Disinflation and the dynamics of mortgage debt

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1. Introduction

A permanent reduction in average inflation should be expected to reduce nominal interest rates on deposits and loans by the same amount. Together with financial deregulation, which reduced interest margins and made housing finance more accessible, the reduction in nominal interest rates in Australia since the 1980s has eased the initial repayment burden of a given-sized debt. Households have therefore taken advantage of their increased capacity to borrow, resulting in rapid growth in household debt over the past decade or so, as shown in Graph 1. Consequently, the ratio of household debt to disposable income in Australia has increased from a level well below that in other developed countries, to something close to the upper end of the range of international experience.

In the process of transition to the new equilibrium, household credit should be expected to grow much more quickly than income. This has certainly been the situation in Australia in recent years. However, knowing that such a transition is in progress is not enough when trying to interpret correctly the current expansion in credit. It is also important to understand when the transition will end, and what the new equilibrium debt levels will be - or indeed, whether the process has gone too far and must partly reverse to reach its long-run sustainable path. This paper reports some analysis that tries to provide a sense of the likely magnitude of the change and its determinants, although it does not goes as far as predicting the timing of the end of the transition or the new equilibrium debt/income ratio.

After describing the workings of the key financial product of interest - the standard, variable rate mortgage loan - in the next section, in Section 3 we use a simple mechanical simulation to show the effects of a permanent reduction in nominal interest rates on indebtedness, given various assumptions about demographics and the growth and distribution of income. We then refine this simple framework in Section 4 to incorporate optimising behaviour by households in their choices about housing tenure and consumption of housing services, and the financing of those choices. We use this model to investigate the implications of a permanent disinflation for household sector indebtedness, housing prices and quality, as well as other characteristics of the housing market such as owner-occupation rates. As well as discussing the comparative statics of the long-run equilibria given different average inflation rates, transitions from the high-inflation to low-inflation equilibria receive particular attention. We summarise these conclusions and draw out some of the implications for the Australian economy in Section 5.

We must still take a number of things as given to make the analysis tractable. For example, we do not allow for the possibility that disinflation might induce lenders to alter their lending criteria. The results described here depend crucially on borrowing constraints and disappear if they are not present. The ceiling on the ratio of repayments to income, and in Section 4 the downpayment constraint, serve as the only constraints on intermediaries' willingness to lend. Our assumptions about both lending and borrowing behaviour also imply that the ratio of household debt to income will stabilise in the long run. That is, we exclude the possibility that both sides of the household sector balance sheet might deepen as living standards rise. We also focus on home mortgage debt and ignore consumer credit. We exclude a large number of factors that affect households' housing and financing decisions, including taxation and the possibility of government subsidies for particular kinds of housing arrangements. Finally, we ignore the effects of changing demographics on the debt/income ratio, other than allowing for steady population growth.

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[1] The author thanks Andrew Stone for helpful comments about the formal model. Responsibility for any remaining errors rests with the author. The views expressed in this paper are those of the author and should not be attributed to the Reserve Bank.

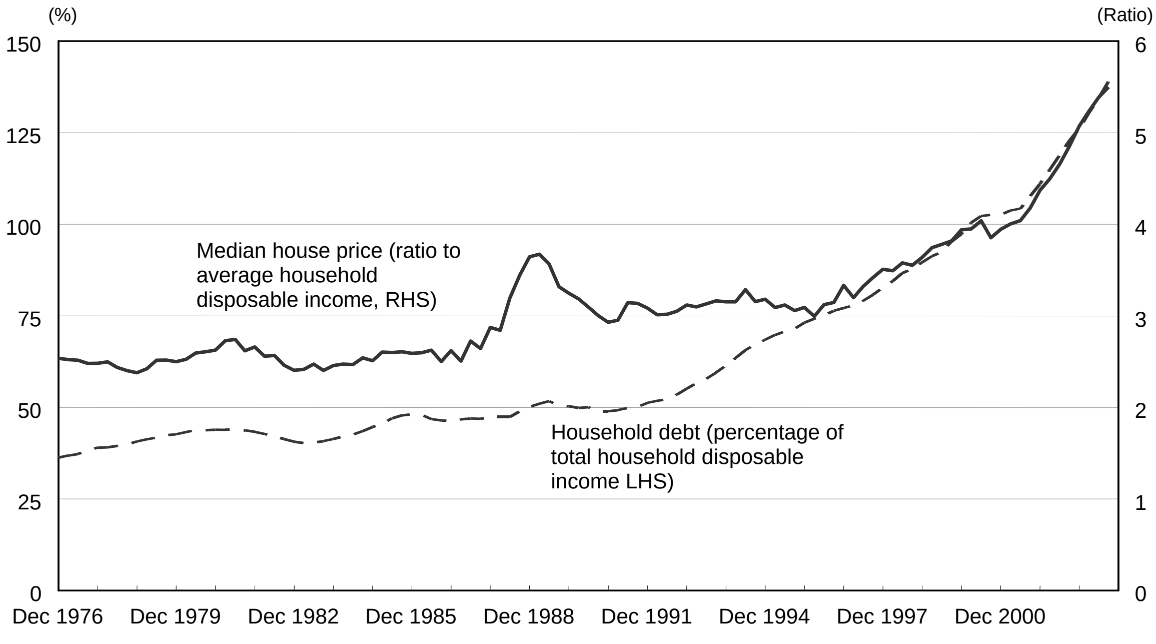
The analysis reported in this paper differs from, but is related to, the considerable literature on the effects of financial deregulation or liberalisation on household balance sheets (Throop (1986), for example). Among other things, this literature finds that borrowing constraints implied by market imperfections and regulation have tended to reduce owner-occupation rates (Zorn (1989), Duca and Rosenthal (1994)), especially for younger households (Haurin et al (1997), Ortalo-Magné and Rady (1999)), as well as constrain housing prices (Meen (1990)). Easing these constraints is therefore likely to increase housing demand and indebtedness, both because existing households can borrow more and because household formation rates rise (Börsch-Supan (1986)), although such mortgage qualification requirements are likely to have some effect even in a deregulated financial system (Linneman and Wachter (1989)). In addition, housing prices are likely to be more sensitive to interest rate shocks when financial sectors are liberalised than when they are regulated (Almeida (2000), Iacoviello and Minetti (2003)), which may be due to the greater responsiveness of asset prices to shocks when leverage is higher (Henley (1999), Lamont and Stein (1999)).[2]

