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Does past inflation predict the future?

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NON-TECHNICAL SUMMARY

Forecasts of non-tradables inflation have been produced using Phillips curves, where capacity pressure and inflation expectations have been the key drivers. The Bank had previously used the survey of 2-year ahead inflation expectations in its Phillips curve. However, from 2014 non-tradables inflation was weaker than the survey and estimates of capacity pressure suggested. Bank research indicated the weakness in non-tradables inflation may have been linked to low past inflation and its impact on pricing behaviour.

This note evaluates whether measures of past inflation could have been used to produce forecasts of inflation that would have been more accurate than using surveys of inflation expectations. It does this by comparing forecasts for annual non-tradables inflation one year ahead. Forecasts are produced using Phillips curves that incorporate measures of past inflation or surveys of inflation expectations, and other information available at the time of each *Monetary Policy Statement (MPS)*. This empirical test aims to determine the approach that captures pricing behaviour best, highlighting which may be best for forecasting going forward.

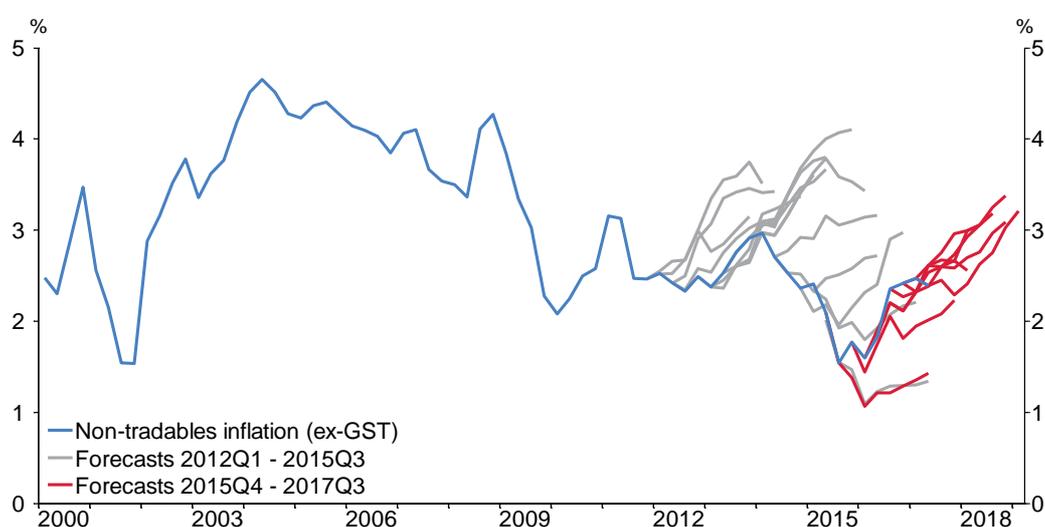
The results show that forecasts constructed using measures of past inflation have been more accurate than using survey measures of inflation expectations, including the 2-year ahead survey measure previously used by the Bank. In addition, forecasts constructed using measures of past inflation would have been significantly more accurate than the Bank's *MPS* forecasts since 2009, and only slightly worse than these forecasts before the global financial crisis (GFC). The consistency of forecasts using past-inflation measures reduces the concern that this approach is only accurate when inflation is low, and suggests it may be a reasonable approach to forecasting non-tradables inflation generally.

From late 2015, the Bank has assumed that past inflation has affected domestic price-setting behaviour more than previously. As a result, monetary policy has needed to be more stimulatory than would otherwise be the case. This price-setting behaviour is assumed to persist, and is consistent with subdued non-tradables inflation and low nominal wage inflation in 2017.

1. Introduction¹

Monetary policy relies on forecasts of inflation to help determine the path of interest rates that ensures inflation settles around the target midpoint in the medium term. Non-tradables inflation is a key component in the Bank's inflation forecasts – it tends to be the most persistent part of the consumer price index (CPI) and correlates best with the business cycle. Through 2014 and 2015, non-tradables inflation was much weaker than the Bank expected, and weaker than suggested by usual economic relationships (figure 1). As such, the Bank undertook analysis to learn why non-tradables inflation had been so weak.

Figure 1: RBNZ forecasts of non-tradables inflation



Note: Throughout this paper, the increase in the goods and services tax (GST) on 1 October 2010 is excluded from annual non-tradables inflation by subtracting 2 percent between 2010Q4 and 2011Q3.

Many factors affect non-tradables inflation and can be used to help explain why it has been weak. The typical drivers of non-tradables inflation are capacity pressure (i.e. the output gap or unemployment rate) and inflation expectations.² Other factors also contribute though, such as technological developments and changes in government charges.³ Even taking these into account, non-tradables inflation has been surprisingly weak.

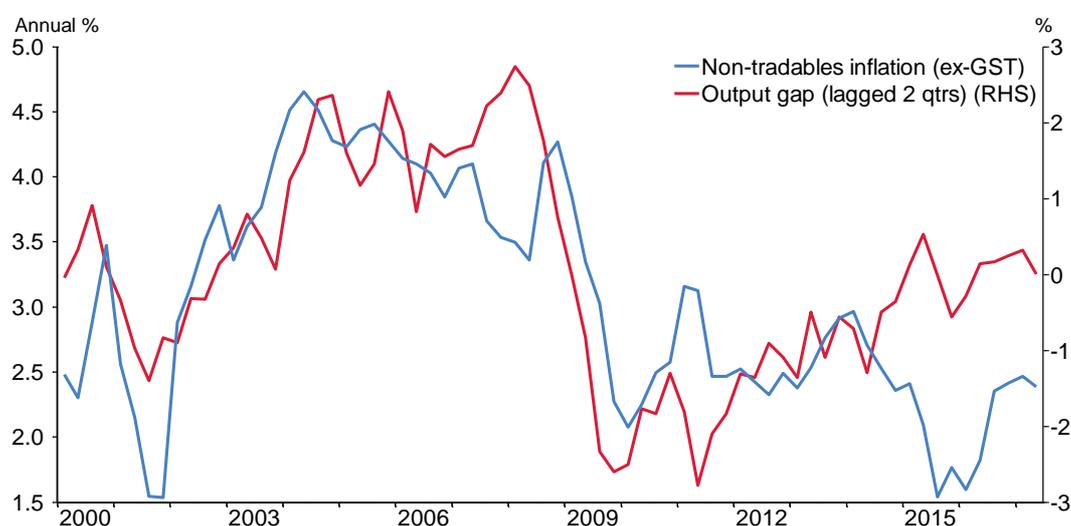
¹ I would like to thank Michelle Lewis, Hayden Skilling, Christie Smith, Gina Williamson and Amy Wood for their useful and constructive comments.

