RESERVE BANK

OF NEW ZEALAND

G98/7

The Forecasting and Policy System: preparing economic projections

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October 1998

Discussion Paper Series

G98/7

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Abstract

This paper outlines how the Reserve Bank of New Zealand's *Forecasting and Policy System* (FPS) is used to prepare the quarterly economic projections. In addition to a very brief overview of the system, the paper focuses on four key issues. First, the current methodology for incorporating a time-varying equilibrium path for the economy is presented. Second, the process for building up the central scenario through the application of judgement is outlined. Third, the use of alternative scenarios for testing the implications of key assumptions embodied in the central scenario is discussed. Finally, the technique employed to examine the implications that unforseen shocks have for the projections is discussed.

1 Introduction

The Reserve Bank of New Zealand produces formal economic projections four times a year. These projections provide a basis for determining the monetary conditions that are required to keep inflation within the Bank's target range of zero to three per cent.[1] Reflecting the Bank's transparent operation of monetary policy, these projections are published upon completion. The chief tools used by Bank staff to prepare economic projections are the models that comprise the *Forecasting and Policy System* (FPS). This document provides an overview of the system with particular focus on four key aspects of generating the economic projections:

i) estimating time-varying equilibrium paths;

ii) incorporating short-run dynamics and staff judgement;

iii) analysing the implications of key assumptions; and

iv) quantifying uncertainty about future events.

As outlined in Black *et al* (1997), one of the key features of the core FPS model is that it embodies an underlying steady state that anchors the dynamic adjustment process. Not only are the steady-state values that the economy is converging towards unobservable, but they undoubtedly change through time. A time-varying steady state is therefore necessary to use the model sensibly with historical data and to formulate plausible economic projections. The first topic in this paper is the technique that is used to estimate how model agents' view of the steady state might have evolved historically and is likely to evolve over the projection horizon.[2]

The focus during the development of the core FPS model was on its medium-term dynamic properties. Consequently, the model does not attempt to reproduce the short-run idiosyncratic properties of the

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[1] As per the current Policy Targets Agreement (PTA) signed in December 1996.

[2] An overview of the steady state of the FPS core model is outlined in Black *et al* (1997).

data. However, these short-run properties can often have important implications for the evolution of inflation over the policy-relevant horizon and so they are essential to incorporate into economic projections. We present how using indicator models to pin down the very near term in the projections allows for the incorporation of these aspects of the data without making them permanent properties of the model. Econometric short-term forecasting tools, like indicator models, *cannot* provide all the richness in dynamics lacking in stylised models. Therefore, there is also a central role for the staff's judgement in determining the short-run dynamic profiles in the projection.

One of the strengths of the FPS is that it provides concise accounting of the staff's judgements. These judgements include both those to the near-term dynamic profiles and those regarding the evolution of exogenous factors, primarily the evolution of the rest of the world. The system allows for the analysis of the implications of these judgements through alternative scenarios. If some judgements have particularly large degrees of uncertainty about them, alternative scenarios can be used to quantify their impact on the projection profile and thus the desired policy setting. The technique that is used to generate those alternative scenarios is outlined in this paper.

The only thing 100 per cent certain about economic projections is that they will always turn out to be incorrect. This arises for three key reasons. First, the models used to formulate projections are simplifications of how economies work. Secondly, no one is prescient and, consequently, unforeseen events will always lead to outcomes that are different than those projected. Finally, given data publication lags and revisions, there is uncertainty about the current state of the economy. Although nothing will ever completely solve these problems, the implications of uncertainty about future events can, to an extent, be quantified. (Examining the implications of the other sources of uncertainty is on the Bank's current research agenda). Quantifying this uncertainty through the use of stochastic simulations to generate confidence bands around the paths contained in the central projection is the final topic covered in this paper.

The structure of this paper is as follows. The philosophy behind the FPS and how this has led to the construction of three quite different types of models is outlined briefly in Section 2. In Section 3, a brief overview of the core model is offered.[3] In Section 4, the methodology for estimating the time-varying short-run equilibrium path over history and the projection horizon is documented. A discussion of how the various model solutions and staff judgements are combined to generate the central scenario is presented in Section 5. In this section, an outline of the technique employed for testing the implications of the staff's key assumptions is also presented. Specific examples of applying judgment and testing assumptions from previous Bank projections are used to illustrate this process. Finally in Section 5, the technique used to quantify how the central scenario may be affected due to uncertainty arising from unforeseen shocks is discussed. A brief summary follows in Section 6.

2 The structure of the FPS

Policy experiments and forecasting place quite different demands on macroeconomic models. The Bank's experience with economic modelling and those of other institutions show a tension between models that are rich enough to relate closely to the data and those that are tractable enough to be useful for analysis of alternative policy choices. Typically, models that forecast well in the short term are often seriously misleading when used for policy analysis. The Bank's solution is a core macroeconomic model that has the minimum structure necessary to conduct sensible policy analysis, and that can be used in a larger system that it is capable of supporting economic projections.

In FPS, many policy questions may be tackled by using the core model alone along with the assumption that the economy is initially in equilibrium. In contrast, for quarterly projections, the economy is not starting from a position of equilibrium. Because of this, it is essential to augment the more medium-term focus of the dynamic structure of the core model with this short-term information. This

[3] A complete discussion of the core model in Black *et al.* (1997).

involves information about the current disequilibria in the economy and how persistent they are expected to be. To accomplish this, the FPS consists of the *core* model plus two types of small models: *indicator* models and *satellite* models. The *core* model incorporates the behavioural relationships among the key macroeconomic concepts that are most central to monetary policy issues. *Indicator* models are pure time-series models designed to capture the high frequency information in the data. *Satellite* models decompose the highly aggregated solutions from the core model into more detailed sectoral information.

The principal aim of the indicator models is to capture the very short-run dynamic properties of the data. These properties provide the key input into the forecasts of the first two quarters beyond the most recent available historical out-turns. This allows for a precise assessment of the state of the economy at the start of each projection round. Additionally, it enables the very short-run properties of the data to influence the projected path for monetary conditions, without making these properties permanent in the core model[4]. This is important because these short-run properties often change substantially through time, particularly in New Zealand where structural change has been so pervasive. Indicator models can be updated quickly without having to change the core model. In their own right, indicator models are useful analytical tools for examining the information content of the data as they can be used quickly and easily between projections to see how new data effects the view on the current state of the economy.

