An empirical assessment of Australasian bank interest rate risk*

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June 16, 2011

Abstract

Financial intermediaries are potentially exposed to interest rate risk through their role in transforming short-term liabilities (such as retail deposits) into long-term assets (such as mortgages). That mismatch implies that sharp increases in interest rates will feed into bank costs faster than revenues, causing a temporary decline in profitability. However, New Zealand banks are widely believed to be subject to little interest rate risk given that most maturity mismatch is hedged through instruments such as interest rate swaps. This paper uses data on New Zealand's largest subsidiary banks and their Australian parents to test the accuracy of this belief. Using three approaches we find that the four largest Australian parent banks and their New Zealand subsidiaries appear to be effectively hedged against interest rate risk.

1 Introduction

Financial intermediaries are potentially exposed to interest rate risk through their role in transforming short-term liabilities (such as retail deposits) into long-term assets (such as mortgages). Unhedged, such maturity mismatch implies that sharp interest rate increases will have detrimental effects on

*The views expressed in this paper are those of the author and do not necessarily reflect the views of the Reserve Bank of New Zealand. The author would like to thank Emmanuel De Veirman, Richard Fabling, David Hargreaves, Leo Krippner, Michelle Lewis, Anella Munro, and Christie Smith for valuable comments and discussions.

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banks' profits and financial health.[1] The interest rate risk we are specifically trying to gauge is this detrimental effect on banks' profits and financial health due to unanticipated changes in wholesale, default-free interest rates, although the limitations of the data mean that some contamination from other risks associated with movements in interest rates is inevitable.[2]

This paper provides an empirical analysis of the degree of interest rate risk for New Zealand's largest subsidiary banks and their Australian parents. Three approaches are taken. The first, the economic value approach, is used frequently in the literature, and looks at the sensitivity of bank stock prices to movements in interest rates. Controlling for general stock price movements, this approach tests whether the individual stock prices of the four largest Australian banks are negatively affected by increases in interest rates of different maturities. The second is the earnings approach that looks at the sensitivity of reported net interest income growth to interest rate movements. Using data from the four largest New Zealand banking groups, the earnings approach examines whether net interest income growth is negatively affected by increases in interest rates, controlling for general economic growth. This approach is also extended to test whether banks manage their interest rate risk over the cycle, given that decreases in interest rates can have positive effects on bank profits when assets have longer maturities than liabilities. The third approach simply considers the interest rate risk reported by the New Zealand subsidiaries in their quarterly General Disclosure Statements (GDSs), and compares this to the results from the first two approaches.

The primary motivation is to assist in the development of macroeconomic models that incorporate financial sectors, modelling that is currently taking place at the Reserve Bank of New Zealand (RBNZ). In models that include maturity mismatch, such as Van den Heuvel's (2006) bank capital channel model, interest rate risk arises naturally unless hedging is explicitly introduced. In such models, interest rate risk reduces the flow of retained earnings into bank capital, which can lead to a reduction in bank lending as the bank moves closer to its capital adequacy requirement. This reduction

[1] It is important to note that this does not refer to rollover risk.

[2] This is the 'purest' form of interest rate risk, sometimes referred to as mismatch risk, and is often the form included in dynamic economic models with multi-period assets or liabilities. Other risks include basis risk (when floating rate assets and liabilities have base rates with different risk characteristics), interest sensitivity of non-interest income (for example, lower mortgage rates could lead to prepayments that shrink the pool of mortgages and thus fee income), and the effect of interest rates on credit risk (higher interest rates could result in more people being unable to repay their loans). See English (2002) for a description of some of the various forms of broad interest rate risk.

in lending then has real flow-on effects to the rest of the economy in a general equilibrium framework. However, New Zealand banks are widely held to be subject to little interest rate risk, given that most mismatch is hedged through the use of instruments such as interest rate swaps. This paper examines the accuracy of this widely held belief and hence the appropriateness of including interest rate risk channels in macroeconomic models for New Zealand. Secondly, this paper extends the geographical coverage of empirical work on interest rate risk; although there is a wide literature on the sensitivity of bank balance sheets to movements in interest rates, empirical studies have tended to focus on the United States.

The rest of the paper will proceed as follows. Section 2 presents the economic value approach, using data on the Australian parent banks. Section 2 first analyses interest rate risk using a common methodology in the literature, and then adapts this methodology slightly to incorporate data on forward-looking measures of interest rates in order to test whether changes in interest rate *expectations* have any impact on bank stock returns. Section 3 presents the earnings approach, using data on the New Zealand banking groups. Section 3 includes a very simple methodology and a slightly more complex adaptation of this methodology that allows for the possibility that banks actively manage their interest rate risk over the cycle. Section 4 compares the results of sections 2 and 3 to the interest rate risk reported by the New Zealand subsidiaries. Section 5 concludes.

2 Economic value approach: Australian banks

When testing for interest rate risk empirically, a common approach in the literature is to analyse the relationship (if any) between interest rate changes and bank stock returns. Bank stock returns should reflect changes in banks' net worth, or economic value, which in turn can be potentially vulnerable to changes in interest rates. For example, consider a bank whose financial assets have a longer maturity than its financial liabilities. A sudden increase in the interest rate results in borrowing for the bank becoming more expensive when it has to rollover its debt. Since the returns on the bank's assets are fixed for a longer period, it takes some time for the bank to offset this increase in its borrowing costs by increasing its lending rates (and hence revenue). As a result, the bank's profits decline as the margin between costs and revenue narrow, and then eventually recover once the bank is able to set a new rate on its assets. Lower profits impact capitalisation through lower retained earnings, and therefore affect bank stock prices. Because the stock price represents the present value of the bank's expected *future* net cash flows, it will also reflect the other impacts of interest rate changes on the bank's financial health such as loan demand, basis risk and customer creditworthiness. However, we would still expect the pure interest rate risk effect to be the dominant effect, since the sensitivity of assets and liabilities to relatively high frequency movements in default-free rates will be greater than, say, the sensitivity of loan demand.

