MONETARY POLICY NEAR THE ZERO LOWER BOUND

(2015) finds that there is a 14 per cent probability of the cash rate being at zero by February 2017.

(2015) finds a 14 per cent probability that the cash rate will reach zero by February 2017.

Economist
Research
Economic Research Department
21 April 2015

Resources

M (2015), 'Estimates of Uncertainty around the Market-implied Cash Rate Path', *ER internal note.*

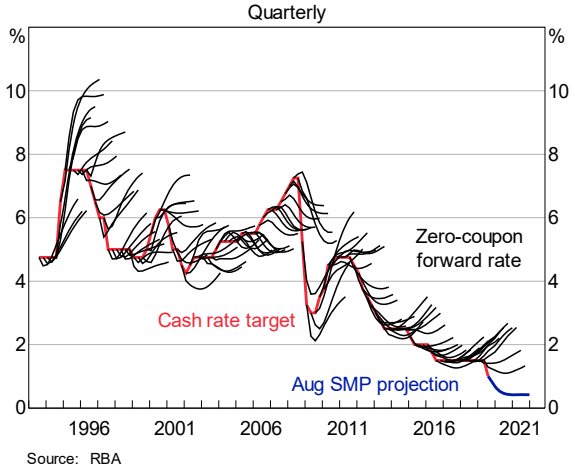
THE PROBABILITY OF REACHING THE ZERO LOWER BOUND

If forward rates make the same size errors as they have in the past, there is a 41 per cent probability of a zero cash rate at December quarter 2021. Stochastic simulations of MARTIN imply a similar probability of 37 per cent.

The August SMP assumed the cash rate will decline to 42 basis points by mid-2021. This raises the prospect that monetary policy could soon be constrained by the zero lower bound (ZLB), limiting the ability of monetary policy to offset future negative shocks.

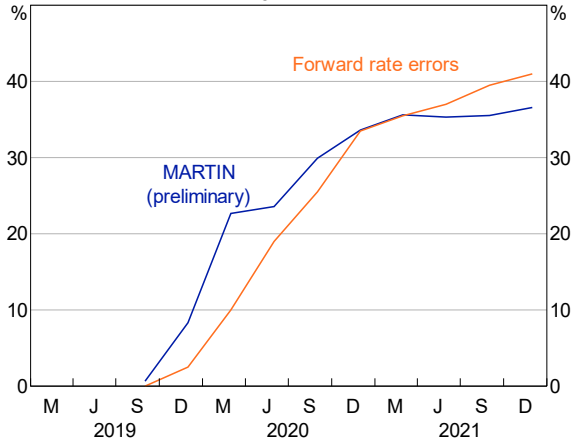
(2015) calculates the distribution of historic errors in market expectations of the cash rate at different horizons (Graph 1). Assuming the market makes similarly sized errors to those in the past gives the probability that the cash rate will be constrained at the ZLB. Updated estimates using this approach are shown as the orange line in Graph 2. The probability of reaching the ZLB is estimated to be 34 per cent at December 2020, and 41 per cent at December 2021. The blue line in Graph 2 shows the probability of reaching the ZLB using stochastic simulations in MARTIN (forthcoming).[1]

Graph 1
Cash Rate and Market-implied Path
Quarterly



Source: RBA

Graph 2
Probability of Zero Cash Rate at Horizon*
As at August 2019 SMP



Source: RBA

The two approaches have different strengths and weaknesses. MARTIN's estimates depend on many assumptions and estimates. In particular, they assume that the cash rate follows a calibrated Taylor-type rule (see & 2018) which is a very simple approximation to past RBA behaviour. The yield curve approach assumes that the OIS curve makes the same size errors as it has in the past. In contrast to MARTIN, forward rates should encompass all available information. Accordingly, unless one thought that forward rates are seriously biased or misinformed, yield curve errors provides more credible point estimates of the probability than MARTIN's stochastic simulations. However, the two big advantages of using MARTIN are that it enables estimation of how alternative policies might interact with the ZLB, and can quantify the costs of constrained monetary policy (for example, in terms of additional unemployment). Both issues are discussed in more detail in (forthcoming). That said, the most important point is that both methods produce very similar results, despite being constructed independently.

These results have important policy implications – if the probability of a zero cash rate is high, monetary policy should arguably be more expansionary than would otherwise be the case, as discussed in 2015, 2016 and 2015).

Research Economist
Economic Research Department
21 August 2019

1 Thanks to for helpful comments and running the MARTIN simulations.

Appendix A - Measurement details

Following (2015), I use zero-coupon forward rates as a measure of market expectations for the path of the cash rate. These forward rates are constructed using overnight index swap (OIS) rates, and yields on Treasury notes and Commonwealth Government Securities. To calculate historic errors in cash rate expectations, I take the market-implied path of the cash rate on the first Wednesday of the months in which the SMP is released. This should approximately reflect the cash rate expectations on which the Bank's forecasts have been conditioned. The cash rate `forecast error' is then defined as the realised cash rate target minus the corresponding zero-coupon forward rate. I use EA's cash rate assumption from the August SMP as the baseline cash rate path.

