DEPARTMENT OF ECONOMICS AND FINANCE

COLLEGE OF BUSINESS AND ECONOMICS

UNIVERSITY OF CANTERBURY

CHRISTCHURCH, NEW ZEALAND

Operating Procedures and the Expectations Theory of the Term Structure of Interest Rates: A Note on the New Zealand Experience from 1989 to 2008

Alfred Guender and Allan G.J. Wu

WORKING PAPER

No. 72/2010

Department of Economics and Finance
College of Business and Economics
University of Canterbury
Private Bag 4800, Christchurch
New Zealand

Operating Procedures and the Expectations Theory of the Term Structure of Interest Rates: A Note on the New Zealand Experience from 1989 to 2008

By

Alfred V Guender*

and

Allan G.J. Wu

Department of Economics

University of Canterbury

November 2010

JEL: E43, E52

Abstract: The operating procedure of a central bank influences in no small measure whether the behavior of interest rates is consistent with the expectations hypothesis. In New Zealand, the predictive content of the term spread improves markedly in the wake of the switch from a quantity-based to a price-based operating procedure in March 1999. The Official Cash Rate system has made it easier for market participants to understand the day-to-day conduct of monetary policy. As a result, market interest rates have become more predictable, thereby contributing to the success of the expectations hypothesis in explaining the behavior of yields on very short-dated financial instruments.

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*Corresponding Author: Department of Economics, University of Canterbury, Private Bag 4800, Christchurch, New Zealand. E-mail: Alfred.Guender@Canterbury.ac.nz

We would like to thank Phil Meguire, Leo Krippner, Mathias Moersch, and seminar participants at the University of Canterbury for making helpful comments and suggestions. All errors are the sole responsibility of the authors.

In an influential paper, Mankiw & Miron (1986) conjecture that the implementation of monetary policy bears on the validity of the expectations hypothesis of the term structure of interest rates (EHTS). Employing a simple two-period framework, they find supportive evidence for the expectations hypothesis in short-term US data before the founding of the Federal Reserve in 1915 but none after. In their view, the founding of the Federal Reserve had led to a dramatic change in the behavior of interest rates – it had significantly reduced the predictability of interest rates – and hence diminished the ability of the term spread to predict future changes in short term interest rates. Mankiw and Miron's findings have not gone unchallenged.[1] For example, Kool & Thornton (2004) argue that the econometric methodology employed by Mankiw and Miron tends to generate supportive results for the expectations hypothesis during periods when short-term interest rates are relatively more volatile than long-term interest rates. They also argued that the EHTS receives more support when the term spread is negative, i.e. when the yield curve is inverted.

In this paper, we test the expectations hypothesis on New Zealand data. Our approach is by and large the same as Mankiw and Miron's (1986). We test the empirical validity of the theory at the short end of the maturity spectrum, using 30-day and 60-day and 90-day and 180-day bank bill rates, respectively, in a two-period framework. The sample period begins in the late 1980s and ends midway through 2008 before the collapse of Lehman Brothers rattled financial markets the world over. Central to our analysis is the occurrence of a substantive change in the operating procedure of the Reserve Bank of New Zealand in March 1999. At the time, the Reserve Bank realized the need to switch from a quantity-based to a price-based operating procedure in an effort to make the conduct of monetary policy more efficient, transparent, and predictable. By international standards the volatility of market interest rates had become unacceptably high under the quantity-based operating scheme and therefore compromised the Reserve Bank's ability to communicate its intentions effectively to financial market participants. We show that the switch to the Official Cash Rate (OCR) system made market interest rates more predictable. More importantly, we find more evidence in support of the expectations hypothesis in the OCR period. The ability of the term

[1] Some of the criticism is actually leveled against a companion paper. Mankiw, Miron, and Weil (MMW) (1987) claim that the founding of the Fed fundamentally changed the behavior of short term interest rates in the United States. Fishe and Wohar (1990) question the reliability of the data used in the study and challenge MMW's finding that the structural break in the 180-day rate coincided with the founding of the Fed. Examining the behavior of short-term interest rates around the time the Fed was created, Angelini (1994) finds no evidence for a regime change. In their reply, MMW (1994) point to the low power of the test employed by Angelini.

spread to predict changes in the short term interest rate improved markedly after the adoption of the OCR system. Our findings thus confirm the connection between the operating procedure, which affects the predictability of interest rates, and the empirical validity of the expectations hypothesis.[2]

The rest of the paper is organized as follows. Section II presents the gist of the expectations hypothesis. Section III describes the operating procedure before and after March 1999. Section IV presents the empirical findings. Section V concludes.

