Refinancing in the Australain mortgage market

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Refinancing in the Australian Mortgage Market

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Declaration

I hereby declare that this submission is my own work and to the best of my knowledge it contains no material previously published or written by another person, nor material which to a substantial extent has been accepted for the award of any other degree or diploma at UNSW or any other educational institution, except where due acknowledgement is made in the thesis. Any contribution made to the research by others, with whom I have worked at UNSW or elsewhere, is explicitly acknowledged in the thesis.

I also declare that the intellectual content of this thesis is the product of my own work, except to the extent that assistance from others in the project's design and conception or in style, presentation and linguistic expression is acknowledged.

Andrew James Pease

4 May 2000

Abstract

This thesis examines the growth in home loan refinancing since 1991. We examine the causes of the growth in refinancing, test whether the abolition of mortgage stamp duty in some states caused an increase in refinancing, and investigate whether the growth in refinancing has caused home loan lending rates to move more closely with changes in the cost of bank funding. Our main findings are that the level of refinancing is influenced by the spread between the standard variable mortgage rate and the three-year fixed mortgage rate, and movements in house prices. We find no conclusive evidence that the abolition of stamp duty on refinanced mortgages caused a rise in activity. We also find that movements in the variable mortgage rate have become more responsive to changes in the marginal cost of funds, suggesting that risk sharing has become less important in the mortgage market.

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Section 1 – Introduction

One of the most striking features of the Australian financial system has been the growth in home loan refinancing in recent years. Since statistics first became available in July 1991, the share of refinancing in monthly housing finance commitments has risen from 10% to around 20% in 1998. The annual growth in refinancing has averaged 25% over the past six financial years. Despite the rapid growth, the Australian market is still to catch up with the more developed United States market where refinancing accounted for 52% of housing loan applications during 1998[1].

Various reasons have been proposed to explain the growth in refinancing. It could be due the emergence of discount mortgage managers, or the aggressive marketing of "honeymoon" fixed term rates by banks. The NSW, Queensland and Victorian governments have attempted to encourage refinancing by abolishing stamp duties on mortgage refinancing. The Consumer Credit Code, introduced in November 1996, has further encouraged refinancing by forcing the disclosure of borrowing costs, including early repayment penalties.

This thesis has three aims. The first is to determine the causes of the growth in home loan refinancing. The second is to test whether the abolition of mortgage stamp duties in some states has helped increase refinancing activity. The final aim is to examine whether the growth in refinancing and increase in lending competition has caused home lending rates to move more closely in line with changes in the cost of bank funding.

Monthly refinancing levels are regressed against the spread between the variable home loan rate and the three-year fixed rate, the spread between the 90-day bank bill rate and the overnight cash rate (to proxy monetary policy expectations), the share of

[1] According to the Mortgage Bankers Association of America. Their survey of mortgage lenders covers approximately 40% of all U.S. mortgage originations.

non-traditional lenders in total lending (to proxy the degree of competition), the unemployment rate (to capture changes in the degree of adverse selection), movements in median house prices, real wages growth and interest rate volatility. Dummy variable and stability tests are conducted on the resulting refinancing equation to determine if the abolition of stamp duty caused an increase in mortgage refinancing. Finally, the variability of mortgage lending rates is tested by regressing the standard variable mortgage rate against a constant and lags of the certificate of deposit rate (the marginal cost of funds).

The main findings are that the level of refinancing is influenced by the spread between the standard variable mortgage rate and the three-year fixed mortgage rate, and movements in house prices. The dummy variable to account for the abolition of mortgage stamp duty is correctly signed, but insignificant. There is, however, evidence of parameter instability around the time of the stamp duty abolition, providing informal evidence of some impact from the stamp duty removal. We also find that movements in the variable mortgage rate have become more responsive to changes in the marginal cost of funds, suggesting that risk sharing has become less important in the mortgage market. This may be partly related to the growth in refinancing.

The thesis is set out as follows. Section 2 presents a review of the literature, focusing on the microeconomic theory underpinning the borrower/lender relationship, and studies of the industrial organisation of the home lending sector, both in Australia and overseas. Section 3 examines the structure of the home lending industry in Australia, looking at the changes in the industry over the past decade. A particular focus is the growth in mortgage managers and the changes in interest rate margins charged by home lenders. This section also examines the extent of measurable switching costs, and provides examples of the impact of the abolition of mortgage stamp duty for different loan sizes.

Section 4 describes the data used in the estimation and presents the results of unit-root testing. Section 5 presents the results from the estimation of the refinancing and the mortgage rate stickiness equations. Finally, Section 6 presents the conclusions of the thesis and outlines suggestions for future research.

Section 2 – Literature Review

2.1: Introduction

Data on mortgage refinancing in Australia have been available only since mid-1991, and as a result there have been no studies on Australian refinancings. Most studies on the Australian housing market have concentrated on issues of market structure, such as the degree of competition, and the consequences of financial system deregulation. Nearly all of the research on mortgage refinancings has been conducted in the United States, where the well developed mortgage backed security market means there is plenty of interest in understanding the factors which cause early loan repayment[1].

This survey follows the following format. First, the various theories of interest rate determination from the banking literature are described. Next, there is a review of studies on the mortgage refinancing decision, and finally there is a discussion of Australian studies on mortgage lending.

This review suggests several factors to be considered by a study on aggregate home loan refinancing. The theories of interest rate determination suggest possible linkages between refinancing activity and interest rate setting. For instance, the rapid growth in refinancing in the past seven years may have changed the way lenders apply switching costs. As the review shows, lower switching costs imply less interest rate stickiness. Also, the growth in refinancing may have changed the risk sharing relationship between

[1] The most common form of mortgage backed security in the United States is the "pass-through" which is created by pooling fixed rate, level payment mortgages. The payments made on the underlying mortgages are "passed-though" to the security holders on a pro-rata basis. Holders of these securities face prepayment risk. Decreases in market interest rates cause mortgage prepayments to rise as a result of refinancing, which forces the investor to reinvest the prepaid mortgages at the lower prevailing market interest rates. Higher interest rates can cause prepayments to slow, increasing the maturity of the security and preventing the security holder from taking advantage of higher prevailing market interest rates.

borrowers and lenders. The advent of mortgage managers, plus the growing popularity of fixed rate loans may have reduced the importance of interest rate smoothing for risk averse borrowers. The implication for a refinancing equation is that mortgage interest rates may be endogenous – refinancing may partly explain interest rate changes.

The mortgage refinancing studies from the United States show that the spread between the existing and new mortgages, switching costs, the expected holding period of the new loan, home equity levels and borrower income influence the refinancing decision. These studies also reveal the importance of option pricing theory in analysing the refinancing decision. One important implication is that greater interest rate volatility should reduce the likelihood of refinancing as it increases the option value of the existing mortgage. There is also evidence that new technology and financial deregulation have increased the propensity to refinance.

The studies also highlight the data limitations facing Australian research on mortgage refinancing. Researchers in the United States are typically able to use pooled data that combines data for individual mortgages across several time periods. For example, Bennett, Peach and Peristiani (1997) use data from the Mortgage Research Group of New Jersey, which until late 1996 maintained a database on 42 million residential properties in 36 states. They were able to draw a sample of 12,835 observations, with individual information on the property purchase price, original mortgage loan, maturity and type of mortgage, subsequent refinancings, defaults, sales, and the credit histories of the occupants. There were monthly observations from January 1984 to December 1994. This thesis, by contrast, is restricted to using aggregate time series data on mortgage refinancing, dating back only to July 1991. The use of aggregate data makes it difficult to directly control for the influence of changes in average borrower quality, individual borrower income and home equity levels, and the type and duration of the mortgage (fixed versus flexible). These factors are imperfectly proxied by the unemployment rate, aggregate real wages growth and median house price inflation. It is impossible to account for the average duration of loans. The US studies consistently highlight that the age (seasoning) of a mortgage pool is an important factor in explaining prepayments, with older mortgages more likely to be refinanced. Most US studies based on pooled data attempt to control for seasoning effects.

The two Australian empirical studies on housing finance draw two main conclusions. Fahrer and Rohling (1992) find that the home loan market did not behave competitively between 1986 and 1990, and Lowe and Rohling (1992) conclude that switching costs and risk sharing contributed to mortgage rate stickiness between 1986 and 1991. The implications for this thesis are that increased competition resulting from the growth in refinancing may have contributed to greater home lending competition and reduced mortgage rate stickiness – again suggesting the possible endogeneity of interest rates spreads in a refinancing equation.

2.2: The borrower/lender relationship – theories of interest rate determination[2]

Under perfect competition with complete information, price should equal marginal cost and the demand curve facing each lending institution will be perfectly elastic. In practice, however, prices (interest rates) in the banking sector do not always respond one for one with the marginal cost of providing a loan. One reason may be a lack of competition, but there are also theories which highlight the information and incentive problems associated with bank lending. The four theories discussed in this section are; adverse selection, switching costs, risk sharing, and irrationality.

[2] This section follows the survey presented in Lowe and Rohling (1992).

2.2.1: Adverse Selection

This is the most well known model of interest rate stickiness and was developed by Stiglitz and Weiss (1981). The firm is assumed to know the riskiness of its projects while the bank cannot distinguish between projects. This information asymmetry introduces problems of moral hazard and adverse selection. Higher interest rates reduce the expected returns for firms with "safe projects" but do not reduce the returns for "risky" firms (because these projects would fail anyway). Therefore, a rise in interest rates will cause those firms with the safest projects to withdraw first, or faced with higher interest rates, firms may decide to undertake riskier projects.

Because of these information problems, the bank's expected earnings may decline following an increase in the loan rate charged by the bank. As a result, the bank may decide not to increase its loan rate following an increase in its cost of funds, and may set the loan rate below the market clearing rate and ration credit.

2.2.2: Switching Costs

Since banks are concerned with the risk profile and potential behaviour of their customers, they need to compile information about their customers. This is a costly activity for the bank. The cost of acquiring this information is often passed onto the buyer by way of a fixed up-front fee. This makes it costly for a buyer to switch from one bank to another. Other forms of "switching costs" are regular search costs or "shoe leather" costs. These include the cost of learning the different rates and conditions on the new loan, and filling out forms and attending interviews. These "search and application" costs are often more significant in banking than in most goods markets because of the bank's need to discover the risk characteristics of its customers.

Klemperer (1987) is the most complete microeconomic analysis of the impact of switching costs. He contends that the existence of switching costs leads to market segmentation, making each individual firm's demand more inelastic. The non-co-operative equilibrium with switching costs leads to outcomes similar to the collusive solution, with the derivative of price with respect to marginal cost being less than one. Klemperer also highlights the welfare costs associated with switching costs. In a differentiated products model, the social cost caused by increased monopoly power is partly offset by the benefit of increased consumer choice. Switching costs, by contrast, differentiate functionally identical products, meaning there are no benefits to set against the cost of restricted output.

Lowe and Rohling (1992) apply Klemperer's general microeconomic model of the impact of switching costs to the banking industry[3]. Their model is set out below.

Two banks, *A* and *B*, produce functionally identical products, such as housing loans. Initially, a fraction, σ^A of consumers are associated with bank A, and the remainder, σ^B ($=1-\sigma^A$) are associated with bank B. Assume that *q* customers have reservation prices greater than or equal to *f(q)*, and that these consumers face a switching cost[4]. Also assume that these customers face search costs which vary across individuals. Let $\Gamma(w)$ be the proportion of a bank's consumers whose cost of switching to the other bank is less than or equal to *w*.[5] Thus, $\gamma(w) = \partial\Gamma(w)/\partial w \geq 0$ is the associated density function of the switching costs. Let $h(\cdot) = f^{1}(\cdot)$ and assume that $p^A \geq p^B$, where *p* is the price of the loan, or the interest rate.

The demand for loans from bank *A* is given by;

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[3] Klemperer solves his model for both price and quantity setting equilibria. Lowe and Rohling apply the price setting equilibrium to the banking industry.

[4] *f(q)* is the inverse demand curve in the absence of switching costs. The switching costs could be loan application fees, or government charges.

[5] $\Gamma(w)$ is the cumulative density function.

$$q^A = \sigma^A h(p^A) - \Gamma(p^A - p^B)\sigma^A h(p^A) \tag{2.1}$$

and the demand for loans from bank B is given by;

$$q^B = \sigma^B h(p^B) + \Gamma(p^A - p^B)\sigma^A h(p^A) + \sigma^A \int_{p^B}^{p^A} \Gamma(r - p^B)[-dh(r)] \tag{2.2}$$

The first term in equation (2.1) represents bank A's existing market share. The second term represents the proportion of bank A's customers who will switch to bank B. In other words, bank A sells only to its own customers with reservation prices greater than or equal to p^A, and switching costs greater than or equal to $p^A - p^B$.

Bank B's customers come from three sources. First it sells to its own customers with reservation prices greater than or equal to p^B (the first term), and to bank A's customers who find it optimal to switch to bank B (the second term). It also sells to those customers, originally associated with bank A, but whose reservation price (r) is less than p^A (and so have not borrowed from A), and who now find it optimal to switch to bank B (the third term)[6].

The non-co-operative price setting equilibrium can be derived from these two demand equations. Bank B's profit maximisation problem is;

$$\max_{p^B} \pi^B = p^B q^B (p^B) - c^B (q^B) \tag{2.3}$$

where π^B is bank B's profit function and c^B is bank B's cost function. This yields the following first-order condition;

$$\frac{\partial \pi^B}{\partial p^B} = q^B + \left[p^B - \frac{\partial c^B}{\partial q^B} \right] \frac{\partial q^B}{\partial p^B} = 0 \tag{2.4}$$

Substituting in equation (2.2) allows (2.4) to be rewritten as;

[6] The reservation price (r) for these customers falls between p^A and p^B, and the reservation price less switching costs is greater than p^B.

$$0 = \sigma^B h(p^B) + \Gamma(p^A - p^B)\sigma^A h(p^A) + \sigma^A \int_{p^B}^{p^A} \Gamma(r - p^B)[-dh(r)] +$$
$$\left[p^B - \frac{\partial c^B}{\partial q^B}\right]\left[\sigma^B h'(p^B) - \gamma(p^A - p^B)\sigma^A h(p^A) + \sigma^A \int_{p^B}^{p^A} -\gamma(r - p^B)[-dh(r)]\right] \tag{2.5}$$

For a symmetric equilibrium where $p^A = p^B = p$ and $\sigma^A = \sigma^B = ½$, (2.5) can be rewritten as;

$$\frac{1}{2}\left[h(p) + \left(p - \frac{\partial c^B}{\partial q^B}\right)(h'(p) - \gamma(0)h(p))\right] = 0 \tag{2.6}$$

Assume that all customers face some switching costs and that switching costs are uniformly distributed over the interval $[0,k]$. This implies that $\gamma(w) = 1/k$ for $0 \le k \le 1$ and $\gamma(w) = 0$ for $w > k$.[7] Using the simplifying assumptions of linear demand, $p = f(q) = \alpha - \beta q$, and linear costs, $c^A(q) = c^B(q) = mq$, means equation (2.6) can be restated as a quadratic equation;

$$\frac{1}{\beta}(\alpha - p) + (p - m)\left(-\frac{1}{\beta} - \frac{1}{k}\left(\frac{1}{\beta}(\alpha - p)\right)\right) = 0 \tag{2.7}$$

Which simplifies to;

$$p^2 - p(2k + \alpha + m) + \alpha k + mk + m\alpha = 0 \tag{2.8}$$

The equilibrium price is found by solving for the roots of (2.8).

$$p = \left[k + \left(\frac{\alpha + m}{2}\right) - \sqrt{k^2 + \left(\frac{\alpha - m}{2}\right)^2}\right] \tag{2.9}$$

$k = 0$ implies no consumers with switching costs and equation (2.7) becomes the competitive solution, $p = m$. As $k \to \infty$, equation (2.7) becomes the monopoly (or fully collusive) solution, $p = (\alpha + m)/2$.

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[7] Recall that $\gamma(w) = \partial\Gamma(w)/\partial w$, where $\Gamma(w)$ is the proportion of customers whose cost of switching is greater than or equal to w.

The price stickiness result can be seen by taking the derivative of price with respect to marginal cost in equation (2.9);

$$\frac{\partial p}{\partial m}=\frac{1}{2}+\frac{1}{2}\left[\frac{\frac{(\alpha-m)}{2}}{\sqrt{k^2+\left(\frac{\alpha-m}{2}\right)^2}}\right] \tag{2.10}$$

As $k \to 0, \partial p/\partial m \to 1$. Without switching costs, prices rise by the same amount as marginal costs. As switching costs (k) become larger, home lending interest rates become stickier.

