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Abstract

The paper develops an overlapping generations model incorporating a realistic depiction of the credit constraints facing home buyers to explain why home ownership rates have declined in New Zealand since 1990 despite a significant relaxation of credit constraints. The model focuses attention on the role of property investors in the property market, and suggests changes in credit constraints mainly affect the tenure decisions of individual households, but not the aggregate level of house prices. The model suggests the decline in real interest rates is likely to be the cause of the rise in house prices and the decline in home ownership rates since 1990.

¹ The views expressed in this paper are those of the author(s) and do not necessarily reflect the views of the Reserve Bank of New Zealand. I would like to thank Aaron Drew, Luci Ellis, Arthur Grimes, Michael Reddell, Christie Smith, participants at the 2007 SWIM conference in Auckland, and members of the Economics Department at the Reserve Bank for comments. Address: Economics Department, Reserve Bank of New Zealand, 2 The Terrace, PO Box 2498, Wellington New Zealand.
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1 Introduction

“There are good reasons to believe that within the existing structure for financing housing acquisitions there are elements which make inflation inherently non neutral even if anticipated correctly. Specifically, adherence to the long-term level nominal payment mortgage (in part because of regulatory constraints) in an inflationary environment may distort relative prices and affect capital accumulation.” J R Kearl (1979, p115)

Monetary economics examines how the prices and quantity of nominal debt contracts affect economic outcomes. Prior to the world wide deregulation of the banking and finance sectors in the 1970s and 1980s, monetary economists focussed on the way that the quantity of money and credit affected the economy. Subsequent to this deregulation their focus switched to the way interest rates affected the economy, and the analysis of quantity measures waned. Nonetheless, it is widely recognized that monetary factors other than interest rates affect the pattern of economic activity, prices, and distribution of output. For example, Modigliani and Lessard (1975) and Kearl (1979) argued that the standard terms and conditions of a table mortgage cause significant economic distortions when the inflation rate is non-zero.

This paper develops a simplified overlapping-generations model of the economy to analyse how changes in the terms and conditions of mortgage contracts may have affected the housing market in New Zealand. While a theoretical paper, it is motivated by three empirical observations. First, the terms and conditions of mortgages were significantly relaxed after the banking sector was deregulated in the 1980s, and mortgage finance became substantially easier to obtain. The amount a young household can borrow has increased by more than 100 percent in real terms since 1990. Second, there has been a four-fold expansion of mortgage debt in New Zealand, from \$30 billion at the end of 1993 to \$120 billion by 2005. Last, New Zealand house prices have increased substantially, by 166 percent between 1993 and 2005, or by 106 percent more than the increase in the consumer price index (see figure 1). Increases in house prices and mortgage debt of this size are unprecedented in New Zealand.

The relaxation in mortgage conditions that occurred after 1990 has two separate causes. Prior to 1984, the New Zealand mortgage market was

heavily regulated and access to bank mortgage finance was limited. These mortgages were subject to fairly stringent terms and conditions, including conservative restrictions on the loan-to-value ratio (the ratio of mortgage loan to property value) and the mortgage-repayment-to-income ratio (the ratio of the mortgage repayment obligation to gross income). After the sector was deregulated during the 1980s, new types of mortgages such as revolving credit mortgages with more flexible terms were introduced. In the 1990s commercial banks further relaxed the terms of their mortgages in an effort to increase their exposure to the residential mortgage market, enabling some classes of borrowers to substantially increase the amount they could borrow.

The decline in the inflation rate that has occurred since 1990 has also allowed previously constrained borrowers to borrow more. Since most mortgages in New Zealand are table mortgages, a borrower is contracted to make the same monthly payment for the term of the mortgage.² When making a loan, banks are careful to ensure that the borrower should be able to meet this payment without recourse to further borrowing, and to this end they limit the amount they lend so that the mortgage repayment is a small fraction of gross income. As Modigliani and Lessard (1975), Modigliani (1976), Kearl (1979), Ellis (2003) and Campbell and Cocco (2003) have pointed out, a curious feature of this lending restriction is that it is expressed in nominal terms and takes no account of the effect of inflation on the size of the payment made by the borrower. In a high inflation environment, nominal interest rates are high and thus the amount a borrower can borrow is rather small. When inflation is low, nominal interest rates are correspondingly smaller and, for a given real interest rate, the borrower can borrow a much larger amount. The decline in the inflation rate that occurred after 1990 has allowed borrowers to borrow approximately thirty percent more than they previously could.

The theoretical model is designed to analyse how these changes in the terms and conditions of mortgages, and the decline in the inflation rate, have affected the housing market. The model is inspired by and similar in style to the models developed by Ortalo-Magné and Rady (1998, 2006) and Ellis (2003). The model examines the steady state or equilibrium allocation of output and prices when there are a series of forward looking optimising

² However, the interest rate on most mortgages is fixed for a period of three years or less. When the interest rate is changed, the minimum monthly payment is recalculated.

agents who choose a sequence of consumption goods and housing options over different stages of their lives. The agents differ by age and income, and face realistic credit constraints. The solution of the model is a set of prices that clear the goods and housing markets, and an accompanying allocation of property and goods to different agents. These prices are used to examine how ownership patterns depend on factors such as the inflation rate, interest rates, and the degree of credit constraints.

The model suggests that credit conditions are an important determinant of tenure decisions for young and very old generations, but that they have a relatively small role in determining property prices. When credit constraints are tight, many young households have to delay their purchase of a first house, or of a larger second house, as they cannot borrow enough — or, more precisely, given the limited amount they can borrow, the sacrifice in terms of current consumption is too great. The homes they don't purchase are not empty, of course, but owned by investors or older households who are less affected by borrowing constraints. Consequently, the effect of credit constraints on property prices depends on the willingness of older generations to buy large houses or rental properties. If the demand elasticities are high, credit constraints have little effect on prices.³ Under the assumption that demand elasticities for rental property are high, a relaxation of credit constraints should increase home ownership rates amongst young people while only having a modest effect on prices.

This prediction is almost the complete opposite of what happened in New Zealand after 1990, for not only did property prices increase rapidly but the home ownership rate for young people declined. The model is consistent with these facts, however, when the effect of declining real interest rates is taken into account. In New Zealand, real interest rates declined substantially over the period. In the model, a decline in real interest rates leads to an increase in property prices because investors bid up the price of property until the return equals the real interest rate. Given that young people are more affected by credit constraints than older investors, they are outbid and forced to delay their purchases. When demand elasticities for rental property are high, the effect of a decline in real interest rates dominates the effect of a relaxation of credit constraints, causing an increase in property prices and a decline in home ownership rates.

³ The demand elasticity is defined in terms of the number of properties demanded as a function of the property price, keeping real interest rates constant.

The model suggests that the fraction of households who are unwilling renters can be used as a measure of liquidity constraints. Since the extent of credit constraints is affected by the inflation rate, the model also provides a way of measuring the welfare costs of inflation. In the main parameterisation of the model, about 25 percent of young households and 5 percent of all households are unwilling renters when the inflation rate is zero. This fraction increases by approximately 3 percent of the young population and 1 percent of all households for every 1 percentage point increase in the inflation rate. Thus a 2 percent increase in the steady state inflation rate could increase the fraction of young households unable to purchase a home by 6 percent. It is to be noted that this cost of inflation occurs in circumstances where all households are forward looking, they all make optimal decisions, and where the inflation rate is perfectly anticipated.

This paper is only a first step in analysing how credit constraints affect the housing market, and only explores how interest rates and credit markets affect the steady state equilibrium properties of an economy when households are forward looking and well informed. At this stage no attempt is made to examine the dynamic response to a change in interest rates or credit market conditions. Nor has there been an attempt to model other factors relevant to the housing market such as taxes, although such extensions are planned. Rather, the aim of the paper is to describe how credit constraints have changed in the last two decades, and to describe the features of the modelling framework that is being used to analyse them. To this end, the paper is organised as follows. In section 2, the evolution of mortgage contracts and home ownership rates in New Zealand since the 1980s are described. In section 3 the model is outlined, and the key results are described in section 4. The implications are discussed in section 5.