Using satellite models to decompose the aggregate concepts used in the core model ensures that the advantages of the core model's general equilibrium solutions are retained, whilst maintaining relatively quick simulation times. To the extent possible, the satellite models embody the same design philosophy as the core model; dynamic adjustment occurs around a well-defined equilibrium path. The more detailed results from the satellite models closely match the detail at which specific information is available to sector analysts. This allows them to see the implication of their aggregate views at a

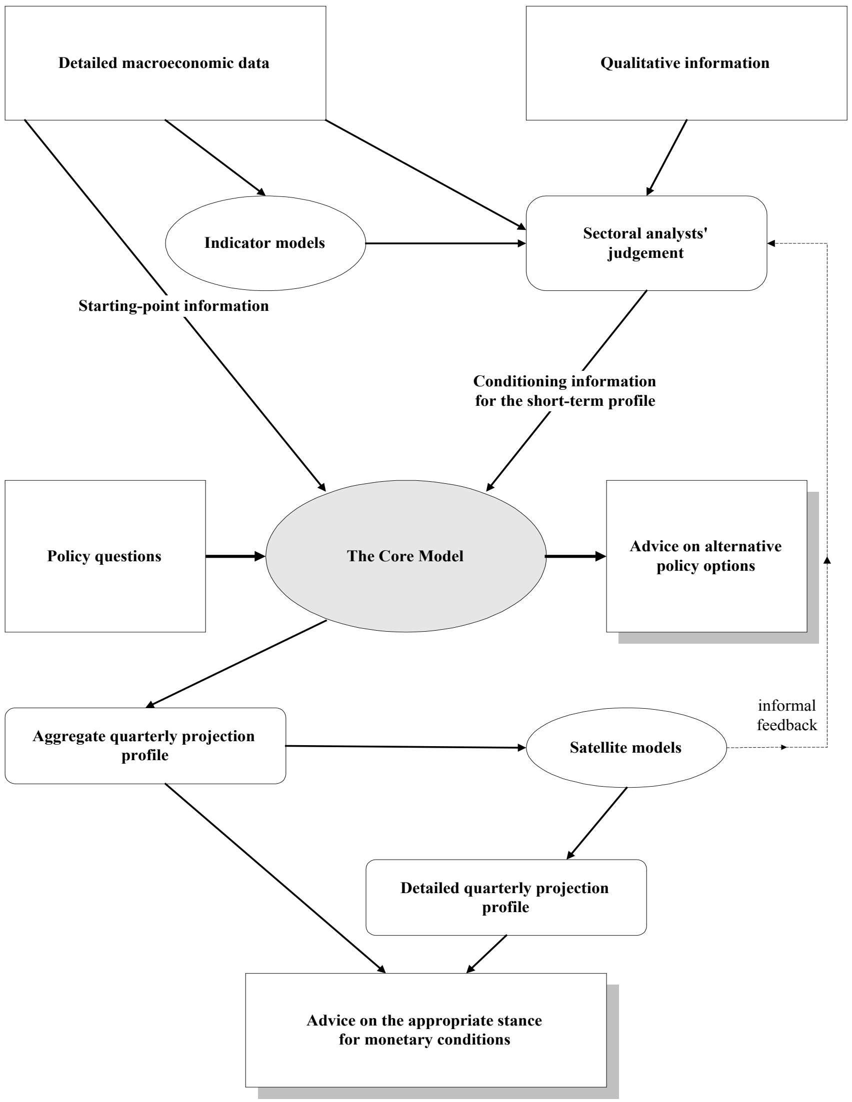
[4] See Section 5.3 for elaboration on this point.

disaggregated sector specific level, possibly leading to a revision of those views.[5]

A graphical representation of the full *Forecasting and Policy System* is represented in Figure 1. In summary, for policy analysis often the core model is all that is required. For projections, the whole system is utilised by Bank staff. Hence, the essence of the system is that it allows staff to use as much of the system as needed for the task at hand.

[5] A description of the demand-side satellite models can be found in Breece and Cassino (1998).

Figure 1 The Forecasting and Policy System



3 The Core Model

The FPS core model describes the interaction of five economic agents: households, firms, government, a foreign sector, and the monetary authority. The model has a two-tiered structure. The first tier is the underlying steady-state structure that determines the long-run equilibrium to which the model will converge. The second tier is the dynamic adjustment structure that traces out how the economy converges towards that long-run equilibrium.

The long-run equilibrium is characterised by a neoclassical balanced-growth path. Along that growth path, consumers maximise utility, firms maximise profits and the government achieves exogenously specified targets for debt and expenditures. The foreign sector trades in goods and assets with the domestic economy. Taken together, the actions of these agents determine expenditure flows that support a set of stock equilibrium conditions that underlie the balanced growth path.

The dynamic adjustment process overlaid on the equilibrium structure embodies both “expectational” and “intrinsic” dynamics. Expectational dynamics arise through the interaction of exogenous disturbances, policy actions and private agents’ expectations. Policy actions are introduced to re-anchor expectations when exogenous disturbances move the economy away from equilibrium. Because policy actions do not immediately re-anchor private expectations, other real variables in the economy must follow disequilibrium paths until expectations return to equilibrium. To capture this notion, expectations are modelled as a linear combination of a backward-looking autoregressive process and a forward-looking model-consistent process. Modelling expectations in this way partially addresses the critique, initially raised in Lucas (1976), that examining alternative policy actions in reduced form econometric models gives misleading conclusions[6].

[6] The Lucas critique states that the estimated parameters of reduced-form models are dependent on the policy regimes in place over the estimation period. Consequently, simulating reduced-form models in which behaviour is invariant to policy actions produces misleading policy conclusions. Although FPS has

Intrinsic dynamics arise because adjustment towards long-run desired positions is costly. The costs of adjustment are modelled using a polynomial (up to fourth order) adjustment cost framework (see Tinsley (1993)). In addition to expectational and intrinsic dynamics, the behaviour of both the monetary and fiscal authorities also contributes to the overall dynamic adjustment process.

On the supply side, FPS is a single good model. That single good is differentiated in its use by a system of relative prices. Overlaid on this system of relative prices is an inflation process. While inflation can potentially arise from many sources in the model, it is fundamentally the difference between the economy's supply capacity and the demand for goods and services that determines inflation in domestic goods prices. Further, the relationship between goods markets disequilibrium and inflation is specified to be asymmetric. Excess demand generates more inflationary pressure than an identical amount of excess supply generates deflationary pressure. Although direct exchange rate effects have a small impact on domestic prices and, consequently, on expectations, they primarily enter CPI inflation as price level effects[7].