2.2.3: Risk Sharing

Fried and Howitt (1980) apply the Azariadis (1976) model of risk sharing in the labour market to credit markets. Borrowers are assumed to be more risk-averse than banks, meaning that banks charge an interest rate which is less variable than the cost of funds. In return, banks receive a higher average interest rate than would be charged to risk-neutral borrowers. Therefore, customers will not change banks when the spread between the lending rate and the cost of funds widens, since this reflects the insurance premium paid by the risk-averse borrower. The Fried and Howitt result also depends on the existence of switching costs. Both the bank and the customer face switching costs, providing an incentive for both parties to enter the risk-sharing contract. Without switching costs, there would always be an incentive to renege on the implicit contract.

2.2.4: Irrationality

Ausubel (1991) develops a model of consumer irrationality to help explain interest rate stickiness in the credit card market. Ausubel argues that there are a class of borrowers who believe they will pay the outstanding balance on their credit cards by the due date and avoid credit charges, but fail to do so. These are the best customers from the bank's viewpoint because they borrow at high interest rates and (mostly) repay their loans. These customers are insensitive to interest rate changes because they do not intend to borrow at the outset. There is a second class of borrowers, claims Ausubel, who intend to borrow on credit card accounts. These consumers are the bad credit risks who lack less expensive alternatives, and are more likely to be interest rate sensitive because they intend to borrow on their credit cards. A reduction in credit card interest rates will attract the second class of customers who are the bad credit risks. Ausubel calls this a "reverse" adverse-selection problem. Calem and Mester (1995) find empirical support for Ausubel's theory using data from a 1989 survey of credit card usage by 1600 households in the United States.

2.3: Mortgage Refinancing Studies

There is a well-developed literature in the United States looking at prepayment probabilities for mortgage backed securities. These studies typically look at data for pools of mortgages, and attempt to compute probabilities using factors such as mortgage age, income, house price indices, indicators of mobility, and interest rate spreads. Logit or probit models are typically used for estimation.

Follain and Tzang (1984) is typical of the early literature on the microeconomics of refinancing. They simply apply a net present value rule to the refinancing decision, after formulating the following expressions for the present values of the costs and savings from refinancing; for a loan made in period 0 and refinanced in period k.

$$\begin{aligned} C_k = {} & [PNTS + (1 - MTR)PEN]LE_k + FC \\ & - \frac{MTR * PNTS * LE_k}{MN} \sum_{t=k+1}^{H-1} \frac{1}{D^{t-k}} - \frac{UP * MTR}{D^H} \end{aligned} \tag{2.11}$$

$$S_k = \sum_{t=k+1}^{H} \frac{(PE_t - MTR * IE * LE_{t-1}) - (PN_t - MTR * IN * LN_{t-1})}{D^{t-k}} + \frac{LE_H - LN_H}{D^H} \tag{2.12}$$

where;

C = the after tax costs of refinancing

S = the after tax savings from refinancing

PEN = prepayment penalties on the existing loan as a percent of the outstanding balance

MN = maturity of the new loan (years)

UP = amount of points not yet deducted for tax purposes ($)

IN = interest rate on the new loan

IE = interest rate on the existing loan

MTR = the borrowers marginal tax rate (mortgage interest payments are tax deductible in the United States)

D = 1 + (1 – MTR)*IN

PNTS the percentage points the lender charges for making a loan, as a percentage of the outstanding loan balance

LE_t = balance on the existing loan in period t

FC = other financing costs

PE_t = payment on the existing loan in period t

PN_t = payment on the new loan in period t

H = expected holding period of the new loan, that is the number of the years the household expects to remain in the new house.

Equation (2.11) defines the costs of refinancing, which equal the sum of prepayment penalties, and other fees, minus the discounted value (over the expected loan holding period) of the income tax deductions from the new loan. Equation (2.12) shows the savings from refinancing, which are the difference between the after-tax mortgage payments on the new and old loans, and the difference in the discounted value of the loan balances on the new and existing loans at the end of the holding period.[8] Refinancing is justified if $S_k - C_k > 0$.

Follain and Tzang calculate the interest rate differential needed to justify refinancing a $100,000 mortgage under different assumptions about the holding period, prepayment penalties, points charged on the new loan, and the marginal tax rate of the borrower. They find that for reasonable assumptions, the interest rate on the new loan needs to be between 26 and 120 basis points below the existing interest rate for refinancing to be profitable when the loan has an expected holding period of eight years. The interest differential becomes larger, the higher are the fixed costs (points, repayment penalties etc.) of refinancing, and the smaller is the expected holding period of the new loan.

The problem with the application of a simple net present value rule to the refinancing decision is that it ignores that future interest rates are uncertain; there may be a benefit from postponing the refinancing decision in case interest rates fall still further. Any analysis of the refinancing decision should take this uncertainty into account.

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[8] The specific tax deductibility features of these equations are relevant only for investors in the United States. Owner-occupied housing investment is not subject to taxation in Australia, and hence there are no income tax considerations when refinancing. Investment in housing for investment purposes attracts taxation in Australia on both the rental income earned and capital gains. Australian tax considerations would be important in refinancing decisions for investment properties, especially where negative gearing strategies are employed.

Follain, Scott and Yang (1992) apply a binomial option-pricing model[9] to the refinancing problem to account for future interest rate uncertainty[10]. The ability to delay a refinancing decision is like a financial "call option"[11]. Mortgage borrowers have the right, but not the obligation, to refinance the loan at a future time of their choosing. This option has a value which should be accounted for when calculating the interest rate differential needed to make refinancing profitable.

The option pricing analysis begins with the observation that a residential mortgage can be characterised as a callable, default-free, bond, where the mortgage borrower is the bond issuer[12]. The value of this bond, $P(c)$, depends on the value of the non-callable portion, $P(nc)$, and the value of the call option, $V(c)$.

$$P(c) = P(nc) - V(c) \tag{2.13}$$

It is profitable to refinance when the value of the existing callable bond exceeds the present value of the payments on a new mortgage plus transactions costs. Refinancing occurs when;

$$P_e(c) \geq PV(i_n) + TC \Rightarrow P_e(nc) - PV(i_n) \geq TC + V(c) \tag{2.14}$$

---

[9] Option-pricing theory has also been employed to explain business investment decision making under uncertainty. See, for example, Dixit and Pindyck (1994).

[10] Follain, Scott and Yang is the most direct example of the application of option pricing to the refinancing decision. Hendershott and Van Order (1987) and Kau and Keenan (1995) provide comprehensive surveys on pricing mortgages using option pricing theory, examining both prepayment and default. These articles focus on the pricing of mortgage backed securities.

[11] A "call" option is a contract giving its owner the right to buy a specified financial security at a stated exercise price on a stated expiration date. A "put" option is the same thing but gives its owner the right to sell.

[12] Strictly speaking only a government guaranteed mortgage, such as a "ginnie mae" in the United States could be called default free. However, mortgage backed securities in Australia have universally been rated AAA by the major agencies, suggesting they are viewed as having minimal default risk.

Where;

$P_e(c)$ and $P_e(nc)$ are the value of the callable and non-callable bonds at the existing interest rate.

$PV(i_n)$ equals the present value of the payment on the new mortgage discounted at the new interest rate.

TC are the transaction costs in refinancing.

The main difference between equation (2.14) and the simple net present value approach is the introduction of the call option. The interest rate spread needed to justify refinancing now includes the value of the option, as well as the transaction costs. The best way to show this is through a simple example which computes the value of the embedded call option in a mortgage.[13]

Assume that a \$100 mortgage has two remaining payments, one coupon payment (10%), and the final payment (balance plus interest). Also assume that the market interest rate on a non-callable bond is 10% and it will either increase or decrease by 1% in the next period. Because the mortgage is callable, it is less valuable to an investor than an equivalent non-callable bond. A binomial option-pricing model can be used to solve for the difference between the value of the callable and non-callable bonds.

The option-pricing model simply solves for the value of the option which makes investors indifferent between the callable and non-callable bonds. An investor buying one unit of the callable bond can sell *N* call options to generate the risk-free outcome. In the example, there are two possible outcomes for the portfolio. If interest rates rise, the price of the non-callable bond declines from \$100 to \$99.10 (=\$110/1.11). In this case,

[13] This is similar to the example shown in Follain, Scott and Yang (1992).

the value of the call option, V(c), is zero[14]. If interest rates decline, the price of the non-callable bond increases to \$100.92 (=\$110/1.09), and the value of the call option will be \$0.92 at the end of the period. There is a \$1.82 difference in the possible high and low values for the non-callable bond and a \$0.92 difference for the option. Therefore, the investor must sell 1.98 (=\$1.82/\$0.92) options for each non-callable bond bought in order to create a risk-free portfolio.

If the interest rate rises, the price of the bond falls to \$99.10, the coupon payment is \$10, the outcome of the portfolio equals \$109.10, and the holders of the options will not exercise them because they are worthless. If the interest rate falls, the bond plus coupon is worth \$110.92. However, the investor has to settle up on the 1.98 call options sold at the beginning of the period, losing \$1.82 (=1.98*\$0.92), meaning the outcome of the portfolio is again \$109.10.

Because the portfolio has the same outcome whether interest rates rise or decline, it should yield the riskless rate of return of 10% – the market rate on the non-callable bond. This is the key insight which underlies option-pricing models and it allows the value of the call option to be calculated as follows:

$$\frac{Year\,end\ portfolio\ value}{P(nc)-N*V(c)}=1+r_f \tag{2.15}$$

where,

N = the number of options contracts,

r_f is the riskless rate of return.

[14] Because no investor will want to exercise the right to buy a non-callable bond for \$100 when its market price is lower.

This equation can be solved for the option price which yields the risk-free rate, and for our example gives a value for *V(c)* of \$0.41. In other words, the callable mortgage will sell for \$0.41 below the price of the non-callable bond[15].

Follain, Scott and Yang use this option pricing methodology to examine the interest rate differential required to generate refinancing for various types of mortgages. They create a simulated pool of mortgages where the expected holding periods of the borrowers vary. They model the non-callable interest rate process as a linear combination of the previous period's rate plus or minus a random error that follows a binomial process. The option-pricing model used in the simulations is more complex than the simple example shown above because it has to account for multiple time periods, but the intuition is identical[16].

Follain, Scott and Yang generate the differential required for refinancing under different assumptions about interest rate variability, expected holding periods and transaction costs. They find a differential of around 200 basis points is required to justify refinancing for a typical mortgage with an expected holding period of 10 years. They show that the interest rate differential (and the value of the call option) increases as the expected holding period increases. A higher standard deviation for interest rates also increases the value of the option (and hence the differential) because higher volatility increases the probability that the option will be exercised. Finally, transaction costs reduce the value of the call option, because transaction costs make refinancing less valuable (but they still increase the differential).

[15] The example can also be solved for the interest rate differential at which the callable bond equals par.

[16] The multiperiod version of the model must be solved backwards from the last period to the first because the payoff to the call option is only known with certainty in the last period.

Peristiani, Bennett, Monsen, Peach, and Raiff (1997) find that home equity levels and personal credit ratings have a significant impact on the probability of mortgage refinancing. As described earlier, they use data from the Mortgage Research Group of New Jersey, creating a sample of 12,835 observations, with individual information on the property purchase price, original mortgage loan, maturity and type of mortgage, subsequent refinancings, defaults, sales, and the credit histories of the occupants. They estimate a logit model which takes a value of 1 when the homeowner refinances and zero otherwise and find that a poor credit history, as measured by loan collection agency reports, significantly reduces the probability a homeowner will refinance a mortgage, even when the financial incentive for doing so is strong. They also find that home equity levels play a large role in the ability to refinance. Interest rate volatility, as measured by the standard deviation of US 10-year bond yields during the time interval from purchase to refinancing, or from purchase to the end of the sample period, is positive and strongly significant. Perisitani *et al* postulate that volatility should reduce the incentive to refinance (as suggested by option pricing theory) and explain the result by arguing that high interest rate volatility provides more opportunities for the mortgagor's embedded refinancing option to be "in the money".

Bennett, Peach, and Peristiani (1997) hypothesise that technological, regulatory and structural changes have made mortgage origination more efficient and increased the propensity of households to refinance. They use the same database as Peristiani, Bennett, Monsen, Peach and Raiff (1997). Instead of a logit model, however, they estimate a proportional hazard model where the dependent variable is the duration until refinancing measured in months[17]. They confirm that personal credit ratings and home equity levels have significant effects on the probability of refinancing. In contrast with the previous study, they find that homeowners postpone refinancing in the face of increased interest rate volatility, consistent with option pricing theory.

Bennett *et al* test whether there has been a change in refinancing behaviour by dividing the sample period between mortgagors that purchased their homes between 1984-1990, and those who purchased between 1991-1994, and estimate their model over the two sub-samples. They found that borrowers in 1990s exhibited a much greater propensity to refinance after controlling for the factors that explain refinancing. Borrowers in the 1990s were significantly more sensitive to interest rate volatility and transaction costs, while the size of the loan was less important than in the 1980s. Bennett *et al* use these results to conclude that changes in the mortgage market which have contributed to the growth in competition and the lowering of financial and non-financial transactions costs have increased the propensity to refinance. In particular they highlight the growth in securitisation and improvements in information technology which have increased competition and reduced information barriers. Borrowers nowadays are much better informed about profitable refinancing opportunities, and advances in computer technology now allow lenders to identify mortgagors with interest rates above prevailing market rates. Better information processing technology has lowered the explicit costs of financial transactions associated with obtaining a mortgage, and the mortgage application and approval process has been streamlined.

[17] In the logit model the dependent variable is a discrete binary indicator that assumes the value of 1 when the homeowner refinances and zero otherwise. Hazard models are a type of limited dependent variables model, which estimate the conditional probability of an event.

Other studies on mortgage pools have reached broadly similar conclusions about the importance of home equity levels and income. For example, Archer, Ling and McGill (1995) use matched records from the 1985 and 1987 national samples of the American Housing Survey and find that home equity and borrower income are significant in the refinancing decision. Cunningham and Capone (1990) estimate post-origination loan-to-value ratios, and post origination payment to income ratios for a sample of mortgages in the Houston, Texas area. They found that equity levels were a key determinant of both the refinancing and default probabilities, while income was insignificant. Dickinson and Heuson (1993) reach similar conclusions from a sample of 1,067 United States refinancings between 1987 and 1990.

2.4: Australian studies on the housing sector

There have been no studies conducted on mortgage refinancing in Australia. In part this is because the Australian Bureau of Statistics has collected data on refinancing only since July 1991. It is also because the type of pooled mortgage samples used in studies in the United States have not been made publicly available by Australian mortgage lenders.

In fact, there have been very few studies conducted on the mortgage market in Australia, possibly reflecting its highly regulated nature until the late 1980s[18]. The best examples of Australian mortgage market research have come from the Reserve Bank, due to its interest in the monetary policy transmission mechanism and access to detailed bank lending data.

[18] Interest rate ceilings on new housing loans were lifted in April 1986.

Fahrer and Rohling (1992) test the degree of competition in the home lending market. They construct a Herfindahl index using data on individual bank lending for housing from May 1986 to December 1990.

$H = \sum_{i=1}^{n} s_i^2$, where s_i is the share of each bank, and H=1 indicates monopoly.

The article plots the Herfindahl index for housing lending from 1986 to 1990, and shows a small decline in concentration during this period. The index averages 0.14, indicating that the housing market is only reasonably competitive, with the equivalent of only seven equal sized banks (1/0.14≈7).

But as Fahrer and Rohling concede, the Herfindahl index is a flawed measure of competition, as it takes no account of the behaviour of firms in the market under consideration. As a more sophisticated test of competition, they estimate a conjectural variations model in order to take into account the behaviour of banks when assessing the degree of competition. They estimate a model with separate equations for each of the five major banks based on the real value of loans, the marginal cost of funds (bill-rate), the housing loan interest rate and seasonal dummies. They decisively reject the hypotheses of perfect competition and perfect collusion, but are unable to reject the hypothesis that the housing market can be characterised as a Cournot oligopoly. Unfortunately, the sample period estimated by Fahrer and Rohling does not cover the period from 1992 to 1998 when the share of non-bank lenders rose from 6.5% to 14.0%, and refinancing averaged growth of 25% per annum. It may be that these two factors have more than offset bank mergers over the same period, to make home lending more competitive.

