Market expectations of the official cash rate

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The Reserve Bank is interested in expectations of the official cash rate that are held by financial market participants. In this article we discuss two formal methods by which the Bank measures these expectations; a direct survey of market surveys, and extracting OCR expectations indirectly from financial market prices.

1 Introduction

This article introduces issues related to market expectations of New Zealand's Official Cash Rate (OCR). The first part of the article discusses the general concept of expectations, and why the Bank is interested in OCR expectations in particular. The main part of the article is concerned with two formal approaches used to gauge market expectations of the OCR, namely, market surveys and extracting information from market prices. The article finishes with a discussion of the related research in progress at the Bank, and the potential for ongoing work.

2 What are "expectations"?

Everyone has some expectations about the future. For example, many people will have an opinion on the questions: Which team will win next year's Super 12 rugby final? What political party will win the next general election? Will it rain tomorrow, or next week, etc? Other people might not have an opinion, but are often willing to default to "expert" views on the matter.

Likewise, people may have specific expectations of the economy and financial market prices. For example, how much will GDP grow this year, and what will inflation be? Will interest rates or the exchange rate be higher or lower tomorrow? Next week? Next year? Some people even make a career of forecasting economic data and market prices (a "formal" expectation) for their own financial market trading, or to advise others. Other people's opinions might not be so formal, but their savings and spending decisions may imply a view. For example, fixing a term mortgage rate today might be based on an expectation that floating mortgage rates are likely to rise in the future.

So an expectation, or forecast, is formed today for an event due at a future date. That expectation should incorporate all information currently available, and expectations will naturally change as new information is incorporated. For example, knowing the winner of this year's Super 12 final might shape opinions on next year's winner. On the day of the final next year, the half-time score will give an even more specific clue. Hence, expectations can change continuously right up until the event occurs (the Super 12 final full-time score). In financial markets, new information may take the form of updated indicators of how the economy is performing, advances in understanding "how the world works", and completely unexpected events.

3 Why are OCR expectations useful to the Bank?

Background

The Reserve Bank is responsible for implementing monetary policy to maintain price stability, and the OCR has been used since March 1999 for adjusting the stance of monetary policy. The OCR is reviewed at eight pre-announced dates per year; four associated with the (approximately quarterly) release of a *Monetary Policy Statement*, and four at reviews conducted roughly half-way between each *Monetary Policy Statement*.[2]

[1] We thank Michael Reddell, Kelly Eckhold, and Geof Mortlock for extensive comments on earlier drafts. We also thank Philip Barker, Andrew Allan, and Michael Pearce for ongoing discussions on the topic.

[2] This is the normal mode of operation, although the Bank reserves the right to adjust the OCR at any time as required, in exceptional circumstances for example.

Any change to the OCR is in multiples of 25 basis points, for example 25 or 50 basis points.[3]

Market participants usually have expectations about what the Bank will do, and often views about what the Bank "should" do. Of course, the Bank ultimately sets the OCR based on its own assessment of what is required to maintain price stability, but is interested in these market views and expectations as a "reality check" on its own thinking, and also because peoples' expectations will influence how they react to an OCR announcement. Both of these points are expanded on below.

For convenience, we often refer to a collection of market participants' expectations as "the market expectation", implicitly taking for granted that "the market" is really a vast collection of independent individuals, each with potentially different expectations. For example, participants in "the market" will include traders, analysts, economists, investors, borrowers, both retail and wholesale, both domestic and offshore, and of both large and small financial size. Some will express their expectations by directly trading in markets, and others by way of commentaries or advice to market participants.

Typically, the Bank is most interested in the "average" market expectation, although the range of expectations is also of interest. In addition, it is often useful to have OCR expectations for different sectors of the market, if possible. For example, what do foreign exchange traders expect compared to interest rate traders? Or what do domestic participants expect compared to foreign investors? Does any sector, or individual participant, have a strongly held OCR expectation, with a substantial associated trading position?

The "reality check"

One main use of market OCR expectations, particularly for horizons well into the future, is a "reality check" or "peer review" for the Bank's own thinking. The market has access to much of the same information as the Bank, and the Bank's objectives are clearly and publicly defined. However, uncertainty is a dominant feature in economic forecasting and setting monetary policy, and well informed people will often have legitimate differences in their interpretation of the current state of the economic cycle, the economic outlook (and uncertainties associated with that outlook), and/or "the way the world works."

If market participants do have a different assessment to the Bank's broad view, this is likely to be reflected in expectations of the future OCR path that are different to the Bank's own expectations. However, sometimes the market may generally share the Bank's assessment of the broad economic outlook, but the difference in OCR expectations might only imply a different view of how the future effects of the exchange rate and interest rates are likely to combine to deliver the desired inflation outcome.[4]

How market expectations of the OCR change in response to individual data releases may also provide the Bank with information on what the market considers to be the key uncertainties in the outlook for monetary policy. For example, it might be useful to know whether the market is currently most sensitive to growth or inflation data, or information about particular sectors of the economy.

Tactical considerations

In finalising the OCR decision and the accompanying statement, the Bank likes to have a reasonable assessment of their likely market consequences. What others expect the Bank to do will influence how they react to an OCR announcement. If the decision and the tone of the statement is expected, and regarded as appropriate by the market, then any market reaction to the release should be minor. Similarly, an unexpected OCR decision that is nonetheless widely regarded as appropriate by market participants should typically prompt a reaction consistent with the Bank's policy intentions.

The situation could be different if the market is both surprised and disappointed with the Bank's OCR decision, and/or the tone of the accompanying statement. For example, a decision

[3] A basis point is 0.01 percentage points.

