
Forecasting at the Reserve Bank of New Zealand

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Forecasting plays a central role in the formulation of monetary policy that is focused on maintaining price stability. To produce a forecast it is important to understand the short-run, cyclical and long run influences on the economy. This article discusses how the Bank's *Forecasting and Policy System* has been designed to reflect these influences and how this system is put to use in order to produce a projection. Both how and why the Bank communicates its projections to the market is also discussed.

1 Introduction

Forecasts of the economy play a central role in monetary policy formulation given the long lag between policy actions and inflation outcomes. The quarterly forecasts published in the *Monetary Policy Statement (MPS)* present the Bank's best prediction of the current state and future evolution of the economy. Given this prediction, monetary conditions are set in order to keep CPIX inflation between 0 to 3 per cent.

Understanding the short-run, cyclical and long-run adjustment in the economy is crucial for formulating good economic projections. The interaction of all these forces impacts upon the economy in the medium run, which is defined to be around one to two years into the future, the horizon over which monetary policy has its greatest impact upon inflation. With these factors in mind, a core macroeconomic model that focuses upon the economy's medium-term dynamics sits at the heart of the Bank's *Forecasting and Policy System (FPS)*. Three tools are used to determine the forces influencing the economy: short-run indicator models, models used to define the underlying trends in the data, and the core model itself. These tools are discussed in section 2 of this article.

It is during the process of producing a projection that the tools of the *FPS* and the 'human element' come together. This process is outlined in section 3. During the projection process, judgement is applied to the projected path for the economy until a plausible macroeconomic picture arises. In a very real sense, it is people who produce the projections, rather than models. Furthermore, it is up to Bank staff to identify the most important risks underlying any projection.

Examining these risks forms the basis of alternative scenarios published in the *MPS*.

Communication of the projections to the market and the wider economic community, and the operation of policy between projections, also play an important role in maintaining price stability. Of particular importance is the frequency of forecasts and the subsequent resets of policy, if necessary, to maintain price stability. These issues are discussed in section 4 of this article.

2 Tools of the trade

2.1 Short-term forecasting

Short-term movements in the economy often have important implications for the evolution of inflation over the policy-relevant horizon. It is crucial to understand the current state of the economy, as well as being aware of unusual events, or 'shocks', and how long they will impact in the economy.

To help evaluate short-term fluctuations, the Bank has developed a range of 'indicator models'. Forecasts from these models, together with judgement where appropriate, provide the estimates of the first two quarters of the projection period. These quarters are termed the 'monitoring quarters', and provide the starting point for the Bank's medium-term projection of the economy.

Indicator modelling

Many of the variables the Bank requires to evaluate the current state of the economy are not available at the time of preparing an economic projection.² Despite this informational lag, more timely data can often provide an early

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² For example, official GDP statistics are on average released one quarter after the date they relate to

Table 1: Variables used in selected indicator models

Real production-based GDP

Real retail sales
Cement sales (tonnes)
Real road user charges

Road vehicle investment

New vehicle registrations
Consumer confidence
National Bank activity outlook

Total private consumption

Real retail sales
Real credit card billings
Real house prices

Commercial construction investment

Cement sales (tonnes)
Value of building consents
National Bank activity outlook

indication of the likely outcome for the variable the Bank is interested in. When the relationship between the 'leading indicator' and the variable the Bank is trying to forecast is quite reliable, the Bank will place considerable emphasis on the relationship conveyed.

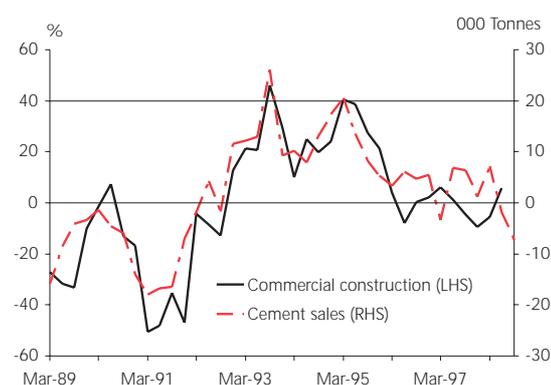
An example of a leading indicator for road vehicle investment is the number of new motor vehicle registrations. Quarterly data on new motor vehicle registrations is available approximately two months prior to the release of the road vehicle investment data. Another example is the tonnes of cement sold per month and its close relationship to commercial construction. These indicators are seen in figures 1 and 2 below.

Where issues such as timeliness and series length suffice, relationships can be exploited on a formal basis in indicator models.³ A summary of the variables that feed into indicator models for GDP, private consumption, vehicle investment, and commercial construction are seen in table 1 below. A key benefit of these models is that they can be constantly updated with new information and quickly re-estimated. In addition, new indicators can be constantly sought after and institutional knowledge can be retained.

Figure 1: Indicators of economic activity: Motor vehicle registrations and road vehicle investment



Figure 2: Indicators of economic activity: Cement sales and commercial construction



³ Ideally an indicator will provide statistically significant and reliable information about the target variable. Standard econometric analysis including unit root tests for stationarity, cointegration, and Granger causality tests are carried out to select the time series that are best related to the target variable. Estimation of the models involves a two-step process. The first step incorporates the contemporaneous indicators and is estimated as an autoregressive lag in first differences using ordinary least squares. The second step incorporates the forecast from the first step and produces a forecast beyond the current quarter using a vector autoregression model in first differences.