The implications of disinflation and deregulation for household debt and housing are similar, with both events tending to enable greater debt accumulation by home-buying households. In recent decades, many developed countries including Australia have experienced both disinflation and deregulation, so that their long-run effects on debt/income ratios would have tended to compound each other. Both events seem to be necessary in order to generate the substantial deepenings in household balance sheets that have been observed (Ellis and Andrews (2001)). However, there are some subtle differences in outcomes from the two events. They therefore have different implications, particularly in terms of distributions of wealth and debt. This paper should therefore be viewed as complementary to existing literature on borrowing constraints and the effect of financial liberalisation, in effect disentangling the effects of disinflation in the increase in household indebtedness from those arising from financial deregulation.

Graph 1

Household debt and house prices

Relative to household disposable income



Sources: Reserve Bank of Australia; Real Estate Institute of Austrialia; Australian Bureau of Statistics.

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2 This is true on the condition that mortgage finance is primarily provided at variable interest rates. In economies such as the United States where long-term fixed interest rate mortgages are the norm, demand and construction activity appear to have become less sensitive to interest rates with deregulation, because the supply of mortgage finance is now less sensitive to variable interest rates (McCarthy and Peach (2002)).

2. The fundamental object: credit-foncier home mortgages

The basic object of analysis in this paper is the standard, variable rate loan of the credit-foncier type. Under this type of loan contract, the borrower must repay the original principal over an agreed maximum term, by making regular repayments. The repayments are a constant nominal amount if interest rates do not change; and if interest rates do change, the repayment is recalculated to ensure the debt is still fully repaid over the original term. (With debt contracts of this type, the borrower may also be permitted to make early repayments without penalty.) The required repayment rp per period is a function of the initial amount borrowed (P), the per-period interest rate (i) and the number of repayments (T) to be made over the life of a loan, as shown in equation (1).[3] This is a standard calculation available in spreadsheet packages and handheld calculators. Given this repayment, the remaining principal outstanding falls slowly at first, and then more quickly later in the life of the loan, as shown in the top left-hand panel of Graph 2. Credit-foncier loan contracts have the property that the remaining debt outstanding in any period k part-way into the life of the loan is equal to the loan size that would generate the same per-period repayment rp over the shorter loan life $T - k$. Therefore there is an analytical expression for the remaining outstanding debt P_k in period $k \geq 1$, as shown in equation (2). The fixed total repayment therefore changes in composition through time, with a declining fraction being interest and a greater fraction being repayments of principal, as shown in the top right-hand panel of Graph 2. The real burden of this fixed nominal repayment naturally declines at a rate determined by the rate of growth in nominal incomes.

$$rp = P\,[i\,(1+i)^T] \,/\, [(1+i)^T - 1] \qquad (1)$$

$$P_k = P\,[(1+i)^T - (1+i)^k] \,/\, [(1+i)^T - 1] \qquad (2)$$

A permanent disinflation can result in an increase in the ratio of household debt to disposable income because lower nominal rates allow borrowers to service larger debts with the same repayment. This is particularly true in a country like Australia where most home mortgage finance is provided at variable rates.[4] The bottom left-hand panel of Graph 2 shows how large the initial loan size can be at different interest rates, while maintaining the same nominal total repayment as on a AUD 100,000 loan at 10% interest with a 20-year term repaid monthly. If it is the initial burden that is the binding constraint on households' ability to borrow, a disinflation will clearly allow households to borrow more. This is known as the repayment tilt effect (Howitt (1990)). Although the dollar value of the repayment is unchanged over these different combinations, the implications for debt and repayment ratios to income are very different. The burden of the fixed nominal repayment declines more slowly when nominal income growth is lower, as shown in the bottom right-hand panel of Graph 2 (Stevens (1997)). In addition to the effect on repayment burdens, slower growth in income - taken in Graph 2 to vary by the same amount as nominal interest rates - compounds the effect of the higher initial value of the maximum allowable debt on aggregate debt/income ratios. This occurs because an individual borrower's ratio declines less quickly when incomes grow at a slower rate.

