Yield Curve Responses to Monetary Policy in the Presence of Asymmetric Information*

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March, 2006

Abstract

In response to monetary policy shocks, the market yield curve has been observed to shift or rotate. We use detailed data on the history of monetary policy changes in Australia and New Zealand over the past 15 years as an identification scheme in a latent factor model on daily term structure data. We demonstrate that the differing yield curve responses to unanticipated changes in monetary policy may reflect reactions to different types of monetary policy shock rather than differing reactions to the same policy shock. These different responses have recently been hypothesized to reflect information asymmetries between the monetary authority and other market participants.

Keywords: Monetary policy, yield curve, latent factor model, asymmetric information
JEL Classification: E44, E52, G12

*We are grateful to Vance Martin for comments and help, Christie Smith, Richard Gray, Andrew Stone and Mark Rodrigues for providing data and for comments from Renée Fry, Adrian Pagan, Warwick McKibbin, Chris Kent, and Iris Claus and participants at seminars at the Australian National University, the New Zealand and Australian Treasuries, the Reserve Bank of New Zealand and at the workshop "Recent Advances in Modelling Monetary Policy Shocks" on December 10, 2004 at the University of Melbourne. Dungey acknowledges funding from ARC Grant DP0343418.
1 Introduction

Changes in monetary policy do not produce consistent effects on the yield curve. In most instances, in line with the expectations hypothesis of the term structure, the yield curve shifts, as shown in Figure 1a. In other instances the yield curve rotates following a change in monetary policy, when changes in inflationary expectations mean that decreased short term rates result in higher long term rates, as shown in Figure 1b.

Figure 1: Response of Australian yield curves to a change in monetary policy

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<th>Figure 1a: Before and after a 25 b.p. decrease in the target cash rate</th>
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<td>![Graph 1a](source: Reserve Bank of Australia)</td>
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In this paper we investigate whether these observed yield curve responses reflect reactions to different types of monetary policy shock rather than alternative reactions to the same policy shock. Building on Craine and Martin (2003, 2004), a latent factor model that allows for two different yield curve reactions to monetary policy shocks is applied to Australian and New Zealand daily term structure data. As in Craine and Martin (2003, 2004) the model parameters are estimated with GMM. Monetary policy shocks occur on identifiable days within the sample period. The different moments generated on the policy and non policy days are used as information in estimating the model parameters. The empirical results for Australia support the notion that the type of yield curve response depends on the nature of the monetary policy shock while the findings for New Zealand are weaker.

Throughout this paper, yield data on secondary markets for all maturities are assumed to represent the yield curve. No compilation of intermediate maturities is undertaken here. In addition, the data are not stripped of their coupon payments to represent zero coupon yields.

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1 The monetary policy shocks are not random events over the entire sample, and hence estimation methods such as the Kalman filter are inappropriate. It is possible that the Kalman filter methodology may be applied to the two sub-samples while allowing for the same common and idiosyncratic shocks on monetary policy compared to non policy days. This is scope for future research.
yields. This is not anticipated to affect the results.  

The empirical model can be related to a recent theoretical model by Ellingsen and Söderström (2001) that reconciles the two observed yield curve reactions to monetary policy changes through the medium of information asymmetries. Both responses reflect information asymmetries between market participants and the central bank. The model distinguishes between two types of information asymmetry each triggering a specific change in market interest rates. Essentially, the response of the yield curve depends on whether the observed change in monetary policy reflects a change in the inputs to the central bank’s objective function or a change in the central bank’s objective function itself. In the first case, where new input information is received, this information is only apparent to the central bank but not to other market participants. This results in a shift in the yield curve. In the second case, the new central bank objective function is not known to the other market participants a priori, and has to be learned by the central bank’s response to new observed information. This is the case of a yield curve rotation.

Allowing for two distinct monetary policy shocks is consistent with recent work by Gürkaynak, Sack and Swanson (2004). Using an event study approach, the authors show that the effects of monetary policy on US asset prices are more accurately captured by two factors, rather a single monetary policy factor.

This paper also contributes to a new stream of literature identifying parameters for models of infrequent events using relatively high frequency data, in this case to identify monetary policy response parameters from daily term structure data; see Rigobon and Sack (2004) and Craine and Martin (2003, 2004).

The paper proceeds as follows. Section 2 outlines an empirically implementable specification for estimating the effects of changes in monetary policy on the yield curve. Section 3 links the empirical specification with the theoretical work of Ellingsen and Söderström. Section 4 gives a brief overview of monetary policy in Australia and New Zealand followed by the estimation results in Section 5. Section 6 extends the sample of monetary policy days to include those predetermined announcement days on which policy remained unchanged to explore whether these days provide additional relevant information. Section 7 offers some concluding remarks.

2 Other authors have used market interest rate data to represent yield curves; see, for example Mishkin (1990) and Diebold, Rudebusch and Aruoba (2004).
2 An Empirically Implementable Specification

Our aim is to investigate the presence of two types of unanticipated monetary policy shock causing shifts or rotations in the yield curve. One approach to understanding the effects of monetary policy moves on the yield curve is an event study along the lines of Cook and Hahn (1989) who set the scene for a considerable number of subsequent studies; see for example Hardy (1998) and Thornton (1998, 2004). In event studies, infrequent monetary policy event days are extracted from the higher frequency yield curve observations. A weakness of this type of model is that some changes in policy may be entirely expected by the market and can therefore not be construed as a ‘pure’ policy shock.

Addressing the unanticipated nature of monetary policy shocks, Sims (1992), Edelberg and Marshall (1996), Bagliano and Favero (1998), Evans and Marshall (1998) and Peersman (2002), for example, examine the effects of monetary policy in a VAR context. An alternative to the VAR approach is to use futures data to account for unexpected changes in monetary policy; see, for example, Kuttner (2001), Faust, Swanson and Wright (2004), and Gürkaynak, Sack and Swanson (2005).

Romer and Romer (1989, 1994, and 2004) pursue a completely different avenue for analyzing monetary policy shocks and examine historical Federal Reserve Board documents to isolate changes in US monetary policy that were in response to changed economic conditions from those that were in response to changes in the Federal Reserve’s preferences. In spirit similar to Romer and Romer, but relying on more formal quantitative analysis, Owyang and Ramey (2004) build a regime switching model to separate US monetary policy changes in response to changed economic activity from those in response to changed central bank preferences.

There are several draw-backs in using any of the above methods to test for the presence of differing monetary policy shocks. The use of VAR models including economic variables is problematic in the sense that the highest frequency possible are quarterly data. Interest rate data typically respond to shocks expeditiously. It may be difficult to extract from quarterly data the reaction of interest rates to an event occurring on a specific day.

A more important draw-back of any of the models discussed above is that they only distinguish between anticipated and unanticipated changes in monetary policy but do not differentiate between differing types of unanticipated monetary policy move. A potential avenue could be the Romer and Romer (2004) or Owyang and Ramey (2004) method aug-
mented with futures market data. However, neither central bank documents nor appropriate futures data are readily available for either Australia or New Zealand. Further, even if appropriate sources and data were available, an integrated model that identifies the shocks and estimates their effects on various market interest rate is preferable to a two step approach of first identifying the shocks and then estimating their effects on market interest rates.