Incorporating judgement into short-term forecasts

Models that take advantage of statistical relationships are only as good as the information they are generated from and generally do not capture all the available information relevant for forecasting the variable of interest. Judgement is always necessary to take into account the quality of that information.

Qualitative information is used to complement the indicator model forecasts. Such information feeds into the Bank's view of the direction of the economy and, in some cases, helps pick turning points. Two of the main sources of qualitative information the Bank utilises are business consultations and surveys. Business consultations provide the Bank with a direct link to private and public sector industries, and umbrella groups such as Chambers of Commerce. At a qualitative level, business consultations provide a mechanism for determining the major factors influencing the economy. At present, the Bank visits approximately 60 businesses around the country and across sectors every quarter. Business opinion surveys, consumer confidence surveys and expectation surveys can also provide additional information on the direction of the economy and turning points. We now turn to the tools that look at the economy beyond the short term.

2.2 Evolution towards the long run

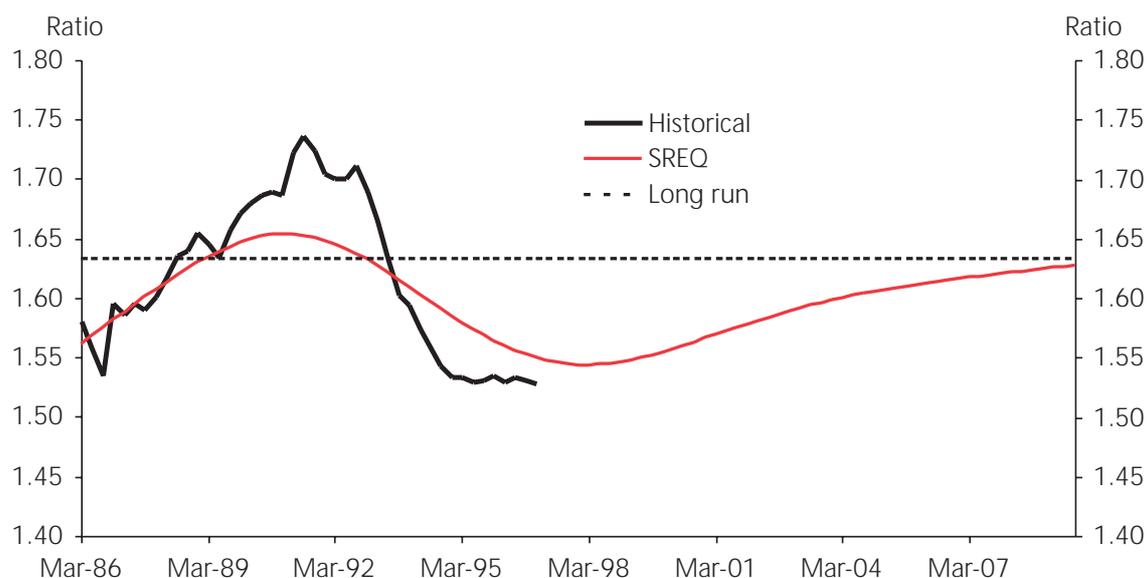
The FPS core model sits at the centre of the Bank's projection efforts. In an economic projection, the FPS core model solution converges to numerical long-run relationships or 'steady states'.⁴ In reality however, the adjustment in the economy towards that long run depends on the structure of

institutions and markets in the past, the present, and how they are expected to evolve in the future. Furthermore, the process of adjustment is likely to be slow. This is because when fundamental changes to the economy (such as structural reform) occur, it is often quite difficult for people in the economy to completely understand the true nature of the change. Permanent and temporary changes will often initially appear to be quite similar. People require time to ascertain whether changes are credible or not, and they need time to learn about permanent changes and their implications, and thus alter their behaviour.

To capture the underlying adjustment in the economy, the process by which people "learn" or update their beliefs is proxied. We do this by estimating what are called short-run equilibrium paths (SREQs).⁵ These SREQ paths respect historical trends in the data, and over the projection horizon converge towards their long-run steady-state values.

An example of a SREQ path is illustrated in figure 3, where three stages of the capital-to-output ratio are graphed. The solid line is the actual capital-to-output series. The thin line represents the estimated, time-varying SREQ for its desired level. The dotted line is its long-run value to which it will converge.