II. The Basic Model

This section briefly reviews the expectations hypothesis of term structure in a simple two-period model. Let r_t and R_t be the one-period and two-period bank bill rate, respectively. The expectations hypothesis posits that

$$R_t = \theta + \frac{1}{2}(r_t + E_t r_{t+1}) \ , \tag{1}$$

where E_t defines the expectation formed at time t. Equation (1) describes the arbitrage-free condition that the return from investing in a two-period bill equals the expected return from investing sequentially in two one-period bills, plus a constant term premium θ. Rewrite Equation (1) as

$$E_t r_{t+1} - r_t = -2\theta + 2(R_t - r_t) \ . \tag{2}$$

The term spread between the long rate and the short rate should reflect the market's prediction about future movements in short-term interest rates. Assuming that market forecasts are correct on average, the future short rate equals the sum of the expectation and a forecast error:

$$r_{t+1} = E_t r_{t+1} + v_{t+1} \ , \tag{3}$$

[2] In an earlier study of the expectations hypothesis covering only the pre-OCR period, Guthrie, Wright and Yu (1999) report that the theory describes the behavior of interest rates in New Zealand reasonably well, at least in comparison with the United States. They conjecture that the success of the expectations hypothesis in New Zealand is a direct consequence of the Reserve Bank's manipulation of short-term interest rates over the 1989-1998 period. Because short term interest rates were far more predictable in New Zealand compared to the United States, the expectations hypothesis describes the behavior of short-term interest rates better in New Zealand than in the United States. This is essentially the argument advanced by Mankiw and Miron (1986), Rudebusch (1995), and McCallum (2005).

where v_{t+1} is orthogonal to information available at time t.

To set up the conventional test of the expectations theory, substitute (3) into (2) and parameterize the equation as

$$r_{t+1} - r_t = \alpha + \beta(R_t - r_t) + v_{t+1} \quad (4)$$

For the expectations theory to hold, point estimates of β should not be significantly different from two. The null and alternative hypotheses underlying the test are:

H_0: $\beta = 2$ and H_A: $\beta \neq 2$ (5)

For the constant, the null and alternative hypotheses are:

H_0: $\alpha = -2\theta$ and H_A: $\alpha \neq 2\theta$ (6)

We test examine the predictive ability of the term spread using yields on New Zealand bank bills. Bank bills are backed by or issued by commercial banks to raise funds in the wholesale money market. They usually have a term to maturity of 30, 60, 90, or 180 days. 90-day bank bills are a major source of funding for home mortgages and working capital. The simple two-period framework allows us to consider two cases. The first case treats the 30-day bank bill rate as the short rate and the 60-day bank bill rate as the long rate. The second case treats the 90-day bank bill rate, which is by far the most watched interest rate in the money market, as the short rate and the 180-day as the long rate.

Given the critical importance of a central bank's operating procedure in determining the validity of the expectations hypothesis in empirical tests, we describe in the next section the distinctive features of the two operating procedures which the Reserve Bank of New Zealand has followed since the 1980s.

III. Operating Procedures

A. The Cash Settlement Balances (CSB) System

The complete overhaul of the monetary policy framework in New Zealand preceded the adoption of the Reserve Bank Act of 1989 by about three years. The hallmark of the operating procedure by which monetary policy was implemented from 1986 until March 17th, 1999 was an announced target for the supply of cash settlement balances (free reserves in circulation at the end of the business day). By its very nature the focus of this operating procedure rested squarely on ensuring that the quantity of actual cash settlement balances in circulation was roughly in line with the announced target after accounting for all inflow into and outflows from the government account. To meet the target for cash settlement balances, the Reserve Bank carried out open market operations on a daily basis.

