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The Implementation of Monetary Policy in New Zealand: What Factors Affect the 90-Day Bank Bill Rate?

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ABSTRACT: This paper discusses the implementation of monetary policy in New Zealand and its flow-on effects on the 90-day bank bill rate over the 1999-2005 period. The effects of external factors are considered as well. Our findings indicate that the maturity spectrum ratio exerted a positive effect on the 90-day rate while the allotment ratio did not. This interest rate had a tendency to revert to the level set by its Australian counterpart. No such link exists between the NZ 90-day rate and the US 90-day rate. Neither the maturity spectrum nor the allotment ratio contributed to the volatility of the New Zealand 90-day rate.

JEL Category: E5

Keywords: 90-Day Bank Bill Rate; Open-Market Operations; Allotment Ratio; Maturity Spectrum Ratio; Foreign Interest Rate Linkage

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1. Introduction

At present the majority of central banks in the industrialized world implement monetary policy by setting a short-term nominal interest rate. The interest rate in question is often an overnight rate. To steer the overnight rate, a central bank typically relies on both standing facilities and open-market operations. Standing facilities can be thought of as an automatic conduit through which liquidity enters or leaves the financial sector of the economy. Trading banks that need additional cash balances to cover their position can access the standing facility at a rate slightly higher than the overnight rate. Alternatively, trading banks that have surplus cash balances can park them overnight at a rate slightly below the prevailing interest rate. Standing facilities are not a new concept per se. They were widely used during the days of the operation of the gold standard. However, in those days the standing facilities were one-sided in the sense that the central bank would only provide liquid funds to trading banks in exchange for discountable securities.[1] There were no arrangements whereby trading banks could deposit surplus reserves. In this set-up the discount rate played a key role in the implementation of monetary policy as it served as the benchmark for short-term interest rates in the financial market.

Through discretionary open-market operations the central bank manages the liquidity of the financial sector of the economy. A central bank structures its open-market operations in such a way so as to keep the policy instrument at the target level. Open-market operations are central to the implementation of monetary policy in the Euro area, the United States, Australia and New Zealand and many other countries. However, the frequency of use (daily versus weekly operations), types of transactions (outright purchases and sales of securities vs repurchase agreements, fixed versus variable rate tenders) and purpose (signal of change in monetary policy) differ markedly amongst central banks. For instance, the Federal Reserve follows no fixed schedule in its operations and has a habit of purchasing securities outright from dealers. In contrast, the European Central Bank prefers to engage mainly in regular weekly reverse repurchase agreements to provide additional liquidity directly to the banking sector. Interestingly, the European Central Bank switched from fixed to

[1] Indeed to this day, the standing facility operated by the Federal Reserve System in the United States is one-sided. Trading banks can borrow reserves from the Fed but cannot deposit surplus funds and earn interest on them. Standing facilities were operated in a similar way by the German Bundesbank until 1999.

variable rate tender auctions in June 2000 to relieve the overbidding problem.[2] The Reserve Bank of New Zealand does not use open-market operations to signal a change in monetary policy while such operations are central to implementing a change in monetary policy in the United States.

Until recently, daily open-market operations were the norm in New Zealand. The daily transactions provide the unique opportunity to study the day-to-day implementation of monetary policy in New Zealand. The central concern of this paper is to show how the daily conduct of monetary policy affected the behaviour of the 90-day bank bill rate over the March 1999 – June 2005 period. Our empirical study aims to verify to what extent the structure of open-market operations affected the mean and the volatility of this market-determined interest rate over the sample period in a small, relatively open economy.[3] Essentially, our aim is to determine whether the methods used by the Reserve Bank of New Zealand to provide adequate liquidity to the financial sector of the New Zealand economy had any bearing on the behaviour of the 90-day bank bill rate. We also examine whether short-term interest rates in foreign capital markets had any measurable impact on the 90-day bank bill rate in New Zealand. Towards this end, we study the behaviour of comparable short-term interest rates in Australia, an important regional financial market, and the United States, the world's largest financial market. The point of departure of our analysis is, however, a close examination of changes in the stance of monetary policy in New Zealand, Australia, and the United States over the sample period. The reason for scrutinizing the timing of changes in monetary policy is to establish whether there is a systematic

[2] For a study of the overbidding problem encountered by the European Central Bank, see Nautz and Oechssler (2003). Ayuso and Repullo (2003) argue that the extreme overbidding phenomenon associated with fixed rate tenders is consistent with an asymmetric loss function that punishes low interbank rates more severely than high interbank rates.

[3] A few recent empirical studies examine the behavior of interest rates in the larger economies of Europe and North America. Bartolini and Prati (2006) show that differences in the way central banks operate their standing facilities can account for the observed cross-country differences in the volatility of overnight interest rates. Looking at the German experience before and after the establishment of the EMU, Perez Quiros and Mendizabal (2006) find that a central bank that retains the right to impose reserve requirements over a maintenance period and offers borrowing and lending facilities exercises tight control over the overnight interest rate. Their model offers an explanation for why the overnight interest rate does not follow a martingale process. Nautz and Offermanns (2006) study the dynamic behavior of the European overnight interest rate and its response to policy and term spreads. A study similar in approach to ours is by Kugler and Jordan (2004). They examine the effect of allotment and maturity spectrum ratios on the 30, 60, and 90-day LIBOR in the daily implementation of monetary policy in Switzerland.

leader-follower pattern in the conduct of monetary policy that is also evident in the market-determined short term interest rates.

Our most important results can be summarized briefly here. Regarding the hypothesised link between the structure of open-market operations and behaviour of the 90-day bank bill rate in New Zealand, we find that the maturity structure of open-market operations affected the mean but not the variance of the 90-day bank bill rate. The allotment ratio, the extent to which the Reserve Bank accommodated the financial sector's bids for cash balances, had no flow-on effects or repercussions for the most important short-term interest rate. The level of the 90-day bank bill rate in New Zealand also appeared to adjust to the level of the 90-day bank bill rate in Australia, albeit at a slow speed. There is no evidence that 90-day rates in New Zealand responded to 90-day rates in the United States over the whole sample period. More generally, our findings suggest that short-term interest rates in Oceania moved independently of those in the United States for much of the sample period. This conclusion emerges after reviewing the timing of changes in the policy instrument in the three countries.

The remainder of the paper is organised as follows. Section 2 offers a brief analysis of monetary policy changes in New Zealand, Australia, and the United States. Section 3 provides an overview of the implementation of monetary policy in New Zealand. Section 4 presents the empirical findings of our study of the effects of open-market operations and foreign interest rate linkages on the behaviour of the 90-day bank bill rate in New Zealand. Section 5 offers a brief summary and conclusion.

2. A Short Descriptive Analysis of Monetary Policy Changes in New Zealand, Australia, and the United States

Our primary focus in this section is on the monetary policy changes that occurred in New Zealand, Australia, and the United States over the period from March 17th, 1999 to June 30th, 2005. The beginning of the sample period coincides with the switch by the Reserve Bank of New Zealand from targeting cash settlement balances to setting the official cash rate. Figure 1 shows the setting of the official policy instrument in each country over the sample period. Table 1 lists the dates of the policy changes, the announced new level of the policy instrument, the size of the change in the instrument as well as additional information that characterizes the conduct of monetary policy in the three countries. The ancillary information consists

of the day of the week the policy change was announced, the duration of the announced policy change in trading and calendar days, respectively, and the flow-on effect on short-term market interest rates. The last two columns give an indication of the same-day effect of the change in the official cash rate in New Zealand, the overnight cash rate in Australia and the federal funds rate in the United States on key short-term market interest rates. In New Zealand and Australia the 90-day bank bill rate is arguably the most important short-term market interest rate. For the United States, we chose the 90-day commercial paper rate. The three interest rates represent the yields on short-term debt instruments issued by banks and corporate entities to secure financial capital.

The information arrayed in Table 2 proves helpful in interpreting the statistics contained in Table 1 and the constellation of interest rates in Figure 1. Over the sample period the stance of monetary policy was changed most often in the United States. The Federal Open Market Committee saw fit to change the target for the federal funds rate on 28 occasions. There were 24 changes in the official cash rate in New Zealand. Australia had the fewest policy changes with 16. The Reserve Bank of New Zealand increased the official cash rate 16 times and lowered it eight times. The Reserve Bank of Australia tightened the stance of monetary policy ten times and eased on six occasions. The Federal Open Market Committee raised the federal funds rate target 15 times and lowered it 13 times. Most of the policy changes in the three countries occurred in steps of 25 basis points. Closer scrutiny of the policy changes in the United States reveals that the Federal Open Market Committee eased the stance of monetary policy more aggressively in steps of 50 basis points rather than 25 basis points (9 as opposed to 4) but preferred to tighten the stance of policy in steps of 25 basis points rather than 50 basis points (14 as opposed to 1). No such pattern is evident in the behaviour of either the Reserve Bank of New Zealand or the Reserve Bank of Australia. Both central banks showed far less willingness to ease the stance of monetary policy in steps of 50 basis points, relying instead more often on 25 basis point decreases. Notice though that the Reserve Bank of New Zealand raised the official cash rate by 50 basis points on three occasions while the Australian central bank did so only once.