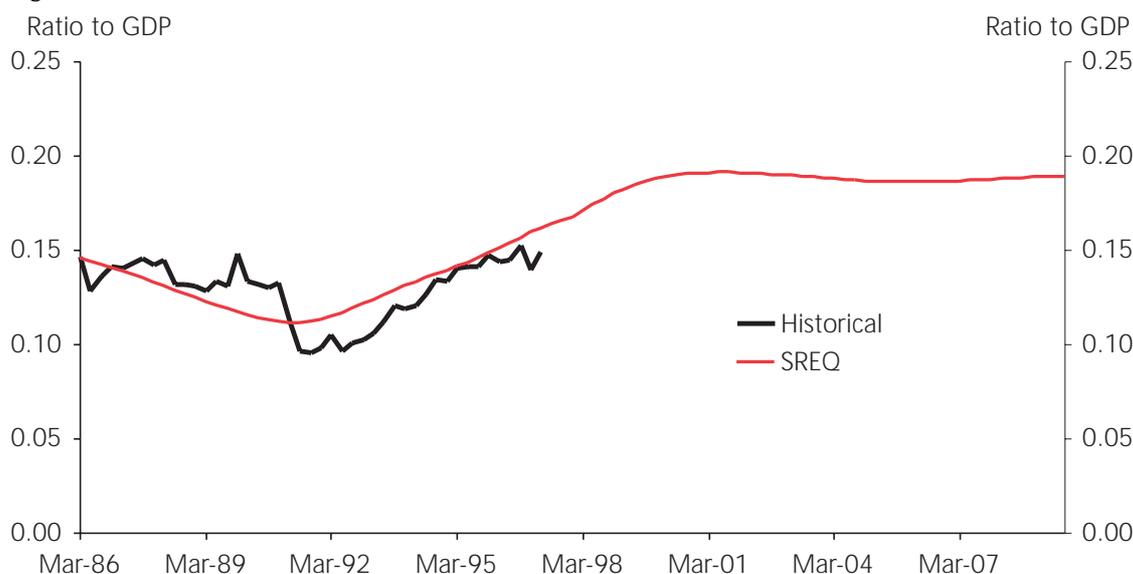
Figure 3: Capital-to-output ratios



⁴ A full description of the numerical steady state and the rationale for the steady-state choices are available in Black *et al* (1998).

⁵ A comprehensive picture of underlying adjustment of the economy towards the long run is then available for assessment. See Drew and Hunt (1998b) for a complete description on the estimation methodology employed.

Figure 4: Investment



The actual capital-output ratio declined in the early 1990s, as capital growth did not keep pace with rapid output growth. Structural reform is sometimes cited as the key factor driving rapid growth in real output over this period. However, firms may have been uncertain of the impact of the reforms or their permanence. Combined with a certain degree of scrapping of old capital, firms desired capital-output ratio might have declined over this period. The decline in the SREQ between 1990 and 1996, or the desired capital-output ratio is consistent with this argument.

Figure 3 also shows that the actual capital-output ratio is below the SREQ, or desired level. This has occurred because actual investment flows, while increasing, have not increased as fast as desired flows, as seen in figure 4. This implies that for the capital-to-output ratio to converge towards its desired SREQ path, actual investment flows in future will need to increase above their desired path.

An overview of the key SREQ paths

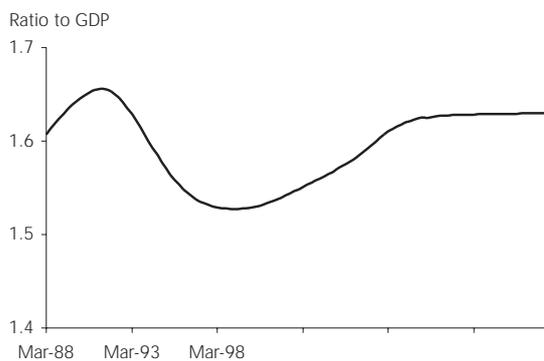
Adjustment in the projected economy is largely embodied in the ratios to output of four key stocks: capital, government bonds, financial assets, and net foreign assets. Given the depreciation rate of capital, firms' desired ratio of capital to output determines the required investment flows. The ratios of government debt to output and government expenditure to output determine the required level of taxation. Given labour income net of taxes, households' choice

for the ratio of financial assets-to-output determines simultaneously the sustainable flow of consumption and the ratio of net foreign assets to output. The net export position is then determined by the service cost (benefit) of net foreign assets.

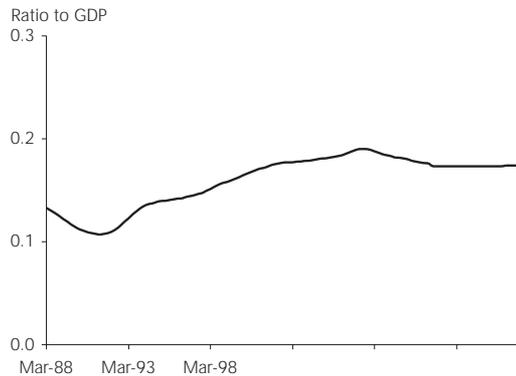
The evolution of this time-varying steady-state story is illustrated in figure 5. The left-hand column contains the desired paths for the key stock-to-output ratios and the right hand column contains all the resulting flow-to-output ratios that comprise aggregate demand. In summary, the first two charts in the left-hand column contain the desired path for the total stock of domestic assets (capital and government debt). Subtracting financial assets held by households from the total stock of domestic assets leads to the stock of net foreign assets. In other words, domestic assets minus household financial assets equals net foreign assets.