2 Trends in the New Zealand housing market, 1990–2005

2.1 Trends in mortgage contracts

Until the late 1980s, access to bank mortgage finance was limited in New Zealand. Young people wanting a mortgage normally had to establish a saving record with a bank or building society by making regular deposits for a period, at which point they would be entitled to apply for a loan. The loans

were subject to quite stringent conditions: for instance, in 1981 a leading bank noted that “principal and interest payments should not exceed 20% of the breadwinner’s annual gross earnings, or at most 25% where other commitments are of little consequence,” and that in making such calculations a 20 year table mortgage would be the standard contract. Moreover, banks would not normally lend more than 75 percent of the value of the house. Following deregulation, banks started to relax some of these requirements. At the end of the decade revolving credit mortgages were introduced, so that customers could draw down additional funds if they wanted, and banks made finance available to people who did not have an established saving record with them. Nonetheless, at the start of the 1990s the banks retained fairly conservative conditions. The same bank noted that a mortgage applicant needed “sufficient discretionary income available to meet minimum monthly payments without recourse to overdraft”; that repayments must be “covered within 30 % of sole income or 25 % of joint income”, where the repayment amount was assessed with reference of table loan repayable over 20 years; and that the size of the loan should be less than 75 percent of the value of the property.

During the 1990s, most banks relaxed the terms and conditions of their loans in response to better information technology and a desire to increase the fraction of residential mortgages in their overall lending portfolios. If customers purchased mortgage indemnity insurance, they could borrow up to 95 percent of the value of a property, rather than the previous 75 percent, and mortgage-repayment-to-income ratios were progressively relaxed. Moreover, by the end of the decade banks started to customise their requirements according to the demographic and income characteristics of their clients. For instance, couples without children on near average incomes could borrow until their repayment-to-income ratio was 33 percent, or slightly more if they had a large deposit. Couples with children had lower limits, but their maximum mortgage-repayment-to-income ratios still typically exceeded 25 percent unless their incomes were very low.

A second relaxation of borrowing constraints occurred after 1990 because of the reduction in inflation that occurred in New Zealand. Because the mortgage-repayment-to-income restriction is expressed in nominal terms and takes no account of the effect of inflation on the size of the payment made by the borrower, for the same real interest rate borrowers can borrow much more in a low inflation environment than in a high inflation environment. Figure 3 shows the hypothetical maximum a household with

\$50000 income could have borrowed each year since 1990 under different assumptions about the mortgage-repayment-to-income ratio and the term of the loan. In December 1989, when inflation was 7 percent and nominal interest rates were 14.8 percent, it could have borrowed \$79000, assuming a twenty year term and a 25 percent mortgage-repayment-to-income ratio. In December 2005, the inflation rate was 3.1% and the mortgage rate was 7.7 percent and the household could have borrowed \$126000, an increase of 58%. (If real interest rates had remained the same, the decline in inflation would have raised the borrowing limit to \$102000, or by 29%.) If the household was allowed to increase its mortgage-repayment-to-income to 33 percent, the maximum it could have borrowed would have increased to \$166 000, or by 32 percent. If the length of the term were also increased from 20 years to 30 years, the mortgage could have been increased to \$191000, or by another 15 percent. These increases are clearly large, totalling 142 percent over 16 years.

2.2 Trends in tenure patterns

Mortgage borrowing constraints affect the timing of individual household decisions to purchase a house. The most accurate information on housing tenure patterns is collected every five years in the census. These data can be supplemented by information from the Household Economic Survey. The Household Economic Survey indicates that the fraction of households renting rather than owning increased from 28 percent to 34 percent between 1990 and 2004, with the rate of increase accelerating after 1998 (see figure 5). The increase is most marked in private rentals, from 16 percent to 25 percent. The census provides more detailed age-specific information about housing tenure, but relevant data is only available for 1991, 1996, and 2001. According to the summary provided by DTZ (2005), the fraction of people aged 25 - 29 owning a house declined from 54 percent to 41 percent between 1991 and 2001. During the same period, the fraction of people aged 30 - 34 owning a house declined from 69 percent to 56 percent. Somewhat surprisingly, therefore, it appears that home ownership rates have declined at the same time that credit constraints have been substantially relaxed.

3 A simple intergenerational model of housing demand

3.1 The basic framework

The model has a form similar to that of Ortalo-Magné and Rady (1998), which in turn is derived from the classic formulation by Modigliani and Brumberg (1980). It is an overlapping generations model where each cohort lives five periods and then dies. In the current version of the model there is no uncertainty. Agents have exogenously determined income and consume a single non-storable good. They also have the option of renting or purchasing a single unit of housing, which gives them utility. These housing units come in two sizes, small flats or large houses. In the last period of life agents consume all wealth except their house, which is inherited by a younger generation. Agents are assumed to choose among different patterns of housing and consumption to maximise their utility. The number of houses and flats is set exogenously.

3.2 Agents

There are N agents in each cohort, and each agent lives for five periods labelled $i = \{0,1,2,3,4\}$. A period is T years long. Agents differ by income and while any pattern of income is possible, agents are assumed to have a constant place in the within-cohort income distribution each period, with agent 1 having the lowest income. In period t , agent j born in period $t-i$ has real labour income

$$Y_t^{i,j} = \omega_j \cdot g_i \cdot Y_{t-i}^0 \quad (1)$$

where ω_j = idiosyncratic factor affecting agent j relative to average cohort earnings;
 g_i = factor reflecting life-cycle earnings for the cohort in its i th period; and
 Y_{t-i}^0 = average income of cohort at time of birth

The factors g_i are chosen to reflect life-cycle household earnings. Average cohort income is allowed to differ between cohorts by allowing Y_t^0 to vary through time; for simplicity it is assumed to grow at a constant rate γ . In

nominal terms, the prices of goods and incomes both increase at a constant inflation rate π , where $1 + \pi = P_{t+1}/P_t$.

In each period agents get utility from the consumption of goods and housing. Let $\mathbf{I}_t^{i,j,h}$ be a vector of three indicator variables $\{I_t^{i,j,R}, I_t^{i,j,F}, I_t^{i,j,H}\}$ that equal one if an agent has housing tenure h in period i of his or her life, and zero otherwise. There are three possible housing tenures: an agent can rent a flat (R), purchase a flat (F), or purchase a house (H). In period t agents obtain utility

$$u(c_t^{i,j}, \mathbf{I}_t^{i,j,h}) = \ln(c_t^{i,j}) + \sum_h v^h I_t^{i,j,h} \quad (2)$$

It is assumed $v^H > v^F$ as houses are bigger than flats, and $v^F > v^R$, as agents can shape an owned flat in their own image, whereas they cannot modify a rented flat. Agents can only live in one housing unit in any period. They choose consumption and housing paths to maximise discounted lifetime utility:

$$U = \sum_{i=0}^4 \beta^i u(c_{t+i}^{i,j}, \mathbf{I}_{t+i}^{i,j,h}) \quad (3)$$

Agents can borrow and lend at an interest rate r_t through non-profit banking intermediaries. Agents can also purchase flats to lease out, although some restrictions (discussed below) apply. Agents are assumed to receive their income, purchase, rent, or sell property, borrow or lend, and consume at the start of each period, although they gain utility from housing by living in it throughout the period. In the last period, agents are assumed to sell or realise all assets except their last owned housing unit, repay any debts, and consume all of their wealth. They die at the end of period 4, at which point their housing unit is distributed to younger cohorts. At time t a fraction κ_i is left to the cohort born at $t-i$ for $i=0,1,2,3$; by assumption it is either equally distributed across all agents of that cohort, or left to the j th agent, thus preserving the income distribution. The weights κ_i are chosen so that agents do not receive an inheritance until relatively late in life. This proves to be an important choice, for if agents inherit early, they have much less need to save for a housing unit. In this paper, $\kappa_2 = \kappa_3 = 0.5$.

