

# The Taylor rule and its relevance to New Zealand monetary policy

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The Taylor rule is a simple formula devised to mimic the United States Federal Reserve's interest rate decisions and is thought to perform well in the United States. It is based on relationships between the output gap, neutral real interest rates and the extent to which actual inflation has departed from the desired inflation rate. This article discusses some strengths and weaknesses of the Taylor rule, and then puts it into the New Zealand context. To the extent that it is appropriate for New Zealand, the Taylor rule might provide a useful input into the monetary policy decision-making process at the Reserve Bank. We compare New Zealand's short-term interest rate path with that suggested by the Taylor rule, and discuss how the Bank can use the Taylor rule as part of its framework for thinking about interest rate decisions.

## 1 Introduction

Where should the Reserve Bank set interest rates so that inflation remains within, or returns to, the target range of 0 to 3 per cent? The Governor of the Reserve Bank considers this question and makes scheduled announcements on his conclusion eight times each year. In deciding on where to set the Official Cash Rate (OCR), the Bank considers all available information relevant to inflationary pressures, particularly information relating to the future state of the economy.

Because it is recognised for its ability to mimic the general pattern of interest rate movements, we keep an eye on a range of New Zealand formulations of the Taylor rule when reaching a view on the OCR. The Taylor rule was first proposed by John Taylor (1993). It is a simple formula to calculate an appropriate level of the short-term interest rate as a function of three key variables: the neutral real interest rate, the level of inflation relative to the inflation target, and the output gap (the level of excess demand or spare capacity in the economy). Not only does the Taylor rule mimic the general pattern of interest rates, it seems to be a relatively useful way of thinking about monetary policy decisions in many different models of how actual economies work.

However, the Taylor rule only directly controls for two variables that the policy-maker uses in the monetary policy decision – inflation and the output gap – and assumes that the neutral real interest rate is constant. Therefore, it leaves out many other factors that might affect the future state of the economy and hence the monetary policy decision. As Taylor points out in his 1993 paper, it is not clear that the policy-maker should respond in the same way every time to changes in the output gap or inflation. As discussed later in this article, there are important factors that cause a central bank to set interest rates at a level that differs materially from what the Taylor rule suggests, which is why the Taylor rule mimics actual monetary policy decisions imperfectly.

It is also important to recognise that the Taylor rule relies on estimates of variables that are robust in concept, but very difficult to measure in practice, such as the neutral real interest rate and the output gap. Notwithstanding these limitations, the Taylor rule is a useful analytical framework to assist a central bank in the monetary policy decision making process.

This article discusses some strengths and weaknesses of the Taylor rule in section 2, and whether the Taylor rule is better thought of as a broad benchmark for interest rate decisions rather than as a rule per se. In section 3, we compare and contrast actual interest rates with those the Taylor rule would have implied for the New Zealand economy in recent periods. Section 4 examines some difficulties in using the Taylor rule

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to give policy advice in real time. We summarise our main points in the conclusion.

## 2 The Taylor rule – assessing its strengths and weaknesses

There is an extensive literature on the relative merits of the Taylor rule. This section provides a brief summary of some key points in the debate from the Bank's perspective, rather than a comprehensive survey.

### The form of the Taylor rule

The Taylor rule is a simple reaction function. Its simplicity is both a virtue and a weakness. The Taylor rule says that short-term interest rates should be "neutral" on average, so that the central bank does not cause persistent inflationary or disinflationary pressures, and that interest rates should be adjusted in response to the current state of the economy. If demand is high relative to productive capacity, short-term interest rates should be raised, and if inflation is above target, interest rates should be raised. Conversely, if the economy is operating below its capacity, or inflation is running below the target inflation rate, the Taylor rule suggests that short-term interest rates should be reduced.

More precisely, the Taylor rule is summarised by the following equation:

$$\text{Desired interest rate} = \text{Neutral real interest rate} + \text{Inflation} + \frac{1}{2}(\text{Inflation} - \text{Inflation target}) + \frac{1}{2}\text{Output gap}$$

To determine what the OCR implied by the Taylor rule is at any point in time, we must know the neutral real interest rate (NRR), the output gap, inflation, and the Bank's inflation target.

