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**The stabilisation problem:  
The case of New Zealand**

**Kirdan Lees**

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## The stabilisation problem: The case of New Zealand

### Abstract<sup>1</sup>

This paper examines stabilisation bias — the difference between the inferior macroeconomic outcomes attained with discretionary monetary policy relative to the ideal that could be attained with commitment policy. The paper works within the linear-quadratic framework and represents the monetary policy problem for the central bank as setting the interest rate in order to minimise an explicit loss function for macroeconomic variables. The government's problem is one of "optimal negotiation", whereby the government, representing society, joins with the central bank to search for the optimal set of loss function parameters to be embedded in a contract with the central bank. The framework, due to Rogoff (1985), is usefully applied to the case of New Zealand where recent Policy Target Agreements — contracts between the government and the central bank — are interpreted as representing society's preferences between inflation, output and other dimensions of macroeconomic stability. Within the context of an estimated, small open economy model, a sizeable stabilisation bias is found for New Zealand. Substantial reductions in the stabilisation bias can be achieved by strategic optimal delegation behaviour on the part of the government. It transpires that the weight the central bank should have on the variance of the output gap is considerably lower than the weight society places on the variance of the output gap.

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<sup>1</sup> Correspondence: Economics Department, Reserve Bank of New Zealand, 2 The Terrace, PO Box 2498, Wellington, New Zealand. The author thanks, without implication, David Archer, Nils Bjorksten, Alfred Guender, Leni Hunter, Chris Plantier, Satish Ranchhod, Weshah Razzak, Isabelle Sin, Ken West and seminar participants at the University of Canterbury, NZAE, and the Reserve Bank of New Zealand. The views expressed in the paper are those of the author and do not necessarily reflect those of the Reserve Bank of New Zealand. The usual disclaimer applies. © Reserve Bank of New Zealand.

## 1 Introduction

Stabilisation bias is the difference in outcomes between monetary policy under commitment and monetary policy under discretion, measured by evaluating the central bank's loss function under optimal policy in each case. The commitment outcome is universally superior to the discretion outcome because by committing to a rule and sticking to it, the central bank can effectively shape agents' expectations, which helps the central bank achieve its objectives. In game theory terms, the central bank acts first under commitment and agents form expectations on the basis of the rule chosen by the central bank.<sup>2</sup>

The problem is one of time inconsistency, which can be characterised as a dynamic game that is played out between the central bank and the other agents in the economy.<sup>3</sup> If monetary policy is conducted under discretion, agents recognise that the central bank may reoptimise its policy rule at a later date. Effectively, under discretion, the central bank acts second, taking agents' expectations as given. This hinders the central bank in achieving its objectives because the central bank is limited in its ability to shape expectations in a useful manner.

A number of papers examine both the magnitude of the welfare loss and possible methods to reduce stabilisation bias (see for example, Nessen (1999), Adolfson (2002), Dennis and Söderström (2002), Gaspar and Smets (2002) and Jensen (2002)). Typically, the stabilisation bias is calculated for a central bank that optimises society's preferences. Society's preferences are assumed to take the form of a quadratic loss function over some of the macroeconomic variables in the model, frequently a weighted average of annual inflation and the output gap.

The first-best outcome results from a scenario in which the central bank can pre-commit to a policy rule that optimises society's loss function. However, this paper makes the common assumption that

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<sup>2</sup> Note that no stabilisation bias exists in a purely backward-looking model since there are no expectational variables.

<sup>3</sup> See Walsh (1995) for a detailed principal-agent description of monetary policy.

commitment to a particular policy rule is not possible. The central bank is assumed to want to reoptimise the rule and makes policy under discretion, incurring a stabilisation bias.

Both the central bank and the government want to minimise the stabilisation bias. As society's representative, the government acts strategically, attempting to find the optimal parameterisation of the loss function for the central bank to minimise under discretion, in order to minimise society's loss function. If monetary policy cannot commit to a rule, it may be the case that the discretionary outcome can be improved by the central bank and the government agreeing that the central bank should minimise a loss function that is different to society's loss function. This is referred to as optimal negotiation on the part of the government.<sup>4</sup>

This avenue of research is founded on Rogoff (1985), which suggests that the stabilisation bias can be reduced by appointing a conservative central banker who places a higher weight on the variance of deviations of inflation from target than on the variance of output deviations from trend.

In this paper, Rogoff's (1985) framework is applied to the New Zealand economy. Relevant loss functions are represented by a range of interpretations of the two most recent Policy Target Agreements (PTAs), which are not regarded as attempts at optimal negotiation. Recent PTAs are interpreted as illustrating society's preferences in two specific directions: (i) across a wider range of variables; and (ii) over a longer horizon measure of the variance of inflation. The objective of the paper is to calculate the magnitude of the stabilisation bias and to examine how policy may be improved by strategic optimal negotiation of the loss function the central bank should minimise.

The approach considered requires evaluating alternative monetary policy regimes. Hence structural models of the economy, where the parameters of the model can be considered invariant to changes in policy regime, are required to address the Lucas critique. To this

<sup>4</sup> See Levine and Pearlman (2002) for an open economy application to a similar combined fiscal and monetary policy problem.

end, a new-Keynesian, open economy model is estimated using quarterly New Zealand data over the period 1990:1 to 2002:4, to help quantify the magnitude of the stabilisation bias.

The paper proceeds as follows. Section 2 discusses the standard linear-quadratic framework for monetary policy, formulates the central bank's problem, formulates the negotiation problem and considers how recent PTAs fit this framework. Section 3 presents the new-Keynesian open economy model and the estimates for the New Zealand dataset. Impulse response functions are used to depict the dynamics of the model. Section 4 presents the results, which assess the magnitude of the stabilisation bias and the magnitude of policy improvement under optimal delegation. Three robustness checks based on the form of the model are also conducted. Section 5 concludes.

## 2 A monetary policy framework

### 2.1 The central bank's problem

The linear-quadratic (LQ) framework describes a class of macroeconomic models that satisfy a specific set of assumptions. In particular, it is assumed there exists a linear model for the evolution of the economy and a quadratic loss function that the central bank seeks to minimise. These assumptions are useful because they yield models with unique solutions for optimal monetary policy.

Linear models may also yield good approximations to more complex models.<sup>5,6</sup> Linear models include representative agent models, forward-looking rational expectations models and aggregate backward-looking macroeconomic models of the economy. Both backward-looking and forward-looking models can be encompassed by the equation:

<sup>5</sup> See, for example, Obstfeld and Rogoff (1996).

<sup>6</sup> Rudebusch and Svensson (1999) also note that linearity may actually approximate the manner in which policymakers think about setting policy instruments.

$$A_0 y_t = A_1 y_{t-1} + A_2 E_t y_{t+1} + A_3 x_t + A_4 E_t x_{t+1} + A_5 v_t, \quad (1)$$

where  $v_t$  is a vector of mean zero i.i.d. processes with variance-covariance matrix  $\Sigma$ ,  $y_t$  represents a vector of state variables and  $x_t$  represents the policy instrument — the nominal interest rate for most models of monetary policy. The matrices  $A_0$ ,  $A_1$ ,  $A_2$ ,  $A_3$ ,  $A_4$  and  $A_5$  contain the coefficients that define the model.

The second requirement of the LQ framework is to specify the functional form for the expression which aggregates the determinants of welfare losses — the “loss function”. The intertemporal loss function, that the central bank operates against, may be stated as:

$$E_t \sum_{t=0}^{\infty} \beta^t L_t^{cb} \quad (2)$$

where  $\beta$  represents the rate at which future periods are discounted. The period loss function,  $L_t^{cb}$ , is restricted to be quadratic in order to ensure a unique solution to the dynamic programming problem. Note that the superscript “cb” denotes the loss function that is used by the central bank, which may or may not also be society’s loss function.