3.3 The housing market

Flats and houses cost P_t^F and P_t^H to purchase. Flats can also be leased, at price P_t^R which is paid in advance at the beginning of the lease. The rent is paid to a landlord, who, for convenience, is restricted to be an agent in period 2 or 3 of their lives. The number of landlords is endogenous; an indicator variable I_t^{i,j,R^*} indicates whether or not the j^{th} agent owns a rental property. Because there is no uncertainty, the return from purchasing a flat in period t , leasing it, and selling it in period $t+1$ is equal to the interest rate. As such, the link between rent, house prices, and interest rates is

$$P_t^R(1+r_t) + P_{t+1}^F = P_t^F(1+r_t) \quad (4)$$

or

$$P_t^R = P_t^F \left(\frac{r_t - \pi_t^F}{1+r_t} \right) \quad (5)$$

where π_t^F is the rate of price appreciation for flats.⁴

In each period, agents choose between one of three housing options, or not having housing. Consequently, there are potentially 1024 different housing patterns possible through an agent's lifetime. Rather than calculate the utility of each of these patterns, I only let agents choose from a much smaller set of patterns, H . To reduce the number of possible patterns, I impose a series of somewhat arbitrary rules of which the most important are: (i) only 0 period agents may choose no housing; (ii) only period 0 and period 1 agents may choose to rent; (iii) except in the last period, agents' housing choices must not worsen through time; and (iv) if agents choose a house, they choose it for at least two consecutive periods. By this means, the set H is reduced to a manageable size of ten, $H = \{0RFFFF, 0FFFF, RRFFF, RFFFF, RFHHF, RFHHH, FFFFF, FFHHF, FHHHF, FHHHH\}$. An agent's optimal discounted utility is calculated for each of these patterns, and the agent is assumed to choose the pattern that provides the greatest discounted utility. When there are no financial market imperfections, an agent will never choose to rent because the cost of renting and purchasing a flat are the same, but ownership delivers higher utility.

⁴ Because the return to a rental flat is the same as the interest rate, investors are indifferent as to whether or not they own them. I assume rental properties are owned by the agents in cohorts in 2 and 3 that have the highest income.

The number of houses and flats is set exogenously. There are n^H houses and n^F flats. It is assumed that $n^H + n^F \leq 5N$. This means there are no vacant houses, so property prices and rents are positive in equilibrium.

3.4 The lending market

There is a non-profit financial intermediary that accepts deposits and issues mortgages at an interest rate r_t . Agents can lend or borrow as much as the bank allows them at the one period interest rate r_t , subject only to the restriction that they have a zero debt position at the end of their life. There are no restrictions on the deposit contract, and interest on a deposit made at time t is paid at time $t+1$. The mortgage contract is subject to three restrictions.⁵

i) *The loan to value restriction.*

The mortgage may not exceed a certain fraction of the value of the property. In particular, the gross amount borrowed $B_t^{i,j-}$ cannot exceed the value of property multiplied by the loan to value ratio θ : that is

$$B_t^{i,j-} \geq \sum_{h \in F,H} -\theta P_t^h I_t^{i,j,h} \quad (6)$$

(Note $B_t^{i,j-} < 0$ if the agent borrows.) This restriction means that agents who rent cannot borrow to smooth consumption, although they can save.

ii) *The regular cash payment restriction.*

The second borrowing constraint is that banks only issue τ -year table mortgages, and require a “cash payment” in the period the mortgage is issued. τ is assumed to be 25 years.⁶ This restriction is imposed to mimic a standard condition of a table mortgage, namely that a customer is required to make regular cash repayments P of equal size throughout the life of the mortgage rather than a large repayment at its terminal date. The payment

⁵ Note that it is assumed that banks impose these restrictions even though there is no uncertainty in the model.

⁶ Until recently, this has been the standard term for a table mortgage in New Zealand, although recently it has been increased to 30 years. However, in previous times many bank managers had the authority to increase the term to 30 years if this enabled the customer to meet the mortgage-repayment to income ratio requirement.

size P is chosen to ensure the mortgage is retired at the end of the term: if B^{0-} is initially borrowed, the annual payment is

$$P = B^{0-} r \left[\frac{(1+r)^\tau}{(1+r)^\tau - 1} \right] \quad (7)$$

It is not possible to exactly replicate this feature of a standard mortgage contract in the model. However, a close approximation is achieved by requiring the customer to make a payment that pays off some of the interest and principal in any period he or she has debt. In particular, a customer with gross debt of $B_t^{i,j-}$ is required to open up a separate account with the bank and make a deposit of size

$$B_t^{i,j+} = B_t^{i,j-} \frac{r_t}{1+r_t} \left[\frac{(1+r_t)^{\tau/T}}{(1+r_t)^{\tau/T} - 1} \right] \quad (8)$$

into this account. This deposit earns interest at rate r_t . This means that the net borrowing position of a borrowing agent, $B_t^{i,j} = B_t^{i,j+} + B_t^{i,j-}$, is less than the gross borrowing position. Without this “cash payment” feature, in many circumstances an agent would prefer to purchase rather than rent simply because the interest payment occurs a period later than the rental payment. When the “cash payment” requirement is imposed, purchasing a house requires a larger payment to the bank in period t than the cost of renting a house.

iii) *The mortgage-repayment-to-income restriction.*

The maximum amount an agent can borrow is restricted by the need to keep the mortgage repayment given by equation 8 smaller than a fraction δ of income:

$$B_t^{i,j-} \frac{r_t}{1+r_t} \left[\frac{(1+r_t)^{\tau/T}}{(1+r_t)^{\tau/T} - 1} \right] \leq \delta Y_t^{ij} \quad (9)$$

Note that this constraint is expressed in terms of nominal interest rates.

The mortgage conditions are only imposed on agents in the first two periods of their lives in order to simplify the solution algorithm. In periods 2 and 3 agents can borrow unrestricted amounts. In practice, this relaxation has little effect because agents are in their peak earning years in periods 2 and 3, receive their inheritances in these years, and are actively saving or reducing debt to finance their retirement. Consequently, very few agents wish to

borrow more than the amount they would be able to borrow if borrowing restrictions were imposed in these periods.

3.5 Utility maximisation

An agent (omitting the j superscript) solves the following constrained maximisation problem.

$$\begin{aligned}
\text{Max}_{\{c_{t+i}, I_{t+i}^{i,h}\}} U = & \sum_{i=0}^4 \beta^i u(c_{t+i}, \mathbf{I}_{t+i}^{i,h}) & (10) \\
& - \lambda_0 (Y_t^0 - B_t^0 - c_t^0 - \sum_h P_t^h I_t^{0,h}) \\
& - \sum_{i=1}^4 \lambda_i \left((1+\pi)^i Y_{t+i}^i - B_{t+i}^i - (1+\pi)^i c_t^0 - \sum_h P_{t+i}^h I_{t+i}^{i,h} + B_{t+i-1}^i (1+r_{t+i-1}) \right. \\
& \quad \left. + \sum_{h=F,H} P_{t+i}^h I_{t+i-1}^{i-1,h} + \kappa_i \text{Inherit}_{t+i} + [(P_{t+i}^R - P_{t+i}^F) I_{t+i}^{i,R*} + P_{t+i}^F I_{t+i-1}^{i-1,R*}] \right) \\
& - \sum_{i=0}^1 \chi_i \left(B_{t+i}^{i,-} + \sum_h \theta P_{t+i}^h I_{t+i}^{i,h} \right) \\
& - \sum_{i=0}^1 \varphi_i \left(B_{t+i}^{i,-} \frac{r_{t+i}}{1+r_{t+i}} \left[\frac{(1+r_{t+i})^{\tau/T}}{(1+r_{t+i})^{\tau/T} - 1} \right] + \delta Y_{t+i}^i \right)
\end{aligned}$$

The budget constraints in lines 2 and 3 of equation (10) state that the difference between (i) nominal income plus the return from previous bond holdings plus rental income plus inheritance income, and (ii) nominal expenditure on consumption goods plus expenditure on rent plus the net expenditure on property purchased that period, must equal the change in bond holdings. Net debt in period 4 is restricted to equal zero. The Kuhn-Tucker conditions in lines 4 and 5 reflect the loan-to value ratio constraints and the mortgage-repayment-to-income ratio constraints respectively. The agent solves the problem by calculating the maximum utility for each housing pattern in the set H, and then selecting the housing pattern with the highest utility. The use of log-linear utility functions means it is relatively straightforward to calculate an analytical solution for the optimal consumption path given a particular housing pattern, even though each solution has sixteen parts corresponding to the sixteen possible combinations of Kuhn-Tucker conditions.

