Attributing inflation forecast bias to other variables' forecast bias using FPS

James Twaddle

Editor's note

After identifying which forecast variables appear to be most prone to bias, we then searched for ways to quantify their relative importance. One way of doing this is to put the measured bias into the FPS model as a 'shock'. As a note of warning, this kind of analysis inevitably has to rely heavily on essentially arbitrary assumptions. Note also that for the variables other than the TWI, the bias numbers are sourced from the "Analysis of bias and RMSE in forecasts of key variables" paper, which as stated earlier, possibly understates the bias by using the then most-recent forecast round as 'actual' data in order to extend the sample period. In the case of the trade-weighted index (TWI) we used the figures found by Satish Ranchhod in "TWI forecast errors".

Key points

- We put the estimated mean forecast errors for key variables into the Forecasting and Policy System (FPS) model as 'shocks' to see their impact on CPI inflation. According to FPS, biases in our forecasts of the domestic output gap and the trade-weighted index (TWI) have probably been key contributors to our CPI inflation forecast bias. Additionally, there is evidence that that our world growth forecasts could be a plausible source of inflation forecast bias. However, we are wary of taking the world growth forecast bias result too much at face value because we have used two different series for relatively short periods as our proxy for world activity in projections, making the bias measurement inaccurate.
- The results in this paper are sensitive to assumptions about how quickly we learn that we have made a forecast error and how we imitate the forecast error in FPS. Under 'reasonable' assumptions, the output gap forecast bias and TWI forecast bias are most important, followed by world growth. Modelling the learning of the central bank about TWI errors is particularly hard because the TWI forecast bias gets larger as we project further into the future, yet we learn about our quarter-ahead errors relatively quickly.
- An important caveat to bear in mind of course is that FPS is not 'the truth'; results are only indicative.

1 Introduction

As part of the inflation forecast errors project, a range of series that we use in our forecasts were checked for forecast bias.[1] Appendix 2 contains some of the relevant results from McCaw ("Analysis of bias and RMSE in forecasts of key variables") and Ranchhod ("TWI forecast errors" and "TWI forecast error comparison"). As well as our known CPI inflation forecast bias, five series came out as having significant bias – the output gap, world GDP, world import and export prices, and the TWI.[2]

1 The sample (1994 to 2002) over which the forecast errors are calculated is quite short in business cycle terms; the forecast bias results are likely sensitive to the sample size.

2 Other series that showed bias include private consumption and plant and machinery investment. We would expect this bias to show up in the output gap bias.

Finding forecast bias in a number of forecast variables does not necessarily tell us about the relative importance of each variable in explaining our CPI inflation forecast bias. This paper uses one understanding of the economy – FPS – to get a rough guide of the importance of each in contributing to explaining our CPI inflation forecast bias.

The following caveats should be borne in mind about this analysis:

- FPS is only one representation of how the economy works, and cannot capture all aspects of macroeconomic reality.
- FPS has evolved through time. If this development simply represents FPS catching-up to the true way the economy works (ie we have been removing technical problems and misjudgements about relationships in the economy), then it makes sense to use the latest version of FPS. However, if instead FPS has evolved to mirror changes in the economy, then it is not clear which version of FPS to use to get an idea of the inflationary impact of bias in different forecast variables. The truth likely lies somewhere in the middle. For these simulations we use the version of FPS from the May 2002 projection round.
- The results presented here are very sensitive to how long it takes the monetary authority to learn they made a forecast error. We try a range of reasonable assumptions on learning, but have no way of choosing between them. In modelling central bank learning we assume that the central bank learns about all of their forecast error anytime in the six quarters following the error. In practice this means we hold nominal short-term interest rates constant at neutral for between one and six quarters to represent the central bank not knowing they have made a forecast error.
- In holding the interest rate at its FPS neutral equilibrium we are implicitly assuming that the central bank ignore the higher inflation outturns that result from their errors until they realise their errors – not a particularly realistic assumption.

As a consequence of these caveats the results here should be interpreted as indicative as to which errors are likely to have been important, not a definitive conclusion. We now look at each of the significant sources of forecast bias.

2 The output gap

To imitate the output gap forecast bias we impose a positive output gap over the first three quarters equal to the average one, two, and three quarter ahead output gap forecast bias (see appendix 2).[3] While the output gap beyond the first three quarters is less than the output gap forecast bias found statistically at that horizon, it has enough persistence to be broadly consistent with the longer horizon forecast bias results.

A range of inflation and output gap profiles are then derived from different assumptions about how long it takes the central bank to realise they made an error, from the quarter after the last shock (ie the fourth quarter), to 6 quarters after the last shock. Where the central bank takes longer to learn about their forecast errors the positive output gap persists for longer as monetary does not move to close it (figure 1a).

[3] We impose it for three quarters because the output gap forecast bias is increasing over these quarters, and let the 'usual' degree of model persistence take over after that.

Figure 1a
Output gap shock - Output gap

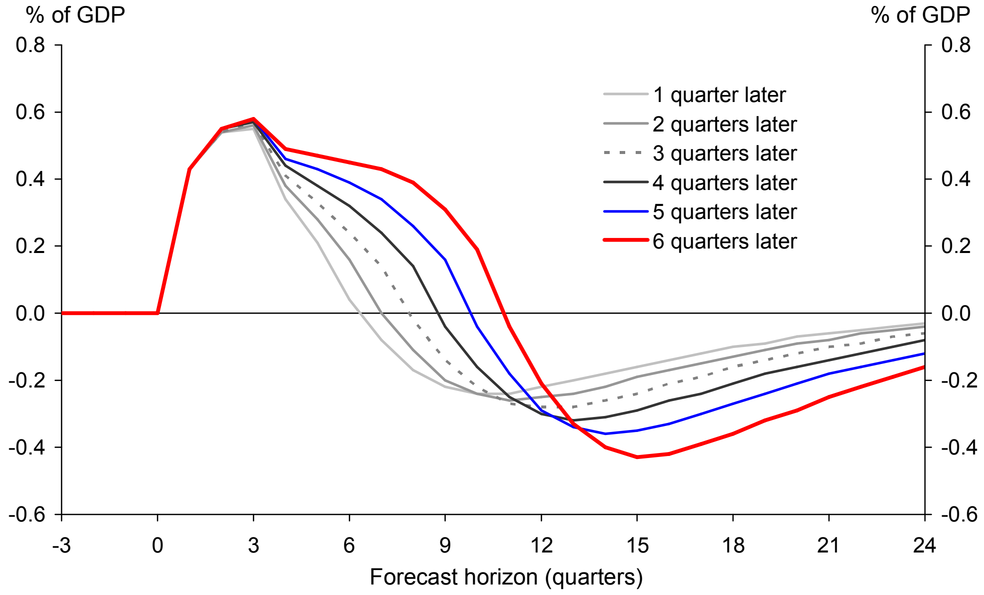
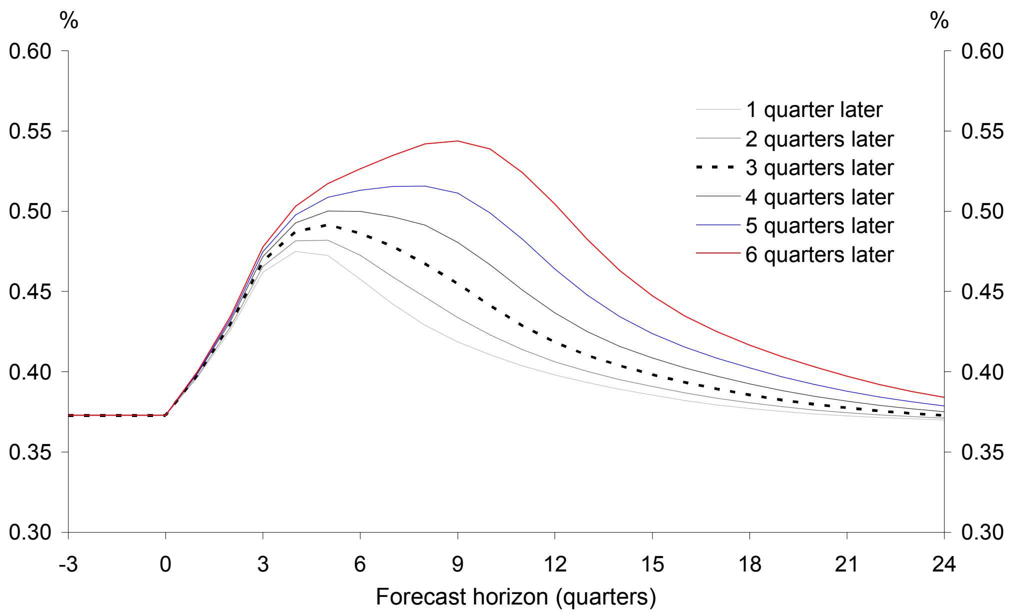