[4] The Bank's projections use technical assumptions for the exchange rate, rather than genuine forecasts. Market participants will generally forecast the exchange rate, and if those forecasts are materially different to the Bank's projections, then the market's expected OCR path may also be quite different. However, this difference would be "purely technical".

to raise the OCR that the market regards as inappropriate and unwarranted could prompt sharp selling of the currency, perhaps leaving overall monetary conditions easier than they were before the policy "tightening". Several central banks saw this type of reaction last year.

The Bank reviews the reaction in financial markets after an OCR announcement. If the reaction is vastly different than the Bank expects, this could indicate that the Bank had misread market expectations, or the way the market would respond to the accompanying commentary. Or alternatively, perhaps only some individual sectors of the market, or even just some dominant market participants, were disappointed in the decision, and are trading quickly to "cut" unprofitable trading positions.

4 Gauging market expectations of the OCR

There is a range of ways the Bank can gauge market expectations of the OCR and the likely impact of the release of an OCR announcement. One important method is simply to talk freely with market participants from a wide variety of groups, discussing their individual views and trading positions, and noting anecdotal information on market flows. This source of information is available to the Bank due to the "neutral" relationship it has with many market participants (ie the Bank is not in competition with them), and obviously this information is strictly confidential between the Bank and those individual parties. Through a variety of contacts, the Bank can often construct a central view of market expectations of the OCR, and directly gauge likely market reactions, particularly with nuances of information that are not always widely available. Apart from that, the Bank also regularly reads market commentaries to stay in touch with individual views, particularly following important data releases that might challenge or alter those views.

In addition to market liaison, there are essentially two other obvious methods that the Bank can use to gauge market expectations of the OCR: monitoring formal surveys of market participants, or extracting market expectations from financial market prices. We now proceed to discuss these in more detail, before comparing these two methods later in the article.

5 Market surveys of the OCR

A survey is simply a collection of the opinions of selected individuals. In New Zealand, there are three reasonably regular and timely surveys of OCR expectations. These surveys are undertaken and published by Reuters, Standard and Poor's MMS, and Westpac. There are other occasional surveys, for example by Bridge and Bloomberg.

The Reuters OCR survey is conducted among approximately twelve market analysts and economists of the major banks (including investment banks) that participate in New Zealand financial markets. Those participants are asked where they expect the OCR to be set in the upcoming review, and then at three-monthly intervals in the future. Publication is via Reuters' own newswire service. Reuters' surveys are fairly frequent but are sometimes irregular; in the past there have been as few as one and as many as five surveys between OCR reviews. Reuters often holds snap surveys after major events, such as OCR reviews or data releases, particularly if these events go against expectations. One notable feature of the Reuters' survey is that it publishes the identity of individual forecasters with their forecasts, whereas the other surveys show only aggregate data.

The Standard and Poor's MMS OCR survey includes forecasts from up to eleven respondents (a similar pool to the Reuters' survey). Expectations are collected for the next three OCR announcement dates, and the published results include the high, low, average and median forecasts of the OCR for those dates. Typically the survey is held and published every Friday, although they are sometimes less frequent, particularly during holiday periods. The results are forwarded to survey participants, selected media, and some other recipients.

The Westpac OCR survey is the least frequent (monthly), but the most comprehensive, and it also draws opinions from a different section of the market. It includes forecasts from fourteen domestic fund managers for the next eight OCR reviews, ie all reviews for the next year. The published results cover the average, high, low, and median forecasts, and the distribution of responses for each OCR announcement date. The OCR question is part of a wider survey, and the results are limited to survey participants and selected recipients.

Figure 1
Example of 25 May 2001 Standard and Poor's MMS OCR survey

Item/Event	OCR 4 Jul Review	OCR 15 Aug MPS	OCR 3 Oct review
Median	5.75	5.75	5.75
High	5.75	5.75	5.75
Low	5.50	5.25	5.25
Average	5.64	5.61	5.61
Mode	5.75	5.75	5.75
Standard deviation	0.13	0.20	0.20
Respondents	7	7	7

Source: Standard and Poor's MMS. Published with permission.

6 OCR expectations implied by market prices

Another way to measure market expectations of the OCR is to estimate the expectations implied from financial market prices. This is more complex than survey methods, but it does offer a useful complement to survey data. We first discuss the general background behind this method, and then discuss the approach to extracting OCR expectations being investigated within the Bank.

OCR expectations and the "yield curve"

The OCR and OCR expectations influence many different financial market prices, but the focus of this article will be on the wholesale interest rate market. This market is essentially banks, major investors, and major borrowers transacting among themselves in very large amounts for terms ranging from one day to more than ten years.

The influence of the OCR and OCR expectations on the interest rate market is very powerful, though somewhat indirect. Without delving into the inner workings here, the interest rate on one day lending or borrowing (the "overnight cash market") is almost always at the OCR.[5] Hence, an investor will typically have a choice today between investing at a term rate, or investing for a succession of one day rates; at the OCR today, and at the OCR prevailing at each day in the future. Ultimately then, anyone investing in term rates is likely to have a view on the average expected OCR over the term of the investment (and the same will apply to term borrowers).

As a specific example, consider a trader deciding today on the choice between a one day and two day term investment. He or she could invest at the two day rate of 6.10 (per cent per annum; omitted for clarity hereafter) that is currently available. The alternative is investing at today's one day rate (the current OCR) which is fixed at 6.00, and reinvesting tomorrow at tomorrow's one day rate (tomorrow's OCR).

Now, assume there is an OCR review due tomorrow.