3.6 Equilibrium conditions

The steady state equilibrium can either be found for a closed economy or an open economy model. In the steady state, the following price relationships hold:

$$r_t = r \quad (11a)$$

$$\frac{P_{t+1}^F}{P_t^F} = 1 + \pi^F \quad (11b)$$

$$\frac{P_t^H}{P_t^F} = \rho^H \quad (11c)$$

$$\frac{P_t^R}{P_t^F} = \left(\frac{r_t - \pi_t^F}{1 + r_t} \right) = \rho^R \quad (11d)$$

For a set of parameters $\{N, T, Y_t^0, \omega_j, g_i, \gamma, \pi, \beta, v_h, \kappa_i, H, n^H, n^F, \tau, \theta, \delta\}$, the steady state equilibrium is described by a set of prices $\{r, \pi^F, \rho^H, \rho^R\}$, a set of housing and consumption demands $\{c_{t-i}^{ij}, \mathbf{I}_{t-i}^{i,j,h}\}_{i=0,\dots,4}$ for each agent j in each cohort born in period $t-i$, and a net foreign asset position B^{net} such that all agents have maximal utility and

$$\sum_{i=0}^4 \sum_{j=1}^N c_t^{i,j} - \left(\frac{r - \pi}{1 + \pi} \right) B_t^{net} = \sum_{i=0}^4 \sum_{j=1}^N y_t^{i,j} \quad (12a)$$

$$\sum_{i=0}^4 \sum_{j=1}^N I_t^{i,j,R} + I_t^{i,j,F} = n^F \quad (12b)$$

$$\sum_{i=0}^4 \sum_{j=1}^N I_t^{i,j,H} = n^H \quad (12c)$$

$$\sum_{i=0}^4 \sum_{j=1}^N B_t^{i,j} = B_t^{net} \quad (12d)$$

Equation (12a) requires that total consumption plus real earnings on the net bond position in each period equals total production. Equations (12b) and (12c) require that the total demand for flats equals the supply of flats, and that the total demand for houses equals the supply of houses. When the interest rate r is set exogenously, equation (12d) determines the net bond supply; alternatively, if one solves the model with the net debt position equal to zero, the interest rate is endogenously determined. All of the following discussion refers to the open economy case when interest rates are

determined exogenously, and the economy can have a non-zero net stock of financial assets (bonds) and a non-zero current account position.⁷

3.7 Parameterisation

The first purpose of the model is to examine how housing tenure, housing prices, and interest rates are affected by changes in bank lending terms and conditions. To this end, a set of baseline parameters $\{T, Y_t^0, \omega_j, g_i, \gamma, v^h, \kappa_i, n^H/N, n^F/N, \tau\}$ have been chosen to approximate features of the New Zealand economy. These are listed in table 1. With the exception of the income distribution, the income parameters approximately match the basic lifecycle and cohort income patterns of New Zealanders reported in census documents, 1966-2001, under the assumption that the basic agent is a household comprised of a male and female of the same age. For simplicity, income is assumed to be uniformly distributed over the range \$20000 to \$80000.⁸

In the baseline model, 60 percent of the properties were large houses, real income growth between cohorts was 0 percent, the inflation rate was 0 percent, and real interest rates were 4 percent. Several variations of the basic model were considered, in which either the real interest rate, the inflation rate, the income growth rate, or the fraction of properties that are large houses were varied.

3.8 Solution technique

The solution is found numerically. In the open economy version of the model, the algorithm searches for a set of prices $\{P_t^F, P_t^R, P_t^H\}_{t=-4, \dots, 4}$ so that when each agent j born in period $t-i$, $i = -4, \dots, 0$, is consuming a sequence of goods and tenure options $\{c_{t-i+s}^{s,j}, \mathbf{I}_{t-i+s}^{s,j,h}\}_{s=0, \dots, 4}$ that solves their constrained utility problem given by equation (10), the aggregation conditions 12a – 12d

⁷ The model is also solved for the case that the interest rate is determined endogenously and the net stock of financial assets is zero. However this “closed economy” model is not that interesting as interest rates tend to adjust to undo the effects of credit market liberalisation. In any case, New Zealand has open financial markets and seemingly no problems borrowing offshore.

⁸ According to the 2001 census, 17 percent of all households had income less than \$20000, 26% had income over \$70000, and 13% had income over \$100000.

applied at time t are satisfied. In the steady state, the vector $\{P_t^F, P_t^R, P_t^H\}_{t=0, \dots, 4}$ can be calculated from the vector $P^* = \{P_0^F, \pi^F, \rho^H\}$. The basic structure of the algorithm is as follows.

- a) Let the vector $P^{*,k} = \{P_0^F, \pi^F, \rho^H\}^k$ be the k^{th} estimate of the steady state solution P^* . Given $P^{*,k}$, calculate the optimal consumption and housing tenure paths for each of the N households in cohort zero by searching over the different possible tenure paths in the set H .
- b) Use these results to calculate the demand for consumption goods and housing at time $t=0$ for all households in the economy.
- c) Use these results to calculate aggregate consumption, the aggregate demand for flats, and the aggregate demand for houses at time $t=0$. Then calculate the excess demand functions given by 12a – 12c.
- d) If the excess demand functions are not sufficiently close to zero, a new estimate of the equilibrium prices $P^*, P^{*,k+1}$, is calculated. This is done using a discrete approximation to the Newton-Rhaphson method. A set of quasi-derivatives is calculated by recalculating the set of excess demand functions at the prices $\{P_0^F + \Delta_1, \pi^F, \rho^H\}$, $\{P_0^F, \pi^F + \Delta_2, \rho^H\}$, and $\{P_0^F, \pi^F, \rho^H + \Delta_3\}$, and these are used to calculate the updated price vector. The process is continued until the sequence of estimates $P^{*,k}$ converges.

3.9 Comparison to other models

The model differs from that of Ortalo-Magné and Rady (1998, 2006) in at least three respects. First, it imposes additional bank lending constraints: in particular it imposes the mortgage-repayment-to-income constraint, as this appears to be the constraint that most frequently binds in New Zealand. Secondly, it changes the assumption that utility is linear. When utility is linear all consumption takes place at the end of an agent's life, so the timing of saving matters little. In this model, the timing of saving is very important as there is an opportunity cost from delaying consumption. Lastly, Ortalo-Magné and Rady impose more severe restrictions on the possible housing patterns H in order to get an analytically tractable model. Since tractability

is lost when the linear utility function is changed, there is little cost from easing some of their restrictions on H.⁹

4 Results

4.1 Overview of the results

Three features of the results are of particular interest.

First, borrowing constraints only have a small effect on property prices since they do not affect investors. However, borrowing constraints have a large effect on the housing tenure as young, low income agents are forced to rent or to delay their purchase of large houses. When credit constraints are relaxed, ownership patterns change significantly, as younger cohorts rather than investors purchase flats and higher income members of young cohorts rather than low wealth members of the oldest cohort purchase houses.

Secondly, inflation worsens the effects of borrowing constraints. An increase in the inflation rate exacerbates the mortgage-repayment-to-income constraint facing young cohorts, and leads to a reduction in the fraction of the youngest cohorts that owns flats and houses.

Thirdly, the demand for investment property means that flat prices are very sensitive to real interest rates. Since investors face fewer credit constraints than young households, a large shift in ownership also occurs when real interest rates change. For example, a decline in real interest rates will raise property prices out of the reach of credit constrained young households, and the fraction of young households renting increases.

These results stem from the fundamental factors that determine flat and house prices. Flat prices are primarily determined by rents, real interest rates, and credit constraints in the following manner.

i) Investors provide a floor for flat prices by bidding prices up to the rent/real-interest-rate ratio. Since investors are not constrained by bank

⁹ It should be noted that the simplifying assumptions made by Ortalo-Magné and Rady allow them to derive a tractable solution for the steady state and dynamics of the model, which is not possible in this model.

lending conditions, the “investor floor” price is proportional to rents and inversely proportion to real interest rates.

ii) Rents are determined by the utility the marginal household obtains from renting rather than having no home, which depends on their income. The marginal income earner is typically a poor young person, so rents depend on the supply of flats relative to population size, the income distribution, and the preference for renting a flat rather than having no housing. (Given the parameters in table 1, the marginal household is the 20th poorest young person, and they are prepared to pay approximately 35 percent of their income as rent.) Consequently, the “investor floor” price is determined by these factors and real interest rates.

iii) Flat prices approach this floor when credit constraints are stringent. As they are eased, flat prices increase because households value owned flats more than rented flats and thus will pay more than the investors for them. The amount they pay depends on this additional valuation, as well as the extent to which they can borrow to finance the purchase and thus maintain consumption of other goods. If, as is likely, v^F is little more than v^R , flat prices will respond little to the extent of credit constraints, because young constrained households and older unconstrained landlords will have similar valuations.