Turning our attention to the coordination of policy moves between New Zealand on the one hand and Australia and the United States on the other, we find that monetary policy changes in New Zealand were closely aligned with monetary policy

changes in the United States from November 1999 to mid-November 2001. Of the ten policy changes that occurred in New Zealand during this period, all of them were in the same direction as interest changes in the US; five policy changes in New Zealand occurred within 24 hours of the announcement of policy changes in the United States.[4] The Reserve Bank of Australia also followed the US lead in changing interest rates over the November 1999 to December 2001 period. A series of interest hikes had raised the overnight cash rate from 5 to 6.25 percent by August 2000, only to be followed by a series of decreases. The synchronous policy moves underscore the fact that in the early part of the sample period, the economies of New Zealand, Australia, and the United States were in the same phase of the business cycle.

The leader-follower pattern evident in the behaviour of the three central banks disappears at the end of 2001 in the wake of the terrorist attacks in the United States. For the remainder of the sample period there is also not much evidence for a close coordination of monetary policies between the Reserve Bank of New Zealand and the Reserve Bank of Australia. It is true that in May and June 2002 the Australian central bank tightened the stance of monetary policy and that the Reserve Bank of New Zealand followed suit. But the cycle of monetary policy tightenings had begun in New Zealand as early as March 20th, 2002, thus preceding the move by the Australian central bank by approximately 50 days. The seeming coordinated policy move in March 2005 between the two central banks came on the heels of a series of tightenings in New Zealand in 2004.

It is instructive to examine the range of settings of the policy instrument in the three countries. According to Table 2, the overnight cash rate in Australia had the narrowest range, varying from a low of 4.25 percent to a high of 6.25 percent. The range of the official cash rate was slightly wider in New Zealand where the lowest and highest settings coincide with the instrument settings observed at the beginning and end of the sample period. The United States experienced the widest swings in the policy instrument due to the continued decreases in the federal funds rage target which began in January 2001 and ended in June 2004 when the federal funds rate target was raised from 1 to 1.25 percent. Notice that in the United States the target for

[4] Because of the 18 hour time difference between New Zealand and the Eastern Time Zone of the United States, the move to adjust interest rates in New Zealand on September 19th, 2001 in the wake of the easing of monetary policy in the US on September 17th falls roughly into the 24 hour window. The dates of the closely coordinated policy changes were: Nov. 17th, 1999, May 15th, 2000, April 19th, 2001, and May 16th, 2001.

the federal funds rate at the beginning of the sample period (4.75 percent) exceeded the target at the end of the sample period (3.25 percent). Just the opposite holds for the target for the overnight cash rate in Australia and the official cash rate in New Zealand. In both countries, the respective target rate at the end of the sample period exceeded the target at the beginning, with the difference amounting to 2.25 percent in New Zealand but only 0.75 percent in Australia. Comparing the average length of duration, we find that the average duration in calendar days of a given policy stance was about 3 months for New Zealand and the United States. For Australia the average length was considerably higher. There the policy setting was left unchanged on average for almost 5 months.

The last two columns of Table 1 capture the effect of changes in the policy instrument on the 90-day bank bill or commercial paper rate.[5] Inspection of these columns reveals that the same day response of market interest rates to changes in the policy setting varied considerably in the three countries. In New Zealand, an announced change in the official cash rate was accompanied by a change in the 90-day bank bill rate of more than 10 basis points in the same direction on eight occasions. In Australia, the response of the 90-day bank bill rate to changes in the target cash rate was much more muted, with only three changes in the 90-day rate exceeding 10 basis points and following the direction of the change in the policy instrument. The commercial paper rate in the US reacted least sensitively to changes in the policy target. Of 28 changes in the federal funds rate target, only four announced decreases in the policy instrument led to more than 10 basis point decreases in the 90-day commercial paper rate. [6,7]

[5] Monetary policy changes are announced in the morning, usually around the time when financial markets open for the day.

[6] Kuttner (2001) calculates the surprise element of a monetary policy action by examining observed changes in the federal funds rate futures on the day of the policy announcement. Futures contracts for the overnight cash rate (interbank borrowing rate), the equivalent interest rate in New Zealand, do not exist.

[7] An earlier version of this paper also looked at the extent to which market interest rates anticipated and responded to actual policy changes in the three countries over the sample period. An examination of the co-movements between changes in the setting of policy instrument and 12 leads as well as 12 lags of changes in the market interest rate reveals that the 90-day bank bill rate in New Zealand moved much more ahead of actual policy changes than its counterpart in Australia and the United States.

3. The Implementation of Monetary Policy in New Zealand

Since March 17th, 1999 the Reserve Bank of New Zealand has been relying on an operating procedure that has the official cash rate as its fulcrum.[8] The Reserve Bank sets the official cash rate. The level at which the official cash rate is set is reviewed eight times per year at pre-announced dates. The operating procedure rests on two pillars. The first pillar is the provision of a standing facility whereby the Reserve Bank stands ready to accept surplus cash settlement balances from and lend additional cash settlement balances to registered financial institutions overnight at interest rates that lie 25 basis points below and 25 basis points above the official cash rate, respectively.[9] The second pillar is the daily interaction with the financial market through open-market operations. The intended aim of this operating procedure is twofold: first, to ensure that the overnight market interest rate at which banks borrow from and lend to each other remains within this corridor of ± 25 basis points around the official cash rate. Second, the official cash rate serves as a benchmark for short-term interest rates in the domestic financial market. A further characteristic of the current regime is that the Reserve Bank has set an objective of NZ$ 20 million for the volume of "free" cash settlement balances at the end of each trading day.[10,11]

[8] This section describes the original operating procedure that was in place over the sample period (March 17th 1999- June 30th 2005). Since then a few changes have been introduced to improve the provision and allocation of liquidity in the financial sector. See footnote 11 for further details. The operation of the cash rate system in New Zealand has been described by Archer et al (1999) and Brookes and Hampton (2000). Frazer (2004) gives an overview of the liquidity management operations of RBNZ. Nield (2006) describes the rationale for changing the operational framework in June 2006.

[9] Apart from the overnight borrowing facility, there also exists an *autorepo* facility by means of which banks can secure *intraday* liquidity at no cost. However, extending this source of borrowing to *overnight* borrowing incurs a penalty rate of 5 additional basis points which puts the total cost of borrowing at 30 (25+5) basis points above the official cash rate.

[10] Under unusual circumstances this quantity target was altered. For instance, after the end of the sample period on February 2nd, 2006, the target was raised temporarily to NZ$ 500 million. Shortly thereafter it was raised even higher to NZ$ 2 billion. At the time the Reserve Bank cited the shortage of government stock, which serves as collateral in open-market operations and other financial transactions, as being behind the temporary increase in the volume of cash balances. Leaving more cash balances in the system simply obviated the need for securing liquidity through the standing facilities of the Reserve Bank. This move had no implications for the conduct of monetary policy but laid bare the inefficiency of the existing framework.

[11] In June 2006, the Reserve Bank proposed to change the operation of the official cash rate regime somewhat. The changes to the modus operandi had two basic objectives: first, to improve the provision of liquidity to the financial sector by de-emphasizing the use of open-market operations in the daily implementation of monetary policy; second, to generate a more vibrant market for inter-bank borrowing. Among the proposed innovations were the abolition of the *autorepo* facility, a substantial increase in the target for cash balances supplied by the Reserve Bank, the remuneration of cash balances on deposit with the Reserve Bank at the official cash rate (OCR), and an increase in the cost of borrowing cash balances from the Reserve Bank from OCR + 25 basis points to OCR + 50 basis points. Under the new arrangement, the official cash rate forms the floor of a 50 basis-points corridor.

The purpose of open-market operations is to smooth the liquidity flows in and out of the financial sector.[12] If the expected liquidity position of trading banks is covered by the successful implementation of open-market operations, then trading banks should be no more likely to have to seek additional funds from the standing facility than to have surplus cash balances at the end of the day. This implies that the official cash rate is at the centre of a symmetric corridor. Algebraically, the official cash rate is a weighted average of the two interest rates that define the corridor where either interest rate is weighted by the respective probability of lacking or excess liquidity in the financial sector.

$$i_t = i_t^b P(L_t^d - L_t^s > 0) + i_t^d P(L_t^d - L_t^s < 0) \quad (1)$$

where i_t = official cash rate

i_t^b = interest rate at which trading banks borrow funds from the Reserve Bank

i_t^d = interest rate at which trading banks deposit surplus funds at the Reserve Bank

$P(L_t^d - L_t^s > 0)$ = probability that banks' liquidity needs exceed liquidity supply.