The atemporal or period loss function may include some or all of the state variables and the instrument itself.<sup>7</sup> Thus this loss function takes the form:

$$L_t^{cb} = \{y_t' R y_t + x_t' Q x_t\}. \quad (3)$$

where the matrix  $R$  parameterises the weights on the macroeconomic variables,  $y_t$ , that enter the loss function, and  $Q$  parameterises the weight on the policy instrument,  $x_t$ , in the loss function. Variables that are in the loss function are referred to as the

<sup>7</sup> As the discount rate tends to 1, minimising the intertemporal criterion (equation (2)) is equivalent to minimising the period loss function.

goal variables for the central bank. By definition, an inflation targeting central bank has the variance of deviations of inflation (from target) as a goal variable.<sup>8</sup>

Dennis (2001) presents numerical algorithms that solve for the optimal rule under commitment and discretion.<sup>9</sup> The optimal interest rate rule under discretion takes the form:

$$x_t = F_1 y_{t-1} + F_2 v_t. \quad (4)$$

The optimal interest rate rule under commitment is complicated by the addition of a vector of lagged Lagrange multipliers ( $\phi_t$ ), which represent the cost of an additional unit of model constraint, i.e.:

$$x_t = G_1 y_{t-1} + G_2 v_t + G_3 \phi_{t-1}. \quad (5)$$

Thus under discretion, the central bank’s problem amounts to choosing the parameter vectors  $F_1$  and  $F_2$  to minimise equation (2). Under commitment based policy, the central bank’s problem is to choose the parameter vectors  $G_1$ ,  $G_2$  and  $G_3$  to minimise equation (2). The differences in outcomes under commitment and discretion are now considered in more detail.

<sup>8</sup> Strictly, it is the squared deviations of inflation from target that enter the loss function. As  $\beta \rightarrow 1$ , the arguments in the loss function approach variances.

<sup>9</sup> Söderlind (1999) presents solution methods for a similar set of models.

## 2.2 Commitment, discretion and the stabilisation bias

Under commitment, it is assumed that the central bank can credibly commit to a particular monetary policy rule. The central bank's rule is known and other agents in the model form their expectations based on the rule the central bank chooses to pursue.<sup>10</sup> This stands the central bank in good stead because the expectations channel can be exploited to help achieve outcomes desired by the central bank. For example, influencing the expectation of inflation within a Phillips curve helps the central bank minimise the variance of inflation.

Under discretion, it is assumed that the central bank does not have the ability to credibly implement a commitment rule. Instead, the central bank can change its policy approach and reoptimise its rule every period. This flexibility actually works to the disadvantage of the central bank because, *ceteris paribus*, it mitigates the extent to which the central bank can influence expectations to induce superior outcomes. Solving the model backwards in time reveals an optimal discretionary rule, which is inferior to the optimal commitment rule.

Dennis and Söderström (2002) show clearly how commitment-based policy outcomes differ from discretion-based policy outcomes in the case of a closed economy. When expectations of inflation enter the Phillips equation, the central bank can attain a lower value of the loss function by using a commitment rule. Under commitment, when faced with a cost-push shock, the monetary authority can credibly commit to reducing output below trend which temporarily drives inflation below its equilibrium level. This reduces current inflation expectations, which in turn assists the monetary authority in reducing inflation to target.

Under discretion, the idea that the central bank would push output below trend is not credible. When inflation is returned close to target, there is no incentive for the central bank to maintain a

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<sup>10</sup> The position of the central bank under commitment is akin to the first mover within a Stackelberg game between two oligopolies. Fudenberg and Tirole (1991) offer the example of generals burning their bridges behind them, to prevent the option of retreat, as an example of commitment behaviour. In this case, commitment is to a policy of attack.

negative output gap because it is costly to drive inflation below target. As Dennis and Söderström (2002) observe, the time-consistent discretionary policy brings the output gap and inflation back to target slowly, and without any overshooting. This proves to be suboptimal because quadratic preferences place a premium on returning the macroeconomic variables to equilibrium quickly, and do not distinguish between negative and positive values.

Compared with the closed economy case, the existence of an open economy channel helps the central bank achieve its goal in the face of a cost push shock. This is because an increase in the real interest rate causes the real exchange rate to appreciate. The effect of monetary policy on both nominal and real variables is enhanced. The foreign good component of consumer price inflation decreases and, in addition, output is reduced through expenditure switching behaviour on the part of domestic consumers (Adolfson, 2002).

In addition to the form of the model of the economy (i.e. the parameterisation of the matrices in equation (1)), the form of the central bank's loss function (equation (3)) affects the magnitude of the stabilisation bias. For example, Adolfson (2002) shows that if the central bank already has a low weight on the output gap, including an exchange rate term in the loss function cannot reduce the size of the stabilisation bias. Jensen (2002) suggests that targeting the growth in nominal income may reduce the stabilisation bias.

## 2.3 Optimal negotiation

The institutional framework of the central bank, the legislation that covers the policy setting process and the credibility of the bank may be sufficient to induce the public to form expectations on the basis of the commitment rule. If, on the other hand, the monetary policy framework does not provide for complete commitment, the central bank is assumed to be setting policy under discretion.

However, by setting up the contractual arrangements so that the central bank optimises a loss function different to that of society, the government may be able to induce outcomes close to those under commitment and superior to outcomes under discretion. The problem is to attain society's preferred outcomes by choosing the

parameterisation of the loss function implicit in the PTA with the central bank. The government and central bank negotiate the form of the alternative loss function, assuming that the central bank will minimise this loss function, subject to the constraint of being restricted to discretionary monetary policy. This behaviour is labelled “optimal negotiation”.

The negotiation problem, undertaken by the government and the central bank, takes the form:

$$\min_{\lambda_1^{cb}, \lambda_2^{cb}, \lambda_3^{cb}} E_t \sum_{t=0}^{\infty} \beta^t L_t^s \quad (6)$$

The parameters  $\lambda_1^{cb}$ ,  $\lambda_2^{cb}$  and  $\lambda_3^{cb}$  represent the optimal loss function parameterisation that the government and the central bank establish as the optimal loss function for the central bank to optimise.<sup>11</sup> It transpires that it may be optimal not to ask the central bank to minimise society’s loss function.

This is not a new result in the literature. The seminal paper is Rogoff (1985), who shows that under discretion it is optimal for the central bank to minimise a loss function that has a higher weight on the variance of deviations of inflation (from target) than that of society. Gaspar and Smets (2002) and Mishkin (2002) also find that focussing on output stabilisation produces worse outcomes. Guender (2003) shows that the existence of a real exchange rate channel mitigates the extent to which a higher relative weight should be placed on inflation, but notes that the central premise of Rogoff (1985) still holds. Thus the implication of Guender (2003) is that with regard to inflation, a discretionary central bank operating within an open economy should be less conservative than its closed economy counterpart, but more conservative than society.

A simple optimising routine is used to solve the negotiation problem as follows. A guess is made as to the optimal parameterisation of the

<sup>11</sup> Note that this negotiation problem is a restricted version of a more general case. The government and the central bank may negotiate over the parameterisation of the loss function, but not the variables that take arguments within the loss function, which are restricted to be identical to those in society’s loss function.

loss function to pass to the central bank. The central bank calculates the optimal policy reaction function that minimises the loss under discretion for this loss function parameterisation.<sup>12</sup> This rule is used to obtain a reduced form law of motion for the economy under which society’s loss function is computed. Another guess of the optimal parameterisation is made and compared to the initial guess. The routine continues, choosing the parameterisation that minimises society’s loss function until convergence occurs (when any possible gains from alternative parameterisations are negligible).

## 2.4 A welfare metric

To evaluate the magnitude of the stabilisation bias and the gains to optimal delegation, a metric is required. Dennis and Söderström (2002) suggest using an inflation-equivalent measure that is the permanent increase in inflation required to make the central bank indifferent between policy under commitment and discretion. That inflation equivalent measure, denoted  $\hat{\pi}^c$ , is given by:

$$\hat{\pi}^c = \sqrt{L_d - L_c} \quad (7)$$

where  $L_c$  represents the loss under commitment and  $L_d$  represents the loss under discretion.<sup>13</sup> The superscript “c” denotes the inflation equivalent welfare measure from commitment policy.

