Examining the Expectations Hypothesis of the Term Structure of Interest Rates and the Predictive Power of the Term Spread on Future Economic Activity in New Zealand

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Abstract

This thesis consists of two parts: the first examines the Expectations Hypothesis of the Term Structure for New Zealand, and the latter examines the predictive power of the term spread on future economic activity in New Zealand. For both parts, I divide the sample period into two sub-sample periods – the pre-OCR period and the OCR period. Using Mankiw & Miron's (1986) approach for testing the expectations hypothesis, the findings in this paper suggest that the theory is consistent with New Zealand data during the OCR period. I attribute the success of the theory to the introduction of the Official Cash Rate system in March 1999. The change from targeting the settlement cash balance to targeting an interest rate variable has substantially improved the predictability of short-term interest rates.

In regards to the predictive power of the spread, the findings in this paper support the conventional view that the spread is positively related to future economic activity. Using Hamilton & Kim's (2002) approach, I decomposed the term spread into an expectation component and a term premium in an attempt to find out whether these two variables have distinctly separate effect on future economic activity. My findings are in contrast to that reported by Hamilton & Kim. In particular, I find that the term premium in some cases is significant and negatively related to future economic activity in New Zealand. I attribute the negative relationship to lower long-term interest rates and a fallen term premium in New Zealand.

PART I

THE EXPECTATIONS HYPOTHESIS OF THE TERM STRUCTURE FOR NEW ZEALAND

1. INTRODUCTION

The Expectation Hypothesis of the Term Structure, henceforth EHTS [1], is a fundamental building block of financial and macroeconomic theory. It has particularly important implications for understanding and predicting future movements in interest rates and for the conduct of monetary policy by central banks. The theory posits that the slope of the yield curve should reflect market expectations of future movements in interest rates – an upward-sloping (downward-sloping) yield curve implies that the expected future short rates will be higher (lower).

Perhaps one of the most influential papers that tests the expectations hypothesis is Mankiw & Miron (1986), henceforth, MM. They found supportive evidence for the EHTS for the US before the founding of the Federal Reserve in 1915 but not after. According to MM, the founding of the Federal Reserve had led to a dramatic change in the behaviour of interest rates – it had significantly reduced the predictability of interest rates, thereby reducing the ability of the term spread to predict future changes in interest rates. I use similar econometric methodology as MM to test the EHTS for New Zealand for the period from 1988:12 to 2006:12. I divide the sample period into two sub-periods – the pre-OCR period (1988:12 to 1999:02) and the OCR period (1999:03 to 2006:12), in an attempt to investigate how the change in monetary operating procedure in March 1999[2] affected the behaviour of interest rates and thus the predictions underlying the expectations theory. To provide an understanding of the relationship between the expectations theory and the Reserve Bank's implementation of monetary policy, I will discuss and compare New

[1] I use 'EHTS' and 'expectations theory' interchangeably throughout this paper.
[2] The Reserve Bank of New Zealand changed its monetary operating procedure with the introduction of the Official Cash Rate (OCR) system in March 1999. The regime change will be discussed in more details in Section 5.

Zealand's monetary operating procedure both before and after the introduction of the OCR system. Estimating MM's specification using New Zealand data, I find that in contrast to the founding of the Federal Reserve system in the US, the introduction of the OCR system in New Zealand in March 1999 had dramatically improved the predictability of short-term interest rates. My findings suggest that the EHTS holds for New Zealand for the OCR period, but not for the period preceding it.

Kool & Thornton (2000) argued that the econometric methodology employed by MM tends to generate supportive results for the EHTS 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 (inverted yield curve). Given that I follow MM's procedure in testing the EHTS, I will also examine Kool & Thornton's specification using New Zealand data to check whether their conjecture holds for New Zealand. My findings suggest that their arguments do not hold for New Zealand. By decomposing the term spread into a 'positive' and 'negative' spread, I show that irrespective of the sign of spread, the EHTS holds during the OCR period for New Zealand.

Whilst the EHTS has been extensively tested and well documented for many countries, especially the US, little empirical work on the theory has been done for New Zealand[3]. Thus, this research is the first (as far as I am aware) to examine the validity of the EHTS after the introduction of the OCR system in New Zealand.

The rest of this paper proceeds as follows: Section 2 briefly reviews the existing literature on the EHTS. Section 3 discusses the model and data. Section 4 presents the empirical findings. Section 5 discusses the implementation of monetary

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[3] An exception is Guthrie *et al* (1999), who empirically tested the EHTS for New Zealand but only for the period from 1989 to 1998. As their sample period ends in 1998, Guthrie *et al* were not able to capture the impact of the regime change on the behaviour of interest rates.

policy by the Reserve Bank before and after March 1999. Section 6 empirically tests the predictability of the short rates before and after March 1999. Section 7 concludes.

2. LITERATURE REVIEW

There exists an extensive empirical literature that tests the Expectations Hypothesis of the Term Structure of interest rates.

Mankiw & Miron (1986) empirically examined the EHTS for the US for the period from 1890 to 1979 by testing the following specification:

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

where R_t and r_t are the long and short rates, respectively, and v_{t+1} is orthogonal to information available at time *t*. The mathematical procedure for deriving the above specification will be formally explained in Section 3. The simple specification implies a linear relationship between the changes in short-term interest rate and the term spread. Dividing the whole sample period into five sub-sample periods (1890 -1914; 1915 -1933; 1934-1951; 1952-1958; 1959-1979)[4], MM found supportive evidence for the theory only for the period from 1890 to 1914 (before the founding of the Federal Reserve). For the remaining four sub-periods, the theory was found to be inconsistent with the data.

[4] MM divide the sample period into five regimes. The first regime (1890 to 1914) ends at the founding of the Federal Reserve System; the second regime (1915 to 1933) ends at the time that saw the introduction of the New Deal banking reforms; the third regime (1934 to 1951) ends with Accord, the agreement between the Fed and the Treasury Department that the Fed would no longer peg interest rates; the fourth regime (1952 to 1958) ends at the time when the market for short-term Treasury Bills becomes deeper; the last regime (1959 to 1979) ends at the time when the Fed announced the change in its operating procedure.

They used the *R*-square value (R^2) as the main criterion to determine the validity of the EHTS. While the R^2 values for the four sub-periods from 1915 to 1979 never exceeded 0.06, the value increased to 0.40 for the period from 1890 to 1914, implying that the slope of the yield curve in that period contained substantial information on the path of future short rates.

MM claimed that the short rates were more predictable during the period from 1890 to 1914 because interest rates exhibited a significant seasonal pattern. However, the short rates became nearly a random walk after the founding of the Federal Reserve in 1915, and have remained so throughout the period from 1915 to 1979. The founding of the Federal Reserve, together with its particular interest rate smoothing behaviour, had consequently led to the observed rejection of the EHTS.

Other researchers who also rejected the EHTS include Melino (1988), Campbell & Shiller (1991), Campbell (1995), Tzavalis & Wickens (1997). In particular, Campbell & Shiller (1991) provided a comprehensive study of the EHTS using post-war US data. Using monthly data from 1952 to 1987, they found that for almost any combination of maturities between one month and ten years, a positive term spread predicted rising short-term interest rate but declining long-term interest rates in the future, which is inconsistent with the theory. They argued that the failure of the term spread to correctly predict future movements in interest rates was due to the overreaction of long rates to current short rates.

Tzavalis & Wickens (1997) attempted to explain the failure of the EHTS by introducing a proxy for time-varying term premium. Using monthly data for the period 1946 to 1992, they first tested the EHTS without including a time-varying term premium. In contrast to the theory, the coefficient estimates of the term spread that predict future movements in long rates were negative and increased in absolute value with maturity. Furthermore, the residuals exhibited serial correlation and conditional heteroskedasticity. To determine whether the serial correlation is caused by omitted variables, Tzavalis & Wickens tested the EHTS by including a proxy for the time-varying term premium in the regression. As a result, the coefficient estimates of the term spread that predict future movements in long rates were not significantly different from unity[5]. The test that includes a time-varying term premium appeared to support the EHTS, implying that the failure of the EHTS was mainly caused by ignoring the time-varying property of the term premium.

A study that is in similar spirit to this paper is by Cort *et a l*(2007), who re-examined the EHTS at the very short end of the maturity spectrum using US repo rates with maturities ranging from overnight to three months for the period from 1991 to 2005. The authors tested the EHTS on two grounds. First, following the procedure developed by Bekaert & Hodrick (2001), the authors tested the parameter restrictions implied by the EHTS on a vector autoregression (VAR) of the long- and short-term repo rates. Second, they proposed an economic analysis on the validity of the EHTS that explores the economic value of the deviations from the EHTS. Specifically, they compared the performance of a trading strategy that is consistent with the theory to a strategy that exploits the deviations from it. While Cort *et al* (2007) found that the EHTS is statistically rejected for all maturities in their study, the economic analysis, in contrast, is supportive of the EHTS. They showed that no tangible economic profit can be gained by an investor who exploits the deviations from the EHTS relative to an investor whose trading strategy is consistent with the EHTS.

[5] According to MM's specification, the coefficient estimate of the term spread can not be significantly different from two in order for the EHTS to hold. However, depending on how the estimation regression is derived, this theoretically desired value can be unity. See also Guthrie *et al* (1999) for an example.

Although tests on the EHTS using US data had generally been rejected statistically, some researchers have reported evidence in favour of the hypothesis elsewhere. Guthrie *et al* (1999) tested the EHTS for New Zealand for the period from 1989 to 1999, and found considerable support for the hypothesis. Using daily, weekly, and monthly data, they tested both the short and long version of the hypothesis, where the short (long) version relates to predicting the future movements in short (long) rates using the term spread. For the long version, the EHTS can not be rejected in 30 out of 34 regressions while for the short version, the hypothesis can not be rejected in 11 out of 27 regressions. In more than two thirds of the cases where the theory was not rejected, the coefficient estimates of the spread were significantly greater than unity. In contrast to MM, who attributed the failure of the EHTS to the founding of the Federal Reserve, Guthrie *et al* attributed the success of the EHTS for New Zealand to higher predictability in interest rates.

Gerlach & Smets (1995) tested the EHTS for 17 countries using the Euro-rates, and found that the term spreads contained information about the future short-term rates in all 51 regressions estimated. Using cross-sectional regressions, they estimated the variance of the term premium and the correlation between the term premium and the expected change in short rates. They found that for many countries the EHTS was overwhelmingly consistent with the data.

A number of researchers have attempted to explain why the EHTS is inconsistent with the data. Froot (1989) used survey data on interest rate expectations to explain the poor predictability of the term spread for the US. They argued that the failure of the spread to predict changes in future long-rate can be attributed to systematic expectational errors. The behaviour of the expectational errors suggests that expected future rates under-react to changes in the short rate. McCallum (1994) argued that the failure of the term spread to predict future movements in short-term interest rates was due to monetary policy behaviour that features interest rate smoothing, an explanation that is consistent with that proposed by MM. Bekaert *et al* (1997) investigated the small sample properties of five commonly-used regression tests of the expectation hypothesis. They concluded that very large biases and skewness existed even in what seemed to be relatively large sample sizes. The presence of these extreme biases and dispersion in the small sample distribution of test statistics arose because of high persistence of short-term interest rates.

3. MODEL AND DATA

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 rates, respectively. The EHTS then posits that

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

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.

One underlying assumption of the EHTS is that the term premium θ is time-invariant. A few authors, including Cuthbertson (1996) and Tzavalis & Wickens (1997), argued that the failure of the term spread to predict future changes in interest rates can be attributed to the presence of a time-varying term premium. In the context of New Zealand, Gordon (2003) empirically examined the properties of the term premium for New Zealand for the period from March 1985 to February 2003. While he argued that the term premium has been time-varying throughout the period examined, it has decreased significantly in value over time and usually converged to a constant during the OCR period. Based on Gordon's argument, I let the term premium θ enter Equation (1) as a constant.

Rewrite Equation (1) as

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

The EHTS implies that 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:

(3) $r_{t+1} = E_t r_{t+1} + v_{t+1}$,

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

To obtain the conventional test of EHTS, substitute (3) into (2) and parameterize the equation as

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

For the EHTS to hold, point estimates of β should not be significantly different from the theoretically desired value of two. Consequently, the null hypothesis is β = 2 and the alternative hypothesis is $\beta \neq 2$, that is:

H_0: β = 2 and H_A: $\beta \neq 2$

Data

The data set comprises monthly observations of 30-, 60-, 90- and 180-day bank bills rate from December 1988 to December 2006. The selected sample period is an extension of that used by Guthrie *et al* (1999), which ends at the introduction of the OCR system in March 1999. The whole sample period is divided into two sub-periods – the pre-OCR period (1988:12 to 1999:02) and the OCR period (1999:03 to 2006:12[6]). According to Guthrie *et al* (1999), the use of bank bills rate as opposed to Treasury bill rate in testing Equation (4) can be justified on the following grounds:

- The market for bank bills rate is more liquid than that for Treasury bills rate;
- Bank bills demand a small premium over Treasury bills and this premium is relatively stable over time, implying high credit ratings of the banks.

All interest rates were obtained from the Reserve Bank of New Zealand. Due to availability of data, the 180-day bank bills rate is only available from January 1991 to June 2006. While Figures (1) to (4) present the raw data, the actual data set that is used to estimate Equation (4) had been adjusted for continuous compounding[7], an approach that is consistent with the literature.

Data Source

The short-term bank bills rate can be found via the following URL: http://rbnz.govt.nz/statistics/exandint/b2/hb2.xls

These bank bills rate are generally issued in the form of Registered Certificates of Deposit (RCD) but can also be a Bill of Exchange issued or accepted by a bank. Bills of Exchange represent only a small proportion of total securities issued in this category.

[6] This only refers to the end date of the sample period, not the end date of the OCR period.

[7] Let the raw interest data be *i, then* $r = \ln(1 + i/100) \times 100$. The same applies to *R*.

4. EMPIRICAL ANALYSIS

This section presents the empirical findings of the examination of the EHTS for New Zealand. The organisation of this section is as follows: First, I will test Equation (4) using Ordinary Least Square (OLS) over the three different sample periods – the pre-OCR period from 1988:12 to 1999:02, the OCR period from 1999:03 to 2006:12 and the whole sample period from 1988:12 to 2006:12. I use the conventional test of Newey and West (1987) to correct for autocorrelations in the error term of Equation (4). Second, I will estimate Kool & Thornton's specification to find out whether their findings for the US are consistent with New Zealand data.

This paper sets the criteria for determining the validity of the EHTS for New Zealand based on both the value of R^2, which represents the explanatory power of the spread and the *t*-statistics of the coefficient. For the expectations theory to hold, the coefficient estimates of the term spread should be statistically significant around the theoretical value of two.

Table 1 and 2 report the empirical findings for estimating Equation (4). The purpose of breaking the whole sample period into the pre-OCR and the OCR period is to capture the effect of the change in the conduct of monetary policy by the Reserve Bank of New Zealand in March 1999 on the behaviour of interest rates.

Table 1 shows the test statistics for the 60-day and 30-day term spread. Although significantly positive, the coefficient estimates of β for the pre-OCR and the whole sample period are significantly different from two. Furthermore, the values of R^2 for these two periods are very close to zero (0.09 and 0.06, respectively), which suggests that the spread does not contain much information about future movements in the short rates over the pre-OCR or the whole sample period.

However, the opposite is observed for the OCR period. Not only is the point estimate of β (1.87) significantly positive, it is insignificantly different from two. The null-hypothesis that β = 2 can not be rejected at the 1% significance level. Furthermore, the value of R^2 is impressive, as it now increases substantially to 0.62. This indicates that the spread between the 60-day and 30-day bank bill rates contains substantial information in regards to future movements in the 30-day rate during the OCR period. Overall, the results appeared to support the EHTS for New Zealand during the OCR period.

Table 2 reports the test statistics for the 180-day and 90-day term spread. Although all of the point estimates of β are significantly different from two, the value of R^2 for the OCR period is comparatively much higher than that for the other two periods. The spread between the 180-day and 90-day bank bill rates contains virtually no information in regards to future movements in the 90-day rate during the pre-OCR and the whole sample period. However, the explanatory power of the spread has dramatically improved (R^2 = 0.44) in the OCR period. Although the results from Table 2 do not fully conform to the EHTS, the term spread between these two rates do contain significant information about future movements in the 90-day rate.

The empirical findings in Table 1 and 2 have two important implications:

1. The EH fares much better for the OCR period than the pre-OCR period. In fact, the results for the OCR period are consistent with the expectations theory at the very short end of the maturity spectrum. The coefficient estimate of the term spread between the 30-day and 60-day rates is positive and not significantly different from two. Consequently, we can not reject, at the very short end of the interest rate spectrum, the null hypothesis that the EHTS holds for New Zealand during the OCR period.

2. The change in the conduct of monetary policy by the Reserve Bank in March 1999 had substantially improved the term spread's ability to predict future changes in short rates. This is reflected in the values of R^2, which have increased dramatically in the OCR period. The conduct of monetary policy and its implication on the predictability of interest rates will be discussed in detail in the following section.

While findings in Table 1 and 2 appear to support the EHTS for New Zealand for the OCR period, all Durbin Watson statistics in Table 1 and 2 never exceed 1.45, which indicates presence of residual autocorrelation in the model. The presence of serial correlation can arise from omitted variables or misspecification of the model[8]. Consequently, one should treat results from Table 1 and 2 with care.

Equation (4) was originally proposed by MM in testing the EHTS for the US. Using exactly the same set of data, Kool & Thornton (2000) argued that the test employed by MM tends to produce results that are more favourable to the EHTS when:

1. short-term interest rates are more volatile than long-term interest rates and
2. the term spread is negative (an inverted yield curve).