² The model used to produce the Bank's inflation forecasts (NZSIM) is outlined in Kamber et al (2015) and in Austin and Reid (2017).

³ For example, the communications component of the CPI (including telecommunications and broadband services) reduced annual non-tradables inflation by 0.2 percentage points on average since 2011Q3. In addition, the reduction in ACC levies on vehicle licenses reduced annual non-tradables inflation by 0.6 percentage points from 2015Q3 to 2016Q2.

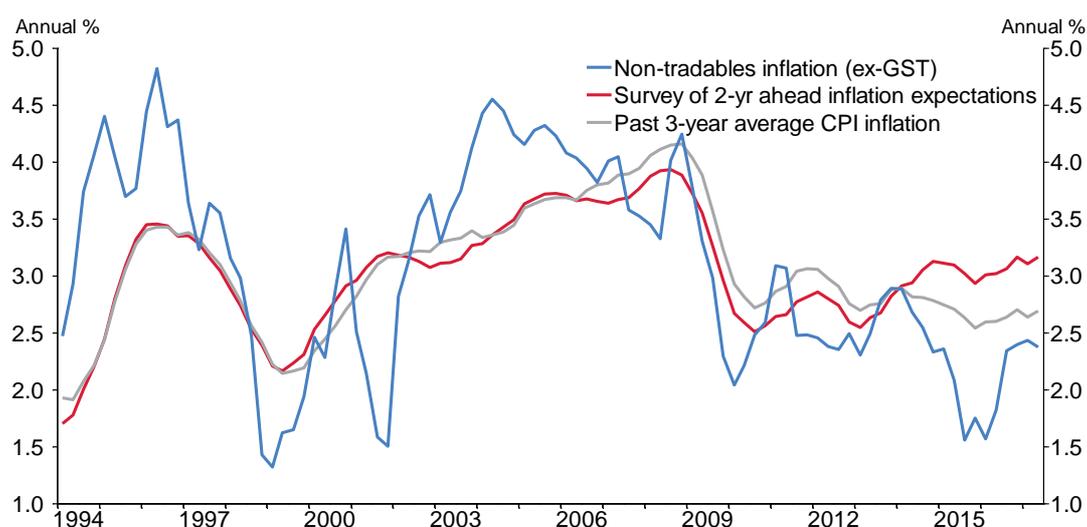
One approach the Bank used to explain low non-tradables inflation was to assume a lower output gap, implying more spare capacity in the economy. The Bank lowered its estimate of the output gap in 2014 and early 2015 in line with the suite of indicators in Armstrong (2015).⁴ However, the reduction in the output gap was not enough to fully explain the low level of non-tradables inflation. Figure 2 shows that non-tradables inflation has been subdued since late 2014 relative to the output gap estimate from the August 2017 *MPS*. Although part of this divergence reflects the reduction in ACC levies on vehicle licenses in 2015, similar divergences also exist when comparing the output gap to wage inflation and core inflation, and likewise for the unemployment rate and these inflation measures.

Figure 2: Non-tradables inflation and the output gap



Another avenue the Bank has explored is the role of past inflation and inflation expectations in firms' price-setting decisions. McDermott and Karagedikli (2015) found that when estimating a time-varying Phillips curve for CPI inflation, the weight on past inflation had been steadily increasing since 2008, and less weight was being put on survey measures of inflation expectations. Figure 3 shows that a Phillips curve using the 3-year average of past inflation better explains the low level of non-tradables inflation since 2014 than when using the survey of 2-year ahead inflation expectations. Similarly, the low level of core non-tradables inflation is also better explained by Phillips curves with the 3-year average of past inflation than with the survey of 2-year ahead inflation expectations (figure B.2 of the August 2017 *MPS*).

⁴ The revision to the output gap was discussed in Box A of the June 2015 *MPS*.

Figure 3: Inflation estimates from non-tradables Phillips curves

The Bank's understanding of low non-tradables inflation, such as the role of past CPI inflation in firms' pricing decisions, has been informed by retrospective analysis – i.e. explaining with hindsight why inflation had been so weak. This note provides a different perspective by looking at how accurately various approaches to capturing price-setting behaviour would have forecast non-tradables inflation had they been used from 2003 until recently. A range of measures of past inflation and surveys of inflation expectations are used to produce forecasts and are compared to the Bank's *MPS* forecasts. This empirical test aims to determine which approach captures pricing behaviour best, highlighting which may be best for forecasting going forward.

2. Methodology

To evaluate each approach, various measures of past inflation and surveys of inflation expectations are used along with other information available at the time of each *MPS* to forecast non-tradables inflation. The analysis focuses on 1-year ahead forecasts of annual non-tradables inflation (although results for 2-year ahead forecasts are shown in the appendix).

The 1-year ahead horizon is chosen to focus the analysis on the near-term drivers of price-setting behaviour. Forecasts at this horizon also highlight the persistent effects of current economic conditions on inflation, helping to inform how monetary policy should respond. The near-term drivers become less relevant for forecasts beyond the next year because monetary policy adjusts to offset them. For example, if current conditions suggest inflation will be below target for some time, interest rates will be reduced so that inflation returns to target by the medium term. As a result, simple statistical models that rely on current estimates of the output gap and the unemployment rate (like the Phillips

curves used here) have little ability to predict inflation beyond the next year. This is also why the Bank uses a structural model (NZSIM) to forecast inflation in the medium term.