$P(L_t^s - L_t^d > 0)$ = probability that liquidity supply exceeds banks' liquidity needs.

As the intended aim of open-market operations is to make the two probabilities equal, it follows that equation (1) reduces to

$$i_t = i_t^b(\frac{1}{2}) + i_t^d(\frac{1}{2}) \quad (2)$$

In New Zealand the width of the corridor is 50 basis points.[13]

Hence $i_t^d = i_t^b - 0.5$ (3)

Since July 2006, open-market operations have not been conducted on a regular daily basis. Foreign exchange swaps have become the preferred instrument of the Reserve Bank to affect liquidity conditions in the financial market.

[12] This explanation draws on Bindseil and Wuertz (2005). Their paper provides an overview of issues in the implementation of monetary policy. The operation of the interest rate corridor has also been aptly described by Woodford (2001).

[13] Interest rates are expressed as percentage points, i.e. 5 percent.

Substituting (3) into (2) yields

$$i_t = i_t^b - 0.25 \qquad (4)$$

The rate at which trading banks borrow from the standing facility at the Reserve Bank exceeds the cash rate by 25 basis points. Similarly, the deposit rate i_t^d lies 25 basis points below the cash rate.

The provision of adequate liquidity to the financial sector of the economy is central to the successful implementation of the current cash rate system. To ensure that sufficient cash settlement balances are maintained in the settlement accounts of the major financial institutions of the country, the Reserve Bank conducts open-market operations. These operations are conducted daily at 9:30 am by means of variable rate tenders.[14] All registered participants have 15 minutes to submit their bids. To meet its objective for cash settlement balances at the end of each trading day, the Reserve Bank needs to have precise information about the government's transactions with the public. The expected daily flows of funds from and into the government's coffers occur through the trading banks and hence affect their liquidity position. The Reserve Bank aims to anticipate these flows by coordinating its open-market operations with the help of advice from the New Zealand Debt Management Office (NZDMO). This advice comes in the form of detailed information about expected disbursements of government funds to the public such as the payment of pensions, payment of salaries, the maturity of long-term government debt or the collection of tax revenue and customs duties. Once the Reserve Bank has up-to-date information about the expected inflows and outflows of cash from the financial sector, it is in a position to structure its open-market operations to meet the liquidity needs of the financial sector. More specifically, the Reserve Bank can then determine and announce to the registered participants the size and maturity dates of its open-market operations. If the Reserve Bank wishes to inject additional cash balances into the financial sector, the Bank offers to engage in a *reverse* repurchase agreement (repo). If it desires to withdraw cash, it offers to engage in an ordinary repurchase agreement.[15] These transactions involve the immediate exchange of cash balances for securities or vice versa and fix the date on which the transaction is reversed. The

[14] With a few exceptions, open-market operations were conducted on every trading day over the March 17th 1999-June 30th 2005 period.

[15] The Reserve Bank also occasionally invites bids for seasonal treasury bills with a maturity of 1 to 3 months.

Reserve Bank also announces the minimum (maximum) interest rate that it is willing to accept (pay) on a given security that is involved in a transaction.[16] A noteworthy feature of the liquidity management operations conducted by the Reserve Bank is that it offers overnight reverse repos starting the week prior to an announced policy review date. These overnight transactions complement the standard transactions that involve longer terms to maturity. The provision of overnight reverse repos allows the trading banks to opt out of transactions of repos that mature after the policy review date.

Figures 2 and 3 provide some feedback on the maturity spectrum of open-market operations conducted by the Reserve Bank over the period beginning on March 17th, 1999 and ending on June 30th, 2005. Figure 2 shows the maturity spectrum of the transactions that the Reserve Bank offered to undertake. There are two noteworthy features about the transactions on offer. First, the data reveal a series of spikes and a distinct saw-tooth pattern on three occasions. Second, barring a few exceptions, the term to maturity of transactions offered becomes shorter beginning in the first half of 2004 and continues to the end of the sample period.

Closer examination of the open-market operations reveals that with one exception all spikes are accounted for by transactions whereby the Reserve Bank offered to sell Treasury Bills to withdraw cash from the financial sector. The three distinct saw teeth are due to reverse repurchase agreements that were offered to offset the injection of cash brought about by maturing government debt on February 15th 2000, February 15th, 2001, and March 15th, 2002. Consider the first saw tooth. Its shape was arguably influenced by the Y2K factor. Also from October 11th, 1999 onward, the Reserve Bank offered reverse repurchase agreements that matured on January 12th and January 27th, 2000 to soak up potential excess liquidity. On the same day in October, the Bank also began to offer reverse repurchase agreements with maturity date February 15th, 2000 and repeated this offer on every trading day until February 15th. The willingness by the Reserve Bank to inject cash daily over this 4-month period is behind the saw tooth pattern. Figure 2, however, is just part of the story as it reflects only the maturity spectrum of transactions *offered* by the Reserve Bank. The maturity profile of *actual* transactions that occurred on each trading day between the Reserve Bank and the registered participants in open market operations

[16] The Reserve Bank also informs the participants of the actual cash settlement balances that were left in the banking sector at the end of the preceding trading day and of its estimate for the flow of funds into and out of the financial sector on the trading day.

appears in Figure 3. It is apparent that the distinct saw tooth pattern of Figure 2 is absent from Figure 3. Evidently, financial institutions did not take up the offer of reverse repurchase agreements that were made well in advance of the maturity date of government bonds but deferred accepting reverse repurchase agreements until shortly before the government bonds matured. For instance, the first actual completion of a reverse repurchase agreement with maturity date February 15, 2000 occurred on December 1, 1999, approximately 50 days after it had been first offered on October 11th, 1999. Notice that beginning midyear in 2004 the maturity profile of offered transactions looks very similar to actual transactions. The term to maturity of actual reverse and ordinary repurchase agreements also declined somewhat.

To complete the description of how the Reserve Bank interacts with financial institutions in the day-to-day implementation of monetary policy, we also have to examine the bids for reverse and ordinary repurchase agreements. Figure 4 depicts the volume of bids submitted by registered participants in open-market operations. In addition, Figure 4 also shows the volume of transactions per maturity as offered by the Reserve Bank. In the overwhelming majority of the cases, the volume bid by the registered participants far exceeded the volume of offers announced by the Reserve Bank. Total volume offered by the Reserve Bank remained low and steady until mid-September 2001 ("9/11") after which the Reserve Bank increased its offers of reverse repurchase agreements markedly.[17] There are a few solid spikes, indicating that at times the volume of cash offered by the Reserve Bank exceeded the volume bid. Towards the end of 2004 there is a marked decline in the size of offers per maturity. Indeed the volume of transactions offered at the end of the sample period is approximately the same as at the beginning. Also notice that the bidding behaviour by the registered participants changed at the end of the sample period. The size of bids declined markedly relative to the beginning of the sample period.[18]

Given the above information about open-market operations, we now propose to construct two variables that are meant to capture important characteristics of the implementation of monetary policy in New Zealand. The first variable describes the

[17] Over the September 12, 2001 – April 1, 2005 period the Reserve Bank of NZ undertook only eight ordinary repurchase agreements and three transactions involving Treasury Bills. All other transactions carried out during this period were reverse repurchase agreements.

[18] This is consistent with the Reserve Bank's view that a slight underbidding problem had developed at the very end of the sample period. Due to the shortage of government securities the existing mechanism through which liquidity was provided to the market had become inefficient. As a result, trading banks began to turn increasingly to the standing facilities provided by RBNZ.

extent to which the Reserve Bank accommodated the bids submitted by the registered participants. We call this variable the *allotment ratio (AR)*. This ratio is simply the total amount transacted in an open-market operation divided by the volume of bids submitted by the registered participants on a given day. The second variable indicates the importance of one-day reverse and ordinary repurchase agreements in open-market operations. We call this variable the *maturity spectrum ratio (MS)*. This ratio is the volume of one-day reverse or ordinary repurchase agreements divided by the volume of *all* repurchase agreements. Figures 5 and 6 illustrate the frequency distribution of the allotment ratio and the maturity spectrum ratio. Inspection of Figure 5 reveals that in 1999 and 2000 a number of open-market operations resulted in no transactions. Since 2001 zero allotment ratios have been much rarer. Full allotment occurred in nearly ten percent of all transactions. The mean allotment ratio over the sample period is 0.483 which suggests that on average the Reserve Bank accepted nearly 50 percent of the total volume of bids received. The allotment ratio remained fairly stable over the sample period. However, there is a noticeable surge in the allotment ratio at the end of the sample period. According to Figure 6, the MS ratio at the end of the sample period is very different from the MS ratio at the beginning of the sample period. The presence of sizeable gaps along the time axis suggests that virtually no open-market transactions involving one-day repos (ordinary and reverse) were carried out as the new operating system was being put in place. However, there is a tight cluster of daily open-market operations that involved overnight repos near the end of the sample period. This suggests that one-day repos became the preferred vehicle to change liquidity conditions in the New Zealand financial market only a few years after the change in the operating regime. Also note that in 2004 and the first part of 2005 the MS ratio is frequently unity which suggests that only overnight repos and reverse repos were carried out. Over the whole sample period, the mean ratio of the volume of one-day repos to the volume of *all* repos was *0.130*.