If the trader fully expects no change to the OCR tomorrow, then it is obviously better to invest for the two day term at 6.10, rather than invest for one day at 6.00, and for one day again tomorrow at the expected 6.00. The latter would effectively be an investment at an average rate of 6.00 for the same two day period: (6.00 + 6.00) / 2 = 6.00, which is less attractive than 6.10.

However, if the trader fully expects the OCR to be raised to 6.50 tomorrow, then it is better to invest for one day at 6.00, and for one day again tomorrow at the expected 6.50, rather than invest at 6.10 for the two day term. The former would effectively be an investment at an average rate of 6.25 for the same two day period: (6.00 + 6.50) / 2 = 6.25, which is more attractive than 6.10.

Now, what if the trader thinks there is a 60 per cent chance that the OCR will remain at 6.00 tomorrow, and a 40 per cent chance of a change to 6.50? In this case, the known return for a 6.10 two day investment is identical to the return from the known one day investment at 6.00 today combined with the "expected" return for the one day investment tomorrow:

[5] Details regarding the introduction of the OCR system are contained in Archer, Brookes, and Reddell (1999). A related article is that of Brookes and Hampton (2000).

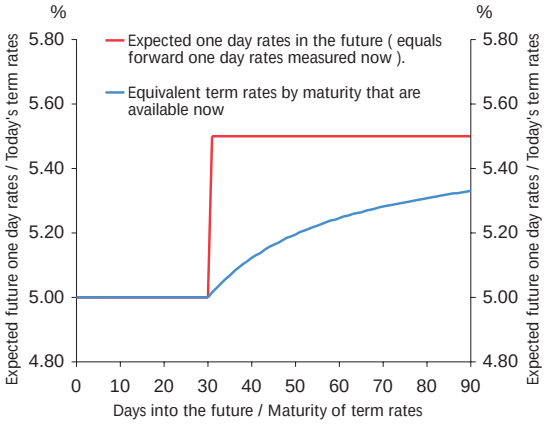
(6.00 + [6.00 * 60% + 6.50 * 40%]) / 2 = 6.10. Hence, the trader should be indifferent between either choice, since the expected average rate is the same for both.

This example illustrates the assessment that all market participants make, either implicitly or explicitly. Their transactions reflect those assessments, and those transactions cause market prices to change until "the collective view" of the market is reflected in the two day term rate. Hence, the two day term rate of 6.10 in this example implies that the "average" market expectation of tomorrow's OCR is 6.20 per cent.[6] If that "average" market expectation changes, then so should the two day term rate. By extension, term rates for longer maturities (eg three days, three months, or three years) should naturally reflect expectations of the OCR over those longer horizons.

It would be convenient if expectations of the future OCR were the only consideration that the market took into account when "arriving at" the appropriate two day term rate. In this case, we could calculate the implicit market expectation for the OCR tomorrow by simply calculating tomorrow's "break-even one day rate" from today's OCR and today's two day term rate. That would be the 6.20 noted above. This "break-even one day rate" is known as the one day rate one day forward. Likewise, we could also calculate the implicit market expectation for the OCR in two days time, by using today's two day and three day term rates to calculate the one day rate two days forward. This series of forward one day calculations could be continued indefinitely, so long as the term rate data for longer maturities exists to calculate it.

Technically, the series of term rates by maturity (6.00 per cent for one day, 6.20 per cent for two days, ..., 6.50 per cent for three months, ..., 7.00 per cent for one year, etc)

Figure 2
Expected one day rates and current term rates according to the pure expectations hypothesis



that are available today is known as the "yield curve". From the discussion above, we could equally represent today's yield curve as a series of forward one day rates (an example of this is shown in figure 2). Then, if market expectations of the OCR were the only factor responsible for the pattern of term rates along the yield curve, these forward one day rates should represent the market expectation of the path of the OCR going forward.

Some may recognise this as the "expectations hypothesis" of the yield curve. The expectations hypothesis has two direct implications. Firstly, that a term rate is defined *only* by the average of expected OCR rates (one day rates) over the term of the investment. Secondly (and equivalently) the expected OCR is *equal* to the forward one day rates calculated from the day-by-day term rates. Hence, if today's term rates are above the current OCR, the path of forward one day rates would also be above the current OCR, and the implied market expectation (according to the expectations hypothesis) is that the OCR will rise over time. The stylised example in figure 2 illustrates the concept of today's term rates being an average of the one day rates expected in the future.

As appealing as the expectations hypothesis is (since it makes the task of extracting OCR expectations a simple mechanical task of calculating forward one day rates from the yield curve of term rates), it does not accurately describe the "real world". An investor must also consider other factors when deciding whether to make a term investment.

Two of the several other factors that have to be allowed for are "credit risk" and "liquidity risk". Credit risk arises because

[6] Although we do not discuss it further in this article, the interpretation of the "average" market expectation is interesting in itself. In the example discussed in the text, the expected OCR of 6.20 could imply that *all* market participants put the chances of 6.00 or 6.50 at 60 per cent and 40 per cent respectively. Or 60 per cent of market participants could expect no change to the OCR, while 40 per cent could expect a change to 6.50. Or 80 percent of market participants could expect a change to 6.25. There are obviously many other combinations of rates, probabilities, and proportions of the market that could correspond to an "average" expectation of 6.20 for the OCR.

banks are private companies with limited shareholder liability, and there is naturally some risk of a company defaulting on interest or principal payments on their debt due to some adverse event that might arise during the term of the loan. Credit risk is allowed for by investors demanding higher term rates when lending to banks (or other companies) than they would if expectations of the OCR were the only consideration. Note that investments with no risk of default, such as deposits with the government, need no allowance for credit risk, and so bank term rates usually sit above government term rates for the same maturity.