Both the neutral real rate and the output gap are unobserved variables, unlike nominal interest rates or exchange rates. Because of their unobservable nature, there exists substantial disagreement on the precise definitions, and uncertainty over how well different measurement techniques capture the underlying concepts. This problem is not unique to the Taylor rule though, and is common to many other alternative formulae and models as well. For example, the Bank's

Forecasting and Policy System (FPS), the model the Bank uses for forecasting the economy to assist it in formulating monetary policy decisions, produces forecasts of inflation that depend on both the neutral real rate and the output gap. These inflation forecasts feed into policy advice on what the appropriate level of the interest rate is.

The Bank defines the neutral real rate as 'the interest rate that would prevail if there were no inflationary or deflationary pressure requiring the central bank to lean in either direction' (Archibald and Hunter, 2001, p 17). When inflation is at target and the output gap is zero the Taylor rule recommends a nominal interest rate equal to the neutral real rate plus inflation.

Although the concept of the neutral real rate is valid, there are significant difficulties in actually measuring it. As Archibald and Hunter explained, the neutral real rate can be estimated in a number of different ways, but not very precisely. Moreover, the neutral real rate is unlikely to be constant through time; it is likely to vary depending on investor/borrower preferences, risk premia and other factors. Reflecting these uncertainties, the Bank has estimated a wide range of possible neutral real rates for New Zealand, ranging from 2.8 per cent to 5.6 per cent. Plantier and Scrimgeour (2002) suggest that uncertainty about the level of the neutral real rate poses a problem for the Taylor rule. Moreover, average interest rates over recent history may not be a good indication of what the current neutral real rate is. However, more sophisticated estimation techniques do not reduce the uncertainty about the level of the neutral real rate a great deal.

Another difficulty associated with the Taylor rule is the estimation of the output gap. The output gap measures the difference between the sustainable productive capacity of the economy (potential output) and the actual level of production or demand in the economy (typically measured by Gross Domestic Product). In the absence of countervailing factors, a positive output gap (where demand exceeds the sustainable productive capacity of the economy) will give rise to inflationary pressures, while a negative output gap will cause inflationary pressures to subside.

Although the output gap is conceptually useful, it is difficult to measure. Measuring potential output is particularly

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problematic, given inadequacies in the data available and the inherent difficulty in identifying capacity constraints. Moreover, potential output growth is not constant through time – it varies in line with a range of factors, such as shifts in the labour force, productivity and technology. There are also difficulties in estimating actual output accurately, due to lags in data becoming available and the measurement difficulties in various data series. Orphanides et al (2000) argue that monetary policy should take less account of the output gap when there is uncertainty about how to measure potential output. Instead it should focus more on inflation developments. Furthermore, Orphanides (2001) suggests that these measurement problems require a cautious interpretation of the interest rate profile currently suggested by the Taylor rule for past years, as it incorporates information about potential output available now, but not at the time policy decisions were made.

In addition, we have many different measures of inflation available, and it is not always clear which is the most appropriate indicator of future inflationary pressure. The Taylor rule normally incorporates a response to CPI-based “headline” inflation. The headline inflation rate does not incorporate an adjustment for the effects of transitory factors such as changes in indirect taxes or one-off changes in oil prices. Headline inflation can therefore misrepresent the nature of underlying or persistent inflation in the economy, and is not necessarily the most appropriate measure of inflation for monetary policy decision making purposes. Therefore, it may be appropriate for the Taylor rule to use a measure of “core” inflation, which excludes such one-off influences on prices.

Another potential difficulty for the Taylor rule is that it requires an inflation target that is expressed as a particular inflation rate. For New Zealand, the official inflation target is a range – currently 0 to 3 per cent. However, for the purpose of the Taylor rule and models such as FPS, we usually represent the mid-point of that range as our inflation target – ie 1.5 per cent.

### Optimality vs robustness

There is a large range of alternative reaction functions (that is, ways of adjusting interest rates in response to economic

developments) that central banks can consider when setting monetary policy, of which the Taylor rule is just one. Ideally, the central bank would like to use the “optimal” reaction function – the one that most consistently produces interest rate outcomes consistent with keeping inflation within the target range. The relative merit of the different rules available is at the heart of recent international research in monetary policy. Many academics and central bankers have compared different policy rules and have identified strengths and weaknesses in each of them. (See Drew and Hunt, 2000, for an example of this type of work.)

Often the Taylor rule is one of the options considered in this type of research. The research suggests that the Taylor rule usually does not provide the best way of deciding where to set interest rates for a given model of how the economy works. Usually there is another formula for setting interest rates that takes into account a broader set of information that is more helpful in controlling inflation rates and dampening economic fluctuations.