4. The Behaviour of the 90-Day Bank Bill Rate in New Zealand: Examining the Effects of Open-Market Operations and the Existence of Foreign Interest Rate Linkages.

The purpose of the current section is twofold. First, we examine whether the behaviour of the 90-day bank bill rate in New Zealand is influenced by the structure

of open-market operations. More specifically, we seek to establish to what extent the allotment ratio (*AR*) and the maturity spectrum ratio (*MS*) influence the path of the 90-day bank bill rate.

Our first hypothesis is that there ought to be an inverse relationship between the allotment ratio and the 90-day bank bill rate. A decrease in this ratio signals rationed access to liquidity in the banking sector which in turn should lead to upward pressure on short-term interest rates such as the 90-day bank bill rate. If trading banks do not succeed in covering their liquidity position through open-market operations and minimize or refrain altogether from accessing the more expensive standing facilities at the Reserve Bank, they have to enter the inter-bank market for settlement balances. With demand for reserves increasing, the borrowing costs for banks are expected to increase, the flow-on effects of which cause the 90-day bank bill rate to rise.[19,20]

Second, an increase in the maturity spectrum ratio implies that the Reserve Bank becomes more cautious in allocating liquidity to the financial sector. An increase in the volume of overnight reverse repos to the total volume of reverse repos marks a shift in emphasis from providing liquidity on a longer-term basis to a shorter-term basis. This effect, too, should spill over into the financial market, putting upward pressure on the 90-day bank bill rate immediately as it signals greater uncertainty about trading banks' ability to secure cash balances in open market operations on future trading days.

[19] Making use of the standing facility, i.e. borrowing from the Reserve Bank is generally more expensive than borrowing in the inter-bank market as the lending rate is 25 basis points above the official cash rate.

[20] It is important to be mindful of the fact that decreases in the allotment ratio can also come about because of a change in the bidding behaviour of trading banks in the period leading up to a review of the monetary policy stance. Specifically, if trading banks expect an easing of monetary policy, they withhold bids to procure additional settlement cash balances prior to the date of the policy review as such cash balances can be obtained at lower cost after the decrease in the official cash rate is announced. Over the sample period, there were two episodes in which the Reserve Bank lowered the official cash rate by 75 basis points in three consecutive steps of 25 basis points each. The first episode occurred in 2001 when the Reserve Bank lowered the official cash rate on March 14th, April 17th, and May 16th. The second round of 25 basis-point decreases in the official cash rate took place on April 24th, June 5th, and July 24th, 2003. In each of the six cases, we picked the five days preceding the policy review date. For each day we calculated an allotment ratio that is based solely on bids and transactions with dates of maturity up to the date of the policy review. We compared this alternative allotment ratio to the simple AR ratio used in the paper which is based on all transactions and bids – irrespective of the date to maturity - over the same five-day trading period. The correlation between the two allotment ratios is extremely high, ranging from a low of 0.985 to 1 in five cases. No meaningful correlation exists for the sixth case as transactions and bids occurred only on two days prior to the policy review date. We interpret the high correlation between the two variants of the allotment ratio as evidence that the AR ratio reported in the paper is not distorted by the bidding behavior of trading banks in the lead-up of an expected interest rate decrease.

The other question we address concerns the possible link between short-term interest rates in New Zealand on the one hand and short-term interest rates abroad, i.e. short-term interest rates in Australia and the United States. The financial market of New Zealand is fairly small and fully integrated with capital markets elsewhere. There are no restrictions on the flow of capital in and out of New Zealand. It is therefore natural to ask whether short-term interest rates in New Zealand respond to short-term interest rates in the region, i.e. in Australia or to short-term interest rates set in the world's largest economy, the United States.

To assess the effects on the mean of the 90-day bank bill rate of the liquidity management operations undertaken by the Reserve Bank and to verify the existence of an interest rate link with foreign capital markets, we propose the following regression equation:

$$\Delta r_t^{NZ} = \alpha_0 + \sum_{j=1}^{n} \alpha_j \Delta r_{t-j}^{NZ} + \beta_1 (r_{t-1}^{NZ} - r_{t-1}^{AUS}) + \beta_2 (r_{t-1}^{NZ} - r_{t-1}^{US}) + \beta_3 ARI_t + \beta_4 ARW_t + \beta_5 MSI_t + \beta_6 MSW_t + \beta_7 D1_t + \beta_8 D2_t + \beta_9 D3_t + v_t \quad (5)$$

where $ARI_t = AR_t * I_t$ $I_t = 1$ if reverse repo, *0* otherwise

$ARW_t = AR_t * W_t$ $W_t = 1$if repo or Treasury Bill transaction, *0* otherwise.

$MSI_t = MS_t * I_t$

$MSW_t = MS_t * W_t$

The change in the NZ 90-day bank bill rate is regressed on its own lags, the lag of the difference between the NZ 90-day bank bill rate and the Australian 90-day bank bill rate, the lag of the difference between the NZ 90-day bank bill rate and the US 90-day commercial paper rate, the allotment and the maturity spectrum ratio, respectively, where a distinction is made between liquidity-adding and liquidity-draining transactions, and three dummy variables. *D1* captures the effect of monetary policy tightenings while *D2* captures the effects of monetary policy easings. *D3* is meant to capture the effect of special events such as "9/11". Special events are interpreted as days on which the 90-day-bank bill rate changed by more than 15 basis points.[21] We

[21] *D3=1* on October 1st, 1999, December 13th, 1999, September 12th, 2001, and December 4th, 2003, and zero otherwise. Three of the above dates are associated with easily identifiable events. On October 1st, 1999, NZ Treasury finalized its economic outlook for the years ahead. The terrorist attack in the United States occurred on September 12th, 2001 NZ time. On December 4th, 2003 the Reserve Bank

also estimate the following parsimonious specification for the time-varying variance of the NZ 90-day bank bill rate:[22]

$$h_t = c_0 + c_1 v_{t-1}^2 + c_2 h_{t-1} + c_3 ARI_t + c_4 ARW_t + c_5 MSI_t + c_6 MSW_t + c_7 D1_t + c_8 D2_t + c_9 D3_t \quad (6)$$

The empirical estimates of the relevant coefficients appear in the top two panels of Table 3. Our preferred empirical specification for the conditional mean equation contains only the fifth lag of the dependent variable as a right-hand side variable. All other lagged dependent variables have coefficients that are statistically insignificant. The bottom panel of both tables also provides some feedback on the goodness of fit and the standard error of the regression for equation (5).

According to the findings of Table 3, there is substantial evidence for the claim that the 90-day bank bill rate in New Zealand is far more responsive to its Australian counterpart than to its American counterpart. In case the 90-day rate in New Zealand exceeds the 90-day rate in Australia, there is a tendency for the New Zealand rate on the following day to revert to the level set by the Australian rate. If the NZ 90-day bank bill rate exceeds the Australian rate by one percentage point, then the New Zealand rate is expected to decrease by approximately 0.3 basis points per day towards the Australian rate.[23] Thus the adjustment speed is rather slow but it is statistically significant at the 5 percent level. No such adjustment mechanism shows up in the results for the lag of the difference between the NZ 90-day and US 90-day interest rates.[24] The second noteworthy finding relates to the positive effect of the maturity spectrum ratio on the change in the NZ 90-day bank bill rate.[25] The greater the proportion of one-day reverse repo transactions relative to all transactions conducted by the Reserve Bank, the greater the impact on the 90-day bank bill rate. It

announced that it would not change the official cash rate. Apparently financial market participants had expected an increase in the official cash rate as the 90-day bank bill rate decreased markedly on the day of the announcement.

[22] Assessing the impact of the lagged interest rate differentials on the variance turned out to be problematic due to the negative association between the lagged NZ and US interest rate differential and the time-varying variance. The negative association poses a problem as the variance is by definition a positive number.

[23] We also estimated the effect of the lagged difference between the NZ and US 90-day rate on the Australian 90-day bill rate. The error correction coefficient was statistically insignificant. Thus, there is feedback from Australian to New Zealand interest rates but not the other way around.