Lowe and Rohling (1992) examine why bank loan rates exhibit less variance than the cost of funding. They examine possible reasons, other than collusive behaviour, (such as adverse selection, switching costs, risk sharing and irrationality) for the stickiness of bank loan rates and use data on the various lending rates of Australian banks to examine the degree and causes of stickiness. They regress the monthly certificate of deposit (CD) rate (the cost of funds) against various bank lending rates to assess the degree of stickiness using a sample period from July 1986 to August 1991. They find that credit card interest rates display the greatest degree of stickiness and that housing lending rates are less flexible than overdraft rates.

Lowe and Rohling dismiss credit rationing as a source of stickiness in the home lending market because banks are able to inspect and value the collateral for home loans, minimising adverse selections problems, and because the actions of the borrower are unlikely to prejudice the value of the collateral, making moral hazard considerations unimportant. They suggest that risk-sharing and switching costs may be a better explanation for mortgage rate stickiness. They argue that switching costs are especially high for home lending, and that the household sector is more risk averse than bank shareholders. The sample period used by Lowe and Rohling does not cover the most recent interest rate cycle where the margin between the CD rate and the standard variable home loan has narrowed considerably as interest rates have fallen – in contradiction to risk sharing theory which predicts that the margin should rise when interest rates are falling, in order to pay the insurance premium to enjoy narrower margins when interest rates are rising.

2.5: Conclusion

This survey has attempted to draw together the theories of interest rate determination, mortgage refinancing research, and Australian empirical studies on housing finance. It has highlighted several implications for a study on Australian refinancing;

- The existence of switching costs and risk sharing make mortgage interest rates sticky, in that they move less than proportionally with changes in the marginal cost of funds. Accordingly, a reduction in switching costs and/or lowering in the importance of risk sharing should be reflected in movements in mortgage rates more closely following the marginal cost of funds.
- There is an implied "call option" embedded in a mortgage contract. Interest rate volatility increases the value of the call option, meaning there should be a negative relationship between refinancing and interest rate volatility.
- Borrower income and home equity levels are positively related to refinancing, and transaction costs reduce refinancing.
- Technological and structural changes in the mortgage market have increased the propensity to refinance. Profitable refinancing opportunities are now easier to identify and the growth in securitisation has led to increased competition.

These implications are formally tested using Australian data in Section 5. An error correction model is estimated to find the determinants of refinancing, and the Lowe and Rohling (1992) model of mortgage rate stickiness is re-estimated with the sample extended to May, 1999.

Section 3 – The Australian Housing Finance Market

3.1: Introduction

This section describes the major features of the Australian home lending market. The types of mortgage lenders are examined as well as the major developments over the past decade. The growth in refinancing is discussed and the section concludes with an examination of switching costs. The potential benefits from refinancing are illustrated from an example based on a typical home loan. It shows that;

- An interest rate benefit of at least 180 basis points is required to cover the cost of refinancing a standard $100,000 loan into a one-year fixed "honeymoon" rate.
- The required interest rate differential becomes smaller, the larger is the loan, and the longer the period the new interest rate is fixed for. The break-even differential falls to 40 basis points for switching to a five-year fixed rate.
- The interest rate differential is larger at higher interest rates.
- The abolition of mortgage stamp duty on refinancing in some states has reduced the profitable interest rate differential by around 40 basis points for switching into a one-year fixed rate, and around 10 basis points for switching to a five-year fixed rate.

3.2: Mortgage Lenders

Banks have traditionally been the main lenders for housing in Australia and as Chart 3.1 shows, their dominance has been largely unchallenged over the past decade. The share of building societies has declined, mostly due to their conversion to banks, and the share of "other lenders", mainly credit unions, has been stable. The biggest change has been in lending by mortgage originators, which has grown from 4% of all outstanding lending in 1989 to 10% in 1998. Chart 3.1 refers to the *stock* of existing loans. Data on new lending tells a similar story. In 1997, banks accounted for 82% of new housing finance commitments, building societies 4%, mortgage originators 7%, and "other lenders" 7%.

Chart 3.1

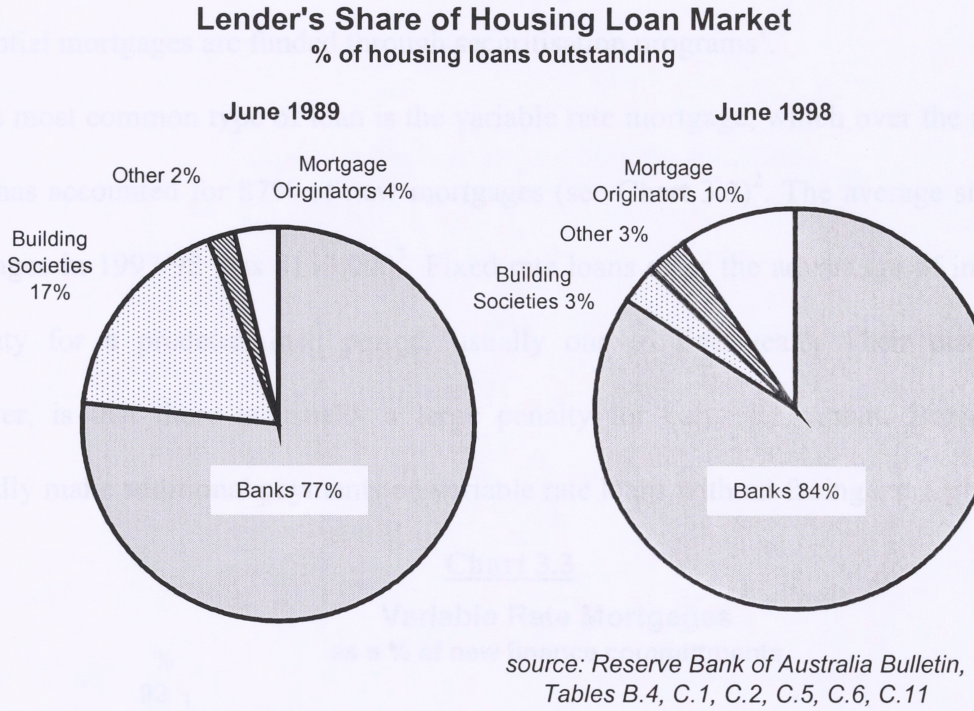
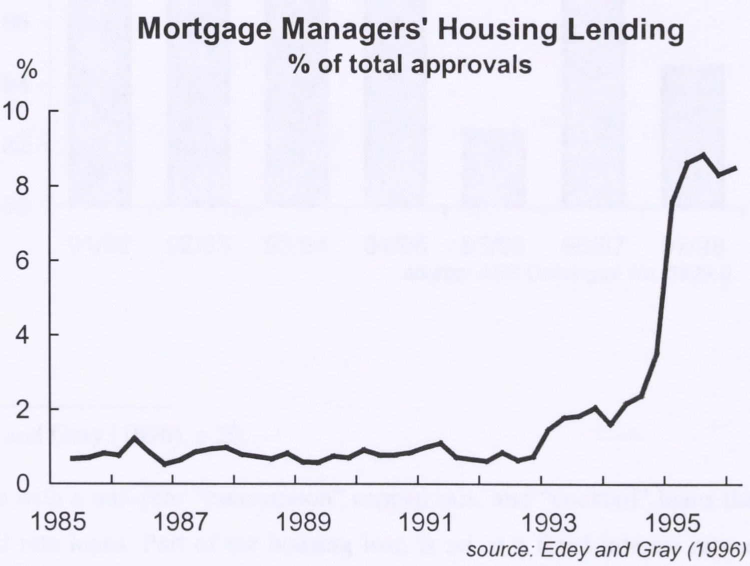


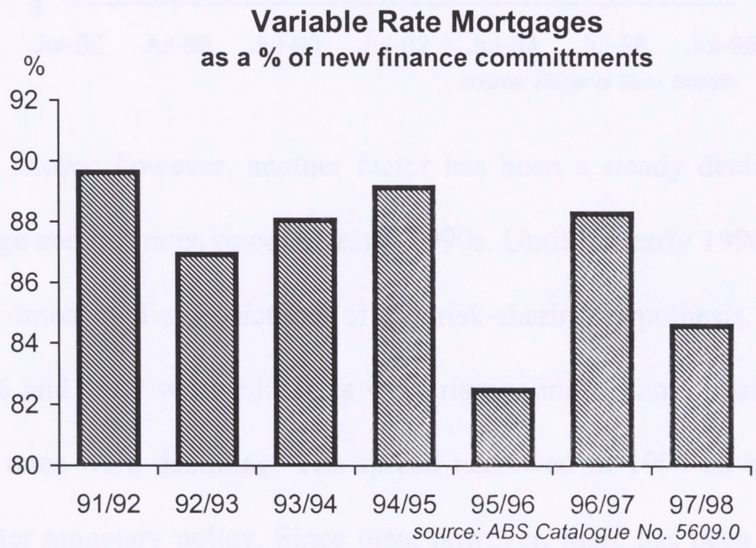
Chart 3.2



Mortgage originators are specialist mortgage providers, which lend funds raised in the wholesale market through the securitisation of mortgages. Although relatively new in Australia, these lenders are common in the United States, where almost two-thirds of residential mortgages are funded through securitisation programs[1].

The most common type of loan is the variable rate mortgage, which over the past seven years has accounted for 87% of new mortgages (see Chart 3.3)[2]. The average size of new mortgages in 1997/98 was $113,000[3]. Fixed rate loans offer the advantage of interest rate certainty for a predetermined period, usually one to five years. Their disadvantage, however, is that there is usually a large penalty for early repayment. Borrowers can generally make additional payments on variable rate loans without facing extra penalties.

Chart 3.3



[1] According to Edey and Gray (1996), p.20.

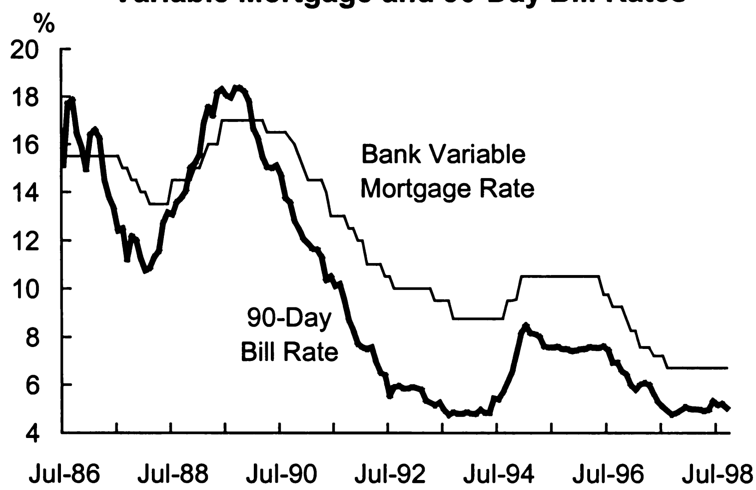
[2] This includes loans with a one-year "honeymoon" capped rate, and "cocktail" loans that are a combination of variable and fixed rate loans. Part of the housing loan is set at a fixed interest rate and the remainder is variable. There are no statistics on the proportion of cocktail loans.

[3] Source: Australian Bureau of Statistics, *Housing Finance*, Catalogue No. 5609.0.

Interest rate controls on new housing lending were lifted in April 1986. Chart 3.4 shows that variable interest rates have generally been on a downward trend after peaking at 17% in 1989. The major reason for the downward trend has been declines in the marginal cost of funds, represented in the chart by the 90-day bank bill rate.

Chart 3.4

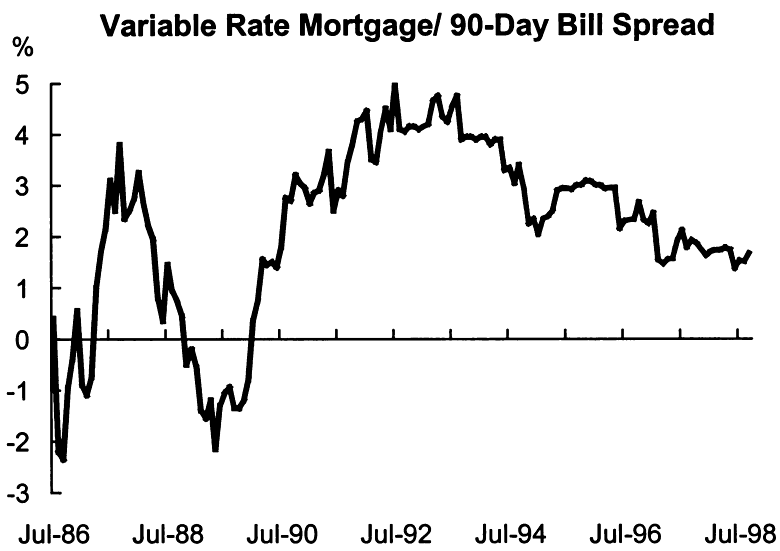
Variable Mortgage and 90-Day Bill Rates



source: Reserve Bank Bulletin

As Chart 3.5 shows, however, another factor has been a steady decline in the spread between mortgage and bill rates since the early 1990s. Until the early 1990s, movements in the spread conformed to the predictions of the risk-sharing hypothesis. The spread was negative in 1986 and 1989 when bill rates were rising, and became positive in 1987 and 1990 when bill rates were declining. The spread narrowed in 1994 as bill rates lifted in response to tighter monetary policy. Since then, however, there has been a further decline in spreads even though the bill rate has been declining – in contradiction to the risk-sharing hypothesis. According to Edey and Gray (1996), mortgage managers can profitably deliver a residential mortgage at the bill rate plus around 150 to 200 basis points, and it has been the competition from specialist mortgage providers which has forced banks to lower margins.

Chart 3.5

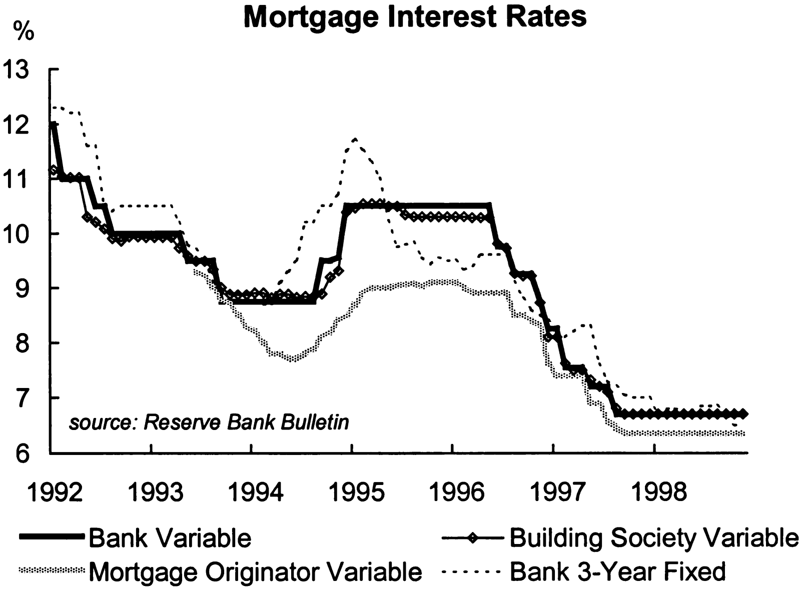


source: Reserve Bank Bulletin

Chart 3.6 compares the various lending rates since the early 1990s. The standard variable rates offered by banks and building societies have been almost identical over this period, reflecting the similarities between these two types of institutions in the post-deregulation period.

Data on the standard variable mortgage rate offered by mortgage managers has been available only since June 1993. Over this period, the rate offered by mortgage managers has been consistently below the bank variable rate, averaging a discount of 85 basis points. The maximum differential was 200 basis points in late 1994.

Chart 3.6
Mortgage Interest Rates



3.3: Refinancing

One of the features of the housing finance market in the 1990s has been the rapid growth in refinancing. This has risen from 8.4% of new lending in 1991/92 (when statistics were first collected) to a peak of 23.1% in 1996/97, before slowing to 19.8% in 1997/98. These figures understate the importance of refinancing as they count only loans refinanced at a different institution. Switching from a variable rate loan to a fixed rate loan at the same lending institution is not included in the figures.

Banks have accounted for 69% of the growth in refinancing since 1991/92, with mortgage managers and other lenders making up the remainder[4]. The proportion of loans refinanced by banks has declined from 84% in 1991/92 to 74% in 1997/98. The share of mortgage managers and other lenders has risen from 6% to 22% over the same period[5].

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[4] Separate statistics on mortgage managers are available only since July 1995.

[5] Unfortunately, there are no statistics on the split of refinancing into variable and fixed rate mortgages.