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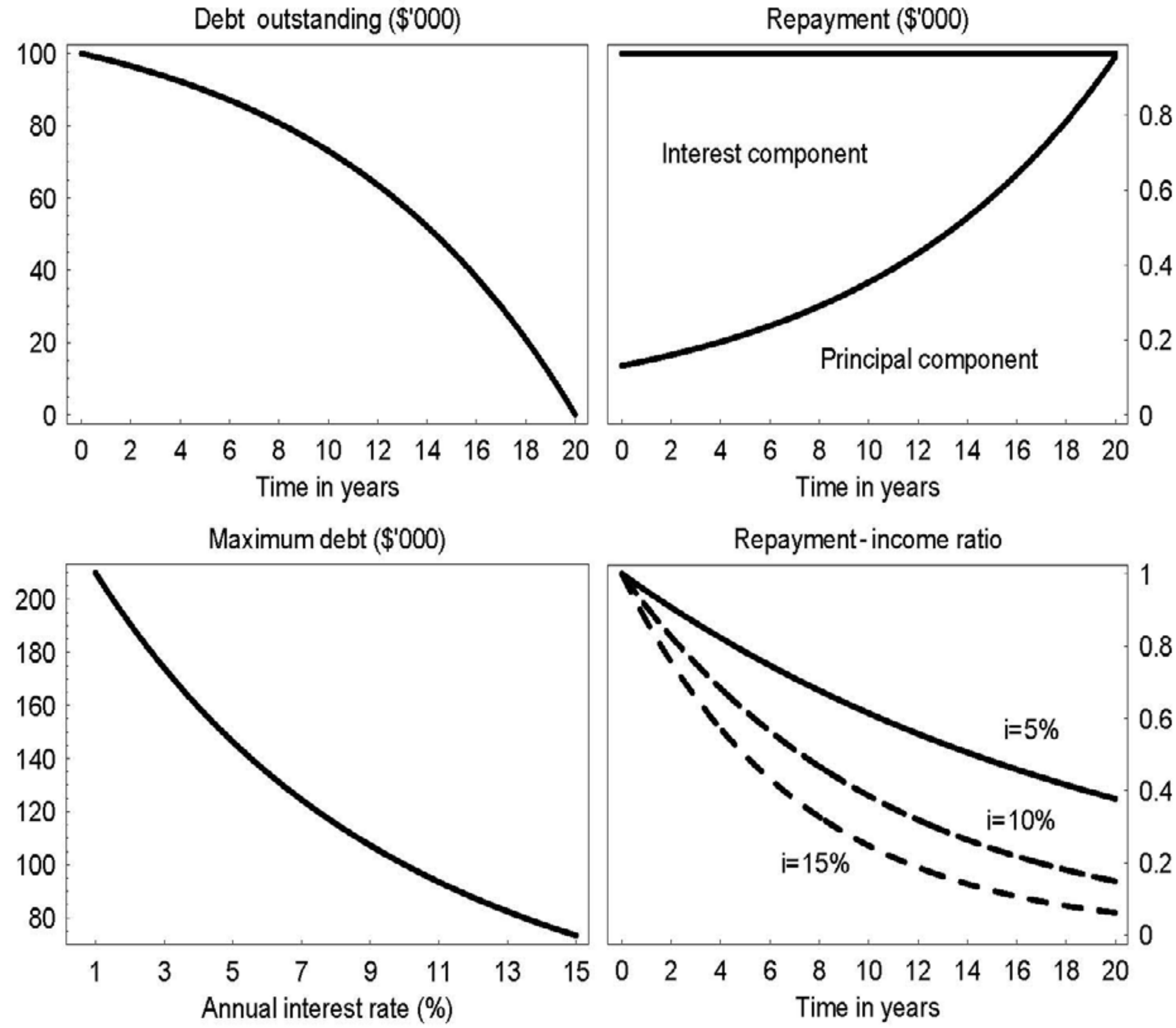
3 This formula assumes that repayments are made in arrears, that is, at the end of the period, and that the loan is fully paid off at the end of the term.

4 Although a minority of new borrowers (usually between 10 and 20%) do fix the rate on some or all of their mortgage loan, lenders generally only offer products with a fixed interest rate of one to three years, with five- and 10-year fixed rates being very much the exception. After the fixed period has expired, the loan reverts to the interest rate applying to a standard variable home loan.

Graph 2

Debt and repayment profiles for credit-foncier home mortgages



Source: Reserve Bank of Australia.

3. Disinflation and aggregate mortgage debt

From the preceding discussion, we can see that a permanent, recognised reduction in inflation and nominal interest rates can increase debt/income ratios. This occurs both because initial loan sizes can rise in absolute terms, and because the ratio of debt to income diminishes more slowly through the life of the loan when nominal income growth is slower. In this section, we develop a first pass at quantifying these effects on aggregate household debt and repayment burdens, using a highly stylised model of households incurring and then paying off home mortgage debt. We assume that lenders impose a *repayment ratio test*, lending to the individual household only up to the amount that would generate a prespecified ratio of the total repayment to current nominal income. We assume that households are always willing and able to borrow this amount; effectively, the repayment ratio test is the only constraint on households' decisions to borrow. Initially, we will ignore downpayment requirements - effectively assuming that homebuyers can borrow 100% of valuation - and instead defer this consideration to Section 4. We then show how the mechanics of the credit-foncier loan contract imply that the ratio of aggregate household debt to aggregate income converges on a long-run equilibrium level that depends on the nominal interest rate, the rate of nominal income growth and the distribution of income by age.

The model is extremely simple and mechanical. Households are formed at age 25, and purchase a home using 100% debt funding. To do so, they borrow the maximum amount lenders will extend to them, given their income. This maximum is determined by a repayment ratio test imposing a maximum ratio of repayments to gross income of 30%. We choose this figure because it approximates the kinds of lending conditions actually imposed by Australian banks. The loan repayments are calculated on the basis of monthly repayments for a 25-year term (300 payments) at the prevailing interest rate. Households pay down their mortgage according to the required schedule, and then spend the remainder of their life until age 75 as outright owners of their home. Given the implied path for debts of households of different ages, and an assumed distribution for household income by age, the debt/income ratio for the whole household sector can be calculated by simply aggregating debts and income across cohorts. For a given rate of inflation, nominal interest and nominal income growth, as well as the age/income distribution and ratio imposed by the repayment ratio test, there is a steady state debt/income ratio for the whole household sector.

The top left-hand panel of Graph 3 shows how this aggregate debt/income ratio varies with inflation, given the repayment ratio test of 30% mentioned above and real income growth of 2%, for a range of levels of real interest rates. The income distribution by age used is that implied by the 2001 Household, Income and Labour Dynamics in Australia (HILDA) Survey, smoothed using a non-parametric lowess regression, as shown in the bottom right-hand panel of the graph.[5] The property of the income distribution that matters most for the long-run debt/income ratio is the ratio between (average) household income at the age the loan is borrowed, and the average income of the whole household sector. This is because the repayment ratio test is only applied when the loan is first borrowed. As discussed earlier, for a given level of real interest rates, lower inflation increases the aggregate debt/income ratio in two ways. First, the resulting lower nominal interest rates allow young households to take out larger loans and still meet the repayment ratio test. Therefore every cohort of households have higher nominal debt relative to their income when nominal rates are lower. Second, the implied lower rate of nominal income growth implies a slower decay in the ratio of debt to income. Higher growth in real income naturally results in faster nominal income growth for a given rate of inflation. Therefore higher real income growth results in a lower long-run debt/income ratio, given the rate of inflation, as shown in the centre left-hand panel of Graph 3. Similarly, the longer the loan term, the higher the long-run debt/income ratio, as shown in the bottom left-hand panel of Graph 3. This occurs because a larger proportion of all age cohorts still have debt if the term is longer, and because the path at which the debt is paid down is more gradual.