Figure 5: Desired asset stocks and expenditure flows relative to output

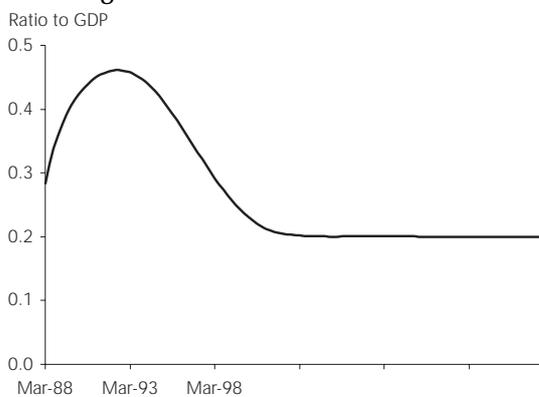
Desired capital stock



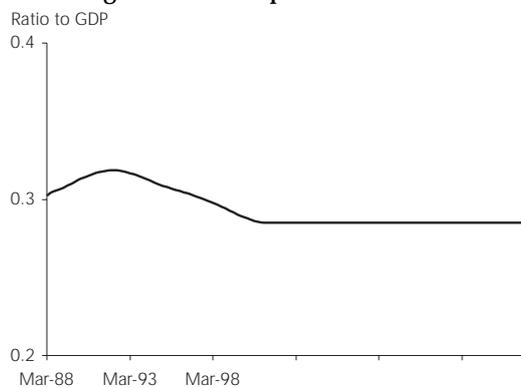
Desired investment flow



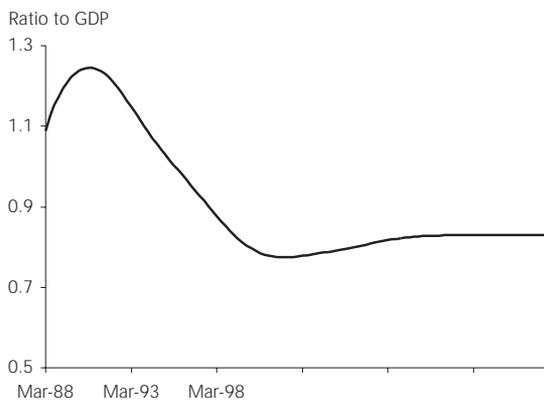
Desired government debt stock



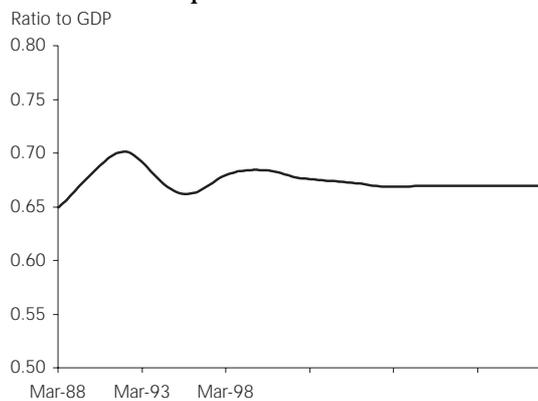
Desired government expenditure flow



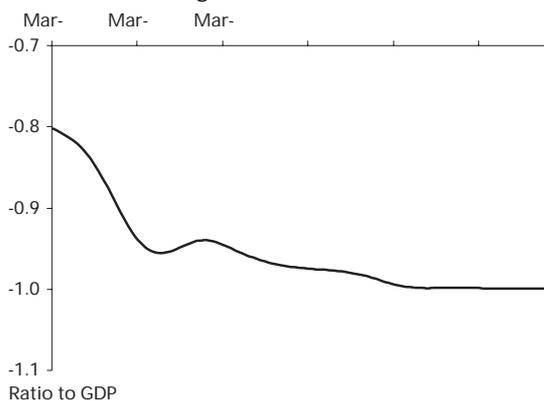
Desired financial asset stock



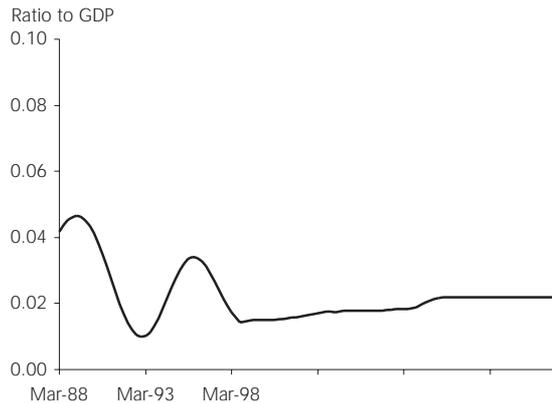
Desired consumption flow



Desired net foreign asset stock



Desired trade balance flow



3 The Forecasting Process

The forecasting process the Bank undertakes each quarter is illustrated in figure 6 opposite.

As outlined, the Bank employs various tools to forecast the short run, and proxies simple learning mechanisms (SREQs) to forecast underlying adjustment to the long run. In addition, variables that are not explained by the core FPS model ('exogenous' variables) need to be forecast. These variables include: projections of international growth and interest rates, export prices, and fiscal assumptions such as tax rates and government expenditure. In many cases the Bank takes these forecasts directly from outside sources. These sources generally have both more information and experience in forecasting these variables. For example, tax rates and fiscal expenditures are taken from forecasts provided by The Treasury. Similarly, the forecasts of foreign variables are usually taken directly from international *Consensus Forecasts*, which are an average of forecasts by international forecasters and are published on a monthly basis.