Figure 1b shows the corresponding quarterly inflation profiles. Lower inflation profiles are associated with the central bank learning relatively quickly about their forecast error. Under the quickest learning assumption the output gap forecast error causes quarterly inflation to be around 0.1 percentage points higher a year later than if the central bank had not made a forecast error. It is unsurprising that the output gap is able to generate large inflation outcomes as the output gap is the main channel through which activity affects inflation in FPS. Also worth noting is that the flow-through from the output gap bias to inflation is relatively quick.

Figure 1b
Output gap shock – Quarterly CPI inflation



3 The TWI

Of the sources of forecast bias we examine here, the most difficult to model is the forecast bias for the TWI. The TWI forecast bias differs from other variables' forecast bias because it increases as the forecast horizon increases, whereas for other variables the forecast bias falls (beyond a few quarters) as the forecast horizon increases. A further complication is that real-time data is available on the TWI, so shorter-horizon forecast errors are discovered relatively quickly.

The dichotomy of discovering the TWI errors relatively quickly, yet the forecast bias getting larger with the forecast horizon, poses particular problems for modelling the bias. If we let the monetary authority learn about their error quickly because of the real-time data available then we disregard the fact that they have a larger bias at longer horizons.[4]

We have tried a number of ways of modelling the TWI forecast error, with none wholly satisfactory.[5] The best of the bunch was to put in the first four quarters of the TWI error and then let the central bank learn about those errors the quarter after, as a compromise between the central bank learning about shorter horizon errors quickly but making more biased errors as the forecast horizon increases. It is also after around four quarters that the forecast bias becomes significant (exact results depend on the sample period).

In figure 2a we plot the range of exchange rate paths from the different learning assumptions; in figure 2b the corresponding inflation profiles. The effects of the exchange rate shock persist for longer when the monetary authority does not respond to it. In common with the output gap shock, learning about the forecast bias becomes more important for the CPI at longer horizons because of the lags between monetary policy and inflation – there is a wider spread between the CPI paths under different learning assumption at longer horizons. For the fastest learning assumption, where the central bank learns about all the forecast errors in the fifth quarter after the last of the four shocks we put in, CPI inflation is around 0.1 per cent percentage points higher at peak than if they had not made the forecast error.

4 Having them discover earlier errors but not later ones is difficult to model well – we cannot have the monetary authority seeing future forecast errors!