In the finance literature, yield curves are often modeled in a latent factor model framework where yields are a function of one or more latent factors. Craine and Martin (2003, 2004) have recently applied this framework to modeling the effects of monetary policy shocks on financial assets. A factor model along these lines is an example of an integrated approach to identifying shocks and their effects within one empirical model. A latent factor model can incorporate the high frequency data and infrequent events into a single model.

It is relatively common to model financial markets data with

\[ r_{j,t} = \gamma_j a_t + \delta_j d_{j,t}, \]  

where \( r_{j,t} \) is the demeaned first difference of the interest rate at maturity \( j \) at time \( t \), \( a_t \) is a shock common to all maturities at time \( t \), and \( d_{j,t} \) represents the idiosyncratic shocks to \( r_{j,t} \); see the key study of Cox, Ingersoll and Ross (1985). The parameters \( \gamma_j \) and \( \delta_j \) are the factor loadings. These common shocks to all maturities may be, but do not necessarily have to be, macroeconomic shocks; see Ramchander, Simpson and Chaudhry (2005) for examples of macroeconomic surprises affecting six different US daily interest rates.\(^3\) This simple factor model is often extended to include more than one common shock, as for example in Knez, Litterman and Scheinkman (1994) and Dai and Singleton (2000). Multiple factors are included to represent different movements in the yield curve, such as changes in the level, the slope or the curvature of the yield curve; Diebold, Rudebusch and Aruoba (2004). Two curvature factors are added to equation (2), one which distinguishes the shorter end of the yield curve, and another which distinguishes the longer end of the yield curve. Augmenting equation (1) with these two additional common factors leads to

\[ r_{j,t} = \gamma_j a_t + \kappa_j I_k b_t + \tau_j I_\tau c_t + \delta_j d_{j,t}, \]  

where \( b_t \) and \( c_t \) are common factors representing changes in curvature and

\[ I_k = \begin{cases} 1 & \text{for } j < j^* \\ 0 & \text{otherwise} \end{cases} \]

\(^3\)The interest rates are the federal funds rate, the 3-year Treasury note rate, the 10-year Treasury note rate, the 30-year Treasury bond rate, the prime interest rate, and the Moody’s Baa corporate bond rate.
The value of \( j^* \) represents the maturity at which the long and short ends are distinguished.

The process in equation (2) applies to the interest rates on all days. In addition to these four shocks, the yield curve is presumed to respond to changes in monetary policy so that additional shocks apply on monetary policy days. Incorporating a monetary policy shock in equation (2) gives the Craine and Martin (2003) model

\[
  r_{j,t} = \alpha_j m_t + \gamma_j a_t + \kappa_j I \kappa b_t + \tau_j I \tau c_t + \delta_j d_{j,t},
\]

where \( m_t \) is the monetary policy shock with factor loading \( \alpha_j \) which is only applied on monetary policy days.

The focus of this paper is to investigate the existence of two different types of monetary policy shock causing different reactions in market yields. Thus the Craine and Martin (2003) model is extended to include a second monetary policy shock to allow for potentially differing responses to monetary policy shocks in the yield curve, as shown in Figures 1a and 1b. In the final model all interest rates respond to two types of monetary policy shock that apply only on monetary policy days. Including a second monetary policy shock in equation (3) gives,

\[
  r_{j,t} = \alpha_j m_t + \beta_j n_t + \gamma_j a_t + \kappa_j I \kappa b_t + \tau_j I \tau c_t + \delta_j d_{j,t},
\]

where \( n_t \) represents the second monetary policy shock with factor loading \( \beta_j \) which is only applied on monetary policy days. By assumption all shocks are independent and identically distributed with zero means and unit variances.

2.1 Identification

While initially equation (4) seems unidentified, there are identifying features. Monetary policy shocks (\( m_t \) and \( n_t \)) occur only on exogenously identified monetary policy days and can be separated from the common shock, \( a_t \). The common shocks \( b_t \) and \( c_t \) can be separated from each other and from \( a_t \) because they do not all apply to the same maturities. To separate the two monetary policy shocks, a restriction is imposed such that the effect of a given size of monetary policy movement at the short end of the yield curve is the same in each case so that \( \alpha_1 = \beta_1 \) where \( r_{1,t} \) represents the short term interest rate which is most closely related to changes in the central bank rate.

Imposing a rotation point in the estimation is an additional identification condition that could be imposed in an attempt to separate rotations from shifts in the yield curve. This is
achieved by setting $\beta_l = 0$ for some maturity $l = j$. That is, the yield curve does not change at some particular point identified as the rotation point. In the practical example which follows in Section 5, the maturity considered for the rotation point is the 5-year bond rate for both Australia and New Zealand. An alternative identification scheme may be to impose a shift in the yield curve for one of the monetary policy shocks, i.e., $\alpha_j = \alpha_l$, $\forall j, l$. However, to retain consistency with the theoretical model outlined below which postulates that the response of interest rates declines with maturity, no parallel shift is imposed in Section 5.

The practical separation of the shocks means that empirical identification can be achieved through the covariance matrix of the changes in interest rates across maturities. Using the independence assumption, on non monetary policy days, when $m_t = n_t = 0$, the covariance matrix, $\Omega_X$ of a system of $k$ maturities with $j^* = 3$ for the curvature shocks, is given by

$$
\Omega_X = \begin{bmatrix}
\gamma_1^2 + \kappa_1^2 + \delta_1^2 & \gamma_2 \gamma_1 & \gamma_2^2 + \kappa_2^2 + \delta_2^2 \\
\gamma_2 \gamma_1 & \gamma_1^2 + \kappa_1^2 + \delta_1^2 & \gamma_2^2 + \kappa_2^2 + \delta_2^2 \\
\ldots & \ldots & \ldots \\
\gamma_k \gamma_1 & \gamma_k \gamma_2 & \gamma_k^2 + \gamma_k^2 + \delta_k^2
\end{bmatrix}.
$$

On monetary policy days, the covariance matrix, $\Omega_M$ is given by

$$
\Omega_M = \begin{bmatrix}
\alpha_1^2 + \gamma_1^2 + \kappa_1^2 + \delta_1^2 & \ldots & \ldots \\
\alpha_2 \alpha_1 + \beta_2 \beta_1 + \gamma_2 \gamma_1 + \kappa_2 \kappa_1 & \ldots & \ldots \\
\ldots & \ldots & \ldots \\
\alpha_{k-1} \alpha_1 + \beta_{k-1} \beta_1 + \gamma_{k-1} \gamma_1 & \ldots & \alpha_{k-1} \alpha_k + \beta_{k-1} \beta_k + \gamma_{k-1} \gamma_k + \tau_{k-1} \tau_k \\
\alpha_k \alpha_1 + \beta_k \beta_1 + \gamma_k \gamma_1 & \ldots & \alpha_k \alpha_k + \beta_k \beta_k + \gamma_k^2 + \tau_k \tau_k + \delta_k^2
\end{bmatrix}.
$$

The model is estimated using GMM techniques, based on the second moments as specified in equations (5) and (6). In the case of an overidentified model, which occurs when there are four or more interest rates, the Hansen (1982) method for combining the generated moment conditions with the number of parameter estimates is implemented, using a Newey-West weighting scheme (Newey and West (1987) to determine the truncation for the autocovariance matrix. For examples of similar approaches see Craine and Martin (2003,2004) and Dungey (1999).