I now show that their arguments do not hold for New Zealand. Table 3 reports the standard deviations of changes of the four short-term interest rates (30, 60, 90 and 180-day rate) for the three sample periods. The table shows that the behaviour of all four interest rates exhibits a similar pattern across the three sample periods. All four interest rates were highly volatile in the pre-OCR period but became much more stable in the OCR period. To be precise, the standard deviations of the 30-day short

[8] For further discussion about omitted variables and model misspecification, see Maddala (2001).

rate fell by 92%[9] from the pre-OCR period to the OCR period, while the standard deviations of the other three short rates also fell by similar but slightly less magnitude.

Comparing the standard deviations of the short rates, we notice that the 30-day rate (variance = 0.0183) is slightly less volatile relative to the 60-day rate (0.0189). Therefore, according to Kool & Thornton's argument, the expectations theory should receive less support for this period. However, results from Table 1 and 2 suggest the otherwise – the EHTS fares much better in the OCR period. Furthermore, Kool & Thornton argued that Equation (4) would produce results that are more favourable to the theory when the spread is negative (an inverted yield curve) and otherwise when the spread is positive. They separated the term spread into a 'positive' and 'negative' spread and examined their predictive power individually according to the following equations, where R_t is the longer-term rate and r_t is the shorter- term rate:

(4.1) $r_{t+1} - r_t = \alpha + \beta(R_t - r_t)^{(+)} + \varepsilon_t$, where $(R_t - r_t)^{(+)} > 0$

and

(4.2) $r_{t+1} - r_t = \alpha + \beta(R_t - r_t)^{(-)} + \varepsilon_t$, where $(R_t - r_t)^{(-)} < 0$

I estimate Equation (4.1) and (4.2) using New Zealand data and find that Kool & Thornton's second argument does not hold for New Zealand. Results are reported in Table 4 and 5. For the 60-day and 30-day spread, all coefficient estimates of the spread are positive and statistically significant, except for the pre-OCR period when the spread is positive. Similar results are obtained for the 180-day and 90-day spread. According to Table 5, all coefficient estimates of the spread are positive and statistically significant, except for the pre-OCR period. Taken altogether, these findings suggest that:

[9] (0.2443-0.0183)/0.2443 = 0.9251

1. Regardless of the sign of the spread, the values of R^2 for the OCR period are substantially higher than that for the other two sample periods. This is consistent with earlier findings reported in Table 1 and 2.
2. When the spread is *positive*, the 60-day and 30-day spread produces result that is entirely consistent with the EHTS during the OCR period. The coefficient estimate of the spread is significantly positive and insignificantly different from two. The underlying value of R^2 is 0.51, which suggests that the *positive* spread contains substantial information in regards to future changes in the 30-day rate.

The results for New Zealand are in stark contrast to Kool & Thornton's findings for the US. It appears that any particular testing methodology and/or interest rate volatility alone are not enough to justify the validity of the EHTS. It is important to understand the country-specific monetary policy framework and its implications for the behaviour of interest rates. Because the monetary operating procedure in New Zealand differs in some important aspects from the monetary framework developed by the Federal Reserve, it is not surprising to find that Kool & Thornton's conjectures do not hold for New Zealand.

5. IMPLEMENTATION OF MONETARY POLICY

The empirical findings from previous section suggest that the implementation of monetary policy by a central bank has particularly important implications for the behaviour of interest rates and ultimately, the EHTS. New Zealand underwent a major change in its monetary operating procedure at the turn of the millennium. The Reserve

Bank of New Zealand changed from targeting a monetary aggregate to targeting an interest rate instrument in its conduct of monetary policy.

This section reviews New Zealand's monetary operating procedure and the underlying implications for the behaviour and predictability of interest rates both before and after the introduction of the OCR system in March 1999.

(5.1) Implementation of Monetary Policy in pre-OCR Period

I) Background

The Reserve Bank of New Zealand Act 1989 sets out the Bank's responsibilities and economic objectives. In particular, one of the Bank's main objectives is to achieve and maintain stability in the general level of prices. The Policy Targets Agreement (PTA) between the Governor of the Bank and the Minister of Finance lays out the specific policy targets for monetary policy implementation.

During the pre-OCR period (1988:12 to 1999:02), the cash settlement system[10] played a crucial role in providing the foundations for implementing monetary policy. We shall see, in the following discussion, how the Bank established and implemented monetary policy in the cash settlement system in New Zealand during the pre-OCR period.

II) Demand for Settlement Cash

Over the course of a banking day, large volumes of financial transactions take place between commercial banks and their customers and between the commercial banks

[10] The cash settlement system simply refers to the operation of the inter-bank payments and settlement system. Broadly speaking, all commercial banks must settle daily inter-bank transactions with settlement cash balances held at the Reserve Bank. See Frazer (2004) for a detailed discussion of the inter-bank payments and settlement system in New Zealand.

themselves. For example, a customer may write a cheque to a retailer. When the retailer presents the cheque at his bank, the retailer's bank then enters an arrangement with the customer's bank for a transfer of funds. Given the huge volumes of business transactions undertaken each day and the fact that they must be settled at the end of the day, this gave rise to the demand for settlement cash. In general, the settlement cash balances simply referred to the commercial banks' balances held in the Reserve Bank. Apart for inter-bank settlements, commercial banks are required to hold settlement cash balances in the Reserve Bank to cover:

1. **The Purchase of Bank Note and Coins**

   Commercial banks are required to pay, through settlement cash balance, for the notes and coins received from the Reserve Bank.

2. **Government Revenue and Expenditure Flows**

   Benefits from and payments to the Government, for example the Goods and Services Tax (GST), were settled through settlement cash balances held in the Reserve Bank.

III) Supply for Settlement Cash

Because of its unique position as the sole supplier of bank notes and coins and its undoubted credit rating, the Reserve Bank could affect the aggregate supply of settlement cash through the purchase and sales of government securities. By altering the supply of settlement cash, the Reserve Bank could influence the level of the short-term interest rates.

The supply of settlement cash was determined through Open Market Operations (OMO) – a day-to-day operation by the Reserve Bank that involved the sales and purchases of government securities. OMOs were conducted to smooth out government revenue and expenditure flows that could affect the daily settlement cash balances.

If the cash flow to the banking sector on a given business day was expected to exceed the cash flow from the banking sector (a net increase in settlement cash balance in the economy), the Reserve Bank would withdraw cash from the banking system by issuing government securities through OMOs. On days when the Reserve Bank needed to inject cash into the banking system, it normally did so through repurchase agreements, in which commercial banks would sell some of their government securities to the Reserve Bank and simultaneously entering an agreement to reverse the transaction on a pre-specified future date.

IV) The Settlement Cash Target

During the pre-OCR period, the Reserve Bank targeted a monetary aggregate – the settlement cash balance – in its conduct of monetary policy in attempt to achieve and maintain price stability.

Daily OMOs formed the platform for the quantity-based monetary operating procedure and were used to achieve and maintain the settlement cash target. With the settlement cash being the key quantity variable in the system, there were no other alternative assets (apart from the Reserve Bank bills) that the commercial banks could use to effectively substitute for settlement cash. Thus, in principle, the Reserve Bank could alter monetary conditions by simply adjusting the settlement cash target. To understand how this operates, suppose there is an increase in the cash target. This will leave excess of funds in the banking system. Consequently, commercial banks would not need to compete so vigorously for settlement cash, causing the short-term interest rates to fall and ultimately, economic activity to slow down. A lower cash target would result in the opposite.

V) Adjusting Monetary Conditions

The settlement cash target was rarely changed by the Reserve Bank in managing monetary conditions. Although the Reserve Bank could influence the daily level of short-term interest rates by altering the supply of settlement cash through daily OMOs, it would not choose to do so. Instead, the Bank conducted OMOs only to maintain the settlement cash target, and it let the market itself determine the daily level of interest rates primarily based on quarterly inflation projections published in the Economic Projections and/or the Monetary Policy Statement by the Bank.

In the period between the release of inflation projections, the Reserve Bank continued to access any new information that could have steered the prevailing monetary condition off its desired level. Theoretically, there would be no need for the Reserve Bank to make any public announcements between the release of each inflation projections in response to new information affecting inflation and monetary conditions, because market participants should be able to predict the probability of a response from the Reserve Bank. Thus, market participants would react first in response to new information by adjusting their investment portfolio rather than waiting for the Reserve Bank to lead the move.

Whenever the market failed to adjust to changes in monetary conditions, the Bank would lead the move by adjusting one or more policy instruments in order to bring monetary conditions to its desired level. This could potentially leave market participants exposed to huge financial risks at the time the policy action was implemented. Thus, there existed strong incentive for the market to anticipate policy actions from the Reserve Bank, and such incentive had greatly reduced the need for formal actions by the Reserve Bank, such as altering the cash target.

In fact, whenever the market interest rates deviated from the Reserve Bank's preferred level, all was needed for the Reserve Bank to bring the market rates in line with its preferred level was its public announcements or statements. The threat of the Reserve Bank to adjust policy instruments alone was often enough to manage monetary conditions. Guthrie and Wright (2000) provided a comprehensive study of the use of 'Open Mouth Operations' by the Reserve Bank in its implementation of monetary policy before the regime change. They empirically proved that *unexpected* announcements made by the Reserve Bank could have significant effects on both interest rates and exchange rates. If the Reserve Bank's announcements were predictable and market participants knew that there would be a change in monetary conditions, the prevailing market rates would have already entailed such expectations.

VI) High Interest Rates Volatility

Figures 1 – 4 graph the monthly 30-day, 60-day, 90-day and 180-day short rates, respectively. All four graphs exhibit similar trends. All interest rates appear to be very volatile during the pre-OCR period (1988:12 to 1999:02) but have become much smoother during the latter OCR period (1999:03 to 2006:12).

Given the fact that the Reserve Bank primarily used public announcements to manage monetary conditions and set monetary policy without explicitly targeting a financial variable, the short-term interest rates could fluctuate substantially on a daily basis as market's perception of inflation outlook and monetary conditions changed. For example, in the event of increasing inflationary pressure, the Reserve Bank would threaten to adjust settlement cash target through public announcement. This would cause large swings in demand for settlement cash balance. Since the threat itself was often enough to adjust monetary conditions, there was no need for the Reserve Bank to actually adjust the settlement cash target. Holding the target constant, large swings in demand for cash settlement balance could cause interest rates to fluctuate dramatically on daily basis.

(5.2) Implementation of Monetary Policy in OCR Period

I) Background

During the pre-OCR period, short-term interest rates were highly volatile, but the volatility was disregarded by the Reserve Bank. High interest rates volatility made it difficult for market participants to interpret and respond to changes in financial market prices. Furthermore, high and volatile inflation rate at that time also made it difficult to interpret changes in interest rates and the exchange rate. In particular, it was difficult to determine what the real and nominal interest rates were in face of highly volatile inflation rate.

Gradually, the Reserve Bank became more aware of the fact that high interest rate volatility was costly and unnecessary, in terms of both its impact on the economy and its impacts on public support for monetary operating framework. The implementation of monetary policy based on targeting a quantity variable was generally seen by the public as ineffective in managing day-to-day monetary conditions. Thus, the move towards adopting a cash-rate operating system was inevitable, and the Reserve Bank eventually introduced the Official Cash Rate (OCR) as the policy instrument in March 1999.

II) The New Cash-Rate System

The OCR system took effect as of 17 March 1999. The move from a targeting a quantity variable to targeting a price variable in monetary policy setting was also consistent with international practise, as Central Banks in other developed countries had already adopted similar operating system.

Under the OCR system, commercial banks now borrow and lend at an overnight interest rate that is set at 25 basis points above and below the OCR. Because the Reserve Bank is willing to provide and accept funds in large volume, this effectively provides a channel within which the overnight interest rate is free from large unexpected fluctuations. The Reserve Bank reviews the OCR at regular interval, currently eight times a year (approximately every 6 weeks). At each review, the OCR may be adjusted or remain unchanged depending on real-time monetary conditions and inflation outlook, and the adjustment, if necessary, is made in multiples of 25 basis points.

III) Interest Rates Volatility and Predictability

Under the current monetary framework, short-term interest rates have appeared much less volatile than in the pre-OCR period. In face of increasing inflationary pressure, the Reserve Bank tightens monetary policy by raising the OCR. Consequently, trading banks respond by raising short-term interest rates on loans in order to slow down economic activity and to reduce inflationary pressure, and vice versa.

Section 4(c) of the Policy Target Agreement states: "In pursuing its price stability objective, the Bank shall implement monetary policy in a sustainable, consistent and transparent manner and shall seek to avoid unnecessary instability in output, interest rates and the exchange rate." This suggests that under the OCR system, one of the Bank's main objectives is to maintain stability in interest rates and other financial variables.

Consequently, the immediate effect after the introduction of the OCR system was a sharp reduction in the volatility of interest rates. Under the new OCR system, market short-term interest rates move more or less in the same direction as the OCR. A tightening monetary policy would raise the OCR, and hence the market short rates, and vice versa. Although movement in the market short rates can fluctuate on a daily basis due to other macroeconomic influences, fluctuations are now limited. The reason is that the OCR is reviewed at six-weeks intervals, and depending on real-time monetary conditions and inflation outlook, the OCR is adjusted appropriately. Because movement in the market short rates is closely tied to the movement in the OCR, the market short rates have become much less volatile and more predictable in the OCR period. The increase in predictability of short-term interest rates had in turn generated supportive evidence for the expectations theory in the OCR period.

6. TESTING THE PREDICTABILITY OF INTEREST RATES

In order to test the predictability of short-term interest rates, the following two forecasting equations were estimated.

(5) $r_{t+1} - r_t = \alpha_{10} + \beta_{11} r_t + \beta_{12} r_{t-1} + \beta_{13} R_t + \beta_{14} R_{t-1} + \nu_t$

and

(6) $r_{t+1} - r_t = \alpha_{20} + \beta_{21}(r_t - r_{t-1}) + \beta_{22}(R_t - R_{t-1}) + \nu_t$,

where r_t is the shorter-term rate and R_t is the longer-term rate.

Forecasting Equation (5) was originally proposed and estimated by Mankiw and Miron (1986). However, one shortcoming of this equation is that it is not a balanced equation. While the dependant variable on the LHS of the equation is stationary by first differencing, the explanatory variables on the RHS remain non-stationary. Therefore, Equation (5) needs to be modified to create a balanced regression equation. Equation (6) is a modification of (5) where both dependant and explanatory variables are stationary[11]. Table 6-9 reports empirical results for Equation (6) and Table 10-13 reports results for Equation (5)

Table 6 reports the regression results for Equation (6) where r_t is the 30-day rate and R_t is the 60-day rate. While all coefficient estimates were significant, the most striking difference between the pre-OCR and OCR period is that the value of R^2 is substantially higher in the OCR period (0.56) than in the pre-OCR period (0.09). This suggests that the short-term interest rates exhibit much higher predictive power in the OCR period than in the pre-OCR period.

The presence of a lagged dependant variable ($r_t - r_{t-1}$) in Equation (6) suggests that it is necessary to address the issue of residual autocorrelation. I test for the presence of residual correlation using the Lagrange Multiplier test. The associated *p*-values of Chi-Square with 2 degrees of freedom are reported in the last row. For both the OCR and the whole sample period in Table 6, the null hypothesis of no residual autocorrelation can be rejected at 5% level, as indicated by the *p*-values. The opposite is observed for the pre-OCR period.

Table 7 breaks down the total standard deviation of changes in the 30-day rate into expected and unexpected components. The first row reports the total standard deviation of the change, which suggests that the 30-day rate was substantially more

[11] Results for testing the presence of unit-root in all variables are presented in the Appendix.

volatile in the pre-OCR period than in the OCR period. The second row gives the standard deviation of the change of interest rate that the forecasting equation fails to predict. The third row is the difference between the first two standard deviations. The proportion of the total standard deviation that can be explained by the forecasting equation is much lower in the pre-OCR period (0.1342/0.4943) than that in the OCR period (0.1000/0.1353). Again, this confirms earlier finding that short rates were much less predictable in the pre-OCR period.

Similar results hold for the 180-day and 90-day rates, as reported in Table 8 and 9. The value of R^2 for the forecasting equation is more than twice larger in OCR (0.41) period than in the pre-OCR period (0.18). Table 10-13 report the regression estimates for Equation (5), which was initially tested by Mankiw & Miron (1986). Although this specification does not take into account the non-stationary property of interest rates, the results from estimating Equation (5) are similar to that produced by Equation (6). These forecasting equation estimates confirm that the short rates exhibited low predictive ability in the pre-OCR period, probably due to high volatility, and the predictive power was significantly improved after the introduction of OCR. Consequently, the failure of the EHTS for the pre-OCR period can be attributed to high volatility and poor predictability of interest rates.

7. CONCLUSION

Part I of this thesis has re-examined the Expectation Hypothesis of the Term Structure for New Zealand for the period from January 1989 to December 2006. The whole sample period is divided into two sub-periods – the pre-OCR and OCR period in order to investigate the impact brought about by the change in monetary operating procedure in March 1999 on the behaviour of interest rates and the thus expectations theory.

The study shows that during the pre-OCR period, short-term interest rates appearred to have no predictive power due to high volatility. The Central Bank's approach to targeting the settlement cash balance, together with the use of open-mouth operations in the day-to-day management of monetary conditions, had caused short-term interest rates to fluctuate substantially during the pre-OCR period. Because short-term interest rates were highly volatile during this period, the term spread appears to have no predictive power. As a result, the study fails to find convincing support for the EHTS for the pre-OCR period.