In calculating the probabilities presented in this note I have used historic *absolute* forward-rate errors. Doing so assumes that the forward curve is an unbiased forecast of the cash rate. An alternative approach could be to assume that the cash rate forecast errors follow the same distribution as the historical distribution of *actual* forecast errors. Under this approach, the probability of zero cash rate at December quarter 2021 is 60 per cent.

THE EFFECTIVE LOWER BOUND AND ITS IMPLICATIONS

As the cash rate declines, the possibility of reaching its Effective Lower Bound (ELB) becomes a more pressing concern. Stochastic simulations in MARTIN show that the likelihood of a zero cash rate in December 2021 has risen to around 40 per cent as at the August 2019 SMP from around 20 per cent at the May 2019 SMP.

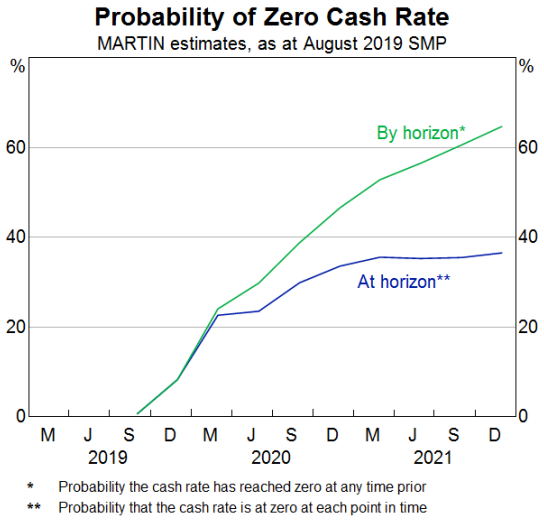
Introduction

In this note I estimate the probability of reaching the ELB using MARTIN, incorporate an ELB in to MARTIN's policy rule and discuss some of the implications of being constrained by the lower bound.

Probability of reaching the ELB

Stochastic simulations in MARTIN estimate that the likelihood of reaching an ELB is relatively high and has increased recently (Graph 1).[3] For example, there is a 37 per cent chance of being at the zero lower bound at the end of the forecast horizon, according to MARTIN. This estimate was just 18 per cent at the May 19 SMP. Non-parametric methods using market pricing produce similar results (2019). If we measure the probability of having reached a cash rate of zero by the forecast horizon, instead of necessarily being at zero at the forecast horizon, the estimate is around 60 per cent.

Graph 1



3 I use 10,000 draws of historical errors, apply these errors as shocks to MARTIN and measure how many of the scenarios result in a cash rate at or below 0. See 2019 for more detail on stochastic simulations in MARTIN.

Limitations and further work

This work abstracts from agents' expectations of future monetary policy, which are likely to be an important element when the central bank is constrained by the ELB. Further work will look to incorporate expectations into the ELB framework presented in this note.

Conclusion

Stochastic simulations in MARTIN show that the likelihood of a zero cash rate in December 2021 has risen in recent months to around 40 per cent as at the August 2019 SMP. Simple

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8 October 2019

ESTIMATES OF UNCERTAINTY AROUND THE MARKET-IMPLIED CASH RATE PATH

This note estimates the uncertainty around a market-implied path of the cash rate using the historical distribution of differences between zero-coupon forward rates and the actual cash rate target. The width of the estimated 90 per cent confidence interval is about ±3 percentage points at the two-year horizon. If the distribution of forward-rate errors is similar to that over the past two decades, the market path at the time of the February SMP implies that the probability of a zero cash rate in February 2017 is 14 per cent.

Introduction

Forecasts presented in the February Statement on Monetary Policy (SMP) were conditioned on the assumption that the cash rate moves broadly in line with expectations inferred from market pricing.[1] While the SMP was careful to stress that 'this assumption does not represent a commitment by the Board to any particular path for policy', it may be desirable to reinforce this point. One way of doing this is by graphically presenting confidence intervals around the market-implied cash rate path (i.e. the cash rate 'forecast'), as is done for the SMP forecasts of GDP growth, inflation and, more recently, unemployment. Additionally, estimates of uncertainty around the cash rate forecast can be used to estimate the probability of the cash rate reaching zero, which may be an important consideration when determining the appropriate path of policy.[2]

Some other central banks present measures of uncertainty around their policy rate projections. For example, the US Federal Reserve publishes model-based confidence intervals and the distribution of Federal Open Market Committee participants' projections of the appropriate path of the federal funds rate. The Riksbank publishes a forecast repo rate path, with confidence intervals based on the Riksbank's own forecasting errors and the historical ability of forward rates to forecast the repo rate (Kjellberg and Villani 2010; Sveriges Riksbank 2015).[3] Norges Bank publishes forecasts of the 'key policy rate' based on judgement about the appropriate path of monetary policy, with confidence intervals generated using a macroeconomic model (Norges Bank 2005, 2014).