$^4$The model in equation (4) is overidentified when there are four or more interest rates (when the number of unique moments exceeds the number of parameters to be estimated).
3 Yield Curve Behavior in the Presence of Asymmetric Information

Ellingsen and Söderström (2001) posit a model based on information asymmetries as a means of generating yield curve shifts and rotations following a change in monetary policy. The model reconciles observed behavior of the yield curve to a consistent theoretical framework. The key is the potential existence of different information asymmetries between the monetary authority and other market participants. The first type of information asymmetry is information on the shocks impacting on the economy. Here, the central bank has superior information from the market. Market participants infer the nature of these shocks on the economy from the reaction of the central bank (and the central bank preferences remain unaltered) and the yield curve shifts. Thus the yield curve shifts in response to new information, and we label this an information move. The second type of information asymmetry occurs when the central bank changes its preferences. The market cannot observe this until a shock hits the economy and the central bank does not react in the anticipated way. In response to the new inferred information about the central bank preferences the yield curve rotates. This we label a preference move.

More formally, the model builds on the Svensson (1997, 1999) approach, augmented with an equation representing the term structure. The building blocks of the model are as follows:

\[ \pi_{t+1} = \pi_t + \alpha y_t + \epsilon_{t+1}, \]  \hspace{1cm} (7) \\
\[ y_{t+1} = \gamma y_t - \gamma (i_t - \pi_{t+1}|t) + \eta_{t+1}, \]  \hspace{1cm} (8) \\
\[ y_{t+1} = \gamma y_t - \gamma (i_t - \pi_t) + \eta_{t+1}, \]  \hspace{1cm} (9) \\
\[ i_t = \frac{1}{n} \sum_{s=0}^{n-1} i_{t+s}|t + \xi_t^n. \]  \hspace{1cm} (10)

Equation (7) represents a Phillips, where \( \pi_t \) is the deviation at time \( t \) of the inflation rate from its long run average (given the central bank’s inflation target) and \( y_t \) is the output gap. The output gap is mean reverting and negatively related to the ex ante short term interest rate, \( i_t \), as shown in equation (8) where \( i_t \) is the deviation of the short term interest rate (set

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3 An example of this superior information is described in Romer and Romer (2000). The authors show that Federal Reserve inflation forecasts outperform those of commercial forecasters.


7 Ellingsen and Söderström labelled information and preference moves as endogenous and exogenous moves - while the origin of these terms is appealing, they create confusion within the context of the empirical application so that we have chosen new labels.
by the central bank) from its long run equilibrium level. \( \pi_{t+1|t} \) is the inflation gap in \( t + 1 \) as expected in \( t \), or \( E_t[\pi_{t+1}] \). Taking the expectation of equation (7) and using equation (8) gives the output gap in equation (9), where \( \tilde{\beta} = \beta + \alpha \gamma \). Ellingsen and Söderström add the yield curve shown in equation (10). The interest rate on a discount bond of maturity \( n \) at time \( t \), denoted \( i^n_t \), is the average of expected future interest rates until maturity plus a term premium, where \( i_{t+s|t} \) is the expected short term interest rate \( s \) periods ahead, and \( \xi^n_t \) is the term premium at time \( t \) for maturity \( n \).

As is standard in this literature, the central bank minimizes an intertemporal loss function \( L_t \), which is quadratic in the deviations of inflation and the output gap, with a positive discount rate, \( \delta \), and a relative weight on output stabilization versus inflation stabilization given by \( \lambda \), with \( \lambda > 0 \) and \( \delta \geq 0 \).

\[
L_t = E_t \left[ \sum_{s=0}^{\infty} \delta^s L \left( \pi_{t+s}, y_{t+s} \right) \right] \tag{11}
\]

and

\[
L \left( \pi_t, y_t \right) = \frac{1}{2} \left[ \pi_t^2 + \lambda y_t^2 \right]. \tag{12}
\]

While market participants consider \( \lambda \) to be invariant, it is allowed to shift discretely. The central bank’s optimization problem is solved with respect to the expected output gap and leads to an optimal interest rate for the central bank given by:

\[
i_t = (1 + A) \pi_t + By_t, \tag{13}
\]

where \( A \) and \( B \) are both positive and depend on the parameters \( \alpha, \beta, \gamma, \delta \) and \( \lambda \) in a non-linear fashion.\(^8\) Equation (13) shows that the optimal interest rate is an increasing function of the current inflation rate and the output gap. Using this equation, the economy’s yield curve can be computed as a function of current inflation and output gaps as

\[
\sum_{s=1}^{n-1} i_{t+s|t} = [1 + A \left( 1 - \gamma B \right)] X_n [\pi_t + \alpha y_t], \tag{14}
\]

and the market interest rate of maturity \( n \) at any time \( t \) is given by

\[
i^n_t = \frac{1}{n} \left\{ \left[ 1 + A \right] \pi_t + B y_t + \left[ 1 + A \left( 1 - \gamma B \right) \right] X_n \left[ \pi_t + \alpha y_t \right] \right\} + \xi^n_t, \tag{15}
\]

where

\[
X_n = \frac{1 - (1 - \alpha \gamma A)^{n-1}}{\alpha \gamma A}. \tag{16}
\]

\(^8\) \( A = \frac{\alpha \delta k}{\gamma (1 + \alpha^2 \delta k)} > 0 \), \( B = \frac{\alpha}{2} + \alpha A > 0 \) and \( k = \frac{1}{2} \left[ \left( 1 - \frac{(1-\delta)\lambda}{\alpha^2 \delta} \right) + \sqrt{\left( 1 + \frac{(1-\delta)\lambda}{\alpha^2 \delta} \right)^2 + \frac{4 \lambda}{\alpha^2}} \right] \).
From equation (15) it is evident that when both the inflation and output gap are zero, market interest rates at different maturities are determined by their term premia, $\xi_t^n$. Equation (15) can be used to analyze the effects of shocks on the yield curve.

Ellingsen and Söderström show that their model can produce both shifts and rotations in the yield curve in response to monetary policy shocks. In their model, two potential types of asymmetric information are considered. The first is when the central bank has private information about a current demand or supply shock, (where demand and supply shocks correspond to $\eta_t$ from equation (8) and $\epsilon_t$ from equation (7)). In this case the resulting response of the yield curve to either a demand or supply shock is a shift in a single direction across all maturities; illustrated in Figure 2.

**Figure 2: Yield curve response to an information rise in the central bank rate**

![](image)

The second potential source of asymmetric information concerns the preference parameter of the central bank, $\lambda$. If the central bank changes the weight it attaches to output relative to inflation, and only the central bank knows this new value of $\lambda$ prior to the central bank reacting to a demand or supply shock, then the yield curve will rotate. The mechanism for this can be illustrated through a fall (rise) in the value of $\lambda$. A lower (higher) value of $\lambda$ represents a greater (smaller) emphasis on inflation stabilization by the central bank. Hence, a lower (higher) $\lambda$ is associated in the model with a larger (smaller) interest rate response by the central bank to a given shock. An unexpectedly large (small) response to a shock by the central bank causes market participants to revise downwards (upwards) their perceived value of $\lambda$ which leads to a higher (lower) short term interest rate, but lower (higher) long rates. Hence an unexpectedly high central bank rate tilts the yield curve clockwise while an unexpectedly low rate tilts the yield curve counterclockwise;\textsuperscript{9} illustrated in Figure 3.

