Modelling for monetary policy: the New Zealand experience

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This article is an edited version of a paper written for the Centre of Central Banking Studies' Chief Economists Workshop in London in May 2006. The article reviews the evolution of modelling at the Reserve Bank of New Zealand from the 1970s to today, focusing on the changing role of inflation expectations. It discusses the impact of theoretical developments on the evolving approach to monetary policy and the models that have been built to support policy. The article highlights the important impact that the Lucas critique has had on both monetary policy, and the Bank's approach to modelling.

1   Introduction

The concept of 'rational expectations' (RE) and its relevance for macroeconomics gathered momentum in the mid-1970s with the contributions of Robert E. Lucas Jr. In particular, Lucas' critique of macro-econometric modelling and its use in discretionary demand management (Lucas 1976) had a gradual but pervasive influence on monetary policy and modelling worldwide. New Zealand was no exception. The Lucas critique argued that the parameters of the large macroeconometric models of the 1960s and 1970s depended implicitly on the expectations of economic agents regarding future policy. If agents were assumed to be rational, then the parameters of these models were likely to change as policymakers changed their behaviour. This critique effectively undermined the use of macroeconometric models for policy simulation work, and indeed for forecasting in situations where the approach to policy – the reaction function – was changing through times.

The insight of Lucas had a major impact on how policy-makers thought about policy, and on how researchers built their models. This was reflected in the rules versus discretion debate in monetary policy, (Kydland and Prescott 1977), in the development of rational expectations econometrics (eg Sargent 1973, Barro 1977, McCallum 1983) and in the construction of models with forward looking agents.

This article reviews the development of modelling for monetary policy in New Zealand from the pre-RE period of the early 1970s through to today. It looks at the impact of broad theoretical developments through this period on both the evolving approach to policy and the models used to support that policy. The discussion is structured around four periods:

i)   Seeking control: pre-1985

ii)   The search for anchors: 1985 —1990

iii)   Inflation targeting: 1990 — 2002

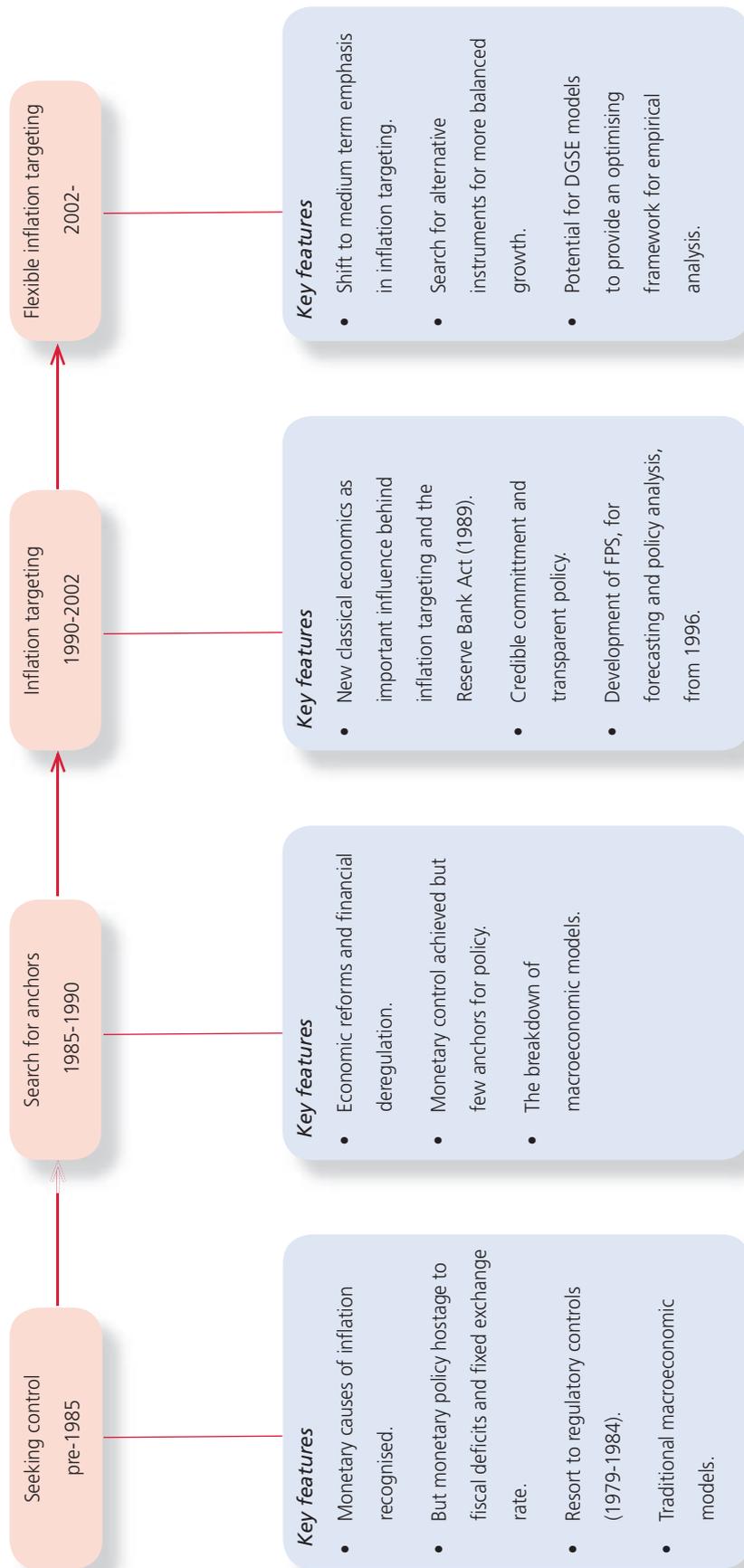iv)   Flexible inflation targeting: 2002 — 2006

2   Seeking control: pre 1985

In the 1960s and the early 1970s, the Phillips Curve (Phillips, 1958) was at the centre of the Keynesian macroeconomic consensus among policy-makers. This seemingly stable relationship between wage inflation and unemployment suggested that government policymakers could permanently lower the unemployment rate through expansionary monetary and fiscal policies, provided they were willing to accept an increase in nominal wage inflation. A widespread attempt to exploit this relationship in the 1960s contributed to the global inflation of the late 1960s and early 1970s.

By the late 1960s, the emphasis in theoretical macroeconomics was shifting from Keynesian principles to monetarism. Monetarists asserted that emerging inflation problems were a result of excessive rates of growth in the money and credit supply. Phelps (1967) and Friedman (1968) brought into question the policy trade-off that had been inferred from the empirically observed Phillips curve. They argued that monetary and fiscal expansions could not affect real variables in a sustained way and, in particular, could not bring about

Figure 1
Monetary policy phases since the 1970s

Seeking control pre-1985	Search for anchors 1985-1990	Inflation targeting 1990-2002	Flexible inflation targeting 2002-
Key features	*Key features*	*Key features*	*Key features*
• Monetary causes of inflation recognised.	• Economic reforms and financial deregulation.	• New classical economics as important influence behind inflation targeting and the Reserve Bank Act (1989).	• Shift to medium term emphasis in inflation targeting.
• But monetary policy hostage to fiscal deficits and fixed exchange rate.	• Monetary control achieved but few anchors for policy.	• Credible committment and transparent policy.	• Search for alternative instruments for more balanced growth.
• Resort to regulatory controls (1979-1984).	• The breakdown of macroeconomic models.	• Development of FPS, for forecasting and policy analysis, from 1996.	• Potential for DGSE models to provide an optimising framework for empirical analysis.
• Traditional macroeconomic models.			

a sustained deviation of unemployment from its 'natural' rate. Phelps and Friedman also postulated that monetary policy could affect real economic activity only if inflation was increased above existing inflation expectations. The natural rate theory and the importance of inflation expectations became key concepts conditioning discretionary monetary policy in New Zealand and elsewhere in the 1970s.

