Appendix: Assessing the probability of different inflation outcomes

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Full article: Assessing the probability of different inflation outcomes

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This appendix explains the methodology for Anthonisz (2021). This includes details of:

A.1: Method

A.2: Results

A.3: Robustness checks

A.4: Data

A.1: Method

The method for both Approach 1 & 2 is below.

Approach 1

Approach 1 estimates the probability that inflation will sit within different ranges in two years time. These estimates are based on the relationship between different inflation forecasts and actual trimmed mean inflation [1] over time, as well as the latest forecasts of inflation.

First, the approach requires different forecasts of inflation. In this article, I have used both model-based forecasts and forecasts from other sources.

- The model I developed is a Factor Augmented Vector Autoregression (FAVAR), which was inspired by the FAVAR described by Jackson, Kliesen & Owyang (2015) (though there are some notable departures from their specification). [2]
- The other forecasts of two-year ahead inflation are from various contributors, including the RBA, consumers, [3] union officials, as well as financial market economists and financial market instruments. Details of these series are included in Table 5 in Section A.4. [4]
- The evaluation period for these forecasts begins in 2003 Q1.

I then identified ranges for which the probability of inflation sitting within are to be assessed and created dummy variables accordingly. The ranges selected (and the associated dummy variable values) used in this analysis were:

- Less than 1.5 per cent (1)
- Between 1.5 per cent and 2.0 per cent (2)
- Between 2.0 per cent and 2.5 per cent (3)

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[1] As in the main paper, the term 'inflation' refers to trimmed mean inflation

[2] The key differences from the model described by Jackson, Kliesen & Owyang are firstly, my model is not Bayesian and secondly, their model utilises nine factors to estimate inflation while mine uses three (observed inflation, short-term expectations of inflation and demand for goods and services). Fewer factors were selected to facilitate a more parsimonious specification. Those selected were considered most likely to align to future inflation outcomes. The Kalman Filter was used to estimate the factors based on the series in Tables 1 to 3 in section A.4.

[3] These series are re-scaled to have same mean as trimmed mean inflation. This is designed to remove the upward bias in consumer inflation expectations. Issues with consumer (and other types of) inflation expectations are summarised in Moore (2016).

[4] These expectations are for headline CPI inflation but are being used to estimate the probability of trimmed mean inflation outcomes in two years time. At short horizons, the discrepancy between forecasts for the two measures of inflation can be significant but at longer periods – such as two years ahead – tend to be limited.

- Between 2.5 per cent and 3.0 per cent (4)
- More than 3.0 per cent (5)

I then estimated an ordered probit model for each forecast to obtain the probability that, based on the relationship between expectations and outcomes observed historically and the latest forecast, inflation in two years time could fall into one of the ranges identified.

- The dependent variable in these regressions is the dummy variables as specified above, and the independent variables are the relevant two-year ahead forecasts.

Approach 2

Approach 2 involves preparing density forecasts for inflation. From these, estimates of the probability of future inflation outcomes being observed can be calculated. The method employed to do this is below.

- Calculate the forecast error[5] for the model and different forms of inflation expectations

- Generate estimates for each percentile of the distribution of inflation forecast errors, relative to a set of conditioning variables, by using quantile regressions.[6] The dependent variable in these regressions are the forecast errors and the variables that could explain it are the independent variables. On the latter:
  - The variables included in the quantile regression to explain the forecast errors are the Citi Inflation Surprise Index and the Citi Inflation Consensus Change Index, both from when the forecast was made (two years ago).
  - These variables capture how inflation outcomes differ from financial market economist expectations and how the consensus of economists regarding inflation changes over time. They are thus proxies for how predictable inflation is. The predictability of the economy has been identified as an appropriate way to define uncertainty.
  - In principle, if the inflation forecasts were perfectly efficient in incorporating the information content of incoming inflation data surprises and shifts in the consensus view on inflation, then these variables should not have any explanatory power. That said, it is possible that the information content from these conditioning variables provides false leads or is not able to be efficiently processed by the forecaster. Further, they may make other errors in forming their expectations or be wrongfooted by events which could not have been reasonably foreseen. So there are many reasons to think that forecast errors will be non-zero, though there are variables which could explain in part what could drive the size of these.
  - The R-squared's of the quantile regressions were low which suggests the variables chosen don't have substantial explanatory power over forecast errors.[7] This is not particularly surprising: if the forecasts were perfectly efficient in incorporating new information, these errors would simply reflect unexpected 'shocks' which are not forecastable. However, the models do have some limited explanatory power over forecast errors, which is why I used them as a basis to create conditional distributions of inflation forecasts.