In identifying the optimal reaction function, the researcher needs to use a particular model of the economy. The best reaction function may depend on how different parts of the economy are related. However no one knows for certain which model is the right one to use in the analysis. In addition, the structure of the economy (and hence how it should be modelled) changes over time. This brings us to the issue of robustness. Because the merit of a particular rule for setting policy depends on the way the economy works, and because no one has complete understanding of how the economy works, it would be desirable to have a rule that performs well across a range of different conceptions of what drives economic activity and inflationary pressures. It seems that the Taylor rule goes some way to fulfil this robustness criterion (see Levin, Wieland and Williams, 1999, 2001 and Taylor, 1999).

### Independence from FPS

As noted earlier, the Reserve Bank maintains a large model of the New Zealand economy. This model, known as FPS, is a key feature of the Bank’s analysis of where the economy is going, and where interest rates need to be set in order to maintain CPI inflation within the middle of the inflation target. Although FPS is a valuable tool in our analysis, it

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provides an abstraction of how the actual economy works, as all models do. Sometimes the equations in FPS may not do a good job of modelling the effects of particular shocks. This does not stop FPS from being useful, but there may be occasions where its advice will not be the best possible advice.

To protect ourselves from such a risk, the Bank uses FPS in combination with a wide range of other tools for assessing inflationary conditions, including a good measure of judgement honed from long observation of how the economy works. One such tool is the Taylor rule, which does not depend on a particular model of the economy. (Thus, the Taylor rule is a greater simplification of the problem facing the policy-maker than FPS is.) This can be helpful when there are shocks that FPS cannot model well. Looking at the Taylor rule may help us reduce the risk of making policy errors, by limiting the exposure to any one view of how the actual economy works. The Taylor rule tends to be a good alternative to consider because it seems to be relatively robust to different transmission mechanisms, as highlighted above.

### **Backward-looking nature of the Taylor rule**

It is widely held that monetary policy needs to be forward-looking to be most effective. Due to the lags inherent in monetary policy – some suggest monetary policy can take up to two years to have its full impact – central banks must think about where the economy is going in the future. When the central bank is forward-looking, it is more likely to be effective in preventing inflationary or deflationary pressures. On the other hand, the Taylor rule is backward-looking – its inputs are data on the recent state of the economy. Therefore, it is arguable that this makes the Taylor rule less useful for monetary policy purposes, given that it does not anticipate the future state of the economy.

The extent to which this is a problem depends on the length of the monetary transmission mechanism and the extent to which the current output gap and inflation provide a reliable guide to the future state of the economy. For example, the longer the monetary transmission lag is, the more forward-looking monetary policy should be (see Batini and Nelson, 2001, and Ha, 2000). Moreover, although the output gap at the time monetary policy is being formulated might be a guide to the future state of the economy (at the time when

monetary policy decisions taken today have their full effect on the economy), monetary policy is more likely to be effective if it is based on a more extensive forecast of the future state of the economy – ie by reference to more than just the current output gap. The inability to forecast the future state of the economy with the current output gap and inflation helps to explain the limitations of the Taylor rule in some models.

One way to limit the criticism that the Taylor rule is backward-looking is to use forecasts of inflation and the output gap in the Taylor rule, so as to make the Taylor rule forward-looking. However, this would remove an advantage of the Taylor rule – that its inputs are based on relatively hard data – and would require the specification of a model of how the economy works so that inflation can be forecast.

It is worth noting that the rate of inflation and the level of the output gap both tend to be quite persistent. If inflation is low now, then it is likely to be low in the next quarter and the quarter after that. Similarly, if the output gap is positive now, then it is likely to remain positive for some time. This inertia means that current inflation and the output gap may not necessarily be bad predictors of future inflation and the output gap. In addition, it is difficult to find variables other than current inflation that contain information about future inflation. Therefore, using forecasts of inflation and the output gap may not make a big difference to the advice of the Taylor rule.

### **The Taylor rule in an open economy**

The Taylor rule does not include an explicit allowance for the effects of the exchange rate. This can be seen as a crucial weakness of the Taylor rule in a small, open economy such as New Zealand's, where the exchange rate can play a major role in economic developments. For example, exchange rate movements can have significant direct effects on the level of prices, inflation expectations and inflationary dynamics. In addition, the exchange rate could be expected to have some impact on the demand conditions for New Zealand goods and services, and therefore indirect effects on inflationary pressures.