2.1 Methodology

The standard regression for the relationship between interest rate changes and stock returns is known as the two-index model (Stone 1974) and takes the following form:

$$R_{it} = \beta_0 + \beta_1 R_{mt} + \beta_2 INT_t + \epsilon_t \quad (1)$$

where

R_{it} = Log change in bank i's stock return

R_{mt} = Log change in market index

INT_t = Change in interest rate

The return on an index of market stock prices is included to reflect changes in overall market or economic conditions that may influence the stock return of any individual bank.[3] The dependent variable is the log change in each bank's stock price. It is appropriate to specify this variable as the *change* in stock price for two reasons. Firstly, from an economic perspective, it is the change in stock prices, not the level, that we are interested in when considering the realised impact of interest rate risk. Secondly, from an econometric perspective, the stock prices (and the market stock index) all have unit roots. Differencing eliminates these unit roots. The coefficient of interest is β_2. A negative and significant value for this coefficient indicates that the bank being analysed is exposed to interest rate risk (i.e. as interest rates increase, the stock price falls).

[3] Note that the literature tends to apply this regression to non-financial firms as well as banks. However, it is banks we are interested in here for modelling purposes. In addition, Yougourou (1990), among others, finds that non-financial firms have little or no sensitivity to interest rate changes.

An issue in the empirical literature is whether changes in interest rates (INT_t) should be treated as current or unanticipated. Current interest rate changes incorporate both anticipated and unanticipated changes. In efficient markets, anticipated changes in interest rates should already be included in the calculation of stock prices (Staikouras 2003). As a result, only unanticipated changes should have any influence on these prices. However, given a high enough frequency of interest rate data, current changes can be seen as approximating unanticipated changes. Studies in the literature tend to use either unanticipated or both unanticipated and current changes. To estimate unanticipated changes in interest rates it is common to use residuals from autoregressive processes (often AR(3) regressions). Yet it is not clear that the use of unanticipated changes in this manner yields significantly different results for the coefficients in equation (1) (Faff and Howard 1999). For example, Flannery and James (1984) find that results using either current changes or residuals from an AR(3) process are virtually identical. In contrast, Bae (1990), among others, finds that unanticipated changes affect stock prices to a greater extent than current interest rate changes. As a result of this divergence in the literature, we consider both unanticipated and current changes in interest rates in this section.

A potential problem with the specification in equation (1) is the multicollinearity between the market index and the interest rate variable. Policy rates are set in response to economic conditions; a rapidly rising market index (a potential sign of overheating in the economy) may encourage the central bank to raise interest rates in response. We want the variance in each bank's stock price that is explained by interest rates alone (Chace and Lane 1980). The literature deals with this problem by orthogonalising the market index and interest rate series as follows:

$$INT_t = \alpha_0 + \alpha_1 R_{mt} + \vartheta_t \tag{2}$$

The residual from this regression (ϑ_t) is then substituted for INT_t in equation (1). This ϑ_t represents the changes in the interest rates that are not explained by changes in the market stock price index. Once the series have been orthogonalised by equation (2), the regression in equation (1) can be carried out without multicollinearity problems. However, studies such as Mitchell (1991), Neuberger (1991), and Faff and Howard (1999) find that orthogonalised results are not significantly different from those obtained without orthogonalisation.

2.2 Data

Our aim is to establish the level of exposure to interest rate risk experienced by New Zealand's largest banks. Unfortunately, New Zealand's locally-incorporated banks are not listed on a stock market, so a direct and comparable empirical analysis cannot be carried out. However, New Zealand's four largest banks, which hold over 85 percent of banking sector assets in New Zealand, are subsidiaries of Australian parent banks that *are* listed on the Australian Stock Exchange. The Australian parent banks and the New Zealand subsidiary banks have similar risk management approaches and institutional setups. As such, we would expect regressions involving the Australian parents to shed some light on the degree of interest rate risk experienced by the New Zealand subsidiaries.

The four banks considered are ANZ (parent of ANZ National in New Zealand), CBA (parent of ASB in New Zealand), NAB (parent of BNZ in New Zealand), and Westpac (parent of Westpac New Zealand Ltd.). The data are weekly, monthly, and quarterly observations between October 1996 and June 2010. Different data frequencies are used to assess the robustness of results. Interest rates of five different maturities are analysed in separate regressions. These interest rates are: the policy (cash) rate of the Reserve Bank of Australia, the 90-day bank bill rate, and the yields on 1-year, 5-year and 10-year Australian generic bonds (government bonds). Five maturities are considered because the sensitivity of a bank's stock price to changes in short-term rates may be different from its sensitivity to movements in long-term rates. This is because interest rate risk may be present at some maturities and not others, and because short-term rates are more volatile (Madura and Zarruk 1995). It is common in the literature for rates of various maturities to be considered, given potentially unique effects of short- or long-term rates on bank equity (Faff and Howard 1999). Madura and Zarruk (1995), Akella and Chen (1990), and Faff and Howard (1999) all find that bank stock prices are more sensitive to changes in long-term interest rates than short-term interest rates. Four series are used for the INT_t variable. First, the current interest rate change is used (simply the interest rate at time t minus the interest rate at time $t-1$). Second, residuals from autoregressive regressions on the raw interest rate series are used to analyse the influence of unanticipated changes. The current and unanticipated changes are then orthogonalised according to equation (2).

2.3 Results

Results are reported in table 1. Regressions are corrected for heteroskedasticity and autocorrelation through the use of the Newey-West standard errors. The orthogonalised and non-orthogonalised versions of both the current and unanticipated interest rate series produce near identical coefficients and standard errors (to four decimal places) in their regressions, consistent with the various studies previously mentioned. As a result, the coefficients and significance levels reported are only for the orthogonalised regressions, although they could as accurately be for the non-orthogonalised regressions.[4]

Regressions that use weekly data produce very similar coefficients and standards errors for current and unanticipated changes. Such similarity of results is consistent with Flannery and James (1984), who also use weekly data. The similar impacts of current and unanticipated changes in interest rates on stock prices suggest that a large portion of current changes are unanticipated (Bae 1990). This is consistent with the relatively high frequency of data (weekly) used, as changes over a shorter period of time are less likely to be anticipated. The weekly results in table 1 suggest that all four banks' stock prices are sensitive to movements in long-term interest rates. As long-term interest rates (5- and 10-year) increase stock prices fall, as shown by the negative and significant coefficients. However, the four major banks appear insensitive to movements in short-term interest rates, with the exception of WBC in the current change regression. These results imply that the banks do experience some interest rate risk, but primarily only in response to movements in long-term interest rates. As mentioned previously, various other studies have found similar results; most attribute this to the less volatile nature of long-term interest rates. These results are consistent with Faff and Howard (1999), who look at the exposure of the Australian financial sector to interest rate risk between 1978 and 1992, with a focus on the impacts of regulatory change on this exposure.