5 There are a range of different ways the TWI errors could be modeled, some of which we lacked time to examine fully.

Figure 2a
TWI shock – Exchange rate

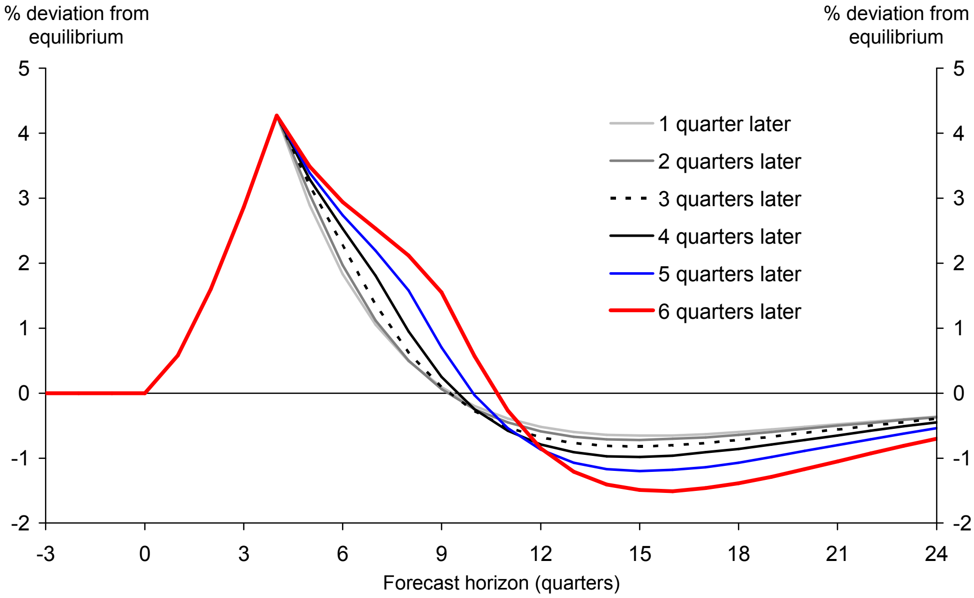
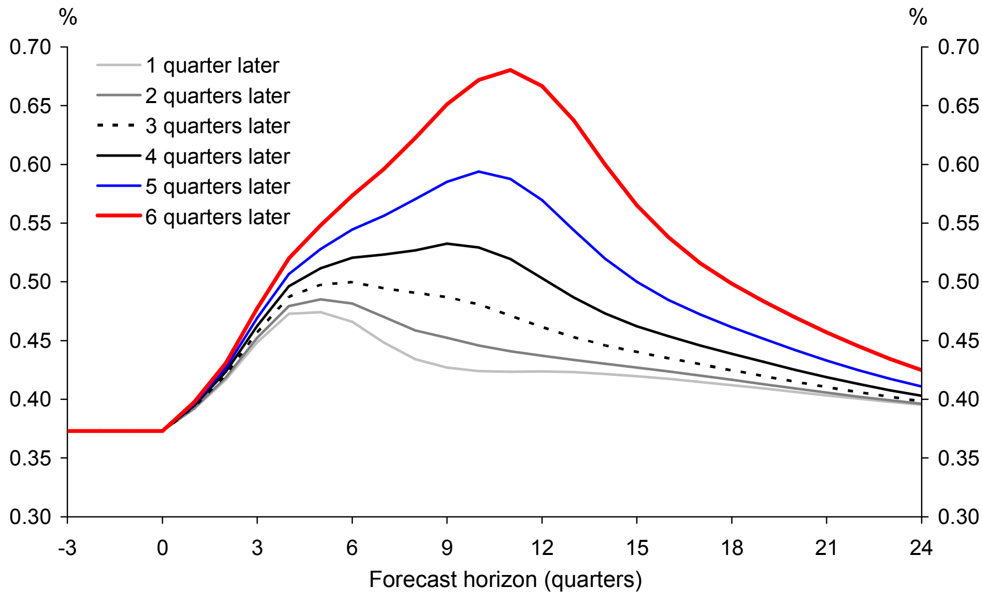
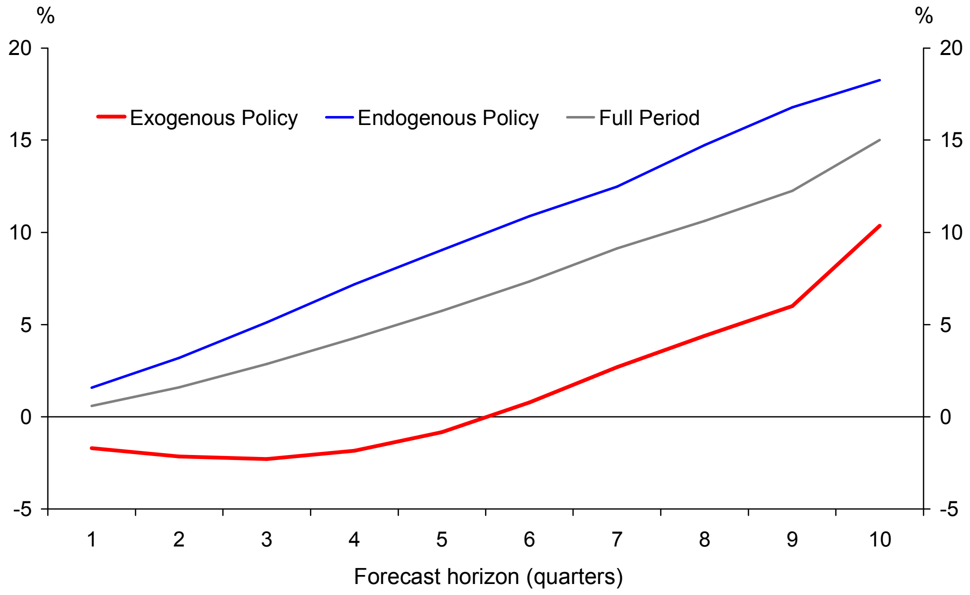


Figure 2b
TWI shock – Quarterly CPI inflation



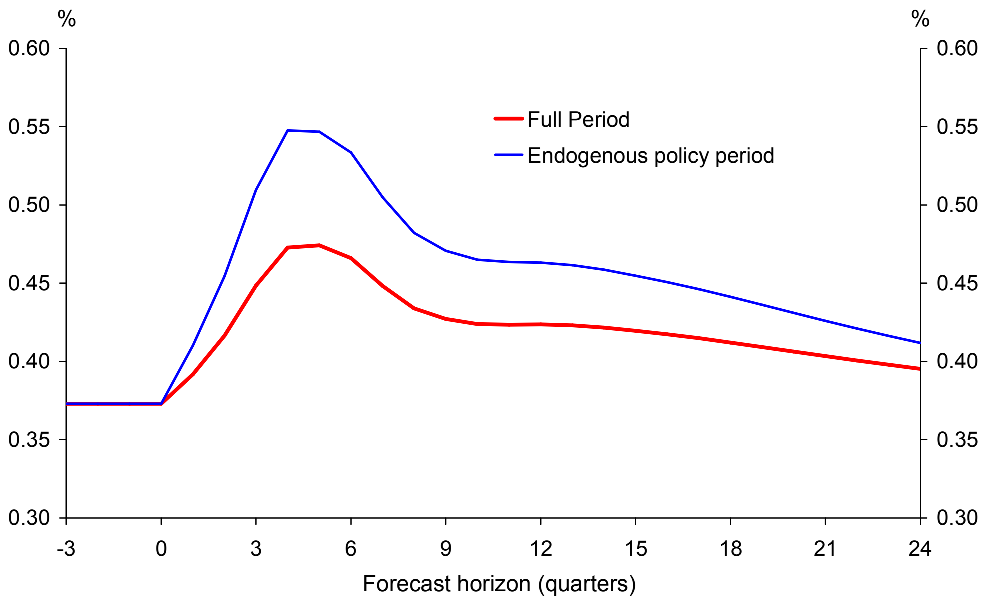
So far for the TWI we have looked only at the forecast bias from the full sample. The full sample results mask two distinct periods in our TWI forecasts – those incorporating exogenous (no-response) monetary policy assumptions and those with endogenous policy assumptions (after mid-1997). Over the endogenous policy forecasts period our TWI forecasts have been a lot more biased than over the whole sample period (figure 2c).

Figure 2c
Exchange rate bias



The impact of the TWI forecast bias on CPI becomes even stronger if we only make use of the endogenous policy forecasts sample. Under the fastest learning assumption the higher TWI forecast bias increases the impact on CPI inflation to around 0.17 per cent (figure 2d). So since 1997 the TWI forecast bias is likely to have become a more important factor in explaining the CPI forecast bias.

Figure 2d
TWI shock – Quarterly CPI inflation



4 World GDP growth

We have used forecasts of two world activity series to produce our projections: world industrial production (1996 to 1998), and world GDP (since 1999). With such small sample periods for both series we are cautious about reading too much into the forecast bias results coming from them. Despite our wariness about the results, we have put the world activity bias into FPS because of the large impact the world has on the domestic economy.

Developments in the world economy could be particularly important in our sample period, which included the IT sector boom in the US, as well as the Asian crisis.

In FPS the world output gap is used as the indicator of global activity rather than world growth. Translating our starting point world output growth surprise into a world output gap gives a world output gap about 0.45 per cent higher than expected in the first quarter and 0.34 per cent in the second quarter.[6] The second quarter surprise is almost exactly the same as the world output gap that we would see if we allowed the endogenous foreign sector model in FPS to calculate the world output for the second period after being 0.45 for the first quarter. Because the propagation channels within the foreign sector of FPS seems to match the second step ahead forecast bias well, we only impose the world output gap for the first quarter.