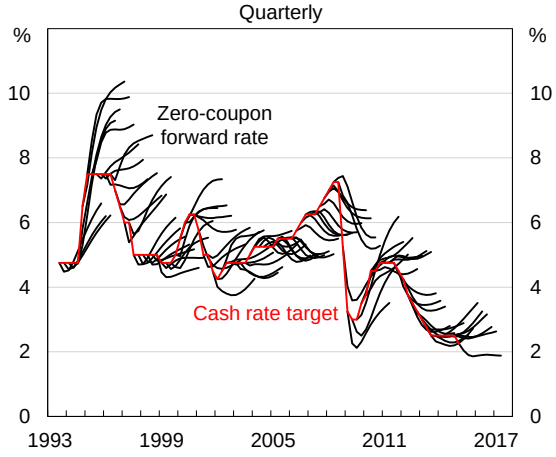
Data and methodology

I use estimated zero-coupon forward rates as a measure of market expectations for the path of the cash rate (Graph 1). These forward rates are constructed using overnight index swap (OIS) rates, and yields on Treasury notes and Commonwealth Government Securities.[4] For the purposes of this analysis, the market-implied path of the cash rate is taken as being the zero-coupon forward curve on the first Wednesday of the months in which the SMP is released (i.e. the day after the Board's cash rate decision), as this should be a reasonable approximation of the cash rate expectations on which the Bank's SMP forecasts could be conditioned. The realised cash rate target is taken to be the cash rate target on the same days. The cash rate 'forecast error' is defined as the realised cash rate target minus the corresponding zero-coupon

Graph 1

Cash Rate and Market-implied Path

Quarterly



Source: RBA

1 In previous SMPs, forecasts were conditioned on the assumption of a constant cash rate.

2 (forthcoming) reviews the literature discussing the appropriate setting of monetary policy given the existence of a lower bound on nominal interest rates.

3 The Riksbank uses two sources of forecasts errors because the history of its own forecasts is too short to precisely estimate confidence intervals around the repo rate projection.

4 There are three main sources of data used by the Bank to infer market-implied cash rate expectations: interbank cash rate futures (e.g. Figure 4.1 of the February SMP); OIS (e.g. DM Monthly Note – March 2015); and estimated zero-coupon forward rates (e.g. Statistical Table F17, Finlay and Chambers (2008) and Finlay and Olivan (2012) – see these papers for details on how the zero-coupon forward rates are estimated). Differences between cash rate expectations implied by these data sources appear to be small. I use zero-coupon forward rates because of their longer horizon and availability from an earlier date.

forward rate. Cash rate forecast errors are calculated at quarterly horizons up to nine quarters ahead over the inflation-targeting period.

Summary statistics

Table 1 presents statistics describing cash rate forecast errors. The market-implied cash rate path appears to be roughly unbiased at short horizons, but the size of the average error (or bias) increases with the horizon (although it is not significantly different to zero at the 5 per cent level of significance at forecast horizons less than eight quarters ahead). The bias at longer horizons could reflect the existence of a positive term premium (discussed below). The average magnitude of errors, as measured by the mean absolute error (MAE) and root-mean-square error (RMSE), also increases with the forecast horizon.

Table 1: Cash Rate Forecast Errors Based on Zero-coupon Forward Rates – Summary Statistics

Percentage points

	Forecast horizon			
	One quarter	Two quarters	Four quarters	Eight quarters
Average error[(a)]	0.04	−0.06	−0.21	−0.67
	(0.22)	(0.48)	(0.26)	(0.03)
MAE	0.23	0.39	0.81	1.39
RMSE	0.34	0.64	1.07	1.56
Maximum absolute error	1.59	3.36	3.64	3.84
Forecast origin	August 2008	August 2008	May 2008	February 1995
No. of observations	86	85	83	79

(a) p-values (in brackets) based on a constant-only regression with Newey-West standard errors
Source: RBA

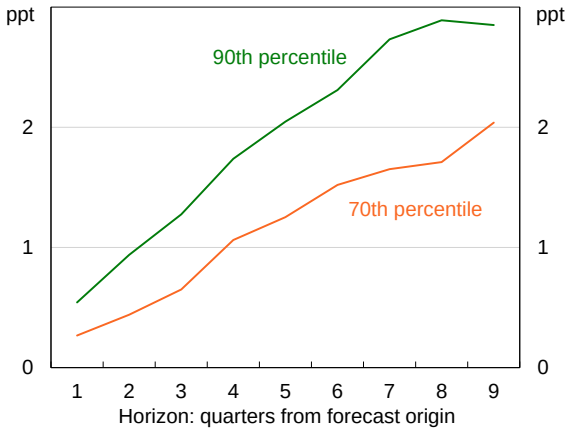
Confidence intervals

Graph 2 presents the 70th and 90th percentiles of the historical distribution of absolute forecast errors.[5] As expected, the percentiles tend to increase with the forecast horizon; the 90th percentile of absolute four-quarter-ahead forecast errors is around 1.7 percentage points, while it is around 2.9 percentage points at the eight-quarter-ahead horizon. Using the distribution of *absolute* forecast errors to construct confidence intervals assumes that the distribution of forecast errors is symmetric and centred at zero; that is, it assumes that any bias and skewness in the sample of forward-rate errors will not persist into the future (it is not necessary to assume normality). These are the same assumptions made in constructing the confidence intervals presented in the SMP.