House prices are determined with reference to flat prices. Without credit constraints, the ratio of house prices to flat prices depends on the benefit that the marginal household gains from owning a house rather than a flat, and this depends on the distribution of income and real interest rates. House owners will be the highest income households in all but the youngest cohort. When there are credit constraints, some young households are prevented from living in large houses, and their place is taken by older households. As credit constraints are relaxed, house prices rise as the marginal high income young households purchase houses from the marginal low wealth old households. They do not increase by much, however, because the marginal old households are willing sellers as they face a relatively high cost of housing.¹⁰ Put differently, the members of the oldest cohort have an elastic

¹⁰ This is because a household in a young or middle aged cohort can sell the house and move back into flat in a subsequent period, so the opportunity cost of living in a house rather than a flat is $r(P^H - P^F)$; but a household in cohort 4 faces the full opportunity cost of $(P^H - P^F)$ if they choose to live in a house rather than live in a flat.

demand curve for large houses, so only small price changes occur as the cohort changes the number of houses they occupy.

4.2 Numerical results

4.2.1 Zero inflation and zero income growth

Figures 5-8 show how house prices, flat prices, and the fraction of people renting and living in flats vary as credit constraints and interest rates are varied. The graphs are calculated for the baseline parameterisation, with zero inflation, but the results are qualitatively similar for other parameterisations. In the graphs, the loan-to-value ratio is varied from 80 percent to 100 percent, and the mortgage-repayment-to-income ratio from 17.5 percent to 50 percent.

Figures 5, 6 and 7 show how house prices and flat prices vary with borrowing constraints, for interest rates $r = 4.0$ percent and $r = 3.25$ percent. The graphs have a characteristic shape: as the mortgage-repayment-to-income ratio increases, property prices increase approximately linearly up to a threshold that depends on the loan-to-value ratio. Above this threshold, further relaxation of the mortgage-repayment-to-income constraint has no further effect as the loan-to-value ratio is binding. As the loan-to-value ratio constraint is relaxed, the threshold and thus the property price increases.

Three features of the graphs warrant comment. First, credit constraints have only a small effect on property prices. As borrowing constraints are relaxed from their most stringent (mortgage-repayment ratios of 17.5 percent and loan to value ratios of 80 percent) to their most relaxed (mortgage-repayment ratios of 50 percent and loan to value ratios of 100 percent), house prices increase by between 2 and 9 percent, and flat prices increase between 2 and 6 percent, with the effect greater at low interest rates. The relaxation of credit constraints that occurred in New Zealand, from mortgage-repayment ratios of 25 percent and loan to value ratios of 80 percent to mortgage-repayment ratios of 35 percent and loan to value ratios of 95 percent, had effects less than half this large.

Secondly, interest rate changes have a large effect on property prices, much larger than the effect of a change in credit constraints. A reduction in real interest rates from 4.0 percent to 3.25 percent leads to a 15 – 25 percent increase in flat prices, and a 4 – 10 percent increase in house prices. The

changes were larger when credit constraints were less stringent. The different responsiveness of flat and house prices to interest rates means that the house/flat price ratio is decreasing in interest rates. The reason is two fold. Flat prices are responsive to interest rates because landlords are unaffected by credit constraints and bid the flat price up until the return equals the lower real interest rate. However, the house price reflects the opportunity cost of the marginal rich household purchasing a large house rather than engaging in additional consumption. If the marginal household is young, the lost consumption from purchasing a house rather than a flat for one period and then reselling is $r(P^H - P^F)$. However, if the marginal household is elderly, the lost consumption from purchasing a house rather than a flat is trade-off is $(P^H - P^F)$. So long as elderly people are the marginal purchaser, they will be willing sellers of houses when interest rates fall and will thus prevent a large increase in house prices.¹¹

Thirdly, 100 percent loan-to-value ratios constrain property prices, even when mortgage-payment-to-income ratios are high. This is the reason why changes in the loan-to-value ratio and the mortgage-repayment rate have smaller effects on house prices when interest rates are high rather than when they are low. 100 percent loan-to-value ratios constrain property prices because consumption loans are not allowed in the model. Even though young households can borrow the full cost of the loan, the bank's terms require a higher mortgage payment than the cost of rent. Since young people are trying to smooth consumption in the face of rising life-cycle income, the additional mortgage payment – the principal repayment plus an allowance for inflation – has a high opportunity cost and limits the demand to purchase property. The popularity of interest-only mortgages in the United States is perhaps testimony to the importance of this effect.

Figures 8 and 9 indicate how the fraction of households renting varies as credit constraints and interest rates are varied. The graphs have a characteristic kinked shape: as the mortgage-repayment-to-income constraint is relaxed, the number of households renting flats decreases, until a critical threshold is reached where the loan-to-value constraints binds. At this point, further relaxation of the mortgage-repayment-to-income constraint has no additional effect. This threshold is decreasing in the loan

¹¹ When the model is solved for the case that large houses are relatively scarce (40 percent not 60 percent of properties are houses), the price of houses is so much higher than the price of flats that no elderly people choose to live in them. In this case, house prices and flat prices have nearly the same responsiveness to interest rates.

to value ratio, and decreasing in the level of real interest rates. For instance, at a 30 percent mortgage-repayment-to-income ratio and a four percent real interest rate, a relaxation of the loan-to-value ratio from 80 percent to 90 percent will lead to a decrease in the fraction of the population renting from 7.1 percent to 5.2 percent. However, if real interest rates were to fall to 3.25 percent, the fraction of renters would increase to 9.9 percent.¹² The fraction renting rises as interest rates fall because young credit constrained potential purchasers are outbid by landlords who compete amongst each other to reduce the return from leasing housing to the real interest rate.

4.2.2 Non-zero inflation

The above graphs indicate the effects of changing credit constraints and interest rates when inflation is zero. A similar set of exercises shows the effects of changing the inflation rate. Since nominal interest rates increase as the inflation rate increases, a rise in the inflation rate has an effect similar to a tightening of the mortgage-repayment-to-income ratio. This has a modest effect on house and flat prices, but a noticeable effect on the fraction of households who rent. Figure 10 shows how the fraction of households renting varies with credit constraints when real interest rates are 4 percent, and the inflation rate is 2 percent. It is noticeable that more people are forced to rent (compared to the situation when there are no credit constraints) at all levels of loan-to-value and mortgage-payment-to-income ratios than when the inflation rate is zero. The fraction of the population renting increases by between 1 and 2 percentage points. There is almost no effect on house or flat prices when the mortgage-payment-to-income restriction is 0.30 or higher, although when this restriction is very tight house prices decline by approximately 3 percent.

Table 2 shows how the fraction of unwilling renters changes as the inflation rate is increased from 0 percent to 5 percent, for a loan to value ratio of 90 percent and a mortgage-repayment-to-income ratio of 35 percent. The table suggests the effect of changes in the inflation rate on the fraction of the population that rents is highest at low inflation rates. In the simulations, each 1 percentage point increase in the inflation rate increases the fraction of the young cohort that is renting by 3 percentage points, while it increases

¹² Most renters are in the youngest cohort. The fraction of the youngest cohort renting decreases from 31.5 percent to 26 percent when credit constraints are eased, and increases to 44 percent when interest rates fall.

the fraction of the whole population that rents by 1 percentage point. It also shows that while there is little effect on large house prices, there is a noticeable change in the tenure arrangements of the oldest households. In particular, as the inflation rate increases, and credit constraints tighten on young households, more old households choose to remain in their houses rather than trade down to a smaller flat. In the simulations, a 1 percentage point increase in the inflation rate causes 3 percent more old people to remain in their houses rather than sell for an inadequate price. This high elasticity is the main reason why house prices are relatively unresponsive to credit constraints.

The simulations indicate that when inflation is high, the mortgage-repayment-to-income-constraint rather than the loan-to-value constraint is the binding constraint for most households, and that it continues to bind even at extraordinarily high values such as 100 percent. This result reflects the importance of the bank-imposed requirement that agents have to pay the mortgage in regular instalments. Households are willing to make larger nominal payments than the banks will allow them to make because they recognize that in real terms most of these payments represent saving. If they can borrow 100 percent of the value of the house, many are willing to consider 65 percent or even 100 percent mortgage-repayment-to-income constraints because they can live off their period 0 savings while they use their period 1 income to pay off the mortgage. However, banks do not allow them to make this substitution as they insist in writing their borrowing constraints in nominal rather than real terms. This refusal lowers the number of cohort 1 households able to purchase houses, and thus lowers house prices.