\textsuperscript{9}Inertia in inflation and output are essential for these results, because changes in current monetary policy have long lasting effects. However, only a small degree of inertia is necessary.
In summary, the model has three key predictions: (i) the magnitude of the response of interest rates should be declining with maturity on non monetary policy days; (ii) short and long rates should move in the same direction if the central bank rate change is an information move; and (iii) short and long rates should move in opposite directions if the change is a preference move.

The implication of the Ellingsen and Söderström model is that the presence of both shifts and rotations in the yield curve in response to monetary policy changes is due to a difference in the monetary policy shock, characterized as either an information or preference change, rather than a change in the response to a single type of monetary policy shock. To examine this further we implement the empirical model described in Section 2 to consider first whether two separate shocks are identified in the data, and second whether the responses to those separate shocks clearly represent a shift and a rotation in line with the theoretical model.

The data requirements to implement the empirical model are a sufficient number of maturities in the term structure to identify the parameters (here the identification requires a minimum of four separate maturities) and an exogenous identification of monetary policy days. To obtain the latter in particular we consider data from Australia and New Zealand, both of whom have a relatively long history of explicitly announcing changes in monetary policy, and for whom a series of announcement dates prior to that exists in the literature. The next section briefly outlines the characteristics of monetary policy in these two countries.

4 Monetary Policy in Australia and New Zealand

New Zealand was the first country to implement a specific inflation target for monetary policy, announced in 1989. Australia followed a few years later, with the formal announcement of
inflation targeting occurring in 1993, but in practice probably some years earlier (see de Brouwer and Gilbert (2003)). However, more importantly for the current purposes is that both central banks began explicitly announcing and explaining changes in monetary policy, the Reserve Bank of Australia (RBA) in 1990 and, formally, the Reserve Bank of New Zealand (RBNZ) in 1999. This, with other information detailed below, gives an explicit chronology for the dates of monetary policy changes in the two countries.

**Australia**

Dating Australian monetary policy changes from January 1990 is straightforward due to the record of RBA press releases. Prior to this data are available in Dungey and Hayward (2000) from 1985 to 1989; these dates are used here with some adjustments for errors in the original work.\(^{10}\) The instrument of monetary policy in Australia has been the target cash rate (TCR) over the entire period, although the target of monetary policy was less clear in the mid-1980s (see, for example, the description of this period in Grenville (1997)). Since 1993 the RBA has been explicitly targeting inflation measured by the consumer price index (CPI),\(^{11}\) aiming at a band of 2-3 percent inflation per annum on average over the business cycle (or alternately phrased more recently as in the medium term). Since July 1997, the RBA has announced changes to the target rate on the day following its 11 monthly Board meetings - on the first Tuesday of each month except January - so that all changes since then have occurred on the Wednesday mornings following the first Tuesday of the month.

In total, there are 57 days on which monetary policy changed between October 1985 and May 2003. In those 18 years, the RBA decreased the TCR 37 times and increased the rate 19 times. As October 1985 is the first data point, it cannot be identified as an increase or a decrease. In addition, there are 50 Wednesdays following the first Tuesday of the month since July 1997 on which the TCR did not change.\(^{12}\)

Monetary authorities are often modeled as adjusting the central bank rate in response to changes in the output gap and the inflation gap with possibly higher preferences attached to one compared to the other, the so-called Taylor rule; see Taylor (1993). To see how past changes in the target cash rate might reflect the relative weight the RBA places on

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\(^{11}\) Until 1999 the headline inflation rate in Australia included mortgage interest costs, and hence was inappropriate. In practice the so-called underlying inflation rate (or Treasury underlying rate) was used as an indicator. In 1999 the CPI was amended to included imputed rent and became the formal focus of the inflation target.

\(^{12}\) The complete chronology of changes in monetary policy in Australia between 1985 and 2003 is available from the authors.
inflation and output stabilization we constructed these variables. Both are only available quarterly. The inflation gap reflects the deviation from a Hodrick-Prescott filter of inflation for the period 1985 to the end of 1992, with $\lambda = 1600$. From the first quarter of 1993, target inflation is represented by the mid-point of the target band, that is 2.5 percent per annum. The output gap was supplied by the RBA based on the methodology of Gruen, Robinson and Stone (2002) using real time data as described in Stone and Wardrop (2002).

Figure 4 plots the output and inflation gap of those quarters containing changes in the target cash rate. A decrease in the cash rate is identified by a square in the graph, while an increase is identified by a circle.

**Figure 4: Monetary policy moves - Australia**

Source: Australian Bureau of Statistics, Reserve Bank of Australia, The Australian Treasury and author estimates

Observations in the first (fourth) quadrant of coordinate system indicate above (below) long run values for both inflation and output. Hence, observations in the first quadrant are expected to be increases in the cash rate, and observations in the fourth quadrant to be decreases. Observations in the second (third) quadrant show combinations of above (below) long run inflation rates but below (above) long run output. Increases in the cash rate in the second quadrant and decreases in the third quadrant indicate greater preference toward inflation stabilization. The reverse supports a preference for output stabilization.

Figure 4 suggests that the RBA over this period has tended to decrease the cash rate when
output was below potential, even in the face of a positive inflation gap. Most moves in the second quadrant, including the two post 1993, have been falls in the cash rate. An interesting aside is the rises in the cash rate in 1988 and 1989 while output was below potential. This lends support to the view that the RBA held policy tight longer than was optimal; see, for example, Weber (1994), Dungey and Pagan (2000) and Gregory (2000).

**New Zealand**

New Zealand provides a particularly interesting case for examining information and preference shocks. Since inflation targeting was adopted in 1989, the target band has been adjusted twice. From 1990 to 1996, the RBNZ targeted CPI inflation of 0 to 2 percent per annum, 0 to 3 percent between 1996 and 2002 and has been targeting 1 to 3 percent per annum over the medium term since 2002.

Since March 1999, the official cash rate (OCR) has been the main monetary policy instrument. It is formally reviewed eight times a year, at the time of each quarterly *Monetary Policy Statement* and about halfway between each of these. Prior to March 1999 the RBNZ operated more informally, implementing monetary policy through public announcements, so called open mouth operations. These announcements generally caused market interest rates to change without any other formal actions by the RBNZ. Before June 1997, open mouth operations concerned the RBNZ’s desired path of short term interest rates, and between 1997 and 1999 on the desired path of the short-lived monetary conditions index (MCI) which was a weighted average of the 90-day bank bill rate and the trade-weighted exchange rate (TWI).

The dates for monetary policy changes from January 1989 to June 2003 were compiled from three sources: (i) the chronology of open mouth operations in Guthrie and Wright (2000) (covering January 1989 to September 1997); (ii) the RBNZ announcements of changes in the OCR (between March 1999 and June 2003); and (iii) the intervening period compiled by Claus (2005), who details the entire chronology of changes for our sample period.