Moreover, the magnitudes of these coefficients are relatively small, which means that the economic significance of interest rate risk is small. For example, a one percentage point increase in the 5-year government bond rate (from 4 percent to 5 percent, for example) would only lead to a 1.22 percent decrease in ANZ's stock price. Yet the average weekly percentage point change for the 5-year government bond rate is only 0.109. On average then we would expect the impact of changes in the 5-year government bond rate on ANZ's stock price to be approximately 0.12 percent. The impacts on

[4] The non-orthogonalised results are available on request.

Table 1: Regression results - β_2 value and significance

	Current (weekly)	Current (monthly)	Current (quarterly)	AR residuals (weekly)	AR residuals (monthly)	AR residuals (quarterly)
ANZ						
Cash rate	0.0021	-0.0154**	-0.0103	0.0019	-0.0262***	-0.0120
90-day	0.0013	-0.0072	-0.0127**	0.001	-0.0083	-0.0150
1-year	-0.0004	-0.0091	-0.0160*	-0.0007	-0.0102	-0.0216**
5-year	-0.0120***	-0.0118**	-0.0205***	-0.0122***	-0.0127**	-0.0216**
10-year	-0.0145***	-0.0161***	-0.0231***	-0.0145***	-0.0118**	-0.0218**
CBA						
Cash rate	-0.0057	0.0023	0.0027	-0.0053	-0.0032	0.0179
90-day	-0.0053	-0.0022	-0.0017	-0.0067	-0.0122	0.0046
1-year	-0.0058**	-0.0025	-0.0044	-0.0058**	-0.0085	-0.0087
5-year	-0.0087**	-0.0004	-0.0018	-0.0087**	-0.0025	-0.0023
10-year	-0.0117***	-0.0031	-0.0037	-0.0116***	-0.0026	-0.0024
NAB						
Cash rate	0.0025	-0.0123*	-0.0206***	0.0021	-0.0139	-0.0231***
90-day	0.0024	-0.0061	-0.0214***	0.0011	-0.0055	-0.0225***
1-year	0.0012	-0.0022	-0.0184*	0.001	-0.0032	-0.0199**
5-year	-0.0088**	-0.0028	-0.0171*	-0.0088**	-0.0038	-0.0189
10-year	-0.0132***	-0.0078	-0.0187*	-0.0132***	-0.0060	-0.0183
WBC						
Cash rate	-0.0092*	-0.0084	-0.0066	-0.0091	-0.0135	0.0042
90-day	-0.0041	-0.0091	-0.0076	-0.0043	-0.0146*	-0.0005
1-year	-0.0026	-0.0014	-0.0083	-0.0027	-0.0023	-0.0087
5-year	-0.0079**	-0.0007	-0.007	-0.0080**	-0.0003	-0.0095
10-year	-0.0102***	-0.0037	-0.0104	-0.0102***	-0.0033	-0.0113

*** denotes significance at a one percent level, ** denotes significance at a five percent level, * denotes significance at a ten percent level. The order of the AR process was determined by starting at AR(15) and sequentially removing insignificant autoregressive coefficients from the process, as in Bae (1990). The coefficients for the market stock price index (β_1) are always positive (with a coefficient between 0.90 and 1.30) and significant at a one percent level, for all observational frequencies. R^2 values are typically between 0.4 and 0.5, slightly lower than those reported in the literature (although such statistics are not always reported). Durbin-Watson statistics are very close to 2.0 or slightly larger. The regression-specific β_1 results, R^2 statistics and Durbin-Watson statistics have been omitted in the interests of saving space, but can be obtained from the author on request.

the other three banks are similar. Few of the previously mentioned studies consider the magnitude of the coefficients that they report. However, the coefficients presented in table 1 using weekly observations are smaller than those reported in other studies, suggesting that any interest rate risk experienced by these Australian banks is smaller in magnitude than in other studies examined (mainly based on United States data).

The regressions that use monthly and quarterly data show only slightly more sensitivity to the use of current or unanticipated interest rate changes than the weekly regressions. The results obtained from the ANZ regressions using weekly data appear robust to the use of monthly or quarterly data. ANZ's stock price is negatively affected by movements in longer-term interest rates at all three frequencies. ANZ also appears to be negatively affected by movements in the cash rate at the monthly frequency but the magnitude of this sensitivity is small, as it is for the longer-term interest rates.

When monthly or quarterly data are used CBA no longer appears sensitive to movements in interest rates of any maturity; nor does WBC. The NAB regressions show the greatest sensitivity to the frequency of data used. When weekly data is used, NAB is negatively affected by movements in 5- and 10-year interest rates. When monthly data is used, NAB appears insensitive to interest rate movements at any maturity, except to the cash rate when current changes are used. However, when quarterly data is used NAB's stock price becomes sensitive to movements in *short-term* interest rates. This indicates that the results involving NAB are the least robust to the frequency of data used in the analysis. Overall, it appears that the Australian parent banks have little exposure to interest rate risk. Although the regressions using weekly data show that the Australian banks' stock prices are affected by movements in longer-term interest rates, the magnitudes of these effects are small, and tend to be sensitive to the frequency of data used.