Producing a no-judgement round

Once forecasts for the monitoring quarters are complete and the projections for these 'exogenous' variables are determined, the core model is used for the first time. Reflecting the fact that the core model was calibrated to emulate business cycle properties of the economy, and not short-run attributes of the data, the monitoring quarters are treated by the core model *as if* they were actual historical out-turns.

The model's initial projection is termed the 'no-judgement' round in that only minimal forecasting judgements are imposed on the model's raw output. There are two steps undertaken to generate this projection. The first step is to understand where we are today relative to where the model would have us. To do this, actual data, our estimates for the monitoring quarters, and exogenous data is fed into the model. The model is then simulated over history and the difference between the actual data and the model estimates of the data is compared. In the second step, this difference is decayed into the future in a mechanical fashion to project an outlook for the economy.

Applying informed judgements

It is at this point that judgement is applied in greater measure to the medium-term projection of the economy. It is quite possible that the shocks present in the economy are different to those experienced in the past, or that shocks are expected to be more or less persistent than their average historical persistence. As such, the no-judgement round may be seen as implausible for a particular sector of the economy and for the broad macroeconomic picture as a whole. Consequently, judgement is applied to adjust the projected path of the economy. To do this, the speed or timing that variables return to their long-run paths can be adjusted by the forecaster.

Such a judgement may be applied, for example, to reflect negative wealth effects arising from a sharp fall in equity markets across the world or domestic weakness in the housing market. Given that these wealth effects are not modelled explicitly, forecast judgement is required. The results of implementing judgement could be a more subdued consumption outlook.

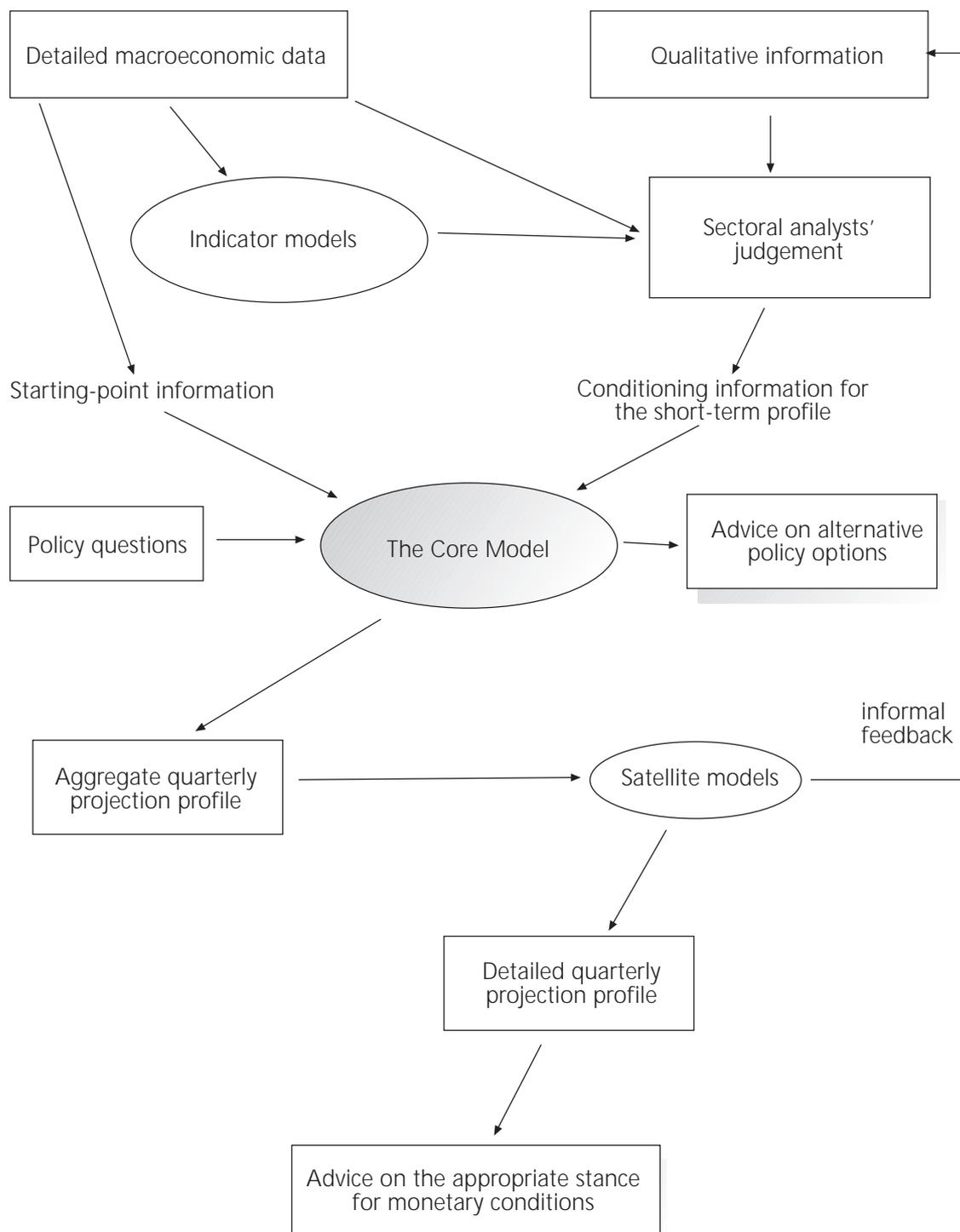
Importantly, judgements made to one sector of the economy must be considered in the context of the whole macroeconomic picture. As the FPS core model is a general equilibrium model, judgements made in one sector will affect the system as a whole. In this sense the system imposes 'judgement accounting'. For example, reducing consumption by too much in the example above may not be consistent with the view on the current account, labour income, or tax revenue. In this case judgements would need to be reconsidered. Through a process of iteration, judgements are altered until the aggregate picture looks reasonable. This final picture makes up the 'central scenario' projection that forms the basis of the Bank's published assessment of the economy appearing each quarter in the *MPS*.