If conditions warranted a change in monetary policy, the Reserve Bank sought to steer market interest rates in the desired direction. To achieve this outcome, the Reserve Bank could either change the supply of or affect the demand for cash settlement balances. By changing the target for cash settlement balances outright, the Bank was in a position to affect commercial banks' access to cash settlement balances, A larger (smaller) supply of settlement balances would lead to lower (higher) overnight interest rates and flow on to other short-term interest rates. The Reserve Bank issued its own short-term securities to affect liquidity in the financial sector. By varying the supply of these bills, the Reserve Bank sought to influence the demand for cash settlement balances.[3] For instance, a reduction in the supply of Reserve Bank bills was to make commercial banks bid more aggressively for cash settlement balances in the inter-bank market, thereby pushing up short-term interest rates. The two remaining tools to affect monetary conditions through the demand for cash settlement balances were the discount margin and the payment of interest on cash settlement balances held on deposit at the Reserve Bank. By increasing the discount margin, the Reserve Bank made it more costly for commercial banks to acquire access to cash settlement balances via the sale of Reserve Bank bills. Hence the commercial banks would again bid more vigorously for cash settlement balances in the inter-bank market, thereby pushing up short-term interest rates. Raising the yield on balances on deposit with the Reserve Bank lowered the opportunity cost of holding cash settlement balances and induced commercial banks to step up their demand for additional cash balances. Interestingly, the yield on these balances was 65 percent of the yield on seven-day bank bills (similar to bank-backed commercial paper), a market-determined interest rate![4]

This operating procedure proved to be wanting in several respects. First and foremost, the quantity-based CSB system failed to translate enunciated changes in the stance of monetary

[3] These bills were auctioned off twice a week in tenders of NZ$ 70 million each and had a term to maturity of 63 days. Bills with less than 28 days to maturity could be redeemed for cash settlement balances without penalty.
[4] Starting in December 1991, the deposit rate was changed to the yield on seven-day bank bills less 300 basis points.

policy to predictable changes in short-term market interest rates. Financial market participants found it exceedingly difficult to map an announced change in the target, say a reduction of the target by NZ$ 5 million, into the desired change in the most important short term interest rate, the 90-day bank bill rate. Was it to bring about a 25 basis point change? Or even a 50 basis point change?[5] Because of the absence of a tight link between changes in the target for CSB and market interest rates, the Reserve Bank had to communicate its policy intentions by way of statements on monetary conditions. Thus monetary policy was factually implemented by commenting on whether current market interest rates and the exchange rate were at levels commensurate with achieving price stability. For a while, every Wednesday the Reserve Bank gave an assessment on the appropriateness of monetary conditions. To facilitate communication with financial market participants, the Reserve Bank adopted in the mid-1990s a monetary conditions index which served as an operating target in the implementation of monetary policy.

Due to the opaque nature of the way monetary policy was implemented the volatility of short-term interest rates in New Zealand was exceedingly high by international standards. Table 1 shows the average absolute daily change in the 90-day bank bill rate in New Zealand was nearly six times higher than in the United States, nearly 4 times higher than in Britain, more than 2.5 times higher than in Australia and more than 1.5 times higher than in Canada. Towards the end of the decade when monetary policy signals were transmitted via the monetary conditions index, fluctuations in the 90-day bank bill rate in New Zealand even worsened while they decreased by more than 50 percent in Canada, the United Kingdom, and the United States. A marked increase in the volatility of the value of the domestic currency vis-à-vis the US Dollar, the Japanese Yen, and the German Mark complicated matters further during the Asian Currency crisis in 1997 and thereafter.[6] At the time the Reserve Bank realized that it could not do much about the ups and downs of the value of the domestic currency in the foreign exchange markets. Foreign exchange market intervention was ruled out as a policy prescription. Faced with this situation, the Reserve Bank concluded that a

[5] The final change of target for cash settlement balances occurred in August 1995, three and a half years prior to the introduction of the Official Cash Rate. The Reserve Bank realized early on that the CSB target operating procedure was beset with systemic problems. For instance, given the small size of the financial markets and the limited supply of Reserve Bank bills in circulation, there was an incentive for commercial banks to hoard them in an attempt to control the cash market. This led to sizeable periodic differences between the overnight cash rate and the 90-day bank bill rate.