4.2.3 Non-zero income growth

The above simulations assume there is no aggregate-level income growth in the economy. One of the key results flowing from this assumption is that the growth of property prices is the same as the inflation rate. When the income growth rate is positive, however, this is no longer true. Rather, property prices increase faster than the inflation rate as the quantity of property is fixed but incomes keep rising. Since agents anticipate that property appreciation rates will exceed the inflation rate, they bid up the price of property in anticipation of being able to sell it to young agents for high prices when they are old. The higher prices they are willing to pay means that rent becomes a smaller part of the total return to property as the

economic growth rate increases. In turn, the higher prices and lower rentals mean that a larger fraction of the young generation face binding credit constraints and rent when the economic growth rate is high.

Table 3 indicates how property prices and ownership rates vary with the rate of income growth. The results are calculated for growth rates of 0, 0.5 and 1 percent per year when the inflation rate is either 0 or 2 percent. The results suggest i) property appreciates at just over the rate of inflation plus the rate of income growth; ii) the level of property prices increases with the rate of economic growth; iii) the fraction of young people renting increases with the rate of economic growth; and hence iv) the number of households constrained by credit constraints increases with the rate of economic growth. The effects are large. The simulations suggest that an increase in the rate of income growth from 0 to 1 percent will cause landlords to bid up flat prices by approximately 30 percent, raising them out of reach of many young, credit constrained households. Rent/flat price ratios decline by about the same amount. In response to cheap rents and high flat prices, the fraction of the youngest cohort renting increases by 12 percentage points, while the fraction of the total population renting increases by 3.5 percentage points. The size of this effect is approximately four times as large as the effect of a one percent increase in the inflation rate.

It should be noted that these simulations reveal some of the limitations of the model. In particular, economic growth has a much larger effect on the steady state level of flat prices than on the level of house prices because it is assumed that landlords can only lease out flats not houses.¹³ It follows that the additional demand for investment property is concentrated in the flat market, not the house market. Moreover, the model only calculates the steady state effects of an increase in the economic growth rate and ignores transitional effects. However, these transitional effects may be important. As landlords bid up the prices of flats, many agents will make one-off capital gains that are likely to be spent on houses, meaning that house prices may increase in the transitional period. This effect is not captured in the model.¹⁴

¹³ In equilibrium flat and house prices both increase at the same rate. The ratio of flat prices to house prices increases when the economic growth rate increases.

¹⁴ The lack of transition effects explains the seemingly odd result in table 3 that the fraction of elderly households living in small flats rather than houses declines as the growth rate increases. This is because there is only a small benefit from trading down, as house prices are not that much more expensive than flat prices; and house prices are

5 Conclusion

This paper has developed a model to ascertain how credit constraints affect the housing market. As documented at the beginning of this paper, mortgage credit constraints were substantially relaxed in New Zealand after 1990, with the result that a typical young borrower can now borrow some 140 percent more than they previously could. Somewhat surprisingly, this model suggests that this relaxation may not have been responsible for the large increase in house prices that occurred during this period. Rather, the main cause of the house price increase appears to have been the substantial fall in real interest rates. The primary evidence for this conclusion is the fact that home ownership among the young declined significantly at the same time that house prices increased. If the credit constraint relaxation had been the cause of higher house prices, home ownership would have increased not decreased.

The main finding of the model is that even though although credit constraints have a large effect on the tenure decisions of young households, property prices are not particularly responsive to credit constraints. This result occurs because other agents have very elastic demand for housing, so changes in the demand for housing by young households are easily offset by changes in the demand for housing by older households. In particular, there is a very elastic demand for rental property by landlords, who, by assumption in the model, are not affected by credit constraints. Since these landlords are very sensitive to real interest rates, rental property prices are very sensitive to real interest rates. If this is an approximately correct description of the situation in New Zealand, the decline in real mortgage rates from approximately 10 percent in 1990 to 8 percent in 1996, and then to 5 percent in 2005 is likely to be the cause of the increase in house prices. As house prices were driven up by property investors, home ownership rates among credit-constrained young households declined.

The model is not currently developed enough to support a proper econometric investigation of the relationship between credit constraints and house prices in New Zealand. Nonetheless, the model in this paper suggests

limited because many cohort 1 households do not purchase houses because they are credit constrained.

that factors affecting landlords should be central in such an investigation. It may be of interest to solve a variant of the model which incorporates a realistic description of the tax treatment of rental properties. One can imagine the current tax law in which the inflation component of interest rates but not property appreciation is taxed causes rental property prices to be higher than they otherwise would be. Indeed, in this case tax policy could cause landlords to value houses more than tenants.

While credit constraints do not have much effect on house prices in the model, they do have large effects on welfare by forcing young cohorts into sub-optimal housing arrangements. It follows that further relaxation of credit constraints could increase welfare significantly, with little effect on the overall price level. The main restriction currently imposed by banks is their insistence that the mortgage-repayment-to-income ratio is calculated using nominal not real interest rates. Campbell and Cocco (2003) estimate that these restrictions may impose welfare costs equal to two-thirds of annual income. It remains curious that banks insist on imposing them, even in a low inflation environment.

The paper has confirmed Modigliani's (1976) and Kearn's (1979) hypothesis that even perfectly anticipated and constant inflation rates can have an adverse effect on the economy if credit constraints are imposed on borrowers in nominal terms. In this model, positive inflation rates affect the tenure arrangements of young and old households, and lower welfare compared to the zero inflation baseline. Even a 1 percent increase in the average inflation rate has discernable effects, increasing the fraction of young household that are unwilling renters by 3 percentage points, and increasing the fraction of the total population that rents by 1 percentage point.

The paper also suggests that an increase in the economic growth rate will lead to higher property prices, greater property price inflation, and, because credit constraints become more likely to bind, a decline in home ownership rates among young households. It is noteworthy that home ownership rates are substantially more sensitive to changes in economic growth rates than to changes in the inflation rate. The rise in property prices and the decline in home ownership rates in New Zealand since 1990 might also reflect rising economic growth rates.

Finally, it must be stressed that this research is incomplete, and as various assumptions are changed the results may change. For example, the model only calculates a steady state equilibrium when all agents are forward looking and future prices are known with certainty. It has a highly simplified housing market and only allows two types of properties rather than the continuous variation in the size and characteristics of houses that exist in reality. It does not allow a supply response in the housing market, in which small houses are upgraded. It has a simplified inheritance structure. Further, the model does not examine the out-of-equilibrium dynamic response of the housing market to shocks. These shortcomings need to be addressed. Nonetheless, the basic results suggest that this type of model is a powerful framework for analysing the economic effects of credit constraints, and that in important respects the overall effect of these constraints depends on the extent to which agents in the economy are heterogeneous.

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Table 1
Basic parameterisation of the model

Parameter	Description	Value	Source/Rationale
T	Length of period	10 years	To approximate work history from age 25 - 75
Y_t^0	Average income of 25-35 cohort	50000	NZ Census 2001: average male and female earnings, 25-35 year olds, are \$32800 and \$23300 respectively
ω_j	Income distribution	Uniform on [20000,80000]	
g_i	Lifecycle income pattern	{1, 1.5, 1.5,1.25, 0.75}	NZ Census, 1966- 2001. Based on real lifecycle earnings of cohort turning 20 in 1946, 1961.
γ	Between cohort income growth	0 or 10%	NZ Census, 1966- 2001. Based on successive real earnings of 25-35 year olds, 1976-1996
β	Discount factor	0.97 annualised	Arbitrary
$\{v^R, v^F, v^H\}$	Utility from housing	{0.33, 0.35, 0.45}	Arbitrary
κ_i	Inheritance timing	{0,0,0.5,0.5,0}	Arbitrary
n^H/N	Fraction of houses	0.60 or 0.40	Arbitrary
n^F/N	Fraction of flats	0.39 or 0.59	Arbitrary
T	Mortgage term	25 years	Standard mortgage term in 1990s

Table 2**Model outcomes as a function of the inflation rate**

Inflation	Fraction of young cohort renting	Fraction of population renting	Fraction of old cohort in small flats	House prices
$\Pi=0$	26%	5.2%	59%	\$290000
$\Pi=1$	29%	6.2%	56%	\$289000
$\Pi=2$	32%	7.4%	53%	\$289000
$\Pi=3$	34%	8.0%	51%	\$286000
$\Pi=4$	37%	8.5%	48%	\$284000
$\Pi=5$	39%	8.9%	46%	\$280000

Real interest rates = 4.0. Loan to value ratio = 0.90. Mortgage-to-payment-ratio = 0.35.