The implications of a permanent, credible disinflation for the debt/income ratio are therefore unambiguous. Suppose that, at some point $t = 0$, inflation falls credibly and permanently, with nominal interest rates and income growth falling in tandem. The households that had originally borrowed when inflation was higher could then potentially lower their repayments, while newer cohorts could borrow greater amounts as implied by the larger maximum permitted under the repayment ratio test. Once all the borrowers who borrowed when inflation was high have paid off their loans - which by definition occurs within 25 years, the assumed loan term - the system reaches a new steady state. The comparative statics of this change can be read off the schedules shown in the top left-hand panel of Graph 3.[6]

Assuming the older borrowers, who now face unexpectedly lower interest rates, lower their repayments (and presumably consume the difference), the transition path is smooth and concave. The debt/income ratio approaches its new steady state level at a diminishing rate; examples of these transition paths are shown in the top right-hand panel of Graph 3. This follows from the concavity of the path for nominal debt as shown in the top left-hand panel of Graph 2 above. The steady state debt/income ratios shown in the left-hand panels of Graph 3 are based on the presumption that all age

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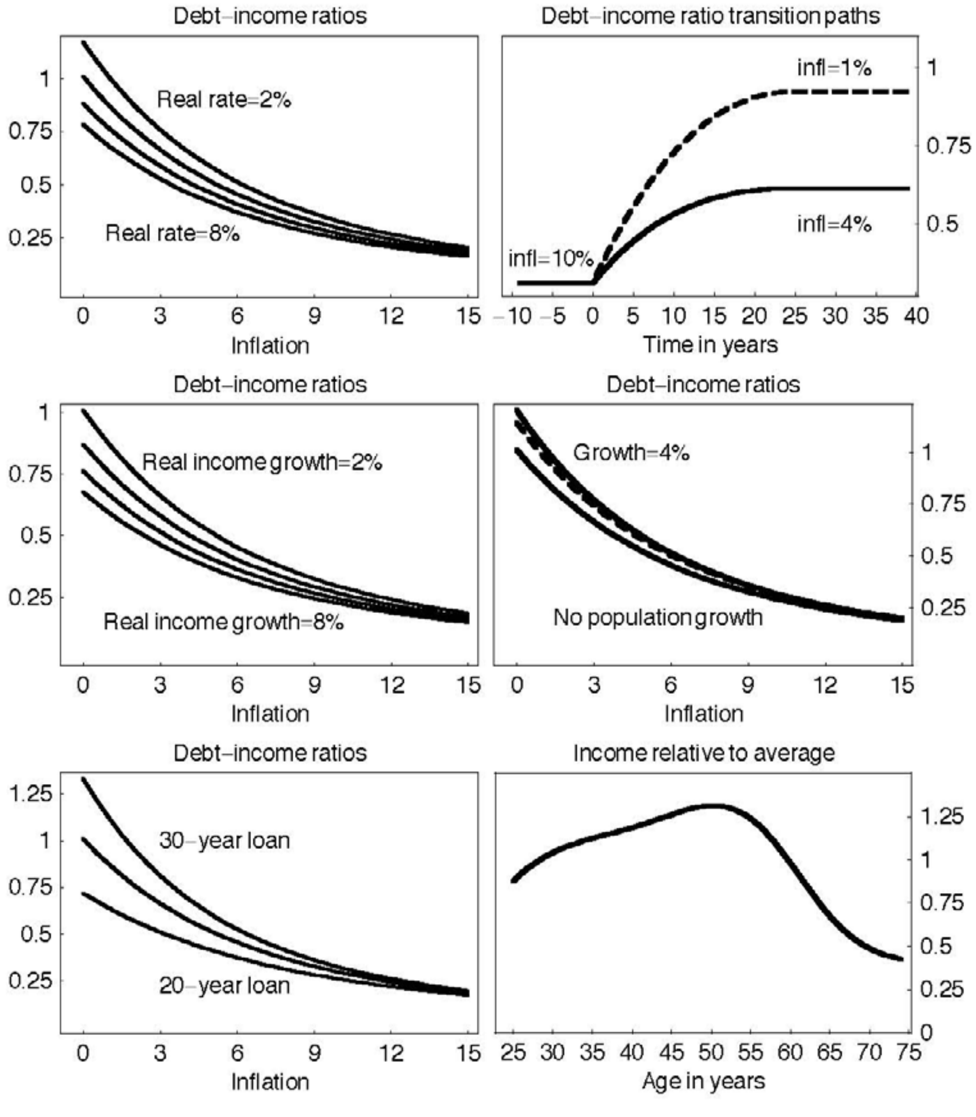
5 For compatibility with the assumptions of the simulations presented here, these income relativities are based on an unweighted average household income rather than one that takes the actual age distribution of Australia's population into account.

6 Similar results were shown in tabular form in Reserve Bank of Australia (2003), without the added complication of population growth or the distribution of income by age.

cohorts are of equal size. That is, there is no population growth and lifespans are identical. It is straightforward to see that population growth will increase the steady state aggregate debt/income ratio. This occurs because, when the population is growing, a greater proportion of households are therefore in their high-debt years. The centre right-hand panel of Graph 3 shows the effects of various constant rates of natural population growth on the steady state debt/income ratio for a range of inflation rates (π), assuming real rates are constant at $r = 4\%$ and real income growth is constant at 2%. Constant population growth affects the assumed long-run level of the debt/income ratio, but it does not alter the factor of proportionality between the ratios implied by different rates of inflation.