Between January 1989 and June 2003, the RBNZ changed monetary policy 157 times. Policy was tightened 92 times and was loosened 65 times. Between January 1989 and March 1999, the RBNZ made 172 announcements. The desired direction of 83 of those announce-
ments was a policy tightening while 58 announcements aimed at loosening policy. The period also contains 31 Wednesday Morning Window (WMW) days on which policy remained unchanged. With the 26 May 1998 Monetary Policy Statement, the RBNZ announced that, barring any exceptional circumstances, statements or cash target changes would be made at 9.00 a.m. on Wednesdays. The RBNZ also announced that it would remain silent on these WMW days if it was broadly satisfied with the way conditions had evolved. Between March 1999 and June 2003, the RBNZ issued 36 statements. In these 36 statements, the RBNZ announced 16 rate changes, 7 decreases and 9 increase in the OCR.\(^\text{15}\)

![Figure 5: Monetary policy moves - New Zealand](image)

source: Statistics New Zealand and Reserve Bank of New Zealand

Figure 5 plots the output and inflation gaps for quarters containing a monetary policy change, where a square represents a tightening in policy and a circle a loosening. Where there was more than one move in a given quarter the assignment was based on the direction of the majority of the statements. In a few cases, 1996Q3, 1996Q4 and 1997Q4 this did not resolve the issue, so judgement was applied, 1996Q4 was identified as a loosening, and the others as tightenings.

The output gap is that published by the RBNZ in their historical Forecasting and Policy System (FPS) database and the September 2003 Monetary Policy Statement.\(^\text{16}\) No real time

\(^{15}\)The complete chronology of changes in monetary policy in New Zealand between 1989 and 2003 is available from the authors.

\(^{16}\)Drew and Hunt (1998) provide an overview of the FPS model and how the model is used to prepare
historical output gap series such as that constructed by the RBA is available for New Zealand. Instead, the output gap series covering the period 1985Q2 to 1991Q2 reported in the historical FPS database is spliced with that for the remaining period reported in the September 2003 Monetary Policy Statement.\textsuperscript{17} The inflation target data were provided by the RBNZ. The mid-points of the target range prior to 1993 are Bank internal estimates. For the remaining period, the target is the mid-point of the official band, that is, 1.0 per cent between 1993 and 1996, 1.5 per cent between 1996 and 2002 and 2.0 per cent thereafter. As before, the figure is a rough indication of the central bank’s preference towards inflation or output stabilization.

Figure 5 indicates that overall the RBNZ has tended to favour output stabilization. This is the same finding as that for the RBA. This is somewhat surprising because New Zealand has a ‘harder’ target than Australia. In New Zealand, the central bank governor may be dismissed if inflation wanders outside the target band.\textsuperscript{18} In Australia, on the other hand, inflation is expected to be within the target band on average over the economic cycle and no dismissal clause for the RBA governor exists.

An interesting aside is the tightening of monetary policy in 1997Q4, when both the inflation and output gap were negative (quadrant four). These tightenings may have been due to the breakdown of the MCI as a useful policy tool, particularly associated with the events of the Asian crisis in 1997-98, see Svensson (2001) and Ball (2000) for a discussion of the New Zealand experience with the MCI.

\section{5 Estimation and Results}

Table 1 presents sample statistics for both data sets. Columns 2 and 4 show the sample standard deviations of changes in Australian and New Zealand interest rates on monetary policy days and columns 3 and 5 on non monetary policy days. All interest rate changes are demeaned and are daily observations at annual rates measured in basis points. The Australian rates are 90-day and 180-day bank bill rates and 2-year, 5-year and 10-year Commonwealth Treasury bond rates. The New Zealand rates are 90-day bank bill rates and 1-year, 2-year, 5-year and 10-year Government bond rates. All interest rates are plotted in levels in Appendix A and in changes in Appendix B.

\textsuperscript{17}Comparing the overlapping output gap observations of the following five sources: series reported in the historical FPS database, the August 2000, August 2001, and September 2003 Monetary Policy Statements revealed similar movements in the series and led to the splicing of just two series to cover the entire estimation period.

\textsuperscript{18}Reserve Bank of New Zealand Act 1989 Section 49 (2) (d)
We excluded the 30-day rate from the estimation to avoid noise from expectation errors on the exact timing of monetary policy moves.\textsuperscript{19} Further, we excluded the changes in monetary policy in Australia between October 1985 and December 1988 from the estimation period. This was because the variability of changes in short term interest rates experienced a large decline in 1988. This break has an impact on the sample’s second moments which led to the exclusion of the first four years of available data. The shorter sample includes 40 monetary policy days.

<table>
<thead>
<tr>
<th>Bill/bond rate</th>
<th>Australia Standard deviation</th>
<th>New Zealand Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Changes in monetary policy</td>
<td>All other days</td>
</tr>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>90-day</td>
<td>22.713</td>
<td>4.831</td>
</tr>
<tr>
<td>180-day</td>
<td>21.295</td>
<td>5.651</td>
</tr>
<tr>
<td>1-year</td>
<td>16.255</td>
<td>8.351</td>
</tr>
<tr>
<td>2-year</td>
<td>17.800</td>
<td>8.049</td>
</tr>
<tr>
<td>5-year</td>
<td>12.661</td>
<td>8.421</td>
</tr>
<tr>
<td>10-year</td>
<td>10.202</td>
<td>8.004</td>
</tr>
</tbody>
</table>

No. of days: 40 (Australia) 3718 (Australia) 157 (New Zealand) 3598 (New Zealand)

Sample: Australia: 4 January 1989 to 30 May 2003
Sample: New Zealand: 26 January 1989 to 18 June 2003

The table shows that all interest rates experience greater variation on monetary policy days compared to non policy days but the gap narrows with increasing maturity. An interesting point is that the variation on non-policy days rises with maturity in Australia but falls with maturity in New Zealand.

The table reveals 40 monetary policy days and 3718 all other days for Australia between January 1989 and May 2003. The model in equation (4) is applied to 5 Australian interest rates implying $15 = k (k + 1) / 2$ identifying restrictions for monetary policy days and 9 monetary policy shock coefficients. The Australian sample includes 40 days on which monetary policy changed which means there are 600 unique moments\textsuperscript{20} to estimate 9

\textsuperscript{19}Coppel and Connolly (2003) show that from January 1985 to December 1989 only 11 percent and from January 1990 to July 1996 only 37 percent of changes in monetary policy in Australia occurred on the day following the RBA Board meetings.

\textsuperscript{20}There are 15 indentifying restrictions and 40 monetary policy days producing 600 unique moments.
coefficients.

Table 1 shows 157 monetary policy days and 3598 all other days for New Zealand between January 1989 and June 2003. The model in equation (4) is applied to 5 New Zealand interest rates implying 15 identifying restrictions for monetary policy days and 9 monetary policy shock coefficients. The sample includes 157 days on which monetary policy changed which means there are 2355 unique moments\(^{21}\) to estimate 9 coefficients.

### 5.1 Estimation results

Tables 2 and 3 show the estimation results from applying the latent factor model in equation (4) to Australian and New Zealand data.\(^{22}\) Both tables are divided into two panels. The upper panel of each table shows the baseline estimation for each country and the lower panel gives the results from imposing a rotation point at the 5-year bond rate for one of the two types of monetary policy shock. The degrees of freedom for computing the p-value for each coefficient reported in the tables are based on the number of monetary policy days for the two types of monetary policy shock and on the number of all other days for the common, the curvature and the idiosyncratic factors. The models are estimated using the Maxlik procedure in Gauss 5.0. The starting values are randomly drawn from a normal distribution. All estimations are insensitive to the starting values.