[6] The standard deviation of changes in the daily exchange rate of the NZ Dollar to the US Dollar over the July 1996-1999 period increased to 0.0040 from 0.0029 during the 1994- June 1996 period. The standard deviation of changes the NZ Dollar/Japanese Yen exchange rate increased from 0.4563 in the 1994-June 1996 period to 0.6172 in the July 1996 –Jan 1999 period. For the NZ Dollar/German Mark exchange rate, the standard deviation increased from 0.0069 to 0.0086 over the same periods.

complete revamp of its operating procedure was necessary to lessen the volatility of short-term interest rates in the domestic financial market.

B. The Official Cash Rate System

As early as 1996 the Reserve Bank realized the need for switching to a price-based operating procedure. However, the decision to guide market expectations about the course of future monetary policy with the help of a monetary conditions index delayed the introduction of the Official Cash Rate system by a little more than two years. On February 8th, 1999 the Reserve Bank announced that effective March 17th the implementation of monetary policy in New Zealand would revolve around the Official Cash Rate. The Reserve Bank sets the Official Cash Rate and reviews its setting six times a year. In essence, the OCR serves two purposes. First, it acts as a clear and precise signal for the current stance of monetary policy. In that capacity it acts as the benchmark for short-term interest rates in New Zealand. Second, the OCR is the instrumental lever in operating the Reserve Bank's standing facilities. In its original conception, the OCR forms the mid-point of a channel for the overnight cash rate in the interbank lending market.[7] The Reserve Bank offers to lend (on demand against suitable collateral) at a rate of 25 basis points above the announced OCR and agrees to accept deposits at a rate of 25 basis points below the OCR. These two interest rates mark the ceiling and floor of the corridor within which the overnight cash rate fluctuates. Open-market operations were initially the primary tool that the Reserve Bank used to smooth liquidity flows in and out of the financial sector. They have become less important in more recent times in the wake of attempts by the Reserve Bank to improve the operational efficiency of the OCR system. Strains had arisen because of dwindling amounts of outstanding Treasury debt, which serves as collateral in open-market operations. To counteract the problem, the Reserve Bank decided to increase substantially the volume of cash balances in circulation. In addition, the Reserve Bank increasingly relies on foreign exchange swaps to affect liquidity conditions in the financial market.

The OCR system has the advantage that it is transparent, efficient, and easy to understand. By setting an interest rate, the Reserve Bank sends a clear signal to the market about the desired level of interest rates at the short end of the maturity spectrum of the yield curve. The OCR system allows expectations about the future course of monetary policy to affect current

[7] In June 2006 the Reserve Bank made a few modifications to the OCR system. Under the new arrangement, the OCR forms the floor of a 50 basis-point corridor. The cost of borrowing funds from the bank has increased to OCR +50 basis points and funds deposited at RBNZ draw interest at the Official Cash Rate. For further details on the changes introduced see Frazer (2004), Guender and Rimer (2008), and Nield (2006).

interest rates. This is a marked improvement over the CSB system with its diffuse policy signals. Because there was more uncertainty about the future course of monetary policy under the CSB system, the Reserve Bank was also far more activist in that it had to ensure that actual monetary conditions conformed to desired monetary conditions.