Economic theory developed in North America and Europe for a closed economy model is not always fully relevant for a small open economy such as New Zealand. This was particularly true for New Zealand in the pre-1985 period where a fixed exchange rate regime effectively linked domestic monetary policy to international monetary policy developments. The monetary approach to the balance of payments was a useful theoretical model in this regard, pointing to the influence of monetary policy on the balance of payments as well as inflation (see, for example, Spencer 1977).

In the 1970s, the Bank was acutely aware of its responsibility to counter the uptrend in inflation, but it was also aware that monetary policy was hostage to the sustained fiscal deficits of the time and the fixed exchange rate. The main policy challenges related to the development of financial markets and instruments, which would allow the fiscal deficits to be funded in the private sector, and the removal of arbitrary financial regulations such as credit and interest controls, reserve ratios etc. The Bank's aim and preoccupation was to establish effective control over monetary conditions.

During this period, the Bank seriously considered various money and credit aggregates as potential intermediate targets for monetary policy. However, the Bank recognised significant difficulties in the controllability of particular monetary aggregates and the lack of a sufficiently stable relationship between the monetary aggregates and inflation. The official monetary targets instituted in many countries were never established in New Zealand.

The first of the Bank's macroeconomic models was built in 1971 (Deane 1971). It was based on a Keynesian income-expenditure structure, with wages determined by a simple Phillips curve and a cost plus price equation. By the late 1970s, the model incorporated a simple expectations augmented Phillips Curve (eg, Model VIII, Spencer, Smith and Joseph 1979):

$$w_t = \alpha_0 + \alpha_1(u_t - u_t^*) + \alpha_2 p_t^e + \alpha_3 w_{t-1}$$

Prices were then determined by a series of cost-plus equations for components of CPI, each of the form:

$$p_t = \beta_0 p_{t-1} + \beta_1(w_t / a_t) + \beta_2 pi_t$$

where u is the unemployment rate, $u*$ is the natural rate of unemployment, w is the log of wages, p is the log of the price level, pi is the log of import prices, a is the log of productivity. Price expectations are assumed to adapt via a first order adjustment process to the actual price level.

The main challenges for modellers at the Bank during this time were:

- to find ways of handling the supply side shocks of the 1970s in what was essentially a demand driven model;

- to model the monetary transmission mechanism, and in particular find a structural role for the money and credit aggregates; and

- to ensure models had sensible long run properties, through the use of Cointegration and Error Correction structures.

While the Bank acknowledged the potential force of the Lucas critique, the techniques were not yet available to incorporate truly forward-looking expectations. Spencer and Duggan (1984) made an attempt to incorporate "quasi rational expectations" into the Bank's "core model" by linking price inflation directly to money supply growth and import price inflation. They sought to assess how the short term inflation output trade-off might deteriorate in a situation where forward-looking expectations played a more dominant role in short-term production and pricing decisions

In broad terms, the Bank's macroeconomic models were ill equipped to deal with the emerging policy issues of the 1970s. They were essentially Keynesian structures which were not easily adapted to the supply shocks, monetarism and rational expectations of the 1970s.

3 The search for anchors: 1985—1990

In the late 1980's, the theoretical debate in macroeconomics was dominated by the new classical economics (Lucas 1973, Sargent and Wallace 1975) as well as hysteresis and the costs of disinflation (Fischer 1977, Taylor 1983, Blanchard and Summers 1986). Rational expectations and time consistency issues were very much in the New Zealand policy-makers' minds as they applied monetary policy solely to the purpose of reducing inflation to low single digits. However, the policy framework was new; the store of policy credibility was minimal; and the real effects of the tight policy stance through this period were significant.