Graph 2

Cash Rate Forecast Confidence Intervals*

Percentiles of absolute forecast errors since 1993

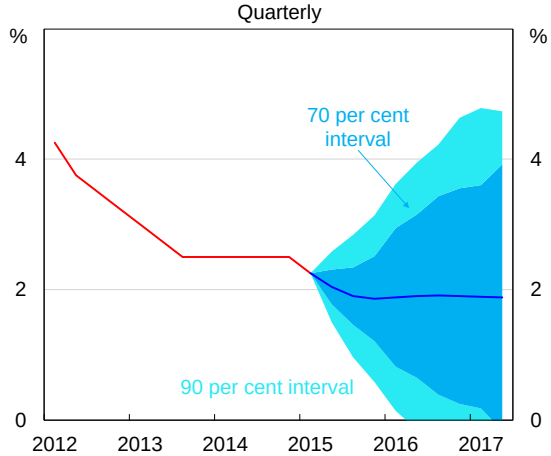


* Forecasts based on zero-coupon forward rates
Source: RBA

Graph 3

Cash Rate Forecast*

Quarterly



* Based on zero-coupon forward rates
Source: RBA

5 This choice of percentiles matches those used in constructing the confidence intervals presented in the SMP.

Graph 3 shows the market-implied cash rate path as at the February 2015 SMP, along with the 70 and 90 per cent confidence intervals based on the distribution of absolute forecast errors. The intervals are substantially wider than some alternatives. For example, the 90 per cent probability interval around the Economic Research (ER) model-based cash rate forecast is around ±2 percentage points at the two-year horizon, although this partly reflects the fact that this interval is based on in-sample fit, rather than on historical out-of-sample forecasting performance.[6] The market-implied intervals are also probably wider than some people's subjective assessment of current uncertainty around the path of the cash rate. However, psychological studies find that subjective estimates of uncertainty tend to be too low (often by large margins), even among experts.[7]

In presenting the confidence intervals, I truncate them at zero, consistent with the approach taken by Norges Bank (Norges Bank 2014).[8] However, in reality the effective lower bound on the nominal policy rate may be different to zero for technical reasons. For example, the Fed and Bank of England have positive effective lower bounds, while the Riksbank and the Swiss National Bank currently have negative policy rates. In contrast to the approach taken here, the Riksbank does not truncate its repo rate forecast distribution at a lower bound, so that the forecast distribution has considerable probability mass at repo rates as low as −2 per cent (Sveriges Riksbank 2015). This may strike some readers as implausible. However, Kjellberg and Villani (2010) argue that this can be justified in two ways: 1) the zero lower bound is not exactly zero, implying that moderately negative interest rates cannot be ruled out; and 2) negative policy rates in the forecast distribution can be taken to represent alternative monetary policy measures with the same effect as though the policy rate were negative.

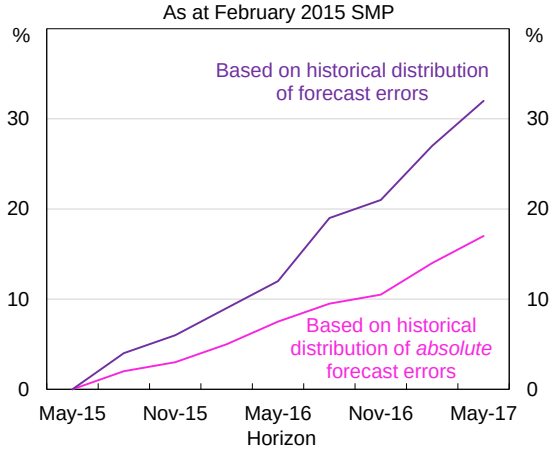
Probability of reaching the zero lower bound

The intersection of the horizontal axis and the confidence intervals in Graph 3 provides an estimate of the probability of a zero cash rate at a given forecast horizon, conditional on the market-implied cash rate path at the time of the February SMP. The pink line in Graph 4 shows this probability at different forecast horizons, assuming that the distribution of absolute forward-rate errors is the same as over the past two decades and that these errors are symmetrically distributed around zero. The market path implies that the probability of the cash rate being at the zero lower bound is 5 per cent in February 2016 and 14 per cent in February 2017.

Graph 4

Probability of Zero Cash Rate at Horizon*

As at February 2015 SMP



* Based on zero-coupon forward rates
Source: RBA

Using absolute errors assumes that the forward curve provides an unbiased forecast of the cash rate. As mentioned above, this assumption is also made in constructing the SMP confidence intervals, although the rationale differs here. Tulip and Wallace (2012) argue that any bias in economic forecasts should not persist into the future, since it is in the forecaster's interest to generate unbiased forecasts. However, in the case of the cash rate, this assumption is equivalent to assuming that any term premia in the zero-coupon forward rates are zero on average. However, this might not be the case if investors require (or a willing to pay) a premium for holding longer-maturity assets.