IV. The Expectations Hypothesis under the Two Operating Procedures during the Low Inflation Period[8]

The impending adoption of the Official Cash Rate system, announced on February 8th 1999, marks a clearly identifiable *exogenous* break in the operating procedure of the Reserve Bank of New Zealand. Consequently, we deem it appropriate in our empirical analysis to distinguish between two sub-sample periods, the CSB system (1989:1-1999:2) and the OCR system (1993:3-2008:6).[9]

A. Behavior of Interest Rates

The Reserve Bank predicted that the adoption of the OCR system would lead to a substantial fall in interest rate volatility and hence to a more predictable course for monetary policy. In a statement released to financial markets on February 8th, 1999, senior Reserve Bank economists wrote: "[However], 90-day volatility is expected to fall [further] under the Cash Rate system. A less volatile 90-day rate, with most significant changes reflecting expectations about future monetary policy, will provide a clearer signal to investors and consumers making financial decisions (Archer, Brookes, and Reddell, p.57).

Table 2 records the behavior of the 30-day, 60-day, 90-day, and 180-day bank bill rates in New Zealand over the whole sample period (1989:1-2008:6), the CSB period (1989:1-1999:2), and the OCR period (1999:3-2008:6). It is evident that the standard deviation of changes in market interest rates fell across the board during the OCR period. Bills with a

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[8] CPI inflation in New Zealand fell from 9 percent in 1988 to 4 percent in 1989. Hence we chose January 1989 as the beginning of the low-inflation period. The beginning of the sample period precedes the enactment of the Reserve Bank Act by almost a year. By January 1989, New Zealand had embarked on a steady course for monetary policy that emphasized the maintenance of price stability. In April of the preceding year, the Minister of Finance had declared "that in future monetary policy would be targeted at price stability," (p. 252 in *Monetary Policy and the Financial System*). The Reserve Bank Act which officially defines price stability as the overriding goal of monetary policy was enacted in December 1989 and took effect on February 1st, 1990.

[9] Some practitioners would prefer to rely on stability tests such as the Quandt-Andrews test to locate a breakpoint. But such tests can produce misleading results. For instance, the Quandt-Andrews test identifies 1993:01 as a breakpoint in the current context. Closer examination of the term spreads reveals that at the beginning of January 1993 the Reserve Bank tightened monetary policy in response to a sharp depreciation of the NZ Dollar. As a result, the spreads turned sharply negative in January. By early February, the Reserve Bank had reversed its monetary policy action due to a marked drop in CPI inflation. Thus, an endogenous albeit temporary tightening of monetary policy is misconstrued by the Quandt-Andrews test as a breakpoint.

maturity of up to 90 days experienced the most dramatic reduction in volatility. The standard deviations of 30-day, 60-day and 90-day bank bill rates decreased by more than 55 percent. The decrease in volatility during the OCR period was somewhat less for the 180-day bank bill rate at nearly 30 percent. Thus, the Reserve Bank's prediction of a substantial decrease in fluctuations of market interest rates under the Official Cash Rate system is borne out by the data. Notice that there are no dramatic differences in the variability of changes in the bank bill rates during the OCR period.

To test whether the predictability of interest rates depended on the operating procedure, we carry out a univariate forecasting exercise. The observed change in the short-term interest rate in period *t+1* is regressed on its current period change and the current period change in the long-term interest rate. The forecasting equations are estimated for the whole sample period as well as for the CSB sub-sample period and the OCR sub-sample period. The results of this exercise are reported in Table 3 for the 30-day/60-day rate scenario and in Table 4 for the 90-day/180-day scenario.

Inspection of the first two columns in both tables reveals that the forecasting equation explains movements in the short term interest rate much better during the OCR period than before. In Table 3, the adjusted R^2 rises almost seven-fold, from 0.08 during the CSB sub-sample period to 0.53 during the OCR sub-sample period. Somewhat less dramatic improvements in the forecasting ability of the regression occur in the 90-day/180-day set-up. In Table 4, the adjusted R^2 increases markedly, almost doubling from 0.24 in the CSB sub-sample period to 0.43 in the OCR sub-sample period.[10] All in all, these findings suggest that changes in the short-term interest rate became far more predictable during the OCR system.