Dennis and Söderström (2002) argue that this measure is useful because it avoids the potential division of small numbers implied by calculation of percentage measures of the stabilisation bias. In addition, expressing welfare differences in terms of the variables in the loss function arguably helps policymakers grasp the extent to which they should be concerned with any stabilisation bias.

<sup>12</sup> The author is grateful to Richard Dennis (2001) for the Gauss procedures (called from within the simple optimising routine), that calculate the optimal rule and loss under both discretion and commitment.

<sup>13</sup> To see how this measure is calculated, consider  $\hat{\pi}^c$ , the amount of beyond target inflation in each period, required to equate the loss under discretion with that under commitment:  $\hat{\pi}^{c^2} = L_d - L_c$ . Taking the square root of both sides and solving for  $\hat{\pi}^c$  gives:  $\hat{\pi}^c = \sqrt{L_d - L_c}$ .

Alternative welfare metrics are available. An equivalent welfare metric to the measure suggested by Dennis and Söderström (2002) is a permanent *decrease* in inflation below target, sufficient to make the policymaker indifferent between commitment outcomes and discretion-based policy outcomes. Alternatively, the welfare metric could be expressed in terms of the output gap.

The inflation-equivalent welfare measure can also be used as a metric for the gains to optimal negotiation. The inflation-equivalent welfare measure for optimal negotiation can be formulated as:

$$\hat{\pi}^{on} = \sqrt{L_d - L_{on}} \quad (8)$$

where  $L_{on}$  denotes the loss from optimal negotiation.

Having detailed the central bank's problem and an assumption regarding the monetary policy preferences implied by the most recent PTAs, it remains to consider the constraint on the central bank's problem, an appropriate model of the economy.

## 2.5 The Policy Target Agreement

Policy Target Agreements (PTAs) contain the contract that exists between the government and the central bank in New Zealand. Since 1990, the PTA, the agreement signed by both the Treasurer and the Governor of the Reserve Bank of New Zealand set out a target for annual consumer price inflation. However, the two most recent PTAs (16th December 1999 and 17th September 2002), added words that are relevant for the analysis in this paper.

Firstly, in 1999, section 4(c) of the PTA was amended to include the following clause:

**“In pursuing its price stability objective, the Bank shall implement monetary policy in a sustainable, consistent, and transparent manner and shall seek to avoid unnecessary instability in output, interest rates and the exchange rate.”**<sup>14</sup>

The conduct of monetary policy prior to the introduction of this clause was not necessarily solely focused on price stability. However, while the primary goal of monetary policy remains price stability, the additional clauses make it explicit that where possible this primary goal is not pursued in the absence of considerations for volatility in other macroeconomic variables.

Secondly, the 2002 PTA carried over the new element of the 1999 PTA, and defined price stability according to the following clause:

**“For the purposes of this agreement the policy target shall be to keep future CPI inflation outcomes between 1 per cent and 3 per cent on average over the medium term.”**

Aside from an increase in the lower level of the band, the 2002 PTA extends the definition of price stability from an annual target for inflation to a medium-term definition.

## 2.6 Representing the PTA

The 1999 PTA states that the central bank should be concerned with the volatility of interest rates and the exchange rate. For this reason, in addition to the variances of annual inflation and the output gap, the loss function used in this analysis includes the variance of the nominal interest rate (relative to mean) and the variance of the real

<sup>14</sup> Whether this PTA is regarded as a break in policy or the reflection of an evolving interpretation of the conduct of monetary policy is a moot point — policy is currently aimed at also stabilising these additional macroeconomic variables.

exchange rate (relative to mean) as goal variables. Thus the loss function can be expressed as:

$$L_t^s = (\bar{\pi}_t - \bar{\pi}^*)^2 + \lambda_1^s \tilde{y}_t^2 + \lambda_2^s i_t^2 + \lambda_3^s q_t^2 \quad (9)$$

where  $\lambda_1^s$ ,  $\lambda_2^s$  and  $\lambda_3^s$  are all positive. The asterisk denotes the inflation target. The bar above inflation and the target is used to represent an annual inflation measure. The output gap is represented by  $\tilde{y}_t$ , inflation is represented by  $\pi_t$ ,  $i_t$  is the nominal interest rate and  $q_t$  is the real exchange rate with an increase in  $q_t$  denoting an appreciation of the domestic currency. The superscript “s” is used to denote society’s preferences. Thus the parameter  $\lambda_1^s$  denotes the concern society has for minimising the variance of the output gap relative to minimising the variance of deviations of inflation from target.<sup>15</sup> An inflation-conservative society would place relatively low weights on  $\lambda_1^s$ ,  $\lambda_2^s$  and  $\lambda_3^s$  while a society concerned with stabilising the output gap, interest rate and exchange rate, would have higher weights on  $\lambda_1^s$ ,  $\lambda_2^s$  and  $\lambda_3^s$ .

Within this paper, it is assumed that the change in the 1999 PTA represents an increase in  $\lambda_1^s$ ,  $\lambda_2^s$  and  $\lambda_3^s$ , the weights that are accorded to the volatilities of the output gap, the nominal interest rate and the real exchange rate respectively.

Several studies in the literature consider interest rate volatility by including the variance of the interest rate or the variance of the change in the interest rate in the baseline loss function.<sup>16</sup> The loss function in equation (3) is sufficiently general to include a baseline preference for minimising the volatility in the nominal interest rate

<sup>15</sup> In the language of Mervyn King, if  $\lambda_1^s$ ,  $\lambda_2^s$  and  $\lambda_3^s$  are zero, the central banker is an “inflation nutter” and is solely concerned with meeting the inflation target.

<sup>16</sup> Inclusion of this term is typically justified by a series of assumptions about central bank behaviour. Central banks may perceive small, incremental changes to the policy instrument to be: (i) beneficial in terms of financial stability; (ii) useful in a world of uncertainty; and (iii) necessary protection against a public perception of frequent changes in the direction of the policy instrument representing mistakes by the central bank.

— simply by including a positive  $\lambda_2^s$  coefficient on the volatility of the interest rate. The 1999 PTA could be interpreted as implying an increased weight on minimising interest rate volatility. Here, this is interpreted as applying to the level of the interest rate rather than the change in the interest rate.

In addition, the generalised loss function, equation (9), includes the variance of the real exchange. The choice of the real exchange rate over the nominal exchange rate stems, at least in part, from concerns regarding the performance of the export sector. Regarding the 1999 PTA, Dr. Michael Cullen, the Minister of Finance, stated:

“The renegotiation sought by the Government reflected a concern not to repeat the experience of the mid-1990s when the export sector was placed under immense pressure by a sharp increase in the value of the dollar.”

Note that it is the variance of the level of the real exchange rate (relative to equilibrium) rather than the variance of the change in the real exchange rate that enters the loss function.

Finally, the loss function is generalised to accommodate the change in monetary policy preferences implied by the 2002 PTA. In particular, the phrase “on average over the medium term” is assumed to imply that the central bank should be concerned with the variance of the deviation of a three year average of annual inflation, from target. Thus the loss function takes the form:

$$L_t^s = (\bar{\pi}_t - \bar{\pi}^*)^2 + \lambda_1^s \tilde{y}_t^2 + \lambda_2^s i_t^2 + \lambda_3^s q_t^2 \quad (10)$$

where the three dots above inflation denote the three year average of annual consumer price inflation. The inflation target is also based on this three year average of consumer price inflation.

### 3 The Model

#### 3.1 A New-Keynesian open economy model

A three equation open economy model is adopted. McCallum and Nelson (1999) show how a forward-looking AD equation can be derived from a consumption Euler equation. Amato and Laubach (2001) show that the addition of habit formation has the implication that the lag of output enters the optimising consumption Euler equation. This forms the core of the AD equation for the model because investment and government spending are assumed to have no impact on output fluctuations relative to trend.

The real interest rate in the aggregate demand equation,  $(\bar{i}_t - \bar{\pi}_t)$ , is the annual average real interest rate.<sup>17</sup> Because output is also a function of net exports, the real exchange rate and a foreign income term are included in the AD equation to model demand for exports and expenditure switching on the part of domestic residents.