An alternative approach is to assume that cash rate forecast errors follow the same distribution as the historical distribution of *actual* forecast errors. This allows the forecast error distribution to have a mean equal to the average forward-rate error, which can be interpreted as the average term premium. It also preserves the historical skewness in the data. Under this approach, shown as the purple line in Graph 4, the

6 See Graph 3 in and (2015) (restricted).

7 See Kahneman, Slovic and Tversky (1982) (Part VI, titled 'Overconfidence') or, for an accessible summary, the Wikipedia (2012) entry 'Overconfidence Effect'.

8 Truncation means that forward rates represent the median but not the mean of the cash rate forecast distribution, since the truncated distribution is asymmetric. However, the expectations theory of the yield curve implies that forward rates should equal the mean. I ignore this complication here, but recognise that it would need to be addressed in further work.

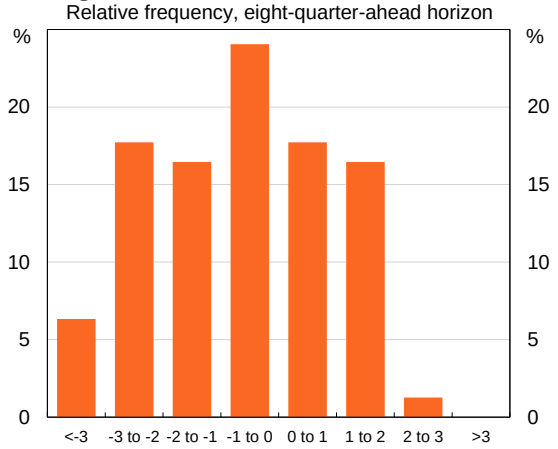
probability of a zero cash rate is estimated to be 9 per cent in February 2016 and 27 per cent in February 2017. These probabilities are substantially higher than those based on the historical distribution of absolute forecast errors, because the sample includes more large negative forecast errors (i.e. where the realised cash rate turned out to be substantially lower than forecast) than large positive forecast errors (Graph 5).

Although the purple line in Graph 4 is simpler to construct and explain, and requires fewer assumptions, the pink line will be more valid if the apparent bias in the market-implied path at longer horizons has arisen by chance and is likely to disappear. Consistent with this, Finlay and Chambers (2008) find evidence to suggest that term premia at maturities up to five years were small and *negative* through most of the inflation-targeting period up to 2007 (although they were positive and relatively large in the mid 1990s, which coincides with several large negative cash rate forecast errors). Additionally, the cash rate expectations presented in the DM Monthly Note and the SMP are not adjusted for term premia.[9]

Graph 5

Histogram of Cash Rate Forecast Errors*

Relative frequency, eight-quarter-ahead horizon



* Based on zero-coupon forward rates
Source: RBA

Stability of uncertainty measures

The estimates in this note are conditional on the shocks experienced during the inflation-targeting period, but this may not be representative of the shocks that will be experienced in the future. Specifically, there may be periods when the path of the cash rate is more or less uncertain (i.e. the cash rate forecast errors could be heteroskedastic). This might be the case if, for instance, the Bank's communications and policy reaction function have become clearer, so that market participants are better able to predict the path of the cash rate, or if the variance of economic shocks has declined.

As a rough test of the stability of the variance of the forecast error distribution, I regress the squared cash rate forecast errors on a constant and a dummy variable that is equal to one after the Bank began explicitly publishing its forecasts in the SMP (February 2007). I use Newey-West standard errors to account for autocorrelation. I am unable to reject the null hypothesis that the coefficient of the dummy variable is equal to zero at any of the forecast horizons considered, suggesting that improvements in the Bank's communication have not improved the market's ability to forecast changes in the cash rate. However, this test is fairly rudimentary and the results are sensitive to the exclusion of the large forecast errors arising during the global financial crisis. At face value, the results provide little evidence to suggest that the variance of the forecast error distribution, and thus the width of the confidence intervals, has changed over time.

Conclusion

As the discussion above indicates, different assumptions about bias, skewness, stability and so on could be made in estimating uncertainty about the market-implied cash rate path. Although these would change numerical estimates, they are unlikely to greatly change the qualitative results. Specifically, uncertainty about the future cash rate is large (arguably, this is the key point that publication of confidence intervals needs to convey) and the probability of hitting the zero lower bound is substantial.

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Economic Research Department
14 April 2015

9 Some central banks adjust forward rates for the existence of risk premia. For example, the Fed uses a rule-of-thumb that the term premium is equal to one basis point per month (e.g. Board of Governors of the Federal Reserve System 2009). Up to September 2008, the Riksbank adjusted forward rates at each horizon by subtracting the average forward-rate error (Kjellberg and Villani 2010). Since then, the Riksbank has adjusted forward rates by subtracting model-based estimates of risk premia.