One advantage of weekly data is that it provides the researcher with a larger data set. In addition, interest rate changes at a weekly frequency may be more likely to represent 'shocks'. However, weekly series may contain so much noise that coefficients are biased towards zero. The use of monthly or quarterly data helps to alleviate this problem, since changes over longer periods are more likely to reflect long-term trends. However, monthly or quarterly data also allow for the possibility that banks may respond to changes in interest rates within the period concerned; banks will be able to re-price more of their assets over the period of one or three months than over a week. It is also difficult to determine whether coefficients are biased by some other omitted factors influencing stock prices over the month or quarter in this simple regression framework.

2.4 Economic value approach: Forward-looking measures

The methods presented so far are consistent with those found in the literature. Another way to empirically test for interest rate risk is to use data on overnight indexed swaps (OISs). These interest rate swaps are a form of bilaterally traded derivative in which one party agrees to pay the other a fixed interest rate in exchange for receiving the average cash rate recorded over the term of the swap. As such, they are a measure of the expectations the market has about movements in the cash rate over the agreed term of the swap.[5] Using OIS data we can approximate changes in market *expectations* about the path of the cash rate. If banks are subject to interest rate risk, we would anticipate that changes in the expected path of the cash rate would affect bank stock prices. This is because stock prices are forward-looking, incorporating expected movements in interest rates. If the markets expect the average cash rate to increase, banks that are believed to be exposed to interest rate risk will (all other things constant) experience a decline in their stock prices.

OIS markets developed in the late 1990s, with the OIS market in Australia formed in 1999. As a result, studies prior to the development of these markets such as Flannery and James (1984) and Bae (1990) would not have been able to use OISs as a means of estimating changes in cash rate expectations. One distinguishing feature of OISs is that they are for relatively short periods of time, normally one year or less. As a result, we are only able to estimate changes in cash rate expectations over the next year. Although there is data available now on 2-year and 3-year OISs in Australia from 2004, these series experience a break for most of 2005. The regression specification used in this subsection is the same as in equation (1) except that in this case INT_t is replaced with the difference between our estimate of the expected OIS rate and the actual OIS rate at time t, reflecting any changes in cash rate expectations.[6] Only weekly data are used, because the linear approximation used to estimate the expected OIS rate is less likely to hold when lower frequency data are used. Regressions were run using both orthogonalised and

[5] A more detailed description of OISs can be found in the June 2002 Reserve Bank of Australia Bulletin.

[6] More detail and an example can be found in Appendix A.

non-orthogonalised values for INT_t, but the resulting coefficients and standard errors were nearly identical. As a result, the coefficients and significance levels reported are for the orthogonalised regressions, although they could as accurately be for the non-orthogonalised regressions.

Table 2: OIS-based regression results - β_2 value and significance

	ANZ	CBA	NAB	WBC
1-month OIS	-0.0216	-0.0031	-0.0006	-0.0152
3-month OIS	-0.011	-0.0031	-0.0006	-0.0039
1-year OIS	-0.0037	-0.0009	-0.0158*	0.0013

* denotes significance at a ten percent level. The coefficients for the market stock price index (β_1) are always positive (with a coefficient between 0.90 and 1.30) and significant at a one percent level. R^2 values are typically between 0.4 and 0.5. Durbin-Watson statistics are very close to 2.0. The regression-specific β_1 results, R^2 statistics and Durbin-Watson statistics have been omitted in the interests of savings space, but can be obtained from the author on request.

As can be seen in table 2, only one of the coefficients is significant at a ten percent level. NAB's stock price is adversely affected by a change in expectations towards a higher future cash rate over the next year. The three other major banks are not affected by changes in expectations, nor is NAB at shorter horizons. These results may not be particularly surprising, since the results in table 1 also indicate that the stock prices are insensitive to movements in *short-term* interest rates. Unfortunately, OIS typically only go out for one year or less, so changes in cash rate expectations over horizons greater than a year cannot be analysed. However, the use of OIS provides a method for examining asset price sensitivity to changes in cash rate expectations.

The preceding empirical analysis suggests that the four largest Australian banks are subject to some interest rate risk, but usually only in regards to changes (both current and unanticipated) in long-term interest rates. However, the sensitivity of these four banks to movements in interest rates depends on the frequency of the data used. This may either suggest that the results are not particularly robust, or that there are other considerations that need to be taken into account when using data at a lower frequency (such as the possibility that the banks have already responded to interest rate changes within each month or quarter). The magnitude of any interest rate risk is small, both in terms of its effect on bank stock prices and relative to magnitudes in the literature. Overall, these results imply that the four major Australian parent banks have effectively hedged their interest rate risk.

3 Earnings approach: New Zealand banks

The methodology used so far has difficulty in isolating the effects of interest rate changes on bank stock prices from all other factors that influence stock prices. The inclusion of a stock market index can account for some of these factors. However, the major four banks make up a large component of the ASX200 index, both in terms of value and in terms of the number of shares traded.[7] This potentially limits the amount of independent information that the ASX200 contains as a control variable.

Another way to assess the degree of interest rate risk is to directly estimate the effect of interest rate changes on the net interest income reported by banks. Net interest income is simply the interest revenue in a given period less the interest expenses in the same period. This approach is consistent with the economic value approach, because the value of the bank is equal to the present discounted value of the bank's cash flows that include net interest income (English 2002). The earnings approach allows us to directly examine whether movements in interest rates significantly influence interest revenue and costs, which we would expect to be the case if banks had not completely hedged their interest rate risk (through interest rate swap markets, for example). The earnings approach also allows us to control for a wider range of variables, and allows us to more directly examine the New Zealand banks instead of using their Australian parents as proxies.

Bank-level data at a quarterly frequency is obtained from the publicly available GDSs between Q3 1996 and Q2 2010. The banking groups examined are ANZ, ASB, BNZ, and WPAC. The banking groups were considered, not the subsidiaries on their own, because any hedging activity takes place within the group (so subsidiary data may not identify any hedging activity). Interest rate data is taken from the Nelson and Siegel dataset of government bond rates used in Krippner and Thorsrud (2009). This dataset has been constructed to ensure that interest rates are more comparable across different maturities and more suitable for research purposes generally.[8] As in the eco-

[7] As of the 12th October 2010, all four banks were among the top ten companies in terms of value and number of shares traded during the previous day. See http://www.asx.com.au/research.