3.1 Households - determines the desired financial asset stock and consumption flows

There are two types of households in the model: "rule-of-thumb" and "forward-looking". Forward-looking households save, on average, and hold all of the economy's financial assets. Rule-of-thumb households spend all their disposable income each period and hold no assets. The theoretical core of the household sector is the specification of the optimisation problem for forward-looking households. This specification is based on the overlapping generations framework of Yaari (1965), Blanchard (1985), Weil (1989) and Buiter (1989), but in a discrete time form as in Frenkel and Razin (1992) and Black *et al* (1994). In this framework, the forward-looking household chooses a path for consumption – and a path for savings – that maximises the expected present value of lifetime utility subject to a budget constraint and a fixed probability of death. This basic equilibrium structure is overlaid with, polynomial adjustment costs, the influence of monetary policy, an asset disequilibrium term, and an income-cycle effect.

partially addressed the Lucas critique, a more explicit modelling of agents' learning behaviour would be required to fully address it.

[7] The direct exchange rate effect on domestic prices is assumed to arise through competitive pressures. See Conway *et al* (1998) for a description on what occurs under stochastic simulation of FPS when exchange rate movements directly enter inflation expectations.

3.2 The representative firm - determines the stock of capital and investment flows

The formal introduction of a supply side requires us to go beyond the simple endowment economy of the Blanchard *et al* framework. The firm is modelled very simply in FPS, but, as with the characterisation of the consumer, some extensions are made to capture essential features of the economy. Investment and capital formation are modelled from the perspective of a representative firm. This firm acts to maximise profits subject to the usual accumulation constraints. Firms are assumed to be perfectly competitive, with free entry and exit to markets. Firms produce output, pay wages for labour input, and make rental payments for capital input.[8] The production technology is Cobb-Douglas, with constant returns to scale. Given this framework, firms choose the profit maximising level for the capital stock and adjust investment flows so as to achieve it. Profit maximisation is sufficient to determine the level of output, the level of employment, and the real wage. FPS extends this framework in a number of directions as firms face adjustment costs for capital and a time-to-build constraint.

3.3 The government - determines the stock of government debt plus expenditure and revenue flows

Government has the power to collect taxes, raise debt, make transfer payments, and purchase output. As with households and firms, the

[8] We also assume that households own the capital stock.

structure of the model requires clear objectives for government in the long run. However, whereas households' and firms' objectives arise through maximisation, we directly impose fiscal policy choices for debt and expenditure. The government's binding intertemporal budget constraint is used to solve for the labour income tax rate that supports the fiscal choices.

3.4 The foreign sector - holds the excess stock of domestic asses and supporting trade flows

The foreign sector is treated as completely exogenous to the domestic economy. It supplies the domestic economy with imported goods and purchases the domestic economy's exports and thus it completes the demand side of the model. Further, the foreign sector stands ready to purchase assets from or sell assets to domestic households depending on whether households choose to be net debtors or net creditors relative to the rest of the world. Several key prices affecting the domestic economy are also determined in the foreign sector. The foreign dollar prices of traded goods and the risk-free real interest rate are assumed to be determined in the foreign sector.

3.5 The monetary authority - *anchoring the nominal economy*

The monetary authority effectively closes the model by enforcing a nominal anchor. Its behaviour is modelled by a forward-looking reaction function that moves the short-term nominal interest rate in response to projected deviations of inflation from an exogenously specified target rate. Although, the reaction function is *ad hoc* in the sense that it is not the solution to pre defined optimal control problem as in Svennson (1996), its design is not arbitrary. The forward-looking nature of the reaction function respects the lags in the economy between policy actions and their subsequent implications for inflation outcomes.[9] Further, the strength of the policy response to projected deviations in inflation implicitly embodies the notion that the monetary authority is not single-minded in its pursuit of the inflation target. Other factors such as the variability of its instrument and the real economy are also of concern.

[9] Research examining efficient policy rules with FPS presented in Drew and Hunt (1998) has shown that the initially specified forward-looking horizon of 6-, 7- and 8-quarters ahead lies very close to the efficient frontier.

4 Time-varying equilibrium paths

In an economic projection, the FPS core model solution converges to a numerical steady-state characterised by a set of constants.[10] The long run that the economy is believed to be headed towards today is quite different than what we might have expected it to be 15, 10 or even 5 years ago. This reflects the fact that the steady-state or long-run position that the economy is heading towards at any one point in time depends on the structure of institutions and markets prior to that that point, their structure at that point, and how they are expected to evolve beyond that point. New Zealand has, in the last two decades, witnessed significant change in these structures and more is expected to follow in the future. Consequently, using a model that embodies a unique steady state with historical data presents a real challenge. What are required are time-varying steady-state paths that, at each point in time, reflect agents' desired long-run positions given the structure of the economy in the past, the present, and its expected evolution in the future. The process that occurs in the real economy must be a relatively complex learning procedure. However, to capture this, we use a relatively simple methodology for estimating time-varying steady-state paths over the historical and projection periods.

4.1 Proxying a learning mechanism

When changes, like structural reform, occur in the economy, it is often quite difficult for economic agents to completely understand their true nature. This is because permanent and temporary changes

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

will often initially appear to be quite similar. When these changes arise because of shifts in government policy, for example, agents are often uncertain as to the level of commitment to the new policy. Although the initial policy actions might be perfectly consistent with a permanent shift in policy, instances of past policy reversals may discourage agents from interpreting them as permanent. The sheer number of changes that may be occurring at any particular moment further limits agents' ability to understand them perfectly. This uncertainty may encourage agents to only adjust their behaviour slowly in response to changes that, if fully understood and credible, would normally imply much faster adjustment. Agents require time to learn about structural reform and its implications, and to make the required alterations in their behaviour.

One possible characterisation of this learning process would be that agents in the economy use a type of updating rule. They know where the economy has been in the past, they can see current outcomes and structure, and they have information about announced future structural changes. They may also have expectations of future unannounced changes as well. Using this information, agents form a view about the long-run implications. However, because of the degree of uncertainty surrounding their interpretations of the changes and consequently their view of the long run, they only adjust their desired position and behaviour slowly. As they move through time, agents acquire more information about these changes and are able to either, confirm their views and allow their desired values to adjust further towards the long run, or they change their views and adjust their desired positions accordingly.