However, the opposite is observed for the OCR period. Not only is the coefficient estimate of the term spread significantly close to two, the R^2 value is also sizeable. The spread between the 60-day and 30-day rate now explains more than 60 percent of future change of the 30-day rate. The shift from targeting the settlement account balance to targeting the OCR has substantially reduced the volatility of short-term interest rates, and in effect, has restored their predictive power. The adoption of the OCR system and its particular implementation procedures are therefore the key factor that contributes the success of the EHTS for New Zealand for the 1999:03 to 2006:12 period.

This paper examines the ‘short-version’ of the EHTS for New Zealand, that is, only the short-term interest rates were used in testing the expectations hypothesis. It would ideal for the purpose of ‘completeness’ to examine the ‘long-version’ of the EHTS, which involves the use of long-term interest rates to test the theory. It would be interesting to find out whether the long-version of the EHTS also holds for New Zealand. This is an avenue for my future research.

PART II

THE PREDICTIVE POWER OF TERM SPREAD ON FUTURE ECONOMIC ACTIVITY IN NEW ZEALAND

1. INTRODUCTION

The second part of this research paper re-examines the predictive power of the term spread on economic activity for New Zealand for the period from December 1988 to December 2007. The spread is defined as the difference between the yield on a long-term and short-term security. As in the first part of this research exercise, the sample period is divided into two sub-periods – the pre-OCR (Official Cash Rate) period from 1988:12 to 1999:02 and the OCR period from 1999:03 to 2007:12[12]. This enables us to identify the effect, if any, brought about by the change in monetary regime in March 1999 on the spread's predictive power.

There exists a large body of literature that examines the predictive power of various financial variables on economic activity. Among these variables, the term spread has attracted considerable attention from financial market analysts, policy makers, and researchers around the world.

The term spread had been generally found in the literature to contain predictive power on future economic activity. Although not the first to examine the relationship, Stock & Watson (1989) found the term spread to be an important component in their constructed index of leading economic indicators, providing much of the foundation and motivation for later research. Estrella & Hardouvelis (1991) found a significant and positive relationship between the slope of the yield curve and real economic activity, claiming that the yield curve should contain useful information for financial market analysis and policy setting. Estrella & Mishkin (1995) examined the term structure and its role in monetary policy setting for the European Central

[12] Note that the OCR period does not end in 2007:12. It is the end date of my sample period.

Bank. They argued that the term spread is a useful economic indicator that contains predictive power for both real economic activity and inflation.

Previous authors who had also found supportive evidence for the predictive power of the spread include Plosser & Rouwenhorst (1994), Haubrich & Dombrosky (1996), Dueker (1997), Bernard & Gerlach (1998), Estrella & Mishkin (1998), and Dotsey (1998). These 'conventional findings' propose a positive correlation between the spread and output. Specifically, a rise in the current short-term interest rate caused by monetary policy tightening generally implies that the expected future short-term interest rates would be relatively lower. If the current short rate is higher than the expected average of future short rates, it would have negative effect on both current consumer spending (higher return on saving) and business investments (higher cost of borrowing). Thus, tightening monetary policy that raises current short rate more than the current long rate generally tends to have negative impact for economic activity that is sensitive to changes in the interest rate.

Some have argued that the extent to which the term spread can predict future economic activity and inflation depends on an economy's prevailing monetary regime. For example, Kotlan (2002) showed that the predictive ability of the spread is not structural but depends on the goals of monetary policy. He argued that the predictive power of the spread on economic activity (inflation) increases as more emphasis is placed on stabilizing economic activity (inflation) in the central bank's policy reaction function. Feroli (2004) argued that expectations of monetary policy actions play an important role in determining the predictive power of the spread. Jenson (2006) showed that the policy parameters in a Taylor type rule could affect the predictive ability of the spread on output growth.

Using a slightly different approach, several authors including Hamilton & Kim (2002), Favero *et al* (2004), Rudebusch *et al* (2007) and Maurer & Rosenberg (2008) decomposed the term spread into two components when estimating its predictive power on future output growth. The first is an *expectation component* that reflects the expected average future short rates over the life of the long-term bond and the second, a *term premium* that reflects the compensation required by investors for the risk associated with holding a longer-term asset. Hamilton & Kim (2002) found that the coefficient estimates for both the expectation component and the term premium are significant and positive as well as significantly different from each other. Their findings suggest that a fall in the term premium is associated with subsequent decline in output growth.

Following Hamilton & Kim (2002), this paper decomposes the spread into an expectation component and the term premium, allowing each of them to have a different impact on future output growth for New Zealand. This approach is chosen for the following reasons:

1. The decomposition of the term spread into an expectation component that reflects monetary policy actions and a term premium that captures changes in investors' risk appetite allows us to better understand why the predictive ability of the spread may fluctuate over time. Specifically, we want to find out whether the term premium tends to distort the spread's ability to signal a recession[13].
2. Using New Zealand data, we want to identify the 'real cause' for changes in output growth in New Zealand over the sample period examined, that is, whether it is caused by changes in interest rate expectations as a result of

[13] As pointed out by Maurer & Rosenberg (2008), many did not believe that the yield curve inversion in August 2006 was a signal for subsequent economic recession in the US, because the yield curve inversion was not caused by changes in interest rate expectations but a lower term premium.

policy actions or by changes in the term premium due to other macroeconomic factors; and

3. This paper would be the first (as far as I am aware of) to extend the analysis of the relationship between spread and economic activity by decomposing the spread into an expectation component and a term premium for New Zealand[14].

Bernanke (2006) had also shed some light on the subject in a speech before the Economic Club of New York in March 2006. He pointed out that the US ten-year Treasury yield had moved only a little on average during the monetary tightening cycle that began in June 2004. Bernanke (2006) attributed the unusual behaviour of the ten-year Treasury yield during that period to the fallen term premium, which had left the long rate relatively unchanged.

Conventional wisdom suggests that a tightening of monetary policy would raise the current short-term interest rates to be higher than the expected future short rates. According to the expectations hypothesis, long-term interest rates should rise but by a smaller magnitude relative to the short rates, causing the yield curve to flatten or invert and the economy to slow down. However, Bernanke (2006) argued the opposite – a flattening yield curve does not necessarily signal an impending recession. If the flattening yield curve is caused by a falling term premium that lowers long-term interest rates, and if an economy's spending depends on long-term interest rates, then factors that narrow the spread may stimulate economic activity. Rudebusch *et al* (2007) provides a comprehensive empirical analysis which supports Bernanke's argument.

[14] An earlier study on the relationship between the yield spread and real economic activity was by Guender & Moersch (1994), who empirically tested the relationship between the spread and output growth rate for both New Zealand and Australia. Their sample period was dated from 1977 to 1992, which did not account for the monetary regime change in March 1999.

Using Hamilton & Kim's decomposition method, I find that the coefficient estimates of the term premium, in a couple of cases, are significant and negative for New Zealand. Although in contrast to Hamilton & Kim's findings, the result is consistent with Bernanke's argument that the term premium can be negatively related to output growth. The term premium for New Zealand, to some extent, contains predictive power for future output growth. It carries some information about the future growth rate that can not be explained by the yield curve alone. On the other hand, the coefficient estimates of the expectation component are significant and positive in some cases, a result that conforms to earlier findings in the literature.

The rest of this paper proceeds as follows: Section 2 presents the model and provides a simple procedure for the decomposition of the spread; Section 3 discusses the data and econometric technique; Section 4 presents the empirical findings; Section 5 proposes some possible explanations for the findings and Section 6 concludes.

2. THE MODEL

This section revisits the methodology employed by Hamilton & Kim (2002) in decomposing the term spread.

(2.1) The Baseline Model

A specification that has been widely used[15] to examine the relationship between the spread and output growth takes the form of:

(1) $y_t^k = \alpha_0 + \alpha_1 Spread_t + \varepsilon_t$

(1.1) $y^k = (400/k) * (\ln Y_{t+k} - \ln Y_t)$

[15] Authors who tested the above specification include Estrella & Hardouvelis (1991), Guender & Moersch (1994), Estrella & Mishkin (1995), Haubrich & Dombrosky (1996), Dotsey (1998), and Jensen (2006).

(1.2) $Spread_t = i_t^n - i_t^1$

where y_t^k is the annualized real GDP growth k quarters ahead, $\ln Y_{t+k}$ is real GDP in quarter $t+k$, i_t^n and i_t^1 are the *n*-period long rate and the one-period short rate at time *t*, respectively[16].

To test the robustness of the predictive ability of the term spread, additional explanatory variables such as the overnight inter-bank borrowing rate (m_t^*), the five-year government bond rate (i_t^{TB5}) and lagged output growth rates, will be added to the above specification:

(2) $y_t^k = \alpha_0 + \alpha_1 Spread_t + \alpha_2 y_{t-1}^1 + \alpha_3 y_{t-2}^1 + \alpha_4 y_{t-3}^1 + \alpha_5 y_{t-4}^1 + \varepsilon_t$

(3) $y_t^k = \alpha_0 + \alpha_1 Spread_t + \alpha_2 m_t^* + \alpha_3 y_{t-1}^1 + \alpha_4 y_{t-2}^1 + \alpha_5 y_{t-3}^1 + \alpha_6 y_{t-4}^1 + \varepsilon_t$

(4) $y_t^k = \alpha_0 + \alpha_1 Spread_t + \alpha_2 i_t^{TB5} + \alpha_3 y_{t-1}^1 + \alpha_4 y_{t-2}^1 + \alpha_5 y_{t-3}^1 + \alpha_6 y_{t-4}^1 + \varepsilon_t$

These specifications are used to examine whether the spread can retain its predictive ability when a monetary variable, a long-term interest rate, and lagged growth rates are included in the regression. Initially, I will use them to examine whether results for New Zealand are consistent with the conventional findings.

(2.2) Decomposition of the Yield Spread

According to Hamilton & Kim (2002), the time-varying term premium TP_t can be defined as:

(5) $i_t^n = \frac{1}{n}\sum_{j=0}^{n-1} E_t i_{t+j}^1 + TP_t$

[16] Both the long and short rates have been adjusted for continuous compounding. Let the raw interest data be *r, then i* = ln (1+ *r*/100) x 100.

$E_t i^1_{t+j}$ is the market's expectation at time *t* of the one-period short rate at time *t+j*, and the term premium is the difference between the *n*-period long rate and the expected future one-period short rate over the life of the *n*-period bond.

Subtracting i^1_t from both sides of Equation (5) yields:

$$(6)\ \ i^n_t - i^1_t = (\frac{1}{n}\sum_{j=0}^{n-1} E_t i^1_{t+j} - i^1_t) + TP_t$$

Solving Equation (5) for TP_t and substituting it into (6) yields:

$$(7)\ \ i^n_t - i^1_t = (\frac{1}{n}\sum_{j=0}^{n-1} E_t i^1_{t+j} - i^1_t) + (i^n_t - \frac{1}{n}\sum_{j=0}^{n-1} E_t i^1_{t+j})$$

The term spread expressed in Equation (7) now consists of i) changes in the one-period short rate over the next *n*-periods—the expectation component, and ii) the time-varying term premium.

Substituting Equation (7) into (1) to yield:

$$(8)\ \ y^k_t = \alpha_0 + \alpha_1(\frac{1}{n}\sum_{j=0}^{n-1} E_t i^1_{t+j} - i^1_t) + \alpha_1(i^n_t - \frac{1}{n}\sum_{j=0}^{n-1} E_t i^1_{t+j}) + \varepsilon_t$$

After relaxing the assumption that the effects of the expectations component and the term premium on future output growth are the same, we can restate Equation (8) as:

$$(9)\ \ y^k_t = \alpha_0 + \alpha_1(\frac{1}{n}\sum_{j=0}^{n-1} E_t i^1_{t+j} - i^1_t) + \alpha_2(i^n_t - \frac{1}{n}\sum_{j=0}^{n-1} E_t i^1_{t+j}) + \varepsilon_t$$

The decomposition of the spread into an expectation component and a time-varying term premium allows us to examine whether these two components have distinctly separate effects on future output growth.

Let v_{t+n} be the forecasting error of the future one-period short rate, then

$$(10)\ \ v_{t+n} = \frac{1}{n}\sum_{j=0}^{n-1} i^1_{t+j} - \frac{1}{n}\sum_{j=0}^{n-1} E_t i^1_{t+j}$$

After substituting Equation (10) into (9) and rearranging it, we obtain:

$$(11)\quad y_t^k = \alpha_0 + \alpha_1\left(\frac{1}{n}\sum_{j=0}^{n-1} i_{t+j}^1 - i_t^1\right) + \alpha_2\left(i_t^n - \frac{1}{n}\sum_{j=0}^{n-1} i_{t+j}^1\right) + u_t$$

where $u_t = \varepsilon_t + (\alpha_2 - \alpha_1)v_{t+n}$.

The first explanatory variable is the expectation component and the second is the term premium[17]. Equation (11) will be tested to identify the potentially different effect the expectation component and the term premium have on future output growth in New Zealand[18].

Questioning the statistical validity of estimating Equation (11), Rudebusch *et al* (2007) proposed an alternative specification based on the first differencing of the explanatory variables, namely:

(12)

$$y_{t+4} - y_t = \alpha_0 + \alpha_1\left\{\left(\frac{1}{n}\sum_{j=0}^{n-1} i_{t+j}^1 - i_t^1\right) - \left(\frac{1}{n}\sum_{j=0}^{n-1} i_{t-4+j}^1 - i_{t-4}^1\right)\right\} + \alpha_2\left\{\left(i_t^n - \frac{1}{n}\sum_{j=0}^{n-1} i_{t+j}^1\right) - \left(i_{t-4}^n - \frac{1}{n}\sum_{j=0}^{n-1} i_{t-4+j}^1\right)\right\}$$

$$+\alpha_3(y_t - y_{t-4}) + u_t$$

where an additional one-year lag of all right-hand-side variables and a lagged one-year growth rate of output are included in the regression. They argued that the expectation component in (11) should not be related to the *growth rate* of output, but to the *level* of the output gap. Equation (12) now implies that output growth responds to *changes* in the expectations term and *changes* in the term premium, as opposed to the *levels* of these variables.

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[17] It is important to note that Hamilton & Kim constructed the expectation component (the first variable on the right hand side of Equation (11)) by using ex-post realization of short rates rather than ex-ante expected rates, thus providing agents with more information than they have when predicting future short rates in real time.

[18] As pointed out by Rudebusch *et al* (2007), the decomposition of the yield spread to allow the term premium to have different implications for future economic activity is somewhat in contrast to the New Keynesian model of aggregate demand in the existing literature. According to the simple linearized New Keynesian IS curve (see Appendix), the IS curve does not allow the term premium to have effect on output.

3. DATA AND ECONOMETRIC TECHNIQUES

Equation (11) and (12) will be tested using instrumental variables under the assumption that agents form expectations rationally. This implies that the error term u_t should be uncorrelated with any variables at time *t*. In contrast, Equation (2), (3) and (4) are estimated using Ordinary Least Squares (OLS) as in earlier papers. As is standard, I use the procedure of Newey and West (1987) to correct the standard errors for heteroskedasticity and autocorrelations that arises from the overlapping of forecasting horizons.

The data set contains quarterly observations of five and one-year government bond rates and 90-day bank bills rate from December 1988 to December 2007. Two pairs of spreads are considered. The first refers to the difference between the five-year government bond rate and the one-year government bond rate. The second refers to the difference between the five-year government bond rate and the private 90-day bank bill rate. One may argue that it would be more appropriate to use the 90-day Treasury bill rate than the private 90-day bank bill rate in constructing the spread because the private rate includes compensation for default risk. In fact, many earlier studies that examined the relationship between the spread and economic activity had used the US three-month Treasury bill rate in constructing the spread. The reason for choosing the private 90-day rate instead of the Treasury bill rate in this paper is that the market for 90-day bank bill rate is more active and deeper than the market for Treasury bill in New Zealand. One important thing to note is that many previous authors constructed the spread using the ten-year Treasury bond rate and the three-month Treasury bill rate in their analysis[19]. The use of the ten-year rate to construct the spread would result in loss of ten years of data. The use of the five-year rate instead of ten-year in this paper is to avoid such loss of large number of observations.

The data on the five and one-year government bond rates and the 90-day bank bills rates were obtained from the Reserve Bank of New Zealand. Because the data is only available in monthly observations, to obtain quarterly observations I only used the observations corresponding to the last month of each quarter. The quarterly seasonally-adjusted data on real GDP is from New Zealand Time Series.

***Data Source*:**

- The data on the five and one-year government bond rate and the 90-day bank bills rate can be found via the following URL: http://rbnz.govt.nz/statistics/exandint/b2/hb2.xls
- The data on Gross Domestic Product (seasonally-adjusted) is from New Zealand Time Series (Table 51.902-2A: GDP(P): Chain Volume Series (CVS): Seasonally Adjusted).

4. EMPIRICAL FINDINGS

This section presents the empirical findings. First, I present results for Equation (2), (3) and (4), the standard specifications that had been widely used in the literature. Next, I report estimation results for Equation (11) and (12). Finally, I propose some explanations for the established relationship between the term premium and output growth.

[19] These include Estrella & Hardouvelis (1991), Dotsey (1998), Hamilton & Kim (2002), Jensen (2006) and others.

(4.1) The Simple Baseline Model Estimates

Due to the change in monetary regime in March 1999 (the OCR system was introduced half way through the whole sample period), it is necessary to find out whether the parameters in the model are stable over time. I use the Chow's Breakpoint Test to test for the presence of structural break. Results are reported in the Appendix. For all of Equations (2), (3), and (4), the null hypothesis of no structural break can not be rejected, implying that there are no significant differences in the estimated equations in both the pre-OCR and OCR period.

Tables 1 and 2 report results for Equation (2), where the spread and lagged growth rates are the explanatory variables. For the five-year/90-day spread, the estimates of α_1 are positive and significant in 28 out of 30 cases across the three sample periods. While the coefficient estimates of the spread are highly significant in most cases, the size of the coefficient estimates and the explanatory power of Equation (2) – captured by R^2, vary across different sample periods.