The equations used in this note to forecast non-tradables inflation are similar to typical Phillips curves for New Zealand, such as those outlined in Hargreaves et al (2006). Surveyed inflation expectations are included in some of the equations, and in the others measures of past inflation are used instead. A constant is included in all of the equations because non-tradables inflation has historically had a higher mean than CPI inflation, and most of the measures of past inflation and surveys of inflation expectations are based on CPI inflation. Either the output gap or unemployment rate gap are used as measures of capacity pressure. Unlike typical Phillips curves, house price inflation (HPI) is also included in some of the equations. House price movements help predict movements in the non-tradable components that are directly affected by the housing market, such as construction costs, rentals, and real estate services.⁵

The lag of non-tradables inflation is not included in the baseline models. However, a version that more closely resembles the non-tradables Phillips curve in NZSIM is shown in the appendix, and this includes the lag of non-tradables inflation. This version also restricts the sum of the coefficients on the lag of non-tradables inflation and the measure of past inflation or survey of inflation expectations to 1, as in NZSIM.

In total, there are 55 baseline equations used to produce forecasts, given 11 measures of past inflation or surveys of inflation expectations and five sets of explanatory variables (shown in table 1). The models are demonstrated by the following equation:

$$\pi_{t+3}^{NT} = a_{i,j} + b_{i,j} X_{i,t} + c_{i,j} \pi_{j,t}^e + \varepsilon_{i,j,t} \quad (1)$$

where

- π_{t+3}^{NT} represents the forecasts of annual non-tradables inflation a year beyond the latest outturn (three quarters from the current quarter);
- The t subscript represents when the forecasts are produced, and determines which data are available. Data is assumed to be available in the current quarter (t) for the surveys of inflation expectations and for the adaptive inflation measures (outlined below); the unemployment rate, CPI inflation, and other measures of past inflation are

⁵ House price inflation may also act as an indicator of future changes in capacity pressure given it is a leading indicator for construction activity.

- available up to the previous quarter ($t-1$); and the output gap and house price data are only available up to two quarters prior ($t-2$);⁶
- a, b, c are the coefficients in the regression, b can include either one or two coefficients depending on what is included in X ;
 - The j subscript identifies which of the 11 measures of past inflation or surveys of inflation expectations is included in π^e . The measures include four surveys of CPI inflation expectations, including the 1-, 2-, 4- and 7-year ahead measures,⁷ the 3- and 6-year averages of past CPI and non-tradables inflation, and three adaptive inflation measures;⁸
 - The i subscript identifies which of the five sets of explanatory variables are included in X (table 1).

Table 1: Models used to forecast non-tradables inflation

Model no. (i)	Explanatory variables (X)
1	Unemployment rate gap
2	Output gap
3	Unemployment rate gap and annual HP inflation
4	Output gap and annual HP inflation
5	Annual HP inflation

The parameters are estimated using ordinary least squares. The estimation period is from 1994Q1 up until the latest non-tradables inflation outturn (i.e. the previous quarter or $t-1$). The parameters are re-estimated each quarter as new data becomes available. The output and unemployment rate gaps are real-time estimates, the same as those used in the *MPS* projections at the time. We evaluate the forecasts over the period from March 2003 (when the Bank started forecasting non-tradables inflation) to September 2016, giving us 55 forecasts to compare.

3. Results

The first part of the results section compares two measures: the survey of 2-year ahead inflation expectations and a baseline measure of past inflation. The baseline measure of past inflation uses an adaptive approach, which is a weighted average of its previous value and the latest annualised change in the CPI:

$$\pi_t^{adapt} = \rho \pi_{t-1}^{adapt} + (1 - \rho) \pi_{t-1}^{CPI} \quad (2)$$

⁶ The variables available in the current quarter (t) are lagged three quarters relative to the dependent variable, those available at $t-1$ are lagged four quarters, and those available at $t-2$ are lagged five quarters.

⁷ The 1- and 2-year ahead measures of inflation expectations are from the RBNZ Survey of Expectations. The 4- and 7-year ahead measures are from the AON Hewitt Economists' survey.

⁸ The measures of past inflation are constructed excluding the effects of the increase in GST in 2010.

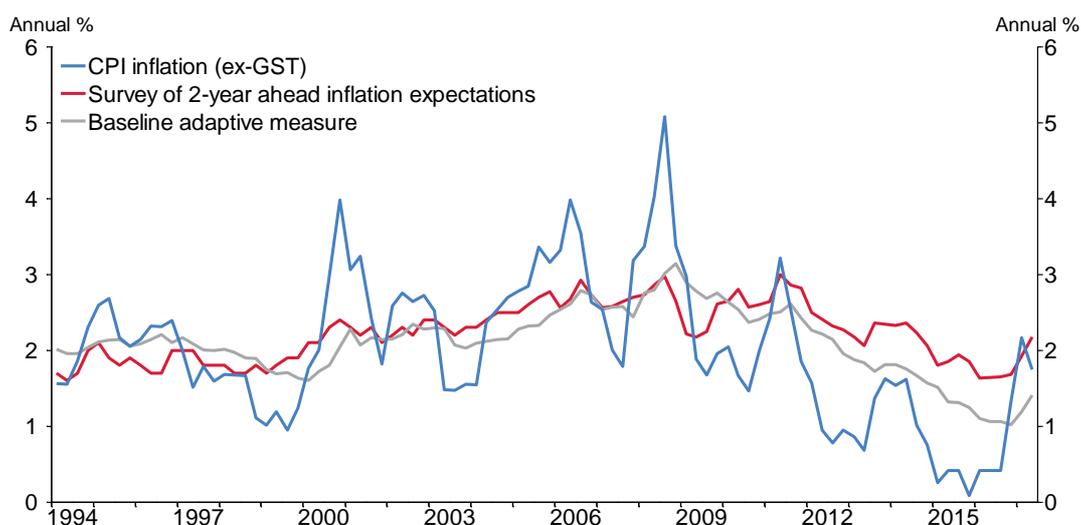
where

- π_t^{adapt} is the adaptive measure of CPI inflation. It is available in the current quarter (t) because it uses inflation data from the previous quarter ($t-1$).
- π_{t-1}^{CPI} is lagged annualised CPI inflation, i.e. the quarterly percent change multiplied by four.
- ρ is set to 0.92 in the baseline measure. This implies a half-life of approximately two years, meaning half of the weight is on inflation in the past two years. We also evaluate alternative measures where ρ is set to 0.85 and 0.95, implying half-lives of around one and three years.⁹

This baseline adaptive measure and other measures of past inflation likely capture several things that affect price setting. For example, low CPI inflation means smaller increases in the cost of living, which may lead to less pressure on nominal wages. Surveys of inflation expectations should also capture this effect. Measures of past inflation may also identify changes in the structure of the economy and their impacts on inflation. If these changes are not well understood, adaptive measures might respond more quickly than survey measures of inflation expectations.