Broader policy developments at this time were dominated by the widespread economic reforms and financial deregulation of the new Labour Government and Minister of Finance, Roger Douglas.[2] In assigning the Bank and monetary policy to the task of securing low inflation, the Minister was primarily concerned with institutional accountability within the context of the principal-agent problem.[3] However, the advice from the Bank and The Treasury supporting this approach was also influenced by the New Classical and Time Consistency literature.

Following the move to market-determined interest rates and the floating of the exchange rate in March 1985, the Reserve Bank gained greater control over monetary conditions. But the widespread economic and financial reforms also led to a period of considerable structural change and volatility in asset markets. For monetary policy, there were no stable anchors or guidelines that could be relied on. Inflation expectations were high and variable, making it difficult to assess the true level of real interest rates. The exchange rate and the slope of the yield curve became the main guides for monetary policy. The Bank adopted a narrow money base concept (Primary Liquidity) as its operating target. The hope was that a stable relationship would develop between this quantity and the broader money and credit aggregates. In the event, such a relationship never eventuated.

From the late 1980s onwards, the Bank's modelling efforts (Model 12 in the early 1990s) focussed on improving the data and introducing new econometric techniques. Internationally, there was a rapidly burgeoning literature on co-integration methodology for estimating the equilibrium relationship between trending variables. Ultimately, however, the results were disappointing for New Zealand, due in part to the lack of stable data series through this period.

Modelling in general became very difficult in the changing economic and policy environment of the late 1980s. The macroeconometric models became highly unstable and ceased to be used at the Bank for either forecasting or policy analysis. Forecasters reverted to spreadsheets and partial sector-based equations. Policy-makers relied on rules of thumb and intuition. New structural modelling efforts were stymied by a lack of data generated under the new policy regime. However, there were some useful developments in reduced form Vector Autoregression (VAR) modelling (Wells and Evans 1985), which were non-prescriptive regarding restrictions on structural parameters.

4 Inflation targeting: 1990 —2002

Theoretical developments in macroeconomics in the 1990s began to re-establish a framework for the legitimate use of a systematic monetary policy. The development of New Classical economics and Real Business Cycle (RBC) theory in the 1980s, had shifted the emphasis away from demand management back to the supply side and the role of technology shocks in generating business cycles. In this framework, based on optimising agents with perfect foresight, there was no substantive role for monetary policy. In the late 1980s and the 1990s, however, a New Keynesian literature developed which provided micro-foundations for the nominal rigidities that existed in traditional economic models, and which provided a basis for an active monetary policy.[4]

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2   See Evans *et al* (1996), and Bollard, Lattimore and Silverstone (1996) for a discussion of the reforms at this time.
3   See Scott and Gorringe (1989) for a discussion in the context of the New Zealand reforms.

4   The most influential papers can be found in Mankiw and Romer (1995).

A further important area of development in the 1990s was the emerging literature on policy rules, based on the work of Taylor (1993). This literature was particularly relevant for monetary policy, and the search by central banks for policy rules that would best achieve price stability in a given economic environment and under varying degrees of uncertainty.

Monetary policy in New Zealand made considerable advances during this period. The Inflation Targeting framework contained in the new Reserve Bank Act (1989) was founded on the earlier rational expectations and time consistency literature, as well as principle-agent theory and the growing literature on central bank independence. Key elements of the framework include: a clear price stability objective for monetary policy; a credible commitment on the part of the Bank and monetary policy to achieving the objective; and the transparent application of monetary policy in pursuing the objective. The credible commitment is underpinned by a signed Policy Targets Agreement (PTA) between the Minister and the Governor of the Bank who is the sole monetary policy decision maker. Transparency is supported by the publication of regular Monetary Policy Statements and detailed economic forecasts.