For the periods from 1988:12 to 1999:02 and 1988:12 to 2007:12, the values of R^2 generally increase as the forecasting horizon increases (as k increases). The opposite is observed for the OCR period (1999:03 to 2007:12), where the value of R^2 is highest when the forecasting horizon is around three quarters ahead (R^2 = 0.60 at k=3). Furthermore, R^2 is generally higher in the OCR period than in the other two periods. This suggests that the introduction of the OCR system in March 1999 led to an increase in the spread's predictive power[20]. The spread can thus explain more of the changes in output growth during the OCR period than in the period preceding it.

[20] While I find that the predictive power of the spread for economic activity in New Zealand is generally higher during the OCR period (1999:03 to 2007:12), others have found just the opposite for the US for roughly the same period. For example, Jenson (2006) found that the predictive power of the spread for future output growth had dramatically declined during the Greenspan era (1987 to 2005). He argued that the extent to which the term spread can predict future output growth depends on an economy's prevailing monetary policy. Consequently, the difference in findings may be due to different monetary operating procedures in the two countries.

Under the OCR system, the Reserve Bank of New Zealand sets and targets the OCR in the conduct of monetary policy, and adjusts it in response to changes in economic and monetary conditions. This implies that the role that interest rates play in monetary policy setting has become more important. If the level or growth rate of the output gap form part of monetary authority's objective function, the move towards using an interest rate as a policy instrument would cause interest rates, thus the spread, to be more related to output growth. This may explain why the predictive power of the spread for economic activity is relatively higher in the OCR period.

In terms of the coefficient estimates, we observe higher values of coefficient estimates of the spread in the OCR period at the early horizon (k = 1 to 4). This means movements in the spread have a larger short-term effect on future output growth in the OCR period than in the period preceding it.

Table 2 presents the coefficient estimates of the five-year/one-year spread, where the estimates of α_1 are positive and significant in 28 out of 30 cases. However, estimates of α_1 are everywhere larger in Table 2 than those in Table 1. This suggests that changes in the five-year/one-year spread would have greater effect on future output growth than the other spread. One possible explanation is that economic activity (such as consumption and investment) may be more responsive to changes in the one-year government bond rate than to changes in the 90-day bank bill rate. Overall, results in these two tables are consistent with the proposed positive relationship between output growth and term spread in the literature. In fact, these results are stronger than that found by earlier authors. For example, Dotsey (1998) found that the spread contains predictive ability on economic activity only up to eight quarters ahead. Both Estrella & Hardouvelis (1991) and Plosser & Rouwenhorst

(1994) found that the spread can predict economic growth only up to six quarters ahead.

Equation (3) examines the predictive power of the spread for economic activity when the overnight inter-bank cash rate (denoted as m^* hereafter), a proxy for the stance of monetary policy, enters the regression as a separate explanatory variable. Results are reported in Table 3 and 4. The purpose of including a monetary policy variable into the regression is to investigate whether the spread contains additional information about economic activity that can not be explained by the monetary policy. For the case at hand, I choose the inter-bank overnight rate because its movement had historically been very closely linked to movements in the OCR.

According to Table 3, the coefficient estimates of the five-year/90-day spread are now significant and positive only in 6 out of 30 cases. In particular, for both the pre-OCR and the whole sample period, the coefficient estimates of the spread are significant only at k =12[21]. After including m^* in the regression, the spread has substantially lost its predictive ability. This suggests that the spread for these two periods contains very little additional information for future output growth apart from that already embodied in m^*. Results for the OCR period are somewhat different. Neither the coefficient estimates of the spread nor the inter-bank cash rate is significant at the short end of the forecasting horizons. The spread is significant only from k = 7 onwards. The coefficient estimates of m^* are significant at k = 12 and 16, yet it gives the wrong sign of prediction[22].

The failure of both the spread and m^* to predict output growth at the short end of the forecasting horizon during the OCR period can be attributed to *multicollinearity* between the two variables. Multicollinearity arises when the explanatory variables in

[21] The coefficient estimate of the spread is marginally significant at k = 16 in the whole sample period.
[22] The coefficient estimate of m^* is marginally significant at k = 4 and 5 with the correct prediction sign in the OCR period.

the regression are highly intercorrelated, and it is difficult to separate the individual effect of these variables on the independent variable. In this case, it is obvious that the five-year/90-day spread should be highly correlated to m^*, given the 90-day bank bills rate is highly correlated with m^*. The correlation coefficient for the spread and m^* equals to -0.92[23] for the OCR period. This suggests that during this period, changes in monetary policy that affect the inter-bank cash rate have more or less the same effect on the 90-day bank bills rate. Comparing with the correlation coefficient for the pre-OCR period (-0.62), I find the introduction of the OCR system had caused the spread to be highly correlated with the inter-bank cash rate. Thus, the failure of these two variables to predict short-term future output growth in the OCR period is due to the presence of multicollinearity that inflates the standard error[24].

Table 4 reports the coefficient estimates for the five-year/one-year spread and m^*. Again similar results are obtained for the pre-OCR and the whole sample period, where the spread can predict output growth only at k = 12 in the pre-OCR period and at k =12 and 16 in the whole sample period. Similar to the five-year/90-day spread, the predictive power of the five-year/one-year spread reduces significantly after the inter-bank cash rate is included as a separate explanatory variable in the regression. However, the findings for the OCR period are different. The five-year/one-year spread now retains its predictive power for all forecasting horizons, whereas the inter-bank cash rate is insignificant up to k = 12. For k = 12 and 16, it generates the incorrect prediction sign. A possible explanation is that while the five-year/90-day spread is highly correlated with m^*, the degree to which the five-year/one-year spread

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[23]All correlation coefficients are determined by running the correlation function in Excel.

[24] Maddala (2001), for example, argues that the presence of multicollinearity among explanatory variables may not necessarily have an adverse impact on statistical inferences. Furthermore, multicollinearity problem can not be entirely attributed to highly inter-correlated explanatory variables. For instance, different parametrizations of the variables would generate different magnitudes of these inter-correlations.

is correlated with *m** is somewhat smaller. For the OCR period, the correlation coefficient for these two variables is now -0.84, compared to that of the five-year/90-day spread and *m** (-0.92) in the same period.

In general, because longer-term interest rates (one-year rate) tend to be less responsive to policy changes than shorter-term interest rate (90-day rate), we observe a lower degree of correlation between the five-year/one-year spread and *m**. The fact that the five-year/one-year spread can retain its predictive power for future output growth after the inclusion of *m** in the regression suggests that during the OCR period, the spread contains additional information regarding future output growth that can not be explained by a proxy for monetary policy. Consequently, special factors that affect the long-term interest rate and hence the spread, such as future inflationary expectations and changes in demand/supply of long-term securities, help explain movement in future output growth.

Table 5 and 6 presents results for Equation (4), where the spread and the five-year rate enter together in the regression. Results are very similar for both pairs of the spread. In many cases, both the spread and the five-year rate enter significantly in the regression with the correct prediction sign. This suggests that the spread can retain its predictive ability even after including the five-year rate in the regression. Furthermore, by comparing the values of R^2 in Tables 5 and 6 with those reported in Tables 1 to 4, we can see that the explanatory power of Equation (4) – a specification that includes the five-year rate as a separate regressor, is generally higher than that of previous specifications. This finding suggests that the five-year government bond rate may have important implications for future output growth in New Zealand. The relationship between the long-term government bond rate and output growth will be discussed in details in the following section..

The presence of lagged dependant variables on the right hand side of Equations (2), (3) and (4) raises the issue of residual autocorrelation in the regressions. I use the Lagrange Multiplier test to test for the presence of residual autocorrelation. The LM test statistics are reported in Tables 1 to 6. In most cases, the p-values are significantly low that the null hypothesis of no residual autocorrelation can be rejected at 1% level.

According to Maddala (2001), residual autocorrelation is generally caused by omission of significant variables in the regression and/or a misspecified model. In the case of omitted variables, Equations (2), (3) and (4) can be improved by adding in variables that relate to the model, such as population growth, housing prices, unemployment rate and other macroeconomic variables. Given that there is a large number of variables that relate to the model, residual autocorrelation caused by omitted variables is rather difficult to tackle. In the case of a misspecified model, we can correct residual autocorrelation by changing the structural form of the model. For example, the explanatory variables m_t^* , and i_t^{TB5} can be transformed by first-differencing. This is plausible because Equations (3) and (4) relate the *changes* in output level to the *level* of the overnight cash rate and the long-term interest rate, respectively, and by first-differencing m_t^* and i_t^{TB5}, these equations would relate the *changes* in output level to the *changes* in these two variables. Given the presence of residual autocorrelation, results should be interpreted with care.

In this section, we decompose the spread into an expectation component and the term premium with the intention of separating their contributions to changes in output growth. This requires a forecasting model that separates interest rates expectations from the term premium. However, an accurate measure of the term premium can be extremely difficult to obtain as the term premium is not directly observable. Several computation methods had been proposed in the literature for measuring the term premium[25].

As these computations require an estimation technique beyond the scope of this paper, I use the same method as Hamilton & Kim (2002) in measuring the term premium. The term premium component in Equation (11) is constructed using ex-post realized short rates instead of ex-ant expected rates. It is then estimated using instrumental variables[26] under the assumption that the error term is uncorrelated with any explanatory variables (Rational Expectations). Results for the three sample periods are presented in Table 7 and 8.

For the five-year/90-day spread, the coefficient estimates of the expectation component are insignificant for all values of k for the 1988:12 – 1999:02 period, suggesting that changes in short-term interest rates do not have any effect on future output growth. For the OCR period, the expectation component is significant and positive at k = 1 and 2 (marginally significant at k = 3), the very short end of the forecasting horizon. This suggests that changes in short-term interest rates can predict future output growth up to two or three quarters ahead. In general, a monetary policy tightening that increases current short rate relative to expected future short rate ($\frac{1}{n}\sum_{j=0}^{n-1} i_{t+j}^{1} - i_t^{1} < 0$) tend to have negative effect on future output growth, as higher cost of borrowing puts downward pressure on consumer spending and investment activity.

For the whole sample period 1988:12 to 2007:12, the expectation component is significant and positive only at k = 12, and the size of the coefficient estimate is

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[25] Rudebusch *et al* (2007) compares five measures of the term premium proposed in the existing literature and find that the different measurement techniques tend to generate different estimation results. The measures of the term premium include the VAR measure, Bernanke-Reinhart-Sack measure, Rudebusch-Wu measure, Kim-Wright measure and the Cochrane-Piazzesi measure.

[26] The instrument list includes a constant, i_t^1 and i_t^n, which implies that Equation (11) is estimated in a just-identified model.

much smaller (0.43) than that for the OCR period (2.94 and 2.16). This suggests that the expectation component does not have immediate effect on output growth for the whole sample period. Similar results hold for the five-year/one-year spread, where the expectation component is significant and positive up to three quarters ahead for the OCR period and only significant at k = 11 during the whole sample period. Although results for the expectation component estimates are not very strong, they are consistent with earlier findings by Hamilton & Kim (2002) and Ang *et al.* (2004)[27].

Various authors including Hamilton & Kim (2002), Ang *et* al (2004), Bernanke (2006) and Rudebusch *et al* (2007) have studied the relationship between the term premium and economic activity. The findings in this section are largely consistent with the view expressed by Benanke (2006) and Rudebusch (2007) but in stark contrast to the findings reported by Hamilton & Kim (2002) and Ang *et* al (2004).

For the five-year/90-day spread, the term premium estimates are insignificant in most cases. The coefficient estimates are marginally significant and negative at k = 3 and 4 in the pre-OCR period and at k = 5 and 6 in the OCR period[28]. However, the results improve in the whole sample period, where the coefficient estimates are significant and negative at 5% level at k = 4 and 5 and marginally significant at k = 3 and 6. Under the null hypothesis that $\alpha_1 = \alpha_2$, the Wald test statistic is distributed as χ_1^2 with 1 degree of freedom. According to the χ_1^2-statistic, the null hypothesis can be rejected at 1% level, indicating that the term premium component does carry independent information on economic activity that can not be fully explained by changes in short rates. For the five-year/one-year spread, the term premium estimates

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[27] Ang *et al* (2004) found significant and positive coefficients for the expectation component but not for the term premium component.
[28] Results for the OCR period should be treated with care due to loss of large number of observations. The effective sample period is from the second quarter of 1999 to the first quarter of 2003.

are insignificant everywhere except for k = 4, 5 and 6 during the whole sample period, where the estimates are marginally significant and negative. When interpreting the coefficient estimates of the term premium, it is important to point out that the two pairs of spread that are used to construct the term premium component in Equation (11) are different in nature. While the five-year/one-year spread is the difference between two public interest rates, the five-year/90-day spread consists of a public and a private interest rate. The 90-day bank bills are issued by private banks, implying that the 90-day bank bill rate is not risk-free. Consequently, the term premium component that is constructed using the five-year/90-day spread should have more pronounced effect on output growth than the term premium component constructed using the public spread. This is consistent with results in Table 7 and 8. For the whole sample period, the term premium has a more pronounced effect on output growth for the five-year/90-day spread than the five-year/one-year spread.

Although not very strong, the observed negative correlation between the term premium and output growth in this paper is in contrast to findings reported by Hamilton & Kim, who initially proposed a positive relationship between term premium and economic activity.

Note that the results in Table 7 and 8 are obtained from estimating a specification (Equation 11) that relates the slope of the yield curve to the *growth rate* of output. According to Rudebusch *et al* (2007), the use of Equation (11) may lead to misleading results. They argued that according to the New Keynesian IS curve, the level of output is related to deviation of short-term interest rate from it equilibrium level. This suggests that the expectation component should only be related to the level rather than the growth rate of output. Conversely, Equation (11) relates the expectation component to the growth rate of output, which differs from the New

Keynesian model by a derivative. Furthermore, the term premium variable in Equation (11) is likely to be non-stationary while the growth rate of output seems to be stationary[29]. Taken these into account, Rudebusch *et al* proposed an alternative specification, namely Equation (12), that relates the *changes* of the expectation component and the term premium to the growth out of output. Results are reported in Table 9. For both definitions of the spread, the coefficient estimates of the expectation component and the term premium are significant only for the OCR period, and according to the χ_1^2 -statistic, the null hypothesis of $\alpha_1 = \alpha_2$ can be rejected at 1% level. This is consistent with results in Table 7 as both the expectation component and the term premium in this specification give the correct sign of prediction for future output growth[30].

5. POSSIBLE EXPLANATIONS

The yield spread is the difference between a long-term and a short-term interest rate, where the long rate reflects both the market's expectations of future short rates and a term premium. Thus, the relationship between the yield spread and economic activity can be explained either in terms of changes in market's expectations of future short rates or changes in term premium, or both. For example, a tightening monetary policy generally means a rise the current short rate. If market participants have come to expect that the economy will slow down and thus an easing of monetary policy will occur in near future, the expected future short rates would fall. The expectations

[29] I can reject the null hypothesis of non-stationarity for the growth rate of output at 1% significance level but fail to reject the null hypothesis of non-stationarity for the term premium even at 10% level.
[30] Due to loss of large number of observations, there are only 16 observations for the OCR period, so results for this period should be treated with care.

hypothesis then posits that if current short rate is higher relative to expected future short rate, long-term interest rates would rise less than the current short rate, causing the yield curve to flatten or invert. In the past, a yield-curve inversion has generally been followed by a subsequent economic downturn[31]. However, since the yield spread consists of expectations of future short rate and the term premium, it is necessary to isolate the separate effect these two variables have on future economic activity.

Figures 1 and 2 plot the measured term premium for both pairs of the spread over the period from 1988:12 to 2003:03[32] for New Zealand. The term premium has been generally declining during this period and started to fall below zero from 2002:06 onwards. Since the long rate is determined by the average expected future short rates and the term premium, a falling term premium implies that the long rate would be lower relative to short rates. Figure 3 shows that the five-year government bond rate has been generally declining after the introduction of the OCR system. In fact, on many occasions, the 90-day rate has been higher than the five-year long rate.

The behaviour of the five-year government bond rate in New Zealand during the OCR period has been in fact similar to that of the ten-year Treasury yield in the US, which has only moved a little since the monetary tightening cycle that began in June 2004. Some explanations for this 'conundrum' have been put forward in the literature. For example, Rudebusch *et al* (2006) attributed the unusual behaviour of the US ten-year Treasury yield in 2004 and 2005 to a decline in long-term bond volatility. On the other hand, Kim & Wright (2005) attempted to address the

[31] Using US data, Estrella and Hardouvelis (1991) found a compelling link between yield –curve inversion and subsequent economic recession. When the spread between the ten-year Treasury note and the three-month Treasury bill inverts, their model predicts a decline in real economic activity twelve months in the future. Estrella and Mishkin (1996) also found the yield spread a good predictor for future recessions in the US.

[32] This paper is unable to provide measurement of the term premium beyond March 2003. The mathematical approach for deriving the term premium, as shown in Section 2.2, results in the loss of 19 observations.

phenomenon and attributed the falling term premium and low level of long-term interest rate to the increase in outstanding long-term government securities. The latter argument holds for New Zealand. The falling term premium can be largely attributed to an increase in outstanding long-term government security, which had maintained long-term interest rates at relatively lower level compared to short rates. Figure 4 shows the total government security (five-year or more in maturity) on issue during the whole sample period. The saw-tooth pattern is caused by the government repurchasing the security at a given point in time. The steady increase in the quantity of outstanding government securities with maturity of five-year can be traced to the following two factors:

(5.1) Better-anchored Inflation Expectations and Reduced Economic Volatility

Demand for long-term government securities may have increased because they have become more attractive due to improved and more credible monetary policy, which stabilized and maintained inflation within a target band. Figure 3 shows that the five-year government bond rate has become relatively lower in the OCR period compared to pre-OCR period. The introduction of the OCR system in March 1999 has significantly reduced economic volatilities. Table 10 reports the standard deviation of the Consumer Price Index and annual real GDP growth for the pre and post-OCR period. After the regime change, quarterly monetary policy statements and other public announcements issued by the Reserve Bank allowed market participants to make better projections about future changes in monetary policy and economic outlook. Volatility of both inflation and real GDP growth decreased substantially in the OCR period because of more transparent and credible monetary policy implementation. Better-anchored inflation expectations and decreasing volatility in economic activity means investors are willing to accept less compensation for the risk (both interest rate and inflation risk) of holding longer-term security, and thus a lower term premium is required for holding long-term security.