Ideally one would like to embody any forecasting model of the economy with learning mechanisms that closely replicate the complex processes that occur in the real world. However, given the current state of knowledge, constructing such a model is no small task.[11] Consequently, a procedure is employed that tries to proxy for the type of behaviour that one might expect of agents who are learning about the implications of change as they move through time.

[11] For a discussion on issues related to the modelling of learning mechanisms see Sargent (1993).

The procedure entails estimating time-varying short-run equilibrium paths (SREQs) for all the exogenous series used to calibrate the steady state of the core FPS model. These SREQ paths respect the historical trends contained in the actual series and converge over the projection horizon to their long-run steady-state values. The core model is then simulated using these *exogenous* SREQ paths and the steady-state structure solves for all the *endogenous* SREQ paths. The same constraints that ensure consistency in the long-run end point, ensure consistency across all the SREQ paths over history and the projection horizon.

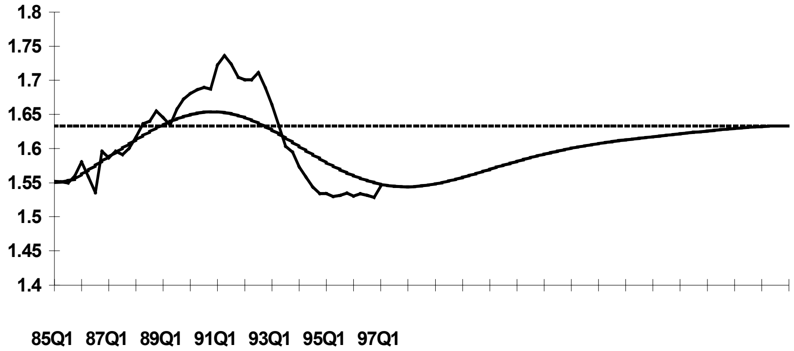
4.2 An illustrative example - the SREQ path for the desired level of the capital stock

To see how a SREQ path is estimated consider Figure 2. Three notions of the capital-to-output ratio are graphed.[12] The solid line is the path for the actual capital-to-output series. The dashed line represents the estimated, time-varying SREQ for its desired level. The dotted line is its long-run value. The long-run value is the solution to the representative firm's profit maximisation problem given its expectations of long-run productivity growth, long-run cost of capital and the long-run labour input. The estimate of the SREQ over history is generated using a variant of the Hodrick-Prescott (1997) filter. The same filter is used to converge this estimate to its long-run value over the projection period.[13]

[12] At the time of writing there is no official capital stock series for New Zealand. The capital stock employed in the FPS core model has been estimated using the perpetual inventory methodology. Details are available from the authors on request.

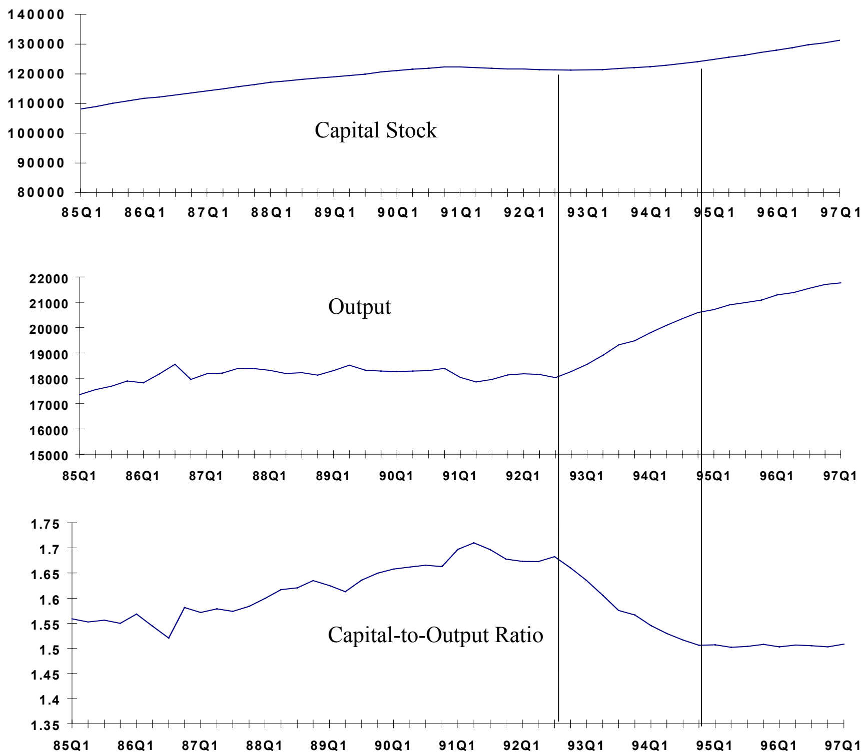
[13] One aspect of the HP filter that has raised concern is that the choice of the smoothness parameter has important implications for the decomposition of time series into trend and cyclical components. It is not clear what value is appropriate for different time series (see for example Harvey and Jaeger (1993), Cogely and Nason (1995) and Guay and St-Amant (1996)). Because this is precisely what the HP filter is being used for here, it is important that the choice of the smoothness parameter is not having a significant impact on the path for monetary conditions coming out of the projection process. To test this, "no-judgement" projection rounds have been compared using values of the smoothness parameter of 160, 800, 1600 (the standard), 3200 and 16,000. These tests confirm that the choice of the smoothness parameter has very little impact on the path for monetary

Figure 2: Capital-to-Output Ratios
Historical (solid), SREQ (dashed), Long Run (dotted)



conditions and virtually no effect at all over the first year and a half of the projection period. The authors will provide the details to the interested reader upon request.

Figure 3: Historical Components of the Capital-to-Output Ratio



It can be argued that the historical estimate of the SREQ for the capital-to-output ratio (the dashed line in Figure 2) is a reasonable proxy for a representative firm's desired path given that it was learning about what are believed to have been the key historical changes. The three graphs in Figure 3 illustrate that the decline in the capital-to-output ratio over the 1992Q3 to 1994Q4 period is largely due to the fact that capital growth did not keep pace with the rapid growth in real output. Structural reform is generally cited as the key factor driving the rapid growth in real output over this period. However, firms may have been uncertain of the impact of the reforms or their permanence, consequently, their desired capital-to-output ratio may have declined over this period. The filter estimate of the SREQ path suggests that firms' desired capital-to-output ratio did decline. This is consistent with firms being reluctant to interpret all of the rapid increase in the level of real output as permanent.