B. Test of the Expectations Hypothesis on New Zealand Data

If Mankiw and Miron's claim that the success of the expectations hypothesis hinges critically on the predictability of short-term interest rates is correct, then one would expect the theory to receive more support in New Zealand during the OCR sub-sample period. After all, due to the shift from the CSB system to the OCR system, interest rates across the board became more predictable.

[10] A similar picture emerges if one, first, decomposes the change in the observed interest rate into the change explained by the regression and the unexplained change (and, second, compares the associated standard deviations across the subsample periods. For instance, in the 30-day/60-day set up, the standard deviation of relative to the standard deviation of is 0.0415/0.1323=0.3137 during the OCR period and 0.0161/0.4943=0.0325 during the CSB period Further details on the breakdown of total variation in short-term interest rates are available upon request from the authors.

Tables 5 and 6 report the empirical findings for estimating equation (4). Table 5 shows the coefficient estimates of the regression and the associated test statistics for the 60-day/ 30-day term spread for the whole sample period and the two sub-sample periods. While the coefficient estimate on the term spread is positive and statistically significant at the one percent level in all three regressions estimated, only the coefficient estimated for the OCR sub-sample period is close to the hypothesized value of two.[11] Indeed, a Wald test fails to reject the hypothesis that the estimated coefficient equals two for the OCR sub-sample period but not for the CSB sub-sample period. The p-value of the test is 0.315 for the former and 0.05 for the latter. It is also evident that the 60-day/30-day term spread has far greater predictive content for the short rate during the OCR period than the CSB period or the whole sample period. The predictive power of the estimated regression rises more than eightfold, from 0.06 in the CSB sub-sample period to 0.53 in the OCR sub-sample period when short-term interest rate variability was substantially lower than before the change in the operating procedure.[12]

The findings for the 180-day/90-day term spread appear in Table 6. Using bills with longer terms to maturity changes the results somewhat. The term spread has no predictive content for changes in the 90-day bank bill rate during the CSB sub-sample period. The adjusted R^2 of 0.03 is abjectly low. In sharp contrast, the term spread predicts changes in the 90-day bank bill rate rather well in the OCR sub-sample period. The adjusted R^2 rises more than tenfold. However, the coefficient estimate of 0.79, while statistically significant at the one percent level, is much smaller than the hypothesized value of 2.

C. Sensitivity Analysis

To check the robustness of our findings, we examined their sensitivity to shifting the date of the exogenous breakpoint in March 1999 backward. The announcement of the switch to (as opposed to the implementation of) the OCR regime was made in February 1999. Including February in the OCR sub-sample period actually increases the predictive ability of the 60-day/30-day term spread slightly (*Adj.* R^2*=0.54*) and the estimated coefficient on the term spread increases to *1.91* (from *1.83)*. For the 180-day/90-day term spread regression, the adjusted R^2 also rises slightly from *0.40* to *0.41* and the coefficient estimate on the term

[11] Attention focuses on the estimate of the slope coefficient.

[12] These results are thus immune to the criticism that the expectations hypothesis appears to be valid only in times of high variability of short-term interest rates, a point made by Kool and Thornton (2004) in the context of the Mankiw and Miron (1986) study of the behavior of short term interest rates prior to the founding of the Fed.

spread increases from *0.78* to *0.79*. However, breakpoints dating back further produce much lower coefficients of determination and lower coefficient estimates.[13] Thus, 1999:02 and 1999:03, the date of the announcement and implementation, respectively, of the OCR regime represents the beginning of the sample interval during which the predictive ability of the term spread peaks.