Figure 3a
World growth shock – World output gap

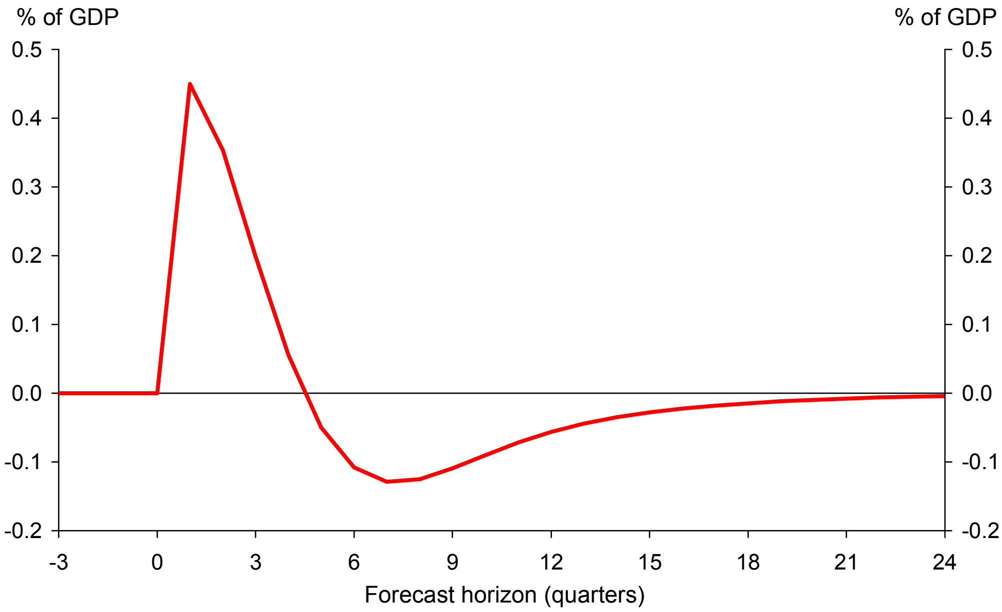


Figure 3a shows the world output gap from this shock. There are three broad channels within FPS by which the strength in world demand is transmitted to domestic CPI inflation. The first is through the world price of New Zealand's imports.[7] In figure 3b the response of world consumption import prices to this shock is plotted. McCaw finds that our quarterly per cent change forecast of world import prices is biased at two quarters ahead, matching the lags in FPS (1 to 2 quarters from the world output gap to world import prices in FPS).

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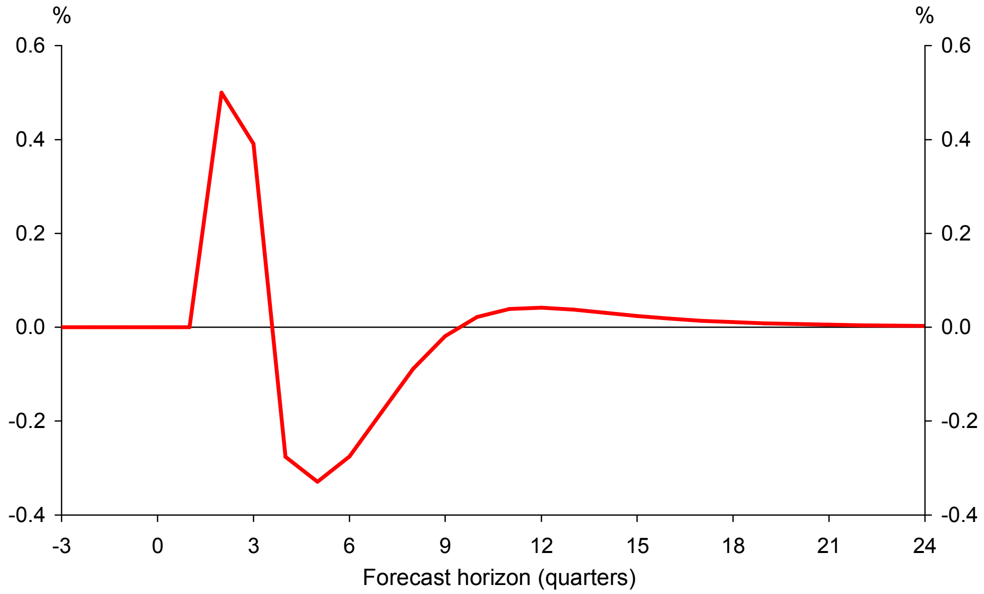
6 Two series have been used to represent world demand/growth since 1996 (see appendix 2). I have averaged the initial *annual* world growth surprise over the two series (they were each used for similar amounts of time), giving a starting point surprise of 0.68. Using a rough rule of thumb that two-thirds of the annual surprise in world growth goes into the world output gap, we are surprised by a world output gap 0.45 higher than expected in the first quarter (similar calculations were used for the second quarter number).

7 The link from world demand to world prices (for both imports and exports) was only introduced into the FPS projection environment in the last year, but was used informally before then.

Figure 3b
World growth shock - Quarterly % change in world consumption import prices



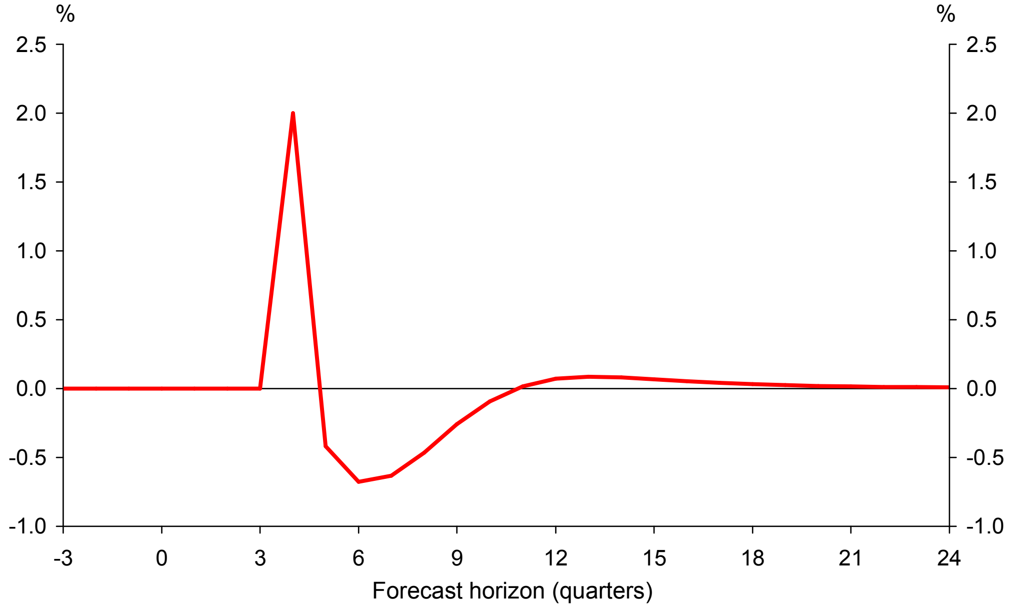
The matching of the lags from world demand to world import prices to the forecast bias statistics suggests that a portion our world import price bias could originate from our world output gap. It is also likely that part of our world import price bias comes from other sources, like volatile oil prices.