[24] The correlation between the lags of the two interest rate differentials is *0.47*.

[25] The open-market operations carried out by the Reserve Bank precede the determination of the 90-day bank bill rate. As a result, there is no problem of endogeneity between the dependent variable and ARx_t or MSx_t where $x=I$ or W.

thus seems that the behaviour of the 90-day bank bill rate depends to some extent on the way the Reserve Bank structures its open-market operations. The more the Reserve Bank engages in overnight reverse repo transactions the more it moves the 90-day bank bill rate. This is consistent with the scenario that the Reserve Bank's injection of additional cash into the financial sector and then its subsequent withdrawal on the following day left the financial participants with little room to manoeuvre. The shorter the average maturity of reverse repos, the larger the average shortage of cash available to trading banks.[26,27] This effect filtered through to the wider financial market, resulting in upward pressure on the 90-day bank bill rate. In contrast, the allotment ratio does not seem to exert any effect on the mean of the 90-day bank bill rate. This implies that the extent to which the Reserve Bank accommodates the bids for ordinary or reverse repo transactions by the financial sector has no repercussions for the behaviour of the mean of the 90-day bank bill rate. Notice that the coefficients on the two dummy variables, which indicate changes in monetary policy, bear the expected sign and are both highly significant. In contrast, the coefficient of the third dummy variable which ought to capture idiosyncratic effects on the 90-day bank bill rate is statistically insignificant.[28]

The estimates of the coefficients for the variance equation appear in the second panel from the top. We observe that neither the allotment ratio nor the maturity spectrum ratio had any discernible effect on the time-varying variance.[29] Notice that in the GARCH (1,1) specification the coefficient on the dummy variable associated with a monetary policy tightening exercises a positive effect on the dependent variable. The coefficients on the other two dummy variables are

[26] William A. Allen (2004), p. 27 expresses a similar view.

[27] There is no statistical evidence that the Reserve Bank's willingness to supplement their standard open-market operations with additional overnight reverse repos in the week prior to the six-weekly review of the official cash rate (OCR) had any bearing on the 90-day bank bill rate. Adding to equation (5) a dummy variable that multiplies all overnight reverse repo transactions during the week preceding the OCR review results in a coefficient on *DUM*MSI* that is statistically insignificant. *DUM=1* on the five trading days prior to each OCR review, *DUM=0* otherwise.

[28] We also experimented with adding leads of changes in the 90-day bank bill rate to the specification. The leads are proxies for the forward-looking expectations of changes in the 90-day bank bill rate. However, adding the leads to the specification creates an endogeneity problem. The results reported in Table 3 concerning the allotment and maturity spectrum ratios are robust to this change in the specification of the regression equation.

[29] We initially distinguished between reverse and ordinary repo transactions in the construction of the allotment and maturity spectrum ratios. As neither injections nor withdrawals of liquidity had a systematic effect on the variance, we report only the coefficient estimates for the simple AR and MS ratios.

statistically insignificant. Taken altogether, there is no evidence that the structure of open-market operations affected the variability of the 90-day bank bill rate in New Zealand over the sample period. Announced increases in the official cash rate were the only factor that added to the variability of the most important short-term interest rate in New Zealand.

5. Summary and Conclusion

This paper discusses the implementation of monetary policy in New Zealand over the period from 1999 to 2005 from an empirical perspective. The then operating procedure of the Reserve Bank was based on a symmetric channel where the deposit rate offered and lending rate charged by the Reserve Bank served as the lower and upper bound, respectively. The announced official cash rate was the midpoint of the channel and served as the benchmark for market-determined interest rates. Over the sample period, open-market operations served as the primary vehicle with the help of which the Reserve Bank of New Zealand controlled the volume of liquidity that the Bank thought was consistent with the announced target for the official cash rate.

Against this background, we examine whether the way in which the Reserve Bank structured its open-market operations influenced the behaviour of the key short-term interest rate in New Zealand, the 90-day bank bill rate. We create two variables that capture important characteristics of the structure of open-market operations carried out by the Reserve Bank. They are the allotment ratio and the maturity spectrum ratio. The former measures the extent to which the Reserve Bank accommodates the bids submitted by trading banks in the daily auctions. The latter variable reflects primarily the importance of the provision of overnight liquidity in the transactions entered into by the Reserve Bank with the registered participants.

Our empirical findings suggest that the higher the share of overnight reverse repos in the total volume of transactions, the greater the effect on the 90-day bank bill rate. While the maturity structure ratio thus had a discernible effect on the 90-day bank bill rate no such effect was exerted through the allotment ratio. Assessing the impact of the maturity spectrum ratio and the allotment ratio on the volatility of the 90-day bank bill rate, we find that neither variable contributed materially to the variability of this market-determined interest rate.

Given its small size, the financial market of New Zealand is subject to the influence of external factors such as conditions in financial markets abroad. The most natural foreign candidates that might influence the 90-day rate in New Zealand are its counterparts in Australia and the United States. Indeed, over the sample period the Zealand 90-day bank bill rate had a tendency to revert to the level set by its Australian counterpart, though at a relatively slow speed. No such link existed between the NZ 90-day bank bill rate and the US 90-day commercial paper rate. This result is largely due to the fact that monetary policy changes in New Zealand and the United States went in opposite directions for a substantial length of time over the March 1999-June 2005 period.

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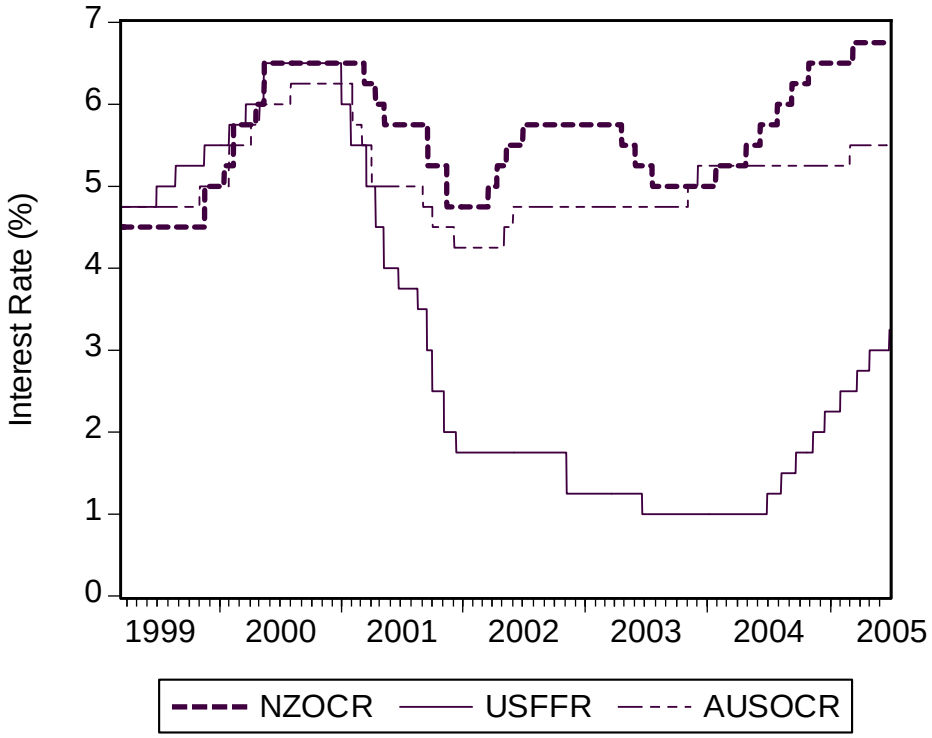
Figure 1
The Policy Instrument: March 1999-June 2005



NZOCR = Official Cash Rate in New Zealand
AUSOCR = Overnight Cash Rate in Australia
USFFR= Federal Funds Rate in the United States