Chart 3.7

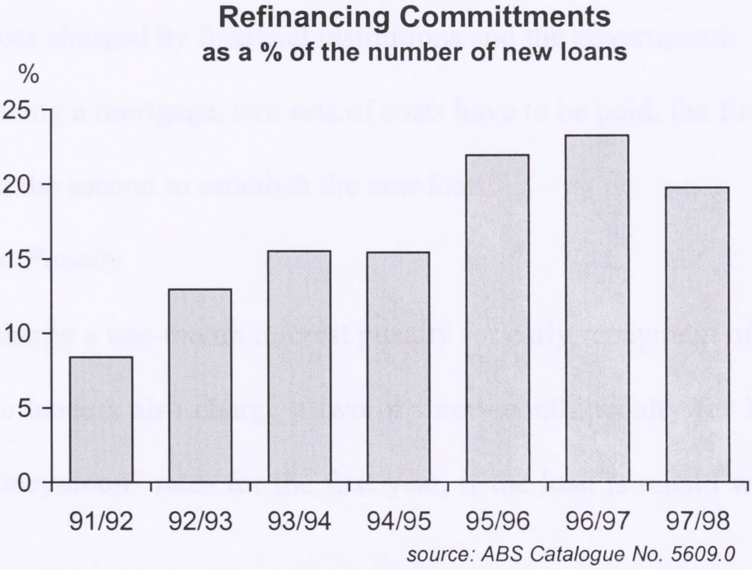
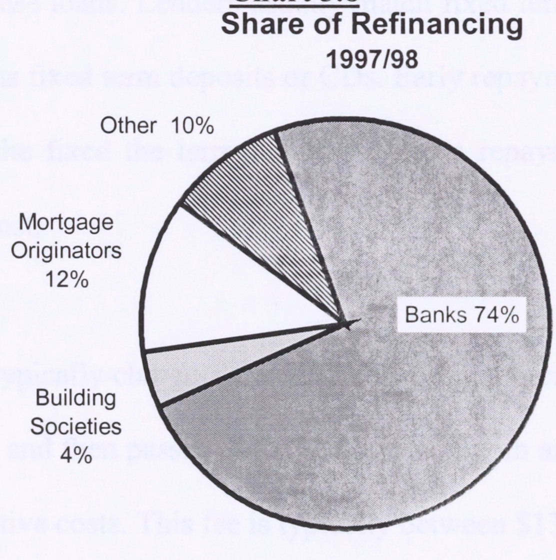


Chart 3.8



source: ABS Catalogue No. 5609.0

3.4: Switching Costs

Switching costs can include search and "shoe leather" costs such as the cost of learning the different rates and conditions on the new loan, and filling out forms and attending interviews. Lenders typically charge commencement fees to help offset the cost of assessing the creditworthiness of potential borrowers. There are also costs imposed by the government, such as stamp duty and financial transactions tax. This section will examine the switching costs charged by financial institutions and the government.

When refinancing a mortgage, two sets of costs have to be paid, the first to terminate the original loan and the second to establish the new loan.

Early Repayment Penalty

Most banks charge a one-month interest penalty for early repayment of standard variable rate loans. Some lenders also charge a two or three-month penalty for loans with special introductory "honeymoon" rates for the first year, if the loan is repaid within the first few years.

There is generally an early repayment penalty on fixed rate loans. This is because of the way lenders finance these loans. Lenders usually match fixed term loans with liabilities of similar maturity, such as fixed term deposits or CDs. Early repayment leaves the lender still committed to paying the fixed the term liabilities, and a repayment penalty is generally charged to offset this cost.

Mortgage Discharge

State governments typically charge a fee for discharging a mortgage. This fee is usually incurred by the lender, and then passed onto the borrower, with an extra fee added to cover the lender's administrative costs. This fee is typically between $130 to $200.

Financial Institutions Duty

Financial Institutions Duty (FID) of around 0.06% is charged on deposits to accounts (such as mortgage repayment) in all states except Queensland.

Establishment Fees

Most lenders charge an establishment fee, which averages around $600 for banks. Some lenders charge additional fees for valuation of the property, their own legal costs, and title searches. However, lenders are often willing to reduce or waive these fees to attract low risk borrowers. Lenders sometimes offer special reduced fee offers during campaigns to increase market share.

Mortgage Stamp Duty

Stamp duty is levied by all states (but not by the ACT or NT) on new mortgage lending at an average level of around $350 on a $100,000 mortgage. Since 1996, some states have offered stamp duty exemptions for refinanced mortgages in a bid to increase home lending competition. NSW and Queensland introduced refinancing exemptions in July 1996 and Victoria followed in May 1997. NSW Treasurer Michael Egan made the following comment in 1996 after he abolished stamp duty on refinancing;

"*Up until now banks and financial institutions have been protected by this tax on refinancing. Now borrowers will be able to chase the best interest rate deals.*"[6]

NSW Treasury estimated that the stamp duty exemption would cost the NSW government $20 million per annum in foregone revenue.

[6] NSW Budget Paper No. 1, May 1996, p.11.

Table 3.1
Mortgage Stamp Duty

	Mortgage Amount	Stamp Duty	Duty on $100,000	Refinancing Exemption
ACT		none	$0	
NT		none	$0	
NSW	up to $16,000	$5		Yes
	over $16,000	$5 plus $4 for every $1,000 over $16,000	$341	since July 1996
QLD	up to $70,000	None		Yes – the first $100,000 only
	over $70,000	$4 for every $1,000 over $70,000	$120	since July 1996
SA	up to $4,000	$10		No
	$4,000 to $10,000	$0.25 for every $100 over $4,000		
	over $10,000	$0.35 for every $100 over $10,000	$340	
TAS	up to $10,000	0.25% of value		No
	over $10,000	0.35% of value	$340	
VIC	up to $10,000	$4		Yes
	over $10,000	$4 plus $0.80 for every $200 over $10,000	$364	since May 1997
WA	up to $35,000	0.25% of value		No
	over $35,000	0.40% of value	$348	

Mortgage Registration

Most state governments charge a fee of between $50 to $90 for the registration of a new mortgage with the Land Titles Office.

3.5: Refinancing Examples

Table 3.2 illustrates some simple refinancing examples for three different sized mortgages at an existing interest rate of 7%. The switching costs are assumed to include a one-month early repayment interest penalty. The example is shown for the case where stamp duty is levied on the mortgage (at NSW rates), and where no stamp duty is charged. Three refinancing scenarios are examined. The first is for refinancing into a new loan offering a one-year fixed "honeymoon" rate before converting to the standard variable rate.

The second is for switching into a three-year fixed rate and the third is for switching to a five-year fixed rate. The break even interest rate saving is the interest rate differential required to make the cost of switching equal to the present value of the interest savings, discounted at the new mortgage rate. In other words, it is the interest rate reduction required for the borrower to be indifferent between switching or retaining the existing mortgage, in discounted present value terms.

Table 3.2
Refinancing an Existing 7% Mortgage

Loan Balance Outstanding	$50,000	$100,000	$200,000
Annual Interest Bill	$3,500	$7,000	$14,000
Switching Costs;			
Early Repayment Penalty	$292	$583	$1,167
FID	$30	$60	$120
Mortgage Discharge & Registration	$200	$200	$200
Loan Establishment Fee	$600	$600	$600
Stamp Duty	$141	$341	$741
Total	***$1,263***	***$1,784***	***$2,828***
Break even interest rate saving			
with mortgage stamp duty			
1-year "honeymoon" rate	2.5%	1.8%	1.4%
3-year fixed rate	0.9%	0.6%	0.5%
5-year fixed rate	0.6%	0.4%	0.3%
without mortgage stamp duty			
1-year "honeymoon" rate	2.2%	1.4%	1.0%
3-year fixed rate	0.8%	0.5%	0.4%
5-year fixed rate	0.5%	0.3%	0.2%

The examples are based on the *expected* savings from refinancing, assuming that the variable rate on the old mortgage is unchanged during the period of the new interest rate.

The examples show that for a typical $100,000 mortgage, there needs to be an interest rate discount of more than 1.8 percentage points, or 1.4 percentage points if stamp duty is not levied, in order for refinancing into a one-year fixed rate to be profitable. The interest rate differential becomes smaller as the duration of the interest rate on the new loan increases. The differential falls to 40 basis points for a five-year fixed rate.

The differential also becomes smaller as the size of the loan increases because a proportion of the switching costs are fixed. Only the early repayment penalty, FID and stamp duty, rise in proportion to the size of the loan.

The break even interest rate differential is larger for higher existing interest rates. This is because of two factors. First, the interest rate penalty for early repayment is larger at higher interest rates. Second and more importantly, the higher discount rate means that future interest payment savings are less valuable in present value terms. Table 3.3 shows the same refinancing examples for an existing mortgage interest rate of 10%.

Table 3.3
Refinancing an Existing 10% Mortgage

Loan Balance Outstanding	$50,000	$100,000	$200,000
Annual Interest Bill	$5,000	$10,000	$20,000
Switching Costs;			
Early Repayment Penalty	$417	$833	$1,667
FID	$30	$60	$120
Mortgage Discharge & Registration	$200	$200	$200
Loan Establishment Fee	$600	$600	$600
Stamp Duty	$141	$341	$741
Total	***$1,388***	***$2,034***	***$3,328***
Break even interest rate saving with mortgage stamp duty			
1-year "honeymoon" rate	2.8%	2.0%	1.7%
3-year fixed rate	1.0%	0.7%	0.6%
5-year fixed rate	0.7%	0.5%	0.4%
without mortgage stamp duty			
1-year "honeymoon" rate	2.5%	1.7%	1.3%
3-year fixed rate	0.9%	0.6%	0.5%
5-year fixed rate	0.6%	0.4%	0.3%

Section 4 – The Data

4.1: Introduction

This section describes the data used in the estimation of the models. Two models are estimated. The first is a time series analysis of the determinants of refinancing. It also investigates whether refinancing was boosted significantly by the removal of mortgage stamp duty on refinancing in NSW, Queensland and Victoria. The second model updates the Lowe and Rohling (1992) model of mortgage rate stickiness to examine whether the rise in refinancing has contributed to lower mortgage rate stickiness.

4.1.1: Data Used in the Refinancing Model

The literature review suggests that the following factors should influence the refinancing decision:

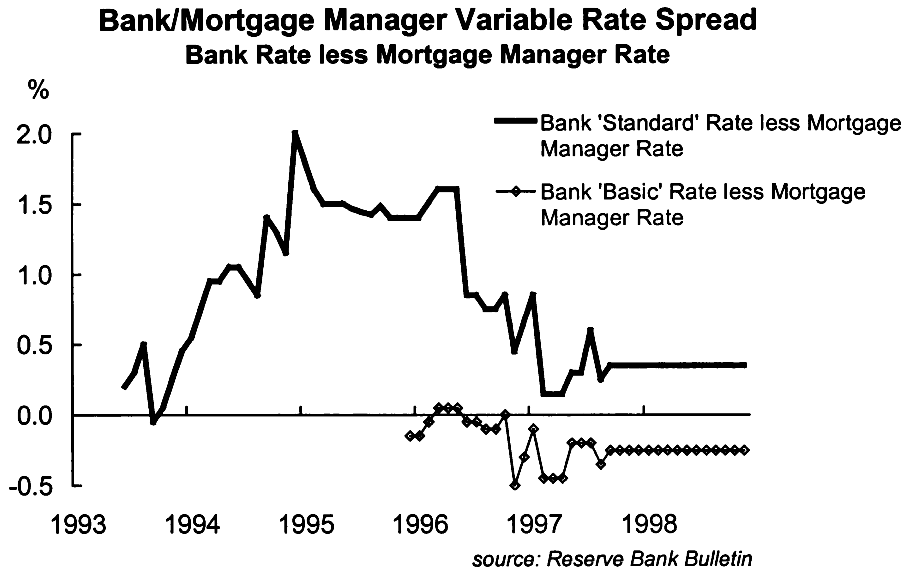
- the spread between the existing interest rate and the refinancing rate,
- home equity levels,
- personal income,
- mortgage interest rate volatility.

Most previous studies of the refinancing decision have been based on micro-data. This is a study of aggregate refinancing levels, so some of the variables listed above are unavailable. For instance, individual personal income and individual home equity levels. Instead, we use real average weekly ordinary time earnings (AWOTE) to measure personal income, and median house prices to capture variations in collateral values. All of these data suffer from aggregation problems. AWOTE, for instance, is a measure of average labour income of wage and salary earners and may not adequately represent the earnings of potential mortgage refinanciers. Furthermore, it does not capture non-labour income such as interest, dividends and social welfare payments, nor does it account for taxation changes affecting disposable income. And as a measure of individual worker earnings, it does not measure trends in household income where more than one member of the household is employed. Household income is likely to more important than individual income for the refinancing decision.

Median house prices suffer similar aggregation problems. The median, being the central point in the distribution, masks movements in either end of the price distribution, which could influence the decisions of many mortgage borrowers to refinance.

The choice of the refinancing interest rate is also problematic. We use the three-year fixed mortgage rate charged by banks. The use of this rate presumes that most refinancing is from variable rate to fixed rate mortgages. Anecdotal evidence, however, indicates that some refinancing is from a bank variable rate mortgage to a variable rate loan offered by a mortgage manager. The refinancing statistics do not identify the type of loans in the refinancing transaction. Furthermore, the Reserve Bank has been publishing the average variable loan rate charged by mortgage managers only since June 1993. This means there are too few observations to be able to tell, econometrically, whether the fixed rate or the mortgage manager variable rate has the greatest influence on refinancing behaviour. The variable rate loans offered by mortgage managers and banks may not be directly comparable also. Banks typically offer cheque accounts with ATM access and mortgage offset accounts with their loans. Offset accounts allow part, or all of a customer's debit account balances to be offset against the outstanding housing loan when calculating interest payments. Banks may also offer flexible redraw facilities that allow the customer to borrow extra amounts to finance renovations or general spending. The loans offered by mortgage managers typically have fewer, or none, of these features. Chart 4.1 shows that the spread between the bank and mortgage manager variable rates peaked at two percentage points in late 1994, possibly high enough to trigger refinancing.

Chart 4.1



The response of banks to the competition from mortgage managers has been twofold. First, banks have lowered their standard variable interest rate closer to the rate charged by mortgage managers. The spread has settled at 35 basis points since September 1997. Second, banks have introduced a basic, no-frills, variable rate mortgage. The basic bank variable rate mortgage typically comes without cheque and offset accounts and redraw facilities, and often has monthly and annual fees. The basic bank rate has been offered at a 25 basis point discount to the mortgage manager rate since September 1997. The refinancing examples presented in Section 3 suggest that spreads at these levels are unlikely to create an incentive to swap a bank variable rate for a mortgage manager variable rate loan. It seems likely that banks will maintain the spread to mortgage managers within a relatively narrow range. If so, there is likely to be little refinancing between bank and mortgage manager variable rate loans, and the spread between the variable and 3-year fixed mortgage rate should be a better explanator of refinancing behaviour.

In addition to the variables suggested by pooled data studies from the United States, we also consider several additional variables that could influence aggregate refinancing levels. These are:

- The unemployment rate. This is to capture changes in the degree of adverse selection. Adverse selection problems should be greater when unemployment is high or rising.
- The degree of competition. This is measured by the share of housing lending by "other" lenders[1] in total lending. If a lack of competition has been preventing borrowers from profitably refinancing, then increases in the degree of competition should be accompanied by a rise in the level of refinancing. This variable should also capture some of the "structural change" factors highlighted by Bennett, Peach and Peristiani (1997), which they found increased the propensity to refinance.
- The abolition of stamp duty on mortgage refinancing by the NSW, Queensland and Victorian governments in 1996 and 1997.
- The spread between the 90-day bank bill rate and the Reserve Bank's official overnight cash rate target. This is to capture expectations about the future stance of monetary policy. Refinancing is likely to rise when the bill rate is above the official cash rate, signalling money market expectations of a monetary policy tightening.

4.1.2: Data Description and Results of Unit Root Testing

This section contains the results of unit root tests on the data used in estimation. The tests are conducted using the step by step procedure suggested by Holden and Perman (1994). The equation $y_t = \alpha + \beta t + \rho y_{t-1} + \sum_i \vartheta_i \Delta y_{t-i} + e_t$ is estimated with sufficient lags of the differenced term to remove any autocorrelation. The critical values for the

[1] Which includes mortgage managers, credit unions, insurance offices, State government housing schemes, and superannuation funds. It does not include permanent building societies.

Φ_3, Φ_2, Φ_1 tests are from Dickey and Fuller (1981). The critical values for the ADF test are from Mackinnon (1991). All of the critical values are presented for the 95% significance level.