Undoubtedly, in an open economy such as New Zealand's, the best way of making monetary policy decisions explicitly

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takes into account changes in the exchange rate and their effect on the economy. However, predicting the effects of the exchange rate is not always easy. Recent experience in New Zealand suggests that the exchange rate is not always a reliable indicator of the future state of the economy, and its effect on inflation is by no means predictable.

While the Taylor rule does not account directly for the exchange rate, it does so implicitly. When the exchange rate falls, cyclical output and inflation typically rise. As these two variables are incorporated into the Taylor rule, the Taylor rule takes some account of the effects of exchange rate movements. It is therefore fair to say that, although the Taylor rule does not respond directly to the exchange rate, it does respond indirectly to the effects of the exchange rate.

Some research, eg Conway *et al* (1999), suggests that the central bank should respond to domestic inflation, rather than the CPI (where the latter includes import price inflation). If this is the case, then the Taylor rule's response to headline inflation will be appropriate when domestic inflation is prominent, but not so when inflation in the tradable sector is dominant. A simple remedy for this problem is to use a measure of domestic inflation, such as non-tradable price inflation, in the Taylor rule. On the other hand, Svensson's (2000) results suggest that it is better to respond to CPI inflation than domestic inflation, whether the central bank uses a Taylor rule or a more complex reaction function.

### 3 Does the Reserve Bank follow a Taylor rule?

As noted earlier in this article, the Reserve Bank considers a wide range of factors when making monetary policy decisions. These include a large number of data series on the real economy, monetary and credit data, information on inflation and inflation expectations, information on business and consumer confidence, financial market developments and comprehensive data on the world economy (focusing principally on our main trading partners). And as discussed earlier, we make use of the Bank's FPS model to generate forecasts of the economy and to assess alternative inflation scenarios. We also draw on the information provided to us by the many businesses and economists that we meet with in the course of a forecast round. All of this helps the Bank

to build up a picture of the economy, both as it is at the time a monetary policy decision is being made, and as it is expected to be when monetary policy decisions taken at the present will have their effects.

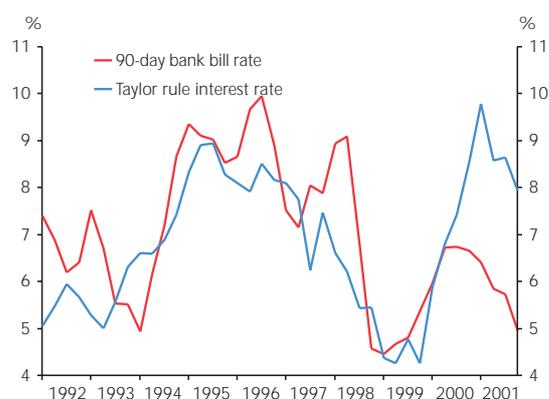
Within this context, the Bank considers other sources of information that may shed light on where the OCR should be set in order to keep inflation within the target band. And this is where the Taylor rule and other models play an important role. Whereas other indicators, such as recent changes in commodity prices, may provide advice on the direction interest rates need to move in, the Taylor rule provides a useful benchmark for checking our thinking on the appropriate level for the OCR. If the Taylor rule suggests an interest rate that deviates significantly from what FPS and our own judgement suggest, that prompts us to reflect further on our assessment of the appropriate setting for monetary conditions.

So the Taylor rule is not used as a "rule" that we implement, but a source of information. Similarly the policy recommendations provided by FPS are not used as rules, but as advice about what interest rates are needed to keep prices stable. Instead of making a commitment to adjust interest rates in one way or another according to some formula, we are committed to maintaining price stability as set out in the Policy Targets Agreement. For us, the Taylor rule is an indicator we look at to help us achieve our price stability objective.

#### Taylor rule compared with New Zealand interest rates

Given that the Taylor rule is backward-looking, we might expect quite significant differences between the 90 day interest rates suggested by the Taylor rule and the 90 day interest rates resulting from the Bank's actual monetary policy decisions. Interestingly, there is a broad similarity between the Taylor rule's interest rate profile for New Zealand and the interest rate profile that has resulted from policy decisions made by the Bank, although there have been periods when we have deviated from the interest rate track suggested by the Taylor rule. Figure 1 shows the actual 90 day interest rate track from 1992 onwards and alongside it the interest rate track suggested by the Taylor rule computed for the same period. The graph shows that, while there are differences between what we have done and what the Taylor

**Figure 1**  
New Zealand interest rates and the Taylor rule since 1992



rule suggests we should have done, the Taylor rule does mimic the general pattern of the 90 day rate in New Zealand for most periods.