The Phillips equation is based on a simple wage contracting process developed in Batini and Haldane (1999). The domestic price level is the average of the contemporaneous nominal wage and the lag of the nominal wage. Real wage contracts are formed as a weighted average of last period's real wage and the expected real wage in the following period. A wage premium is added, under the assumption that periods of excess output demand (relative to trend) induces an increase in the real wage. These equations are listed in Appendix A.

The exchange rate itself is modelled with an uncovered interest rate parity condition. Thus the model takes the form:

$$\begin{aligned} \tilde{y}_t = & \beta_1 \tilde{y}_{t-1} + (1 - \beta) E_t \tilde{y}_{t+1} - \beta_2 (\bar{i}_t - \bar{\pi}_t) \\ & - \beta_3 q_{t-1} + \beta_4 \tilde{y}_{t-1}^f + \varepsilon_{yt} \end{aligned} \quad (11)$$

<sup>17</sup> Rudebusch and Svensson (1999) motivate this form of the real interest rate to capture consumption that responds to both short rates and long rates.

$$\begin{aligned} \pi_t = & \alpha_1 E_t \pi_{t+1} + (1 - \alpha_1) \pi_{t-1} + \alpha_2 (\tilde{y}_t + \tilde{y}_{t-1}) \\ & + 2(1 - \phi) [(1 - \alpha_1) \Delta q_t - \alpha_1 E_t \Delta q_{t+1}] + \varepsilon_{\pi} \end{aligned} \quad (12)$$

$$q_t = E_t q_{t+1} + i_t - E_t \pi_{t+1} - (i_t^f - E_t \pi_{t+1}^f) + \varepsilon_{qt}. \quad (13)$$

All the parameters are positive according to theory. The parameter  $\phi$ , in the Phillips equation, represents the proportion of imported goods in the Consumer Price Index. This is set to 0.5.<sup>18</sup> Foreign inflation and the foreign output gap are restricted to simple AR(1) processes with a coefficient of 0.8 on their lagged values, while the foreign interest rate is restricted to obey the Taylor rule.<sup>19</sup> The exogenous foreign sector is given in Appendix B.

#### 3.2 Model estimation

The model outlined in equations (11) to (13) contains expectational variables. Survey data are used to proxy for inflation expectations and output expectations. Expectations of the real exchange rate are constructed using US inflation, domestic inflation, the nominal NZ/US cross rate and the expected NZ/US cross rate one quarter ahead.<sup>20</sup> Note that the variables in the model are demeaned.

The output gap was constructed using the Hodrick-Prescott filter with  $\lambda$ , the smoothing parameter, set to 1600. Initially, the foreign income variable is the US output gap, which was also calculated using a Hodrick-Prescott filter with  $\lambda$  set to 1600.<sup>21</sup>

<sup>18</sup> The weight on the nontradable goods component of the CPI used in RBNZ forecasts is 0.4715. Batini and Haldane (1999) calibrate an open economy to the United Kingdom using 0.5 as the appropriate weight.

<sup>19</sup> Svensson (2000) calibrates the exogenous foreign sector in a similar manner.

<sup>20</sup> Expectations of GDP, inflation and the NZ/US cross were proxied by the Reserve Bank of New Zealand survey expectation series `ergdp1.q`, `ercpi1.q` and `erus2.q` respectively.

<sup>21</sup> Harvey and Jaeger (1993) examine the optimal choice of  $\lambda$ , the signal-to-noise ratio for a variety of series. It is an open question whether the optimal choice of  $\lambda$  is 1600 for New Zealand output. However, this choice of  $\lambda$  is frequently used at the RBNZ and policymakers may be familiar with the magnitudes of output gaps associated with a signal-to-noise ratio of 1600.

The inflation variable is a core measure of inflation, the 57th percentile measure, which adjusts a weighted-median measure of inflation for skewness in inflation. The median measure of inflation is useful as a proxy of the core, underlying measure of inflation that the central bank attempts to control in practice. The real exchange rate is a CPI-based real exchange rate measure, constructed from the weights within the Trade-Weighted Index for New Zealand.

The model is estimated over the period 1990:1 - 2002:4, covering most of the inflation targeting period in New Zealand. The initial estimation results show that the forward-looking component of the aggregate demand equation is insignificant. The real exchange rate and the foreign income term were insignificant. The forward-looking component was removed, the real exchange rate removed and the Australian output gap (again constructed by HP filter with  $\lambda=1600$ ) substituted into the model for the foreign income term.

This yielded the following model, where  $p$ -values are bracketed beneath the coefficient estimates.

$$\tilde{y}_t = \underset{(0.000)}{0.871} \tilde{y}_{t-1} - \underset{(0.101)}{0.112} (\bar{i}_t - \bar{\pi}_t) + \underset{(0.084)}{0.219} \tilde{y}_{t-1}^f + \varepsilon_{yt} \quad (14)$$

$$R^2 = 0.769, \quad \sigma_{\varepsilon_y} = 0.794, \quad DW = 1.870$$

$$\begin{aligned} \pi_t = & \underset{(0.001)}{0.564} E_t \pi_{t+1} + \underset{(0.001)}{0.436} \pi_{t-1} + \underset{(0.059)}{0.077} (y_t + y_{t-1}) \\ & + \underset{(0.001)}{0.436} \Delta q_t - \underset{(0.001)}{0.564} E_t \Delta q_{t+1} + \varepsilon_{\pi} \end{aligned} \quad (15)$$

$$R^2 = 0.395, \quad \sigma_{\varepsilon_y} = 0.847, \quad DW = 2.115$$

The aggregate demand equation shows a negative response to an increase in the real interest rate. The coefficient is close to the parameter estimate Rudebusch and Svensson (1999) and Rudebusch (2002) find using US data over the period 1965:1-1996:4.

The real exchange rate was not significant in the aggregate demand equation. A variety of specifications, that trialled the lead, lag and the change of the real exchange rate as regressors, were estimated.

Variations using the world output gap, the US output gap and the Australian output gap in the regression, were also trialled. In every case, the real exchange rate was incorrectly signed relative to theory or insignificant in the regression.

When lags of the real exchange rate were included, the real exchange rate had a negative but insignificant coefficient. The  $J$ -curve effect, where exports increase initially after an appreciation of the real exchange rate, may explain the impact of the real exchange rate on the New Zealand output gap. However, given the long and arbitrary number of lags associated with this channel, the real exchange rate was omitted from the aggregate demand equation.

The Phillips curve returns a relatively low adjusted  $R^2$  value. The coefficient estimates are plausible and significant at the 5 per cent level. Unlike the aggregate demand equation, the forward-looking component of the Phillips curve is substantial and statistically significant.

In addition to the aggregate demand and Phillips equations, the uncovered real interest rate parity condition was imposed on the model.

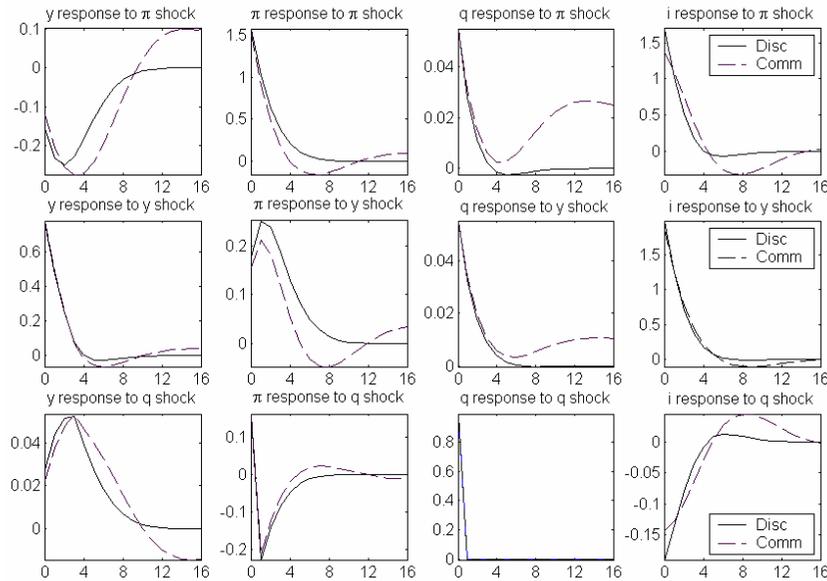
### 3.3 The dynamics of the Model

The next step is to examine the impulse response functions under commitment and discretionary behaviour, especially with regard to a cost push shock. These impulse responses serve as a check on the plausibility of the model. Particular attention is paid to a cost push shock, because this shock involves a direct trade-off between minimising inflation volatility and output gap volatility and proves more revealing about differences in dynamics under commitment and discretion.