[8] A more detailed description of the data is contained in Appendix A of Krippner and Thorsrud (2009). The regressions in section 2 used 'raw' interest rate data to be more comparable with the existing literature. However, the regressions were also run using a Nelson and Siegel dataset of Australian interest rates, and these results are provided in Appendix B. The results using Nelson and Siegel data did not differ significantly from the original results using 'raw' data.

nomic value approach in section 2, interest rates of five different maturities are analysed in separate regressions. These interest rates are: the policy rate of the RBNZ (the OCR),[9] and the 90-day, 1-year, 5-year, and 10-year rates. Two different regressions have been estimated, one that simply looks at the effect of interest rate changes and one that looks at the effect of interest rate changes during easing cycles. Because only quarterly data are available, there are only 54 observations for each series. This reduces the number of additional explanatory variables that can be included given this particular set of data.

3.1 Earnings approach: Interest rate changes

The first regression is the most simple, and also the most comparable to the results obtained using the economic value approach. The regression takes the following form:

$$NII_{it} = \beta_0 + \beta_1 GDP_t + \beta_2 INT_t + \epsilon_t \tag{3}$$

$$\begin{aligned} &where \\ NII_{it} &= \text{Net interest income (qpc) for bank } i \\ GDP_t &= \text{GDP (qpc)} \\ INT_t &= \text{Change in interest rate} \end{aligned}$$

Quarterly percent changes in GDP have been included to control for the state of the economy. Because we might expect changes in GDP to have an impact on interest rate movements, the interest rate series have first been orthogonalised to GDP (instead of the market index) as in equation (2). In this case orthogonalisation does make a small difference to the results, and so the orthogonalised results are reported in table 3.

Overall, the results suggest that there is little interest rate risk. However, WPAC's net interest income growth shows sensitivity to changes in the 1-year, 5-year, and 10-year rates. The coefficients are negative as expected, suggesting that increases in these interest rates lead to decreases in WPAC's net interest income growth. In this case the magnitude actually appears quite large: a 100 basis point increase in the 10-year rate, for example, leads to

[9] The OCR was introduced in April 1999. Prior to this, the overnight interbank cash rate has been used.

a decrease in WPAC's net interest income growth of 6.38 percentage points. The average (orthogonalised) change in the 10-year rate over this sample is 34 basis points, so the average impact on WPAC's net interest income growth is 2.17 percentage points, which is still quite large. It is possible that this result is driven by variations in accounting practices (within the overall standards) between banks in regards to the inclusion of hedging activity in net interest income. Overall, it is likely that there are more factors influencing net interest income growth than interest rate changes and GDP alone, and these results are indicative only since other factors are not accounted for in this analysis.

Table 3: Regression results - Earnings approach: Interest rate changes

	OCR	90-day	1-year	5-year	10-year
ANZ					
GDP (β_1)	3.2474	2.9520	2.9520	2.9520	2.9520
INT (β_2)	-0.7145	-0.1248	0.4372	0.4320	-0.7277
ASB					
GDP (β_1)	-0.4921	-0.2695	-0.2695	-0.2695	-0.2695
INT (β_2)	0.7797	-0.9610	-10.5287	-18.6812	-9.2187
BNZ					
GDP (β_1)	-0.5837	-0.9825	-0.9825	-0.9825	-0.9825
INT (β_2)	0.8307	0.1462	-0.7226	-3.2257	-3.1584
WPAC					
GDP (β_1)	-0.3404	-0.5459	-0.5459	-0.5459	-0.5459
INT (β_2)	0.6650	-1.8091	-3.5664**	-7.6811**	-6.3752**

** denotes significance at a five percent level. Constants were included in all regressions but have been omitted in order to save space. R^2 are typically very low for these regressions, usually below 0.1. Durbin-Watson statistics are usually slightly above 2.2.

3.2 Earnings approach: Interest rate changes during easing cycles

When there is maturity mismatch, interest rate risk arises because increases in interest rates increase bank funding costs relative to revenue. Interest rate risk thus lowers profits, since the bank is unable to increase interest rates on its assets immediately. However, if interest rates decrease, bank funding costs *decrease* relative to revenue, which actually increases profit (all else equal). So it may be optimal for a bank to actively manage its mismatch risk over the cycle; during easing cycles, when interest rates are expected to fall, banks may actively expose themselves to 'optimal' levels of mismatch risk to capture potential gains from downward movements in interest rates. If banks indeed expose themselves to greater levels of mismatch risk during easing cycles, any *increases* in the interest rate (against their expectations) would be expected to have a more severe impact on net interest income growth. To examine this possibility, a dummy variable for the easing component of the cycle and an interaction term between the easing dummy and interest rate changes are added to the simple regression, as can be seen in equation (4) below:

$$NII_{it} = \beta_0 + \beta_1 GDP_t + \beta_2 INT_t + \beta_3 Easing_t + \beta_4 INT_t \times Easing_t + \epsilon_t \quad (4)$$

$$\begin{aligned} & where \\ NII_{it} &= \text{Net interest income (qpc) for bank } i \\ GDP_t &= \text{GDP (qpc)} \\ INT_t &= \text{Change in interest rate} \\ Easing_t &= \text{Dummy for easing part of the cycle} \\ INT_t \times Easing_t &= \text{Interaction term between } INT_t \text{ and } Easing_t \end{aligned}$$

The two-year swap rate is used to determine whether the quarter was in an easing part of the cycle or not, since market expectations of interest rate movements over a relatively long horizon is the relevant factor when assessing how actively banks manage mismatch risk. If the market expects rates to increase, exposure to interest rate risk should be reduced even if the expectation turns out to be incorrect. The restriction $\beta_2 + \beta_4 = 0$ is tested for all regressions (see Wooldridge 2006, for example) to establish whether the effect of interest rate changes *during easing cycles* is significant. The results are shown in table 4.