The unit root tests have non-stationarity (a unit root) as the null hypothesis. One problem is that the tests have low power[2]. This means they will only reject the hypothesis of a unit root when there is strong evidence against it. Despite this, the augmented Dickey-Fuller equation is the most popular basis for unit root tests. This is due to its simplicity and because Monte Carlo studies such as Haug (1993, 1996) have found that it performs well.

[2] The power of a significance test is the probability of rejecting an untrue null hypothesis.

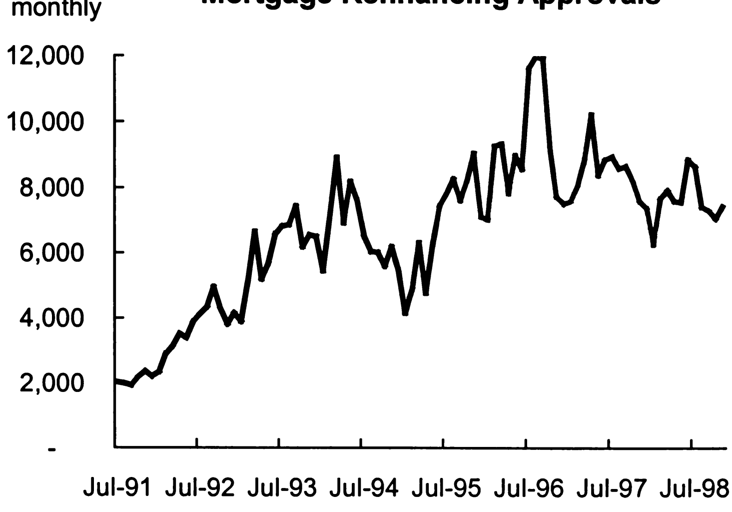
Refinancing

Data on refinancing are available from the Bureau of Statistics on a monthly basis from July 1991. The data are seasonally adjusted and relate to the number of secured housing finance commitments made by significant lenders to individuals. According to the Bureau of Statistics, the data covers at least 95% of secured finance commitments for housing. The refinancing statistics exclude an institution's refinancing of its own loans over the same dwelling. Therefore, the switching from a variable to a fixed rate loan at the same institution is not captured in the refinancing statistics.

Table 4.1: Results of Unit Root Testing

	Test Statistic	Critical Value	Null Hypothesis
Australia Wide Refinancings 1991:7-1998:11			
Φ_3	6.15	6.49	$(\alpha,\beta,\rho)=(\alpha,0,1)$
ADF	-2.58	-3.46	$\rho=1$
Φ_2	5.13	4.88	$(\alpha,\beta,\rho)=(0,0,1)$
Φ_1	7.60	4.71	$(\alpha,\rho)=(0,1)$
Result: Unit Root with drift			

Chart 4.2
Mortgage Refinancing Approvals



Fixed Spread

This is the difference between the bank standard variable mortgage rate and the three-year fixed mortgage rate. Both series are available on a monthly basis from table F.4 in the Reserve Bank Bulletin.

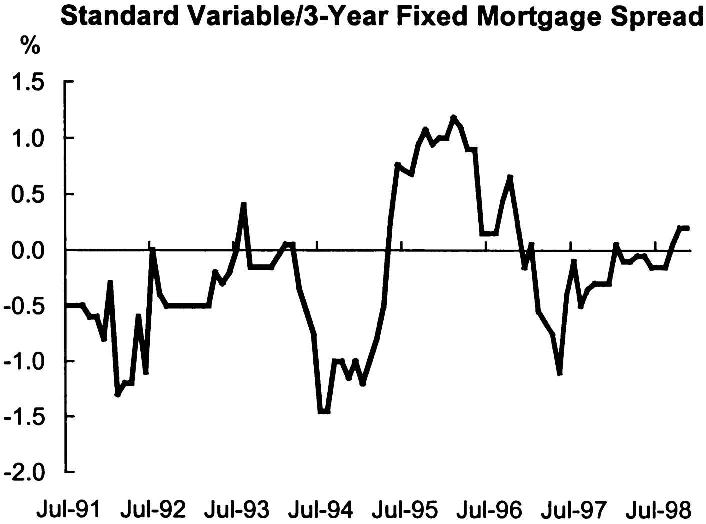
Table 4.2: Unit Root Test – Fixed Spread

	Test Statistic	Critical Value	Null Hypothesis
Fixed Spread 1991:7-1998:11			
Φ_3	2.43	6.49	$(\alpha,\beta,\rho)=(\alpha,0,1)$
ADF	-2.20	-3.46	$\rho=1$
Φ_2	1.65	4.88	$(\alpha,\beta,\rho)=(0,0,1)$
Φ_1	2.11	4.71	$(\alpha,\rho)=(0,1)$
Result: Unit Root with Zero Drift			

The finding of a unit root in the spread between the variable and fixed mortgage interest rates should be treated cautiously. As mentioned previously, the unit root tests have low power, meaning they have a tendency to falsely accept the null hypothesis of non-stationarity. It makes little economic sense for an interest rate spread to exhibit non-stationarity – they cannot become arbitrarily large. It may be that over a longer sample period, covering more than one economic cycle, the data would exhibit stationarity. However, as the testing finds evidence of a unit root for the available sample period, we will treat the variable as I(1) for the purposes of estimation.

Chart 4.3

Standard Variable/3-Year Fixed Mortgage Spread



Cash Spread

This is the difference between the 90-day bank accepted bill rate and the Reserve Bank's target for the official overnight cash rate. Both series are available on a monthly basis from table F.4 in the Reserve Bank Bulletin.

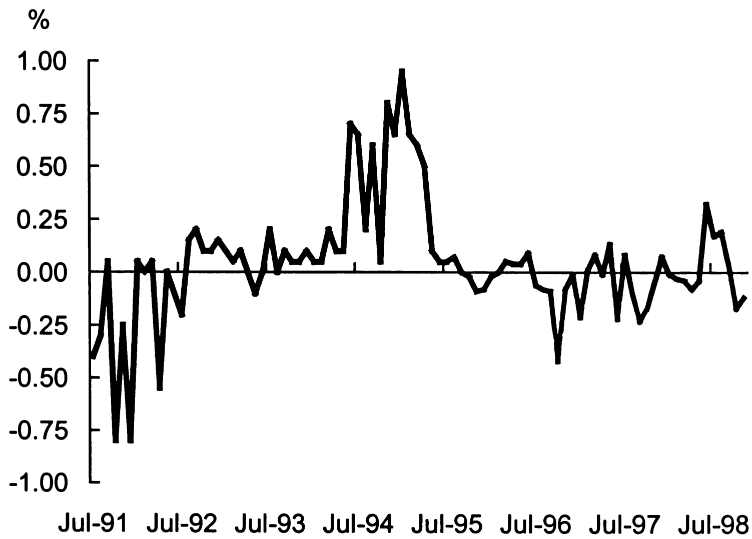
Table 4.3: Unit Root Test – Cash Spread

	Test Statistic	Critical Value	Null Hypothesis
Cash Spread 1991:7-1998:11			
Φ_3	4.31	6.49	$(\alpha,\beta,\rho)=(\alpha,0,1)$
ADF	-2.88	-3.46	$\rho=1$
Φ_2	2.79	4.88	$(\alpha,\beta,\rho)=(0,0,1)$
Φ_1	4.21	4.71	$(\alpha,\rho)=(0,1)$
Result: Unit Root with Zero Drift			

The finding of non-stationarity for the spread between the 90-day bill rate and the Reserve Bank official overnight cash rate should be treated cautiously for the same reasons as discussed for the variable/fixed rate spread.

Chart 4.4

90-Day Bank Bill/Official Cash Rate Spread



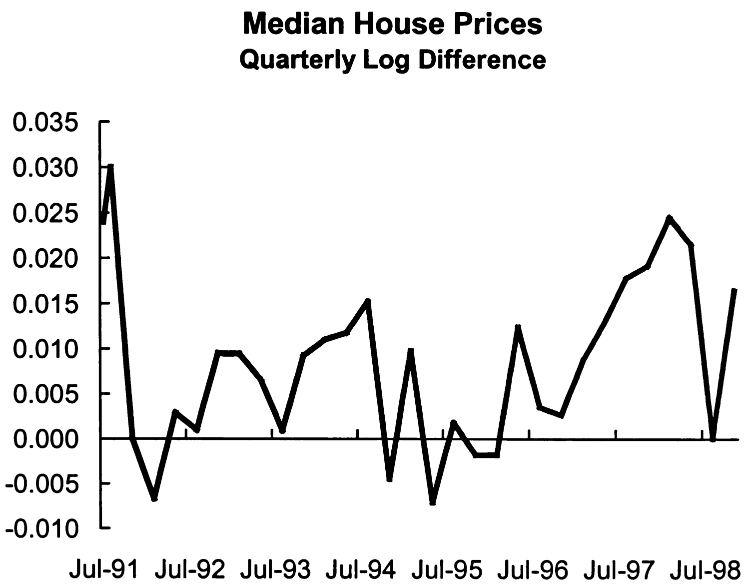
House Price

The median house price index is from ABS catalogue number 6416.0 and is available only on quarterly basis. A monthly series was created by linear interpolation between the quarterly observations. That is, the quarterly growth rates were converted to monthly rates using a compounding formula. The quarterly observations were applied to the mid-month of the quarter. The 3-month log difference of the interpolated series was used in the estimation.

Table 4.4: Unit Root Test–House Prices, Quarterly Log Difference

	Test Statistic	Critical Value	Null Hypothesis
Australian House Price 1991:7-1998:11			
Φ_3	3.95	6.49	$(\alpha,\beta,\rho)=(\alpha,0,1)$
ADF	-2.64	-3.47	$\rho=1$
Φ_2	2.75	4.88	$(\alpha,\beta,\rho)=(0,0,1)$
Φ_1	4.13	4.71	$(\alpha,\rho)=(0,1)$
Result: Unit Root with zero drift			

Chart 4.5



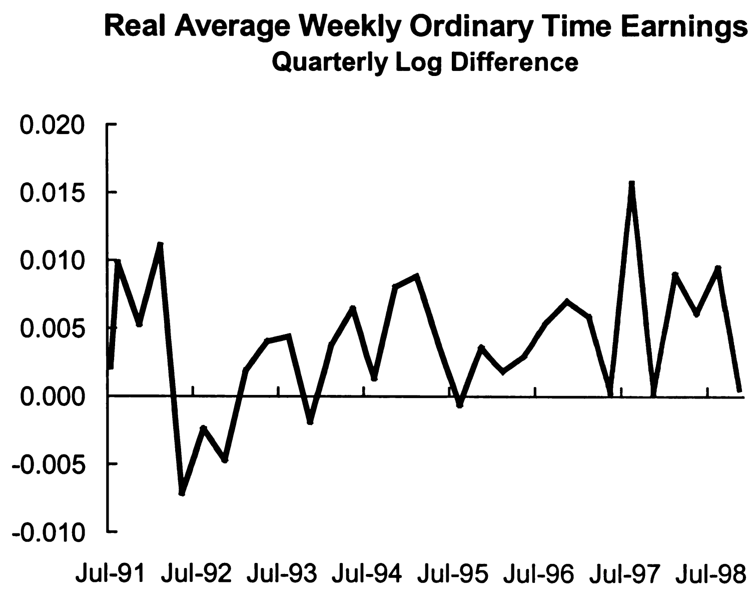
Earnings

Seasonally adjusted average weekly ordinary time earnings (ABS catalogue no. 6301.0) divided by the "Treasury Underlying" measure of the Consumer Price Index (ABS catalogue no. 6401.0). As for the house prices series, the quarterly figures have been converted into monthly series by linear interpolation, and the three-month log difference has been used in estimation.

Table 4.5: Unit Root Test – Earnings - Quarterly Log Difference

	Test Statistic	Critical Value	Null Hypothesis
Real Earnings 1991:7-1998:11			
Φ_3	7.82	6.49	$(\alpha,\beta,\rho)=(\alpha,0,1)$
t-statistic	-3.95	-2.00	$\rho=1$
t-statistic	3.15	2.00	$\beta=0$
Result: Stationary series with a linear trend			

Chart 4.6



Unemployment

Seasonally adjusted unemployment rate from ABS catalogue no. 6203.0.

Table 4.6: Unit Root Test – Unemployment Rate

	Test Statistic	Critical Value	Null Hypothesis
Unemployment Rate 1991:7-1998:11			
Φ_3	3.68	6.49	$(\alpha,\beta,\rho)=(\alpha,0,1)$
ADF	-2.71	-3.47	$\rho=1$
Φ_2	3.01	4.88	$(\alpha,\beta,\rho)=(0,0,1)$
Φ_1	1.57	4.71	$(\alpha,\rho)=(0,1)$
Result: Unit Root with Zero Drift			

Chart 4.7

Other Share

The share of seasonally adjusted "other lenders" in total monthly home finance commitments from ABS catalogue no. 5609.0.

Table 4.8: Unit Root Test – Other Share

	Test Statistic	Critical Value	Null Hypothesis
Other Share 1991:7-1998:11			
Φ_3	3.90	6.49	$(\alpha, \beta, \rho) = (\alpha, 0, 1)$
ADF	-2.75	-3.47	$\rho = 1$
Φ_2	2.61	4.88	$(\alpha, \beta, \rho) = (0, 0, 1)$
Φ_1	0.58	4.71	$(\alpha, \rho) = (0, 1)$
Result: Unit root with zero drift			

Chart 4.7

"Other Lenders" Share of Commitments

Interest Rate Volatility

Interest rate volatility is the most difficult variable to measure correctly. The pooled data studies from the United States typically use volatility measures that match the borrowing horizons of individuals within their samples. For example, Dickinson and Heuson (1993) measure volatility as the standard deviation of the ten monthly 10-year constant maturity Treasury yields that preceded refinancing, lagged two months, for each of the 496 observations on refinancing in their pooled data set. This measure of volatility was insignificant in their refinancing equation.

Giliberto and Thibodeau (1989) measure volatility as the variance of monthly averages of mortgage interest rates over their sample period. They find that the probability a mortgage will be refinanced is negatively related to mortgage rate volatility. Peristiani, Bennett, Monsen, Peach and Raiff (1997) measure volatility as the historical standard deviation of the ten-year Treasury bond rate during the time from purchase to refinancing for each individual in their sample. They find this variable is significant, but has the wrong sign. Bennett, Peach and Peristiani (1997) measure volatility using the implied volatility calculated from options on 10-year Treasury note futures contracts. Bennett, Peach and Peristiani (1997) find that this measure of volatility is correctly signed and significant.

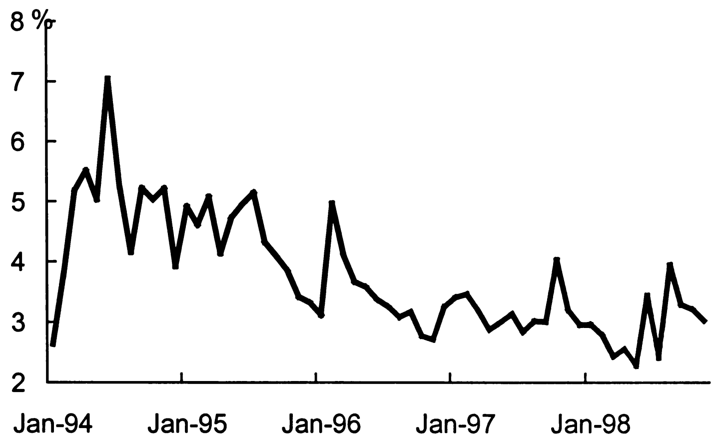
We follow the example of Bennett, Peach and Peristiani (1997) and use implied volatility as our measure of interest rate volatility. We use the implied volatility from rolling 3-month futures options contracts for three-year bonds traded on the Sydney Futures Exchange. Volatility is measured as at the last trading day of the month.

Implied volatility measures the market's current prediction of a security's future volatility[3]. Volatility is the standard deviation of the security's return over one year. The three-year bond future is used in order to match the horizon of our refinancing rate – the three year fixed rate mortgage. The data are sourced from Bloomberg and are available from January 1994.

Table 4.8: Unit Root Test – Interest Rate Volatility

	Test Statistic	Critical Value	Null Hypothesis
Implied Volatility 1994:1-1998:11			
Φ_3	13.02	6.49	$(\alpha,\beta,\rho)=(\alpha,0,1)$
t-statistic	-5.01	-2.00	$\rho=1$
t-statistic	-4.40	-2.00	$\beta=0$
Result: Stationary series with a linear trend			

Chart 4.9
Interest Rate Volatility
Implied Volatility on 3-Year Bond Futures



[3] Implied volatility is derived from the Black-Scholes pricing formula. See Hull (1991) for a description of the derivation of implied volatility.