The second channel through which the domestic economy feels the impact of world activity is world interest rates. World long-term interest rates influence domestic long-term interest rates in FPS. New Zealand long-term interest rates were not directly tested for forecast bias, so we do not consider this channel further here.

The final channel linking world activity and domestic CPI inflation in FPS is through export values – both prices and volumes. World activity affects export volumes directly, and indirectly though an inducement-to-supply link from world export prices. However, at a quarterly frequency, our forecasts of export volumes do not appear to be significantly biased. This sheds doubt on whether direct effects on export volumes from the world output gap, and indirect inducement-to supply effects through export prices, are channels that are transmitting world output growth forecast bias to the domestic economy. Despite this we would still expect higher export incomes, by way of increased export prices, potentially to translate bias in forecasts of world demand conditions into CPI inflation forecast bias.

Looking at the response of world export prices to the shock to world activity (figure 3c), there are two things worth noting. The first is that the peak response of world export prices is larger than the largest quarterly bias estimate indicates (which is 1.06 per cent 2 quarters ahead). The second is that the timing is different, with world export prices responding 4 quarters after the world output gap shock in FPS, yet the significant forecast bias appears much sooner in the statistics (2 quarters). A portion of the world export price forecast bias appears to be distinct from world GDP growth bias.

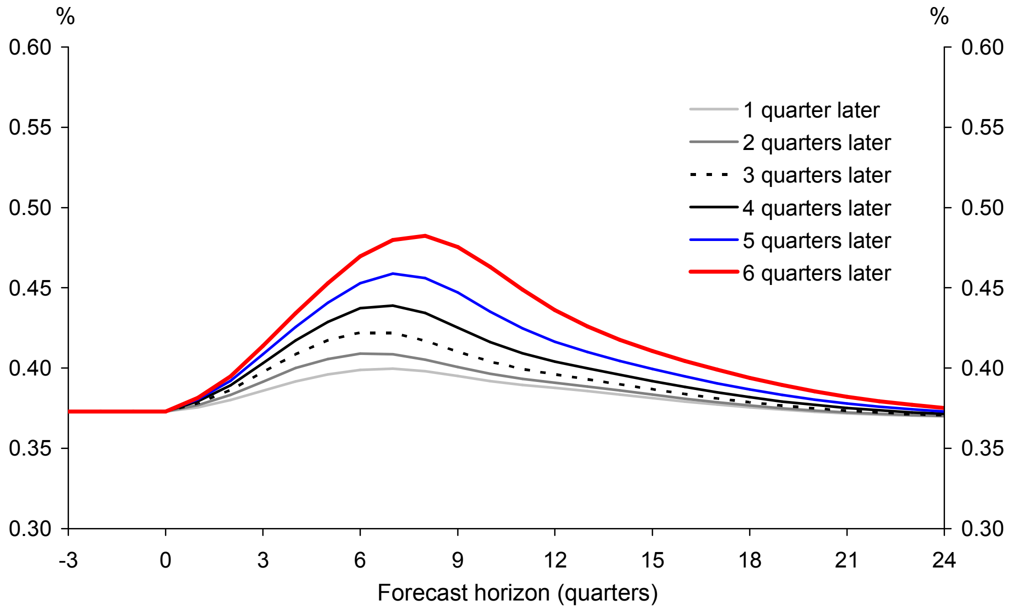
Figure 3c
World growth shock – Quarterly % change in world export prices



Because material parts of both our world import and export price forecast bias could be emanating from our world output gap forecast bias, we relegate examination of their direct impact to appendix 1.

These results tend to suggest that the transmission mechanism from world activity to domestic demand though export volumes demand may be working less than FPS suggests, and is a caveat to this analysis. In figure 3d we see the impact of the world demand shock on inflation. The peak of these effects is at longer horizons (6 to 8 quarters ahead) because of the lags in FPS from world activity to domestic activity. The effects on CPI inflation peak at around 0.1 per cent in quarters 7 and 8 for the slower learning methods.

Figure 3d
World growth shock – quarterly CPI inflation



5 Can these shocks explain our inflation forecast bias?

As we have already discussed, uncertainty about how quickly the central bank learns they made a forecast error creates a range of plausible estimates for the inflationary impact. Table 1a below adds up potential annual CPI bias from some 'reasonable' estimates of how long it takes the central bank to realise that they have made a forecast error.

The table assumes that the TWI error is discovered in the quarter following the last of the four quarters of shocks we hit the model with – a compromise between the central bank being able to discover their short horizon errors quickly, yet still making large errors at longer horizons. For world GDP we assume that it takes three quarters for the central bank to realise all of their bias. GDP data is typically available with a 1 to 2 quarter lag, and is often subject to revision in the quarter after it is released, making three quarters seem like a potential minimum. Applying the same logic to the domestic output gap allows the central bank to learn they made an error three quarters after the first shock (which is the quarter immediately after the third shock). The table indicates that forecast biases in these variables (which are largely exogenous to our forecasting process) are, when simply added together, able to explain our CPI forecast bias at all horizons.

In some cases the three variables we have analysed over-explain the CPI inflation forecast bias. The over-explanation likely comes from a mix of factors. First, by simply adding the simulations together we are double counting shocks, as they are not independent. For example, some of our output gap forecast bias could be potentially be emanating from our biased world growth forecasts. Secondly, we unrealistically assume that the central bank ignores the higher inflation outturns that result from their errors until they realise their errors. Finally, it could also reflect our imperfect modelling of the forecast biases and when, and to what extent, the central bank learns about them.

Table 1a. Quarterly Per cent change in CPI – Step Learning								
	Forecast Quarters Ahead.							
Quarters ahead	1	2	3	4	5	6	7	8
Output Gap	0	-0.02	-0.05	-0.09	-0.10	-0.10	-0.08	-0.07
TWI	-0.02	-0.04	-0.08	-0.10	-0.10	-0.09	-0.08	-0.06
World GDP	0	-0.01	-0.01	-0.02	-0.04	-0.04	-0.05	-0.05
Sum	-0.02	-0.07	-0.14	-0.21	-0.24	-0.23	-0.21	-0.18
Actual Bias	0.04	-0.04	-0.12**	-0.19***	-0.21***	-0.19***	-0.19***	-0.19***

Note to table:
The long publication lags for GDP (and other SNA data such as export prices) mean that the 'first' forecast quarter is actually the quarter preceding the quarter in which the forecasts were published. So that we are comparing the right CPI inflation contributions, we move the contributions from the output gap and world GDP ahead one quarter.

If we included the CPI paths from the endogenous policy forecasts TWI period, rather than from the whole sample period, the TWI forecast bias becomes larger than that coming from the output gap. That is, the TWI is likely to be a major contributor to our inflation forecast bias since the introduction of endogenous policy forecasts.