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ALTERNATIVE INTEREST RATE PATHS – APRIL 2015

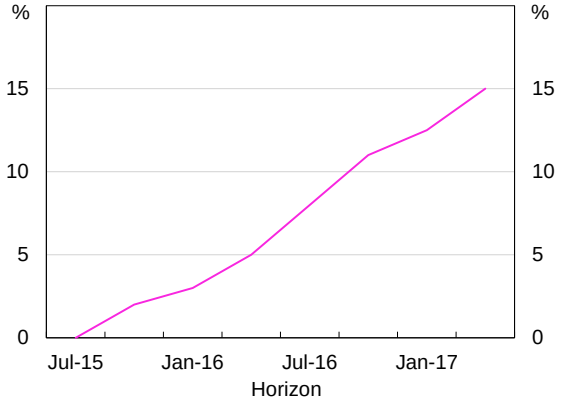
Forecast targeting[1]

Given the market-implied cash rate path in the baseline scenario, and assuming that uncertainty around this cash rate forecast is as estimated in (2015), the probability of a zero cash rate in two years' time is 15 per cent (Graph 2).[2]

Graph 2

Probability of Zero Cash Rate at Horizon*

As at April 2015



* Based on market-implied cash rate path and the historical ability of zero-coupon forward rates to forecast the cash rate; assumes forecast errors are symmetric
Source: RBA

and /Economists/Economic Research Department/23 April 2015

2 This estimate assumes that cash rate forecast errors follow the same distribution as the historical distribution of *absolute* forecast errors (based on zero-coupon forward rates) and that these errors are symmetrically distributed around the cash rate forecast; assuming that cash rate forecast errors follow the historical distribution of *actual* errors results in a substantially higher probability of the cash rate reaching zero.

ALTERNATIVE INTEREST RATE PATHS – JULY 2015

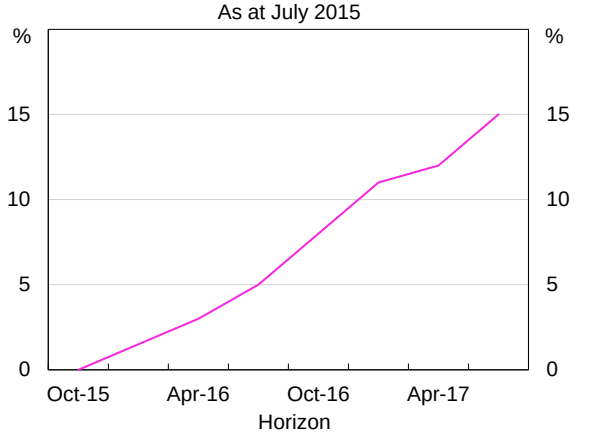
Forecast targeting

Given the market-implied cash rate path in the baseline scenario, and assuming that uncertainty around this cash rate forecast is as estimated in (2015), the probability of a zero cash rate in two years' time is 15 per cent (Graph 2).[2]

Graph 2

Probability of Zero Cash Rate at Horizon*

As at July 2015



* Based on market-implied cash rate path and the historical ability of zero-coupon forward rates to forecast the cash rate; assumes forecast errors are symmetric

Source: RBA

Economist/Economic Research Department/20 July 2015

2 This estimate assumes that cash rate forecast errors follow the same distribution as the historical distribution of absolute forecast errors (based on zero-coupon forward rates) and that these errors are symmetrically distributed around the cash rate forecast; assuming that cash rate forecast errors follow the historical distribution of actual errors results in a substantially higher probability of the cash rate reaching zero.

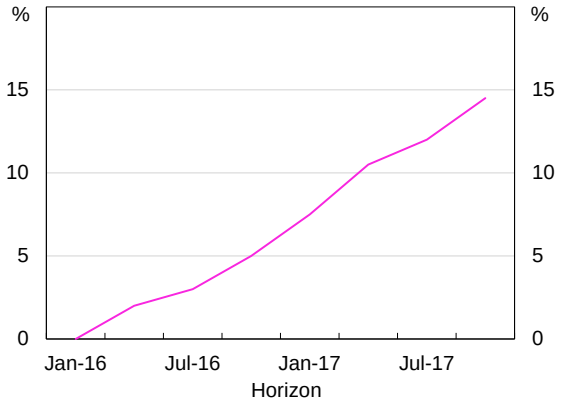
ALTERNATIVE INTEREST RATE PATHS – OCTOBER 2015

Forecast targeting

Given the market-implied cash rate path in the baseline scenario, and assuming that uncertainty around this cash rate forecast is as estimated in (2015), the probability of a zero cash rate in early 2018 is about 15 per cent (Graph 2).[2]

Graph 2

Probability of Zero Cash Rate at Horizon*



* Based on market-implied cash rate path and the historical ability of zero-coupon forward rates to forecast the cash rate; assumes forecast errors are symmetric
Source: RBA

2 This estimate assumes that cash rate forecast errors follow the same distribution as the historical distribution of absolute forecast errors (based on zero-coupon forward rates) and that these errors are symmetrically distributed around the cash rate forecast; assuming that cash rate forecast errors follow the historical distribution of actual errors results in a substantially higher probability of the cash rate reaching zero.