The exercise involves completing the model with a loss function of the form already discussed, where the RBNZ has some concern for both output gap and interest rate volatility. Specifically, the coefficients in equation (9) take the values:  $\lambda_1^S = 0.5$ ,  $\lambda_2^S = 0.1$  and  $\lambda_3^S = 0.0$ . The variance of the shocks  $\varepsilon_{yt}$  and  $\varepsilon_{\pi t}$  were determined by

the estimated model while the variance of the real exchange rate shock was set to 0.01.<sup>22</sup> The impulse response functions of the model to demand, inflation and exchange rate shocks are shown in figure 1.

Figure 1: Impulse responses: New Zealand 1990:1 — 2002:4



The transmission mechanism of the model appears sensible. All the macroeconomic variables are eventually returned close to their equilibrium values.

In response to an inflation shock, the output gap takes a long time to return to equilibrium under commitment. Initially the commitment path falls as steeply as the discretion path, but under discretion, inflation is returned to equilibrium after approximately eight quarters. Following the inflation shock, inflation falls more quickly under commitment than under discretion, actually falling below zero after approximately four quarters before converging back towards zero. The policymaker is prepared to allow inflation to fall below zero because this keeps inflation expectations down. Given quadratic

<sup>22</sup> A simple AR(1) regression indicated that this value was empirically plausible.

preferences, lower expectations help the policymaker return inflation to zero at a lower cost under commitment than under discretion.

After the inflation shock, the real uncovered interest rate parity condition causes the real exchange rate to appreciate initially after the shock. This effect is noticeable under both discretion and commitment.<sup>23</sup> Under commitment, the real exchange rate subsequently falls slightly more slowly, than the discretionary case then returns towards its equilibrium value. Under discretion, the real exchange rate falls slightly more sharply than the commitment case before converging back towards its equilibrium value.

The interest rate responds to the inflation shock by initially increasing sharply under both commitment and discretion. The interest rate then falls quickly under both commitment and discretion and is returned to its equilibrium value about eight quarters after the initial shock for the case of discretion. There is some overshooting associated with the commitment case.

To summarise, the dynamics of the model appear plausible for the New Zealand economy.

## 4 Stabilisation bias

### 4.1 Output, interest rate and exchange rate volatility

Table 1 presents stabilisation results for a range of loss function parameterisations that might encompass, to varying degrees, the clauses of the 1999 PTA. In particular, the variance of the output gap, interest rate and real exchange rate are all present as arguments in the loss function.

Columns I to III present possible calibrations of society's loss function. A range of scenarios are considered. Throughout the table, society considers the variance of the output gap as either half as important as the variance of inflation from target (when  $\lambda_1^s$  is 0.5) or

<sup>23</sup> Note that the baseline loss function includes no preference for stabilising the real exchange rate. Such a preference would presumably reduce the observed exchange rate movements.

equally important as inflation (when  $\lambda_1^s$  takes a value of 1). The weight on the variance of the interest rate is lower; the values 0, 0.1 and 0.25 are specified for the variance of the interest rate. In addition, the variance of the real exchange rate is restricted to 0 for the first six scenarios and allowed to take the value of 0.25 for the second half of the table.

Column IV gives the intertemporal loss (expressed using the welfare metric discussed in Section 2.4) for the central bank that minimises society's loss function (as parameterised in columns I-III) under discretion. Column V shows the equivalent minimisation exercise under commitment. The intertemporal loss under commitment is always lower than that under discretion. The welfare benefits from commitment-based policy in column VI show the extent of welfare gain that the central bank could achieve by moving from discretion to commitment policy — if that were possible.

Column VIII is labelled “ON” — for optimal negotiation. This represents the intertemporal loss to society, evaluated under society's loss function representation, when the government and the central bank negotiate an alternative parameterisation for the central bank to minimise.<sup>24</sup> This value never exceeds the discretionary outcome because the negotiated loss function can simply take society's loss function parameterisation. Column VIII presents the improvement in welfare from optimal negotiation. The final three columns show the optimal parameter set under optimal negotiation.

<sup>24</sup> Note that the loss function parameterisation in columns I-III may not be optimal in terms of alternative welfare metrics. For example, these parameterisations may not represent the variance trade-off that maximises the level of income in one hundred years time. In addition, the loss function parameterisation that maximises the utility of representative agents (see Rotemberg and Woodford (1998), for an example of such an exercise) may be different.

**Table 1: Addressing the 1999 PTA**

	$L_t^s = (\bar{\pi}_t - \bar{\pi}^*)^2 + \lambda_1^s \bar{y}_t^2 + \lambda_2^s i_t^2 + \lambda_3^s q_t^2$										
Column	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
LF	$\lambda_1^s$	$\lambda_2^s$	$\lambda_3^s$	Disc	Comm	$\hat{\pi}^c$	ON	$\hat{\pi}^{on}$	$\lambda_1^{cb}$	$\lambda_2^{cb}$	$\lambda_3^{cb}$
(i)	.5	0	0	2.01	1.46	0.74	1.78	0.49	0.20	0.00	0.02
(ii)	.5	.1	0	3.50	3.03	0.76	3.43	0.41	0.02	0.08	0.21
(iii)	.5	.25	0	5.13	4.15	0.99	4.89	0.49	0.00	0.14	0.24
(iv)	1	0	0	2.51	1.76	0.86	2.24	0.52	0.41	0.00	0.00
(v)	1	.1	0	4.22	3.52	0.84	4.03	0.44	0.30	0.07	0.18
(vi)	1	.25	0	5.76	4.73	1.01	5.50	0.51	0.18	0.14	0.39
(vii)	.5	0	.25	2.51	1.89	0.79	2.26	0.50	0.20	0.00	0.06
(viii)	.5	.1	.25	3.98	3.44	0.74	3.82	0.41	0.02	0.08	0.21
(ix)	.5	.25	.25	5.49	4.60	0.94	5.26	0.48	0.00	0.15	0.23
(x)	1	0	.25	3.02	2.18	0.91	2.72	0.54	0.41	0.00	0.04
(xi)	1	.1	.25	4.61	3.93	0.82	4.41	0.44	0.30	0.07	0.16
(xii)	1	.25	.25	6.12	5.18	0.97	5.87	0.50	0.18	0.15	0.38

The results show that commitment-based policy is superior to policymaking under discretion. Substantial stabilisation bias seems to exist for this model. Furthermore, the inflation-equivalent welfare measure of the stabilisation bias appears to rise when the weight on the output gap variance and the weight on the variance of the interest rate increase. Across the range of loss function parameterisations for society, the intertemporal loss is 15-45 per cent lower under commitment. The loss under discretion is equivalent to the loss under commitment plus (or minus) 75-100 basis points of inflation.<sup>25</sup>

Consider one loss function representation, row (i), where annual inflation and the output gap are the only arguments. The loss under discretion is 2.01; the loss under commitment 1.46. Optimal negotiation acts to reduce this stabilisation bias. Using the optimal negotiation central bank reaction function reduces the loss from discretion-based policy to 1.78, and reduces the societal welfare loss by 49 annual inflation basis points.

<sup>25</sup> Section 2.4 notes that alternative representations of the difference in welfare are possible. Output gap measures could be calculated but would vary with the associated weight on the output gap within the loss function.

How is this result achieved? This result is achieved by specifying a loss function with a much lower weight on the output gap than that of society for the central bank of minimise. In fact, the weight on the output gap falls dramatically. The optimal weight the central bank should place on the output gap is 0.20 — less than half the weight society places on the output gap.