By late 1991, the Bank had succeeded in reducing inflation to the then 0 - 2 per cent target range. The challenge was to stay within the target range as the economy recovered from the early 1990s recession. To inform policy decisions and to generate regular detailed forecasts, a new macroeconomic model was required to support the new Inflation Targeting regime. For this purpose, the Forecasting and Policy System (FPS) was developed in the mid 1990's. The FPS, based on the Bank of Canada's Quarterly Projections Model (QPM), and still in use today, has a number of key characteristics:

- Calibrated parameters, given the lack of stable econometric estimates;

- Keynesian responses to shocks in the short term with optimising General Equilibrium responses in the long term;

- The model converges to well defined steady state values;

- A policy reaction function for short term interest rates – as a function of inflation six to eight quarters ahead; and

- A Phillips Curve based on the output gap with price expectations that are both backward and forward looking.

The Phillips curve within FPS determines non-traded price inflation while traded goods inflation is determined as a cost-plus function of import prices, export prices and the exchange rate. Consumer price inflation is thus a function of the exchange rate and cost pressures as well as inflation expectations and the output gap.

The Phillips Curve in FPS can be characterised as:

$$\pi_t^{NT} = \pi_t^e + \beta_1(y_t - y_t^*) + \beta_2(y_{t-1} - y_{t-1}^*) + \beta_3(y_t - y_t^*)^+$$

where π is inflation, π^e is expected inflation, y is observed output, y^* is potential output and $(y-y^*)^+$ denotes the output gap with negative values set to zero (thus generating an upward asymmetry in inflation responses). Inflation expectations are determined as:

$$\pi^e = \lambda \pi_{t-1}^e + \frac{\delta}{6} \sum_{j=-5}^{1} \pi_{t+j} + \frac{\gamma}{11} \sum_{j=2}^{12} \pi_{t+j}$$

ie, inflation expectations depend on both past price increases and future inflation outcomes. This formulation assumes a hybrid mixture of backward and forward looking economic agents. The forward-looking element ensures that policies inconsistent with the inflation target are punished fairly quickly. The backward-looking element ensures that inflation retains a degree of momentum, as observed empirically.

5 Flexible inflation targeting: 2002 –2006

During the initial inflation targeting period there was a deliberately strict interpretation of the inflation target band and the need to be within it at all times. This was part of the process of building a track record for the Bank in support of its credible commitment to price stability. From the late

1990s through to 2002, however, there was a gradual shift to a more flexible form of inflation targeting. In 1996 the inflation target was widened from 0-2 percent to 0-3 percent. In 1999 a new section (now 4b) was introduced to the PTA requiring the Bank to "avoid any unnecessary volatility in output, interest rates and the exchange rate." The current PTA, introduced in 2002, further modified the price stability objective, requiring the Bank to maintain CPI inflation within the 1-3 percent target band "on average over the medium term". The intention under this less strict approach to inflation targeting is to maintain the Bank's credible commitment to price stability, while giving policy a little more latitude to influence secondary objectives related to balanced growth in the real economy. In practice, however, this more flexible approach has not avoided continued large cycles in the real exchange rate and traded sector activity.

Macro theoretical developments this decade have continued to focus on New Keynesian extensions to the earlier micro-founded RBC models, combining the key elements of forward looking optimising behaviour and tractable nominal rigidities, providing a basis for the application of systematic monetary policy. These models, under the generic heading of Dynamic Stochastic General Equilibrium (DSGE) models, have come to represent a new neoclassical synthesis, (eg Rotemberg and Woodford 1997, Chari, Kehoe and McGrattan 2002, Smets and Wouters 2003, 2004). The simple earlier DSGE models have been extended in sufficient detail to facilitate empirical policy and forecasting applications. The reduced form structure of DSGEs is comparable to traditional IS/LM models. They typically have a forward-looking IS equation, a New Keynesian Phillips Curve, and a policy rule. Unlike the traditional reduced form models, however, the reduced form coefficients of DSGEs have a structural interpretation as functions of deep behavioural parameters.