Figure 2
Transactions on Offer

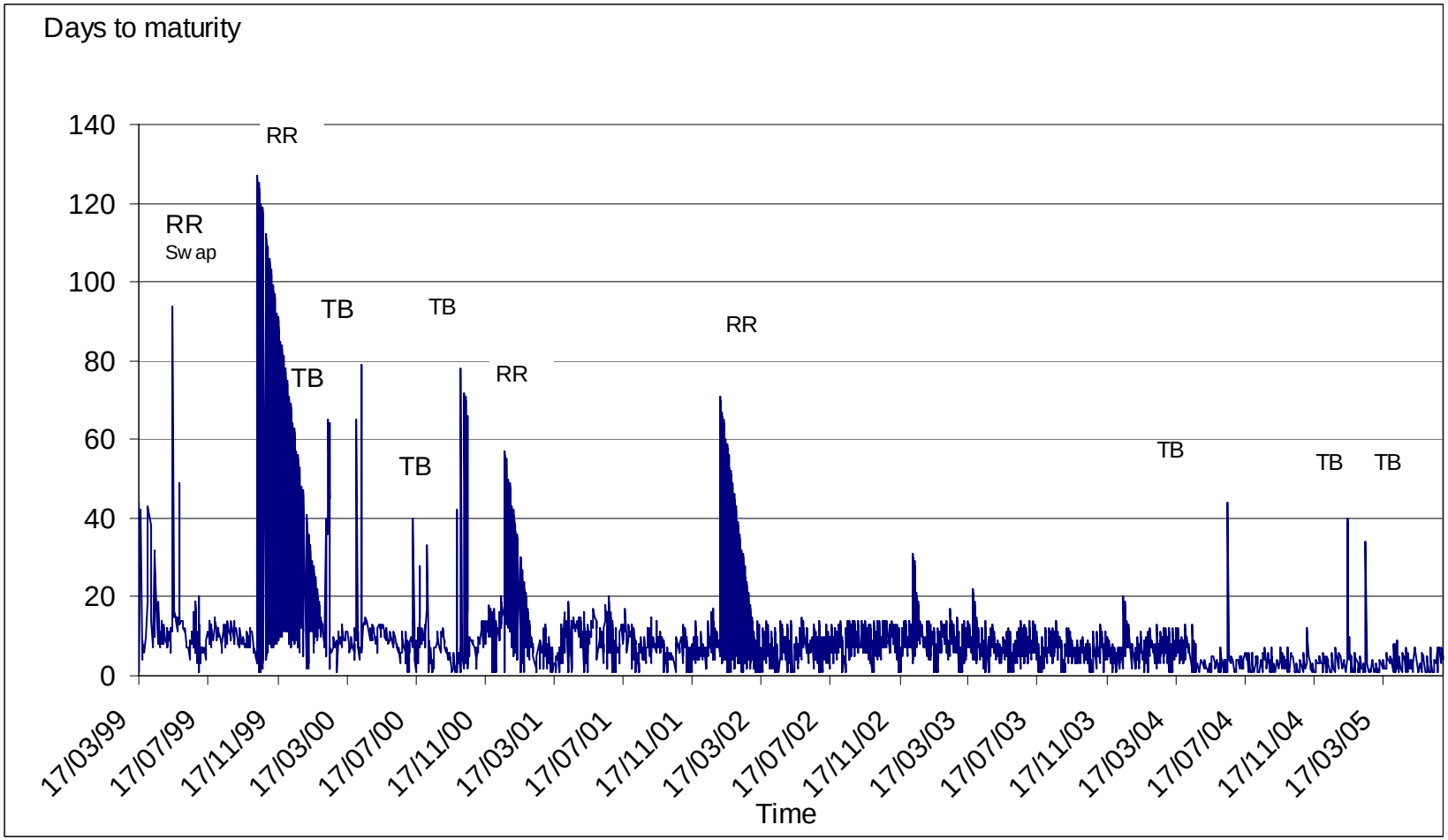


Figure 3
Actual Transactions

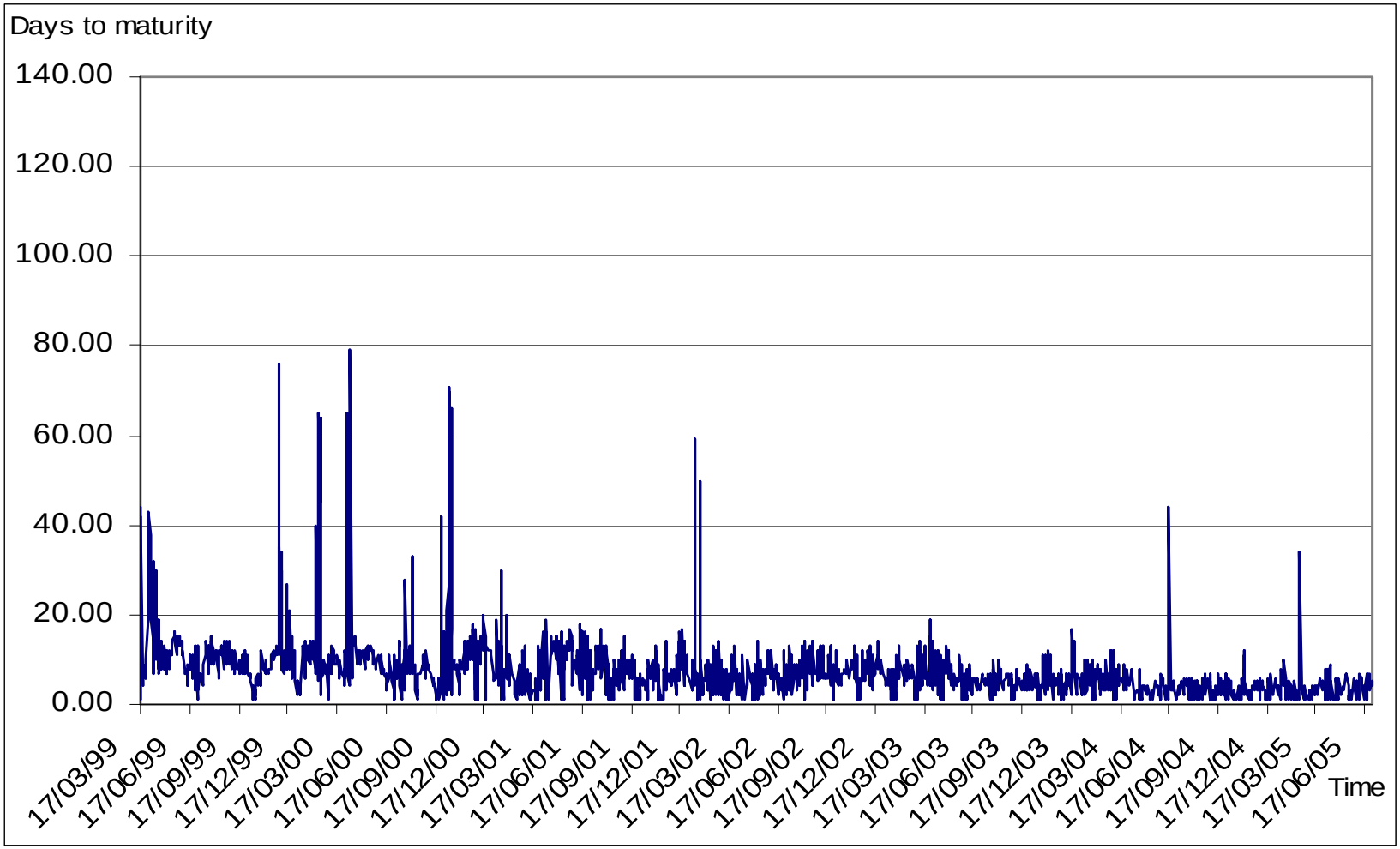


Figure 4
Volume of Offers and Bids

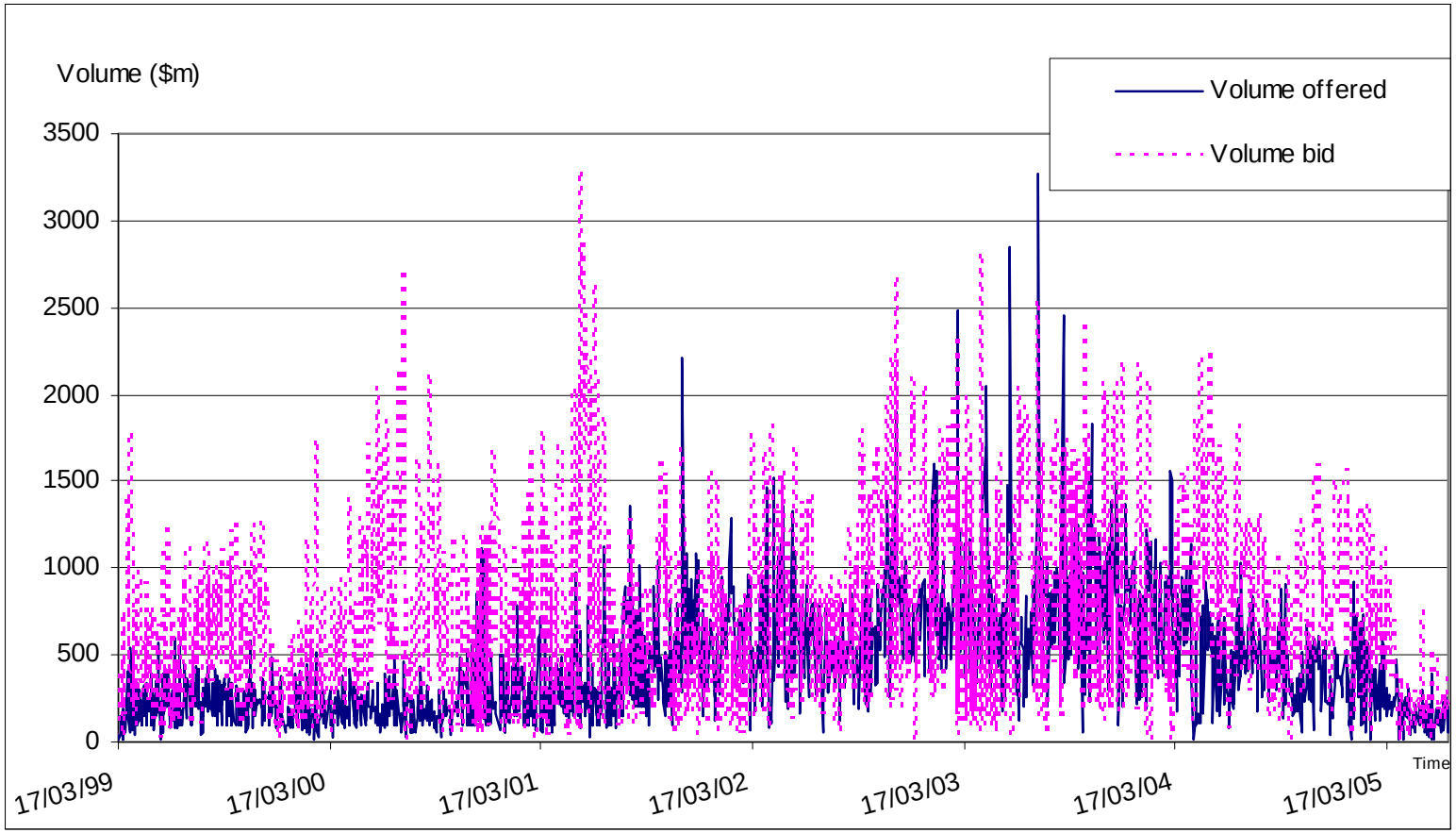


Figure 5
The Allotment Ratio over the Sample Period

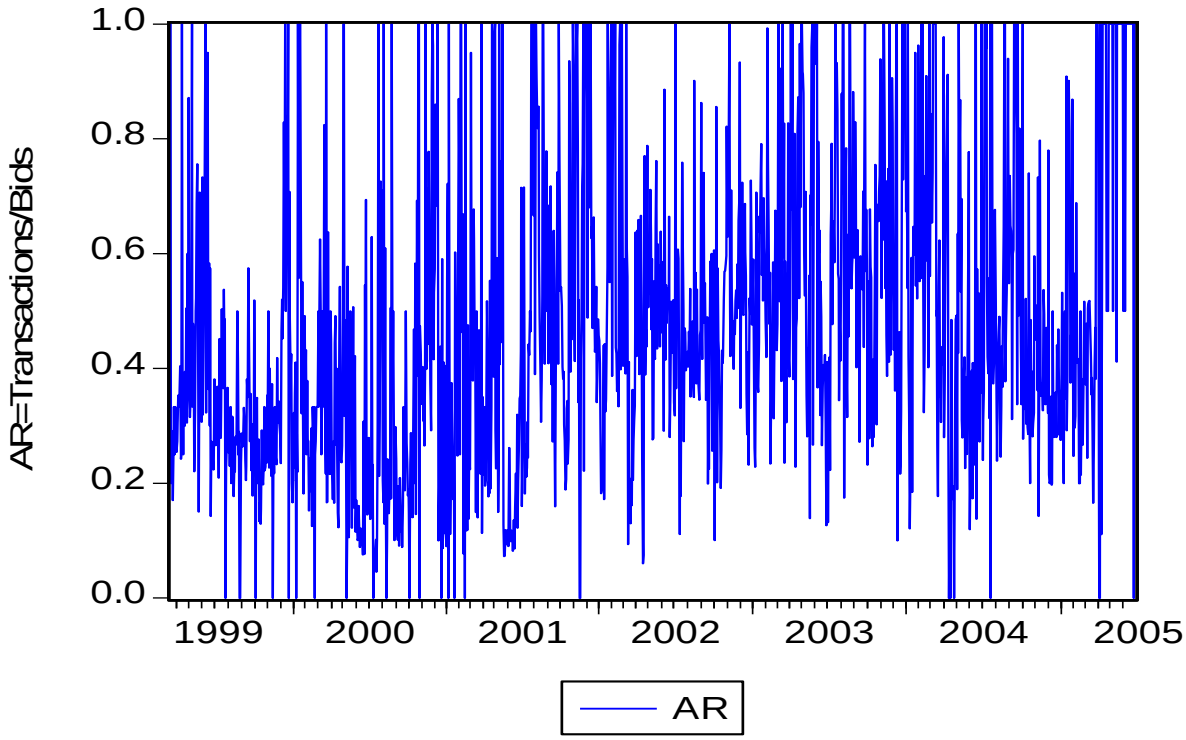


Figure 6
The MS Ratio over the Sample Period

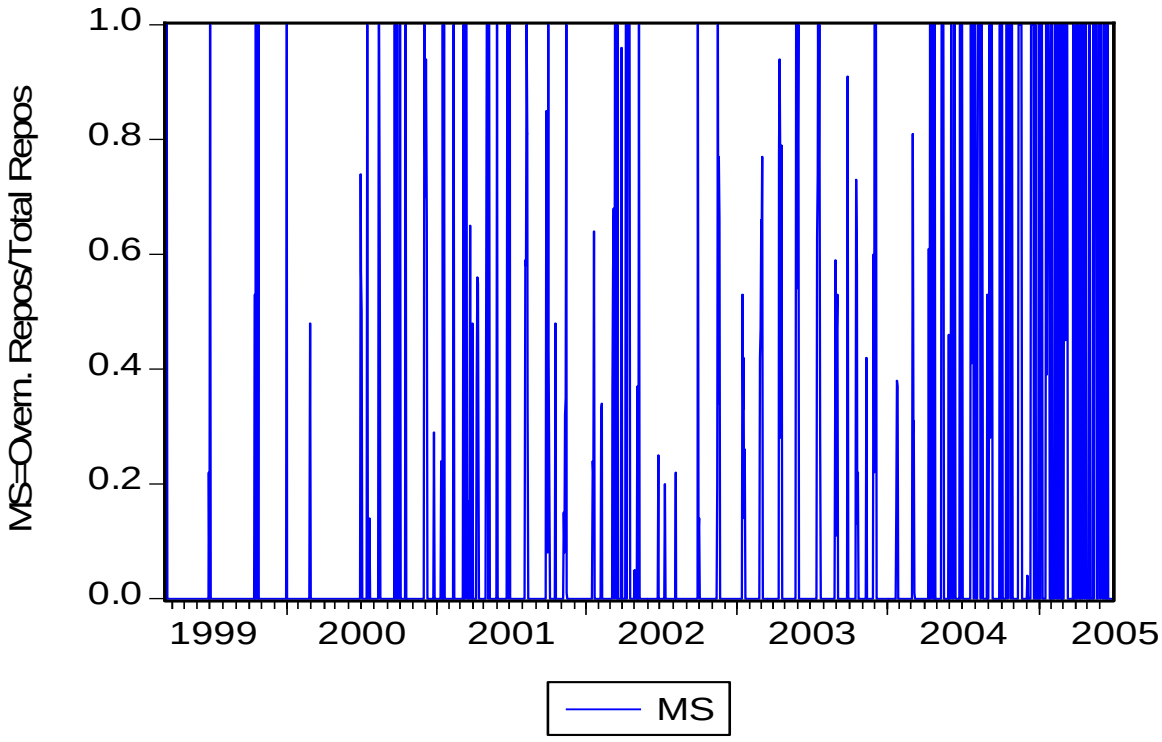


Table 1

An Overview of Monetary Policy Settings and Changes

Date of change	Target value	Target Change	Day of week	Duration in trading days	Duration in calendar days	Change in 90-day bank bill rate	Δ90-day / ΔOCR
New Zealand							
17/03/1999	4.50	na	Wednesday	175	245		
17/11/1999	5.00	0.5	Wednesday	45	63	-0.01	-
19/01/2000	5.25	0.25	Wednesday	19	27	0.05	+
15/02/2000	5.75	0.5	Tuesday	46	64	0.02	+
19/04/2000	6.00	0.25	Wednesday	20	28	0.05	+
17/05/2000	6.50	0.5	Wednesday	215	301	0.05	+
14/03/2001	6.25	-0.25	Wednesday	26	36	-0.11	+
19/04/2001	6.00	-0.25	Thursday	19	27	-0.23	+
16/05/2001	5.75	-0.25	Wednesday	90	126	-0.08	+
19/09/2001	5.25	-0.5	Wednesday	40	56	-0.27	+
14/11/2001	4.75	-0.5	Wednesday	90	126	-0.04	+
20/03/2002	5.00	0.25	Wednesday	20	28	0.14	+
17/04/2002	5.25	0.25	Wednesday	20	28	-0.03	-
15/05/2002	5.50	0.25	Wednesday	35	49	-0.04	-
3/07/2002	5.75	0.25	Wednesday	211	295	-0.03	-
24/04/2003	5.50	-0.25	Thursday	30	42	-0.24	+
5/06/2003	5.25	-0.25	Thursday	35	49	0.05	-
24/07/2003	5.00	-0.25	Thursday	135	189	-0.01	+
29/01/2004	5.25	0.25	Thursday	65	91	0.22	+
29/04/2004	5.50	0.25	Thursday	30	42	0.12	+
10/06/2004	5.75	0.25	Thursday	35	49	0.05	+
29/07/2004	6.00	0.25	Thursday	30	42	0.04	+
9/09/2004	6.25	0.25	Thursday	35	49	0.05	+
28/10/2004	6.50	0.25	Thursday	95	133	-0.03	-
10/03/2005	6.75	0.25	Thursday			0.12	+
			Average	**65.04**	**91.04**		
Australia							
02/Dec/1998	4.75	-0.25	Wednesday	240	336		
03/Nov/1999	5	0.25	Wednesday	65	91	-0.04	-
02/Feb/2000	5.5	0.5	Wednesday	45	63	0.09	+
05/Apr/2000	5.75	0.25	Wednesday	20	28	-0.01	-
03/May/2000	6	0.25	Wednesday	65	91	0.03	+
02/Aug/2000	6.25	0.25	Wednesday	135	189	0.09	+
07/Feb/2001	5.75	-0.5	Wednesday	20	28	-0.31	+
07/Mar/2001	5.5	-0.25	Wednesday	20	28	0.00	+
04/Apr/2001	5	-0.5	Wednesday	110	154	-0.12	+