The inclusion of the easing dummy and interaction term do not considerably change the results from table 3. WPAC still appears sensitive to movements in longer-term interest rates, during both tightening and easing cycles. The null hypothesis that $\beta_2 + \beta_4 = 0$ is rejected for WPAC with respect to changes in 1-year, 5-year, and 10-year interest rates. ANZ also appears sensitive to movements in 90-day and 1-year rates during easing cycles only. However, the F-statistics for the 1-year ANZ and WPAC regressions are insignificant, suggesting that changes in the 1-year interest rate have no effect on ANZ's and WPAC's net interest income growth. The effects of interest rate changes during easing periods (which are simply equal to $\beta_2 + \beta_4$) are negative for the ANZ and WPAC regressions. This is consistent with the view that banks expose themselves to 'optimal' levels of mismatch risk during easing periods, to take advantage of the effect that a fall in interest rates (given maturity

Table 4: Regression results - Earnings approach: Interest rate changes during easing cycles

	Cash rate	90 day	1 year	5 year	10 year
ANZ					
Change in interest rate (INT)	-4.7073	1.0808	2.4880	0.4155	-1.4225
GDP	2.3803	2.6194	2.8064	2.4354	2.2854
Easing dummy (Easing)	-6.7976	-5.0902	-4.9135	-5.4165	-5.4889
INT × Easing	3.3960	-2.7609	-5.1423	-3.7867	-1.2519
F stat (INT and INT × Easing)	0.9953	2.8414*	1.9576	1.2527	1.3368
Test $\beta_2 + \beta_4 = 0$	-1.3112	-1.6801**	-2.6543*	-3.3712	-2.6743
ASB					
Change in interest rate (INT)	-4.0092	3.0901	3.0656	4.7787	5.1650
GDP	-0.6739	0.8736	1.8592	1.7830	0.8187
Easing dummy (Easing)	4.1550	5.6492	3.3537	1.6904	3.8553
INT × Easing	6.4182	-3.7564	-18.3254	-40.7766	-25.0760
F stat (INT and INT × Easing)	1.2086	0.1589	0.6654	1.0830	1.3598
Test $\beta_2 + \beta_4 = 0$	2.4090	-0.6663	-15.2598	-35.9980	-19.9110
BNZ					
Change in interest rate (INT)	2.4978	3.0754	0.2452	0.4846	1.0818
GDP	-0.3500	-0.5015	-0.8741	-0.7592	-0.8628
Easing dummy (Easing)	0.9977	0.6069	-0.2631	-0.7980	-0.6003
INT × Easing	-1.7686	-3.5599	-1.5248	-7.2000	-8.1990
F stat (INT and INT × Easing)	0.5823	1.2446	0.1423	0.7714	1.0711
Test $\beta_2 + \beta_4 = 0$	0.7292	-0.4845	-1.2796	-6.7151	-7.1172
WPAC					
Change in interest rate (INT)	1.6954	1.1915	1.6522	3.6849**	3.5918**
GDP	0.0006	-0.0156	0.2116	0.3494	-0.0758
Easing dummy (Easing)	3.4360	1.0000	0.5944	-0.2232	0.2189
INT × Easing	-0.5560	-3.5549	-7.3387	-20.4899***	-18.5151***
F stat (INT and INT × Easing)	0.5010	0.8190	2.4009	10.1532***	12.3804***
Test $\beta_2 + \beta_4 = 0$	1.1394	-2.3634	-5.6865**	-16.8051***	-14.9235***

*** denotes significance at one percent level, ** denotes significance at five percent level, * denotes significance at ten percent level. Constants were included in all regressions but have been omitted in order to save space. R^2 are typically very low for these regressions, usually below 0.2. Durbin-Watson statistics are usually slightly above 2.2.

mismatch) would have on their interest margin and hence profit. An *increase* in the interest rate when the market expected it to fall seems to have a negative effect on the net interest income growth of ANZ and WPAC, as expected. As with the results from the previous regression that did not take easing cycles into account, and in contrast to the results from the economic value approach in section 2, this negative effect appears quite large. For example, a one percentage point increase in the 10-year rate *during the easing part of the cycle* would result in a 14.92 percentage point decrease in the net interest income growth of WPAC. The average (orthogonalised) change in the

10-year rate during easing cycles is 18 basis points, so the average impact on WPAC's net interest income growth would be 2.69 percentage points, which is still quite large.

WPAC appears sensitive to changes in 5-year and 10-year rates during *tightening cycles*, as can be seen by the significant coefficients on INT_t (in conjunction with significant F-statistics). This significance is unexpected. During tightening cycles, interest rates are expected to increase. Since increases in interest rates can have detrimental effects on bank profits when liabilities have shorter maturities than assets, we would expect banks to hedge this mismatch risk. If this were the case, the coefficients on INT_t would be insignificant. The positive signs on these coefficients are also unexpected. The unexpectedly significant coefficients may reflect the low number of observations available for the regressions and should be treated cautiously as a result.