4.2: Data Used in Model 2 (Lowe and Rohling (1992))

Standard Variable Bank Mortgage Rate

From table F.4 of the Reserve Bank Bulletin.

Table 4.8: Unit Root Test – Variable Mortgage Rate

	Test Statistic	Critical Value	Null Hypothesis
Unemployment Rate 1986:7-1999:5			
Φ_3	3.94	6.49	$(\alpha,\beta,\rho)=(\alpha,0,1)$
ADF	-2.81	-3.45	$\rho=1$
Φ_2	3.10	4.88	$(\alpha,\beta,\rho)=(0,0,1)$
Φ_1	1.18	4.71	$(\alpha,\rho)=(0,1)$
Result: Unit Root with Zero Drift			

Certificate of Deposit Rate

From table B.11 of the Reserve Bank Bulletin.

Table 4.9: Unit Root Test – CD Rate

	Test Statistic	Critical Value	Null Hypothesis
CD Rate 1986:7-1999:5			
Φ_3	5.21	6.49	$(\alpha,\beta,\rho)=(\alpha,0,1)$
ADF	-3.16	-3.45	$\rho=1$
Φ_2	3.70	4.88	$(\alpha,\beta,\rho)=(0,0,1)$
Φ_1	2.81	4.71	$(\alpha,\rho)=(0,1)$
Result: Unit Root with Zero Drift			

Section 5 – Results of Estimation

This section contains the results from the estimation of the two models. The first model is a time series analysis of the determinants of refinancing. It also investigates whether refinancing was boosted significantly by the abolition of mortgage stamp duty on refinancing in NSW, Queensland and Victoria. The second model updates the Lowe and Rohling (1992) model of mortgage rate stickiness to investigate whether the rise in refinancing has contributed to lower mortgage rate stickiness.

5.1: Model 1 – The Determinants of Refinancing

5.1.1: The Estimation Methodology

Section 4 described the variables to be included in the refinancing (REFI) equation.

- Home equity levels (HOUSE),
- The spread between the variable mortgage rate and the 3-year fixed rate (FIXEDSPREAD),
- The spread between 90-day bank bill rate and the official overnight cash rate (CASHSPREAD),
- Personal income (AWOTE),
- Mortgage rate volatility (VOL),
- The unemployment rate (UNEMP),
- The degree of competition (COMP).

Section 4 also demonstrated that REFI, HOUSE, FIXEDSPREAD, CASHSPREAD, UNEMP and COMP can be characterised as non-stationary and first-order integrated or I(1)[1]. The other two variables, AWOTE and VOL, are both trend-stationary.

[1] Although, as mentioned in Section 4, this finding should be treated cautiously for FIXEDSPREAD and CASHSPREAD.

The standard classical methods of econometric estimation are based on the assumption that the means and variances of the variables are constant over time. The presence of non-stationary variables violates this assumption, potentially giving rise to the "spurious regression" problem.[2] The exception is when a cointegrating relationship exists between the integrated variables, meaning that a linear combination of the variables produces a stationary error term. In other words, the variables have a tendency to move together over the long run. The absence of a cointegrating relationship implies the data should be differenced to remove non-stationarity, before proceeding with classical estimation techniques.

The empirical approach to be taken is as follows:

- Test for the existence and number of cointegrating relationships using the procedures suggested by Johansen (1988, 1991),
- Confirm the existence of a cointegrating relationship using the single equation, dynamic OLS method suggested by Stock and Watson (1993),
- Provided only one cointegrating relationship is found, estimate the disequilibrium (short-run) and equilibrium (long-run) relationships using an unrestricted error-correction model,
- Apply the standard diagnostic tests to the error-correction model.

5.1.2: Testing for the Number of Cointegrating Relationships

The number of cointegrating relationships are estimated using the procedure developed by Johansen. This involves applying maximum likelihood estimation to a vector autoregressive (VAR) representation of the series being estimated.

Unfortunately, the Bureau of Statistics has only published refinancing statistics since July 1991, so the sample period for the estimation is from July 1991 to November 1998

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[2] See Phillips (1986).

using monthly data. This means there are just 89 observations, creating degrees-of-freedom limitations when combined with six integrated variables and an unknown number of lagged terms. As a result, this study has adopted a pragmatic approach to testing for the presence of cointegration involving the following steps:

1. Apply the Johansen test to the six integrated variables using up to six lagged terms in the VAR.
2. Examine the cointegrating vector normalised on REFI for the coefficient sign and magnitude, and significance of the other I(1) variables.
3. Exclude a variable from the cointegration test on the basis of step 2 and conduct the test again.
4. Repeat step 3 until a cointegrating relationship is uncovered which is plausible from a theoretical perspective in terms of coefficient sign and magnitude, and is proven econometrically.

Table 5.1 shows the results of the Johansen testing for all six integrated variables, estimated from a VAR including up to six lagged terms. The test allows for the presence of an intercept in the cointegrating equations and a linear deterministic trend in the data. The figures in brackets are the coefficient standard errors. The table also presents the results for testing the number of cointegrating relationships at both the 5% and 1% significance levels. These results are based on the "trace" statistic, which is a likelihood ratio test of the null hypothesis, H_0, that there are exactly r cointegrating relationships, against the alternative, H_A, there are $p>r$ cointegrating relationships[3]. The final row shows the multivariate Akaike information criterion statistic (AIC), derived from an unrestricted vector autoregression involving all the variables. The multivariate AIC

[3] The critical values for the trace statistic are from Osterwald-Lenum (1992).

statistic provides a guide to the appropriate lag length for the Johansen testing. A general rule is that the preferred model has the smallest AIC statistic.

The cointegrating vector representing the largest eigenvalue has been normalised on REFI, and the coefficient signs have been reversed in order to simplify interpretation.

Table 5.1
Results of Johansen Testing
6 variables – normalised on REFI, sample: 1991:7 – 1998:11

No. of lagged terms		6	5	4	3	2	1
FIXEDSPREAD		-0.247	-1.556	1.734	0.704	0.744	0.243
		(0.118)	*(1.348)*	*(1.326)*	*(0.370)*	*(0.231)*	*(0.149)*
HOUSE		96.298	355.640	303.006	-97.385	-43.458	69.350
		(16.074)	*(239.453)*	*(282.279)*	*(66.55)*	*(22.702)*	*(17.436)*
CASHSPREAD		-0.974	-2.97446	2.350	-1.739	0.271	0.222
		(0.328)	*(2.5611)*	*(2.485)*	*(1.556)*	*(0.612)*	*(0.447)*
COMP		-0.341	-1.213	1.037	0.269	0.220	-0.091
		(0.066)	*(0.849)*	*(0.939)*	*(0.185)*	*(0.093)*	*(0.046)*
UNEMP		-1.0255	-3.579	3.006	0.826	0.695	0.295
		(0.202)	*(2.470)*	*(2.831)*	*(0.657)*	*(0.343)*	*(0.160)*
No. of	5%	6	6	6	6	2	3
Coint Eqns	1%	6	4	6	3	1	2
AIC		-9.855	-9.343	-9.183	-9.086	-9.246	-8.455

The results from Table 5.1 are uniformly poor. With six lags, the Johansen test indicates the presence of six cointegrating relationships. In other words, the system is of full-rank and all the variables are stationary, in contradiction of the unit root tests. The signs on all the coefficients vary as the lag length is changed. For example, at six lags, FIXEDSPREAD, CASHSPREAD and COMP are incorrectly signed. The coefficient on HOUSE implies that a one percentage point increase in the rate of quarterly house price inflation will increase refinancing levels by 96% – an implausibly large amount.

The poor results could be due to a number of factors:

1. Insufficient degrees of freedom.
2. Poorly measured explanatory variables.
3. Missing variables.
4. Rejection of the hypothesised refinancing relationship.

We will focus on reason 2 and sequentially exclude variables. The choice of variable to exclude first is relatively arbitrary and the first variable excluded is UNEMP, the unemployment rate. This variable was included to account for the possibility of increased adverse selection problems when unemployment is rising. There are two problems with the inclusion of the unemployment rate. Movements in the unemployment rate tend to lag the economic cycle (mostly due to labour hoarding), meaning it may not reflect the impact of economic downturns on the willingness of lenders to approve refinancing. And movements in the unemployment rate may not reflect changes in the average riskiness of the pool of potential refinanciers. Mortgage borrowers may be less prone to unemployment than the community in general.

Furthermore, UNEMP was only correctly signed at lags 5 and 6 in Table 5.1 and was significant only at lag 6.

Table 5.2 shows the results of Johansen testing after excluding UNEMP.

Table 5.2
Results of Johansen Testing
5 variables – normalised on REFI, sample: 1991:7 – 1998:11

No. of lagged terms		**6**	**5**	**4**	**3**	**2**	**1**
FIXEDSPREAD		0.260	0.211	0.281	0.347	0.499	0.408
		(0.051)	*(0.061)*	*(0.063)*	*(0.075)*	*(0.082)*	*(0.102)*
HOUSE		4.840	17.965	14.503	10.867	20.670	53.446
		(4.978)	*(5.281)*	*(5.477)*	*(6.802)*	*(7.195)*	*(12.55)*
CASHSPREAD		-0.711	-0.328	0.207	-0.021	0.4916	0.633
		(0.242)	*(0.224)*	*(0.196)*	*(0.242)*	*(0.216)*	*(0.259)*
COMP		-0.020	-0.008	0.004	-0.001	0.007	-0.004
		(0.008)	*(0.009)*	*(0.009)*	*(0.013)*	*(0.0129)*	*(0.017)*
No. of	5%	5	3	4	2	1	1
Coint Eqns	1%	3	3	3	1	1	1
AIC		-8.758	-8.537	-8.465	-8.354	-8.384	-7.682

Again the results are poor, with the trace statistic indicating the existence of between one to five cointegrating relationships at the 5% level, and one to three at the 1% level, depending on the number of lags. The magnitude of most coefficients varies with the number of the lags and some coefficients alternate signs. The second variable to be excluded is COMP, the share of "other" lenders in total lending and meant to capture the degree of competition in housing lending. It has the wrong sign three times in Table 5.2, and is insignificant whenever correctly signed.

Table 5.3 shows the results of Johansen testing after excluding COMP.

Table 5.3
Results of Johansen Testing
4 variables – normalised on REFI, sample: 1991:7 – 1998:11

No. of lagged terms		6	5	4	3	2	1
FIXEDSPREAD		0.288	0.178	0.351	0.370	0.537	0.438
		(0.046)	*(0.072)*	*(0.066)*	*(0.072)*	*(0.083)*	*(0.097)*
HOUSE		2.20	2.828	6.879	7.503	26.006	52.100
		(4.615)	*(6.121)*	*(6.197)*	*(6.687)*	*(7.019)*	*(10.474)*
CASHSPREAD		-0.124	-0.141	0.224	0.045	0.554	0.719
		(0.139)	*(0.190)*	*(0.185)*	*(0.210)*	*(0.210)*	*(0.238)*
No. of	5%	3	4	4	4	2	2
Coint Eqns	1%	2	3	4	3	1	1
AIC		-11.297	-11.225	-11.167	-10.857	-10.874	-10.113

Once more the results are poor, with the number of cointegrating vectors and coefficient magnitudes changing with the lag length. CASHSPREAD, the spread between the 90-day bank bill rate and the Reserve Bank's official overnight cash rate, seems the most poorly performing variable, being incorrectly signed at lags five and six.

Table 5.4 shows the results of Johansen testing after excluding CASHSPREAD.

Table 5.4
Results of Johansen Testing
3 variables – normalised on REFI, sample: 1991:7 – 1998:11

No. of lagged terms		6	5	4	3	2	1
FIXEDSPREAD		0.446	0.365	0.410	0.414	0.468	0.349
		(0.048)	*(0.061)*	*(0.068)*	*(0.072)*	*(0.098)*	*(0.109)*
HOUSE		2.160	1.126	2.309	7.734	17.887	52.07
		(5.034)	*(6.402)*	*(6.802)*	*(6.882)*	*(8.517)*	*(12.251)*
No. of	5%	1	3	3	1	3	3
Coint Eqns	1%	1	1	2	1	1	1
AIC		-10.609	-10.726	-10.616	-10.429	-10.471	-10.058

These results appear more promising. The coefficient on FIXEDSPREAD remains within a relatively narrow range, and the trace statistic indicates the presence of one cointegrating vector at the 1% level at all lags apart from four. However, HOUSE becomes implausibly large as the lag length shortens, and is insignificant at longer lags. As is discussed in Section 2, almost all of the US studies find an important role for collateral values in the refinancing decision. The failure of HOUSE to perform better most likely represents measurement problems. It is the quarterly difference in median house prices, interpolated into a monthly series. Median house prices may not provide an accurate guide to changes in the collateral values of refinanced mortgages if house price movements are not distributed uniformly. For example, the median will understate the extent of house price inflation if most of the gains are concentrated at the upper end of the house price distribution.

Table 5.5 shows the results of Johansen testing after excluding HOUSE.

Table 5.5
Results of Johansen Testing
2 variables – normalised on REFI, sample: 1991:7 – 1998:11

No. of lagged terms		**6**	**5**	**4**	**3**	**2**	**1**
FIXEDSPREAD		0.471	0.426	0.472	0.453	0.457	0.429
		(0.052)	*(0.070)*	*(0.079)*	*(0.084)*	*(0.104)*	*(0.127)*
No. of	5%	2	2	2	2	2	2
Coint Eqns	1%	1	1	1	1	1	1
AIC		-1.375	-1.458	-1.542	-1.494	-1.530	-1.593

These results are the most promising. The trace statistic indicates the presence of one cointegrating relationship at the 1% level at every lag. It also shows that two cointegrating relationships exist at the 5% significance level. Either result means that estimation can proceed to an unrestricted error cointegration model. The presence of one cointegrating vector means estimation with REFI and FIXEDSPREAD in levels is appropriate, while two cointegrating vectors implies both variables are stationary, again making levels estimation appropriate.

The coefficient on FIXEDSPREAD is consistently significant and remains within a relatively narrow range, between 0.426 to 0.472. Its magnitude is plausible, suggesting that a one percentage point rise in the spread between the standard variable and three-year fixed mortgage rates will lead to around a 45% increase in the level of refinancing. It should be recalled that this is a long-run coefficient. It implies that a *sustained* one percentage point increase in the interest rate spread will eventually result in a 45% increase in refinancing. The refinancing examples in Section 3 suggested that a $100,000 mortgage could be profitably refinanced at a variable/3-year fixed spread of over 0.5% points, and a $200,000 mortgage could be refinanced at a 0.4% point spread.

Table 5.6 summarises the results of the Johansen testing for all the combinations of integrated variables.

Table 5.6
Results of Johansen Testing using 6 lags

No. of I(1) Variables		6	5	4	3	2
FIXEDSPREAD		-0.247	0.260	0.288	0.446	0.471
		(0.118)	*(0.051)*	*(0.046)*	*(0.048)*	*(0.052)*
HOUSE		96.298	4.840	2.200	2.160	
		(16.074)	*(4.978)*	*(4.615)*	*(5.034)*	
CASHSPREAD		-0.974	-0.711	-0.124		
		(0.328)	*(0.242)*	*(0.139)*		
COMP		-0.341	-0.020			
		(0.066)	*(0.009)*			
UNEMP		-1.0255				
		(0.202)				
No. of	5%	6	5	3	1	2
Coint Eqns	1%	6	3	2	1	1

5.1.3: Testing for Cointegration Using "Dynamic" OLS

One of the difficulties facing this study has been the small sample period, causing a degrees-of-freedom problem. Estimating the Johansen procedure using six variables with six lags takes a large toll on the available 89 observations. In this section we check the robustness of the Johansen results by testing for cointegration within a simpler single equation framework. OLS provides unbiased estimates of cointegrating relationships in large samples[4]. However, Monte Carlo studies (in particular, Banerjee,

[4] OLS estimates of cointegrated systems exhibit "super consistency" in large samples.

Dolado, Hendry and Smith (1986)) have found that OLS performs poorly in small samples.