6 More advanced learning

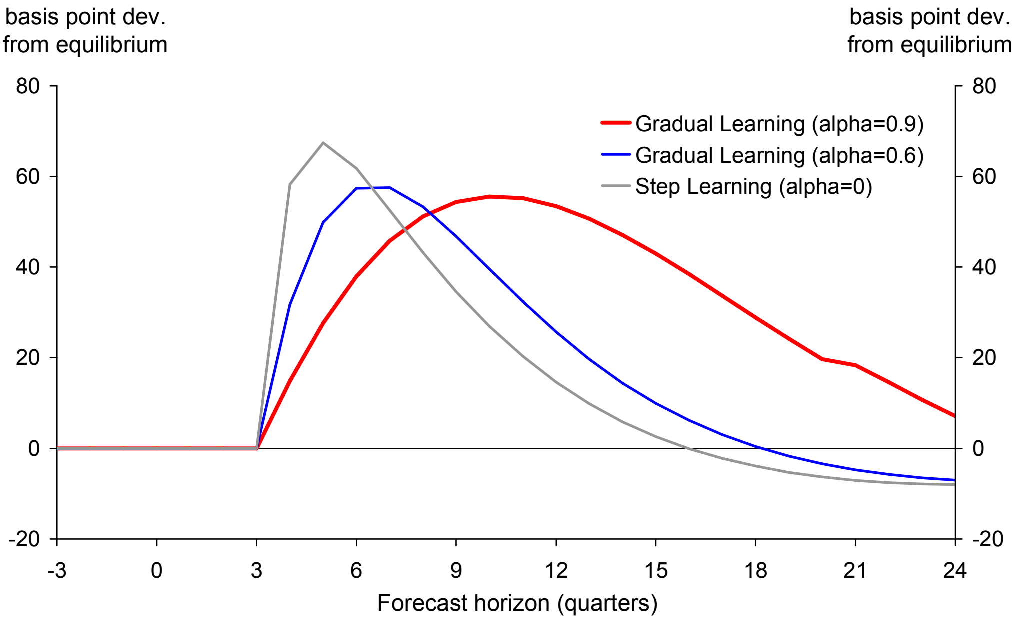
The method of learning we have looked at here is relatively unsophisticated, with the monetary authority learning about all of the shocks at once. Here we look at a more gradual way for the central bank to learn about their forecast errors. Learning about a forecast error all at once is probably plausible for the TWI because data on it is available in real-time. However, the assumption is less satisfactory for the activity data because GDP data is often subject to revision in subsequent quarters and revisions are common to output gap estimates.

A more advanced way of modelling this learning could be in a gradual way similar to an AR(1) process. After the first three quarters, the monetary authority's interest rate decision has weight α on where interest rates would be if they did not know about any of the shocks (that is, they remain at their equilibrium neutral nominal interest rate setting), and (1-α) on their optimal response to knowing all about the errors. In the second quarter their weight on not knowing about the shock is reduced by (1-α) per cent. The central bank learns more gradually about the full extent of the error they have made. The learning we examined earlier can be though of a special case of what we will call gradual response learning, where α=0 and the central bank learns they made a forecast error, and the full extent of that error, all at once.

We apply this method to the output gap and world growth, creating two scenarios for each by arbitrarily setting α equal to 0.9 and 0.6. The only remaining question is when we allow the central bank to begin learning they made a forecast error. We adopt the assumptions we made in table 1a for this. Learning about the output gap and world growth forecast error begins in the third quarter after the first shock (which is the quarter after the last shock for output gap).

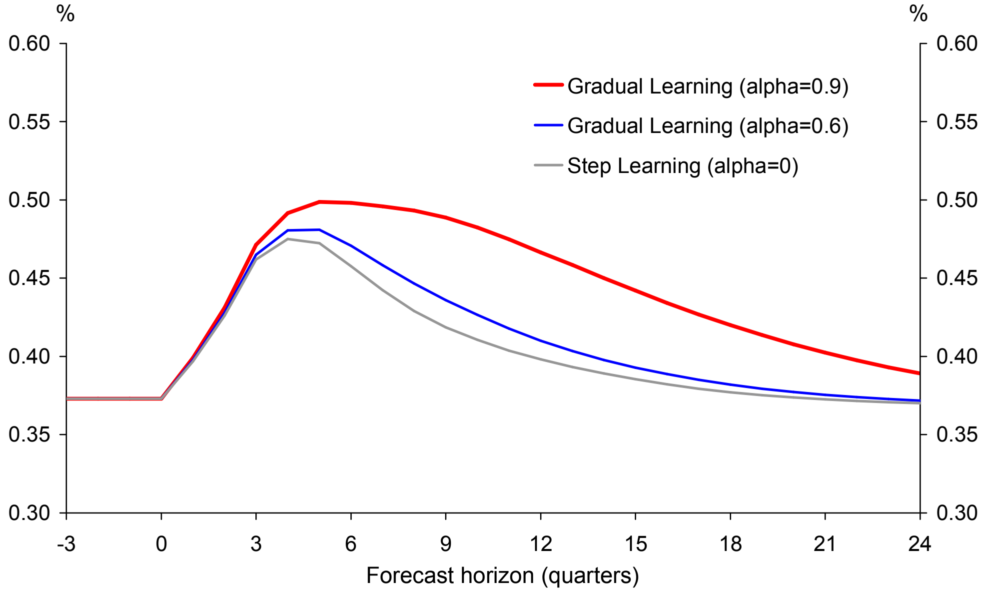
Figure 4a compares the interest rate reactions of step learning, where the quarter after the final shock the central bank learns about all of the shocks (like we examined earlier), and gradual response learning, where the central bank learns only gradually about the shocks from the period after the last shock. As expected, the central bank takes longer to learn about the full extent of their errors under gradual response learning.

Figure 4a
Output gap shock – 90 day interest rate



Accordingly, more gradual learning has a material impact on inflation in the medium-term, though less of an impact in the near-term (figure 4b).

Figure 4b
Output Gap – Quarterly CPI inflation



Figures 4c and 4d apply gradual response learning to the world growth shock. Both figures indicate that more gradual learning can significantly increase the flow-through to inflation from the world demand shock, though again this effect is more heavily felt at longer horizons.