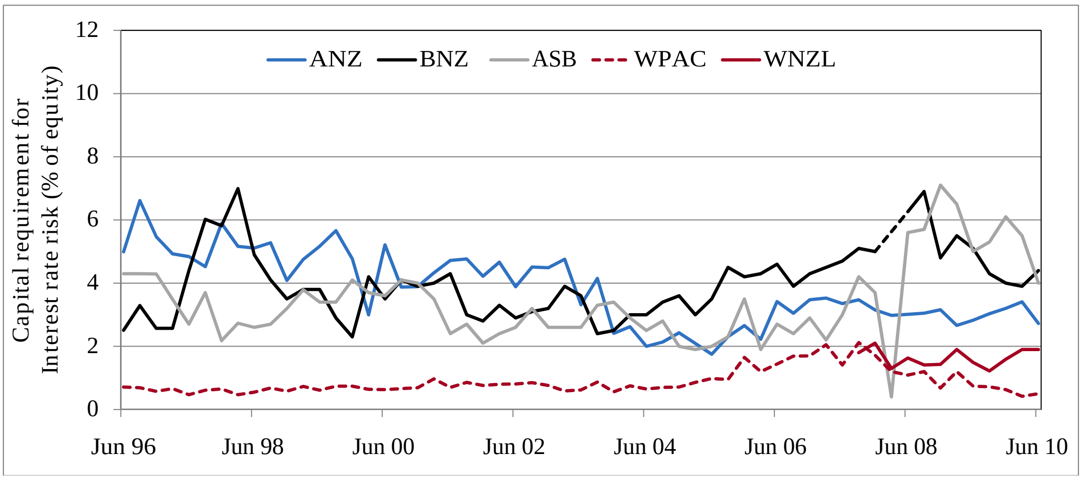
The low number of observations and the unexpected results regarding effects of interest rate changes during tightening cycles imply that any inferences should be treated with caution. As with the results in table 3, WPAC's net interest income growth appears sensitive to movements in long-term rates. However, as already mentioned, this may reflect differences in accounting treatment of hedging activity with regard to net interest income. In addition, there are likely to be multicollinearity issues due to a potentially high level of correlation between the interest rate changes and the easing dummy. Unfortunately, given that the data is quarterly and requires detailed information from bank disclosure statements a longer data set is unavailable. In addition, quarterly data means that it is possible that banks have already managed their interest rate risk *within* the quarter in response to any changes, so the data may not be rich enough to identify any shorter-term impacts.

Regressions were also estimated that included other control variables such as bank-level loan loss growth, bank-level lending growth, and spreads between government interest rates and bank bill rates (in an attempt to partly control for overall risk in financial markets). However, the addition of these variables added very little to the explanatory power of the regressions, and the inclusion of so many variables seemed inappropriate given that there were only 54 observations.

4 Reported interest rate risk

Current levels of interest rate risk exposure of individual banks in New Zealand are reported in the banks' quarterly GDSs. Interest rate risk in these statements is reported in regards to the banks' capital adequacy requirements, in accordance with RBNZ document BS2B *"Capital Adequacy Framework: Internal Models Based Approach"*.[10] Under these requirements, interest rate risk is calculated by subtracting the aggregate change in the value of financial liabilities arising from a directional change in interest rates from the aggregate change in the value of financial assets arising from the same change in interest rates.[11] The level of interest rate risk reported by the four major subsidiary banks in New Zealand since 1996 can be seen in figure 1.

Figure 1: Reported Interest Rate Risk: New Zealand major banks*



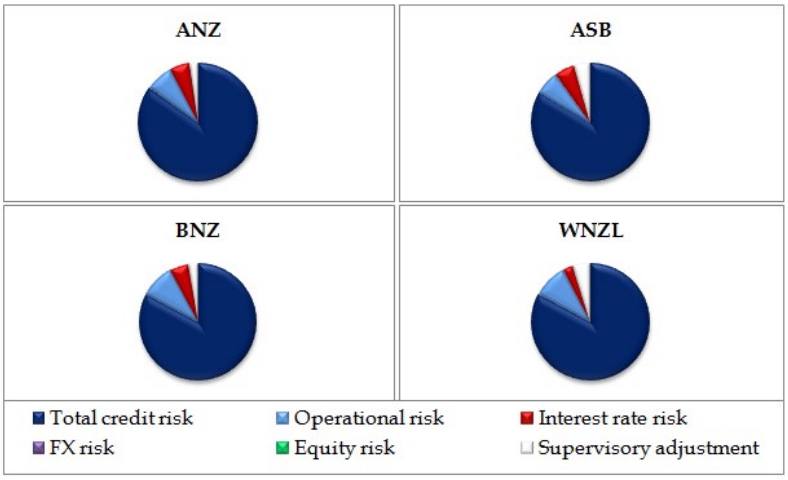
* WNZL (the New Zealand subsidiary of WPAC) only became locally incorporated in 2007. As a result, data from WPAC New Zealand (the Australian parent) has also been included. The dotted line in the BNZ series is due to a break in the data.

[10] http://www.rbnz.govt.nz/finstab/banking/regulation/4357435.pdf

[11] Financial liabilities and assets here exclude equity instruments. More detail on the intuition behind such methods can be found in Harrison (1996). The measure of interest rate risk in the GDS does not take into account the effect that changes in interest rates have on the creditworthiness of customers.

As can be seen in figure 1, the reported capital charge for interest rate risk is usually below six percent of equity. So whilst there is some interest rate risk reported by the major New Zealand banks, it is at a low level. Credit risk arising from the banks' intermediation role is the banks' main source of exposure to risk. Figure 2 provides a snapshot of the typical contributions different risk types make to the banks' total capital adequacy requirements.

Figure 2: Interest rate risk as a share of capital requirements June 2010



The New Zealand subsidiary banks report a fairly low level of interest rate risk, which is largely consistent with the results found by the economic value and earnings approaches in sections 2 and 3 respectively. One noteworthy difference is WPAC; both the parent prior to 2007 and the subsidiary since report the lowest level of interest rate risk relative to the other three banks. Yet in the earnings approach WPAC banking group was the only bank examined whose net interest income growth showed any systematic sensitivity to movements in interest rates. This difference may reflect the low number of observations in the earnings approach, or the possible variation in accounting treatment of hedging activity between banks. The economic value approach did not identify WBC (the Australian parent) as being any more exposed to interest rate risk than the other three parent banks.

5 Conclusion

Empirical results obtained using variants of the method frequently used in the literature suggest that the four largest Australian parent banks are not exposed to interest rate risk to any great extent. This is consistent with the prevailing view that New Zealand subsidiaries are subject to very little interest rate risk. All four major banks' stock prices showed minimal susceptibility to changes (both anticipated and unanticipated) in short-term interest rates. Parent bank stock prices were negatively affected by movements in long-term interest rates, but the magnitude of this effect was very small and tended to be sensitive to the frequency of data used. A more direct approach using New Zealand banking group information was used to assess whether movements in interest rates had any significant impact on net interest income growth. The results provide weak evidence of some interest rate risk and a propensity by some banks to increase their exposure to mismatch risk during easing cycles. However, due to the small number of observations any inferences should be treated with caution. Overall, the results from the different approaches suggest that, when modelling the New Zealand or Australian financial sector, it is important to explicitly introduce hedging, since there is little empirical evidence in favour of interest rate risk.