Following Kool and Thornton (2004), we further examined whether the support of the expectations hypothesis is confined to periods when the yield curve is inverted. Our results for the 30-day/60-day horizon suggest that this is not the case. Although the predictive power of the yield spread in the OCR period is greater when the yield curve is inverted than when it is positively sloped (, the coefficient on the yield spread is much closer to the hypothesized value of 2 when the yield curve is positively sloped (2.72) than when it is inverted (4.14). Both coefficients are significant at the 1 percent level. For the 90-day/180-day horizon, the predictive content of the yield spread is also better when the yield curve is inverted than when it is upward sloping . But again, the coefficients are highly statistically significant irrespective of the slope of the yield curve

V. Conclusion

In summary, solid evidence backing the validity of the expectations hypothesis in New Zealand exists at the very short end of the maturity spectrum (30-day/60-day) for the period starting in the first quarter of 1999 and ending mid-year in 2008. For financial instruments with a somewhat longer term to maturity (90-day/180-day), the expectations hypothesis fares worse. It bears repeating that the operating procedure of a central bank influences in no small measure whether the behavior of interest rates is consistent with the expectations hypothesis. The predictive content of the term spread improves markedly in the wake of the switch from a quantity-based to a price-based operating procedure in March 1999. The OCR system has made it easier for market participants to understand the day-to-day conduct of monetary policy. As a result, market interest rates have become more predictable, thereby contributing

[13] Extending the OCR sub-sample period back to January 1999 causes the adjusted R^2 to drop by 20 percent in the 60-day/30-day term spread regression. Running the regression equation over the 1998:10-2008:6 period (adding 5 months to the OCR period) causes the coefficient of determination to drop to *0.33* (60-day/30-day term spread) and *0.29*(180-day/90-day term spread).

to the success of the expectations hypothesis in explaining the behavior of yields on very short-dated financial instruments in New Zealand.

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Table 1: Average Daily Change in Short-Term Interest Rates (Basis Points)

90-day rate			
	1994-1999 (Jan)	1994-1996 (June)	1996 (July)-1999 (Jan)
New Zealand	8	6.7	9.3
Australia	3	3.4	2.6
Canada	4.5	6.5	2.6
United Kingdom	2.1	2.9	1.4
United States	1.4	2.0	0.9

Taken from Archer, Brookes, and Reddell (1999).

Table 2: Standard Deviations of Changes in New Zealand Bank Bill Rates

	1989:1 -1999:02	1999:03 - 2008:06	1989:1 - 2008:06
30-day rate	0.4953	0.1323	0.3720
60-day rate	0.4510	0.1340	0.3418
90-day rate	0.4240	0.1376	0.3299
180-day rate*	0.4223	0.1510	0.3124

Note:

1. Monthly 30-day, 60-day, and 90-day rates were retrieved from the Reserve Bank of New Zealand website. * 180-day rates are available only from January 1991onward and were supplied by the Reserve Bank.
2. The raw yield x_t on bank bills is converted into a compounded yield by the following formula:

— .

TABLE 3: Forecasting Equation

$$r_{t+1} - r_t = \alpha + \sum_{j=0}^{n} \beta_{1j}(r_{t-j} - r_{t-1-j}) + \sum_{k=0}^{m} \beta_{2k}(R_{t-k} - R_{t-1-k}) + z_{t+1}$$

R_t = 60-day rate r_t = 30-day rate

PERIOD	1989:01 - 1999:02	1999:03 - 2008:06	1989:01 - 2008:06
Constant	-0.0400 (0.0418)	0.0084 (0.0078)	-0.0102 (0.0213)
$r_t - r_{t-1}$	-1.2681* (0.6468)	-1.1854*** (0.2788)	-1.2304** (0.5112)
$r_{t-1} - r_{t-2}$	-0.6578 (0.4322)	-0.7781** (0.3585)	-0.6816** (0.3283)
$r_{t-2} - r_{t-3}$	-0.4229 (0.5612)	-0.2490 (0.2220)	-0.4618 (0.4542)
$R_t - R_{t-1}$	1.7007** (0.7329)	1.6731*** (0.2788)	1.6737*** (0.5696)
$R_{t-1} - R_{t-2}$	0.5367 (0.4848)	0.7591** (0.2994)	0.5804 (0.3625)
$R_{t-2} - R_{t-3}$	0.5379 (0.6263)	0.4994* (0.2661)	0.6016 (0.5018)
Adjusted R^2	0.08	0.53	0.14
s.e.	0.4782	0.0908	0.3464
LM test (*p*-value)	0.1531	0.2634	0.0155

Notes: 1. The number of observations for the CSB, OCR and whole sample period are 120, 112, and 232, respectively.