The low level of CPI inflation since 2012 has had a more significant impact on the baseline adaptive measure than on the survey of 2-year ahead inflation expectations. The adaptive measure is currently 0.8 percentage points lower than this survey measure (figure 4).

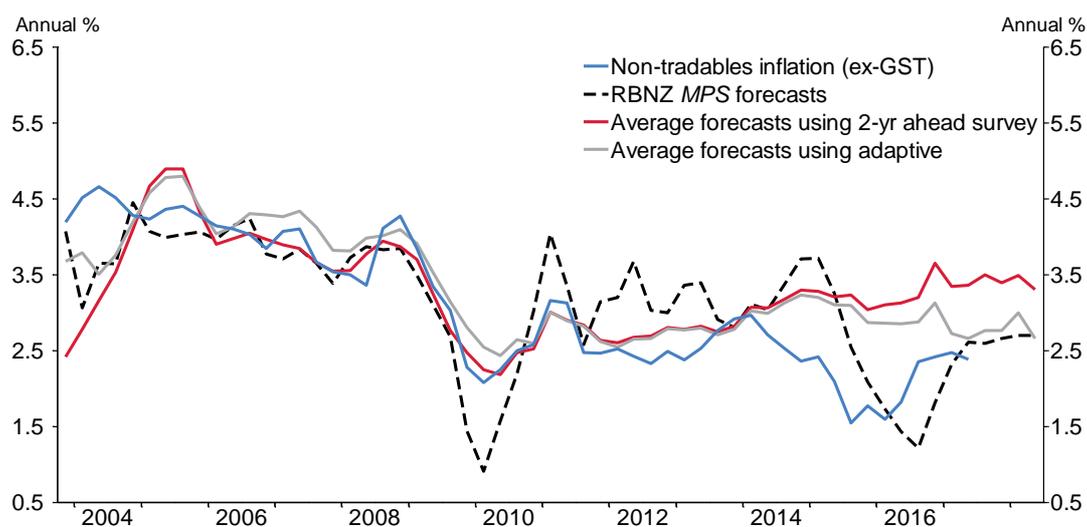
Figure 4: Adaptive inflation measure and 2-year ahead inflation expectations



⁹ The adaptive measure is set to 2.2 percent in 1992Q1, the same value as the survey measure of 2-year ahead inflation expectations. By 1992, inflation and inflation expectations had reduced from the highs of the 1980s, making this a reasonable starting point for the adaptive measure.

Figure 5 shows the average forecast of non-tradables inflation one year ahead when using the baseline adaptive inflation measure (grey line), and when using the survey of 2-year ahead inflation expectations (red line). These model-based forecasts have generally been similar through time. The most noticeable differences were in 2004 when the adaptive measure produced higher forecasts than the 2-year survey measure and since 2015 when the adaptive measure produced lower forecasts.

Figure 5: Non-tradables inflation forecasts 1-year ahead



Note: Forecasts for each quarter are produced using data that was available a year earlier. For example, the forecasts for 2003Q4 are produced using the data available at the time of the March 2003 *MPS*. The increase in GST was removed (by subtracting 2 percent) from the RBNZ *MPS* forecasts in June, September and December 2010.

Both measures produced forecasts that were too strong in 2014 and 2015. This partly reflected the reduction in ACC levies on vehicle licenses in 2015 and the decline in the prices of the telecommunications and broadband services that the models would not have accounted for. More recent weakness in non-tradables inflation, which is also evident in nominal wage inflation, would have been predicted a little better by the adaptive measure than the using the 2-year survey measure.

The Bank's *MPS* forecasts were produced using the 2-year ahead survey measure until late 2015, and have been produced using this adaptive measure ever since. Despite similar approaches, the *MPS* forecasts have tended to be more volatile than the model-based forecasts. This likely reflects other near-term information not included in the models, such as announced changes in government charges, and other differences in the models – see the appendix for an example. Three interesting episodes highlighted by the *MPS* forecasts over the past decade include:

- a) During the global financial crisis (GFC), the Bank projected non-tradables to fall from around 4 percent to 0.9 percent at the start of 2010 but it only fell to 2.1 percent.

- b) When the Bank increased the OCR in early 2014, non-tradables inflation had been expected to rise from 3 percent to above 3.5 percent by early 2015. Instead it declined to around 2.5 percent.
- c) The Bank significantly revised down its outlook for non-tradables inflation through late 2015 and early 2016, reflecting the reduction in ACC levies, revisions to the output gap, and a move towards using a measure of past CPI inflation instead of the 2-year ahead survey measure.

Table 2 shows the root mean squared errors (RMSE) for each of the models listed in table 1 relative to the *MPS* forecasts over the period from 2003 to 2017. The RMSE for the *MPS* forecasts is 0.64 percentage points.¹⁰ A value greater than 1 implies the model is less accurate than the *MPS* forecasts (i.e. a RMSE greater than 0.64); whereas a value less than 1 implies it is more accurate than the *MPS* forecasts.