Graph 3

Aggregate debt/income rate



These steady state debt/income ratios and transition paths can readily be calculated by simulating the debt profiles of the required number of age cohorts, N. An analytical expression for the ratio can also be obtained, although it is rather cumbersome. Using equations (1) and (2), we define the maximum repayment ratio as being some fraction ψ of the income of the youngest cohort $y_0 Y_0(1+w)^t(1+\pi)^t$, where y_0 is the ratio between the youngest cohort's income and average income, $Y_0(1+w)^t(1+\pi)^t$. Y_0 is nominal average household income in the initial period 0, π is inflation and w is real income growth. We can therefore write the steady state debt/income ratio $D(\cdot)$ as equation (3).

$$D(y_0, \psi, N, T, i, \theta, \pi, w) = \frac{\psi y_0}{i} \frac{\sum_{j=1}^{N} \left\{(1+\theta)^{N-j} \left[1-(1+i)^{\min(j-T,0)}\right](1+\pi)^{-j}(1+w)^{-j}\right\}}{\sum_{j=1}^{N}(1+\theta)^{N-j} y_j} \tag{3}$$

The other parameters in equation (3) are the loan term T, number of annual cohorts N, nominal interest rate i, population growth rate θ, and, as mentioned before, inflation π and real income growth w. The ratio between the income of each cohort j and average income is denoted as y_j. This expression assumes that there is only one repayment per period, that is, that households that take out a loan within a single year can only be treated as a single cohort if they make one repayment per year on their loan. The case of multiple repayments per period can be accounted for using a version of equation (3) where the interest rate and rates of inflation and income growth are suitably redefined. The effect of multiple repayments per cohort, given the same annual interest rate, is to allow a higher initial loan size for young households and therefore a slightly higher long-run debt/income ratio.

Putting all these influences together, it would seem that the disinflation and reduction in margins on home loan interest rates seen in Australia since the late 1980s would be broadly consistent with an approximate doubling of the aggregate household debt/income ratio. Since the ratio has in fact more than doubled, from around 50% in 1991 to more than 125% in 2003, it seems likely that this transition has completed, as well as possibly being reinforced by a relaxation of other lending conditions, resulting from financial deregulation. Moreover, any further increase in this ratio is presumably attributable to other factors, such as the easing of other kinds of borrowing constraints, or an increase in the prevalence of refinancing with equity withdrawal.

3.1 Early repayment

Because interest payments on home mortgage debt are not tax-deductible in Australia, households are effectively repaying their mortgages out of post-tax income. Since interest and other investment earnings are taxed, this creates a strong incentive for homebuyers to repay their existing debt ahead of schedule if they can, rather than invest in some other asset where the return is taxed (Zorn and Lea (1989)). This is one of the features of the market that encourages the prevalence of variable rate debt; lenders then have no maturity mismatch, and thus have no incentive to impose a prepayment penalty.

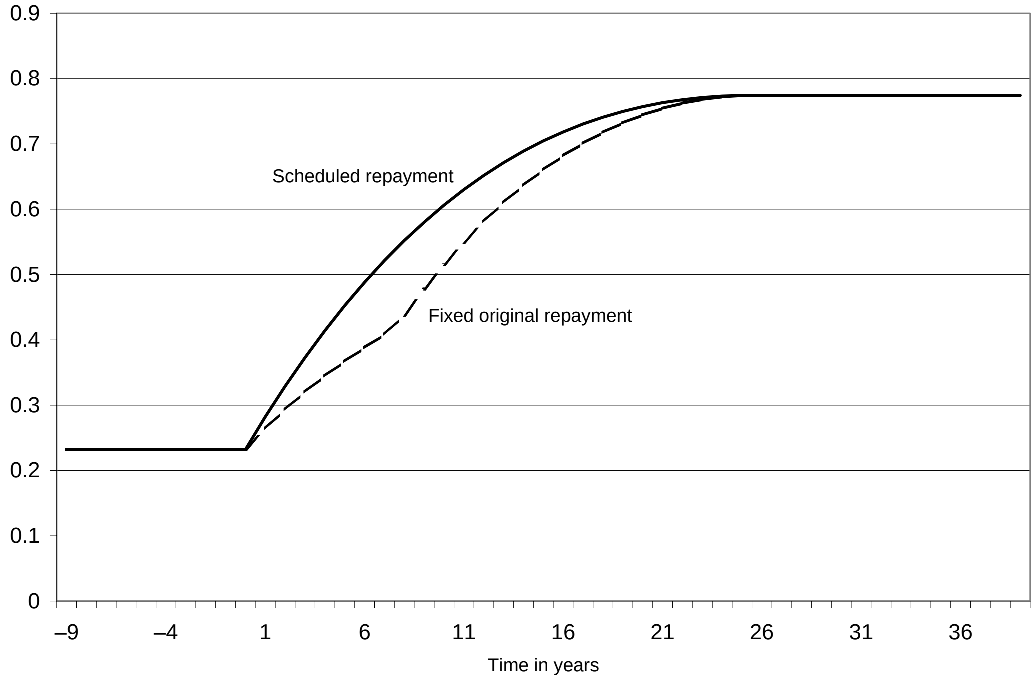
The scope for early repayment is potentially very important for the transition period from a high-inflation state to one with a permanently lower inflation rate. Households that initially borrowed when inflation was high will find that their repayments have fallen below the level they originally expected, although the burden of these lower repayments will also diminish more slowly because income growth is slower in the low-inflation state. These households may choose to maintain their repayments - at least in nominal terms - at or close to the level that would have been implied by the higher nominal interest rates in the high-inflation state. Since rates are actually lower than they had been when the loan was first taken out, this means that the debt is paid down much more quickly than implied by a normal credit-foncier loan contract.