Liquidity risk arises because investors often prefer to hold cash or short-term investments to cover themselves against unexpected cash needs that could lead to their own default or missed investment opportunities. Higher term rates are therefore required to induce investors to invest for longer periods. However, if an investment can usually be readily exchanged *before maturity* for a cash amount close to its quoted market value, then the allowance for liquidity risk need not be so large.

Together, credit risk and liquidity risk are the main elements of the "term premium"; the difference between the level of interest rates based on a pure expectations hypothesis of the yield curve, and their actual level in the "real world" when other practical factors are taken into account. Hence, when extracting OCR expectations from the yield curve, we must make some allowance for the impact of the term premium on the yield curve.

Extracting OCR expectations from the yield curve

Creating an OCR expectations model based on wholesale term interest rate data that we can observe in the market essentially involves the following steps:

- Obtain the required term interest rate data. The analysis discussed in this article uses bank bill rates for standard maturities, and interpolates those rates to obtain day-by-day term rates.
- Calculate forward one day rates from the day-by-day term rates. This is a standard mechanical calculation, similar to the example noted in the previous section.
- Adjust the forward one day rates for an estimated term premium. Ongoing analysis within the Bank suggests that the "term premium function" associated with New Zealand bank bill rates is roughly a "wedge shape" that increases with maturity.
- Average the adjusted forward one day rates between OCR announcement dates. This is required because often the adjusted forward one day rates from the previous step show an "uneven" path between OCR announcement dates, when we actually know that the OCR will remain steady between scheduled announcement dates.

Readers interested in further background and detail on each of these points are referred to the appendix to this article. However, a reader mainly interested in a general overview may continue directly to the graphical example of the above process contained in the next section.

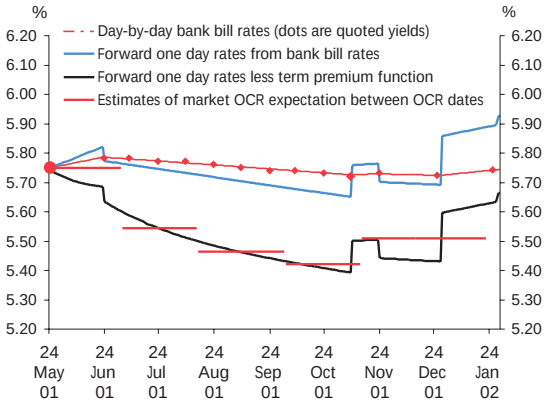
7 A summary example of the Bank's OCR expectations model

Figure 3 represents an example of the calculation of OCR expectations implied from bank bill rates quoted on 24 May 2001:

- The first line shows the dots indicating the quoted bank bill rates (as supplied by a wholesale interest rate broker) and the joining line shows the day-by-day bank bill rates calculated by linear interpolation.
- The second line shows the forward one day rates calculated from the day-by-day bank bill rates.
- The third line shows the forward one day rates less the appropriate value of the "term premium function" (which is illustrated in the appendix, figure A5).
- The fourth line shows the average of the adjusted forward one day rates for each OCR period. This line is therefore an estimate of the market's expectation for the future path of the OCR.

This example is indicative only, but it does illustrate some key points. If we had made no allowance for the term premium, it would appear that, as at 24 May, the "average"

Figure 3
Estimates of market OCR expectations
as at 24 May 2001



Source: RBNZ data and RBNZ estimates.

market expectation was that the OCR would remain "on hold" at 5.75. However, after allowing for the term premium, it actually appears that the market expected one further 25 basis point cut, to an OCR of 5.50, perhaps in the 4 July review, or more likely the 15 August *Monetary Policy Statement*. This result corresponds better to market surveys of the OCR taken at around the same time (for example, the average OCR expectations contained in figure 1 earlier).

Market participants often do this calculation in reverse. That is, they assume a path for the OCR, calculate the "underlying" term rates implied from that path, add an estimated term premium, and then compare the result to bank bill rates quoted in the market. The assumed OCR path is then adjusted until the calculated bank bill rates best match the bank bill rates quoted in the market.

8 Comparing the survey and market price approaches

Advantages and disadvantages

Using surveys or market prices to gauge market expectations of the OCR both have advantages and disadvantages. It is worthwhile discussing these in tandem, because it is then apparent that both approaches are complementary.

The main advantage of OCR surveys is that the printed results are a *direct* gauge of OCR expectations held by market participants. Of course, the results themselves are subject to interpretation, such as whether the mean or median of the survey is most representative of the market's OCR expectation, but at least the "raw data" are definite. On the other hand, OCR expectations extracted from bank bill rates are an *indirect* gauge that requires significant estimation work to obtain reasonable results, and the results can differ depending on the data used and/or the estimation techniques applied. (In the appendix we note the uncertainties associated with estimates derived from a relatively short period of historical data.) Further to that, bank bill rates are only one market in which OCR expectations are reflected. In an ideal world, the effects of the OCR on other markets should be reflected back into the bank bill market, as markets are generally interconnected, but this will not always necessarily occur perfectly or instantaneously in practice.

However, surveys of the OCR also have some disadvantages. Firstly, surveys only contain a subset of opinions, rather than the opinions of the entire market (ie a survey is a sample, rather than a census of the market). Sometimes offshore fund managers, for example, may have completely different expectations of the OCR than the domestic market. Further, the small number of participants in the OCR surveys means that measures of the average and distribution of OCR expectations may be unreliable, particularly if the survey coverage is not consistent from survey to survey. By contrast, the major advantage of OCR expectations implied from financial market prices is that they *should* effectively include the opinions of all market participants. That is, financial market prices may be seen as a type of census, which should be more representative of "the market" than a survey.