2. *, ** and *** denote significance at 10%, 5% and 1% level, respectively

3. Standard errors are reported in parentheses and rounded to four decimal places.

4. All regression results are based on continuously compounded interest rates. Let the raw interest data be *i*. Then $r = \ln(1 + i/100) \times 100$.

5. Standard errors are corrected for autocorrelations using the Newey –West procedure (1987).

TABLE 4: Forecasting Equation

$$r_{t+1} - r_t = \alpha + \sum_{j=0}^{n} \beta_{1j}(r_{t-j} - r_{t-1-j}) + \sum_{k=0}^{m} \beta_{2k}(R_{t-k} - R_{t-1-k}) + z_{t+1}$$

R_t = 180-day rate r_t = 90-day rate

PERIOD	1991:01 - 1999:02	1999:03 - 2008:06	1991:01 - 2008:06
Constant	-0.0234 (0.0384)	0.0112 (0.0101)	-0.0039 (0.0183)
$r_t - r_{t-1}$	-0.9893* (0.5809)	-0.2386 (0.1812)	-0.6666* (0.4019)
$r_{t-1} - r_{t-2}$	1.1524* (0.6743)	-0.4541** (0.2161)	0.5095 (0.4573)
$r_{t-2} - r_{t-3}$	-1.4399** (0.5530)	0.0715 (0.2397)	-0.9142** (0.3659)
$R_t - R_{t-1}$	1.5850** (0.6140)	0.6954*** (0.1991)	1.2083*** (0.4107)
$R_{t-1} - R_{t-2}$	-1.4918** (0.7293)	0.4377** (0.2121)	-0.7323 (0.4618)
$R_{t-2} - R_{t-3}$	1.7533*** (0.6116)	0.1322 (0.2417)	1.1676*** (0.3930)
Adjusted R^2	0.24	0.43	0.26
s.e.	0.3931	0.1041	0.2786
LM test (*p*-value)	0.4598	0.5998	0.1769

Note: see previous table.

TABLE 5: The Term Spread Equation

$$r_{t+1} - r_t = \alpha + \beta(R_t - r_t) + v_{t+1}$$

R_t = 60-day rate r_t = 30-day rate

PERIOD	1989:1 - 1999:02	1999:3 - 2008:06	1989:1 - 2008:06
Constant	-0.0946* (0.0544)	-0.04*** (0.0117)	-0.0607** (0.0304)
$R_t - r_t$	1.219*** (0.4262)	1.83*** (0.1644)	1.395*** (0.3104)
Adjusted R^2	0.05	0.53	0.09
D.W.	1.39	1.40	1.35
s.e.	0.4817	0.0904	0.3548

Notes:

1. The number of observations for the CSB-, OCR- and whole sample period are 122, 112 and 234, respectively.
2. *, ** and *** denote significance at 10%, 5% and 1% level, respectively
3. Standard errors are reported in parentheses.
4. Standard errors are corrected for autocorrelation using the Newey-West (1987) procedure.
5. All regression results are based on continuously compounded interest rates. Let the raw interest data be *i*. Then $r = \ln(1 + i/100) \times 100$.

TABLE 6: The Term Spread Equation

$$r_{t+1} - r_t = \alpha + \beta(R_t - r_t) + v_{t+1}$$

R_t = 180-day rate r_t = 90-day rate

PERIOD	1991:01 - 1999:2	1999:3 - 2008:06	1991:01 – 2008:06
Constant	-0.0815 (0.0582)	-0.0334** (0.0146)	-0.0552* (0.0312)
$R_t - r_t$	0.6224 (0.3966)	0.7856*** (0.0923)	0.7537*** (0.1961)
Adjusted R^2	0.03	0.40	0.08
D.W.	1.19	1.29	1.18
s.e.	0.4402	0.1065	0.3103

Notes:

1. The number of observations for the CSB-, OCR- and whole sample period are 98, 112 and 210, respectively. See also notes to previous table.