The implications of this response by older cohorts serve to make the transition to the new steady state debt/income ratio more drawn out, although the steady state ratio itself is unaffected. The extent of this effect depends entirely on the difference between the original and the new nominal interest rate. Graph 4 shows the effect of a permanent disinflation from 12% per annum to 2%, reducing nominal rates from 16% to 6%, when existing borrowers reduce their repayments to maintain the original term (scheduled repayments), and when they maintain their original repayments.[7] In the latter case, the increase in the debt-income ratio is substantially slower than if the earlier borrowers reduce their repayments, but begins to catch up again after a decade or so. Although it is difficult to be certain, it is possible that this effect served to make the current transition of Australia's household debt/income ratio to be more drawn out than it otherwise would have been, even though the rapid increase in the ratio did begin almost immediately when inflation and nominal rates came down.

[7] For simplicity, this figure shows the case where households make only one, in-arrears payment on their mortgage per year.

Graph 4

Debt/income ratio transition paths



Source: Reserve Bank of Australia.

4. Adding in the downpayment constraint

In the previous section, we assumed that the lenders' repayment ratio test is the only constraint on households' willingness or ability to borrow. A reduction in nominal interest rates would therefore always induce further borrowing to restore households' repayments to the maximum proportion of income allowed. Even though lower nominal income growth increases the burden of a given mortgage repayment in the later part of the life of the loan, it was assumed that this did not affect borrowers' decisions about the initial loan size they would take on. Neither did we account for the *downpayment constraint*: the fact that, even if the household can service a debt of given size, it still must have accumulated enough savings to fund the downpayment, before it can purchase a home. Moreover, we previously assumed that, in the transition period, households that had originally borrowed at the higher interest rate did not respond to the change in circumstances brought about by the disinflation. Previously they just consumed the unexpected reduction in their mortgage repayments (or, in Section 3.1, maintained a constant repayment), because they neither extracted their windfall equity gains by borrowing more, nor did they respond to the resultant increase in the relative price of housing by downgrading to a smaller home.

In this section, we relax these strong assumptions to get a better sense of the consequences of a permanent disinflation, in particular its implications for the level of household debt. Downpayment requirements have previously been recognised as important constraints on access to home ownership (Stein (1995), Haurin et al (1997)) and are frequently considered to be a summary measure of the extent of financial repression or constraint in home mortgage finance (Iacoviello and Minetti (2003)). The analysis presented here assumes no taxes or subsidies, and a fixed minimum downpayment constraint. However some lenders do not impose a downpayment constraint and instead lend 100% of valuation. This eliminates the effects of the downpayment constraint entirely. Government upfront subsidies to first-home buyers would also serve to ameliorate this constraint.

4.1 A model of tenure and housing choice

As in Section 3, we use an overlapping generations model to capture the life-cycle aspects of home ownership and mortgage finance, with 50 cohorts so that a reasonably realistic annual frequency of decision-making is possible. Previous literature used overlapping generations with fewer cohorts, but this requires some heterogeneity within cohorts (Ortalo-Magné and Rady (1999)). The added complexity of a model with many cohorts permits us to assume that households are identical within a cohort, and still permits reasonably smooth responses to small parameter changes. Young households initially rent a home, and save to accumulate a downpayment. Once they have accumulated a downpayment and can meet the repayment ratio test for a home that satisfies their demand for housing services, they will take out a 25-year mortgage and become owner-occupiers. We assume that externalities in the landlord-tenant relationship result in rents exceeding the housing services provided by rental properties, following Henderson and Ioannides (1983). Therefore households will always prefer owning to renting, all else equal. The households will then pay down the debt according to the required schedule, and own their homes outright for the remainder of their lives.

When the household dies, after 50 years of adult life, the home is sold to the marginal young household that is ready to buy its own home. The proceeds of the sale are distributed as a lump sum transfer equally to all households. This implies that when housing prices and the population size are constant, young households could simply passively receive these inheritances and accumulate the required downpayment over a few years - for example, five years if the downpayment requirement is 10%. To ensure an interior solution where young households save from their own labour income, we would need to calibrate the model so that the externality involved in renting is large enough that young households would rather save more and buy sooner than pay another year of rent. Allowing for population growth will also tend to result in young households actively saving in this model, since the number of new young households will therefore exceed that of old households at the end of their lives. Even for relatively low rates of population growth, a sizeable fraction of these new households will have to purchase newly built homes, rather than the deceased estates homes left by the oldest cohort. Although in principle the young households could simply wait longer to accumulate enough of an inheritance, this would result in an ever increasing age at first-home purchase rather than a steady state equilibrium.

We assume that households choose real consumption of a composite consumption good (c), housing services (h) and leisure (l) to maximise their expected utility over their N-period finite lives (4). Utility is assumed to be additively separable through time, and across goods. The price of purchasing housing, relative to the consumption good, is denoted as p. The consumption good's actual price rises at a constant rate π, so at any period t the (normalised) price level is $P \equiv (1+\pi)^t$ and the price of housing is $p_t(1+\pi)^t$.

$$\max U = E\left\{\sum_{j=1}^{N} \delta^{j-1} u(c_j, h_j, l_j)\right\} \tag{4}$$

In each period, households must also choose their housing tenure (χ), where $\chi = 1$ if the household is an owner-occupier and zero if it rents. Because households always prefer to own rather than rent their home, if they can, they will rent while young and own when older, and never choose to revert to renting once they have bought their first home. Therefore the sequence of tenure states χ_j will be comprised of a sequence of zeros followed by a sequence of ones, with combined length N. We denote the age of first-home purchase (first one in the sequence of χ_js) as z. As well as borrowing mortgage debt d with an initial term T to purchase a quantity of owner-occupied housing h, households can use the same debt to invest in rental properties a, from which they receive a rental return R^*.[8] Even if households borrow additional amounts later in life, it is assumed for simplicity that they must still pay off their entire debt by the end of the original term, so any later borrowings must be paid off over a shorter term. The loan contracts are of the credit-foncier form described in Section 2, so that (1) and (2) hold. The j subscript on R and p refers to time periods experienced by a given cohort at each age j, not age-specific prices and rents.