From a fiscal perspective, the government issues long-term government securities to finance budget deficit. Consequently, lower long-term interest rates means the government can finance its budget deficit at a lower cost. Thus, it is in the interest of the government to issue long-term securities during periods when long-term interest rates are relatively lower.

(5.2) Increase in Non-Resident Holdings of Government Bond

A second driver for the increase in demand for government bonds over the last decade is the increase in non-resident holdings of government bonds. Figure 5 shows the percentage of non-resident holdings of New Zealand government bonds. Beginning from the year 2000, demand for New Zealand government bonds from foreign investors has been increasing steadily, keeping longer-term interest rates at a relatively low level. The major factor that has contributed to the increase in non-resident holdings of government bond is the robust domestic economy. Table 11 shows the average annual GDP growth rate for New Zealand, Australia, US, Japan and UK. It compares the average growth rates across the three different sample periods. For the OCR period, annual real GDP growth rates for New Zealand have averaged 3.5% each year, the highest among the five countries. Other factors that have been driving up demand for New Zealand government bond include strong New Zealand currency, low unemployment rate and higher interest rates in New Zealand relative to countries such as Japan, Europe and the US.

In summary, the term premium and the five-year government bond rate have been generally declining since the introduction of the OCR system. The fallen term premium and low level of the five-year rate can be attributed to increase in demand for long-term government bonds. Given this, a negative correlation between the term premium and output growth for New Zealand is plausible. Consequently, I agree with the following statement made by Bernanke (2006).

"……if spending depends on long-term interest rates, special factors that lower the spread between short-term and long-term rates will stimulate aggregate demand. Thus, when the term premium declines, a higher short-term rate is required to obtain the long-term rate……"

This suggests that, holding all else constant, if the yield-curve inversion is caused by a fallen term premium, and if spending and investing activity depends on the long-term interest rate, a flattening or inverted yield curve will have positive rather than negative implications for future output growth.

6. CONCLUSION

The second part of this thesis examines the relationship between the term spread and future economic activity for New Zealand. In particular, the term spread is decomposed into an expectation component that reflects changes in monetary policy and a time varying term premium that reflects changes in perception of risk. The decomposition serves the purpose of examining whether the term premium has a role in affecting future economic activity in New Zealand.

For the specification where the yield spread and lagged growth rates are the only explanatory variable, the results are entirely consistent with earlier findings in the literature, that is, a significant and positive correlation between the yield spread and future economic activity. The inclusion of a proxy variable for monetary policy (over-night inter-bank rate) reduces to some extent the predictive power of the yield spread. In many cases, the yield spread is only able to predict future output growth at the long end of the forecasting horizon.

This paper adopts the approach of Hamilton & Kim (2002) in estimating the term premium. Although one might cast doubt on the method for the decomposition, this paper presents some important findings. For the expectation component, results are generally consistent with those findings reported earlier in the literature. The results for the term premium estimates are, in some cases, at odds with findings by Hamilton & Kim (2002), but they are in line with the argument put forward by Bernanke (2006) and Rudebusch *el al* (2007). The findings in this paper suggest that if monetary policy is credible and thus inflation expectations are well anchored, long-term security may become more attractive to investors. Given that the volatility of annual GDP growth rate and inflation rate for New Zealand have fallen substantially after the introduction of the OCR system, investors have become more willing to accept a smaller term premium for holding longer-term securities, that is, a decline in the term premium. The robust demand for New Zealand government bonds over recent years has left long-term interest rate at relatively lower level. This implies that if spending and investing activities depend on long-term interest rates, special factors that cause the yield spread to flatten or invert may in fact stimulate economic activities.

Using New Zealand data, this paper empirically establishes a negative relationship between the term premium and future economic activity in New Zealand. This important finding is useful in terms of providing a foundation for future related research. In particular, it would be ideal to include a structural interpretation of the proposed empirical relationship between the term premium and future economic activity. This may be an avenue for future research.

Appendix (Part I)

Testing for Presence of Unit Root in All Variables

	TERM SPREAD (60/30)	TERM SPREAD (180/90)	30-DAY RATE	60-DAY RATE	90-DAY RATE	180-DAY RATE	CHANGES IN 30-DAY RATE	CHANGES IN 60-DAY RATE	CHANGES IN 90-DAY RATE	CHANGES IN 180-DAY RATE
Augmented Dickey-Fuller *t*-statistic	-6.72	-4.59	-2.34	-2.32	-2.32	-3.49	-10.98	-9.95	-9.31	-3.94
Probability	0.0000	0.0002	0.1613	0.1655	0.1653	0.0091	0.0000	0.0000	0.0000	0.0022
Test critical value at 5% level	-2.87	-2.88	-2.87	-2.87	-2.87	-2.88	-2.87	-2.87	-2.87	-2.88
H_0 = unit root	Reject	Reject	Not Reject	Not Reject	Not Reject	Reject	Reject	Reject	Reject	Reject

Appendix (Part II)

According to the linearized New Keynesian model of aggregate output, the level of aggregate output is determined by a forward-looking IS curve:

$$(1)\quad y_t = \beta E_t y_{t+1} - \frac{1}{\theta}(i_t - E_t \pi_{t+1}) + e_t$$

where y_t denotes aggregate output and $i_t - E_t \pi_{t+1}$ denotes the one-period ex ante real interest rate.

Solving the above equation forward for y_t, we obtain:

$$(2)\quad y_t = -\frac{1}{\theta} E_t \sum_{j=0}^{\infty} \beta^j (i_{t+j} - \pi_{t+1+j}) + e_t$$

Equation (2) now implies that output is only determined by the expected path of the short-term real interest rates. Thus, the model does not allow the term premium to affect output.

Testing for Presence of Structural Break at 1999:03

	χ_1^2 (***P*-VALUE**)	H_0 = **NO STRUCTURAL BREAK AT 1999:03**
Equation (2)	0.2650	Not Reject
Equation (3)	0.5048	Not Reject
Equation (4)	0.5536	Not Reject

REFERENCES:

Ang, A., Piazzesi, M. and Wei, M. (2004). "What does the yield curve tell us about GDP Growth?" *Journal of Econometrics*, 131, 359-403.

Bekaert, G., and Hodrick, R. J. (2001). "Expectations Hypothesis Tests,' *Journal of Finance,* 56, 1357 to 1394.

Bekaert, G., Hodrick, R. and Marshall, D. (1997). "On Biases in Tests of the Expectations Hypothesis of the Term Structure of Interest Rates." *Journal of Financial Economics,* 44, 309-48.

Bernanke, B. (2006). "Reflections on the Yield Curve and Monetary Policy." *A Speech before the Economic Club of New York, New York, March 20, 2006.*

Bernard, H. and Gerlach, S. (1998). "Does the Term Structure Predict Recessions? The International Evidence." *International Journal of Finance and Economics,* 3, 195-215.

Breusch, T. (1978). "Testing for autocorrelation in dynamic linear models". *Australian Economic Papers* 17, 334-355.

Campbell, J. and Shiller, R. (1991). "Yield Spreads and Interest Rate Movements: A Bird's Eye View." *Review of Economic Studies,* 58, 495-514.

Campbell, J. (1995). "Some Lessons from the Yield Curve." *Journal of Economic Perspectives,* 9(3), 129-52.

Corte, D., Sarno, L. and Thornton, D. L.(2007). "The Expectation Hypothesis of the Term Structure of Very Short-Term Rates: Statistical Tests and Economic Value," *CEPR Discussion Papers 6445,* C.E.P.R. Discussion Papers.

Cuthbertson, K. (1996). "The Expectations Hypothesis of the Term Structure: The UK Interbank Market." *Economic Journal, Royal Economic Society,* 106(436), 578-92.

Dotsey, M. (1998). "The Predictive Content of the Interest Rate Term Spread for Future Economic Growth." *Federal Reserve Bank of Richmond Economic Quarterly* 84, 31-51.

Dueker, M. (1997). "Strengthening the Case for the Yield Curve as a Predictor of U.S. Recessions." *Federal Reserve Bank of St. Louis Review* 79, 41-45.

Estrella, A. and Hardouvelis, G. (1991). "The Term Structure as a Predictor of Real Economic Activity." *Journal of Finance* 46, 555-76.

Estrella, A. and Mishkin, F. (1995). "The Term Structure of Interest Rates and Its Role in Monetary Policy for the European Central Bank." *NBER Working Paper,* No. W5279.

Estrella, A. and Mishkin, F. (1998). "Predicting U.S. Recessions: Financial Variables as Leading Indicators." *Review of Economics and Statistics*, 80, 45-61.

Favero, C., Kaminska, I. and Soderstrom, U. (2004). "The Predictive Power of the Yield Spread: Further Evidence and a Structural Interpretation," *Working Papers* 280, Innocenzo Gasparini Institute for Economic Research, Bocconi University.

Feroli, M. (2004). "Monetary Policy and the Information Content of the Yield Spread." *Federal Reserve Board Working Paper,* No. 2004-44.

Frazer, J. (2004). "Liquidity Management in the New Zealand Banking System." *Reserve Bank of New Zealand Bulletin*, 67 No. 4.

Froot, K. (1989). "New Hope for the Expectations Hypothesis of the Term Structure of Interest Rates." *Journal of Finance,* 44, 283-305.

Gerlach, S. and Smets, F. (1997). "The Term Structure of Euro-rates: Some Evidence in Support of the Expectations Hypothesis." *Journal of International Money and Finance,* 16, 305-21

Godfrey, L. (1978). "Testing against general autoregressive and moving average error models when the regressors include lagged dependent varibles". *Econometrica* 46, 1293-1302.

Gordon, M. (2003). "Estimates of Time-varying Term Premia for New Zealand and Australia." *Discussion Paper Series (Reserve Bank of New Zealand),* DP2003/06.

Guender, A. and Moersch, M. (1994). "Yield Spreads & Real Economic Activity: The Case of New Zealand & Australia." *Discussion Paper, The University of Canterbury*.

Guthrie, G., and Wright, J. (2000). "Open Mouth Operations." *Journal of Monetary Economics,* Vol. 46, Issue 2.

Guthrie, G., Wright, J. and Yu, J. (1999). "Testing the Expectations Theory of the Term Structure for New Zealand." *New Zealand Economic Papers,* 33, 93-114.

Hamilton, J. and Kim, D. (2002). “A Reexamination of the Predictability of Economic Activity Using the Yield Spread.” *Journal of Money, Credit and Banking,* 34, No. 2, 340-60.

Haubrich, J. and Dombrosky, A. (1996). “Predicting Real Growth Using the Yield Curve.” *Federal Reserve Bank of Cleveland Economic Review,* 32, 26-35.

Jensen, M. (2006). “Monetary Policy and the Predictive Power of the Term Spread for Economic Activity.” *Macroeconomics Field Paper,* (Summer 2006).

Kim, D. and Wright, J. (2005). “An Arbitrage-Free Three-Factor Term Structure Model and the Recent Behaviour of Long-Term Yields and Distant-Horizon Forward Rates.” *Finance and Economics Discussion Series,* 2005-33, Board of Governors of the Federal Reserve System (U.S.).

Kool, J. and Thornton, L. (2000). “A Note on the Expectations Hypothesis at the Founding of the Fed.” *Journal of Banking and Finance*, 28, 3055-68.

Kotlan, V. (2002). “Monetary Policy and the Term Spread in a Macro Model of a Small Open Economy.” *Working Paper Series of the Czech National Bank,* 1/2002.

Maddala, G. S. (2001). *Introduction to Econometrics* (3rd ed.). Chichester, England: John Wiley & Sons, Ltd.

Mankiw, G. and Miron, J. (1986). “The Changing Behaviour of the Term Structure of Interest Rates.” *Quarterly Journal of Economics,* 101, 211-28.

Maurer, S. and Rosenberg, J. (2008). “Signal or Noise? Implications of the Term Premium for Recession Forecasting.” *Federal Reserve Bank of New York - Economic Policy Review*, 14, No. 1.

McCallum, B. (1994). “Monetary Policy and the Term Structure of Interest Rates.” *National Bureau of Economic Research Working Paper*, No. 4938.

Melino, A. (1988). “The Term Structure of Interest Rates: Evidence and Theory.” *Journal of Economic Surveys,* 2:4, 335-66.

Newey, W. and West, K. (1987). “A Simple, Positive Semi-definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix.” *Econometrica,* 55, 703-08.

Plosser, C. and Rouwenhorst, K. (1994). “International Term Structures and Real Economic Growth.” *Journal of Monetary Economics,* 33, 133-55.

Rudebusch, G., Sack, B. and Swanson, E. (2007). "Macroeconomic Implications of Changes in the Term Premium." *Federal Reserve Bank of St. Louis Review,* 89(4), 241-69.

Stock, J. and Watson, W. (1989). "New Indexes of Coincident and Leading Indicators." *NBER Macroeconomic Annual,* Vol. 4, edited by Olivier Blanchard and Stanley Fischer. Cambridge, Mass.: MIT Press.

Tzavalis, E. and Wickens, M. (1997). "Explaining the Failures of the Term Spread Models of the Rational Expectations Hypothesis of the Term Structure." *Journal of Money, Credit and Banking*, Vol. 29, 3. 364-80.

Tables and Figures for PART I

TABLE 1

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

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

PERIOD	1988:12 - 1999:02	1999:3 - 2006:12	1988:12 - 2006:12
Constant	-0.10	-0.03	-0.06
	(0.0539)	(0.0118)	(0.03323
$R_t - r_t$	1.16***	**1.87*** **	1.33***
	(0.4348)	(0.1865)	(0.3231)
R^2	0.06	**0.62**	0.09
D.W.	1.40	1.44	1.34
s.e.	0.4821	0.0843	0.3700

Note: 1) The number of observations for the pre-OCR, OCR and whole sample period are 123, 93 and 216, respectively. 2) *** denotes significance at 1% level. 3) Standard errors are reported in parenthesis. 4) All figures except for standard errors are rounded to two decimal places. 5) Standard errors are corrected for autocorrelations using the test of Newey and West (1987).

TABLE 2

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

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

PERIOD	1991:01 - 1999:2	1999:3 - 2006:05	1991:01 - 2006:05
Constant	-0.09	-0.04	-0.06
	(0.0627)	(0.0180)	(0.0372)
$R_t - r_t$	0.68	0.81***	0.79***
	(0.4266)	(0.0988)	(0.2155)
R^2	0.04	**0.44**	0.09
D.W.	1.19	1.22	1.17
s.e.	0.4739	0.1155	0.3524

Note: 1) The number of observations for the pre-OCR, OCR and whole sample period are 98, 88 and 186, respectively. 2) *** denotes significance at 1% level. 3) Standard errors are reported in parenthesis. 4) All figures except for standard errors are rounded to two decimal places. 5) Data on the 180-day interest rate is only available from January 1991 to June 2006. 6) Standard errors are corrected for autocorrelations using the test of Newey and West (1987).

TABLE 3

STANDARD DEVIATIONS OF CHANGES IN SHORT RATES

	1988:12 - 2006:12	1988:12 -1999:02	1999:03 - 2006:12
30-day rate	0.3863	0.4943	0.1353
60-day rate	0.3554	0.4512	0.1375
90-day rate	0.3652	0.4611	0.1493
180-day rate	0.3300	0.4223	0.1616

Note: Standard deviation are computed from Excel.

TABLE 4

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

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

	$R_t - r_t > 0$			$R_t - r_t < 0$		
Period	88:12 to 99:02	99:03 to 06:12	88:12 to 06:12	88:12 to 99:02	99:03 to 06:12	88:12 to 06:12
Constant	-0.13	-0.06	-0.09	-0.02	0.06	0.01
	(0.0624)	(0.0190)	(0.0372)	(0.0655)	(0.0191)	(0.0378)
Spread	1.11	**2.05*** **	1.33***	2.66***	3.53***	2.83***
	(0.7134)	(0.2659)	(0.4671)	(0.5033)	(0.5322)	(0.4547)
R^2	0.03	**0.51**	0.04	0.10	**0.28**	0.12
D.W.	1.50	1.23	1.44	1.29	1.02	1.26
s.e.	0.5303	0.1001	0.4091	0.5089	0.1219	0.3927

Note: 1) The number of observations for the pre-OCR, OCR and whole sample period are 123, 93 and 216, respectively. 2) *** denotes significance at 1% level. 3) Standard errors are reported in parenthesis and rounded to four decimal places. 4) All other figures are rounded to two decimal places. 5) Standard errors are corrected for autocorrelations using the test of Newey and West (1987).

