end of 2011 and across 2012 when the Reserve Bank was expecting a lower exchange rate than other macroeconomic forecasters.

Figure 18
Annual CPI
inflation
forecasts
(1-year
ahead)



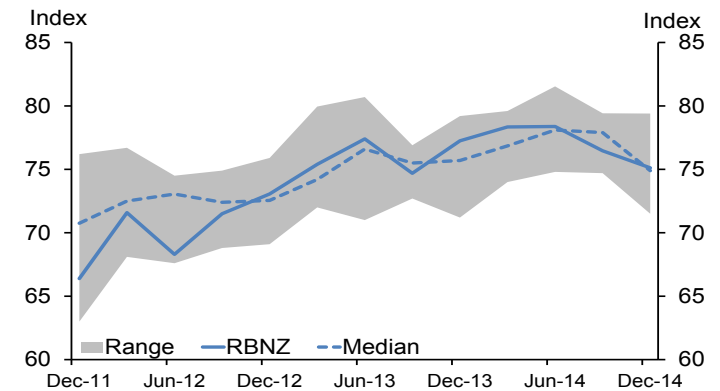
Source: NZIER.

Figure 19
GDP growth forecasts
(2-year ahead)



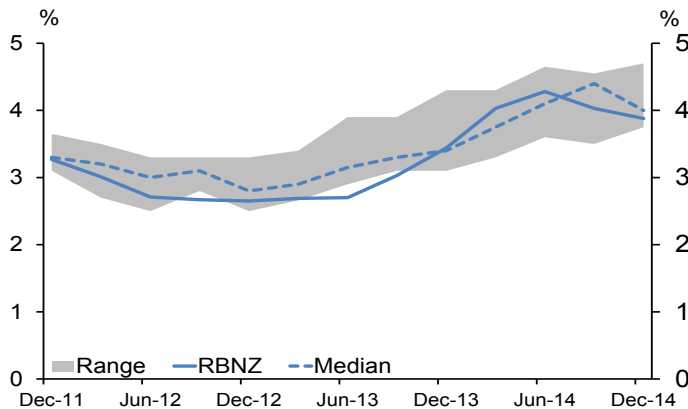
Source: NZIER.

Figure 21
Nominal TWI forecasts
(1-year ahead)



Source: NZIER.

Figure 20
90-day interest rate forecasts
(1-year ahead)



Source: NZIER.

5 Conclusion

Our results show that over the past five years the Reserve Bank's inflation forecasts have outperformed other macroeconomic forecasters. The Reserve Bank's inflation forecasts have tended to be slightly below the median of the other macroeconomic forecasters. The median forecast generally proves tough to beat with no forecaster consistently beating the median across all four variables.

The Reserve Bank also outperformed the median forecast for output growth and the interest rate, but performed relatively poorly on the exchange rate. All forecasters consistently expected a lower exchange rate than transpired. Placing less weight on expectations of a downwards adjustment in the exchange rate would have helped performance over the period.

Digging a little deeper into the nuance of sub-periods may reveal opportunities to improve performance. For example, the Reserve Bank's forecast for output growth in 2012 was lower than almost all other forecasters. Knowing more about the drivers of variation between forecasters at particularly times could provide opportunities for improvement. Further work could also usefully assess the Reserve Bank's own tradables and non-tradables inflation forecasts, to help understand what was behind forecast errors on inflation.

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Appendix 1

Tables

Table 4
Inflation forecast errors

Inflation		RMSE	RMSE	MFE	MFE
Rank	Forecaster	1-year ahead	2-year ahead	1-year ahead	2-year ahead
1	RBNZ	0.91	1.30	0.61	0.81
2	E	1.07	1.49	0.87	1.07
3	I	1.08	2.04	0.77	1.39
4	K	1.12	1.47	0.99	0.99
5	Median	1.13	1.68	0.92	1.11
6	C	1.13	1.76	0.82	0.91
7	J	1.14	1.63	0.96	1.26
8	M	1.14		0.82	
9	D	1.15	1.88	0.73	1.24
10	A	1.18	1.95	0.87	1.36
11	B	1.21	1.49	1.09	1.42
12	G	1.22	1.51	1.00	1.38
13	H	1.22	1.98	0.97	1.41
14	L	1.29	1.61	1.08	1.10
15	F	1.79	1.93	1.20	1.06

Source: NZIER

Table 5
Growth forecast errors

GDP Growth		RMSE	RMSE	MFE	MFE
Rank	Forecaster	1-year ahead	2-year ahead	1-year ahead	2-year ahead
1	B	0.39	0.53	0.02	-0.09
2	G	0.47	0.75	0.10	-0.20
3	A	0.56	0.69	-0.01	0.32
4	RBNZ	0.60	1.04	0.04	0.48
5	Median	0.61	0.89	0.14	0.25
6	J	0.62	1.14	-0.06	0.36
7	E	0.68	1.15	-0.15	0.20
8	I	0.71	1.18	0.30	-0.25
9	M	0.73	0.00	-0.19	0.00
10	L	0.76	0.82	0.18	0.16
11	C	0.80	1.49	0.06	-0.25
12	F	0.85	1.21	0.45	0.92
13	H	0.90	0.74	0.63	0.17
14	D	1.11	1.02	0.57	0.47
15	K	1.18	1.59	0.35	-0.05

Source: NZIER

Table 6
Exchange rate forecast errors

Exchange rate		RMSE	RMSE	MFE	MFE
Rank	Forecaster	1-year ahead	2-year ahead	1-year ahead	2-year ahead
1	H	2.55	5.41	-0.51	-2.16
2	I	2.87	8.20	-0.26	-6.57
3	Median	2.93	6.23	-1.31	-4.76
4	A	2.93	5.52	-0.43	-3.89
5	F	3.02	7.30	-1.95	-4.28
6	D	3.12	5.00	0.03	-2.71
7	K	3.62	7.42	-2.48	-5.36
8	J	3.99	6.20	-2.27	-4.83
9	B	4.04	7.15	-2.35	-5.43
10	C	4.39	6.62	-3.68	-5.97
11	RBNZ	4.50	7.73	-1.63	-4.65
12	E	4.58	8.67	-3.10	-7.34
13	L	4.60	6.68	-1.28	-4.12

Source: NZIER

Table 7
Interest rate forecast errors

Interest rate		RMSE	RMSE	MFE	MFE
Rank	Forecaster	1-year ahead	2-year ahead	1-year ahead	2-year ahead
1	C	0.35	0.99	0.09	0.50
2	E	0.43	1.01	0.24	0.74
3	B	0.48	0.86	0.24	0.48
4	K	0.54	0.93	0.42	0.71
5	RBNZ	0.54	1.03	0.23	0.43
6	Median	0.55	1.07	0.40	0.85
7	M	0.55	0.00	0.35	0.29
8	J	0.55	1.09	0.40	0.78
9	D	0.55	1.24	0.42	1.13
10	A	0.56	0.96	0.35	0.73
11	G	0.59	1.46	0.52	1.40
12	F	0.65	1.51	0.45	1.38
13	I	0.67	1.39	0.57	1.30
14	L	0.71	0.77	0.34	0.56

Source: NZIER