Table 2: RMSEs for non-tradables inflation forecasts 1-year ahead (relative to *MPS*)

Models	2-year ahead survey	Baseline adaptive measure
Unemployment rate gap	1.28*	1.12
Output gap	1.35**	1.15
UR gap and HPI	1.21	0.82*
Output gap and HPI	1.33**	0.97
House price inflation	1.25**	0.92
Average forecast	1.10	0.83

Note: A value greater than 1 implies the model's forecasts are less accurate than the RBNZ *MPS* forecasts. ** implies the model's forecasts are significantly more or less accurate than the *MPS* forecasts with 95 percent confidence and * implies 90 percent confidence.

The baseline adaptive measure has produced smaller forecast errors than the 2-year ahead survey measure. This is true for all of the individual models and for the average forecast across the five models. The RMSE for the average forecast using the adaptive measure is around 25 percent smaller than using this survey measure.

The survey of 2-year ahead inflation expectations has produced forecasts that were also less accurate than the *MPS* forecasts (with the relative RMSEs all greater than 1). The models were between 10 and 35 percent worse, and for many models this difference was statistically significant.

¹⁰ The RMSE for the *MPS* forecasts is less than the standard deviation of the series (0.9 percentage points) implying that they are likely to be more accurate than using the unconditional mean of the series.

The baseline adaptive measure produced forecasts that were more accurate than the *MPS* forecasts in three of the five models and in the overall average. These differences are not statistically significant.

Some other findings evident in table 2 are that:

- The models that include house price inflation produced the most accurate forecasts.
- The average forecast tends to perform well relative to the individual models, most notably when using the 2-year ahead survey measure;

Table 3 shows similar findings when looking at the average forecasts across the 11 measures of past inflation and surveys of inflation expectations. The models with house prices in them have produced smaller RMSEs. Furthermore, the average forecast was more accurate than any of the individual models. The results in tables 2 and 3 suggest that the average forecast has tended to perform as well as any of the individual models. As such, the following section compares the average forecasts for each of the 11 measures of past inflation and surveys of inflation expectations.

Table 3: RMSEs for non-tradables inflation forecasts by model

Models	Average forecast across surveys and measures of past inflation
Unemployment rate gap	1.15
Output gap	1.20
UR gap and HPI	0.99
Output gap and HPI	1.11
House price inflation	1.08
Average forecast across models	0.94

Note: For each model, the RMSEs are based on the average forecast across the 11 measures of past inflation and surveys of inflation expectations. A value greater than 1 implies the model's forecasts are less accurate than the RBNZ *MPS* forecasts. ** implies the model's forecasts are significantly more or less accurate than the *MPS* forecasts with 95 percent confidence and * implies 90 percent confidence.

So far the analysis has mainly focused on the baseline adaptive measure and the 2-year ahead survey measure. Table 4 shows RMSEs for the average forecast for each of the 11 measures outlined earlier, relative to the RBNZ *MPS* forecasts. The evaluation window is also split into the two subsamples. This split is used to determine whether past-inflation measures would have performed well when inflation was elevated, or just when inflation was low, hence checking for cyclical asymmetries in price-setting behaviour. The first subsample includes the forecasts made up until the March 2009 *MPS*, a period of elevated non-tradables inflation. The second subsample includes forecasts from the June 2009 *MPS* onwards, when non-tradables inflation was low.

Table 4: RMSEs for non-tradables inflation forecasts 1-year ahead

Measures	Before 2009Q2	Since 2009Q2	2003Q1 to 2016Q3
<i>RBNZ MPS forecasts</i>	0.50	0.74	0.64
Relative to RBNZ			
1-year ahead survey	0.98	0.92	0.94
2-year ahead survey	1.32	1.00	1.10
4-year ahead survey ¹¹	1.99*	1.01	1.35
7-year ahead survey	1.81*	0.99	1.27
3-year average of NT inflation	1.13	1.11	1.12
6-year average of NT inflation	1.39	0.86	1.03
3-year average of CPI inflation	0.71	0.73**	0.73**
6-year average of CPI inflation	1.21	0.66**	0.85
Adaptive (less persistent, $\rho = 0.85$)	0.89	0.79	0.82*
Adaptive (baseline, $\rho = 0.92$)	0.87	0.81	0.83
Adaptive (more persistent, $\rho = 0.95$)	0.96	0.87	0.90

Note: The first row shows the RMSEs for the RBNZ *MPS* forecasts. For the rows after that, the RMSEs are relative to the *MPS* forecasts. The model RMSEs are calculated from the average forecast of the five models shown in table 1. A value greater than 1 implies the model's forecasts are less accurate than the RBNZ *MPS* forecasts. ** implies the model's forecasts are significantly more or less accurate than the *MPS* forecasts with 95 percent confidence and * implies 90 percent confidence.

The RBNZ *MPS* forecasts of non-tradables inflation were more accurate prior to the GFC than they have been since. The average RMSE was 0.5 percentage points before the June 2009 *MPS*, and 0.74 percentage points since. This highlights that since the GFC non-tradables inflation has been challenging to forecast, partly because existing models could not explain its weakness and partly because of the changes to government charges mentioned earlier.

Before June 2009, around half of the measures produced forecasts that were more accurate than the *MPS* forecasts (having relative RMSEs of less than 1). This includes the 1-year ahead survey, the 3-year average of past CPI inflation and the three adaptive measures. The most accurate of these was using the 3-year average of past CPI inflation, which had 29 percent smaller forecast errors than the *MPS* forecasts. The measures that performed well over this period tended to be the most responsive to past CPI inflation.

Since June 2009, the four survey measures produced forecasts of similar accuracy to the *MPS* forecasts (having relative RMSEs close to 1). In comparison, the measures that used past CPI inflation produced forecasts that were between 13 to 34 percent more accurate than the *MPS* forecasts (having relative RMSEs of between 0.66 and 0.87). This

¹¹ The regressions using the AON 4-year and 7-year ahead surveys are estimated using data from 1994Q3, because of data availability and given these series are lagged four quarters.

supports the finding shown in figure 3 – that past CPI inflation can explain recent low non-tradables inflation better than surveyed inflation expectations.