05/Sep/2001	4.75	-0.25	Wednesday	20	28	0.02	-
03/Oct/2001	4.5	-0.25	Wednesday	45	63	0.13	-
05/Dec/2001	4.25	-0.25	Wednesday	110	154	0.09	-
08/May/2002	4.5	0.25	Wednesday	20	28	0.07	+
05/Jun/2002	4.75	0.25	Wednesday	370	518	-0.04	-
05/Nov/2003	5	0.25	Wednesday	20	28	0.16	+
03/Dec/2003	5.25	0.25	Wednesday	325	455	-0.01	-
02/Mar/2005	5.5	0.25	Wednesday			0.00	+
			Average	**101.88**	**142.63**		

Table 1 Continued

United States

Date of Change	Target Value	Target Change	Day of week	Duration in trading days	Duration in calendar days	Change in 90-day commercial bill rate	Δ90-day CB/ ΔFFR
17/Nov/1998	4.75	0.25	Tuesday	161	225		
30/Jun/1999	5	0.25	Wednesday	39	55	-0.17	-
24/Aug/1999	5.25	0.25	Tuesday	60	84	0.01	+
16/Nov/1999	5.5	0.25	Tuesday	56	78	0.01	+
02/Feb/2000	5.75	0.25	Wednesday	34	48	0.03	+
21/Mar/2000	6	0.25	Tuesday	40	56	0.02	+
16/May/2000	6.5	0.5	Tuesday	166	232	0.02	+
03/Jan/2001	6	-0.5	Wednesday	20	28	0.05	-
31/Jan/2001	5.5	-0.5	Wednesday	34	48	-0.12	+
20/Mar/2001	5	-0.5	Tuesday	21	29	0.06	-
18/Apr/2001	4.5	-0.5	Wednesday	19	27	0.01	-
15/May/2001	4	-0.5	Tuesday	31	43	-0.10	+
27/Jun/2001	3.75	-0.25	Wednesday	39	55	0.03	-
21/Aug/2001	3.5	-0.25	Tuesday	19	27	-0.03	+
17/Sep/2001	3	-0.5	Monday	11	15	0.00	-
02/Oct/2001	2.5	-0.5	Tuesday	25	35	-0.06	+
06/Nov/2001	2	-0.5	Tuesday	25	35	-0.12	+
11/Dec/2001	1.75	-0.25	Tuesday	236	330	-0.06	+
06/Nov/2002	1.25	-0.5	Wednesday	165	231	-0.21	+
25/Jun/2003	1	-0.25	Wednesday	265	371	0.10	-
30/Jun/2004	1.25	0.25	Wednesday	29	41	0.00	+
10/Aug/2004	1.5	0.25	Tuesday	30	42	0.03	+
21/Sep/2004	1.75	0.25	Tuesday	36	50	0.00	+
10/Nov/2004	2	0.25	Wednesday	24	34	0.00	+
14/Dec/2004	2.25	0.25	Tuesday	36	50	0.01	+
02/Feb/2005	2.5	0.25	Wednesday	34	48	0.02	+
22/Mar/2005	2.75	0.25	Tuesday	30	42	0.00	+
03/May/2005	3	0.25	Tuesday	42	58	0.01	+
30/Jun/2005	3.25	0.25	Thursday			0.02	+
			Average	**61.68**	**86.32**		

Note: The sample period extends from 17 March 1999, the day the Reserve Bank of New Zealand changed its operating procedure, to 30 June 2005. The first (last) data entry for Australia and the US corresponds to the first (last) change in the target rate after (before) 17 March 1999 (30 June 2005).

Table 2