Examining the key risks and assumptions in the central scenario

The FPS allows the Bank to examine the key risks and judgements in the central scenario. For those assumptions seen as the most uncertain, alternative scenarios can be generated to illustrate their implications for monetary policy. An alternative scenario adjusts one assumption made in the central scenario, leaving the rest of the assumptions un-

Figure 6: The forecasting process:

The Forecasting and Policy System



changed. Following our example, an identified risk could be that householders could look to maintain high levels of consumption by running down their existing stock of wealth. This would generate different paths for inflation, output, and monetary conditions to consider. The alternative scenarios form the basis for discussion of the risks on the Bank's assessment of the economy, as published in the *MPS*.

3.1 Communicating projections

The forecasting effort that goes into preparing the central scenario, and alternatives where appropriate, is a useful part of policy implementation – but by no means the whole story. Also of importance is how the Bank communicates the projections to the market and wider economic community, and how policy operates between projections.

Forecasting the outlook for the economy will never be a precise science. Fundamentally this is because there are uncertainties surrounding any forecast. These uncertainties arise from three distinct sources:

- the nature, size, and duration of economic shocks;
- the current state of the economy; and
- the workings of the economy.

The upshot of these uncertainties is that our forecasts will always be 'wrong' to some extent. However, this does not in any way lessen the Bank's internal need for forecasting. Given that monetary policy affects inflation with long and variable lags, the Bank must project an outlook for the economy in order to set policy.

Why publish our projections?

The Reserve Bank of New Zealand is quite unique in that its projections are published. Other inflation-targeting central banks use projections to guide policy, but most do not publish these projections. The primary reason we prefer to publish is that it is an important communication tool. Our projections provide financial markets and the wider community a sense of where we believe the economy is headed, and hence the reason for any policy action. Our forecasts can thus be thought of as a 'benchmark' for policy, against which the implications of emerging information can be assessed by both the Bank and financial markets. In an uncertain world, this approach may lessen one important

source of uncertainty – that is, uncertainty about our own reactions as new information arrives.

Policy making under uncertainty

The implications for the economy of incorrect forecasts can be mitigated by two key factors:

- forecasts are updated quarterly, which is frequent enough that monetary policy changes can be made in a timely manner as new information comes to light; and
- financial markets are allowed considerable flexibility to adjust actual monetary conditions in response to new information as soon as it emerges.

The first factor reflects the fact that the Bank conducts a full re-assessment of the economy each quarter and resets monetary conditions accordingly. The second factor reflects the fact that we recognise that the world is an uncertain place, hence inevitably 'surprises' will occur. In allowing financial markets to adjust monetary conditions intra-quarter, in response to these surprises, the need for large quarterly policy resets is mitigated.

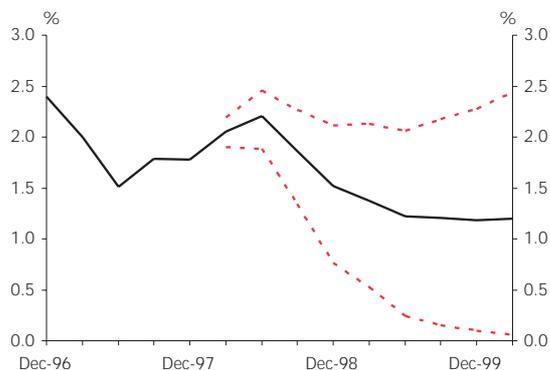
To put some quantitative substance on the discussion above, figure 7 presents 'confidence bands' around the December 1997 projection shock with only uncertainty taken into consideration.⁶ In other words, the confidence bands are derived assuming we know exactly how the economy works and where it is today, leaving only unexpected events.

It is evident that as we move through time, the confidence bands widen. This reflects the fact that the further into the future we look, the more uncertain we are. The bands do not, however, explode. For example, the 95 percent confidence band about CPI inflation stabilises at around +/- 2.0

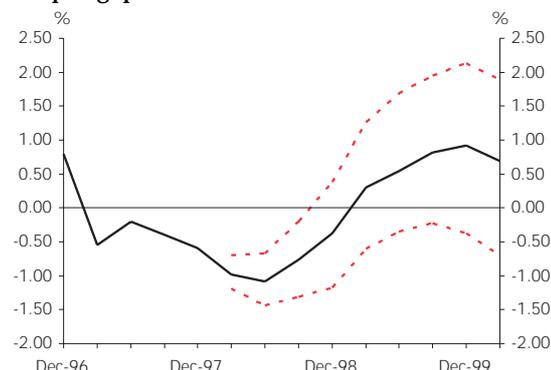
⁶ To calculate these bands, a technique termed "stochastic simulations" is employed. The projected path of the economy from the central scenario is treated as the most likely, or mean outcome, for the economy. The model is then subjected to shocks quarter-by-quarter, with disturbances typical of the type of macro-level disturbances New Zealand has historically faced. The magnitude and direction of these disturbances are randomly drawn. This exercise is repeated 100 times, to produce 100 alternative projected paths for the economy. The 100 paths allow us to calculate standard deviations for key variables in the projections, and hence produce confidence bands. See Drew and Hunt (1998a, 1998b) for a detailed discussion of the techniques employed to perform stochastic simulations around the economic projections.