Over the full sample, there are two measures that produced forecasts that were significantly more accurate than the *MPS* forecasts at the 90 percent confidence level. These measures were the 3-year average of past CPI inflation and the less persistent version of the adaptive measure.

The 1-year ahead survey measure was the only survey measure that performed broadly as well as the measures of past inflation. For the 2-year ahead forecasts shown in table A.1 in the appendix, the 1-year and 2-year ahead survey measures were similarly accurate – although neither performed as well as the Bank's *MPS* forecasts. These results suggest that price-setting behaviour has been more consistent with shorter-term inflation expectation (such as 1- or 2-years ahead) than with longer-term inflation expectations.

A remaining question is whether measures of past inflation would perform well if they were used in the Bank's forecasting model (NZSIM). Without going to the extent of putting each of these measures into NZSIM, and all the complexities that entails, there are a couple of differences between the models used here and the Phillips curve in NZSIM that can easily be accounted for. The Phillips curve in NZSIM includes the lag of non-tradables inflation (i.e. its most recent outturn), and the coefficients on this lag and inflation expectations sum to 1. The second part of the appendix shows the results if these features were built into the models used in this note. Given these additional features, the results continue to support using measures of past inflation to forecast non-tradables inflation (see table A.2 in the appendix). The measures of past inflation perform well since 2009 and, as a result, they have smaller forecast errors over the full sample as well.

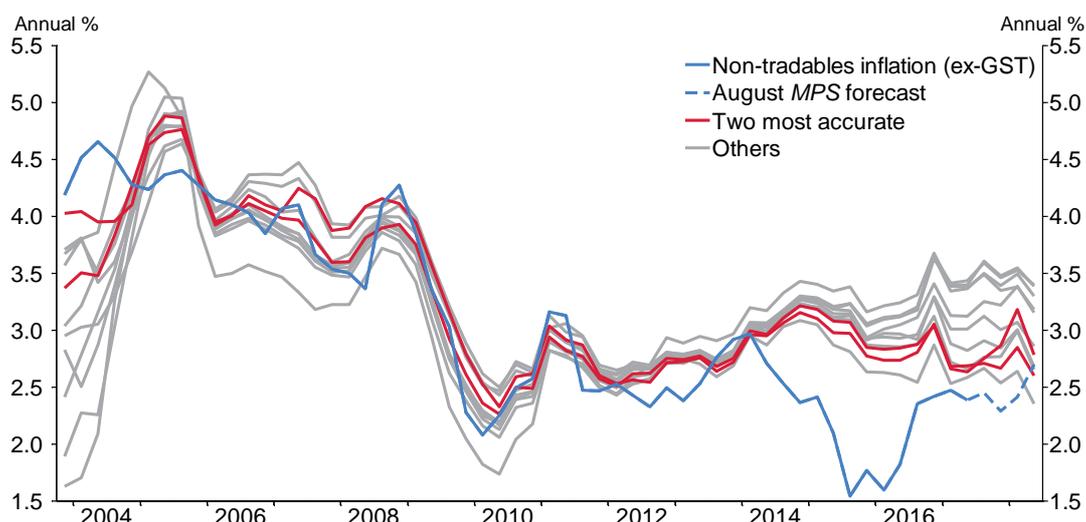
Overall, the results shown throughout this note suggest that accounting for past inflation would have resulted in forecasts that were more accurate since 2009 than using the 2-year ahead survey measure. Prior to the GFC, when inflation was elevated, forecasts that put weight on past CPI inflation also performed at least as well as the 2-year ahead survey measure. This consistency reduces the concern that the adaptive approach is only accurate intermittently and suggests it may be a reasonable approach to forecasting non-tradable inflation generally.

4. What the models imply for non-tradables inflation over the next year?

Figure 6 shows the average 1-year ahead forecast of non-tradables inflation for the measures of past inflation and surveys of inflation expectations. The range of forecasts

produced by the models is currently large relative to history, perhaps reflecting differences between the surveys of inflation expectations and measures of past inflation. The two most accurate measures (shown by the red lines) suggest non-tradables inflation will be between 2.5 and 3 percent in 2018 – similar to the forecast in the August 2017 *MPS* and only a little higher than the latest outturn of 2.4 percent in the June quarter 2017.

Figure 6: Non-tradables inflation forecasts 1-year ahead



Note: The grey and red lines represent the average forecasts for each of the 11 measures of past inflation or surveys of inflation expectations. The red lines are the two that were most accurate, i.e. the 3-year average of past CPI inflation and the less persistent adaptive inflation measure.

5. Conclusion

Non-tradable inflation has been surprisingly weak since 2014. Phillips curves with the survey of 2-year ahead inflation expectations suggest non-tradables inflation should have risen by more than we have seen, given the level of the unemployment rate and the Bank's estimates of the output gap. This note shows that using measures of past CPI inflation instead of surveyed inflation expectations would have produced more accurate forecasts of non-tradables inflation, although not all of the weakness in non-tradables inflation would have been predicted.

The Bank has adjusted its forecasting models to better capture the role of past inflation, moving away from using the survey of 2-year ahead inflation expectations to underpin its forecasts, as discussed in Box B of the August 2017 *MPS*. The results discussed in this note support this adjustment.