Another disadvantage of surveys is that they are not very timely or frequent, at least by the standards of financial markets, where expectations and market prices can change continuously. As noted earlier, the Bank wants to know how market OCR expectations change due to particular events, but this is not possible if a new survey is not available after each particular event. Rather, the changes in expectations between surveys will be due to all of the new information received by the market since the last survey. Indeed, the time between conducting a survey and publishing it may mean that even "fresh" published surveys are sometimes out of date. Changes in financial market prices are very timely and frequent, since market participants have a financial

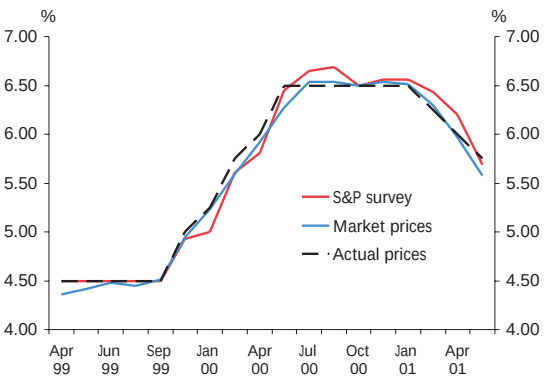
incentive to react quickly to evolving circumstances. Hence, expectations derived from market prices may be updated continuously, so the impact of individual events on OCR expectations can be ascertained.

That said, some of the disadvantages noted for surveys are not as major as they might seem. The opinions of analysts from major banks and fund managers are probably a reasonable representation of the total market, since they are large participants in the New Zealand market, they keep in touch with many market participants, and they also tend to influence others with their opinions. Likewise, the disadvantages for implied OCR expectations are not necessarily that major; in the appendix we discuss practical guidelines for choosing the appropriate interest rate data, and any data that meet these criteria will likely yield similar estimates of OCR expectations. There are also standard guidelines available for the appropriate statistical estimation of the "term premium function."

A quantitative comparison

Figure 4 below shows a comparison of OCR expectations over time. It is apparent that surveys and prices are typically very close, which is a good illustration of how the OCR expectations from both sources complement each other. In principle, one would expect survey expectations and market-based expectations to be close, since markets are dominated by institutions that the surveyed economists and analysts work for.

Figure 4
Market surveys and market-implied OCR expectations over time



Source: RBNZ data and RBNZ estimates. Standard and Poor's MMS survey data used with permission.

However, the results from the two methods are not always exactly consistent, and occasional divergences do occur. For example, implied OCR expectations may sometimes be distorted by abnormal market flows, and periods of market illiquidity. Market surveys may sometimes be misleading if new information is released between the survey being undertaken and its publication, or if there is a change in the survey coverage, for example. In the continued theme of this article, such differences between the two methods can be useful information; if the divergence becomes large, this raises a "flag" that something unusual may be occurring in the market. In turn, the Bank might then put greater weight on our direct conversations with market participants.

Figure 5 below contains a statistical summary of forecast errors (expectations less the actual OCR set later) of market surveys and OCR expectations implied by bank bill rates. Each of the market survey results has been calculated using the most recent survey available before each OCR review, and these surveys are sometimes up to a month old. OCR expectations extracted from bank bill rates have been calculated using data recorded a week and a day ahead of the OCR announcement date.

The important point from figure 5 is that none of the survey results or market price results are "consistently wrong", ie average forecast errors from both methods are essentially unbiased. This at least suggests that neither of the methods (or individual surveys) give consistently misleading results. Regarding forecast accuracy, on the face of it the standard deviations in figure 5 indicate some variation in the reliability of the different expectations. However, this mostly reflects the differences in timing of the surveys relative to the upcoming OCR announcement date. For example, the (monthly) Westpac survey of institutional fund managers *appears* least accurate, but those expectations of the upcoming OCR are sometimes made up to a month before the OCR announcement date; the participants of other surveys and implied OCR expectations have more up-to-date information to work with. A genuine comparison of "forecasting *ability*" would at least require expectations to be recorded at the same time, so each expectation is formed with equal information.

Figure 5
The accuracy of market surveys and market-implied OCR expectations

Method	Forecast error	Immediate	1 Period ahead
S&P	Average	-0.1	3.6
survey	standard deviation	8.5	16.1
Reuters	Average	2.3	-1.3
survey	standard deviation	7.5	32.5
Westpac	Average	3.2	10.5
survey	standard deviation	12.3	27.0
Market prices	Average	-1.1	-5.1
1 day prior	standard deviation	4.2	9.8
Market prices	Average	-1.2	-1.2
1 week prior	standard deviation	6.2	13.3

Note: Statistics are in basis points.

Source: RBNZ calculations from RBNZ data, some of which are recorded from the original Standard and Poor's MMS, Reuters, and Westpac surveys. We thank each for the use of their data, which is used here with permission.

But in any case, since the Bank sets the OCR, it does not require a forecast! The Bank is interested in OCR expectations in their own right.

9 Conclusions and ongoing work at the Reserve Bank

This article has introduced many issues about OCR expectations; in particular why the Bank is interested in them, and how to gauge them through several complementary approaches. It is also a useful "stock-take" for the Bank, as a review of past work, and in setting the scene for several avenues of ongoing and related research.