Figure 7: The 95 percent confidence bands around the December 1997 projection

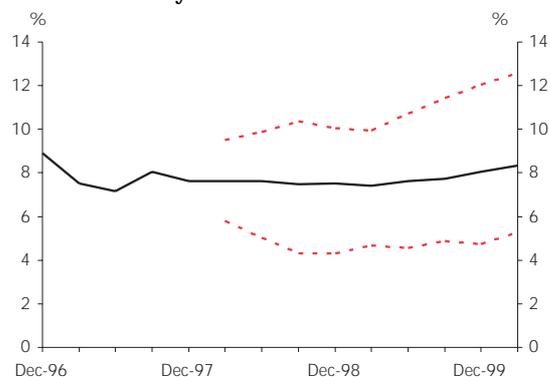
Inflation



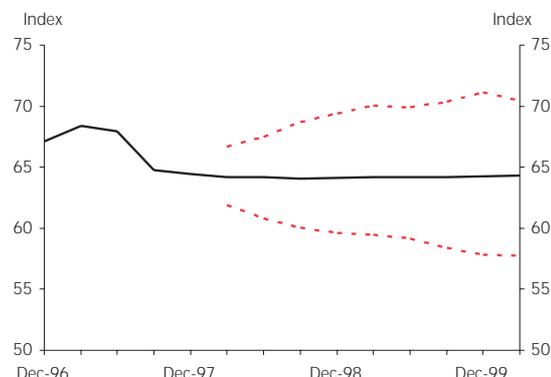
Output gap



Nominal 90 day interest rate



Nominal TWI



percentage points around the projected path for inflation. In other words we are likely to see CPIX inflation between 0 to 3 percent 85 percent of the time (ie we will breach the target range three times every five years). This stabilisation occurs because the monetary authority, at every quarter, resets policy in order to meet its inflation target objective based on the information at that date.

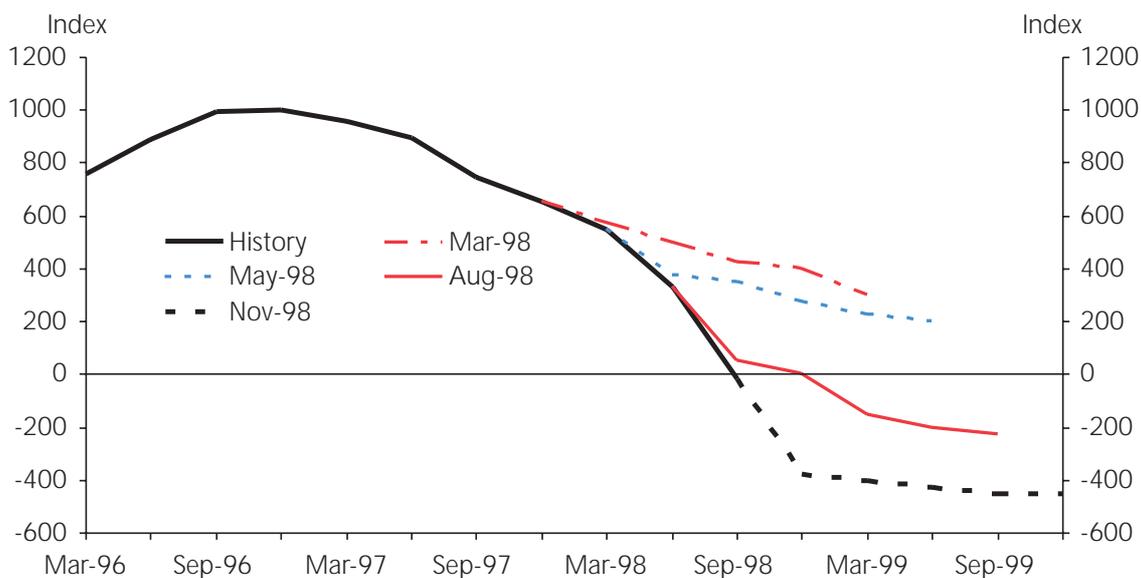
Clearly, in order for the monetary authority to fulfil its low inflation objective, monetary policy needs to be reset each quarter as new shocks hit the economy and new information arrives. The confidence bands about the interest rate and the exchange rate paths above reflect this point. They show an estimate of how much, *on average*, we might expect monetary conditions will need to adjust each quarter, given uncertainty arising from future shocks, in order to keep CPIX inflation within the target band of 0 to 3 percentage points.