This is Rogoff’s “conservative” central banker result. This result is replicated throughout table 1 with the optimal weight placed on the output gap taking values less than half those of society.

Interestingly, the optimal weight that the government should place on the volatility of the real exchange rate increases substantially when society places some weight on the volatility of the interest rate. Reducing the extent to which the exchange rate channel can be utilised appears to help policy outcomes.

The results hold for loss function parameterisations that contain an interest rate variance argument and an exchange rate variance argument. For example, loss function (viii) suggests a very small weight should be accorded to the central bank’s preferences for the output gap (0.02, in column IX) relative to the weight society places on the output gap (0.5, in column I). The results generalise to loss function parameterisations where the output gap is weighted equally with inflation in society’s preferences. For example, the loss function representation in the last row of table 1, row (xii), indicates that the weight the central bank should place on the output gap is 0.18 — about one-fifth of the weight in society’s preferences.

The optimal weight accorded to interest variance,  $\lambda_2^{cb}$ , is somewhat closer to society’s weight on interest rate variance,  $\lambda_2^s$ . For example, for the loss function parameterization in row (ii),  $\lambda_2^s=0.1$ , and the optimal parameter negotiated for the loss function the central banks should minimise,  $\lambda_2^{cb}$ , is 0.08. When  $\lambda_2^s=0.25$ , the parameter that should be passed to the central bank is approximately 0.15. However, the weight that should be placed on the variance of the exchange rate increases relative to society’s weight.

## 4.2 Targeting medium term inflation

The stabilisation results are extended to address the 2002 PTA agreement. This PTA asks the RBNZ to target inflation over the medium term. This is interpreted as extending the horizon for inflation within society’s preferences. This section examines the magnitude of any stabilisation bias under the assumption that it is the average of inflation over a three-year horizon that best represents preferences under the most recent PTA.

Compare any of the inflation-equivalent welfare measures in table 2 with the corresponding inflation-equivalent welfare measures in table 1. The stabilisation bias is smaller when the central bank uses a medium term inflation target. This is likely to be a function of the increase in the weight attached to the path of inflation — fluctuations in inflation up to twelve quarters out still affect the period loss, while only the current value of the output gap enters the period loss function. Interestingly, the gains from optimal negotiation are almost as large as their counterparts in table 1.

**Table 2: Addressing the 2002 PTA**

	$L_t^s = (\tilde{\pi}_t - \tilde{\pi}^*)^2 + \lambda_1^s \tilde{y}_t^2 + \lambda_2^s i_t^2 + \lambda_3^s q_t^2$										
Column	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
LF	$\lambda_1^s$	$\lambda_2^s$	$\lambda_3^s$	Disc	Comm	$\tilde{\pi}^c$	ON	$\tilde{\pi}^{on}$	$\lambda_1^{cb}$	$\lambda_2^{cb}$	$\lambda_3^{cb}$
(i)	.5	0	0	0.90	0.55	0.60	0.71	0.44	0.15	0.00	0.00
(ii)	.5	.1	0	2.13	1.79	0.58	1.99	0.37	0.13	0.05	0.00
(iii)	.5	.25	0	3.35	2.69	0.81	3.09	0.51	0.04	0.11	0.00
(iv)	1	0	0	1.20	0.69	0.72	0.94	0.51	0.28	0.00	0.00
(v)	1	.1	0	2.70	2.26	0.66	2.53	0.41	0.33	0.05	0.00
(vi)	1	.25	0	3.99	3.30	0.83	3.73	0.51	0.24	0.10	0.00
(vii)	.5	0	.25	1.33	0.96	0.61	1.14	0.44	0.16	0.00	0.00
(viii)	.5	.1	.25	2.51	2.21	0.55	2.38	0.36	0.15	0.05	0.00
(ix)	.5	.25	.25	3.72	3.16	0.74	3.48	0.49	0.06	0.11	0.00
(x)	1	0	.25	1.63	1.11	0.72	1.37	0.51	0.28	0.00	0.00
(xi)	1	.1	.25	3.08	2.67	0.64	2.91	0.41	0.34	0.05	0.00
(xii)	1	.25	.25	4.35	3.76	0.77	4.11	0.50	0.25	0.11	0.00

Note that the societal loss under commitment, discretion and optimal negotiation is always lower in table 2 than its table 1 counterpart. Extending the measure of inflation to a three-year measure makes the policy task of the central bank less onerous within the model. A shock to quarterly inflation must be much larger to generate the same impact on the societal loss, relative to the case where inflation is measured annually.

When the measure of inflation is extended to three years, the gains to commitment policy fall, but remain substantial.<sup>26</sup> Comparing the column labelled ON in table 2 with the corresponding column in table 1, the inflation-equivalent welfare measure is on average 25 per cent lower in table 2. However, recall that the inflation equivalent welfare measure is expressed in terms of the metric that enters the loss function — annual for table 1 and the three year measure for table 2.

The welfare gain from optimal negotiation falls five per cent, on average, but the inflation equivalent welfare measure is actually larger in table 2 relative to table 1 for the loss functions in row (iii) and row (ix). The welfare gains from optimal negotiation are approximately the same under most loss function representations.

However, the most striking feature of table 2 is the replication of the inflation conservatism result from table 1. The weight placed on the output gap under optimal negotiation is much lower than society's preference for minimising the variance of the output gap. For example, the first row of table 2, presents the case where society's preferences for output gap variance take a weight of 0.5. Under optimal negotiation, the weight on output gap variance within the loss function that the central bank should minimise, is 0.15 — less than half the weight of the same argument within society's preferences.

<sup>26</sup> The variance of the individual variables may be useful in explaining the persistence of the stabilisation bias. For the loss function parameterisation in table 2, row(ii), the variance of the output gap is actually higher under commitment than discretion (1.14 compared to 0.92) but the reduction in the inflation target is substantial (0.56 compared to 0.93). The variance of the interest rate remains high in both cases (8.09 under discretion and 7.40 under commitment) but the weight on interest rate volatility is small (0.1).

This result is confirmed for all the specifications of society's preferences in table 2. For example, take the parameterisation in row nine of table 2. The weight on the output gap under optimal negotiation,  $\lambda_1^{cb}$ , falls to 0.06 — considerably lower than society's preference on output gap variance,  $\lambda_1^s$ , which takes the value 0.5.

In addition, the parameterisation in row (xii) of table 2 represents the most inflation-liberal interpretation of the PTA. The weight on the output gap is equal to the weight on the three year measure of inflation, and the weights on the variance of the interest rate and the variance of the real exchange rate, are the highest weights considered in the table. Under this scenario,  $\lambda_1^{cb}$ , the weight on the output gap under optimal negotiation, takes a value of 0.25 — one quarter the weight of society's output gap preference.

The weight on the variance of the interest rate under optimal negotiation,  $\lambda_2^{cb}$ , is approximately half the weight society places on the variance of the interest rate. This result holds across all the loss function representations in table 2. The central bank's weights on the variance of the interest rate represent decreases of approximately 40 per cent from the counterpart weight for the annual inflation measure presented in table 1.

Interestingly, the optimal weight on the variance of the real exchange rate under optimal negotiation,  $\lambda_3^{cb}$ , is approximately zero across all the loss function parameterisations in table 2. Thus for these preferences optimal negotiation behaviour suggests that the central bank should have no preference for stabilising the real exchange rate, *ceteris paribus*. This result holds even if society cares about the variance of the real exchange rate. Under optimal negotiation, it appears the central bank should not be restricted from exploiting the real exchange rate channel.

### 4.3 Robustness check (i): the use of survey data

Equations (14) and (15), which form the core of the model, are FIML estimates based on survey data on expectations. In this section, the robustness of the commitment, discretion and optimal

negotiation results presented in table 2, are checked against alternative parameter estimates obtained by GMM estimation, avoiding the use of survey data.