Figure 4c
World growth shock – 90 day interest rate

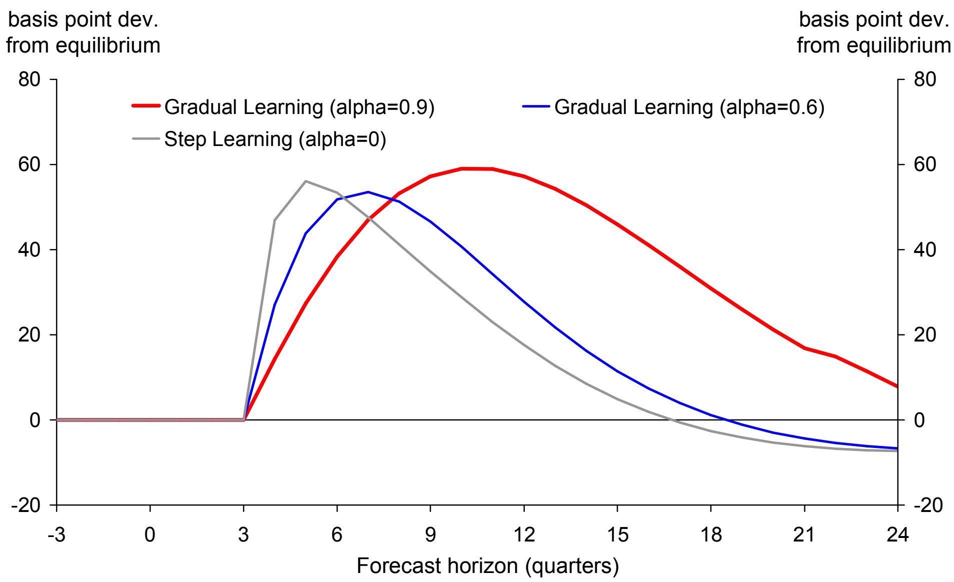


Figure 4d
World growth shock – Quarterly CPI inflation

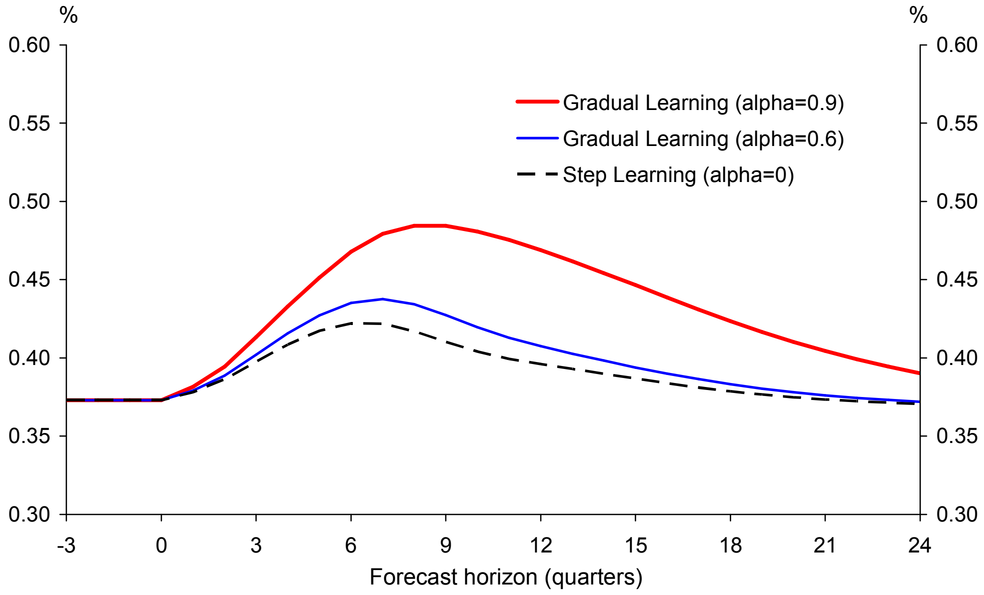


Table 1b updates table 1a using gradual response learning (α=0.6) for the output gap and world growth. Again we over-explain the inflation forecast bias at some horizons, with the earlier reasons most likely applying – imperfect modelling of forecast errors and central bank learning, double counting of shocks, and unrealistically assuming the central bank ignore higher inflation outturns until it realises its forecast error.

Table 1b. Quarterly per cent change in CPI – AR(1) Learning, rho=0.6								
	Forecast Quarters Ahead							
	1	2	3	4	5	6	7	8
Output Gap	0	-0.02	-0.05	-0.09	-0.11	-0.11	-0.10	-0.09
TWI	-0.02	-0.04	-0.08	-0.10	-0.10	-0.09	-0.08	-0.06
World GDP	0	-0.01	-0.02	-0.03	-0.04	-0.05	-0.06	-0.06
Sum	-0.02	-0.07	-0.15	-0.22	-0.25	-0.25	-0.24	-0.21
Actual Bias	0.04	-0.04	-0.12**	-0.19***	-0.21***	-0.19***	-0.19***	-0.19***

Note to table:
The long publication lags for GDP (and other SNA data such as export prices) mean that the 'first' forecast quarter is actually the quarter preceding the quarter in which the forecasts were published. So that we are comparing the right CPI inflation contributions, we move the contributions from the output gap and world GDP ahead one quarter.

7 Summary

All up the results here indicate that the biases in our forecasts of the output gap and TWI, and to a lesser extent world growth, are likely causes of our inflation forecast bias. We are cautious about interpreting the results from world growth too strongly because the world growth forecast bias is not well measured and the linkages from the world environment to the domestic economy and inflation may be different, or have a different lag structure, than represented in FPS.

The TWI forecast bias proved particularly hard to model. Despite the modelling difficulties, using the TWI forecast bias form the whole sample period indicates that the TWI is a likely contributor to our inflation bias. If we look only at TWI forecast data post-1997 (the endogenous monetary policy projection period) the contribution from the TWI gets even stronger, the inflation bias being 75 per cent higher at peak relative to the full sample results.

We reiterate the earlier point that, because of the imperfect way we are able to model how quickly and to what extent the central bank learns they have made a forecast error, the results here should be taken qualitatively. The results act as a pointer to the likely causes of our inflation forecast bias.

References

McCaw, S (2002), "Analysis of bias and RMSE in forecasts of key variables," *Reserve Bank of New Zealand Memorandum.*

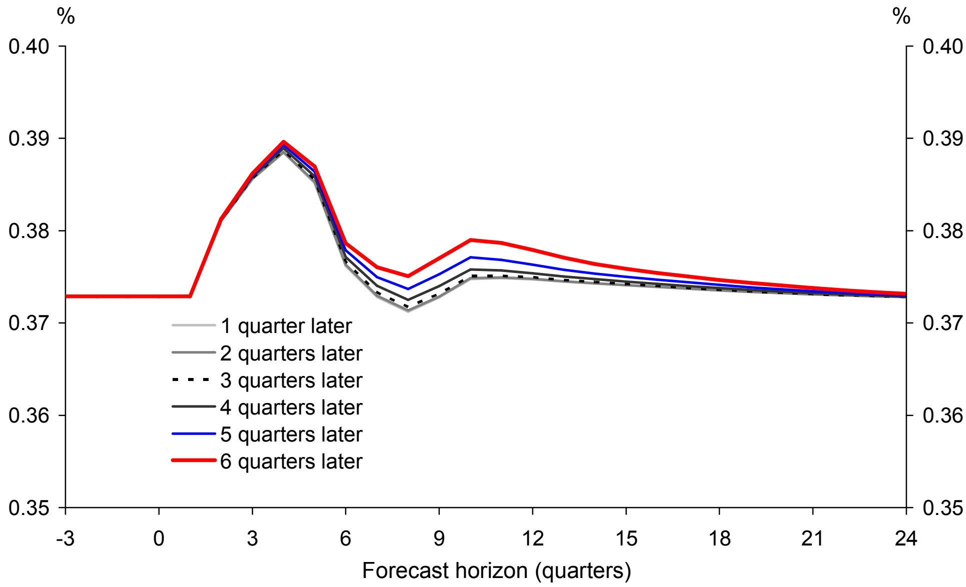
Ranchhod, S (2002), "TWI forecast errors," *Reserve Bank of New Zealand Memorandum.*

Ranchhod, S (2002), "Comparison of TWI forecast errors: Reserve Bank and other forecasters," *Reserve Bank of New Zealand Memorandum.*

Appendix 1: World import and export price bias

Here we examine a 1 per cent increase in world import prices in the second quarter (and the level of import prices remains above its short-run equilibrium for a year). This is the bias in the second step ahead forecast, which is when the bias becomes significant.[8] Figure A1 shows that this shock has small effects relative to the other sources of forecast errors.