- Estimate fitted values for the forecast errors from the quantile regressions. These represent estimates of the forecast error at different quantiles (that is, percentiles) of the distribution of forecast errors relative to the control variables.

- To create the time series of inflation forecasts at different quantiles (Graph 4 in the note) add the fitted values from each of the quantile regressions (that is, the expected forecast error) to the latest forecast. For each quantile, this gives a forecast of inflation that is conditional on information available today.

- To construct estimates of the distribution of different future inflation outcomes (see Graph 5 in the note), Kernel density estimation is used to generate a distribution around the 50th quantile. From here, the probabilities of outcomes sitting within different ranges can be calculated.

A.2: Results

For Approach 1, results for the different sources of inflation forecasts can be seen in Graph 1 below.

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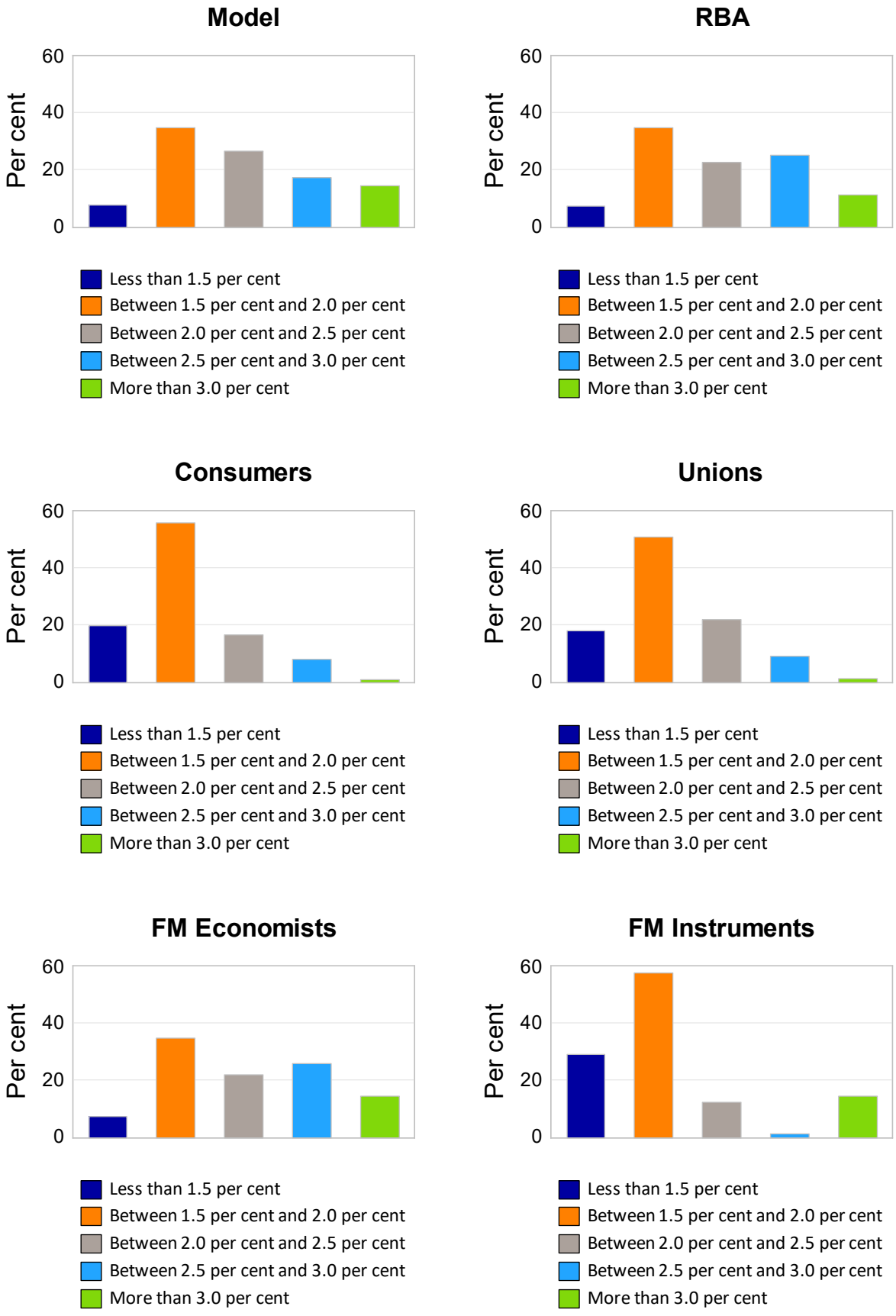
[5] Tulip & Wallace (2012) discuss why historic forecast errors may not be a reliable guide to the future