8 Although it has not always been the case in Australia that households could borrow for investment property on the same terms as for owner-occupied property, we assume that it is possible here.

Households can also hold a risk-free financial asset *b*, which is assumed to return a nominal interest rate of $i - m$, where *i* is the nominal interest rate paid on mortgage debt; households would therefore never borrow to buy the financial asset. Therefore households may receive labour $P\ W_j\,(1 - l_j)$, interest and rental income, as well as receive inheritances from the oldest households.[9] The wage rate may differ across age cohorts *j* in a given time period. They pay out this income for consumption and rent or mortgage repayments as appropriate, with the remainder going into asset purchases, whether of financial assets, or owner-occupied or rental housing. Putting these different sources and uses of income together, it turns out that the household's problem is to maximise *U* subject to the asset accumulation condition (5). Because home-owning households can adjust their consumption of housing services through time, this budget constraint allows for endogenous decisions about renovation or upgrading to a better home.

$$\begin{aligned} b_j - d_j &= W_j P(1-l_j) + (1+i-m)b_{j-1} + R_j^* P a_{j-1} + P p_j h_N \left[\sum (1+\theta)^k\right]^{-1} - P c_j - (1-\chi_{j-1}) R_j P h_j \\ &\quad - \chi_{j-1} d_{j-1}\left(1+i-\frac{i(1+i)^{T+z-j}}{(1+i)^{T+z-j}-1}\right) - (\chi_j - \chi_{j-1}) P p_j h_j - P p_j (a_j - a_{j-1}) - \chi_j \chi_{j-1} P p_j (h_j - h_{j-1}) \end{aligned} \tag{5}$$

The repayment/income ratio test and downpayment test on households' mortgage debt are captured as further constraints on their maximisation problem, as shown in (6) and (7). The maximum ratio of repayment to income is denoted as ψ as in Section 3, while the maximum loan/valuation ratio is denoted as $\overline{\omega}$. We assume that lenders treat owner-occupied and investment properties together when calculating the loan/valuation ratio. Households that own both owner-occupied and investment properties are treated as though they have the same gearing on both types of property, although in a model with taxes they may prefer a different arrangement depending on how the two types of housing are taxed.

$$d_j\left(\frac{i(i+1)^{T+z-j}}{(i+1)^{T+z-j}-1}\right) \le \psi W_j P(1-l_j) \qquad \text{repayment constraint} \tag{6}$$

$$d_j \le \overline{\omega} P p_j (h_j \chi_j + a_j) \quad \text{downpayment constraint} \tag{7}$$

The constraints (6) and (7) only apply if $z \le j \ge T + z$, where again *z* denotes the age at which the household first becomes an owner-occupier. Beyond age $T + z$, it is assumed that debt outstanding $d_j = 0$. In order that all mortgage debt is repaid before the household dies at age *N*, lenders require the following condition to hold (8). In general, *z* will be a product of the equilibrium solution, but for some combinations of parameter values, the term of the original mortgage *T* might also need to be adjusted to satisfy this condition.

$$T + z < N \tag{8}$$

As noted earlier, landlords' required rental returns compensate for an externality in the provision of rental property, so that it costs more to consume a given amount of housing services *h* as a renter than as a homeowner, and landlords effectively receive less in rental income (R^*) than their tenants actually pay (R) (Henderson and Ioannides (1983)). The difference can be assumed to be lost in maintenance or monitoring costs; we assume that this is a constant wedge ϕ between R and R^*. This implies the following relationship between rents, mortgage interest and the rate of return of financial assets (9).

$$R > i > \{R^*, i - m\} \quad \text{where } R - R^* = \phi \tag{9}$$

The relationship between the rental return and the return on financial assets depends on households' expectations of future capital gains. Arbitrage implies that the (risk-adjusted) total return on rental housing, including expected capital gain, equates to the return on alternative assets. This is captured in a standard relation used throughout the literature (Meen (1990), Bourassa (1995), Meen (2000), for example), although in this case there are no taxes, so the relationship is as shown in (10). In this arbitrage condition, p_a denotes the relative housing price that investors are willing to pay (which may be different from the relative price of housing actually transacted in the period p_t), and ω_a is the

[9] These inheritances are assumed here to be evenly distributed across surviving households, although there is some empirical evidence that older households direct their gift-giving towards particular types of households in key home-buying age groups (Mayer and Engelhardt (1996)).

loan/valuation ratio on the rental properties they own. We abstract from the repayment constraint in the case of investing households, since the interest component of the repayment is already included in (10), and the (initial) principal component is small. The downpayment constraint is enforced by requiring that $\omega_a \leq \overline{\omega}$; in this case, ω_a is an overall leverage ratio, including borrowing for both investor and owner-occupied residential property.

$$(R \div p_a) - i\omega_a + \left[(1+\dot{p}^e)(1+\pi)\right] = (i - m)(1-\omega_a) \tag{10}$$

Finally, we have a condition that all the rental properties have to be owned by someone (11). This differs from previous literature, where rental properties were generally assumed to be owned by a separate landlord sector (Ortalo-Magné and Rady (1999), Iacoviello and Minetti (2003)). It is, however, more in keeping with the structure of the rental housing market in Australia to assume that rental households are owned by other households (Yates (1996)).

$$\sum_{j=1}^{N}(1+\theta)^{N-j} a_j = \sum_{j=1}^{N}(1+\theta)^{N-j}(1-\chi_j)h_j \tag{11}$$

There are no taxes in this model, although they could be added as extensions in further work. Although tax policy is widely recognised as a key driver of outcomes for housing tenure (Hendershott and White (2000), Hendershott et al (2002), Yates (2003)), prices (Capozza et al (1996)) and quality (Gobillon and le Blanc (2002)), we ignore the possible implications of differences in tax treatment of different housing tenures in order to focus on those arising from disinflation.