Table 3**Model outcomes as a function of the inflation rate and growth rate**

Inflation and income growth rates	Fraction of young cohort renting	Fraction of population renting	Fraction of old cohort in small flats	Flat prices	House prices	House and flat price growth
$\Pi=0$ $\gamma=0$	26%	5.2%	59%	\$204000	\$290000	0%
$\Pi=0$ $\gamma=0.5$	32%	7.4%	53%	\$242000	\$306000	0.6%
$\Pi=0$ $\gamma=1.0$	37%	8.7%	46%	\$263000	\$312000	1.1%
$\Pi=2$ $\gamma=0$	32%	7.4%	53%	\$208000	\$289000	2.0%
$\Pi=2$ $\gamma=0.5$	38%	8.5%	48%	\$235000	\$295000	2.7%
$\Pi=2$ $\gamma=1.0$	45%	10.9%	31%	\$268000	\$306000	3.2%

Real interest rates = 4.0. Loan to value ratio = 0.90. Mortgage-to-payment-ratio = 0.35.

Figure 1
Average House Price Index, New Zealand, 1980-2005

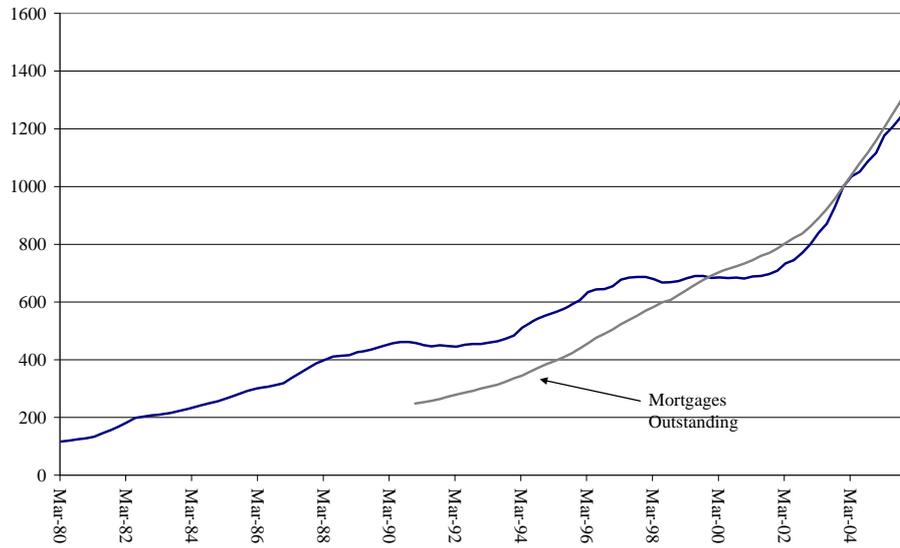
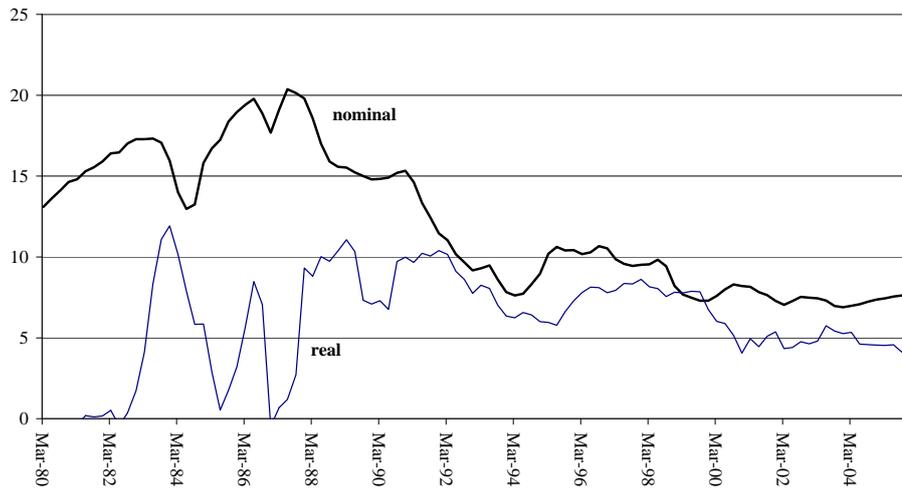


Figure 2
Average mortgage rate, New Zealand, 1980 - 2005



The real rate is the nominal rate minus the past inflation rate.

Figure 3
Theoretical borrowing limit at actual New Zealand borrowing rates
(\$50000 income with x% mortgage-repayment-to-income constraint)

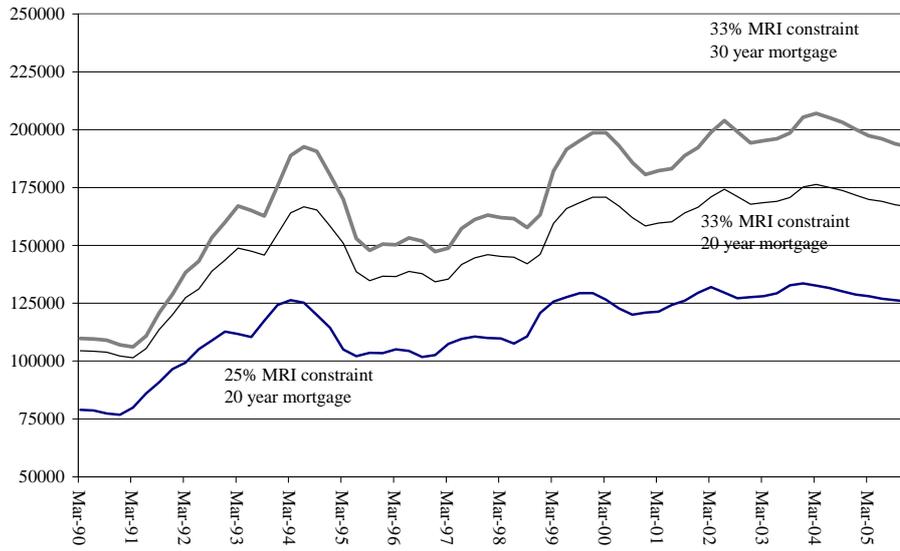


Figure 4
Fraction of New Zealand households renting, 1984-2004



Figure 5
House prices as a function of credit constraints
(inflation = 0, $r=4.0$, $h=1200$)

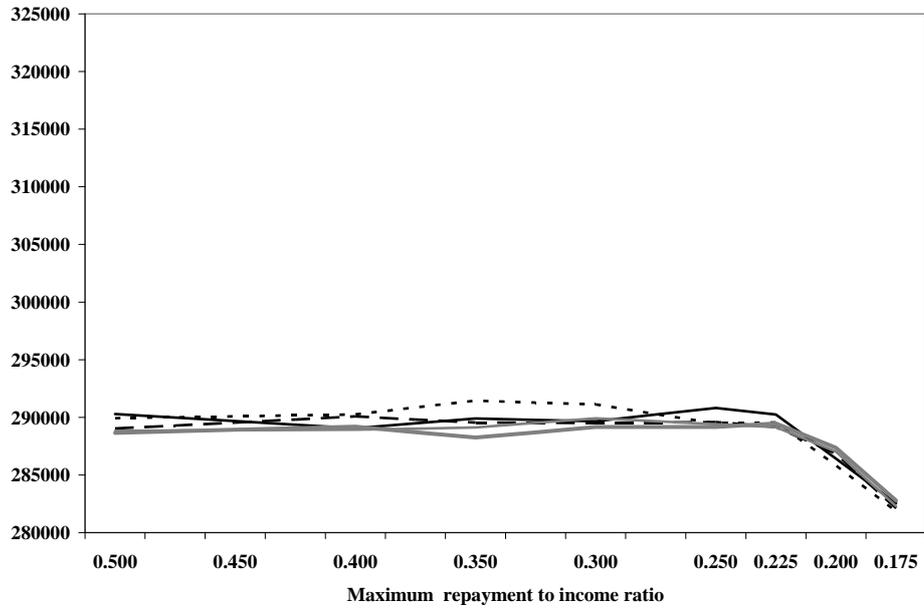


Figure 6
House prices as a function of credit constraints
(inflation = 0, $r=3.25$, $h=1200$)