[6] While Ordinary Least Squares regressions seek to describe the average relationship between variables, Quantile regressions aim to estimate that relationship for particular segments of the data. Paragraphs 10 to 12 on pages 7 and 8 of Laurent & Kozluk (2012) provides useful further explanation. Regressions were run for quantile 1 to 99. With forecast errors for the model plus the five types of inflation expectations and 99 quantile regressions for each, a total of 594 quantile regressions were run.

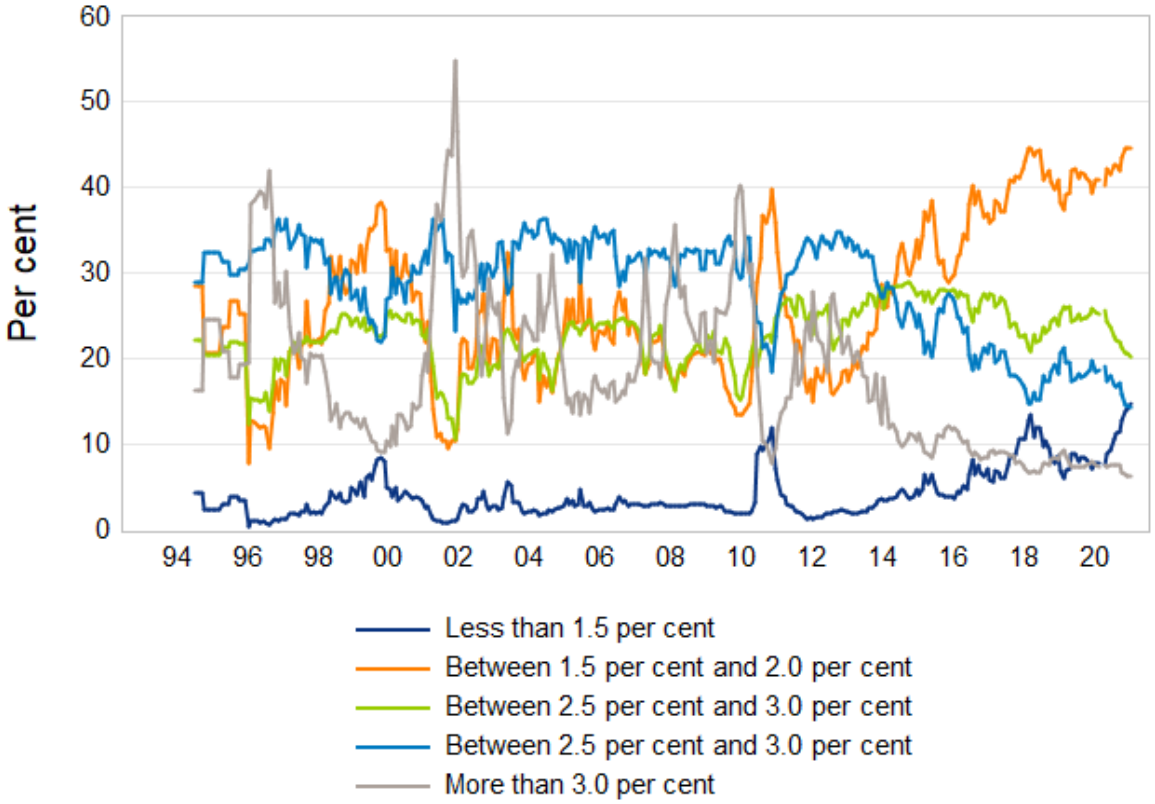
[7] A sample of the quantile regressions revealed R-Squared's commonly less than 10 per cent (though higher for financial market instruments). For the particular control variables, the Citi Inflation Surprise Index generally had a significant relationship with future forecast errors while the Citi Inflation Consensus Change Index typically did not.

GRAPH 1: ESTIMATED PROBABILITIES OF INFLATION OUTCOMES IN TWO YEARS TIME



A time series of these estimated probabilities by range and averaged over the different sources can be seen in Graph 2.