TABLE 5

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

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

	$R_t - r_t > 0$			$R_t - r_t < 0$		
Period	91:01 to 99:02	99:03 to 06:05	91:01 to 06:05	91:01 to 99:02	99:03 to 06:05	91:01 to 06:05
Constant	-0.12	-0.05	-0.10	-0.02	0.06	0.02
	(0.0642)	(0.0224)	(0.0395)	(0.0771)	(0.0206)	(0.0401)
Spread	0.84	0.81***	0.90***	1.02	2.23***	1.36***
	(0.6542)	(0.1152)	(0.2541)	(0.6352)	(0.3053)	(0.4280)
R^2	0.03	**0.36**	0.07	0.03	**0.27**	0.06
D.W.	1.22	1.11	1.19	1.19	1.00	1.15
s.e.	0.4439	0.1168	0.3325	0.4420	0.1251	0.3334

Note: 1) The number of observations for the pre-OCR, OCR and whole sample period are 98, 88 and 186, respectively. 2) *** denotes significance at 1% level. 3) Standard errors are reported in parenthesis and rounded to four decimal places. 4) All other figures are rounded to two decimal places. 5) Standard errors are corrected for autocorrelations using the test of Newey and West (1987).

TABLE 6

FORECASTING EQUATION

$$r_{t+1} - r_t = \alpha_{20} + \beta_{21}(r_t - r_{t-1}) + \beta_{22}(R_t - R_{t-1}) + \nu_t$$

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

PERIOD	1988:12 - 1999:02	1999:03 - 2006:12	1988:12 - 2006:12
Constant	-0.04	0.01	-0.01
	(0.0399)	(0.0090)	(0.0228)
$r_t - r_{t-1}$	-0.85*	-1.00***	-0.95**
	(0.4888)	(0.2198)	(0.4219)
$R_t - R_{t-1}$	1.22**	1.64***	1.36***
	(0.5334)	(0.2365)	(0.4531)
R^2	0.09	**0.56**	0.12
s.e.	0.4757	0.0909	0.3633
LM test (*p*-value)	0.1377	0.0114	0.0231

Note: 1) The number of observations for the pre-OCR, OCR and whole sample period are 122, 93 and 215, respectively. 2) *, ** and *** denote significance at 10%, 5% and 1% level, respectively 3) Standard errors are reported in parenthesis and rounded to four decimal places. 4) All other figures are rounded to two decimal places. 5) Standard errors are corrected for autocorrelations using the test of Newey and West (1987). 6) The null hypothesis of no residual autocorrelation is tested using Lagrange Multiplier. ** denotes rejection of the null at 5% significance level.

TABLE 7

CHANGES IN THE SHORT RATE: TOTAL, UNEXPECTED, AND EXPECTED

$$r_{t+1} - r_t = \alpha_{20} + \beta_{21}(r_t - r_{t-1}) + \beta_{22}(R_t - R_{t-1}) + \nu_t$$

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

PERIOD	1988:12 - 1999:02	1999:03 - 2006:12	1988:12 - 2006:12
Standard Deviation (Δr_t)	0.4943	0.1353	0.3863
Standard Deviation (Δr_t - $E\Delta r_t$)	0.4757	0.0911	0.3633
Standard Deviation ($E\Delta r_t$)	0.1342	0.1000	0.1311

TABLE 8

FORECASTING EQUATION

$$r_{t+1} - r_t = \alpha_{20} + \beta_{21}(r_t - r_{t-1}) + \beta_{22}(R_t - R_{t-1}) + \nu_t$$

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

PERIOD	1991:01 - 1999:02	1999:03 - 2006:07	1991:01 - 2006:07
Constant	-0.04	0.01	-0.01
	(0.0433)	(0.0138)	(0.0242)
r_t -r_{t-1}	-0.56	0.62***	0.41***
	(0.6826)	(0.0635)	(0.0702)
R_t-R_{t-1}	1.10	0.00	0.01
	(0.7787)	(0.0042)	(0.0163)
R^2	0.18	**0.41**	0.18
s.e.	0.4419	0.1186	0.3339
LM test (*p*-value)	0.2969	0.6203	0.1337

Note: 1) The number of observations for the pre-OCR, OCR and whole sample period are 87, 89 and 186, respectively. 2) *** denotes significance at 1% level. 3) Standard errors are reported in parenthesis and rounded to four decimal places. 4) All other figures are rounded to two decimal places. 5) Standard errors are corrected for autocorrelations using the test of Newey and West (1987). 6) The null hypothesis of no residual autocorrelation is tested using Lagrange Multiplier. ** denotes rejection of the null at 5% significance level.

TABLE 9

CHANGES IN THE SHORT RATE: TOTAL, UNEXPECTED, AND EXPECTED

$$r_{t+1} - r_t = \alpha_{20} + \beta_{21}(r_t - r_{t-1}) + \beta_{22}(R_t - R_{t-1}) + \nu_t$$

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

PERIOD	1991:01 - 1999:02	1999:03 - 2006:07	1991:01 - 2006:07
Standard Deviation (Δr_t)	0.4804	0.1530	0.3677
Standard Deviation (Δr_t - $E\Delta r_t$)	0.4419	0.1187	0.3339
Standard Deviation ($E\Delta r_t$)	0.1884	0.0964	0.1539

TABLE 10

FORECASTING EQUATION

$$r_{t+1} - r_t = \alpha_{10} + \beta_{11} r_t + \beta_{12} r_{t-1} + \beta_{13} R_t + \beta_{14} R_{t-1} + \nu_t$$

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

PERIOD	1988:12 - 1999:02	1999:03 - 2006:12	1988:12 - 2006:12
Constant	0.03	0.01	0.04
	(0.1516)	(0.0494)	(0.0777)
r_t	-1.57***	-1.88***	-1.54***
	(0.4803)	(0.2210)	(0.3951)
r_{t-1}	0.13	0.59***	0.19
	(0.3911)	(0.1809)	(0.3341)
R_t	1.93***	2.12***	1.90***
	(0.5219)	(0.2235)	(0.4197)
R_{t-1}	-0.51	-0.84***	-0.56
	(0.4521)	(0.2464)	(0.3899)
R^2	0.17	**0.66**	0.21
s.e.	0.4586	0.0811	0.3468
LM test (*p*-value)	0.5065	0.1068	0.2838

Note: 1) The number of observations for the pre-OCR, OCR and whole sample period are 122, 93 and 215, respectively. 2) *** denotes significance at 1% level. 3) Standard errors are reported in parenthesis and rounded to four decimal places. 4) All other figures are rounded to two decimal places. 5) Standard errors are corrected for autocorrelations using the test of Newey and West (1987). 6) The null hypothesis of no residual autocorrelation is tested using Lagrange Multiplier. ** denotes rejection of the null at 5% significance level.

TABLE 11

CHANGES IN THE SHORT RATE: TOTAL, UNEXPECTED, AND EXPECTED

$$r_{t+1} - r_t = \alpha_{10} + \beta_{11} r_t + \beta_{12} r_{t-1} + \beta_{13} R_t + \beta_{14} R_{t-1} + \nu_t$$

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

PERIOD	1988:12 - 1999:02	1999:03 - 2006:12	1988:12 - 2006:12
Standard Deviation (Δr_t)	0.4943	0.1353	0.3863
Standard Deviation (Δr_t - $E\Delta r_t$)	0.4586	0.0812	0.3468
Standard Deviation ($E\Delta r_t$)	0.1844	0.1082	0.1700

TABLE 12

FORECASTING EQUATION

$$r_{t+1} - r_t = \alpha_{10} + \beta_{11} r_t + \beta_{12} r_{t-1} + \beta_{13} R_t + \beta_{14} R_{t-1} + \nu_t$$

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

PERIOD	1991:01 - 1999:02	1999:03 - 2006:07	1991:01 - 2006:07
Constant	0.33	0.01	0.21
	(0.1941)	(0.0742)	(0.1085)
r_t	-0.64	-0.62**	-0.58
	(0.7605)	(0.2671)	(0.5222)
r_{t-1}	0.19	0.17	0.16
	(0.6816)	(0.2295)	(0.4654)
R_t	1.07	0.99***	1.00*
	(0.7954)	(0.2395)	(0.5316)
R_{t-1}	-0.68	-0.55**	-0.62
	(0.7188)	(0.2416)	(0.4835)
R^2	0.23	**0.53**	0.26
s.e.	0.4324	0.1074	0.3189
LM test (*p*-value)	0.2817	0.5043	0.1438

Note: 1) The number of observations for the pre-OCR, OCR and whole sample period are 97, 88 and 185, respectively. 2) *, ** and *** denote significance at 10%, 5% and 1% level, respectively. 3) Standard errors are reported in parenthesis and rounded to four decimal places. 4) All other figures are rounded to two decimal places. 5) Standard errors are corrected for autocorrelations using the test of Newey and West (1987). 6) The null hypothesis of no residual autocorrelation is tested using Lagrange Multiplier. ** denotes rejection of the null at 5% significance level.

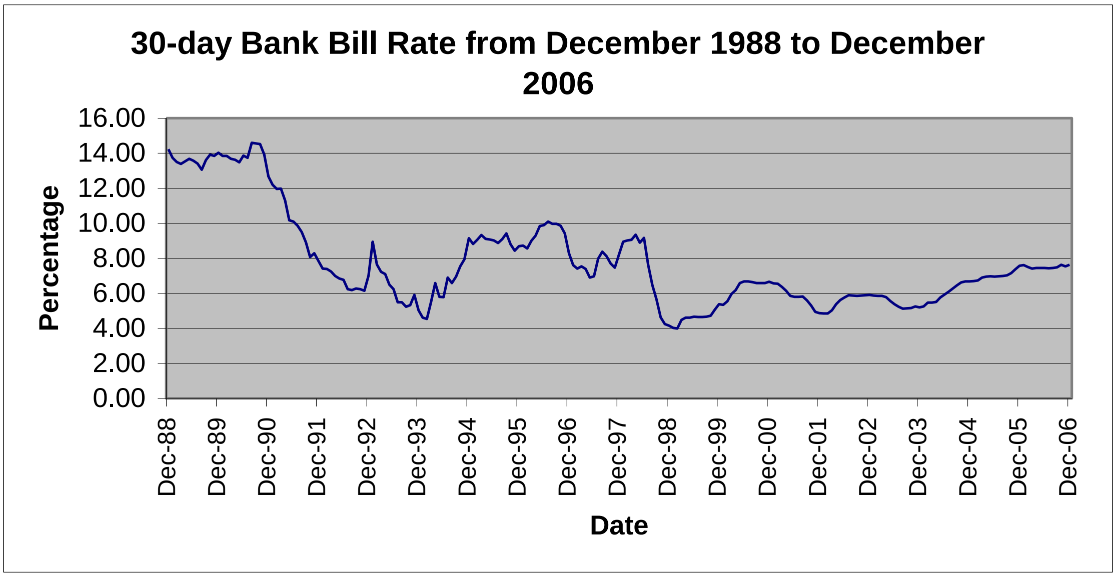
TABLE 13

CHANGES IN THE SHORT RATE: TOTAL, UNEXPECTED, AND EXPECTED

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

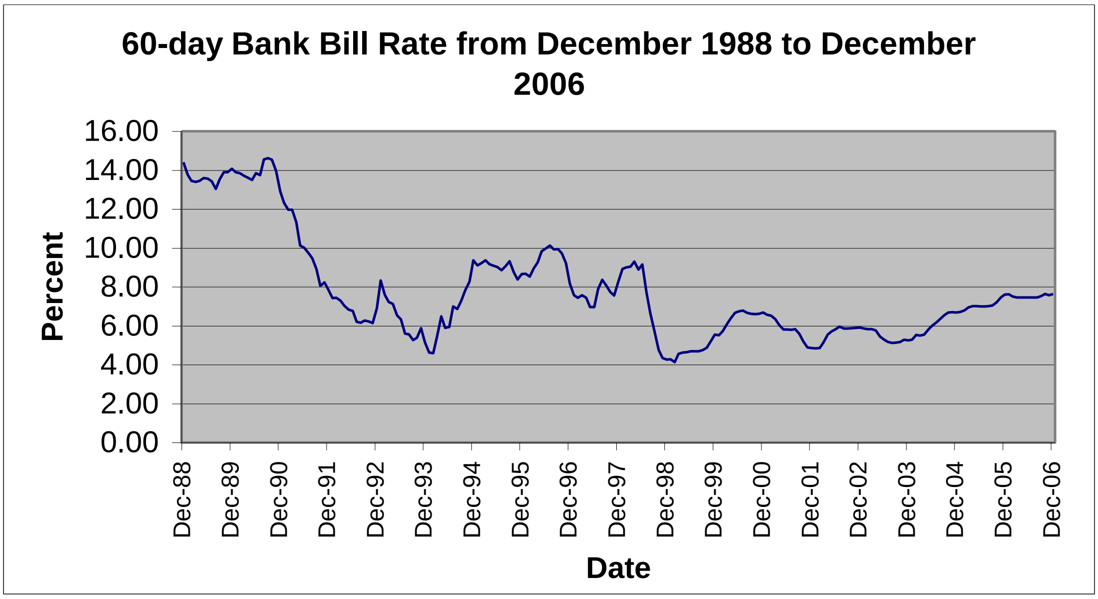
PERIOD	1991:01 - 1999:02	1999:03 - 2006:07	1991:01 - 2006:07
Standard Deviation (Δr_t)	0.4804	0.1530	0.3677
Standard Deviation (Δr_t - $E\Delta r_t$)	0.4323	0.1072	0.3189
Standard Deviation ($E\Delta r_t$)	0.2095	0.1091	0.1830

FIGURE 1



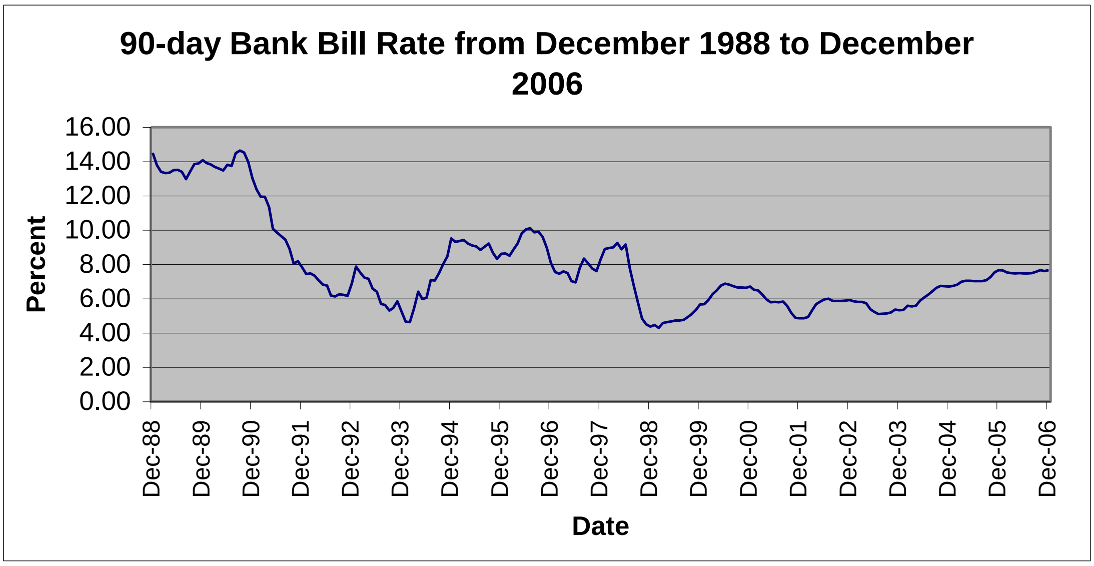
Sourced: Reserve Bank of New Zealand

FIGURE 2



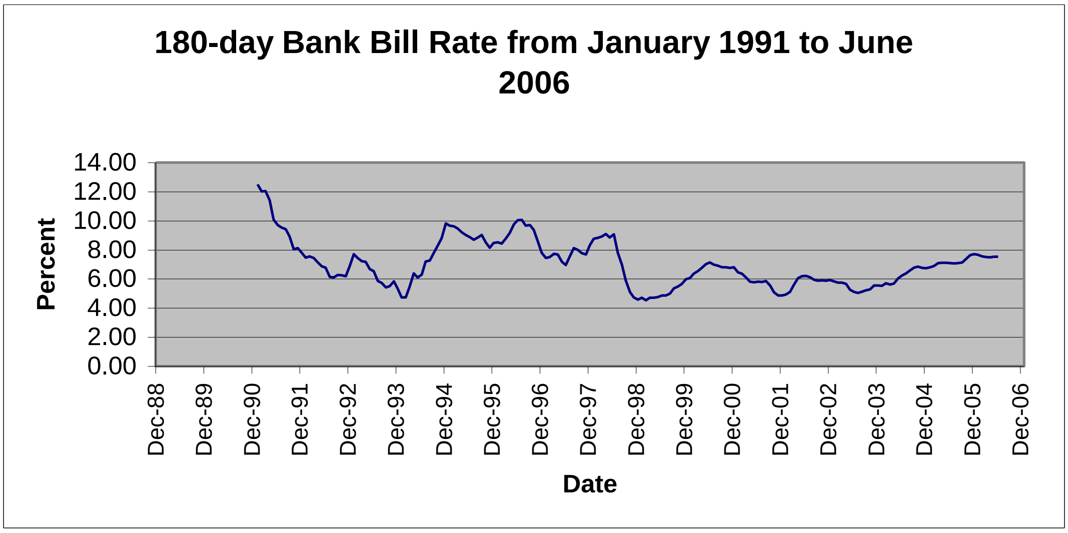
Sourced: Reserve Bank of New Zealand

FIGURE 3



Sourced: Reserve Bank of New Zealand

FIGURE 4



Sourced: Reserve Bank of New Zealand

Tables and Figures for Part II

TABLE 1

$$y_t^k = \alpha_0 + \alpha_1 Spread_t + \alpha_2 y_{t-1}^1 + \alpha_3 y_{t-2}^1 + \alpha_4 y_{t-3}^1 + \alpha_5 y_{t-4}^1 + \varepsilon_t$$

Spread = 5-year rate – 90-day rate

	1988:12 to 1999:02				*1999:03 to 2007:12*				*1988:12 to 2007:12*			
K (quarters ahead)	α_1	α_2	LM (*p*-value)	R^2	α_1	α_2	LM (*p*-value)	R^2	α_1	α_2	LM (*p*-value)	R^2
1	0.72	0.19	0.2976	0.16	1.48**	-0.21	0.3591	0.33	0.67*	0.17	0.3209	0.14
2	1.02***	0.19	0.0005	0.27	1.64***	-0.20	0.0163	0.53	0.86**	0.16**	0.0000	0.21
3	1.12***	0.12	0.0000	0.32	1.64***	-0.30***	0.0003	0.60	0.85**	0.08	0.0000	0.20
4	1.18***	0.09	0.0000	0.36	1.15***	-0.24***	0.0002	0.50	0.84**	0.05	0.0000	0.22
5	1.14**	0.11	0.0000	0.38	0.97***	-0.23***	0.0001	0.45	0.79**	0.05	0.0000	0.23
6	1.11**	0.10	0.0000	0.37	0.83***	-0.21**	0.0000	0.42	0.81***	0.04	0.0000	0.24
7	1.09**	0.07	0.0000	0.35	0.76***	-0.16**	0.0001	0.42	0.85***	0.02	0.0000	0.26
8	1.13***	0.02	0.0000	0.39	0.83***	-0.19***	0.0006	0.49	0.93***	-0.02	0.0000	0.31
12	0.96***	-0.01	0.0021	0.61	0.69***	-0.13**	0.0012	0.44	0.86***	-0.04	0.0000	0.53
16	0.54***	-0.02	0.0000	0.56	0.53***	-0.13***	0.0008	0.46	0.52***	-0.04*	0.0000	0.50

Note: 1) Coefficient estimates of α_3, α_4 and α_5 are not reported due to limited size of the table. Furthermore, the lagged growth rates enter the regression only to serve the purpose of examining whether the term spread can retain its predictive power when these lagged variables are included in the regression. Excluding their coefficient estimates from the table should therefore have no impact on the analysis. 2) The number of observations for the pre-OCR, OCR and the whole sample period are 38, 34, and 72, respectively. 3) *, ** and *** denotes significance at 10%, 5% and 1% level. 4) All figures apart from the *p*-values are rounded to two decimal places. 5) Presence of residual autocorrelation in the regression is tested using the Lagrange Multiplier test.