Given reasonable estimates of the long-run cost of capital, productivity growth and labour input, the solution to the firms' profit maximisation problem from the steady-state of the core model suggests that the optimal capital-to-output ratio is above its current value. That long- run value, however, assumes certainty. To take into account uncertainty, the estimate of firms' desired capital-to-output ratio over the projection horizon converges slowly towards that long-run value. This can be interpreted as a reduction in firms' uncertainty about the true long-run implications of restructuring on the return to capital and expected changes in other components of the cost capital as they move forward in time.

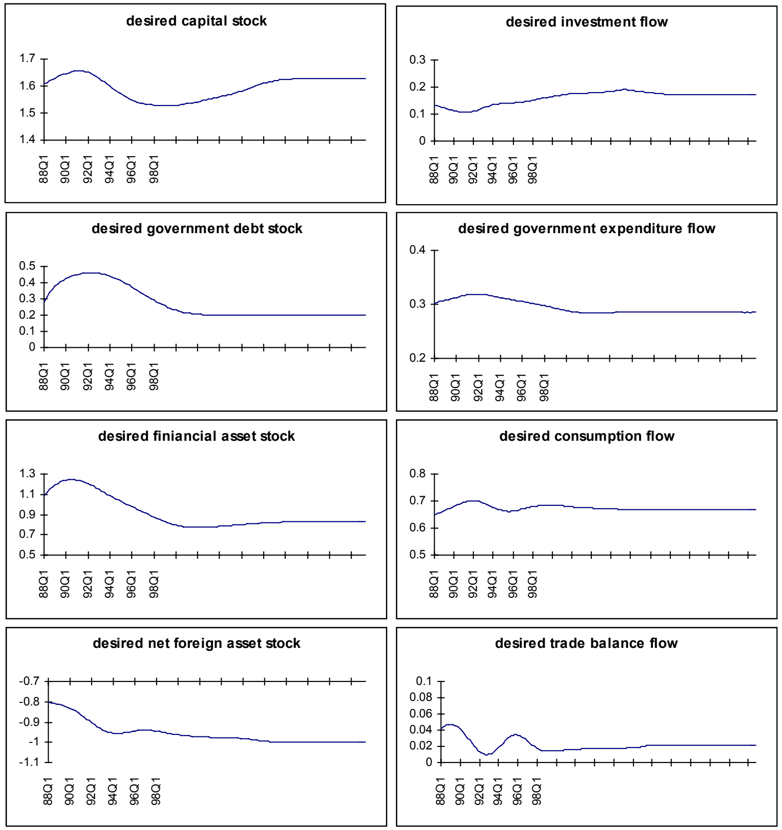
4.3 An overview of the key SREQ paths

The technique outlined above is applied to all the series that are exogenous in the calibration of the core model's steady state, except for potential output, which is estimated using a multivarite filter technique detailed in Conway and Hunt (1997). The steady-state story, outlined in Section 3, 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 4. 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. Together, the first two graphs in the left-hand column contain the

desired path for the stock of domestic assets. Subtracting the desired path for the holding of financial assets by domestic households contained in the third graph leads to the path for the desired stock of net foreign assets contained in the fourth graph. One interesting point is that although the desired path for domestic households' holdings of financial assets declines over the recent historical period, households were able to maintain a desired consumption share of output that is relatively stable. This reflects the fact that consumption occurs out of total wealth and the increase in human wealth arising from restructuring was more than sufficient to offset the decline in the holding of financial wealth as a share of output.

Figure 4: Desired asset stocks and expenditure flows relative to output



5 The forecasting process

The FPS projection process can be broken into five key steps.

- Forecasting the “monitoring quarters” to establish the starting point for the model projection.

- Forecasting the paths for the exogenous variables used in the model.

- Producing a “no-judgement” or naive round using the core model.

- Applying informed judgements to the model to build up the central scenario.

- Examining key risks and the implications of key assumptions embodied in the central scenario.

5.1 Forecasting the “monitoring quarters”

The “monitoring quarters” are defined to be the first two quarters beyond the most recently available historical Statistics New Zealand data for GDP. In terms of using the core model, these quarters are treated as if they are historical out-turns. As previously discussed, the dynamics of the core model were not calibrated to capture the very short-term properties of the data. Consequently, time-series based *indicator* models provide the main input into the forecast of the monitoring quarters. The forecasts from these models are augmented with the informed judgements of sectoral specialists based on other short-term forecasting tools and the feedback obtained from Business Information Contacts (BICs).

Typically, indicator models are used in the first instance to forecast the monitoring quarters. For example, SNA real private consumption is forecast using historical consumption, retail sales (ex automotives), house prices and credit card billings.[14] These model forecasts are examined by the sectoral expert and adjusted if necessary, given qualitative information garnered from meetings that the sectoral analysts have with businesses throughout New Zealand (BICs) each quarter.

5.2 Forecasting exogenous variables

The second step in the projection process is to forecast the paths for variables that are exogenous in the core FPS model. This set can be

[14] A forthcoming research paper will contain a full account of the indicator models used by the RBNZ.

split into domestic and foreign variables. Tracks for foreign variables such as import and export prices, world inflation, interest rates and output growth are derived primarily from consensus forecasts from international organisations. In terms of domestic variables, many of the key fiscal assumptions, such as tax rates and fiscal transfers and expenditure are treated as exogenous over the medium term and are taken directly from The Treasury's forecasts. The forecasts of the exogenous time-varying equilibrium paths, save that for domestic productivity growth, are determined as outlined in Section 4. Consistent with the treatment of monitoring data in the core model, the technique for estimating these SREQs paths treats the monitoring quarters as if they contain historical outturns. The forecast path for domestic productivity is based on an estimated model of productivity convergence outlined in Conway and Hunt (1998).

5.3 Generating the "no-judgement" projection

The initial projection round that the FPS core model is used to generate is called the "no-judgement" round. There are two steps involved in generating the "no-judgement" round. The first step is to solve for the component of the data that the model cannot explain over the historical period and the monitoring quarters. The second step is to simulate the model over the projection horizon, decaying the unexplained component based on its average historical persistence. The term "no judgement round" comes then from the fact that the models unexplained components are run-off in a very naïve and mechanical fashion.

5.3.1 Solving for the unexplained component

Once forecasts for the monitoring quarters are complete and all exogenous paths determined, the core model is used for the first time. A feature of the software used to simulate the model is that the user can define what is treated as exogenous in a relationship and what is treated as endogenous when solving the model.[15] This feature allows the model to be simulated over the historical period and the monitoring quarters to solve for the component of the out-turns that the model structure itself cannot explain. Essentially the model is inverted on its key behavioural equations and the out-turns are treated as exogenous. Then the simulator solves for the unexplained component that is required to get the model to replicate the actual out-turns.