The graph above demonstrates that there are several recent episodes when the Taylor rule did not mimic our behaviour closely. The three recent periods that stand out are 1996, 1998, and 2001. In 1996 and 1998, interest rates were higher than the Taylor rule would suggest, while in 2001 interest rates were set lower than those implied by the Taylor rule. In 1996, the higher level of interest rates than that suggested by the Taylor rule reflected the Bank's general concern that rising inflationary expectations would become entrenched because we were breaching the then 0 to 2 per cent inflation target range, and because house price inflation was in double digits for much of the year. In 1998, the downward pressure on the exchange rate led to a large increase in short-term interest rates that was later unwound.

These Taylor rule calculations benefit from being able to assess key variables with hindsight, and without the many uncertainties prevalent when policy decisions are actually being made. As it happens, in both cases, policy eventually reverted towards the interest rate indicated by the Taylor rule. However, with only two observations to go on, it would be premature to draw any strong conclusions. To shed more light on why the Taylor rule interest rates and actual interest rates occasionally differ, we now discuss the more recent divergence, namely the interest rate track in 2001.

## 2001 and the Taylor rule

The decisions the Bank made in 2001, to lower the OCR in the face of relatively high inflation, ran counter to the interest rate profile suggested by the Taylor rule. Thinking about what the Taylor rule was saying, and why, helped us to reason more clearly about why we lowered interest rates.

First, early in 2001, the CPI inflation figures were influenced by one-off factors, such as increases in taxes on tobacco, exchange rate depreciation and high oil prices. As these factors were temporary, we put less weight on the increase in headline inflation than the Taylor rule did.

Second, the likelihood of a global slowdown spilling over and reducing inflation in New Zealand was a key consideration in reducing interest rates in 2001. We thought this risk was sufficiently high to reduce interest rates as a form of insurance. On the other hand, the Taylor rule, being backward-looking, made no such judgement.

Lastly, the terrorist attacks in the United States dominated the latter part of 2001. We reasoned that those events would worsen the weakness apparent in some of our major trading partners, and so had implications for economic activity and prices in New Zealand. Again, we reduced the OCR because we were looking ahead, whereas the Taylor rule does not.

## 4 Using the Taylor rule in real-time

Having discussed some important properties of the Taylor rule in section 2, and shown in section 3 that the Taylor rule does not match precisely the Bank's OCR decisions, we turn our attention to the matter of how we use the Taylor rule to inform the decision-making process at the Bank.

The practical difficulties associated with using a Taylor rule in real time stem from uncertainty about the Taylor rule's inputs. In this section we discuss some methods used at the Bank to handle these uncertainties. We discuss uncertainty in the neutral real interest rate (NRR), the inflation rate and the output gap.

## The importance of knowing the NRR

As mentioned above, the NRR concept is quite subjective, and necessarily depends on how one thinks the economy works. The Taylor rule suggests that the current or lagged output gap and inflation are sufficiently good indicators of future inflationary pressure. However, in reality, the economy is much more complicated. For this reason, we prefer to think of the NRR in the Taylor rule as a residual term that represents all other factors that make the task of controlling inflation harder or easier. On this view, the NRR should not be treated as a constant. Rather, it should be adjusted based on the perceived transmission mechanism and other factors that impinge on the future path of the economy.

The consequence of this uncertainty is that inflation may be more variable than if we actually knew for sure what the NRR was. Taylor (1994) shows how this works. For example, if we thought the NRR was higher than it really was, then we would consistently set interest rates higher than necessary. (This happens as much in the Taylor rule as in other rules that embed some concept of neutral interest rates.) This would depress the economy and cause inflation to be lower than our target. Conversely, if we think the NRR is lower than it really is, then interest rate settings would mean that inflation becomes higher than we want it to be.

In practice, while we are likely to make small errors in our assessment of the neutral real interest rate, these errors will not have large effects. Sooner or later we would get some feedback from the economy providing information on any policy errors, and we would alter the way we respond to developments in the economy. The bigger the error, the faster the feedback is likely to arrive.