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21 October 2015

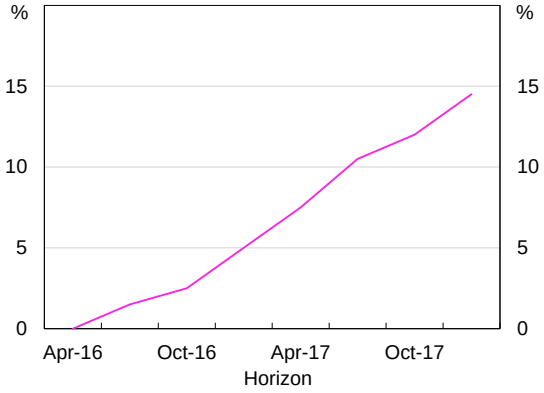
ALTERNATIVE INTEREST RATE PATHS – JANUARY 2016[1]

Forecast targeting

Given the market-implied cash rate path in the baseline scenario, and assuming that uncertainty around this cash rate forecast is as estimated in (2015), the probability of a zero cash rate in early 2018 is about 15 per cent (Graph 2).

Graph 2

Probability of Zero Cash Rate at Horizon*



* Based on market-implied cash rate path and the historical ability of zero-coupon forward rates to forecast the cash rate; assumes forecast errors are symmetric
Source: RBA

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20 January 2016

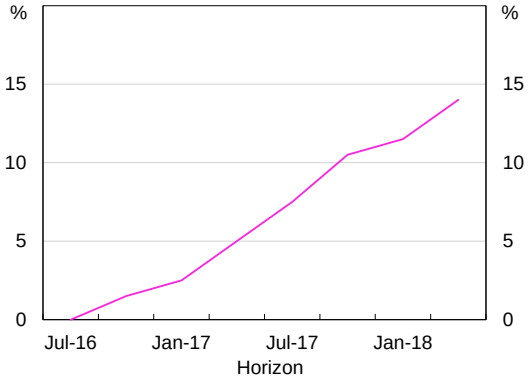
ALTERNATIVE INTEREST RATE PATHS – APRIL 2016[1]

Forecast targeting

Given the market-implied cash rate path in the baseline scenario, and assuming that uncertainty around this cash rate forecast is as estimated in (2015), the probability of a zero cash rate in two years is 14 per cent (Graph 2).

Graph 2

Probability of Zero Cash Rate at Horizon*



* Based on market-implied cash rate path and the historical ability of zero-coupon forward rates to forecast the cash rate; assumes distribution of forecast errors is symmetric
Source: RBA

/Economist/Economic Research Department/20 April 2016

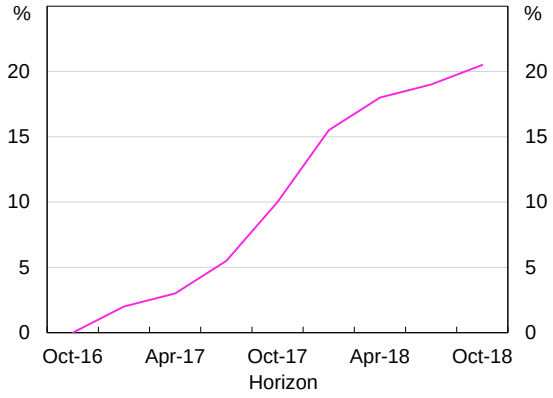
ALTERNATIVE INTEREST RATE PATHS – JULY 2016[1]

Forecast targeting

Given the market-implied cash rate path in the baseline scenario, and assuming that uncertainty around this cash rate forecast is as estimated in (2015), the probability of a zero cash rate at the end of the forecast horizon is 21 per cent (Graph 2).

Graph 2

Probability of Zero Cash Rate at Horizon*



* Based on market-implied cash rate path and the historical ability of zero-coupon forward rates to forecast the cash rate; assumes distribution of forecast errors is symmetric.
Source: RBA

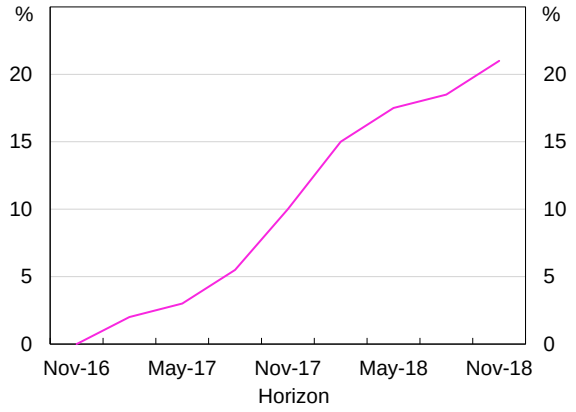
ALTERNATIVE INTEREST RATE PATHS – OCTOBER 2016

Forecast targeting

Given the market-implied cash rate path in the baseline scenario, and assuming that uncertainty around this cash rate forecast is as estimated in (2015), the probability of a zero cash rate at the end of the forecast horizon is 21 per cent (Graph 2).