Figure A1
World import price shock – Quarterly CPI inflation

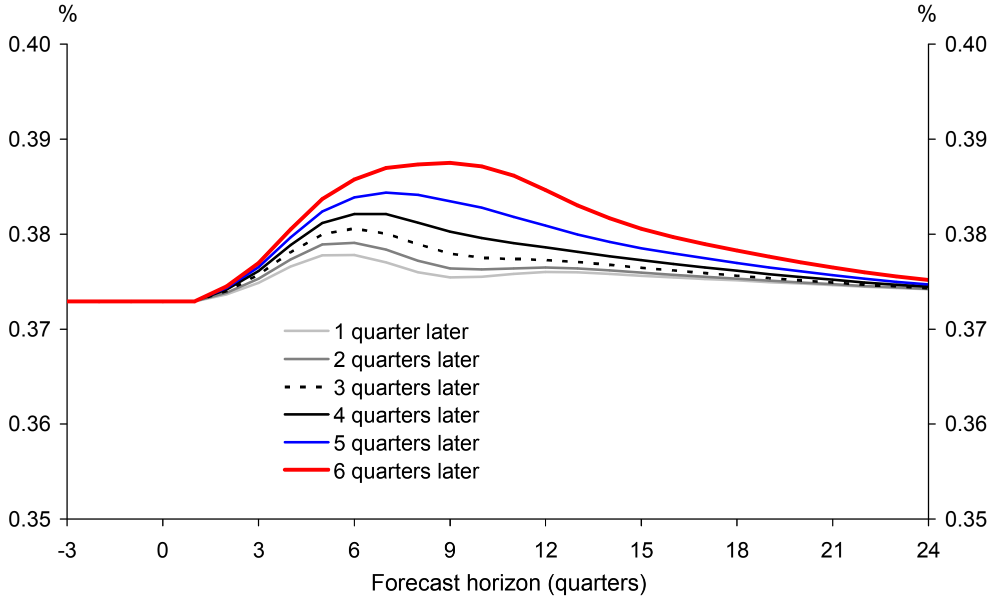


As we have already seen, world output gap errors can lead to world import price errors. Given that the effect of the shock is small, this suggests that it may be better to concentrate efforts on investigating other sources of forecast bias first.

When we move on to the world prices of our exports we see a similar story to that for world import prices. We increase world import prices by 1.1 per cent for a year in the second quarter. In essence it is the same type of shock as the world import price shock. Its impact on inflation is small relative to some of the other sources of bias that we have already discussed (figure A2), and, more importantly, a lot of its impact is felt beyond the 8-quarter window over which the forecast bias statistics have been calculated.

[8] Methodologically the way the shock has been introduced is not perfect as it affects only the cyclical component of import prices and not the trend component. The pass-through from the trend component to CPI inflation is higher than the pass-through from the cyclical component.

Figure A2
World export price shock – Quarterly CPI inflation



Appendix 2: Bias size

The statistics here are taken from McCaw ("Analysis of bias and RMSE in forecasts of key variables") and Ranchhod ("TWI forecast errors" and "Comparison of TWI forecast errors: Reserve Bank and other forecasters"). Please see these papers for a discussion of how these statistics were calculated, particularly for data definitions. Note that:

- The statistical significance of the bias is indicated with asterisks:
  * = significant at the 10 per cent level;
  ** = significant at 5 per cent;
  *** = significant at 1 per cent
- The significant bias results are also shaded for convenience. In recognition that the sample size is relatively small, those biases that were not significant at conventional statistical levels but with a t-statistic over 1.5 (p ≈15 per cent) are also shaded.
- The statistics from McCaw ("Analysis of bias and RMSE in forecasts of key variables") are calculated using the most recent forecasts as 'actuals'. This greatly extends the sample size, but also potentially leads to an underestimation of the bias, in that the recent 'errors' are actually just revisions to our forecasts, which are likely in some cases to be smaller than the true bias. In particular, it likely understates the TWI bias, so we used figures from Ranchhod's closer TWI analysis for the analysis in this paper. These figures are calculated using only released data as 'actuals'.

Table 3
Bias in forecasts of macroeconomic variables

From "Analysis of bias and RMSE in forecasts of key variables":

Quarterly per cent change								
	1	2	3	4	5	6	7	8
CPI	0.04	-0.04	-0.12**	-0.19***	-0.21***	-0.19***	-0.19***	-0.19***
TWI	-0.03	0.57	0.75	0.84	0.92*	0.89*	0.98*	0.95*
World import prices	-0.30	-0.94**	-0.52	-0.34	-0.16	0.16	0.27	0.41
World export prices	-0.48	-1.06*	-0.05	0.03	0.02	0.33	0.60	0.69
World IP	-0.17	0.17	0.04	0.06	0.00	0.13	0.04	-0.11
World GDP	-0.12	-0.06	0.00	0.08	0.14	0.19	0.20**	0.20**

Annual per cent change								
	1	2	3	4	5	6	7	8
World IP	-1.01***	-0.66***	-0.40*	0.10	0.28	0.24	0.24	0.06
World GDP	-0.36	-0.37	-0.32	-0.11	0.15	0.40	0.61	0.74

Note:
'World GDP' was used 1999 to 2002, and is 14-country trade-weighted. 'World IP (industrial production)' was used for 1996 to 1998, and is 5-country trade-weighted

The output gap level								
	1	2	3	4	5	6	7	8
Output gap	-0.42*	-0.54**	-0.58**	-0.56**	-0.47	-0.34	-0.18	0.00

Alternative estimates of TWI bias

(not extending the sample period by using the most recent forecasts as substitute 'actual' data) Source: "TWI forecast errors" and "Comparison of TWI forecast errors: Reserve Bank and other forecasters."

Quarterly per cent change in the TWI								
	1	2	3	4	5	6	7	8
Full Sample	0.58	1.60	2.86	4.27*	5.75*	7.34**	9.12**	10.63**
Exogenous Policy	-1.71***	-2.15*	-2.30	-1.84	-0.83	0.79	2.68	4.38
Endogenous Policy	1.58	3.20	5.11*	7.19**	9.04***	10.88***	12.48***	14.74***

Full sample period refers to December 1994 to June 2002 (note that these numbers are not in fact reported in the above papers but are calculated consistent with them)
Exogenous policy forecasts sample period is December 1994 to March 1997
Endogenous policy forecasts sample period is June 1997 to September 2002