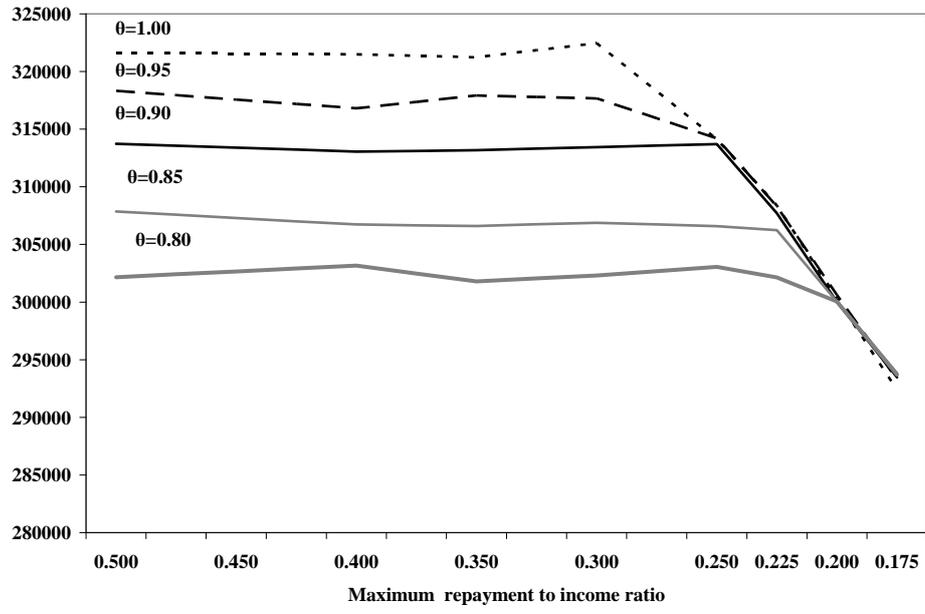


Figure 7
Flat prices as a function of credit constraints
(inflation = 0, $r=3.25$ or 4.0 , $h=1200$)

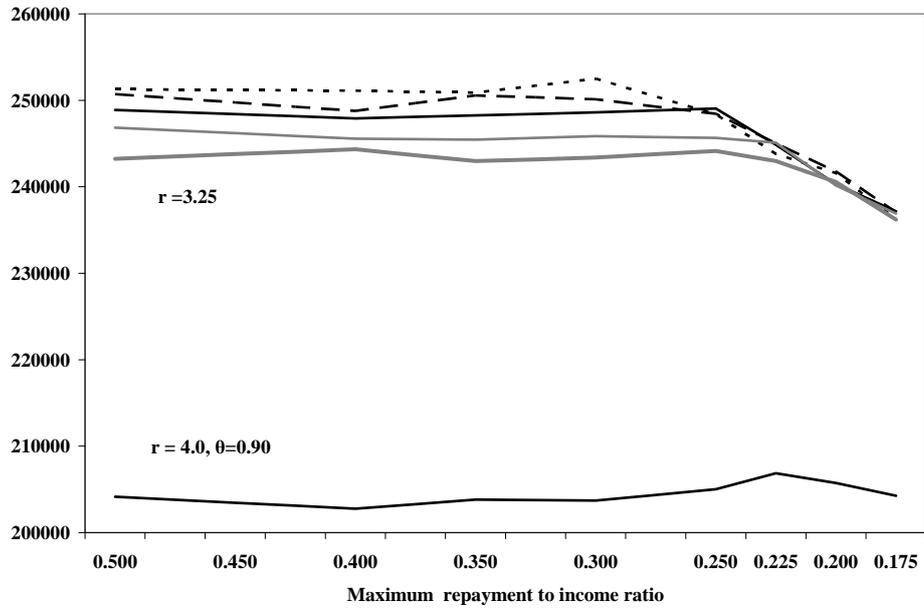


Figure 8
The fraction of the population who rent as a function of credit constraints
(inflation = 0, r=3.25, h=1200)

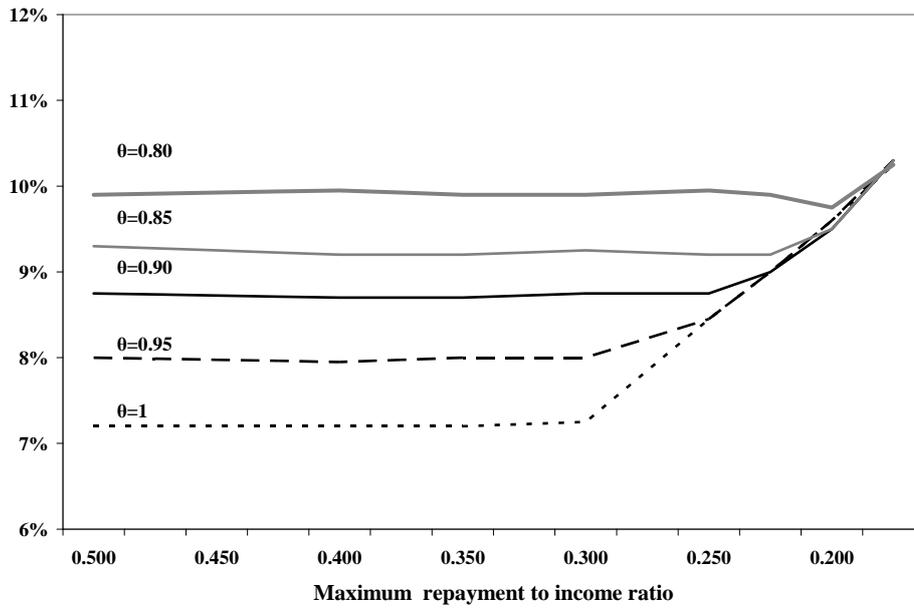


Figure 9
The fraction of the population who rent as a function of credit constraints
(inflation = 0, r=4.0, h=1200)

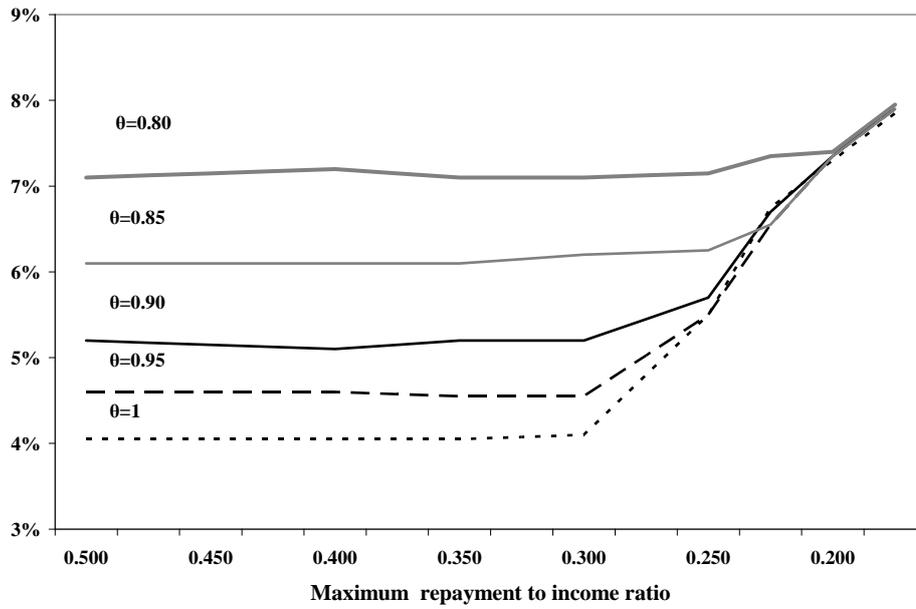


Figure 10
The fraction of the population who rent as a function of credit constraints
(inflation = 2, r=4.0, h=1200)