The estimations for New Zealand include one curvature factor rather than two as in the estimations for Australia. This is because the New Zealand sample includes more longer term interest rates than the Australian sample. The curvature factor for New Zealand is set to zero for the 90-day rate while the remaining curvature factor loadings are estimated in the model.

An interesting feature of the estimation results is that in all four cases reported in the tables, the estimated loadings for the 5-year maturities idiosyncratic factors are zero indicating that the 5-year rate may provide the benchmark behavior for the other maturities. In the final estimations, the factor loadings \(\delta_j\) corresponding to the 180-day and the 5-year maturities in the case of Australia and the 5-year rate in the case of New Zealand are set to

---

\(^{15\cdot40}\).

\(^{21}\) There are 15 indentifying restrictions and 157 monetary policy days producing 2355 unique moments \((2355 = 15\cdot157)\).

\(^{22}\) Craine and Martin (2003) apply the factor model to the errors of a VAR rather than directly to the changes in security prices. This is to purge the variables of their impact on each other and to reflect that all shocks are assumed to be white noise. Whether this approach is more suitable than the one used here is subject for future research.
zero. These parameters were initially estimated to be zero. The models are then re-estimated with a zero coefficient imposed on the parameters to ease the estimation.

5.1.1 Australian results

Table 2 shows the estimation results for Australia. The empirical model identifies two different yield curve responses to monetary policy shocks, a shift in the yield curve and a rotation, corroborating the three key theoretical predictions of the Ellingsen and Söderström (2001) model. The factor loadings for the type 1 monetary policy shock all have the same sign, $\alpha_j > 0$, $\forall j = 1, \ldots, 5$, while the factor loadings for the second monetary policy shock type switch signs. The factor loadings are positive for the 90-day to 5-year rates but negative for the 10-year rate, $\beta_j > 0$, for $j = 1, \ldots, 4$ and $\beta_5 < 0$.

Table 2 shows the response to common shocks is a shift in the yield curve. All factor loadings of the common shock are negative, $\gamma_j < 0$, $\forall j = 1, \ldots, 5$. The factor loadings of the common shock are negative rather than positive as predicted by the theoretical model. This may be a reflection of the type of common shocks that occurred over the sample period. A possible explanation for the negative coefficients is that there may have been more common shocks causing a downward shift than shocks causing an upward shift in the yield curve over the sample period.

Finally, barring the 90-day rate in the case of the type 1 monetary policy shock and the 90- and 180-day rate in the case of the common shock, the response is decreasing with rising maturity. The lower magnitude of the 90-day compared to the 180-day factor loading may be a consequence of the identifying assumption of setting $\alpha_1$ equal to $\beta_1$. This is supported by the estimation results from applying only one monetary policy shock. When applying only one monetary policy factor, the magnitude of response decreases with rising maturity for all yields.\(^{23}\)

All factor loadings in the top panel of Table 2 are significant at the 98 per cent level or higher except those for the 5- and 10-year rate of the type 2 monetary policy shock. Both of these factor loadings are significant at the 80 per cent level.

Figures 6a and 6b are graphical representations of the estimation results for the two types of monetary policy shock in the top panel of Table 2. The solid line is a fictional linear yield curve. The dashed line in Figure 6a shows the response of the synthetic market yield curve to the first type of monetary policy shock reported in column (2) in the top panel of Table 2.

\(^{23}\)The estimation results are available from the authors.
Table 2: Latent factor model parameter estimates for Australia

The results are those for equation (4). The table shows the factor loadings and p-values are in parenthesis.

<table>
<thead>
<tr>
<th>Bill/bond rate</th>
<th>Monetary policy shocks</th>
<th>Non monetary policy shocks</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \alpha_j ) (1)</td>
<td>( \beta_j ) (2)</td>
<td>( \gamma_j ) (3)</td>
<td>( \kappa_j ) (4)</td>
<td>( \tau_j ) (5)</td>
<td>( \delta_j ) (6)</td>
</tr>
<tr>
<td>90-day</td>
<td>14.008</td>
<td>14.008</td>
<td>-2.467</td>
<td>-3.138</td>
<td>0</td>
<td>2.643</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>180-day</td>
<td>15.776</td>
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<td>-4.474</td>
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<td>0</td>
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<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.004)</td>
<td>(0.009)</td>
<td></td>
</tr>
<tr>
<td>2-year</td>
<td>15.479</td>
<td>5.743</td>
<td>-7.668</td>
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<td>1.828</td>
<td>1.401</td>
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</tr>
<tr>
<td>5-year</td>
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<td>4.117</td>
<td>0</td>
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<td>(0.166)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td></td>
</tr>
<tr>
<td>10-year</td>
<td>5.963</td>
<td>-2.025</td>
<td>-5.741</td>
<td>0</td>
<td>4.944</td>
<td>2.582</td>
</tr>
<tr>
<td></td>
<td>(0.004)</td>
<td>(0.166)</td>
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<td>Overidentifying restriction test p-value</td>
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<td>Number of overidentifying restrictions</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Baseline model</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90-day</td>
<td>15.614</td>
<td>15.614</td>
<td>-2.520</td>
<td>-3.085</td>
<td>0</td>
<td>2.640</td>
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<td></td>
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<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>180-day</td>
<td>17.408</td>
<td>10.306</td>
<td>-3.471</td>
<td>-4.407</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td></td>
</tr>
<tr>
<td>2-year</td>
<td>10.362</td>
<td>2.850</td>
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<td>2.208</td>
<td>-1.736</td>
</tr>
<tr>
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<td>(0.000)</td>
<td>(0.003)</td>
<td>(0.000)</td>
<td>(0.001)</td>
<td>(0.000)</td>
<td></td>
</tr>
<tr>
<td>5-year</td>
<td>7.179</td>
<td>0</td>
<td>-6.786</td>
<td>0</td>
<td>4.425</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td></td>
</tr>
<tr>
<td>10-year</td>
<td>5.722</td>
<td>-1.488</td>
<td>-5.604</td>
<td>0</td>
<td>4.963</td>
<td>2.807</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.045)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Value of objective function</td>
<td>15.357</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Overidentifying restriction test p-value</td>
<td>0.082</td>
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<tr>
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<td>Number of overidentifying restrictions</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

*Imposing a rotation point at the 5-year rate*
Figure 6b shows the response of the synthetic market yields to the second type of monetary policy shock reported in column (3) in the top panel of Table 2.

Figure 6: Yield curve responses to monetary policy shocks - Australia

Figure 6a: Yield curve response to type 1 shock

Figure 6b: Yield curve response to type 2 shock

The two figures relate to Figures 2 and 3 in Section 3 which show the responses of market yields to the two types of shock in the presence of asymmetric information in the theoretical model of Ellingsen and Söderström. Figure 2 shows a shift in the market yield curve following an information monetary policy shock and Figure 3 shows a rotation in the yield curve following a preference monetary policy shock. The curves in Figures 6a and 6b resemble the theoretical figures of Section 3 closely.