Several of these avenues are specific to extracting OCR expectations from market prices. The most important ongoing work is to refine the estimate of the "term premium function" as more data become available. From there, it may be useful to test whether the term premium varies in a predictable or stable way: over time; with the general level of interest rates; the general slope of the yield curve; interest rate volatilty; and/or the market's perception of the Bank's "bias". Other avenues of research are to compare implied OCR expectations with survey expectations in a systematic way. Once again, any predictable or stable relationship might prove valuable in providing the Bank with more information about market dynamics related to OCR expectations.

Finally, after looking at these aspects for New Zealand, it will be useful to compare the results against those obtained for other countries where an official rate is also used to adjust the stance of monetary policy.

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Appendix: Extracting OCR expectations from market prices: data selection, manipulation, and the term premium

Choosing the interest rate data

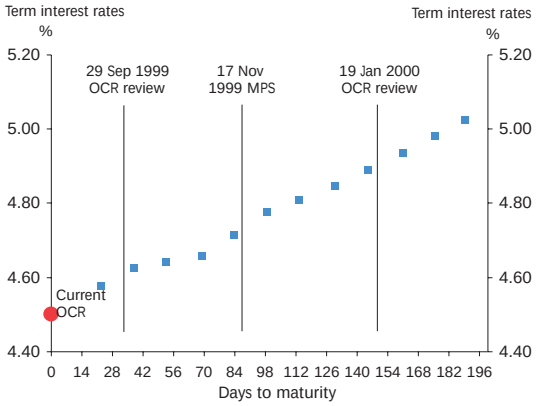
From the discussion on OCR expectations implied from market prices in the main text, the interest rate data we require is a series of term rates (ie a yield curve) with day-by-day maturities, which we can then use to calculate forward one day rates. Banks would offer term rates for any maturity if specifically asked by an investor, but they don't actually "quote" a series of term rates with day-by-day maturities through the wholesale broker. (Access to this information is available via electronic information services, such as Reuters, Bridge, or Bloomberg but is limited to selected recipients.) Rather, banks tend to quote indicative term rates for standard maturities (such as a one month rate, and a three month rate), with the implicit assumption that similar rates would apply for terms "close" to those standard maturities.

So we have to choose a series of quoted term rates that we can use to estimate a yield curve with day-by-day maturities. Interest rate quotes readily available in the New Zealand market include Treasury bill rates, bank bill rates, and derivatives on the latter.[7] Given the choice, it is best to select a set of interest rate data from a "liquid" market, and with "high density" on the yield curve.

Liquid in this instance essentially means an interest rate market that is traded frequently in reasonably large volumes. Liquidity ensures that the rates are likely to reflect the up-to-date views of many market participants that are trading, and eliminates other potential problems associated with low trading volumes. In the New Zealand context, this liquidity requirement rules out using Treasury bills rates to gauge OCR expectations, although this market is very liquid in other countries. However, New Zealand bank bill rates are sufficiently liquid; they are frequently quoted and traded among banks in the New Zealand market, and are used as investments by fund managers, and as benchmark or reference rates for borrowers.

"High density" on the yield curve simply means getting as many term rate quotes as possible, so as to obtain the best approximation to the day-by-day term rates that we ultimately require for calculating forward one day rates. At the very least, it is desirable to have at least one interest rate quote corresponding to a maturity between two successive OCR announcement dates.

Figure A1
Quoted term rates by maturity on 23 August 1999



Source: RBNZ data

Figure A1 illustrates this concept. We have plotted the quoted bank bill rates as at 23 August 1999, and have also indicated the three OCR announcement dates that fell within the period covered by the longest bank bill maturity (the 29 September 1999 review, the 17 November 1999 *Monetary Policy Statement*, and the 19 January 2000 review).

Bank bill rates are quoted for maturities in each half-month (late September, early October, etc), and therefore four observations fall between each of the OCR announcement dates in this example. However, bank bill rate quotes for maturities greater than six months are sparse in the New Zealand market, so beyond this maturity we extend the yield curve out to longer maturities using forward rate agreements on bank bills or FRAs.[8] These are quoted with month-by-month maturities out to twelve months.

[7] For more discussion on interest rate derivatives, see Hawkesby (1999).

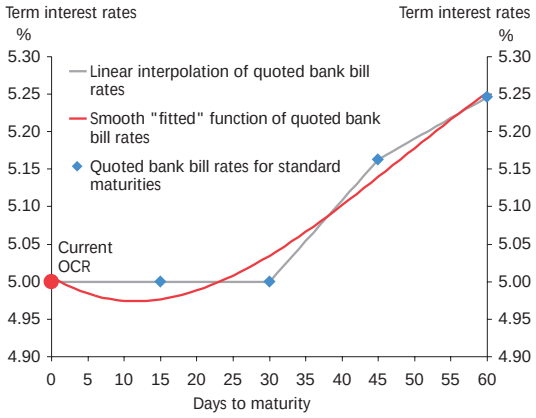
[8] FRAs are an agreement to lend or borrow at a specified future date, for a specified term, at a rate agreed today. They are a derivative of bank bill rates similar to bank bill futures, and can be transformed to a form equivalent to long maturity bank bill rates. Hence, the discussion of bank bill rates in this article should be taken to include the transformed FRA data that is also used. For more discussion on FRAs and bank bill futures, see Hawkesby (1999).

Some market participants use bank bill futures rates to define the yield curve. Futures rates are similar to FRAs, and have the relative advantage of being more liquid, but the disadvantage of a low density on the yield curve (since they are only quoted three months apart: March, June, September, and December). This means that estimations of OCR expectations based only on futures rates would sometimes reflect the combination of OCR expectations for two OCR announcement dates.[9]

Having opted to use quotes for bank bill rates, we need to estimate bank bill rates for each day-by-day maturity. The easiest way to do this is simple linear interpolation. This also has the advantage of retaining the "kinks" of the yield curve. In New Zealand, as in many other countries, kinks arise primarily because the market expects changes to the OCR only on pre-announced dates. For example, the stylised example in figure 2 showed a kink in the yield curve at the 30 day term rate, because future one day rates were expected to "step up" to a higher level in 30 days time.