Dennis and Söderström (2002) analyse the stabilisation bias for a number of closed economy models and conclude that transmission lags, information lags and the degree of forward-looking behaviour are critical in determining the difference in welfare for discretion relative to commitment. This point is made forcibly in Guender (2003), who finds that the stabilisation bias implied by a small open economy is smaller than that implied by a standard closed economy model. Thus the stabilisation bias may be different across alternative models of the economy. Testing the forward-lookingness of the model against alternative estimation techniques appears useful.

The GMM estimates of the model are presented below. The domestic output gap lagged one period, the domestic output gap lagged two periods, the lag of the foreign output gap, the Australian real interest rate (calculated as an annual average) and a constant term were used as instruments for the aggregate demand equation. The lag of annualised inflation, annualised inflation lagged two periods, the change in the real exchange rate lagged two periods, the lag of the domestic output gap and a constant, were used as instruments for the aggregate supply equation.

$$\tilde{y}_t = \underset{(0.000)}{0.900} \tilde{y}_{t-1} - \underset{(0.000)}{0.185} (\bar{i}_t - \bar{\pi}_t) + \underset{(0.214)}{0.158} \tilde{y}_{t-1}^f + \varepsilon_{yt} \quad (16)$$

$$R^2 = 0.761, \quad \sigma_{\varepsilon_y} = 0.807, \quad DW = 1.878$$

$$\pi_t = \underset{(0.094)}{0.451} E_t \pi_{t+1} + \underset{(0.071)}{0.549} \pi_{t-1} + \underset{(0.088)}{0.071} (\tilde{y}_t + \tilde{y}_{t-1}) +$$

$$\underset{(0.094)}{0.451} \Delta q_t - \underset{(0.071)}{0.549} E_t \Delta q_{t+1} + \varepsilon_{\pi} R^2 = 0.400, \quad (17)$$

$$\sigma_{\varepsilon_y} = 0.852, \quad DW = 2.237$$

Broadly, the GMM parameter estimates are close to the FIML parameter estimates obtained using survey data. Again, the forward-looking component within the aggregate demand equation is

insignificant. The foreign output term is also insignificant. However, the parameter is included in the model to allow for some foreign influence on the domestic economy. The most striking feature of the aggregate demand equation is the large increase of the impact of monetary policy. The parameter on the real interest rate takes a value of 0.185 — approximately 50 per cent larger than the FIML estimate of the same parameter. There is about an equal weight on inflation expectations and the lag of inflation in the Phillips equation. The parameter estimate for the output gap term in the Phillips equation is almost identical to the FIML estimate.

Although the GMM parameter estimates are plausible, the increase in the parameter estimate on the real interest rate in the aggregate demand equation shows there may be a degree of instability in the parameter estimates. Furthermore, this parameter is crucial to determining the strength of monetary policy. It is therefore a worthwhile exercise to test the robustness of the stabilisation results, presented in section 4, for these alternative parameter estimates. These results are presented below in table 3.

**Table 3: Addressing the 2002 PTA: GMM model**

	$L_t^s = (\tilde{\pi}_t - \tilde{\pi}^*)^2 + \lambda_1^s \tilde{y}_t^2 + \lambda_2^s i_t^2 + \lambda_3^s q_t^2$										
Column	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
LF	$\lambda_1^s$	$\lambda_2^s$	$\lambda_3^s$	Disc	Comm	$\hat{\pi}^c$	ON	$\hat{\pi}^{on}$	$\lambda_1^{cb}$	$\lambda_2^{cb}$	$\lambda_3^{cb}$
(i)	.5	0	0	2.85	2.00	0.92	2.27	0.76	0.17	0.00	0.00
(ii)	.5	.1	0	3.87	3.31	0.75	3.55	0.57	0.15	0.08	0.00
(iii)	.5	.25	0	5.29	4.60	0.83	4.92	0.61	0.08	0.18	0.00
(iv)	1	0	0	4.47	2.84	1.28	3.39	1.04	0.31	0.00	0.00
(v)	1	.1	0	5.37	4.26	1.06	4.76	0.79	0.34	0.07	0.01
(vi)	1	.25	0	6.73	5.56	1.09	6.12	0.78	0.28	0.17	0.00
(vii)	.5	0	.25	3.16	2.33	0.91	2.58	0.76	0.17	0.00	0.00
(viii)	.5	.1	.25	4.17	3.64	0.73	3.85	0.57	0.15	0.08	0.00
(ix)	.5	.25	.25	5.58	4.95	0.80	5.22	0.61	0.08	0.18	0.00
(x)	1	0	.25	4.80	3.19	1.27	3.71	1.05	0.31	0.00	0.00
(xi)	1	.1	.25	5.68	4.61	1.04	5.05	0.80	0.34	0.07	0.01
(xii)	1	.25	.25	7.04	5.93	1.05	6.41	0.79	0.28	0.17	0.00

Qualitatively, the results from the FIML estimates are the same as the GMM estimates. There is a considerable gain to commitment policy relative to discretion. In addition, the stabilisation bias appears to increase when society places a higher weight on the variance of the output gap. If the central bank cannot implement commitment policy there exists a substantial gain from optimal negotiation between the government and the central bank. Furthermore, the strong Rogoff (1985) inflation conservatism result is replicated. Under GMM, the weights that should be assigned to the central bank under optimal negotiation are very similar to the weights for the model estimated by FIML.

#### 4.4 Robustness check (ii): a weaker tradables sector

The model estimated in section 3 is conditioned on the calibration of  $\phi$ , the parameter that measures the tradables component in the Consumer Price Index. This parameter is set to 0.5 in section 3 based on the split between tradables and nontradables for the Consumer Price Index used at the RBNZ. This calibration is identical to the calibration contained in Batini and Haldane (1999).

However, deciding whether broad categories of goods that comprise the consumer price index, for example fresh food and vegetables, are tradable or nontradable goods, is a difficult task. As a robustness check on the calibration of the tradables component of the Consumer Price Index,  $\phi$  is set to 0.25, implying tradable goods account for one quarter of the CPI.

An alternative view of this calibration is that of a weaker exchange rate channel. The uncovered interest rate parity condition may overstate the ability monetary policy has, in practice, to influence the real exchange rate.<sup>27</sup> The results of the alternative calibration for  $\phi$  are presented overleaf. Note that the loss function contains the three-year measure of inflation and that the FIML estimates are used for the remainder of the model of the economy.

<sup>27</sup> This is the view in West (2003). The UIP condition underpins his examination of the trade-offs involved in minimising exchange rate volatility within the New Zealand economy. However, West points out the “empirical failure” of UIP.

**Table 4: Addressing the 2002 PTA: smaller tradables sector**

$$L_t^s = (\tilde{\pi}_t - \tilde{\pi}^*)^2 + \lambda_1^s \tilde{y}_t^2 + \lambda_2^s i_t^2 + \lambda_3^s q_t^2$$

Column	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
LF	$\lambda_1^s$	$\lambda_2^s$	$\lambda_3^s$	Disc	Comm	$\hat{\pi}^c$	OD	$\hat{\pi}^{od}$	$\lambda_1^{cb}$	$\lambda_2^{cb}$	$\lambda_3^{cb}$
(i)	.5	0	0	0.88	0.54	0.58	0.69	0.43	0.15	0.00	0.00
(ii)	.5	.1	0	2.14	1.82	0.56	2.00	0.37	0.13	0.05	0.00
(iii)	.5	.25	0	3.41	2.49	0.79	3.15	0.51	0.04	0.11	0.00
(iv)	1	0	0	1.17	0.69	0.69	0.92	0.50	0.28	0.00	0.00
(v)	1	.1	0	2.70	2.30	0.64	2.53	0.41	0.33	0.05	0.00
(vi)	1	.25	0	4.04	3.40	0.80	3.77	0.51	0.24	0.10	0.00
(vii)	.5	0	.25	1.30	0.96	0.58	1.12	0.43	0.16	0.00	0.00
(viii)	.5	.1	.25	2.52	2.24	0.53	2.40	0.36	0.15	0.05	0.00
(ix)	.5	.25	.25	3.78	3.26	0.72	3.54	0.49	0.05	0.11	0.00
(x)	1	0	.25	1.59	1.12	0.69	1.35	0.49	0.29	0.00	0.00
(xi)	1	.1	.25	3.08	2.71	0.61	2.92	0.40	0.35	0.05	0.00
(xii)	1	.25	.25	4.40	3.85	0.71	4.16	0.49	0.25	0.11	0.00

The results are very similar to the baseline  $\phi$  calibration. The societal losses are almost identical to the baseline results presented in table 2. This implies that the gains from commitment policy are almost identical to the baseline case. Again, the stabilisation bias appears to be increasing in the weight society accords to the variance of the output gap.