Graph 2

Probability of Zero Cash Rate at Horizon*



* Based on market-implied cash rate path and the historical ability of zero-coupon forward rates to forecast the cash rate; assumes distribution of forecast errors is symmetric.
Source: RBA

Economic Research Department
19 October 2016

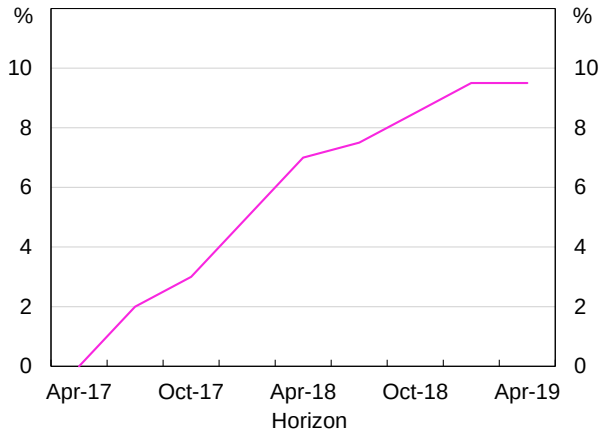
ALTERNATIVE INTEREST RATE PATHS – JANUARY 2017

Forecast targeting

Given the market-implied cash rate path, and assuming that uncertainty around this cash rate forecast is as estimated in (2015), the probability of a zero cash rate at the end of the forecast horizon is 9½ per cent (Graph 2).

Graph 2

Probability of Zero Cash Rate at Horizon*



* Based on market-implied cash rate path and the historical ability of zero-coupon forward rates to forecast the cash rate; assumes distribution of forecast errors is symmetric.
Source: RBA

Economic Research Department
25 January 2017

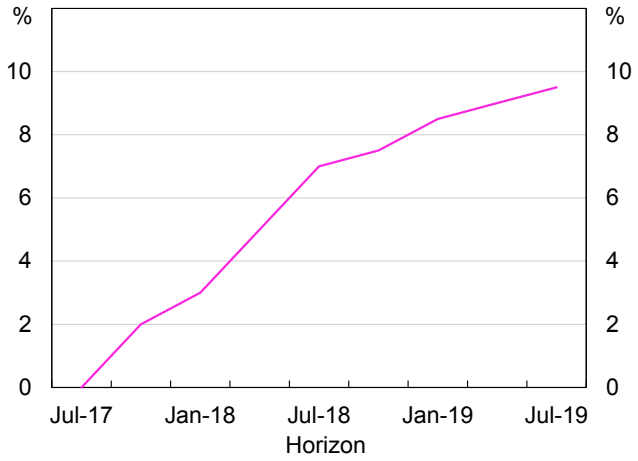
ALTERNATIVE INTEREST RATE PATHS – APRIL 2017

Forecast targeting

Given the market-implied cash rate path, and assuming that uncertainty around this cash rate forecast is as estimated in (2015b), the probability of a zero cash rate at the end of the forecast horizon is 9½ per cent (Graph 2).

Graph 2

Probability of Zero Cash Rate at Horizon*



* Based on market-implied cash rate path and the historical ability of zero-coupon forward rates to forecast the cash rate; assumes distribution of forecast errors is symmetric.
Source: RBA

Economic Research Department
19 April 2017

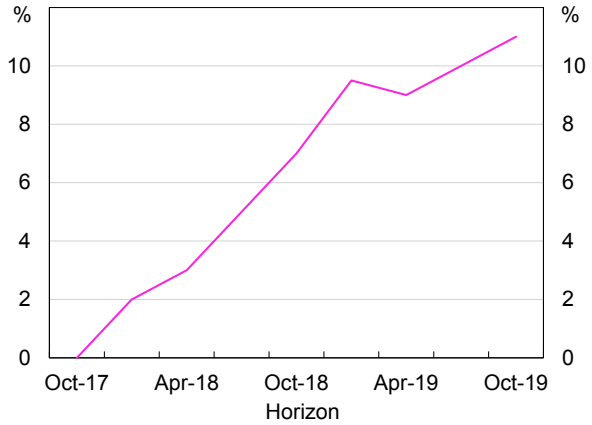
ALTERNATIVE INTEREST RATE PATHS – JULY 2017

Forecast targeting

Given the market-implied cash rate path, and assuming that uncertainty around this cash rate forecast is as estimated in (2015b), the probability of a zero cash rate at the end of the forecast horizon is 11 per cent (Graph 2).

Graph 2

Probability of Zero Cash Rate at Horizon*



* Based on market-implied cash rate path and the historical ability of zero-coupon forward rates to forecast the cash rate; assumes distribution of forecast errors is symmetric.
Source: RBA

Economic Research Department
19 July 2017