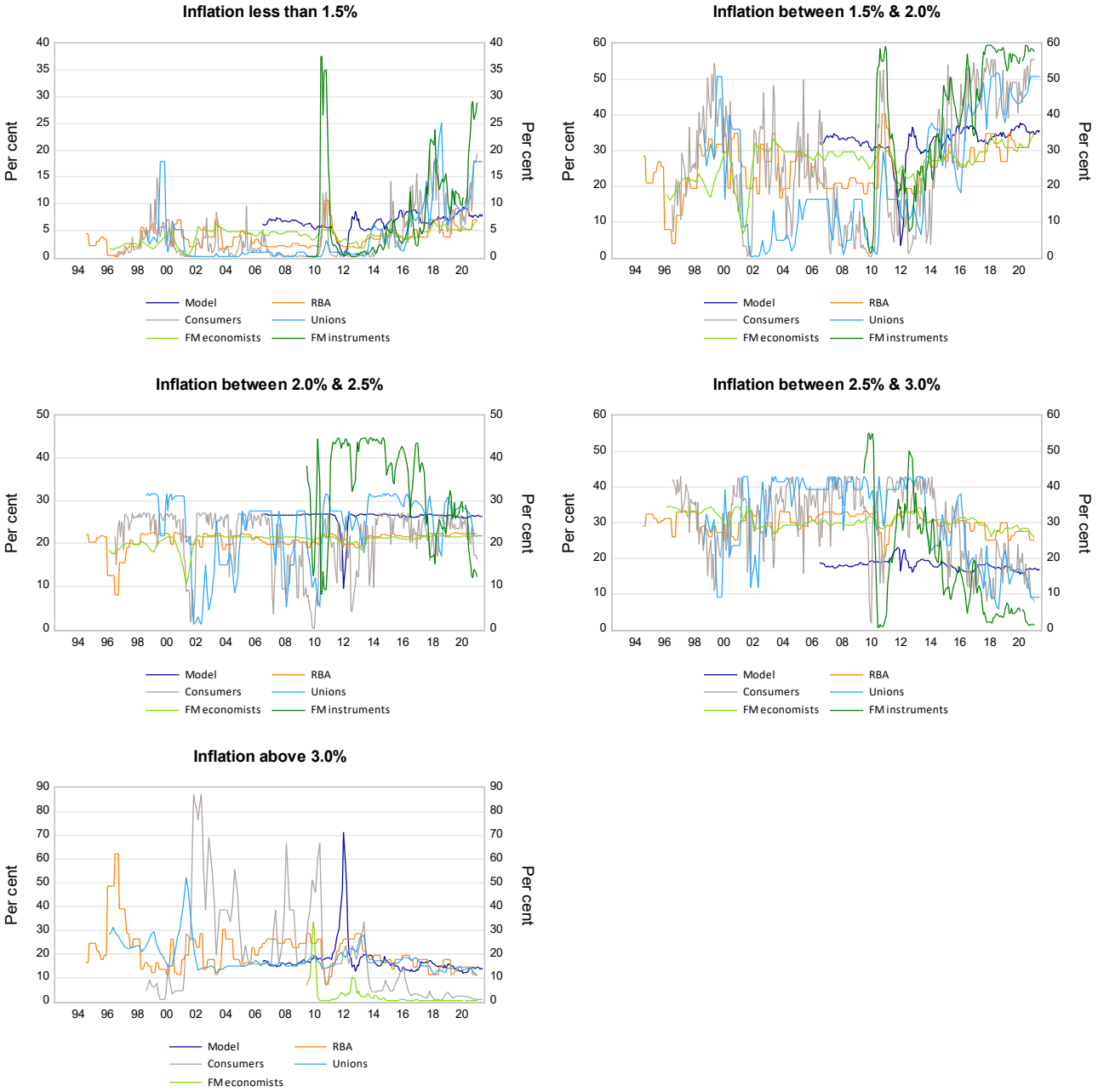
GRAPH 2: TIME SERIES OF ESTIMATED PROBABILITIES OF INFLATION OUTCOMES IN TWO YEARS TIME (SIMPLE AVERAGE)



* - Represents the average probability of particular outcomes for estimates that were available. Those from the model, RBA, consumers, union officials plus market economists & instruments were available from February 2007, January 1995, January 1997, February 1999, August 1996 and January 2010 respectively.

A time series of these estimated probabilities by range and source is set out in Graph 3 below.