The absolute magnitude of the factor loading on the 5-year rate is lower and less significant than that of the 10-year rate. This lead to a second estimation with a rotation point imposed on the 5-year rate. The results are shown in the lower panel of Table 2 and are broadly similar to those in the top panel. But notably, imposing a rotation point produces a negative coefficient at the 10-year rate that is significant at the 5 per cent level for the type 2 monetary policy shock, $\beta_5$ in the table. Testing the restricted model in the lower panel compared to the
unrestricted model in the upper panel by performing a likelihood ratio test produces an LR test statistic of 0.051 with an associated p-value of 0.822 implying that the restricted model cannot be rejected at the 17.8 per cent level.

5.1.2 New Zealand results

Table 3 presents the estimation results for New Zealand. The top panel of the table shows the baseline estimation results while the bottom panel gives those of imposing a rotation point on the type 2 monetary policy shock response at the 5-year bond rate.

The estimation results provide some support for the theoretical predictions of the Ellingsen and Söderström model. The results are similar to those for Australia with the exception that both monetary policy shock responses are shifts in the yield curve. All factor loadings for both types of shock are positive, $\alpha_j, \beta_j > 0, \forall j = 1, \ldots, 5$, but the two shifts can be separated into one with a relatively stronger response and one with a much weaker response. Further, the model identifies a shift in the yield curve in response to common shocks. In line with the findings for Australia, the factor loadings on the common shock, $\gamma_j$, are negative which may also be an indication that the majority of common shocks over the sample period have put downward pressure on yields. Barring the factor loadings on the 90-day rate for the type 1 monetary policy shock, $\alpha_1$, and the common shock, $\gamma_1$, the magnitude of the response is decreasing with maturity. Hence overall, the empirical findings provide support for the first and second key predictions of the theoretical model.

Figures 7a and 7b are graphical representations of the estimation results for the two types of monetary policy shock in Table 3. The solid line is a fictional linear yield curve. The dashed line in Figure 7a shows the response of the synthetic market yield curve to the first type of monetary policy shock reported in column (2) in the top panel of Table 3. Figure 7b shows the response of the synthetic market yields to the second type of monetary policy shock reported in column (3) in the top panel of Table 3.

As before, the two figures relate to Figures 2 and 3 in Section 3 which show the responses of market yields to the two types of shock in the presence of asymmetric information. While Figure 7a is comparable to the theoretical figure of Section 3, less similarity is observed between Figure 7b and the theoretical figure resonating the results that the New Zealand estimation provide only limited support for the theoretical predictions.

As in Australia, the factor loading on the 5-year bond rate of the type 2 monetary policy shock is lower and less significant than that of the 10-year rate which also leads to a second
Table 3: Latent factor model parameter estimates for New Zealand

The results are those for equation (4). The table shows the factor loadings and p-values are in parenthesis.

<table>
<thead>
<tr>
<th>Bill/bond rate</th>
<th>Monetary policy shocks</th>
<th>Non monetary policy shocks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\alpha_j$</td>
<td>$\beta_j$</td>
</tr>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>Baseline model</td>
<td></td>
<td></td>
</tr>
<tr>
<td>90-day</td>
<td>9.870</td>
<td>9.870</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>1-year</td>
<td>11.152</td>
<td>3.744</td>
</tr>
<tr>
<td></td>
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<td>(0.011)</td>
</tr>
<tr>
<td>2-year</td>
<td>8.873</td>
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</tr>
<tr>
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<td>(0.000)</td>
<td>(0.013)</td>
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<tr>
<td>5-year</td>
<td>5.542</td>
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</tr>
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<td>(0.000)</td>
<td>(0.089)</td>
</tr>
<tr>
<td>10-year</td>
<td>2.908</td>
<td>1.994</td>
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<tr>
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<td>(0.004)</td>
<td>(0.038)</td>
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<tr>
<td>Value of objective function</td>
<td>15.326</td>
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</tr>
<tr>
<td>Overidentifying restriction test p-value</td>
<td>0.053</td>
<td></td>
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<tr>
<td>Number of overidentifying restrictions</td>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>

Imposing a rotation point at the 5-year rate

<table>
<thead>
<tr>
<th>Bill/bond rate</th>
<th>Monetary policy shocks</th>
<th>Non monetary policy shocks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\alpha_j$</td>
<td>$\beta_j$</td>
</tr>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>90-day</td>
<td>10.056</td>
<td>10.056</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>1-year</td>
<td>10.325</td>
<td>2.761</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.019)</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>5-year</td>
<td>4.752</td>
<td>0</td>
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<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>10-year</td>
<td>2.283</td>
<td>0.635</td>
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<tr>
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<tr>
<td>Value of objective function</td>
<td>16.784</td>
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<tr>
<td>Overidentifying restriction test p-value</td>
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<td>Number of overidentifying restrictions</td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>

sample: 26 January 1989 to 18 June 2003
estimation with a rotation point imposed on the 5-year rate. The lower panel of Table 3 shows the estimation results. The factor loadings of the two types of monetary policy shock remain virtually unchanged, displaying shifts in the yield curve. While the magnitude of the factor loadings for the common and curvature factors remain the same their signs switch. This is cause for concern and may be a sign that the model is incorrectly specified.

Figure 7: Yield curve responses to monetary policy shocks - New Zealand

Figure 7a: Yield curve response to type 1 shock

Figure 7b: Yield curve response to type 2 shock

6 Alternative Choice of Monetary Policy Sample

In the previous section, the data on monetary policy days included only those days when monetary policy changed. Craine and Martin (2003) however suggest that there is also information in days when monetary policy could have changed but did not. The idea is that unchanged monetary policy may also be unanticipated and may hence represent information or preference monetary policy shocks. This section presents the estimation results from including all predetermined monetary policy days in the sample of monetary policy days. The sample is extended to include all possible policy days, those on which policy changed
and those on which policy could have potentially changed but did not. The latter days can be identified in Australia for the post July 1997 period and in New Zealand for the post May 1998 period as predetermined announcement days. This is the identification approach used in Craine and Martin (2003).

### 6.1 New monetary policy changes

Table 4 shows the updated number of monetary policy days for Australia and New Zealand. The table shows the number of days monetary policy changed (column 2), the number of days policy could have changed but did not (column 3), and the total number of monetary policy days (column 4 = column 2 + column 3).

<table>
<thead>
<tr>
<th>Sample</th>
<th>Change (2)</th>
<th>No change (3)</th>
<th>Total policy days (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Jan. 1989 to 30 May 2003</td>
<td>40</td>
<td>50</td>
<td>90</td>
</tr>
</tbody>
</table>

For Australia, the number of monetary policy days more than doubles. The table reveals 90 monetary policy days between January 1989 and May 2003. These include 40 days when the TCR changed and 50 pre-determined announcement days when the TCR remained unchanged.

For New Zealand, the number of monetary policy days rises 33 per cent. Table 4 shows 209 monetary policy days between January 1989 and June 2003 consisting of 157 days when monetary policy actually changed and 52 pre-determined announcement days on which policy remained unchanged.

### 6.2 New estimation results

Tables 5 and 6 present the new estimation results of the baseline specification of the previous section including the additional monetary policy days. The tables show the factor loadings and p-values are in parenthesis. As before the p-values of the monetary policy factor loadings

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24 Estimating unrestricted models for Australia and New Zealand leads to the same idiosyncratic and curvature factors restrictions as in the previous section.
are based on the number of monetary policy days while all other factor loadings are based on the number of all other days.