TABLE 2

$$y_t^k = \alpha_0 + \alpha_1 Spread_t + \alpha_2 y_{t-1}^1 + \alpha_3 y_{t-2}^1 + \alpha_4 y_{t-3}^1 + \alpha_5 y_{t-4}^1 + \varepsilon_t$$

Spread = 5-year rate – 1-year rate

	1988:12 to 1999:02				*1999:03 to 2007:12*				*1988:12 to 2007:12*			
K (quarters ahead)	α_1	α_2	LM (*p*-value)	R^2	α_1	α_2	LM (*p*-value)	R^2	α_1	α_2	LM (*p*-value)	R^2
1	0.98	-0.19	0.3934	0.16	2.84***	-0.28***	0.2391	0.49	1.27**	0.14	0.6284	0.18
2	1.36**	0.18	0.0003	0.27	2.43***	-0.19*	0.2673	0.64	1.35**	0.15*	0.0000	0.25
3	1.43**	0.16	0.0000	0.31	2.26***	-0.30***	0.0029	0.76	1.30***	0.07	0.0000	0.24
4	1.50**	0.09	0.0000	0.35	1.65***	-0.23***	0.0022	0.62	1.21***	0.04	0.0000	0.25
5	1.42**	0.11	0.0000	0.36	1.29***	-0.20***	0.0005	0.51	1.07**	0.05	0.0000	0.24
6	1.37***	0.10	0.0000	0.34	1.06***	-0.18***	0.0002	0.45	1.06**	0.04	0.0000	0.24
7	1.36**	0.07	0.0000	0.33	0.96***	-0.12*	0.0004	0.43	1.10***	0.03	0.0000	0.26
8	1.42**	0.02	0.0000	0.37	1.06***	-0.15***	0.0010	0.52	1.19***	-0.02	0.0000	0.32
12	1.27***	-0.02	0.0005	0.63	0.66**	-0.08	0.0004	0.38	1.08***	-0.04	0.0000	0.53
16	0.74***	-0.02	0.0000	0.60	0.28	-0.08	0.0004	0.27	0.65***	-0.04*	0.0000	0.50

Note: 1) Coefficient estimates of α_3, α_4 and α_5 are not reported due to limited size of the table. Furthermore, the lagged growth rates enter the regression only to serve the purpose of examining whether the term spread can retain its predictive power when these lagged variables are included in the regression. Excluding their coefficient estimates from the table should therefore have no impact on the analysis. 2) The number of observations for the pre-OCR, OCR and the whole sample period are 38, 34, and 72, respectively. 3) *, ** and *** denotes significance at 10%, 5% and 1% level. 4) All figures apart from the *p*-values are rounded to two decimal places. 5) Presence of residual autocorrelation in the regression is tested using the Lagrange Multiplier test.

TABLE 3

$$y_t^k = \alpha_0 + \alpha_1 Spread_t + \alpha_2 m_t^* + \alpha_3 y_{t-1}^1 + \alpha_4 y_{t-2}^1 + \alpha_5 y_{t-3}^1 + \alpha_6 y_{t-4}^1 + \varepsilon_t$$

Spread = 5-year rate – 90-day rate

	1988:12 to 1999:02				*1999:03 to 2007:12*				*1988:12 to 2007:12*			
K (quarters ahead)	α_1	α_2	LM (*p*-value)	R^2	α_1	α_2	LM (*p*-value)	R^2	α_1	α_2	LM (*p*-value)	R^2
1	0.04	-0.40	0.1756	0.19	0.68	-0.90	0.1182	0.35	0.14	-0.44*	0.1040	0.18
2	0.10	-0.54	0.0006	0.34	1.04	-0.69	0.0229	0.55	0.23	-0.50**	0.0000	0.30
3	0.02	-0.64	0.0000	0.44	0.55	-1.22	0.0002	0.67	0.14	-0.57***	0.0000	0.34
4	0.02	-0.68***	0.0000	0.52	0.35	-1.10*	0.0001	0.58	0.10	-0.58***	0.0000	0.40
5	-0.05	-0.69***	0.0000	0.57	0.44	-0.76*	0.0001	0.50	0.02	-0.59***	0.0000	0.45
6	-0.05	-0.68***	0.0000	0.59	0.63	-0.30	0.0000	0.43	0.06	-0.56***	0.0000	0.47
7	-0.01	-0.64***	0.0000	0.57	0.75**	-0.02	0.0001	0.42	0.13	-0.52***	0.0000	0.47
8	0.15	-0.57***	0.0000	0.61	0.88***	0.07	0.0005	0.49	0.26	-0.46***	0.0000	0.52
12	0.48***	-0.28***	0.0012	0.72	1.15***	0.89**	0.0450	0.65	0.47***	-0.23***	0.0000	0.62
16	0.21	-0.19***	0.0001	0.67	0.94***	0.74***	0.2632	0.80	0.24*	-0.17***	0.0000	0.60

Note: 1) Coefficient estimates of α_3, α_4, α_5 and α_6 are not reported due to limited size of the table. Furthermore, the lagged growth rates enter the regression only to serve the purpose of examining whether the term spread can retain its predictive power when these lagged variables are included in the regression. Excluding their coefficient estimates from the table should therefore have no impact on the analysis. 2) The number of observations for the pre-OCR, OCR and the whole sample period are 38, 34, and 72, respectively. 3) *, ** and *** denotes significance at 10%, 5% and 1% level. 4) All figures apart from the *p*-values are rounded to two decimal places. 5) Presence of residual autocorrelation in the regression is tested using the Lagrange Multiplier test.

TABLE 4

$$y_t^k = \alpha_0 + \alpha_1 Spread_t + \alpha_2 m_t^* + \alpha_3 y_{t-1}^1 + \alpha_4 y_{t-2}^1 + \alpha_5 y_{t-3}^1 + \alpha_6 y_{t-4}^1 + \varepsilon_t$$

Spread = 5-year rate – 1-year rate

	1988:12 to 1999:02				*1999:03 to 2007:12*				*1988:12 to 2007:12*			
K (quarters ahead)	α_1	α_2	LM (*p*-value)	R^2	α_1	α_2	LM (*p*-value)	R^2	α_1	α_2	LM (*p*-value)	R^2
1	0.14	-0.38	0.1878	0.19	2.85**	0.00	0.2208	0.49	0.71	-0.31	0.2826	0.19
2	0.19	-0.52*	0.0006	0.34	2.02***	0.39	0.2358	0.65	0.56	-0.44**	0.0000	0.31
3	-0.03	-0.65**	0.0000	0.44	1.70***	-0.59	0.0016	0.78	0.36	-0.52***	0.0000	0.35
4	-0.05	-0.70***	0.0000	0.52	1.10**	-0.64	0.0011	0.65	0.19	-0.57***	0.0000	0.40
5	-0.18	-0.72***	0.0000	0.57	0.87**	-0.50	0.0003	0.53	-0.01	-0.60***	0.0000	0.45
6	-0.24	-0.72***	0.0000	0.59	0.90**	-0.19	0.0002	0.46	-0.03	-0.58***	0.0000	0.47
7	-0.12	-0.66***	0.0000	0.58	0.95***	-0.01	0.0003	0.43	0.07	-0.54***	0.0000	0.47
8	0.08	-0.60***	0.0000	0.61	1.16***	0.13	0.0013	0.52	0.25	-0.48***	0.0000	0.51
12	0.69***	-0.26***	0.0000	0.73	1.25***	0.96***	0.0208	0.60	0.60***	-0.23***	0.0000	0.62
16	0.35	-0.17***	0.0000	0.69	0.66**	0.61**	0.0025	0.48	0.29**	-0.17***	0.0000	0.60

Note: 1) Coefficient estimates of α_3, α_4, α_5 and α_6 are not reported due to limited size of the table. Furthermore, the lagged growth rates enter the regression only to serve the purpose of examining whether the term spread can retain its predictive power when these lagged variables are included in the regression. Excluding their coefficient estimates from the table should therefore have no impact on the analysis. 2) The number of observations for the pre-OCR, OCR and the whole sample period are 38, 34, and 72, respectively. 3) *, ** and *** denotes significance at 10%, 5% and 1% level. 4) All figures apart from the *p*-values are rounded to two decimal places. 5) Presence of residual autocorrelation in the regression is tested using the Lagrange Multiplier test.

TABLE 5

$$y_t^k = \alpha_0 + \alpha_1 Spread_t + \alpha_2 i_t^{TB5} + \alpha_3 y_{t-1}^1 + \alpha_4 y_{t-2}^1 + \alpha_5 y_{t-3}^1 + \alpha_6 y_{t-4}^1 + \varepsilon_t$$

Spread = 5-year rate – 90-day rate

	1988:12 to 1999:02				*1999:03 to 2007:12*				*1988:12 to 2007:12*			
K (quarters ahead)	α_1	α_2	LM (*p*-value)	R^2	α_1	α_2	LM (*p*-value)	R^2	α_1	α_2	LM (*p*-value)	R^2
1	0.39	-0.47	0.1467	0.20	1.50**	-0.66	0.1484	0.35	0.57	-0.49*	0.0717*	0.20
2	0.59	-0.60*	0.0006	0.37	1.70***	-0.75	0.0270	0.57	0.73**	-0.55**	0.0000	0.33
3	0.66*	-0.64**	0.0000	0.47	1.71***	-1.23**	0.0004	0.71	0.71**	-0.59***	0.0000	0.37
4	0.72**	-0.65***	0.0000	0.53	1.43***	-1.28***	0.0003	0.67	0.68**	-0.58***	0.0000	0.42
5	0.67***	-0.66***	0.0000	0.58	1.23***	-1.03***	0.0001	0.60	0.61**	-0.58***	0.0000	0.47
6	0.65***	-0.66***	0.0000	0.60	1.00***	-0.64**	0.0000	0.49	0.62**	-0.55***	0.0000	0.49
7	0.65**	-0.62***	0.0000	0.59	0.86***	-0.34	0.0000	0.45	0.64***	-0.51***	0.0000	0.50
8	0.74	-0.55***	0.0000	0.63	0.89***	-0.19	0.0002	0.50	0.72***	-0.46***	0.0000	0.54
12	0.76***	-0.28***	0.0012	0.74	0.39	0.54**	0.0091	0.55	0.70***	-0.24***	0.0000	0.64
16	0.40***	-0.20***	0.0001	0.70	0.20*	0.58***	0.2006	0.76	0.41***	-0.16***	0.0000	0.61

Note: 1) Coefficient estimates of α_3, α_4, α_5 and α_6 are not reported due to limited size of the table. Furthermore, the lagged growth rates enter the regression only to serve the purpose of examining whether the term spread can retain its predictive power when these lagged variables are included in the regression. Excluding their coefficient estimates from the table should therefore have no impact on the analysis. 2) The number of observations for the pre-OCR, OCR and the whole sample period are 38, 34, and 72, respectively. 3) *, ** and *** denotes significance at 10%, 5% and 1% level. 4) All figures apart from the *p*-values are rounded to two decimal places. 5) Presence of residual autocorrelation in the regression is tested using the Lagrange Multiplier test.

TABLE 6

$$y_t^k = \alpha_0 + \alpha_1 Spread_t + \alpha_2 i_t^{TB5} + \alpha_3 y_{t-1}^1 + \alpha_4 y_{t-2}^1 + \alpha_5 y_{t-3}^1 + \alpha_6 y_{t-4}^1 + \varepsilon_t$$

Spread = 5-year rate – 1-year rate

	1988:12 to 1999:02				*1999:03 to 2007:12*				*1988:12 to 2007:12*			
K (quarters ahead)	α_1	α_2	LM (*p*-value)	R^2	α_1	α_2	LM (*p*-value)	R^2	α_1	α_2	LM (*p*-value)	R^2
1	0.48	-0.46	0.2598	0.20	2.87***	-0.68	0.0877	0.50	1.01*	-0.41	0.2824	0.21
2	0.71	-0.59*	0.0004	0.37	2.46***	-0.62	0.1299	0.66	1.03**	-0.49**	0.0000	0.33
3	0.72	-0.65**	0.0000	0.45	2.38***	-1.00***	0.0347	0.84	0.96**	-0.53***	0.0000	0.37
4	0.80*	-0.65***	0.0000	0.51	1.81***	-1.00***	0.0103	0.73	0.85**	-0.53***	0.0000	0.41
5	0.69	-0.67***	0.0000	0.56	1.41***	-0.71***	0.0004	0.59	0.70*	-0.55***	0.0000	0.45
6	0.64	-0.67***	0.0000	0.57	1.14***	-0.38	0.0001	0.48	0.67*	-0.53***	0.0000	0.46
7	0.68*	-0.63***	0.0000	0.56	0.99***	-0.12	0.0002	0.44	0.71**	-0.48***	0.0000	0.46
8	0.82**	-0.55***	0.0000	0.58	1.05***	0.02	0.0006	0.52	0.83***	-0.42***	0.0000	0.49
12	1.00***	-0.25***	0.0001	0.73	0.47*	0.63***	0.0201	0.58	0.87***	-0.20***	0.0000	0.61
16	0.54***	-0.18	0.0000	0.70	0.14	0.64***	0.2024	0.75	0.49***	-0.15***	0.0000	0.59

Note: 1) Coefficient estimates of α_3, α_4, α_5 and α_6 are not reported due to limited size of the table. Furthermore, the lagged growth rates enter the regression only to serve the purpose of examining whether the term spread can retain its predictive power when these lagged variables are included in the regression. Excluding their coefficient estimates from the table should therefore have no impact on the analysis. 2) The number of observations for the pre-OCR, OCR and the whole sample period are 38, 34, and 72, respectively. 3) *, ** and *** denotes significance at 10%, 5% and 1% level. 4) All figures apart from the *p*-values are rounded to two decimal places. 5) Presence of residual autocorrelation in the regression is tested using the Lagrange Multiplier test.

TABLE 7

$$y_t^k = \alpha_0 + \alpha_1 (\frac{1}{n}\sum_{j=0}^{n-1} i_{t+j}^1 - i_t^1) + \alpha_2 (i_t^n - \frac{1}{n}\sum_{j=0}^{n-1} i_{t+j}^1) + u_t$$

i_t^1 = 90-day rate $\quad i_t^n$ = 5-year rate

	1988:12 to 1999:02				*1999:03 to 2007:12*				*1988:12 to 2007:12*			
K (quarters ahead)	α_1	α_2	D.W. stat	χ_1^2	α_1	α_2	D.W. stat	χ_1^2	α_1	α_2	D.W. stat	χ_1^2
1	0.25	-0.54	1.85	2.92*	2.94**	0.56	2.02	2.68	0.62	-0.13	1.86	3.36*
2	0.22	-0.81	0.05	9.57***	2.16**	0.09	1.02	3.87**	0.48	-0.49	0.99	11.00***
3	0.16	-1.00*	0.87	22.83***	1.43*	-0.50	0.88	4.53**	0.31	-0.78*	0.87	29.31***
4	0.29	-0.82*	0.75	27.32***	0.57	-0.99	0.59	6.33**	0.28	-0.82**	0.74	43.78***
5	0.34	-0.71	0.73	25.53***	0.03	-1.10*	0.55	5.09**	0.26	-0.80**	0.70	43.95***
6	0.36	-0.64	0.60	25.80***	-0.32	-0.96*	0.75	2.65	0.26	-0.75*	0.59	41.87***
7	0.34	-0.62	0.65	22.86***	-0.36	-0.71	0.36	0.83	0.27	-0.70	0.59	31.52***
8	0.35	-0.58	0.62	20.08***	-0.28	-0.41	0.69	0.15	0.32	-0.60	0.60	24.31***
12	0.44	-0.20	0.38	6.28**	0.02	0.01	0.53	0.00	0.43**	-0.20	0.37	6.77***
16	0.14	-0.29	0.20	3.51*	-0.13	0.16	0.49	3.75*	0.17	-0.24	0.20	3.49*

Notes: 1) The number of observations for the pre-OCR, OCR and the whole sample period are 42, 16 and 58, respectively. 2) *, ** and *** denotes significance at 10%, 5% and 1% level, respectively. 3) All figures are rounded to two decimal places. 4) χ_1^2 is used to test the null hypothesis: $\alpha_1 = \alpha_2$ with 1 degree of freedom. 5) Consistent with Hamilton & Kim, the instruments include a constant, i_t^1 and i_t^n, which implies that Equation (11) is estimated in a just-identified model. 6) Durbin-Watson statistics is reported in the third column of each sample period.