To overcome this, we use the "dynamic" OLS (DOLS) procedure suggested by Stock and Watson (1993). This involves augmenting a traditional OLS regression of the I(1) variables with leads and lags of differences of the right hand side variables. Specifically, we estimate the equation;

$$REFI_t = \alpha + \Phi OtherI(1)_t + \sum_{j=-i}^{i} \lambda_j \Delta OtherI(1)_{t-j} \tag{5.1}$$

Equation (5.1) is estimated for each of the cointegrating combinations tested using the Johansen procedure. To minimise degrees of freedom problems, we set the leads and lags equal to two. We test for cointegration by applying an ADF test to the residuals of the equations. The null hypothesis of non-cointegration is tested using the Phillips and Ouliaris (1990) critical values[5].

Table 5.7 summarises the results of the dynamic OLS estimation. We report only the coefficients and standard-errors for the I(1) variables.

[5] Kwiatkowski, Phillips, Schmidt and Shin (1992) have introduced a test that adopts cointegration as the null hypothesis. As Kennedy (1998) notes, the test frequently draws conclusions opposite to tests based on the non-cointegration null. Given the bias of most tests towards accepting the null unless there is strong evidence against it, the rejection of non-cointegration under the ADF test can be a more powerful finding.

Table 5.7
Results of Dynamic OLS Estimation
Dependent Variable: REFI

equation	A	B	C	D	E
Constant	9.083	8.474	8.615	8.664	8.842
	(1.127)	*(0.060)*	*(0.038)*	*(0.045)*	*(0.035)*
FIXEDSPREAD	0.354	0.390	0.481	0.406	0.384
	(0.076)	*(0.049)*	*(0.050)*	*(0.053)*	*(0.061)*
HOUSE	17.646	20.764	28.74	25.558	
	(7.278)	*(4.405)*	*(3.996)*	*(4.790)*	
CASHSPREAD	0.456	0.733	0.722		
	(0.270)	*(0.141)*	*(0.120)*		
COMP	0.010	0.020			
	(0.029)	*(0.007)*			
UNEMP	-0.0535				
	(0.105)				
$\overline{R}^2$	0.718	0.729	0.665	0.507	0.306
ADF residuals	-4.15	-4.46	-3.80	-3.50	-3.52
5% critical value	-4.71	-4.45	-4.11	-3.77	-3.37

The DOLS estimation broadly confirms the findings from the Johansen estimation. There is conclusive evidence of a cointegrating relationship only between REFI and FIXEDSPREAD (equation E). The coefficient on FIXEDSPREAD of 0.384 is smaller than estimated under the Johansen procedure, but within two standard errors of the coefficient estimates from Table 5.5.

Equation B narrowly rejects the null hypothesis of non-cointegration at the 5% level. However, the coefficients for HOUSE and CASHSPREAD appear implausibly large in this specification.

5.1.4: Formulating the Single Equation Error-Correction Model

Having determined that a cointegrating relationship exists between REFI and FIXEDSPREAD, we can now proceed to the estimation of an error correction model. We estimate an unrestricted error correction model, allowing the short-run dynamics and the long-run coefficients to be estimated simultaneously.

The equation to be estimated is as follows:

$$
\begin{aligned}
\Delta REFI_t = {} & \alpha + \Phi REFI_{t-1} + \Theta FIXEDSPREAD_{t-1} + \sum_{j=1}^{6} \lambda_j \Delta REFI_{t-j} \\
& + \sum_{j=1}^{6} \beta_j \Delta FIXEDSPREAD_{t-j} + \sum_{j=1}^{6} \pi_j \Delta CASHSPREAD_{t-j} \\
& + \sum_{j=1}^{6} \psi_j \Delta HOUSE_{t-j} + \sum_{j=1}^{6} \sigma_j \Delta COMP_{t-j} + \sum_{j=1}^{6} \upsilon_j \Delta UNEMP_{t-j} \\
& + \sum_{j=1}^{6} \pi_j DAWOTE_{t-j} + \varpi DVOL_t
\end{aligned}
\tag{5.2}
$$

where all the variables are as previously defined,

Δ signifies the first difference,

DAWOTE is the detrended AWOTE series (AWOTE is stationary around a linear time-trend).

DVOL (the implied volatility on three-year bond futures contracts) is the de-trended VOL series. It is included in contemporaneous terms only, as it is intended to measure current perceptions about the volatility of interest rate markets. Lagged values of implied volatility are unlikely to influence refinancing decisions.

It should be noted that equation (5.2) includes only lagged values of the explanatory variables (apart from VOL). This means that the potential endogeneity between refinancing and interest rate spreads, highlighted in Section 2, is not an issue in the estimation.

The full estimation of this model poses some practical problems as it uses 53 degrees of freedom (after allowing for lags), leaving only 36 usable observations. As a result, we are forced to bypass the usual general-to-specific methodology and begin with a subset of equation (5.2). We begin by estimating the unrestricted error correction model with only the variables shown in Table 5.5 to be in the cointegrating relationship, REFI and FIXEDSPREAD. That is, we begin with the following equation:

$$\Delta REFI = \alpha + \Phi REFI_{t-1} + \Theta FIXEDSPREAD_{t-1} + \sum_{j=1}^{6} \lambda_j \Delta REFI_{t-j} + \sum_{j=1}^{6} \beta_j \Delta FIXEDSPREAD_{t-j} \quad (5.3)$$

After testing for the significance of the short-run dynamics in this equation, we sequentially add each of the other explanatory variables. Those that are significant and correctly signed are retained, and those that are insignificant are discarded. The seven resulting regressions are shown in Table 5.8.

The first result to note is that the coefficient on lagged log-level refinancing ($REFI_{t-1}$) is negative and has a large *t*-statistic across all specifications, providing ad-hoc support for the Johansen finding of a cointegrating relationship between REFI and FIXEDSPREAD.[6]

The coefficient on the lagged level of FIXEDSPREAD is correctly signed and has a large *t*-statistic across all specifications.[7]

The lags of the difference of REFI are significant at the five percent level for all specifications apart from G, which has a smaller sample size.

The lags of the difference of HOUSE are highly significant.

All of the other short-term variables are either insignificant, or in the case of UNEMP, marginally significant but incorrectly signed.

[6] According to Kremers, Ericsson and Dolado (1992), the t-statistic on the lagged log level of the dependent variable in an ECM can be used to test for cointegration, although it has a non-standard distribution somewhere between the N(0,1) and Dickey-Fuller distributions.

[7] The coefficients on the long-run variables in the error-correction model do not have standard distributions and cannot be tested using conventional statistical tables. The estimates of the short-run variables, however, do have conventional distributions (Holden and Perman (1994)).

Table 5.8
Results of Error-Correction Estimation
Dependent Variable: ΔREFI, sample: 1991:7 – 1998:11

Specification	A	B	C	D	E	F	G
Constant	2.163	2.034	2.022	1.975	1.889	2.052	2.371
	(4.70)	(5.22)	(4.98)	(4.77)	(4.88)	(4.60)	(2.93)
$REFI_{t-1}$	-0.240	-0.226	-0.225	-0.219	-0.210	-0.228	-0.264
	(-4.67)	(-5.18)	(-4.94)	(-4.71)	(-4.82)	(-4.56)	(-2.92)
$FIXEDSPREAD_{t-1}$	0.089	0.079	0.053	0.078	0.078	0.079	0.092
	(3.28)	(4.21)	(2.39)	(4.00)	(4.17)	(3.74)	(3.80)
$\Sigma\Delta$REFI	-0.202	-0.180	-0.183	-0.178	-0.167	-0.177	-0.190
	{0.01}	{0.02}	{0.01}	{0.02}	{0.03}	{0.02}	{0.29}
$\Sigma\Delta$FIXEDSPREAD	-0.012						
	{0.22}						
$\Sigma\Delta$HOUSE		1.441	1.592	1.589	1.417	1.497	3.052
		{0.00}	{0.00}	{0.00}	{0.00}	{0.01}	{0.04}
$\Sigma\Delta$CASHSPREAD			-0.089				
			{0.12}				
$\Sigma\Delta$COMP				-0.001			
				{0.20}			
$\Sigma\Delta$UNEMP					0.006		
					{0.06}		
Σ DAWOTE						-0.016	
						{0.93}	
$DVOL_t$							0.007
							(0.43)
R^2	0.34	0.43	0.49	0.48	0.50	0.44	0.42
$\overline{R}^2$	0.21	0.30	0.33	0.31	0.34	0.25	0.22
Autocorrelation test							
AR(1)	0.53	1.43	1.39	0.53	0.52	1.48	3.45
	{0.46}	{0.23}	{0.24}	{0.47}	{0.47}	{0.22}	{0.06}
AR(6)	10.56	10.08	13.41	10.75	16.27	10.47	24.05
	{0.10}	{0.12}	{0.04}	{0.10}	{0.01}	{0.11}	{0.02}
AR(12)	15.70	18.26	15.13	19.26	29.22	18.12	11.69
	{0.21}	{0.11}	{0.23}	{0.08}	{0.00}	{0.11}	{0.07}
Jarque Bera test	2.01	3.63	9.88	0.99	1.72	2.86	2.84
(normality)	{0.37}	{0.16}	{0.01}	{0.61}	{0.42}	{0.24}	{0.24}

Notes: Numbers in parentheses () are t-statistics. Numbers in brackets {} are p-values.
The mean coefficient for lags 1 to 6 is reported for ΔREFI, ΔFIXEDSPREAD, ΔHOUSE, ΔCASHSPREAD, ΔCOMP, ΔUNEMP, and DAWOTE. The p-values are derived from chi-squared tests of the joint significance of the lags.
Specification G is estimated from 1994:01 due to the smaller sample size for VOL.

Specification B, which includes the lag differences of REFI and HOUSE in the short run dynamics is the best performing model.

After removing insignificant lags, specification B simplifies to:

$$\begin{aligned}\Delta REFI = &\underset{(6.08)}{1.94} - \underset{(-6.03)}{0.216}\, REFI_{t-1} + \underset{(4.11)}{0.068}\, FIXEDSPREAD_{t-1} - \underset{(-2.01)}{0.191}\, \Delta REFI_{t-1} \\ &- \underset{(-1.75)}{0.164}\, \Delta REFI_{t-2} - \underset{(-2.48)}{0.236}\, \Delta REFI_{t-3} - \underset{(-1.66)}{0.159}\, \Delta REFI_{t-6} \\ &+ \underset{(3.88)}{10.68}\, \Delta HOUSE_{t-4} \qquad (5.4)\end{aligned}$$

$$R^2 = 0.38 \quad \overline{R}^2 = 0.32$$

$$AR(1) = \underset{\{0.81\}}{0.06} \quad AR(6) = \underset{\{0.57\}}{4.82} \quad AR(12) = \underset{\{0.58\}}{10.41} \quad Jarque\,Bera = \underset{\{0.01\}}{10.23}$$

Equation (5.4) is free from autocorrelation, but according to the Jarque-Bera statistic, the removal of insignificant lags has made the residuals non-normal.

Equation (5.4) results in the following long-run relationship:

$$REFI = 8.969 + 0.313 FIXEDSPREAD \qquad (5.5)$$

The long-run coefficient on FIXEDSPREAD is smaller than the average of around 0.45 from the Johansen estimation. It is, however, within two standard deviations of the coefficient estimates in Table 5.5, apart from the estimate using six lags.

5.1.5: Diagnostic Testing on the Single Equation Error-Correction Model

Having arrived at a preferred single equation model for the refinancing relationship, the next step is to subject it to the usual barrage of diagnostic tests. We test for heteroskedasticity using the White (1980) test, misspecification using the Ramsey (1969) RESET test, and parameter stability using the Brown, Durbin and Evans (1975) CUSUM of squares test and Chow (1960) predictive failure test.

The White (1980) test involves regressing the squared residuals against all possible squares and cross-products of the regressors. White's test statistic is the observations-times-R-squared from the test regression and is asymptotically distributed as χ^2 with degrees of freedom equal to the number of slope coefficients in the test regression. The null hypothesis is the absence of heteroskedasticity. The test has been conducted using only the squares of the regressors. The cross products have been excluded because of degrees-of-freedom limitations. The test results are:

$$\chi^2(14) = 30.52, \quad p - value = 0.006,$$

which suggests the presence of heteroskedasticity. Coefficient estimates from Ordinary Least Squares are still consistent under the presence of heteroskedasticity, but are relatively inefficient and the variance-covariance matrix is no longer valid. As a result, equation (5.4) is re-estimated using the White (1980) heteroskedasticity consistent covariance matrix estimator, and the results are shown in equation (5.6).

$$\begin{aligned}\Delta REFI = &\underset{(4.86)}{1.94} - \underset{(-4.78)}{0.216}\, REFI_{t-1} + \underset{(3.66)}{0.068}\, FIXEDSPREAD_{t-1} - \underset{(-1.48)}{0.191}\, \Delta REFI_{t-1} \\ &- \underset{(-1.66)}{0.164}\, \Delta REFI_{t-2} - \underset{(-2.46)}{0.236}\, \Delta REFI_{t-3} - \underset{(-1.16)}{0.159}\, \Delta REFI_{t-6} \\ &+ \underset{(2.72)}{10.68}\, \Delta HOUSE_{t-4}\end{aligned} \tag{5.6}$$

The t-statistics are all smaller than in equation (5.4), with some of the lagged dependent variables becoming insignificant. The main conclusions from equation (5.4) are unchanged however, with FIXEDSPREAD and HOUSE remaining strongly significant.[8]

The RESET test involves augmenting the original regression with powers of the predicted values from the model. The significance of the extra variables is tested using an F-test. The additional variables should be insignificant under the null hypothesis of no misspecification. Table 5.9 presents the results of RESET tests on equation (5.4) using the second and third powers of the predicted values.

Table 5.9
Results of RESET Tests

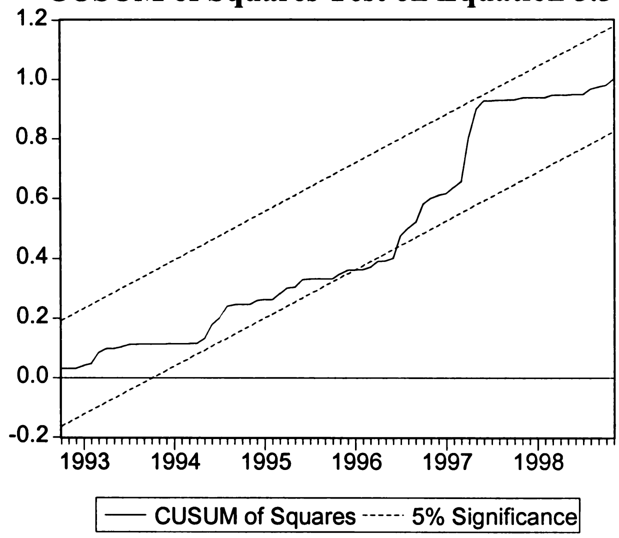
(fitted)^2	$F(1,73) = 4.66$, p-value = 0.03	(fitted)^2, (fitted)^3	$F(2,72) = 3.71$, p-value = 0.03

[8] Although as mentioned previously, FIXEDSPREAD has a non-standard distribution.

Table 5.9 shows that the null-hypothesis of no-misspecification is rejected at the 5% significance level, and is not rejected at the 1% level.

The CUSUM-of-squares test is based on the cumulative sum of recursive residuals squared. Chart 5.1 shows a plot of the outcome of a CUSUM of squares test, along with the 95% confidence band as calculated by EVIEWS. The cumulative sum of recursive residuals squares breaks the 95% confidence band once, but otherwise the test presents no signs of parameter instability. However, as Otto (1994) notes, the confidence bounds shown in Chart 5.1 are not strictly valid for models with lagged-dependent variables, but the test may still provide some informal evidence about parameter stability.

Chart 5.1
CUSUM of Squares Test on Equation 5.3



According to Otto (1994), a more formal test of parameter stability, which is valid for models with lagged dependent variables, is the Chow (1960) predictive failure test. This test estimates the model for a subsample comprised of the first T_1 observations. The estimated model is then used to predict the values of the dependent variable in the remaining T_2 data points. A large difference between the actual and predicted values casts doubts on the stability of the estimated relationship. The test statistic is distributed as χ^2 with degrees-of-freedom equal to the number of forecast points T_2. After accounting for lagged-terms, equation (5.4) is estimated over the period 1992:2 to 1998:11; a total of 82 observations. The Chow test is conducted for two subsamples; $T_2 = 27$ and $T_2 = 20$, representing respectively a third and one-quarter of the sample. For $T_2 = 27$ we obtain $\chi^2(27) = 60.929$ with a p-value of 0.000, and for $T_2 = 20$ we obtain $\chi^2(20) = 36.836$ with a p-value of 0.018. The test shows conclusive evidence of parameter instability in out-of-sample forecasts conducted from August 1996, and mixed evidence for out-of-sample forecasts conducted from March 1997.