Changes in the Policy Instrument and the Impact Effect on the Market Interest Rate: 17 March 1999 – 30 June 2005

	New Zealand	**Australia**	**United States**
Total number of changes in the policy instrument	24	16	28
25 basis points decreases	6	4	4
25 basis points increases	13	9	14
50 basis points decreases	2	2	9
50 basis points increases	3	1	1
Range of Policy Instrument	4.5-6.75	4.5-6.25	1-6.5
Target Rate at Beginning	4.5	4.75	4.75
Target Rate at End	6.75	5.5	3.25
Average Duration of Policy Stance in Trading Days	65.04	101.88	61.68
Average Duration of Policy Stance in Calendar Days	91.04	142.63	86.32

Table 3
How the Conditional Mean and Variance Respond to Interest Rate Spreads and the Structure of Open Market Operations

Mean Equation		
	Coefficient	Std. Error
c	0.0012	0.0012
Δr_{t-5}	0.0762**	0.0279
$r_{t-1} - r_{t-1}^{AUS}$	-0.0029*	0.0013
$r_{t-1} - r_{t-1}^{US}$	0.0002	0.0003
ARI_t	0.0011	0.0021
ARW_t	-0.0030	0.0046
MSI_t	0.0057**	0.0017
MSW_t	0.0006	0.0060
D1	0.0480**	0.0145
D2	-0.0883**	0.0291
D3	-0.0217	0.0646
Variance Equation		
c	0.00002**	0.00002
v_{t-1}^2	0.1041**	0.0268
h_{t-1}	0.8115**	0.01316
AR_t	0.00002	0.00005
MS_t	0.000003	0.00001
D1	0.0013**	0.0005
D2	0.0018	0.0013
D3	0.0066	0.0042
Adj. R^2	0.112	
S.E of regression	0.027	
F-statistic	11.98	
No of obs.	1567	

The standard errors were computed along the lines suggested by Bollerslev and Wooldridge (1992). Their procedure yields a heteroskedasticity consistent covariance matrix.
****** denotes statistical significance at 1 percent level
* denotes statistical significance at 5 percent level.

Specification of Mean Equation:

$$\Delta r_t^{NZ} = \alpha_0 + \sum_{j=1}^{n} \alpha_j \Delta r_{t-j}^{NZ} + \beta_1 (r_{t-1}^{NZ} - r_{t-1}^{AUS}) + \beta_2 (r_{t-1}^{NZ} - r_{t-1}^{US}) + \beta_3 ARI_t + \beta_4 ARW_t + \beta_5 MSI_t + \beta_6 MSW_t + \beta_7 D1_t + \beta_8 D2_t + \beta_9 D3_t + v_t$$

where $ARI_t = AR_t * I_t$ $\quad MSI_t = MS_t * I_t$ (*I=1 for* Reverse Repo, *0* otherwise)
$ARW_t = AR_t * W_t$ $\quad MSW_t = MS_t * W_t$ (*W=1 for* Repo, *0* otherwise)

Specification of Variance Equation:

$$h_t = c_0 + c_1 v_{t-1}^2 + c_2 h_{t-1} + c_3 AR_t + c_4 MS_t + c_5 D1_t + c_6 D2_t + c_7 D3_t$$