GRAPH 3: TIME SERIES OF ESTIMATED PROBABILITIES OF INFLATION OUTCOMES IN TWO YEARS TIME



A.3: Robustness checks

The key robustness checks employed in this note included using:

- The different sources of inflation forecasts.
- Alternate factors in the FAVAR model (for example, labour demand) and variables in the quantile regressions (for example, dispersion in point forecasts as a proxy for forecast uncertainty).[8]
- Using observed and expected forecast error to generate the estimates of future inflation by quantile.
- The two approaches (ordered probit and quantile regression).

A.4: Data

Table 1 – Series used to estimate the short-term inflation expectations factor used in the FAVAR model

[8] Of course, forecast dispersion does not necessarily neatly describe forecast uncertainty as noted by Moore (2016) but was tried given the absence of intuitive variables to describe forecast errors.

Series	Source	Frequency
Retail price next 3 months	NAB Quarterly Business Survey	Quarterly
Final product price next 3 months	NAB Quarterly Business Survey	Quarterly
Consumer Inflation Expectations (2-year ahead)	ANZ	Monthly
Consumer Inflation Expectations 30% Trimmed Mean	Melbourne Institute	Monthly
Consumer Inflationary Expectations Weighted Mean	Melbourne Institute	Monthly
Union officials' inflation expectations (1-year ahead)	RBA Statistical Tables – G3	Monthly
Union officials' inflation expectations (2-year ahead)	RBA Statistical Tables – G3	Monthly
Market economists' inflation expectations (1-year ahead)	RBA Statistical Tables – G3	Monthly
Market economists' inflation expectations (2-year ahead)	RBA Statistical Tables – G3	Monthly
Zero coupon (that is, inflation) swaps	Bloomberg	Monthly
Break-even inflation	Hambur & Findlay (2018) for data to end-2016, Bloomberg for data following that time	Monthly

Table 2 – Series used to estimate the observed inflation factor used in the FAVAR model

Series	Source	Frequency
Retail price	NAB Quarterly Business Survey	Quarterly
Final product price	NAB Quarterly Business Survey	Quarterly
Retail price last 3 months	NAB Quarterly Business Survey	Quarterly
Final product price last 3 months	NAB Quarterly Business Survey	Quarterly
Inflation Gauge	Melbourne Institute	Monthly
Inflation Gauge – Trimmed Mean	Melbourne Institute	Monthly
Inflation Gauge – Excluding volatile items	Melbourne Institute	Monthly
Average Selling Prices – Manufacturing PMI	Ai Group	Monthly
Average Selling Prices – Services PMI	Ai Group	Monthly
Average Selling Prices – Construction PMI	Ai Group/HIA	Monthly

Table 3 – Series used to estimate the demand for goods & services factor used in the FAVAR model

Series	Source	Frequency
AiG Performance of Manufacturing Index (PMI)	Production	Monthly
	New orders	Monthly
	Sales	Monthly
AiG Performance of Services Index (PSI)	Production	Monthly
	New orders	Monthly
	Sales	Monthly
AiG/HIA Performance of Construction Index (PCI)	Production	Monthly
	New orders	Monthly

Series	Source	Frequency
ACCI-Westpac Survey of Industrial Trends	Output, last 3 months	Quarterly
	Output, next 3 months	Quarterly
NAB Business Survey	Forward orders	Monthly
NAB Business Survey	Forward orders, expected	Quarterly
	Sales, change in next 12 months	Quarterly

Table 4 – Series used to generate estimated probabilities of inflation two-years ahead

Series	Source	Frequency
FAVAR model estimates	Author	Monthly
RBA trimmed mean inflation forecasts	For the period up to the end of 2014, these forecasts are available here (Historical Forecasts). For the post-2014 period, these forecasts have been updated using the inflation forecasts provided in each RBA Statement on Monetary Policy (Statement on Monetary Policy).	Quarterly
Consumer inflation expectations (2-year ahead)	ANZ/Roy Morgan	Monthly
Consumer Inflation Expectations 30% Trimmed Mean	Melbourne Institute	Monthly
Consumer Inflationary Expectations Weighted Mean	Melbourne Institute	Monthly
Union officials' inflation expectations (2-year ahead)	RBA Statistical Tables – G3	Quarterly
Market economists' inflation expectations (2-year ahead)	RBA Statistical Tables – G3	Quarterly
Zero coupon (that is, inflation) swaps	Bloomberg	Monthly