An alternative approach to interpolation is to fit a "smooth" function to the observed bank bill rates to provide a continuous function of maturity. Apart from being more complicated, this approach may "mask" useful information regarding the timing and magnitude of OCR expectations by smoothing out kinks in the quoted market rates.[10] If OCR reviews were conducted very frequently, or often occurred between pre-announced dates, then the information lost with this approach may not be great. However, neither of these practices are part of the Bank's approach, and so a "smooth" function model is not likely to be very applicable for gauging OCR expectations in New Zealand.

Figure A2
Estimating all term rates from quoted term rates



The stylised example in figure A2 illustrates both methods. In this example (as in practice) we only observe the rates for bank bills maturing every fifteen days, as shown by the dots. It is obvious in this particular example that bank bill rates fitted using a smooth function (a cubic polynomial spline) are a poor approximation to the actual bank bill rates. This would cause the associated forward one day rates to be a poor approximation to "true" forward one day rates, and hence implied OCR expectations would also be misleading.

The results from either interpolation or yield curve fitting will be affected by the exact maturity date of the bank bill within the half month. This can make a material difference to implied OCR expectations when the yield curve is steeply upward sloping or downward sloping. In a steeply upward sloping yield curve, bank bill rates will generally apply to a date towards the end of the half month. This is because in transactions purely between banks, the borrower decides the exact maturity, and it is more advantageous to borrow "to the end". For example, if faced with borrowing for 31 days (to the last day of one half month) at 6.12, or 32 days (to the first day of the next half month) at 6.20, most will prefer the 6.12 rate for a single day's difference. Similarly, in a steeply downward sloping yield curve, the bank bill rate will generally apply to a date near the front of the half month. This practice gets reflected in the rates quoted to other participants in the wholesale market, such as fund managers and large borrowers.

Once we have estimated the bank bill rates for each maturity, we can mechanically calculate forward one day rates from

[9] For major international markets, it is common practice to use overnight indexed swaps or futures based on an overnight interest rate to gauge official rate expectations directly. These are not established in New Zealand.

[10] We are not aware of anyone in the New Zealand market that uses a curve fitting approach for the bank bill curve. However, there is a model commonly used in many central banks for calculating interest rate expectations that is based on fitting the whole yield curve, and using this model would smooth the kinks. The model is discussed in Nelson and Siegal (1987), and it has also been modified by Svensson (1995). Discussion of both of these models and the extent of their use is contained in the Bank for International Settlements (1999) publication.

the bank bill curve. Then we must allow for the term premium.

Adjusting for the term premium

We have already discussed why a term premium should exist. We can also plainly observe that bank bill rates sit materially above the OCR even during periods when market analysts and other market participants unanimously expect no change to the OCR. So even casual observation suggests that a term premium is present. Therefore, assuming the pure expectations hypothesis in an OCR expectations model would tend to overstate the "true" path of the OCR expected by the market.

More formal preliminary research by the Bank (summarised below) confirms that a term premium does indeed exist, and it also increases with maturity. This result also accords with international evidence and practice.[11] The key task remaining is then to estimate the form and size of the term premium.

Estimating the term premium

If credit risk were the only influence on the term premium, then it could be calculated quite easily as the difference between the Treasury bill yield curve (with no default risk) and the bank bill yield curve. This approach is used by some market participants in New Zealand, but a judgemental allowance is required for (the often variable) liquidity risk, and the fact that even the Treasury bill yield curve tends to have an upward slope when no change in the OCR is expected.

Another approach is to estimate the term premium using historical bank bill rate data. One such approach is to use the simple average of a short-term bank bill rate less the OCR over a suitable period of time as the estimate of the term premium. For example, some participants in the New Zealand market calculate the average difference between the one month bank bill rate less the OCR, excluding periods when the maturity of the one month rate extends over the next OCR announcement date. This will generally give a reasonable estimate of the term premium associated with OCR expectations on a short horizon, and therefore it can be used to reliably gauge estimates of the implied OCR for at least the next OCR period.

However, this approach does have some drawbacks. Most importantly, it does not allow for a term premium that increases with maturity. Indeed, this method of estimating the term premium cannot be reliably used for longer horizons; if the maturity of the bank bill rate regularly extends over an OCR announcement date, then this term premium estimate would become "mixed in" with any expectation of future changes to the OCR.

The analysis discussed below is based on a statistical (econometric) approach to estimating the term premium from historic data.[12] Essentially, this involves calculating forward one day rates ("predictions" of the one day rate) from past yield curve data, and comparing these with the levels where the OCR was later set. Of course, the "prediction error" may be due to new information received subsequent to the expectation being formed (in addition to any term premium), so this possibility is allowed for using an appropriate statistical technique.[13] Any remaining systematic difference in the forward one day rate versus the OCR set later may be interpreted as an estimate of the term premium associated with that maturity.[14] By calculating this for each horizon, we can build up a picture of the "shape" of the term premium, and its magnitude at different horizons.

The following figures illustrate the essence of this approach for the 90 day horizon. In figure A3, we compare the OCR "prediction" for the 90 day horizon (the one day rate 90 days forward, as measured 90 days ago) with the actual path of the OCR. Even in this chart it is apparent that the "prediction" has overstated the actual OCR on average.