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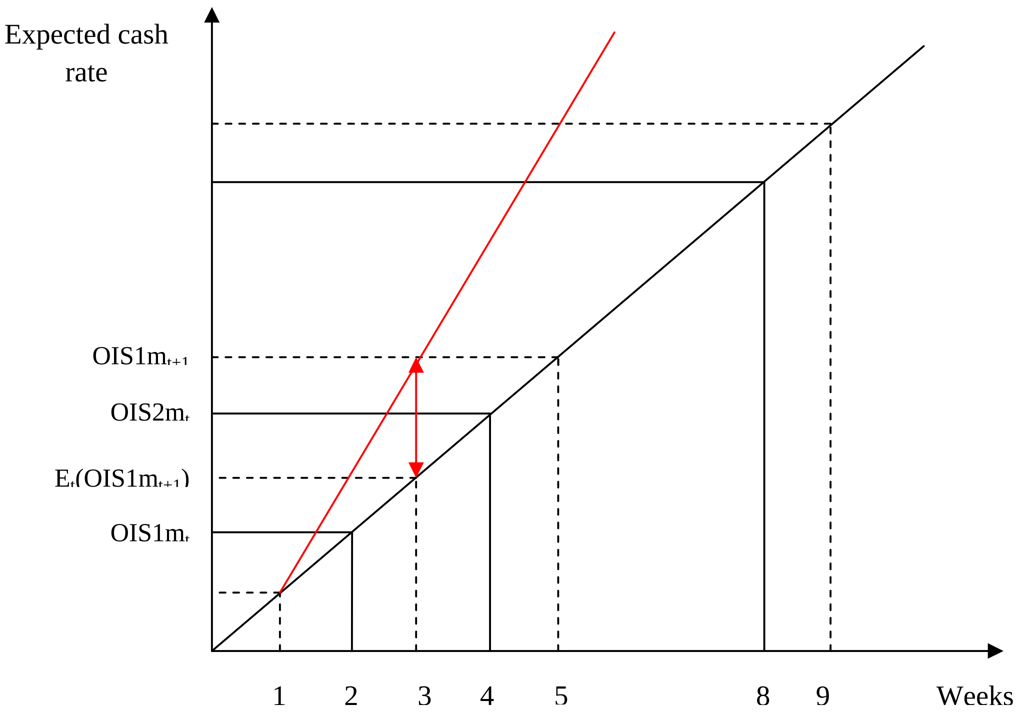
A Estimating changes in cash rate expectations

Figure 3: Example: 1 month OIS



We estimate the expected OIS one week ahead by using simple algebra and making the simplifying assumption that the expected cash rate path is linear (in reality, the expected cash rate path looks more like a step function, as it accounts for the monetary policy announcement dates over the maturity of the OIS). Figure 4 depicts the estimation of the 1 month OIS as an example. The slope is estimated by subtracting the 1 month OIS (which is the average expected cash rate over the next month) from the 2 month OIS, and then dividing this by the movement along the x axis (which in this example is 2 weeks). This slope is then used to calculate the movement along the expected cash rate path by one week, using the current 1 month OIS as the intercept.

This gives us next week's expected 1 month OIS as of today. However, it is possible that expectations of the future cash rate path will have changed one week later. This can be seen as the red line in figure 3. By subtracting our expected 1 month OIS from the actual 1 month OIS we can estimate changes in market expectations of the cash rate path (shown by the double-ended red arrow in figure 3).

B Results for economic value approach using Nelson and Siegel data

Table 5: Regression results - β_2 value and significance

	Current (weekly)	Current (monthly)	Current (quarterly)	AR residuals (weekly)	AR residuals (monthly)	AR residuals (quarterly)
ANZ						
Cash rate	0.0031	-0.0159**	-0.0085	0.0029	-0.0263***	-0.0076
90-day	0.0004	-0.0112	-0.0112**	0.0006	-0.0204*	-0.0154**
1-year	-0.0062	-0.0115	-0.0202*	-0.0065	-0.0118	-0.0257***
5-year	-0.0135***	-0.0161**	-0.0246***	-0.0136***	-0.0138**	-0.0257**
10-year	-0.0155***	-0.0183***	-0.0249***	-0.0155***	-0.0179***	-0.0239**
CBA						
Cash rate	-0.0067	0.0031	0.0025	-0.0068	-0.0036	0.0200
90-day	-0.0084	-0.0043	-0.0063	-0.0110***	-0.0168	-0.0020
1-year	-0.0090**	0.0005	-0.0047	-0.0091**	-0.0056	-0.0063
5-year	-0.0121***	-0.0017	-0.0040	-0.0120***	-0.0024	-0.0042
10-year	-0.0133***	-0.0043	-0.0049	-0.0131***	-0.0035	-0.0033
NAB						
Cash rate	0.0036	-0.0115	-0.0182***	0.0035	-0.0151	-0.0213***
90-day	0.0040	-0.0140	-0.0192***	0.0028	-0.0233*	-0.0253***
1-year	-0.0007	-0.0038	-0.0210*	-0.0009	-0.0040	-0.0224**
5-year	-0.0117***	-0.0059	-0.0188*	-0.0117***	-0.0040	-0.0207
10-year	-0.0158***	-0.0100	-0.0191**	-0.0158***	-0.0100	-0.0189
WBC						
Cash rate	-0.0086*	-0.0062	-0.0010	-0.0086*	-0.0114	0.0117
90-day	-0.0045	-0.0051	-0.0024	-0.0048	-0.0124*	0.0053
1-year	-0.0061	-0.0034	-0.0071	-0.0061	-0.0045	-0.0083
5-year	-0.0117***	-0.0076	-0.0119	-0.0118***	-0.0058	-0.0151
10-year	-0.0139***	-0.0103	-0.0130	-0.0139***	-0.0107	-0.0145

*** denotes significance at a one percent level, ** denotes significance at a five percent level, * denotes significance at a ten percent level.