Clearly, the specification in equation (5.4) suffers from some diagnostic problems. The RESET test suggests missing explanatory variables at the 5% level of significance. And although the CUSUM of squares test finds only mild evidence of parameter instability, the Chow predictive failure test finds strong evidence of parameter instability when out-of-sample forecasts are applied to one-third of the sample.

But the poor diagnostic results are possibly not surprising given the data limitations facing this study. As the literature review shows, most US studies find a consistent role for borrower income, collateral values and mortgage rate volatility in the refinancing decision. All of these variables have suffered from measurement problems in this study. Borrower income has been poorly proxied by real average weekly ordinary time earnings, collateral values by median house price movements and the variable measuring volatility has a truncated sample period.

Nevertheless, equation (5.4) highlights two important features of mortgage refinancing in Australia. First, it is sensitive to movements in the spread between the fixed and variable interest rates, and second, changes in house prices play a role as well. These results appear robust despite the diagnostic problems.

5.1.6: Testing For the Removal of Mortgage Stamp Duty

Section 3 discussed the switching costs involved in refinancing a mortgage. One of the largest is stamp duty on mortgages, levied by state governments. It averages around \$350 on a \$100,000 mortgage. The NSW and Queensland governments exempted refinanced loans from stamp duty in July 1996, and the Victorian government followed in May 1997. NSW accounted for 32% of all refinanced mortgages in 1996, Queensland accounted for 17% and Victoria, 24%. Therefore, nearly half of all mortgage refinancings were exempted from stamp duty in 1996, rising to nearly three-quarters in 1997. The removal of stamp duty could account for some of the parameter instability detected by the CUSUM of squares and Chow predictive failure tests. In Chart 5.1, the cumulative sum of recursive residuals squared moved outside the 95% confidence band at around the same time that stamp duty was lifted in NSW and Queensland. The removal of stamp duty may also account for the strong finding of parameter instability from the Chow predictive failure test for out-of-sample forecasts from August 1996.

Adding a dummy variable to equation (5.4) formally tests the impact of the stamp duty changes. The dummy variable takes a value of zero between July 1991 and June 1996, and a value of one from July 1996. The variable has a coefficient of 0.03, a *t*-statistic of 1.26 and a *p*-value of 0.21[9]. Although correctly signed, the result suggests that the lifting of stamp-duty has not had a statistically significant impact on refinancing behaviour.

[9] The *t*-statistic has been calculated using the White corrected standard error.

5.2: Model 2 – Mortgage Rate Stickiness

This section updates the interest rate stickiness model estimated by Lowe and Rohling (1992). They regressed the bank standard variable home mortgage rate against the certificate of deposit rate (CD rate) using monthly data from July 1986 to August 1991. The CD rate is used to measure the bank's marginal cost of funds, and the sample period begins in July 1986 to capture the post-deregulation period. The interest rate ceiling on new owner-occupied housing loans was removed in April 1986. They estimated the model;

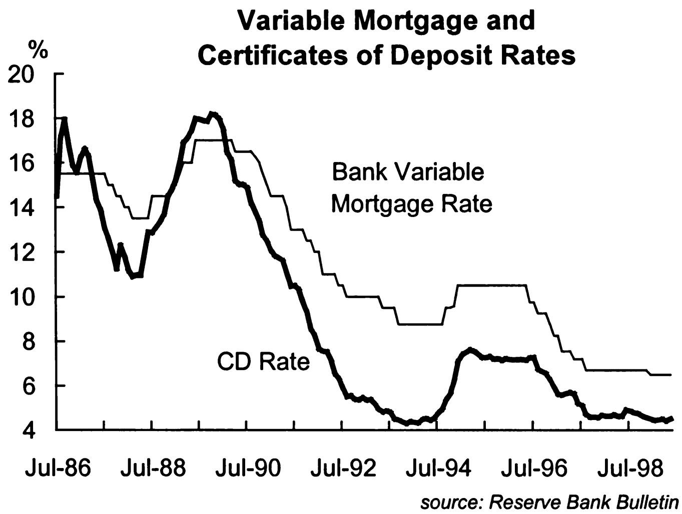
$$Mortgage\,Rate_t = \alpha + \beta\; CD\,Rate_t + \varepsilon_t\,.$$

Lowe and Rohling aimed to determine whether the coefficient on the cost of funds, β, was significantly different from unity. If price equals marginal cost, changes in the marginal cost of funds should be transmitted one for one into changes in the lending rate. They found β=0.40, suggesting that home mortgage rates exhibit some stickiness. They also estimated similar equations for interest rates on personal loans, credit cards, overdrafts, and small and large business lending rates. They found that credit card rates exhibited the highest degree of stickiness, followed by the personal loan rate, the housing loan rate, the overdraft rate and finally the business rates.

Lowe and Rohling dismiss equilibrium credit rationing as a cause of mortgage rate stickiness. They claim that banks are able to minimise moral hazard problems by being able to inspect and value the collateral for the loan. Adverse selection problems are minimal because there are few problems in determining the type of borrower since all owner-occupied housing lending is of similar risk. Lowe and Rohling suggest that switching costs and risk sharing (see Section 2) provide a better explanation for mortgage rate stickiness.

We re-estimate the Lowe and Rohling mortgage rate equation using data up to May 1999, to investigate whether the coefficient on the cost of funds, β, has changed over time. If β has become larger over time (as is the case), then the decline in switching costs and the degree of competition may be better explanators of stickiness than risk sharing (which should be invariant over time). The following chart plots the CD rate and the bank standard variable mortgage rate.

Chart 5.2



As the chart shows, the CD rate rose above the mortgage rate during the late 1980s. During the early 1990s the mortgage rate fell by less than the CD rate. From early 1994 to early 1995, the CD rate rose by 3.25 percentage points and the mortgage rate rose only 1.75 percentage points. These episodes suggest some support for the risk-sharing hypothesis. Between March 1995 and May 1999 however, a 3.1 percentage point *decline* in the CD rate was exceeded by a 4.0 percentage point fall in the standard variable mortgage rate, prima facie evidence at least that risk sharing may be less important in the current interest rate cycle.

Table 5.10 shows the estimation results.

Table 5.10: Test of Mortgage Rate Stickiness

$$Mortgage\ Rate_t = \alpha + \beta\ CD\ Rate_t + \varepsilon_t$$

Sample Period	α	β	$\bar{R}^2$	N
86:07 - 91:08	9.46 (0.67)	0.41 (0.05)	0.71	62
91:09 - 99:05	2.97 (0.88)	1.04 (0.12)	0.64	93
86:07 - 99:05	4.98 (0.46)	0.71 (0.04)	0.90	155

Chow Breakpoint test for 91:09 F=33.24 p-value = 0.00

note: figures in parentheses are standard errors

The equations were estimated using ordinary least squares, and we have followed Lowe and Rohling's example of correcting the covariance matrix for serial correlation and heteroskedasticity using the Newey-West procedure.[10]

The first equation duplicates Lowe and Rohling's sample period, and the second equation estimates over a subsequent sample period from September 1991 to May 1999. The value of β is much higher in the second period than in the first, and the Chow breakpoint test confirms the existence of a break. The final equation estimates the relationship over the entire sample period, showing that the estimate for β has lifted from Lowe and Rohling's estimate of 0.41 to 0.71.

A good way to identify the timing of a change in the relationship between mortgage rates and the CD rate is through recursive estimation. Chart 5.3 plots the residuals from one-step ahead forecasts estimated repeatedly from September 1986. As is evident, the residuals move outside the two standard error range in November 1996, suggesting that the pass-through relationship between changes in the cost of funds and the mortgage

[10] We have also followed Lowe and Rohling's view that interest rates should over time be characterised by a stationary process, making classical inference valid. This is despite Augmented Dickey Fuller tests suggesting both the mortgage rate and the CD rate are characterised by I(1) processes.

rate has changed significantly in the most recent interest rate cycle. This is close to the time of the NSW and Queensland refinancing stamp duty exemptions, providing some informal support for the proposition that the lowering of switching costs may have increased responsiveness of mortgage rates to the cost of funds.

Chart 5.3
Recursive Residuals

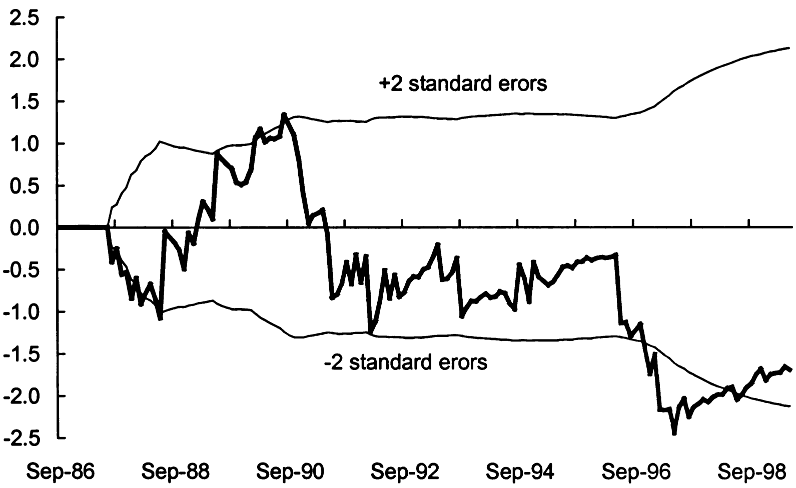
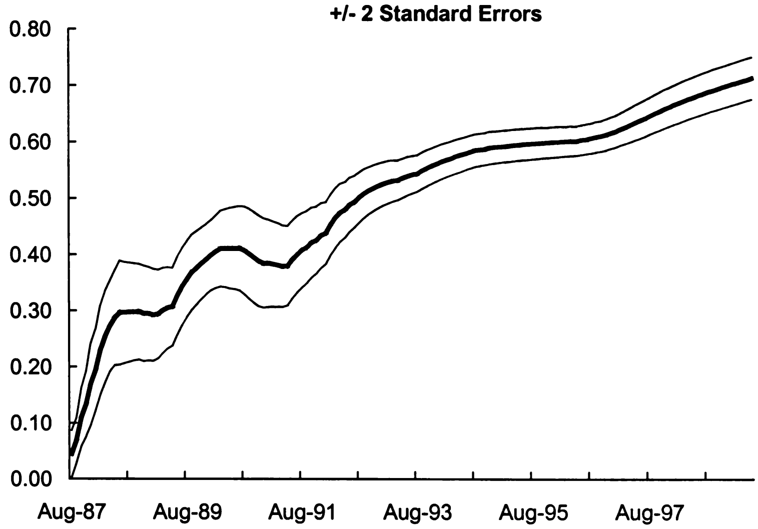


Chart 5.4 traces the evolution of β from recursive estimation, showing that its value has increased steadily over the sample period.

Chart 5.4
Recursive Estimates of β
+/- 2 Standard Errors



The main conclusion is that the variable mortgage rate has become more responsive to changes in the cost of funds. This suggests that risk sharing may not be as important an explanation of mortgage rate movements as Lowe and Rohling argued. Instead, greater competition in the home loan market, and declines in switching costs may be more important reasons for declining mortgage rate stickiness.

5.3: Conclusions

This major aim of this section has been to uncover, econometrically, the determinants of refinancing behaviour. Repeated Johansen testing uncovered evidence of cointegration between the log-level of refinancing and the spread between the variable mortgage rate and the 3-year fixed rate. It suggested that a sustained one-percentage point increase in the spread will lead to a 45% increase in the level of refinancing; a plausible estimate given the refinancing examples presented in Section 3. The Johansen estimation, however, did not find evidence of cointegration between refinancing and house prices, the unemployment rate, the degree of competition and monetary policy expectations.

An unrestricted error correction model was estimated, based on the cointegrating relationship between refinancing levels and the interest rate spread. This equation failed to find a role for interest rate volatility or de-trended real wages growth in explaining refinancing. It did, however, find a statistically significant role for the rate of median house price acceleration, suggesting that refinancing behaviour increases around four months after house price inflation starts rising.

Diagnostic testing provided some evidence of missing explanatory variables and parameter instability in the error correction model. Most likely, these are due to data measurement problems, however there was also evidence that some of the parameter instability occurred around the same time that some state governments abolished stamp duty on refinanced mortgages. A dummy variable to account for the abolition of stamp duty was found to be correctly signed, but insignificant, suggesting that the cut in stamp duty has not helped to increase refinancing.

The Lowe and Rohling (1992) model of mortgage rate stickiness was also updated, with the original July 1986 to August 1991 sample extended to May 1999. Although this model is not directly related to the issue of refinancing, it was updated in order to investigate whether Lowe and Rohling's original conclusion about the importance of risk sharing in the mortgage market is still valid. The extended sample period shows that movements in the mortgage rate have become more responsive to changes in the cost of funds, suggesting that risk-sharing has become less important. The equation also exhibits the greatest degree of parameter instability in late 1996. This is close to the time when stamp duty on refinancing was abolished, and provides informal support for the view that lower switching costs may have helped reduce mortgage rate stickiness.

Section 6 – Concluding Remarks

This thesis has provided the first empirical examination of mortgage refinancing in Australia. It has found a statistically robust relationship between the level of refinancing and the spread between the 3-year fixed mortgage rate and the standard variable mortgage rate charged by banks. It has also shown that the rate of house price acceleration or deceleration plays a role in the refinancing decision.

One of the key policy issues arising from this thesis is the analysis of the impact of the removal of mortgage stamp duty on refinancing in NSW, Queensland and Victoria in 1996 and 1997. The removal of stamp duty was intended to boost competition in the mortgage lending market. The decision cost NSW $20 million in foregone revenue in the first year of operation. The inverse elasticity rule in public finance theory holds that tax rates should be inversely proportional to elasticities. As Rosen (1995)[1] states: "An efficient set of taxes should distort decisions as little as possible." An important question, therefore, is whether the removal of stamp duty resulted in more refinancing and a reduction in mortgage interest rates. If it didn't, those state governments needlessly gave up several million dollars in revenue.

The econometric evidence on the removal of stamp duty is, at best, mixed. A dummy variable to account for the removal of stamp duty has the correct sign when added to the single-equation error-correction model for refinancing. But with a p-value of 0.21, it fails the standard benchmarks of statistical significance. There is, however, some circumstantial evidence to suggest that the removal of stamp duty had an impact. Diagnostic testing finds

[1] Page 333.

evidence of parameter instability in both the refinancing and the mortgage rate stickiness equations at around the same time that stamp duty was abolished.

This is clearly an area for future research. Refinancing statistics are available on a state-by-state basis, and cross-section analysis could reveal whether refinancing is more interest rate sensitive in states without stamp duty, compared to states which still charge stamp duty on refinanced mortgages.

Another issue for future research is the role of mortgage managers in refinancing. This study has concentrated on refinancing from variable to fixed rate loans. But as Section 4 highlighted, the discount on variable rate mortgages offered by mortgage managers in 1994 could have led to profitable refinancing.

This thesis has also shown that the variable mortgage rate has become more responsive to changes in the marginal cost of funds. It would also be worthwhile to examine the impact of mortgage managers on the pricing of bank variable rate mortgages. Specifically, whether mortgage managers played a significant role in reducing the importance of risk sharing in the mortgage lending market.

One of the major constraints on this study has been data quality. Studies in the United States have consistently found a role for borrower income and home equity levels in refinancing behaviour. These variables were proxied in this study by monthly interpolations of quarterly average wage and house price series. Both variables performed poorly, with average wages growth showing no statistical relationship with refinancing. This result could be reversed with better measures of borrower income and collateral.

The aggregate refinancing statistics suffer from a major drawback in that they only record refinancings where the borrower has changed lending institutions. Presumably, the information and "shoe leather" costs of refinancing between institutions are much greater than for refinancing within an institution. Many of the larger banks now appoint “personal bankers” to high-income clients with large loans. One role of the “personal banker” is to advise clients of profitable refinancing opportunities within the institution. As a result, the sensitivity of refinancing to interest rate spreads may be greater than our estimation suggests.

The only solution to these data problems is to obtain micro-data on individual borrowers in a similar manner to many of the studies from the United States. It is unlikely that the major lending institutions would allow detailed scrutiny of their customer records. One potential source could be the securitised mortgage pools such as PUMA and ARMS in the private sector, and Keystart for public sector mortgage lending. These organisations already publish detailed prepayment reports in order to assist in the pricing of mortgage backed securities. These mortgage pools could provide a rich, new source of data for studies on borrower behaviour.

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