A number of central banks have started to utilise DSGE models in recent years, including; Bank of Canada, Federal Reserve Board, European Central Bank, Norges Bank; Riksbank, Czech National Bank, and Bank of Chile. These models are being used for strategic policy analysis, and in some cases forecasting. Some of the advantages of DSGE models are seen in:

- The ability to bring micro-studies to bear on the size of structural parameters, thus facilitating calibration and/or Bayesian estimation;

- the ability to provide a rich narrative alongside the numerical forecasts;

- the use of cross equation structural restrictions to identify the nature of shocks;

- the assumption of forward looking optimising agents and hence the robustness of policy analysis to the Lucas critique; and

- the ability to incorporate uncertainty in a formal manner (eg through the use of fan charts).

At the Bank we have also begun to develop DSGE models. We see this as an opportunity to broaden the Bank's modelling strategy, while at the same time facilitating our research effort. However, the usefulness of these models is yet to be fully tested, especially in forecasting. We are currently commencing a DSGE model development program and will take some time to assess the DSGE structures before making any decision to replace the current FPS model as the core policy and forecasting framework.

Focusing again on the determinants of inflation and inflation expectations, one of the small DSGE models developed at the Bank (Liu 2005) incorporates the following (New Keynesian) inflation process:

Domestic inflation:

$$\pi_{H,t} = \beta(1-\theta_H)E_t\pi_{H,t+1} + \theta_H\pi_{H,t-1} + \lambda_H MC_t$$

Imported inflation:

$$\pi_{F,t} = \beta(1-\theta_F)E_t\pi_{F,t+1} + \theta_F\pi_{F,t-1} + \lambda_F e_t$$

Aggregate CPI inflation is then a weighted average of the domestic and imported components:

$$\pi_t = (1-\alpha)\pi_{H,t} + \alpha\pi_{F,t}$$

where parameters β, θ, and λ are functions of deep behavioural parameters, e is the deviation of the real

exchange rate from the law of one price, and MC is real marginal cost, E is the expectations operator. While expectations are purely forward looking (ie, rational), the assumption of Calvo pricing introduces a degree of price stickiness, and therefore a basis for monetary policy having short term-real effects. The real marginal cost term can effectively be represented by an output gap, thus giving a "New Keynesian" Phillips curve for the determination of domestic price inflation.

6   Conclusion

Developments in macroeconomic theory since the 1970s have had a major impact on the evolution of monetary policy in New Zealand and the models that have been used to support policy, albeit with a lag. In the 1970s and 1980s, the approach to monetary analysis and modelling reflected the global shift from a Keynesian to a monetarist framework. However, the policy environment was dominated initially by attempts to achieve control over monetary conditions, and then by the impact of widespread financial reforms as policy and intermediation shifted to an effective market-based environment. By the 1990s, the underlying theoretical developments were beginning to have a more discernible impact on the monetary policy framework. In particular, the Lucas critique and the time consistency literature had an important influence on the design of the inflation targeting regime introduced in 1990. Under this regime, and under the subsequent flexible inflation targeting policy, the Bank has maintained a credible commitment to price stability by adopting a consistent rule-based monetary policy, supported by a high level of transparency in forecasting and the operation of policy.

As the search continues for greater control over activity and real exchange rate cycles as well as inflation, the lessons of rational expectations and time consistency will be kept firmly in mind. Monetary policy will continue to target price stability – albeit in the context of flexible inflation targeting. Any new policy instruments will only be used to influence real activity if they can be shown to have a sustainable influence over the long term, and they will be applied in a systematic and predictable fashion.

Despite very real challenges along the way, modelling efforts at the Reserve Bank of New Zealand have adapted to handle the new forward-looking approach to monetary policy-making. A calibrated forecasting and policy system (FPS), incorporating both forward- and backward-looking behaviour, has successfully supported policy-making over the past nine years. New approaches in the form of DSGE models are expected to improve our analysis, and potentially also our implementation of monetary policy in the future.

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