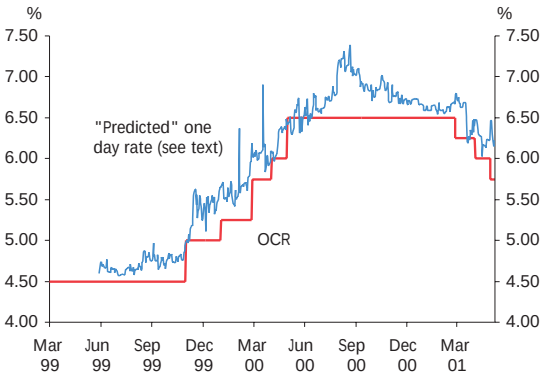
[11] Related research includes Brooke and Cooper (2000), Paquette and Streliski (1998), Gravelle (1998), and Krueger and Kuttner (1995).

[12] Appropriate econometric estimation is often used in related international research. For example, see Gravelle (1998).

[13] Related to the method of Stock and Watson (1993). An explanation of this method is contained in Hamilton (1994). Details of the actual estimation undertaken within the Bank will be published subsequently.

[14] Actually, what has been described here is the calculation of the *forward* term premium, i.e the systematic difference between the one day rate, *n* days forward, and the OCR in *n* days time. At the risk of some ambiguity, we continue to use "term premium" to describe both the usual term premium observed on the yield curve, and the forward term premium estimated from this analysis.

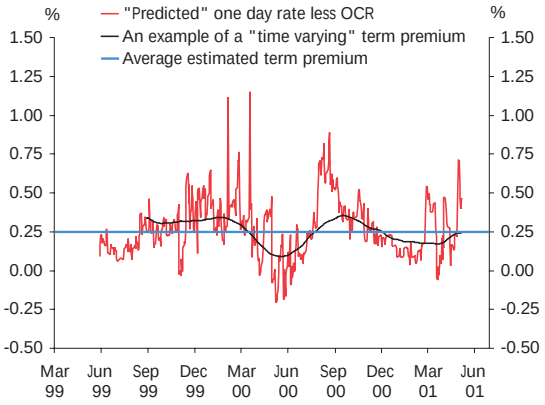
Figure A3
Original data for the 90 day horizon term premium estimate



Source: RBNZ data and RBNZ estimates.

Figure A4 shows these "prediction errors" (the "prediction" less the OCR) more clearly, and suggests that a positive "prediction error" is almost always present. The statistical estimate of the term premium in this example is shown in figure A4.[15] It is also interesting to allow the term premium to vary slowly around that "average", as illustrated in figure A4. This suggests that the term premium for a particular horizon might vary *over time*.

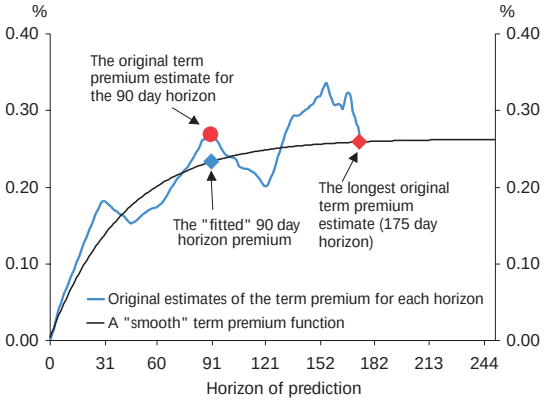
Figure A4
One day rate "prediction errors", and term premium estimates for the 90 day horizon



Source: RBNZ estimates

Figure A5 contains estimates of the term premiums for each horizon (ie the one day term premium, the two day term premium, the 90 day term premium, and the 175 term premium; note that the 90 day term premium estimate from the chart above is indicated specifically on the chart). We have also included an example of a "term premium function" that best represents the series of "raw" term premium estimates for each horizon. A term premium function is useful, because it is unlikely that the "true" term premium really varies *with maturity* as much as the "raw" estimates suggest it might. To clarify, we believe that the term premium *at any given point in time* is close to the "smooth wedge shape", although the "overall size" of this "smooth wedge shape" could possibly change over time.

Figure A5
Actual and fitted term premium estimates by horizon



Source: RBNZ estimates

With an estimate of the term premium function, we can then adjust the initial calculation of forward one day rates from the previous step. This result is likely to show a path for the expected OCR that is "uneven" over time. However, we know that the OCR will remain fixed at a constant level between OCR announcement dates. Hence, we take an average of the adjusted one day rates between successive OCR announcement dates to give an estimate of the expected "step-wise" path of the OCR.[16]

[15] The statistical estimate of the term premium *in this example* is actually very close to the simple average of the "prediction errors". This will not necessarily always be the case, and it is not actually how the estimate is calculated.

[16] We also know that the OCR will be fixed in "steps" of 25 basis points. Hence, when the implied expectation for the OCR is only a fraction of a 25 basis point step, this may loosely be interpreted as a probability of a 25 basis point move.

It is worth stressing that there is only slightly more than two years worth of data for the OCR regime so far, and this does not even span a complete cycle (that is, a period between two definite peaks in interest rates, or two definite lows). In addition, it is quite likely that some of the initial data collected after the introduction of the OCR will cover an "adjustment phase" that might not represent the ongoing environment.[17] Hence, any results obtained from the analysis of historical data collected during the OCR regime so far should still be treated as "work in progress". This particularly applies to the estimate of the term premium function, since this function is itself estimated from "raw" estimates of the term premium for each horizon.

[17] Part of the period also spanned the "Y2K" event. This could be specifically factored out in the estimation technique, but it doesn't appear to have a large impact on the average estimates for the term premium.