Finally, the inflation conservatism result is replicated — the coefficients for the loss function the central bank should minimise are almost identical to the baseline results in table 2.

#### 4.5 Robustness check (iii): AD exchange rate effect

One empirical failure of the theoretical model is the insignificance of exchange rate effects on aggregate demand. However, most economists find plausible the notion that expenditure switching, on the part of both domestic and foreign consumers affects net exports, implying a strong theoretical motivation for including a real exchange rate argument within the aggregate demand equation.

For this reason, this section presents results that check whether the baseline results for targeting medium term inflation (presented in Section 4.2) remain similar to the results for a model augmented with a real exchange rate argument in the aggregate demand equation.

Within the theoretical model, the coefficient  $\beta_3$  represents the effect of the lagged real exchange rate on the output gap. Within this section, a coefficient of -0.2 is imposed on  $\beta_3$ , to represent the effect of the real exchange rate on the output gap. An appreciation of the real exchange rate decreases exports and increases imports implying the output gap falls through the net exports channel. The coefficient value is identical to the coefficient value imposed in Ball (1999) but twice as large as the coefficient Dennis (2003) imposes on the Australian economy.

**Table 5: Addressing the 2002 PTA: a role for net exports**

	$L_t^s = (\tilde{\pi}_t - \tilde{\pi}^*)^2 + \lambda_1^s \tilde{y}_t^2 + \lambda_2^s t_t^2 + \lambda_3^s q_t^2$										
Column	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
LF	$\lambda_1^s$	$\lambda_2^s$	$\lambda_3^s$	Disc	Comm	$\hat{\pi}^c$	ON	$\hat{\pi}^n$	$\lambda_1^{cb}$	$\lambda_2^{cb}$	$\lambda_3^{cb}$
(i)	.5	0	0	0.90	0.61	0.53	0.74	0.39	0.16	0.00	0.00
(ii)	.5	.1	0	2.12	1.87	0.50	2.02	0.31	0.17	0.06	0.00
(iii)	.5	.25	0	3.21	2.78	0.65	3.07	0.37	0.13	0.12	0.00
(iv)	1	0	0	1.13	0.78	0.59	1.00	0.35	0.54	0.00	0.00
(v)	1	.1	0	2.64	2.36	0.53	2.54	0.32	0.41	0.05	0.00
(vi)	1	.25	0	3.80	3.41	0.63	3.68	0.35	0.38	0.12	0.00
(vii)	.5	0	.25	1.32	1.03	0.54	1.17	0.39	0.18	0.00	0.00
(viii)	.5	.1	.25	2.62	2.31	0.55	2.49	0.35	0.19	0.05	0.03
(ix)	.5	.25	.25	3.80	3.33	0.68	3.73	0.26	0.41	0.20	0.25
(x)	1	0	.25	1.57	1.21	0.60	1.39	0.43	0.31	0.00	0.00
(xi)	1	.1	.25	3.13	2.80	0.57	2.99	0.37	0.40	0.04	0.00
(xii)	1	.25	.25	4.37	3.93	0.66	4.19	0.42	0.37	0.10	0.00

Across the selection of preferences in the table, allowing for a real exchange rate effect on aggregate demand, changes the results by a small magnitude only. For example, for the loss function parameterisation in row (i), the loss under discretion takes a value of 0.90, identical to the loss depicted for the baseline model in table 2

while the loss under commitment is 0.61, only marginally higher than the loss under commitment for the baseline model at 0.60. Similar results are obtained from comparing table 5 to table 2 — in general the loss under commitment is slightly higher in table 5, implying that the magnitude of the stabilisation bias is slightly smaller. This can be observed by directly comparing column VI of table 5 with column VI of table 2.

In addition, the gains from optimal negotiation are slightly smaller relative to the baseline model. This can be observed from comparing the inflation-equivalent welfare measures from optimal negotiation (contained in column VIII) in tables 2 and 5. On average, the inflation-equivalent measures are 20 per cent lower in table 5, where the model allows for a direct real exchange rate effect on aggregate demand.

Again, society's preferences are best served by asking the central bank to minimise a loss function with a lower weight on the variance of the output gap relative to the weight society places on the variance of the output gap. Interestingly, for the specification contained in row (ix), the loss function the central bank should minimise contains the same weight associated with minimising real exchange rate volatility as society. This contrasts with the other loss function specifications which suggest the central bank should have no or very little concern for real exchange volatility — even when society has a preference for minimising the variance of the real exchange rate.

However, in general, the broad results of the paper appear stable against the three robustness checks considered here.

## 5 Conclusion

If the Reserve Bank of New Zealand could credibly commit to a policy rule, it could achieve superior outcomes to discretionary policy, avoiding a stabilisation bias. This stabilisation bias could be substantial, based on the new-Keynesian model estimated within this paper.

The magnitude of the stabilisation bias appears to be increasing in the weight attached to minimising output volatility, and in the weight attached to minimising interest rate volatility. Expanding the PTA in these directions increases the stabilisation bias. However, increasing the time horizon of the inflation target appears to reduce the stabilisation bias slightly.

In addition, if (as assumed) commitment policy is not available to the RBNZ, the research presented in this paper suggests that it may be possible to improve on outcomes under discretionary policy by negotiating an alternative loss function — different from that of society — for the central bank to minimise. The improvement from such negotiation may be substantial. These gains to optimal negotiation seem robust against a range of preferences for society and to three model robustness checks.

How would a welfare optimising loss function differ from that of society? Given the model and the set of assumptions regarding societal preferences assumed within this paper, it transpires that the central bank should minimise a set of preferences that place a lower weight on output volatility than does society. This replicates the Rogoff (1985) result, that for strategic reasons, the central bank should be more inflation conservative than society.

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## Appendix A

Batini and Haldane (1999) derive the Phillip's curve (12) from a model of wage contracting. Specifically, the domestically price level is a weighted average of the nominal wage and last period's nominal wage:

$$p^d_t = 1/2[w_t + w_{t-1}] \quad (\text{A.1})$$

where  $p^d_t$  represents the domestic price level and  $w_t$  is the wage level. In addition, the consumer price index is a weighted average of the price of domestic goods and the price of foreign goods:

$$p^c_t = \phi p^d_t + (1 - \phi)e_t \quad (\text{A.2})$$

where  $p^c_t$  is the consumer price index and is the nominal exchange rate  $e_t$ . Note that equation (A.2) implies direct exchange rate pass-through.

Finally, the real wage is determined as a weighted average of the expected future real wage and last period's real wage, with the addition of a term that allows the real wage to respond to the level of demand, i.e.:

$$w_t - p^c_t = \chi_0[E_t(w_{t+1}) - E_t(p^c_{t+1})] + (1 - \chi_0)[w_{t-1} - p^c_{t-1}] + \chi_1(y_t - y_t^*) + \varepsilon_{wt} \quad (\text{A.3})$$

## Appendix B

The block exogenous foreign sector is modelled in a particularly simple fashion. Specifically, the foreign output gap takes an AR(1) process:

$$\tilde{y}^f_t = 0.8\tilde{y}^f_{t-1} + \varepsilon_{y_t^f} . \quad (\text{B.1})$$

The foreign inflation series also follows an AR(1) process:

$$\pi^f_t = 0.8\pi^f_{t-1} + \varepsilon_{\pi_t^f} . \quad (\text{B.2})$$

The foreign interest rate follows the Taylor rule:

$$i^f_t = 1.5\pi^f_t + 0.5\tilde{y}^f_t . \quad (\text{B.3})$$