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Appendix: Robustness checks

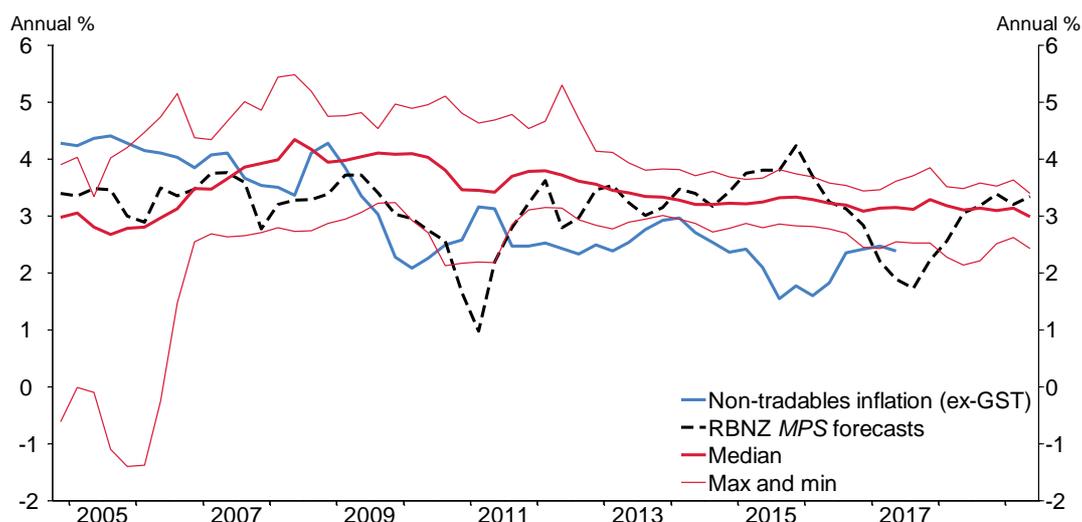
How do 2-year ahead forecasts of non-tradables inflation compare?

This section compares the accuracy of 2-year ahead forecasts using the same Phillips curve approach. Figure A.1 shows the range of forecasts produced using measures of past inflation and surveys of inflation expectations, and the RMSEs for each measure's average forecasts (relative to the Bank's *MPS* forecasts) are shown in table A.1.

Key results

- 2-year ahead forecasts of non-tradables inflation were less accurate than they were 1-year ahead. The RMSE for the RBNZ *MPS* forecasts is 0.98 percentage points for 2-year ahead forecasts, which is around 50 percent larger than the RMSE for 1-year ahead forecasts (0.64 percentage points).
- The range of model-based forecasts in the early part of the evaluation sample was wide. This range seems to have narrowed through time, especially since 2011.¹²
- The *MPS* forecasts were more variable than the median model-based forecast since the GFC. The *MPS* forecasts were higher than any of the models for 2015. This reflects that in 2013, when these forecasts were made, the outlook for domestic growth was expected to be supported by high export prices and strong net immigration. Conversely, the *MPS* forecasts for 2017 were particularly low.
- All measures of past inflation and surveys of inflation expectations produced significantly less accurate forecasts than the Bank's *MPS* forecasts in the first part of the sample (table A.1). As a result, the *MPS* forecasts also outperformed all of the model-based forecasts on average over the full sample. The methodology used to produce the Bank's medium-term inflation forecasts seems superior to these simple models at this horizon.
- There are no clear indications that the measures of past inflation or surveys of inflation expectations produced more or less accurate 2-year ahead forecasts. Of the survey measures, the 2-year ahead survey measure was the about as accurate as the 1-year ahead survey measure. These surveys measures were both about as good as the measures of past inflation for forecasting non-tradables inflation at this horizon.

¹² The length of the sample used to estimate the parameters is quite short for the first few forecasts. For most models the sample is nine years long (1994Q1-2002Q4), but is only seven and a half years when using the 4- and 7-year ahead surveys (1995Q2-2002Q4). This might explain why the 4- and 7-year ahead survey measures produce such inaccurate forecasts before 2009.

Figure A.1: 2-year ahead forecasts of non-tradables inflation**Table A.1: RMSEs for non-tradables inflation forecasts 2-years ahead**

Measures	Before 2009Q2	Since 2009Q2	2003Q1 to 2015Q3
<i>RBNZ MPS forecasts</i>	0.71	1.13	0.98
Relative to RBNZ			
1-year ahead survey	1.50**	0.99	1.14
2-year ahead survey	1.49**	0.97	1.13
4-year ahead survey	3.03**	0.85	1.70**
7-year ahead survey	3.03**	0.78*	1.67**
3-year average of NT inflation	1.30**	0.97	1.06
6-year average of NT inflation	2.40**	0.84	1.41**
3-year average of CPI inflation	1.54**	0.81*	1.04
6-year average of CPI inflation	1.80**	0.76**	1.12
Adaptive (less persistent, $\rho = 0.85$)	1.84**	0.86	1.19
Adaptive (baseline, $\rho = 0.92$)	2.04**	0.98	1.34**
Adaptive (more persistent, $\rho = 0.95$)	2.11**	1.01	1.38**

Note: For each measure, the RMSEs are based on the average forecast from the five models (see table 1). A value greater than 1 implies the model's forecasts are less accurate than the RBNZ *MPS* forecasts. ** implies the model's forecasts are more or less accurate than the *MPS* forecasts with 95 percent confidence and * implies 90 percent confidence.

What if the models are more like the Phillips curve NZSIM?

NZSIM is the Bank's macroeconomic model used to project inflation in the medium term. The non-tradables Phillips curve in NZSIM is driven by the output gap and inflation expectations, as in the models used in this note. Two differences are that in NZSIM the Phillips curve also includes non-tradables from the previous quarter, and the coefficients on this lag and inflation expectations sum to 1. In this section, these features are built into the models to determine how the various measures of past inflation and surveys of inflation might have performed in NZSIM. The following equation defines these adjusted models:

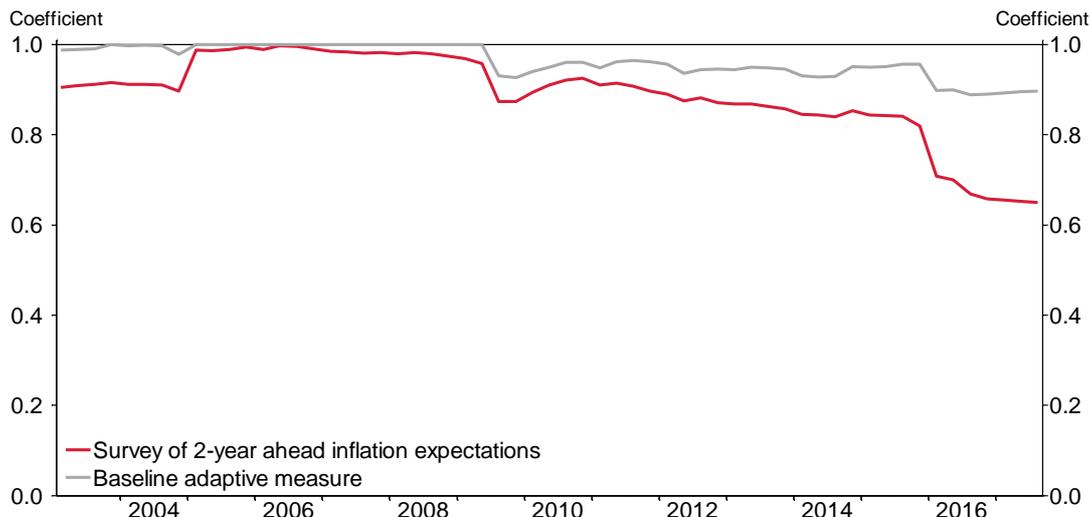
$$\pi_{t+3}^{NT} = a_{i,j} + b_{i,j}X_{i,t} + c_{i,j}\pi_{j,t}^e + (1 - c_{i,j})\pi_{t-1}^{NT} + \varepsilon_{i,j,t} \quad (3)$$

where

- X includes one of the five sets of explanatory variables listed in table 1, and π^e includes one of 11 measures of past inflation or surveys of inflation expectations;
- π_{t-1}^{NT} is annual non-tradables inflation from the previous quarter;
- The parameters are estimated using restricted least squares, with c restricted to be between 0 and 1.

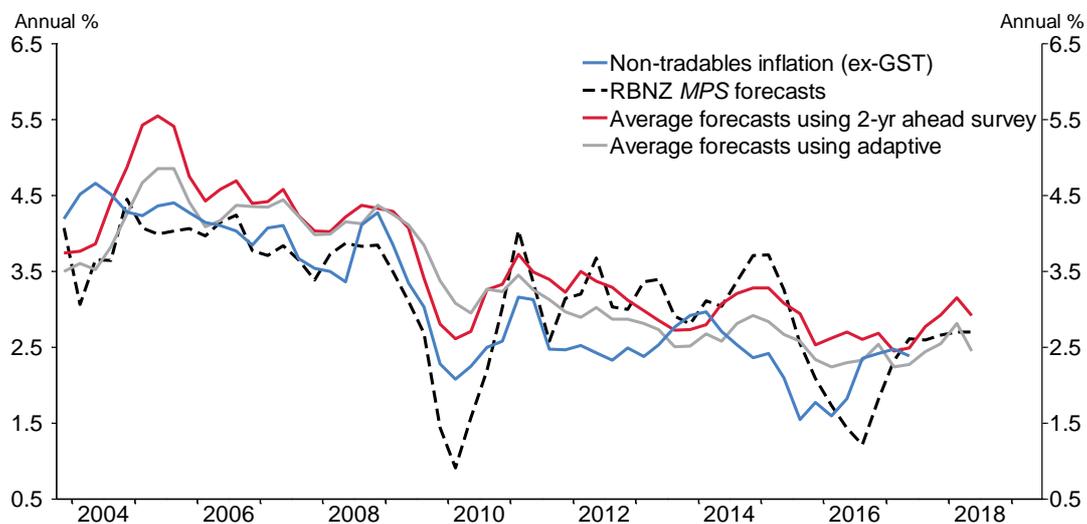
The first notable finding from this adjusted model is the weight that it puts on the various measures of past inflation and surveys of inflation expectations relative to non-tradables inflation in the previous quarter. In the most recent estimates, the weight on the survey of 2-year ahead inflation expectations is 0.65, meaning the weight on non-tradables inflation in the previous quarter is 0.35. The weight on the baseline adaptive measure is higher at 0.95, meaning very little weight is on non-tradables inflation in the previous quarter.

Looking at these estimated weights through time, in the mid-2000s they were both close to 1 and only since the GFC have they reduced (figure A.2). The weight on the 2-year ahead survey declined the most after the GFC, especially in 2015. This seems to be consistent with the recent weakness in non-tradables being best explained by measures of past inflation, rather than surveys of inflation expectations.

Figure A.2: Coefficients on adaptive and survey measures (c)

Note: The coefficients are the average across the five models for each measure at each point in time.

Forecasts using the survey of 2-year ahead inflation expectations have typically been higher than using the baseline adaptive measure, consistent with the survey being higher for much of the time since 2004 (figure A.3).

Figure A.3: Non-tradables inflation forecasts 1-year ahead with adjusted models

All of the measures of past CPI inflation have produced more accurate forecasts than the survey measures, particularly in period after the GFC (table A.2). In the earlier part of the sample, the measures that used past CPI inflation also performed about as well as the survey measures. These results largely support the conclusion found in the main part of this note, that using measures of past inflation would have produced more accurate forecasts than the survey of 2-year ahead inflation expectations.

Table A.2: RMSEs for non-tradables inflation forecasts with adjusted models

Measures	Before 2009Q2	Since 2009Q2	2003Q1 to 2016Q3
1-year ahead survey	1.56**	0.97	1.16
2-year ahead survey	1.27	0.95	1.04
4-year ahead survey	1.25	1.09	1.13
7-year ahead survey	1.12	1.08	1.09
3-year average of NT inflation	1.79**	0.96	1.24*
6-year average of NT inflation	2.37**	0.69**	1.37
3-year average of CPI inflation	1.34	0.68**	0.91
6-year average of CPI inflation	1.33**	0.59**	0.86
Adaptive (less persistent, $\rho = 0.85$)	1.41**	0.69**	0.94
Adaptive (baseline, $\rho = 0.92$)	1.16	0.68**	0.84*
Adaptive (more persistent, $\rho = 0.95$)	1.03	0.74**	0.83*

Note: For each measure, the RMSEs are based on the average forecast from the five models. A value greater than 1 implies the model's forecasts are less accurate than the RBNZ *MPS* forecasts. ** implies the model's forecast is more or less accurate than the *MPS* forecasts with 95 percent confidence, and * implies 90 percent confidence. For each measure, the RMSEs are based on the average forecast from the five models.