5.3.2 Naively running off the unexplained component in the last monitoring quarter

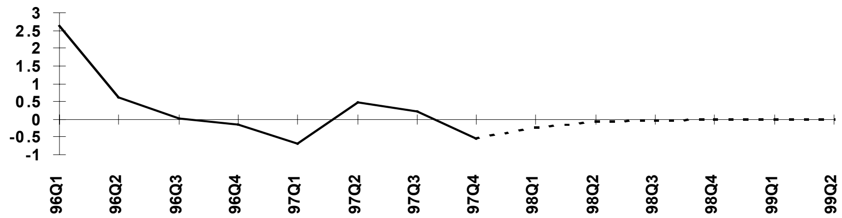
In general, the unexplained component will not be a pure white-noise process; it will exhibit some persistence. This is not seen as a weakness of the model as it has been calibrated to capture the medium- to longer-run dynamics in the data. Consequently, one should expect to see more persistence in the unexplained component than in a white-noise process typical of purely econometrically estimated models.

The persistence in the unexplained component can be used as information to augment the structure of the core model when using it to generate economic projections. In this way, the short-run properties of the data are able to influence the projection, and hence the path of monetary conditions, without making them permanent properties of the core model. To see an example of how this is done consider Figure 5, in which the unexplained component on the core model's consumption equation (as a percentage of the level of consumption) contained in the December 1997 projection is graphed. The solid part of the line denotes the historical values and the first

[15] The FPS core model is simulated using TROLL.

two monitoring quarters. The dashed part of the line denotes its path over the projection horizon. The last observation that is denoted by the solid line is called the 'starting point shock' for the model-based projection. This starting point shock is run-off or decayed over the projection horizon according to its average historical persistence since 1990.

Figure 5: Unexplained component of consumption Historical and monitoring (solid) Projection horizon (dashed)



Projection period paths for all of the unexplained components that exhibit persistence are calculated using this technique. These paths, along with the paths for foreign and domestic exogenous variables are used by the core model to generate a no-judgement projection profile for the key macroeconomic variables. This no-judgement round becomes the basis for sector analysts to evaluate the starting-point shocks implicit in their forecasts for the last monitoring quarter.

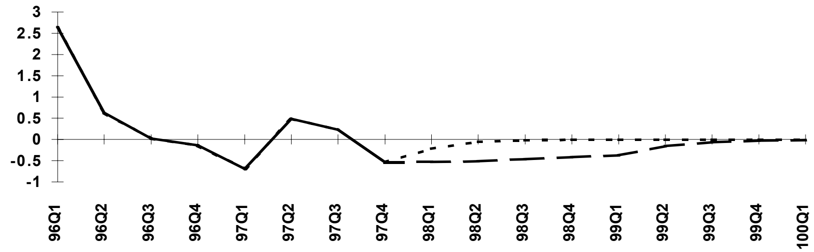
5.4 Building up the central scenario

The first step is to decide if the starting-point shock is a "typical" historical shock or not. If so, then it should be decayed according to its average historical persistence. If not, then the factors explaining why it is "atypical" should suggest how it should be decayed over the projection horizon. In other words, only atypical staring-point shocks have judgements applied to change how quickly they decay over the projection horizon.

In Figure 6, an example of applying judgement to an unexplained component of the model is presented. More persistence than the historical behaviour would suggest has been given to the starting-point shock on the consumption equation. This judgement decreases consumption relative to the no-judgement round, hence decreasing aggregate demand and easing overall projected monetary conditions. This judgement was applied to reflect negative wealth effects arising from the sharp fall in equity markets across the world, and domestic weakness in the housing market, at the time of the December 1997 projection.[16]

[16] In the FPS model agents have only three asset stocks: government bonds, net foreign assets and physical capital. For reasons of simplicity, the housing stock is not included and there are no 'wealth effect channels' arising from re-valuations of the capital stock. However, as this example illustrates, it is possible to proxy wealth effects via the unexplained component of consumption.

Figure 6: Residual on Consumption Historical and monitoring (solid) no judgement path (dotted) judgement path (dashed)



As the FPS core model is a general-equilibrium model, the judgement of one sectoral expert will affect the system as a whole. Judgements seen as plausible in one sector may have unanticipated effects in other sectors that render an implausible, or less likely, general equilibrium story. In this sense the system then imposes 'judgement accounting' on the sector analyst. Through a process of iteration, judgements are altered until there is a consensus view on the aggregate picture and all judgements are well motivated. This is the "central scenario" projection that forms the basis of the Bank's published assessment of the economy appearing each quarter in the *Monetary Policy Statements.*

5.5 Generating alternative scenarios

During the process of building the central scenario, assumptions are required. For those assumptions seen as the most uncertain or 'soft', alternative scenarios can be generated with the core model examining their implications. An alternative scenario adjusts one assumption made in the central scenario, leaving the rest of the assumptions unchanged. This allows staff at the Bank to quantitatively assess the impact on monetary conditions of the soft assumptions. The alternative scenarios form the basis for discussion of the risks on the Bank's assessment of the economy, as published in the *Monetary Policy Statements*.

Example: Alternative exchange rate pass-through

A risk in forecasting inflation arises from the uncertainty about the speed and magnitude of the pass-through of exchange rate movements into domestic prices. In the central projection for September 1997, the nominal exchange rate was projected to begin about 4 percent weaker than in the June 1997 forecast round. This depreciation in the nominal exchange rate followed an appreciation in the nominal exchange rate of approximately 17% from mid 1994 to June 1997. A key assumption made in the September projection was that:

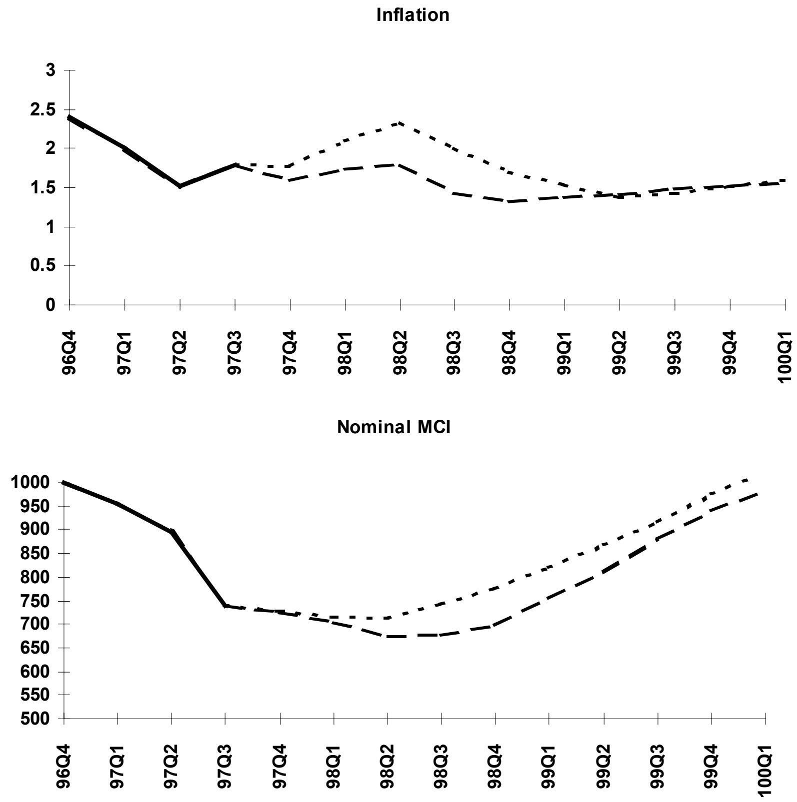
> "…much of the import price margin built up as the exchange rate appreciated will be unwound with the recent depreciation in the exchange rate. This means prices will increase by less than normal for a given depreciation". *Economic Projections*, September 1997, page 24.

As margins were at historically high levels, a more pessimistic view than the central projection was that margins would remain high and all the depreciation would be passed through directly to domestic prices. To examine what the implications of this would be, an alternative scenario was prepared.[17] Relative to the central scenario, maintaining import profit margins at their historically high level implied an increase in the New Zealand dollar price of imports. In the core model, imported consumption price inflation is transmitted, with a lag, into CPI inflation. Furthermore, in the core model economy a substitution occurs away from imported goods to domestic goods whenever the price of imported goods increases relative to the price of domestically produced substitutes. This leads to an increase in domestic demand, stimulating inflation in domestically produced goods as demand pressures increase in the domestic goods market. The combined impact of these inflationary pressures are seen in Figure 7. The increase in inflation results in

[17] Our thanks to Enzo Cassino for providing these simulation results.

nominal monetary conditions tightening by roughly 50 points over the near term, and real monetary conditions that are 50 basis points tighter beyond 1998.

Figure 7: Annual CPI inflation and nominal monetary conditions
Historical and monitoring (solid) central projection (dashed) alternative (dotted)



Quantitative information of the sort presented in the example above allows the policy maker to fully understand the implications of the key assumptions underlying the central scenario. This has led to more informed discussion at the decision making level, and further provides the Bank with an indication of what sort of policy response may be required should the data turn out to be more indicative of an alternative scenario.

5.6 Quantifying uncertainty arising from unforeseen shocks

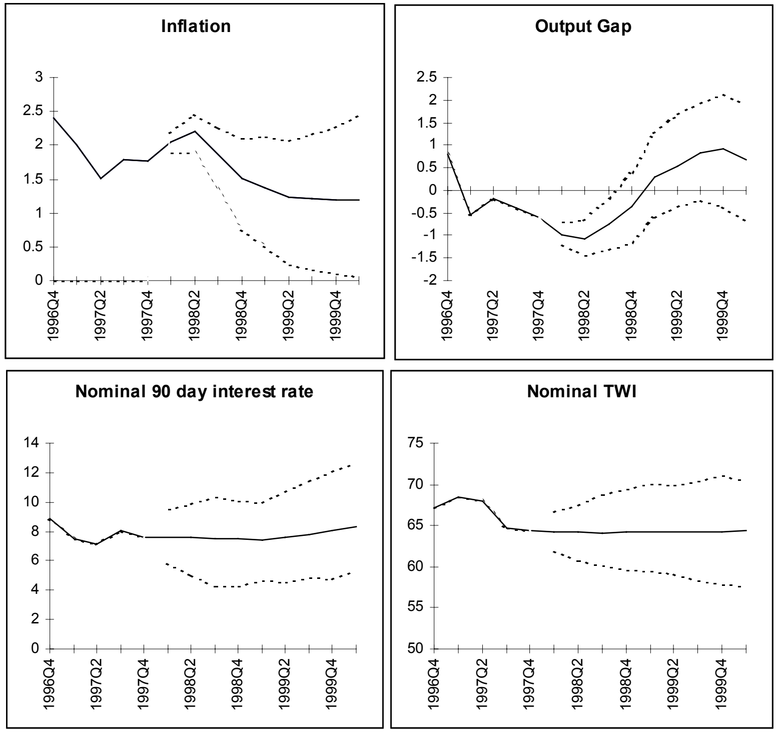
Even after generating alternative scenarios there is still considerable uncertainty surrounding the projected path of the economy. A major source of this uncertainty arises from unforeseen events that the analysis cannot explicitly factor in *ex ante*. We call this form of uncertainty shock uncertainty. Using a technique termed 'stochastic simulations' we are able to quantify the implications that the typical level of shock uncertainty might be expected to have on the projected paths for key macroeconomic variables.

Stochastic simulations involve subjecting the projected path of the economy to quarter by quarter shocks that are representative of disturbances that New Zealand has faced in the past (see Drew and Hunt (1998) for more detail on the technique employed for performing stochastic simulations).[18] Due to data limitations, the disturbances considered are temporary only. This results in alternative paths for the macroeconomic variables of interest. The exercise is repeated 100 times to produce 100 alternative paths. These can be thought of as 100 alternative projections. The central scenario is considered to be the most probable or mean outcome, for the economy. The 100 alternative paths produced allow us to calculate standard deviations for key variables in the projection, and hence produce confidence bands about the central scenario.

[18] These disturbances are shocks to: world output, the terms of trade, the price level, the real exchange rate, and domestic demand. The persistence of the shocks, and the degree to which the shocks effect other key macroeconomic variables, are determined using an estimated VAR model. As FPS is a calibrated model, it is not sensible to use historical residuals to pin down disturbances for use in stochastic simulations of FPS. Instead, a VAR model is used for this purpose. The chief advantage of using the VAR is that the historical auto-correlations and cross-correlations in the macroeconomic data considered are accounted for.