Table 5: New estimation results for Australia
The results are those for equation (4). The table shows the factor loadings and p-values are in parenthesis.

<table>
<thead>
<tr>
<th>Bill/bond rate</th>
<th>Monetary policy shocks</th>
<th>Non monetary policy shocks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\alpha_j$</td>
<td>$\beta_j$</td>
</tr>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>Baseline model</td>
<td>90-day</td>
<td>10.153</td>
</tr>
<tr>
<td></td>
<td>(8.711)</td>
<td>(8.711)</td>
</tr>
<tr>
<td></td>
<td>180-day</td>
<td>9.653</td>
</tr>
<tr>
<td></td>
<td>(10.153)</td>
<td>(5.802)</td>
</tr>
<tr>
<td></td>
<td>2-year</td>
<td>9.653</td>
</tr>
<tr>
<td></td>
<td>(10.153)</td>
<td>(5.802)</td>
</tr>
<tr>
<td></td>
<td>5-year</td>
<td>6.405</td>
</tr>
<tr>
<td></td>
<td>(6.405)</td>
<td>(2.150)</td>
</tr>
<tr>
<td></td>
<td>10-year</td>
<td>2.881</td>
</tr>
<tr>
<td></td>
<td>(2.881)</td>
<td>(0.448)</td>
</tr>
</tbody>
</table>

Value of objective function: 14.331
Overidentifying restriction test p-value: 0.074
Number of overidentifying restrictions: 8

Overall, the estimation results are similar to those of the previous section which include only those monetary policy days on which policy actually changed. While the monetary policy factor loadings are broadly similar, the overall results are much weaker. The p-values associated with the longer end of the yield curve of the type 2 monetary policy shock are less significant in the estimations presented in this section compared to the previous section. This supports the view that little additional information is contained on those predetermined monetary policy days on which policy could have changed but did not. While there probably are some days when markets anticipated a change in policy which did not materialize and which may represent information or preference moves, the share of those days is expected to be small. This means that including the days on which policy could have changed but did not dilutes the robustness of the estimation rather than adding information and may even
bias the results; an avenue for further research is to determine the existence and extent of such bias by Monte Carlo simulations.

### Table 6: New estimation results for New Zealand

The results are those for equation (4). The table shows the factor loadings and p-values are in parenthesis.

<table>
<thead>
<tr>
<th>Bill/bond rate</th>
<th>Monetary policy shocks</th>
<th>Non monetary policy shocks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \alpha_j )</td>
<td>( \beta_j )</td>
</tr>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>Baseline model</td>
<td></td>
<td></td>
</tr>
<tr>
<td>90-day</td>
<td>11.417</td>
<td>11.417</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>1-year</td>
<td>11.260</td>
<td>5.025</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>2-year</td>
<td>8.924</td>
<td>3.174</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.002)</td>
</tr>
<tr>
<td>5-year</td>
<td>5.419</td>
<td>1.188</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.016)</td>
</tr>
<tr>
<td>10-year</td>
<td>3.262</td>
<td>1.532</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.024)</td>
</tr>
<tr>
<td>Value of objective function</td>
<td>8.785</td>
<td></td>
</tr>
<tr>
<td>Overidentifying restriction test p-value</td>
<td>0.361</td>
<td></td>
</tr>
<tr>
<td>Number of overidentifying restrictions</td>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>

Sample: 26 January 1989 to 18 June 2003

### 7 Concluding Remarks

This paper takes a closer look at the effects of changes in monetary policy on the yield curve based on the observation that the yield curve sometimes shifts and sometimes rotates in response to monetary policy shocks. The paper builds a model to investigate if these different responses can be distinguished empirically as suggested by the theoretical framework of Ellingsen and Söderström. Extending Craine and Martin (2003), we propose a latent factor model and show how it can be implemented to test the framework of the Ellingsen and Söderström model. The empirical model is then applied to Australian and New Zealand daily interest rates between 1989 and 2003.

Event studies or VAR models have typically been utilized to investigate the effects of monetary policy changes on market interest rates. A latent factor model has three advantages
over more traditional approaches. First, and most importantly, it allows for the presence
of two types of unanticipated monetary policy shock. Second, it represents an integrated
approach, that is, the types of unanticipated monetary shock are estimated within the model
rather than classifying the monetary policy changes first and then estimating their effects on
market interest rates. Third, the empirical application follows the new literature of identi-
fying less frequent shocks using relatively high frequency data developed in Rigobon (2003),

The empirical results for Australia support the notion that the type of yield curve response
depends on the nature of the monetary policy shock while the findings for New Zealand are
weaker.

The empirical results have important implications for researchers and policy makers.
First, there is strong evidence that it may be desirable to model monetary policy in a flexible
way which allows for different types of monetary policy move. For policy makers the results
show that changes in monetary policy may cause varied responses in asset markets, which
may cause different responses in the real economy.

Second, the estimation results show that identifying monetary policy shocks on those
days when policy changes is preferable to identifying monetary policy shocks on all possible
policy days. Using the latter sample as monetary policy days produces similar but less
robust estimation results. This suggests that little additional information is contained in
those monetary policy days when policy did not change and including them in the estimation
framework dilutes the results.

The third aim of the paper was to contribute to the emerging stream of literature that
identifies parameters for models of relatively infrequent events with more frequent data.
These types of model are particularly useful when analyzing the effects of monetary policy.
For example, Rigobon and Sack (2004) show that events study estimates may be biased.

In a theoretical framework Ellingsen and Söderström postulate that different yield curve
behavior may result from information asymmetry between the central bank and the mar-
ket. The signs of the estimated factor loadings for New Zealand are not supported within
the framework they propose. This may not necessarily mean the theoretical framework is
incorrect. The results could suggest that the preference move is not dominant enough to
identify it as distinctively different from the information move. The RBNZ may simply not
have changed its preferences often enough over the past decade and a half.
References


A Appendix – Levels of Australian and New Zealand Interest Rates

Australia

- 90-day bank bill rate and target cash rate
- 180-day bank bill rate and target cash rate
- 2-year Commonwealth Treasury bond rate and target cash rate
- 5-year Commonwealth Treasury bond rate and target cash rate
- 10-year Commonwealth Treasury bond rate and target cash rate
New Zealand

- **90-day bank bill rate and overnight cash rate**
- **1-year Government bond rate and overnight cash rate**
- **2-year Government bond rate and overnight cash rate**
- **5-year Government bond rate and overnight cash rate**
- **10-year Government bond rate and overnight cash rate**
B Appendix – Changes in Australian and New Zealand Interest Rates

Australia

- 90-day bank bill rate and target cash rate
- 180-day bank bill rate and target cash rate
- 2-year Commonwealth Treasury bond rate and target cash rate
- 5-year Commonwealth Treasury bond rate and target cash rate
- 10-year Commonwealth Treasury bond rate and target cash rate
New Zealand

90-day bank bill rate and overnight cash rate

1-year Government bond rate and overnight cash rate

2-year Government bond rate and overnight cash rate

5-year Government bond rate and overnight cash rate

10-year Government bond rate and overnight cash rate