TABLE 8

$$y_t^k = \alpha_0 + \alpha_1(\frac{1}{n}\sum_{j=0}^{n-1} i_{t+j}^1 - i_t^1) + \alpha_2(i_t^n - \frac{1}{n}\sum_{j=0}^{n-1} i_{t+j}^1) + u_t$$

i_t^1 = 1-year rate i_t^n = 5-year rate

	1988:12 to 1999:02				*1999:03 to 2007:12*				*1988:12 to 2007:12*			
K (quarters ahead)	α_1	α_2	D.W. stat	χ_1^2	α_1	α_2	D.W. stat	χ_1^2	α_1	α_2	D.W. stat	χ_1^2
1	0.20	-0.64	1.83	2.82*	3.33**	1.75	2.19	1.86	0.94	0.22	1.84	2.32
2	0.17	-0.91	1.04	9.04***	2.41***	0.88	1.33	3.39*	0.68	-0.29	0.99	8.59***
3	0.08	-1.14	0.86	21.35***	1.88***	0.16	0.81	4.66**	0.47	-0.65	0.86	23.96***
4	0.26	-0.90	0.74	25.09***	0.83*	-0.81	0.58	7.23***	0.36	-0.78*	0.73	37.21***
5	0.32	-0.77	0.71	23.68***	0.26	-1.10	0.56	6.12**	0.30	-0.82*	0.70	38.86***
6	0.36	-0.67	0.59	24.27***	-0.04	-0.99	0.74	3.97**	0.28	-0.79*	0.60	38.42***
7	0.38	-0.61	0.62	21.25***	-0.12	-0.73	0.36	1.69	0.30	-0.72	0.59	29.43***
8	0.39	-0.56	0.62	18.39***	-0.01	-0.33	0.70	0.71	0.36	-0.61	0.60	22.33
12	0.68*	0.08	0.43	5.25**	0.13	0.10	0.53	0.01	0.59**	-0.02	0.40	5.86**
16	0.31	-0.10	0.22	2.73*	-0.05	0.22	0.48	1.93	0.28	-0.13	0.21	2.90*

Notes: 1) The number of observations for the pre-OCR, OCR and the whole sample period are 42, 16 and 58, respectively. 2) *, ** and *** denotes significance at 10%, 5% and 1% level, respectively. 3) All figures are rounded to two decimal places. 4) χ_1^2 is used to test the null hypothesis: $\alpha_1 = \alpha_2$ with 1 degree of freedom. 5) Consistent with Hamilton & Kim, the instruments include a constant, i_t^1 and i_t^n, which implies that Equation (11) is estimated in a just-identified model. 6) Durbin-Watson statistics is reported in the third column of each sample period.

TABLE 9

$$y_{t+4} - y_t = \alpha_0 + \alpha_1 \left\{ \left(\frac{1}{n}\sum_{j=0}^{n-1} i^1_{t+j} - i^1_t\right) - \left(\frac{1}{n}\sum_{j=0}^{n-1} i^1_{t-4+j} - i^1_{t-4}\right) \right\} + \alpha_2 \left\{ \left(i^n_t - \frac{1}{n}\sum_{j=0}^{n-1} i^1_{t+j}\right) - \left(i^n_{t-4} - \frac{1}{n}\sum_{j=0}^{n-1} i^1_{t-4+j}\right) \right\}$$
$$+\alpha_3 (y_t - y_{t-4}) + u_t$$

i^1_t = 90-day rate i^n_t = 5-year rate

	1988:12 -1999:02	1999:03 - 2007:12	1988:12 - 2007:12
α_1	-0.0039	0.0042**	-0.0020
α_2	-0.0220	-0.0050***	-0.0202
α_3	0.7675***	-0.3284***	0.6537***
LM (*p*-value)	0.0000	0.5773	0.0000
Test: χ^2_1	2.4367	32.7482***	4.6823**

Note: 1) The number of observations for the pre-OCR, OCR and the whole sample period are 37, 17 and 54, respectively. 2) *, ** and *** denotes significance at 10%, 5% and 1% level. 3) All figures are rounded to four decimal places. 4) The instruments used in testing the regression include a constant, i^1_t, i^n_t and lagged growth rate. 5) χ^2_1 is used to test the null hypothesis: $\alpha_1 = \alpha_2$ with 1 degree of freedom. 6) Due to the existence of a lagged dependant variable (y_t), presence of residual autocorrelation in the regression is tested using the Lagrange Multiplier test.

TABLE 10

Standard Deviation of CPI and Real GDP

	1988:12 - 1999:02	1999:03 - 2007:12
Standard Deviation (CPI)	1.87	0.77
Standard Deviation (GDP)	2.48	1.20

Note: Standard Deviation of Consumer Price Index and Real GDP are computed in Excel.

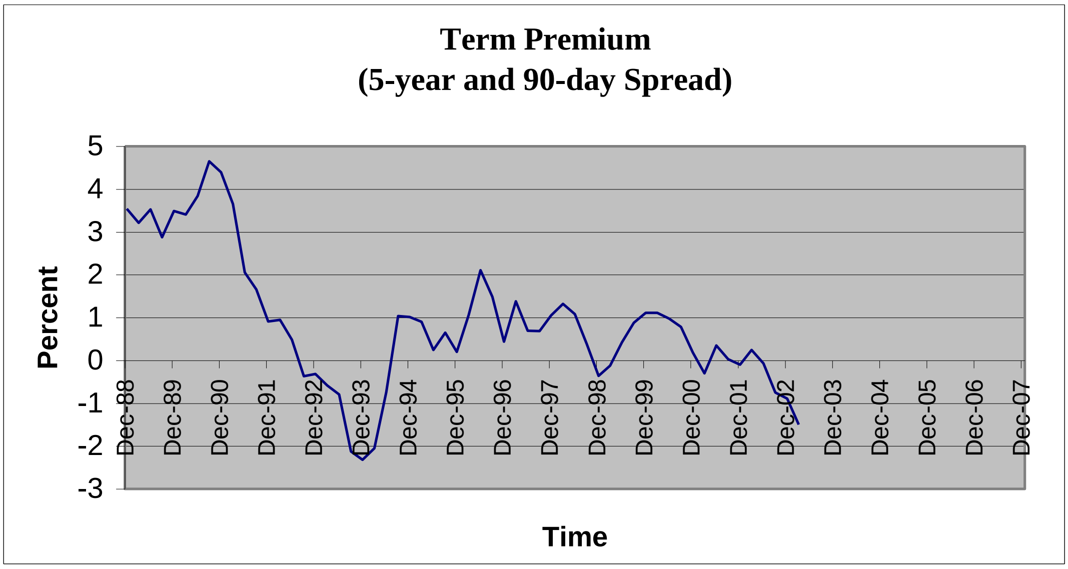
TABLE 11

Average Annual Growth Rates of Real GDP (%)

	1988:12 - 1999:02	1999:03 - 2007:12	1988:12 - 2007:12
New Zealand	2.3	3.5	2.9
Australia	3.2	3.4	3.3
USA	2.9	2.7	2.8
Japan	1.8	1.4	1.6
UK	2.2	2.9	2.55

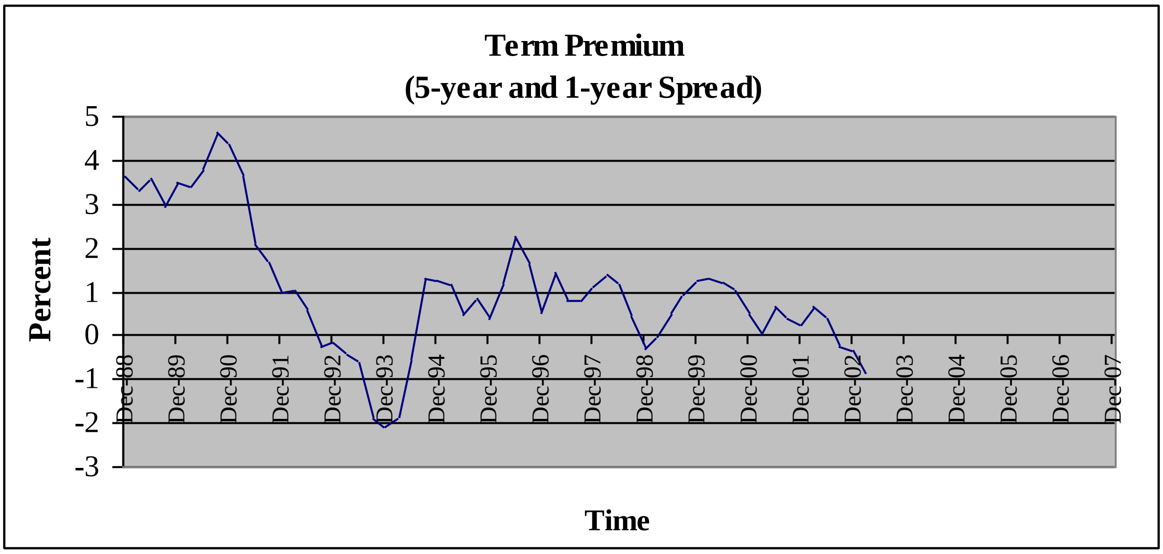
Sourced: Reserve Bank of New Zealand

FIGURE 1



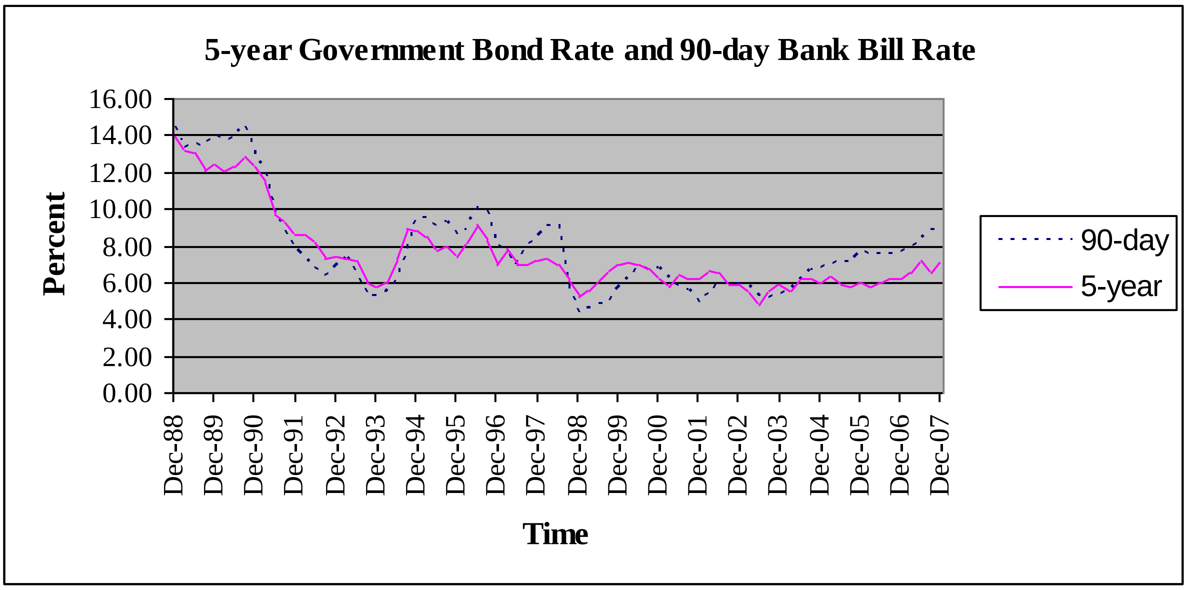
Sourced: Reserve Bank of New Zealand

FIGURE 2



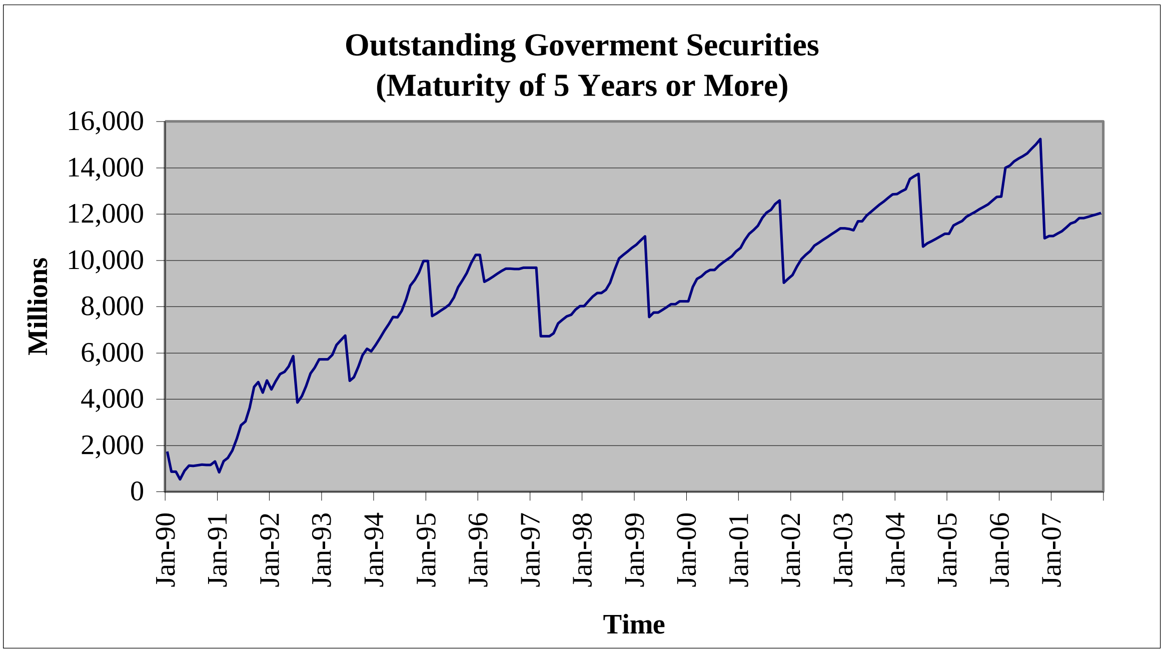
Sourced: Reserve Bank of New Zealand

FIGURE 3



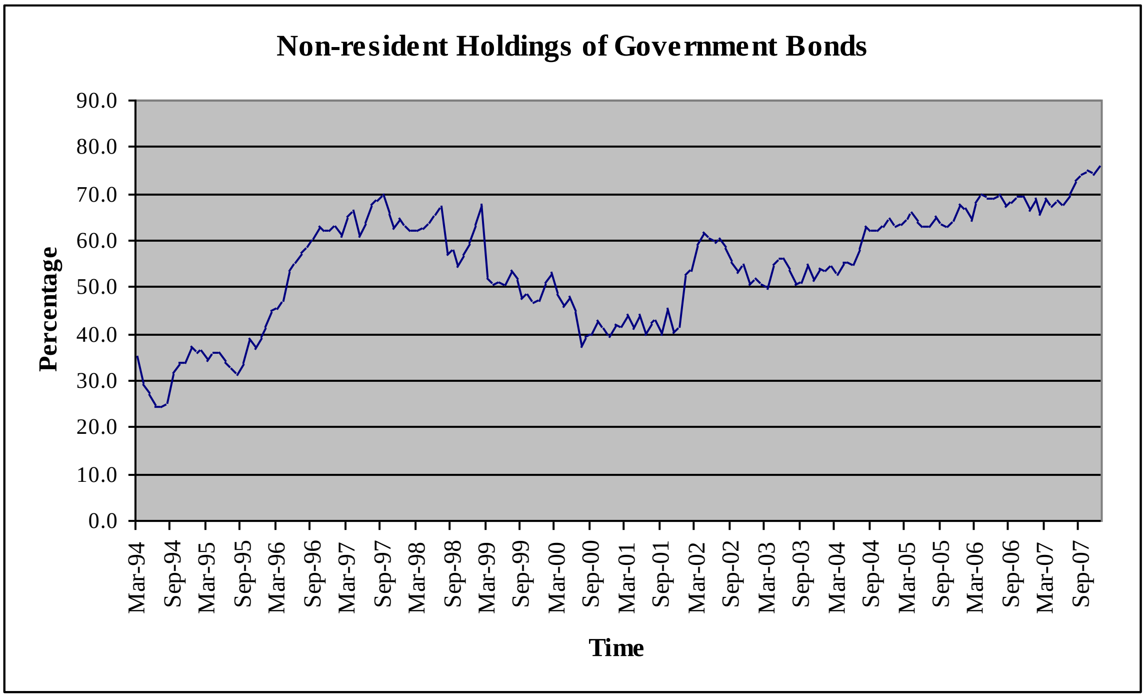
Sourced: Reserve Bank of New Zealand

FIGURE 4



Sourced: Reserve Bank of New Zealand

FIGURE 5



Sourced: Reserve Bank of New Zealand