## Dealing with uncertainty – output gap and the NRR: the grid

As discussed, there is a considerable amount of uncertainty surrounding estimates of both the output gap and the neutral real rate. A different view of the output gap or the NRR can lead the Taylor rule to give a substantially different recommendation for the interest rate. For example, other factors that may affect the future state of the economy could indicate that the NRR should be lower or higher.

In order to demonstrate this uncertainty, we use the following table to illustrate how the Taylor rule interest rate varies with one's view of the output gap and the NRR. In the table below, inflation is assumed to be two per cent, but this table can be adjusted for other views about the level of current inflation. Table 1 below shows that a 25 basis point change in the NRR leads to a 25 basis point change in the Taylor rule's implied interest rate. A half per cent change in the output gap also yields a 25 basis point change in the interest rate implied by the Taylor rule.

From the table, it is clear that there is a wide range of plausible interest rate settings that depend on one's view of the level of the output gap and the NRR. Because of this wide range, the Taylor rule is not particularly helpful in making close calls on interest rate decisions, but should indicate when interest rates are deviating from a plausible range. When this occurs, it does not necessarily indicate that a policy error has been made, but it does suggest that considerable judgement is being applied regarding the future evolution of the economy.

Table 1  
Interest rates implied by the Taylor rule with output gap and NRR uncertainty

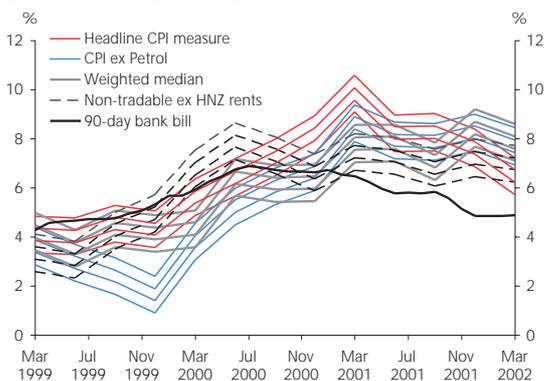
NRR (%)	Output gap (%)				
	-1	-0.5	0	0.5	1
3.5	5.25	5.50	5.75	6.00	6.25
3.75	5.50	5.75	6.00	6.25	6.50
4.0	5.75	6.00	6.25	6.50	6.75
4.25	6.00	6.25	6.50	6.75	7.00
4.5	6.25	6.50	6.75	7.00	7.25

## Dealing with uncertainty – inflation and the NRR: the graph

Looking at several measures of current inflation ensures that the interest rate implied by the Taylor rule is not being driven by one-off factors that do not generate persistent inflationary pressure. For example, if only one of the several measures of inflation is indicating that inflation is above or below target, then it may be safe to ignore the warning coming from that particular Taylor rule. However, if all sensible views of current inflation are above or below target, then the Taylor rule recommendations may deserve more attention.

In the Bank's *Monetary Policy Statement* of May 2001, we included a graph showing what the Taylor rule recommends for a range of different estimates of the NRR and for different measures of inflation, but ignoring uncertainty about the output gap. A more recent version is reproduced here in figure 2. As with table 1, our uncertainty about the current and future state of the economy, as well as inflation, mean that there is a wide range of interest rates that are compatible with a Taylor rule

Figure 2  
Taylor rule suggested 90 day interest rate with different inflation rates



## 5 Conclusions

The Taylor rule is a useful part of the Reserve Bank's analytical toolbox. It provides a framework for checking our thinking on the appropriate level for the OCR. As the subject of much recent research, the Taylor rule seems to be a robust way of setting monetary policy, though it is unlikely to be optimal in all circumstances. Where the interest rate suggested by the Taylor rule departs significantly from the interest rate that the Bank has arrived at through its forecasting process and judgement, this causes the Bank to reflect on what factors might justify the difference between the two interest rates.

A number of factors can justify a difference between the OCR and the interest rate suggested by the Taylor rule. These include differences between the current output gap and the forecast output gap, changing relationships between the output gap and inflationary pressures, changes in the neutral real interest rate, one-off effects on inflation, the expected effects of the world economy on New Zealand and exchange rate developments. All these factors require cautious evaluation of the messages the Taylor rule gives. Measurement difficulties surrounding the neutral real rate and the output gap, and the selection of the appropriate inflation rate, also place constraints on the use of the Taylor rule.

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