In the figure below, 95 per cent confidence bands around key macroeconomic variables for the December 1997 projection are presented. At the 95 per cent level of confidence, there appeared to be little risk that inflation would breach the 0-3 per cent target band. However, given a different starting point, it is possible that the confidence bands could imply that a significant risk exists that inflation could breach the target band over the policy horizon. Such information could lead to a change in the desired policy stance to mitigate that risk.

Figure: 95 % confidence bands around the December 1997 projection



A point of interest is to compare what the confidence bands were around the interest and exchange rates to where we are today. At the time of writing in October 1998, the actual TWI was around 56 and the nominal interest rate was around 5.5 percent. Comparing these outcomes to the bands about the December 1997 projection indicates that for 1998q3, the interest rate is within the band whilst the TWI is not. This reflects the fact that the New Zealand dollar has been subjected to very large shocks that can be regarded as historically unusual. Furthermore, it is also the case that the bands presented above almost certainly understate the 'true' level of economic uncertainty. If model uncertainty, starting point uncertainty and permanent shocks were also considered then the confidence bands about the central projection path would most likely change. Incorporating these additional dimensions of uncertainty is on our current research agenda.[19]

To recap, the first step in the projection process is to forecast monitoring data using the *indicator* models. The next step is to generate the projection paths for exogenous series: foreign, domestic and SREQs. With this data, the unexplained components are solved for and the no-judgement round is generated using the *core* model. Sectoral analysts examine this round in the process of determining whether the starting-point shocks are typical or not. Judgements, where required, are applied and the central scenario is gradually built up. During this phase, *satellite* models are used to aid sectoral analysts in their assessments of the plausibility of the central scenario at a more disaggregated level. Generating alternative scenarios highlight the implications of what are felt to be the key risks in the central scenario. Finally, stochastic simulations about the central scenario provide an indication of the implications of shock uncertainty.

[19] Another source of uncertainty is model uncertainty which arises from not perfectly knowing the way macro relationships work in the real world. To account for model uncertainty, different specifications of the models' structure are considered. See Conway *et al.* (1998) for a discussion of this in the context of how uncertainty about the way exchange rate movements affect inflation.

6 Summary

This paper detailed how the Reserve Bank of New Zealand uses the *Forecasting and Policy System* (FPS) to prepares economic projections. This system provides Bank staff with a sound theoretical economic framework within which to prepare these projections. By using *indicator* models to provide conditioning information for the short-run, and SREQ paths to characterise the underlying equilibrium of the economy, the *core* model is robust to changes in the short-run properties of the economy and the evolution of its underlying structure. The FPS allows for a complete accounting of all the assumptions and judgements embodied in the projection as well as a means to quickly assess alternative views and soft assumptions. Further, the system can be used to quantify the implications of shock uncertainty.

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.

Black, R, D Laxton, D Rose and R Tetlow (1994), "The Steady-State Model: SSQPM", Part 1 of *The Bank of Canada's New Quarterly Projection Model*, Bank of Canada Technical Report No. 72.

Blanchard, O J (1985), "Debt, deficits and finite lives", *Journal of Political Economy*, 93: 223–47.

Breece, J and V Cassino (1998), "The Forecasting and Policy System: demand-side satellite models" Discussion Paper G98/3, Reserve Bank of New Zealand, Wellington, New Zealand.

Buiter, W H (1988), "Death, birth, productivity growth and debt neutrality", *The Economic Journal* 98, 279-93.

Cogely, T and J Nason (1995), "Effects of the Hodrick-Prescott Filter on Trend and Difference Stationary Time Series: Implications for Business-Cycle Research." *Journal of Economic Dynamics and Control* 19: 253-78.

Conway, P and B Hunt (1997), 'Estimating Potential Output: a semi-structural approach' Discussion Paper G97/9, Reserve Bank of New Zealand, Wellington, New Zealand.

Conway, P. and B. Hunt (1998), 'Productivity growth in New Zealand: economic reform and the convergence hypothesis' Discussion Paper G98/7, Reserve Bank of New Zealand, Wellington, New Zealand.

Conway, P, Drew, A, Hunt B, and Scott, A (1998), 'Exchange rate effects and inflation targeting in a small open economy: a

stochastic analysis using FPS', *Topics in Monetary Policy Modelling,* BIS Conference Papers, Vol.6.

Drew, A, and B Hunt (1998) 'The Forecasting and Policy System: stochastic simulations of the core model' Discussion Paper G98/?, Reserve Bank of New Zealand, Wellington, New Zealand.

Drew, A, and B Hunt, Scott, A, (1998) "Efficient Simple Policy Rules and the Implications of Uncertainty about Potential Output", paper presented to the RBNZ Conference on Policy and Uncertainty, June 1998.

Frenkel, J A and A Razin (1992), *Fiscal Policies and the World Economy* Cambridge: MIT Press.

Guay A and P St-Amant (1996), "Do the Hodrick-Prescott and Baxter-King Filters Provide a Good Approximation of Business Cycles?", *Bank of Canada Technical Report* No 78, Bank of Canada, Ottawa.

Havey, A and A Jaeger (1993), "Detrending, Stylized Facts and the Business Cycle." *Journal of Applied Econometrics* 8: 231-47.

Hodrick, R, and Prescott, E (1997), "Post-War U.S Business Cycles: An empirical investigation", *Journal of Money Credit and Banking*, Vol. 29, no. 1.

Lucas, R E Jr (1976), "Econometric policy evaluation: a critique", in K. Brunner and A. Meltzer [eds.], *The Phillips Curve and Labour Markets*, Carnegie-Rochester Conference Series on Public Policy, Vol. 1, Amsterdam: North-Holland.

Reserve Bank of New Zealand (1997) *Monetary Policy Statement*, June 1997

Reserve Bank of New Zealand (1997) *Economic Projections*, June 1997

Sargent, T (1993), Bounded Rationality in Macroeconomics (Oxford: Clarendon).

Svensson, L E O (1996), "Inflation forecast targeting: implementing and monitoring inflation targets," Institute for International Economic Studies *Seminar Paper* No. 615, Stockholm.

Tinsley, P A (1993), "Fitting both data and theories: polynomial adjustment costs and error-correction decision rules," Unpublished paper. Division of Statistics and Research, Board of Governors of the Federal Reserve System, Washington.

Weil, P (1989), "Overlapping Families of Infinitely-Lived Agents," *Journal of Public Economics* 38, 183-98.

Yaari, M E (1965), "Uncertain lifetimes, life insurance, and the theory of the consumer", *The Review of Economic Studies* 32, 137-50.