A point of interest is to compare what the confidence bands were around the interest and exchange rates in our December 1997 projection, to where we are now at the end of

1998. At the time of writing in November 1998, the actual TWI was around 57 and the nominal interest rate was around 4.5 percent. Comparing these outcomes to the confidence bands about the December 1997 projection, indicates that for the December quarter 1998, the interest rate is within the band, whilst the TWI is close to the lower edge. This comparison is made over a period in which the New Zealand dollar was subject to very large shocks. The forecasts were also made in December 1997, conditional on *Consensus Forecasts* for international growth which proved overly optimistic as the Asian crisis deteriorated. Finally, it is also the case that the confidence bands presented above almost certainly understate the 'true' level of economic uncertainty. If both model and starting point uncertainty were also considered, then the confidence bands about the central projection path would likely widen.

The discussion above reflects how policy, on average, needs to be adjusted to keep CPIX inflation within our target band. To put further substance on the issue, consider how our economic projections have unfolded over the past year as the depth of the Asian crisis was revealed. Figure 8 shows the

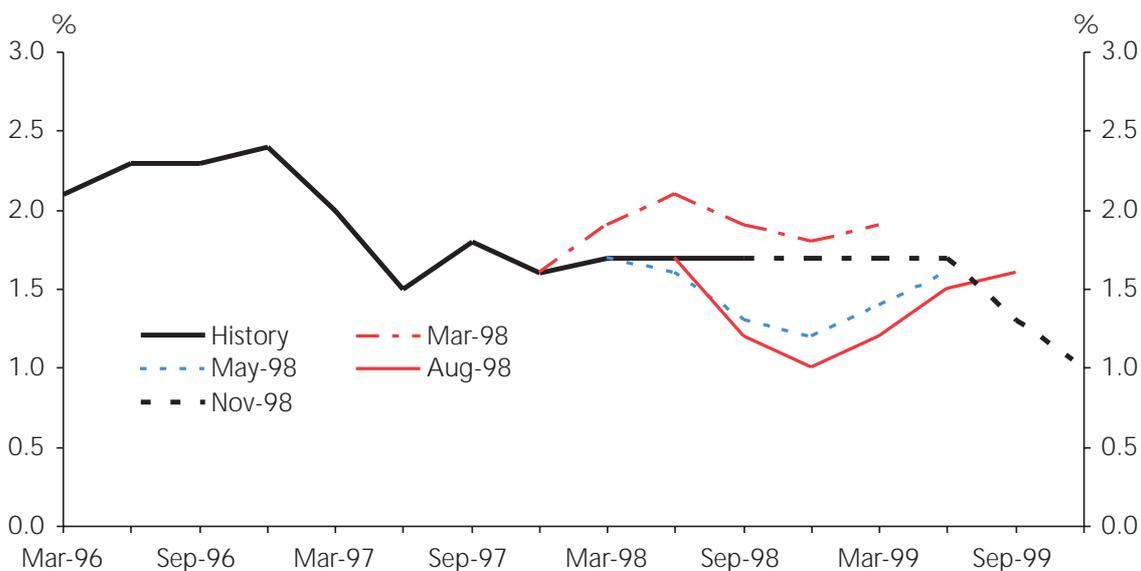
Figure 8: Projections of nominal MCI



path of actual monetary conditions, and the projected paths from the subsequent quarterly projections. Figure 9 shows the associated inflation projections. Consistent with new information suggesting that the Asian crisis was deepening, both the level and forward path of monetary conditions have been steadily revised downwards. As importantly, actual monetary conditions were allowed to absorb the new information and adjust between our projections. The extent of

market adjustment was, to some degree, benchmarked against our most recent projections. Of course, our projections for inflation have remained broadly unchanged. This reflects that monetary policy is able to play the role of 'shock-absorber', with monetary conditions adjusting in order to buffer both inflation and output from the effects of unexpected events.

Figure 9: Projections of CPIX



4 Summary

The Bank's projections released each quarter in the *MPS* provide a 'benchmark' for measuring the size and direction of shocks, and the appropriate policy response. Alternative 'risk' scenarios that are also presented in the *MPS* further enable an assessment of the implications of news for the inflation outlook. This forecasting effort is a central part of policy formulation – but by no means the whole story. Once the projections are released the Bank must also decide how to operate policy between projections. By publishing monetary conditions with a forward path and alternative scenarios where appropriate, financial markets can, to a large extent, anticipate the Bank's quarterly resets. As a result, adjustments of monetary conditions intra-quarter generally remain consistent with the maintenance of price stability.

References

- Black, R, V Cassino, A Drew, E Hansen, B Hunt, D Rose and A Scott (1997), "The Forecasting and Policy System: the core model", *Reserve Bank of New Zealand Research Paper* No. 43.
- Drew, A, and B Hunt, (1998a), "The Forecasting and Policy System: stochastic simulations of the core model", *Reserve Bank of New Zealand Discussion Paper* 98/6.
- Drew, A, and B Hunt, (1998b), "The Forecasting and Policy System: preparing economic projections", *Reserve Bank of New Zealand Discussion Paper* 98/7.
- Reserve Bank of New Zealand (1997) *Economic Projections*, June 1997
- Reserve Bank of New Zealand (1997 - 1998) *Monetary Policy Statement*, December 1997 – December 1998