4.1.1 Equilibrium

Equilibrium in this model requires maximising expected utility (4) by choosing sequences of consumption, housing service consumption, leisure, housing tenure, debt and ownership of financial assets and rental housing for each life stage j, $\{c_j, h_j, l_j, \chi_j, d_j, b_j, a_j\}$ ($j = 1\ldots N$), subject to the $j+1$ equality constraints represented by (5) and (11) (Lagrange multipliers λ_1 and λ_2), the $2 \times j$ inequality constraints (6) and (7) (Lagrange multipliers λ_3 and λ_4), and $3 \times j$ non-negativity constraints affecting a_j, b_j and d_j (Lagrange multipliers λ_5 to λ_7). Conditional on the sequence of housing tenure outcomes $\{\chi_j\}$, this can be depicted as a standard optimisation problem with inequality constraints, using Kuhn-Tucker-style first-order conditions.

$$\begin{aligned}
&V_c = u_c - \lambda_1 P = 0\\
&V_h = u_h \lambda_1 P\left[(1-\chi_{j-1})R_j - (\chi_j - \chi_{j-1} + \chi_j\chi_{j-1})p_j + \delta\chi_{j+1}\chi_j(1+\pi)p_{j+1}\right] - \lambda_2(1+\theta)^j(1-\chi_j) + \lambda_4\overline{\omega}Pp_j\chi_j = 0\\
&V_l = u_l - \lambda_1 W_j P - \lambda_2\psi W_j P = 0\\
&V_a = \lambda_1\delta R^* P(1+\pi) - \lambda_1 P p_j + \lambda_1\delta P(1+\pi)p_{j+1} - \lambda_2(1+\theta)^j + \lambda_4\overline{\omega}Pp_j + \lambda_5 \leq 0 \quad (\text{if } <, a_j = 0)\\
&V_b = -\lambda_1 + \lambda_1\delta(1+i-m) + \lambda_6 \leq 0 \quad (\text{if } <, b_j = 0)\\
&V_d = \lambda_1 - \lambda_1\delta\chi_j\left(1+i-\frac{i(1+i)^{T+z-j}}{(1+i)^{T+z-j}-1}\right) - \lambda_3\left(\frac{i(1+i)^{T+z-j}}{(1+i)^{T+z-j}-1}\right) - \lambda_4 + \lambda_7 \leq 0 \quad (\text{if } <, d_j = 0)\\
&V_{\lambda_3} = \psi W_j P(1-l_j) - d_j\left(\frac{i(1+i)^{T+z-j}}{(1+i)^{T+z-j}-1}\right) \geq 0 \quad (\text{if } >, \lambda_3 = 0)\\
&V_{\lambda_4} = \overline{\omega}Pp_j(h_j\chi_j + a_j - d_j) \geq 0 \quad (\text{if } >, \lambda_4 = 0)
\end{aligned} \tag{12}$$

As noted previously, because of the externality creating a wedge between the cost of renting and the cost of owner-occupation, households would not choose to revert to rental housing after owning a home, unless they received a sufficiently large negative income shock that meant they no longer fulfilled the repayment constraint (6). Therefore, we only consider as candidate equilibria outcomes where the sequence of housing tenure outcomes $\{\chi_j\}$ consists of a sequence of zeros (renting) of length $z-1$ followed by a sequence of ones (owning) of length $T-z+1$. Given this restriction on the possible sequences of housing tenure outcomes, the solution V^* (12) to the households' problem can be solved in two stages: first, solve the problem conditional on some value of z; then, find the value of z which gives the maximum utility of these conditional solutions.

$$V^* = \sup_z V(c, h, l, a, b, d; z) \tag{13}$$

In (13), $V(\cdot; z)$ is the maximised value of utility obtained by choosing $\{c_j, h_j, l_j, d_j, b_j, a_j\}$ ($j = 1\ldots N$), conditional on z. This involves solving the first-order conditions (12), where subscripts of u denote partial derivatives of the utility function with respect to the relevant choice variable, with the *j* subscript dropped for notational simplicity, as well as the first-order conditions with respect to λ_1 and λ_2, (5) and (11). The parameters of the model are ϕ, i, m, θ, ψ, $\overline{\omega}$ and the sequence of wage rates applying through time and (potentially) across age groups $\{W_{t,j}\}$ ($t = 1 \dots \infty$, $j = 1 \dots N$). If inflation remains at a constant rate π and real income growth is also a constant rate of w, then we can simplify the set of wage rates to $\{W_j (1 + w)^t (1 + \pi)^t\}$ ($j = 1 \dots N$).[10]

To close the model, we must also specify the total supply of housing. In the short run, it is reasonable to suppose that the stock of housing is fixed. In the longer run, however, some supply adjustment is likely to take place. We do not explicitly model the microfoundations of the construction industry here. However, we can note that, for a given rate of population growth θ, the supply of new housing required to maintain a given average quality of housing - denoted here as $q = (\Sigma_j (1 + \theta)^{N-j} h_j) / (\Sigma(1 + \theta)^{N-j})$ - in equilibrium is equal to the product of that average quality, and the increment to the population occurring in the period, $s_t\ \Sigma(1 + \theta)^N / \Sigma(1 + \theta)^{N-j}$, where s_t is simply the current population. With some simplification, this implies a stock supply for housing in period t, H_t as shown in (14).

$$H_t = H_{t-1} + q_t s_t \theta(1 + \theta)^N / [(1 + \theta)^N - 1] \tag{14}$$

Making the usual assumption that the supply curve is upsloping therefore implies a supply price that is increasing in both population growth and average quality.

In the steady state equilibrium of the present model, the home ownership rate is constant. That is, in each period, the oldest cohort still renting ($z - 1$) can meet the borrowing constraints and become homeowners at age z. For this to be true, the highest price Pp_{z-1} that the cohort can pay for their preferred level of housing services h_{z-1} must equal or exceed the maximum price Pp_a that older cohorts are willing to pay to add these homes to their portfolio of rental property. If the older households were not also subject to the same borrowing constraints as the younger households, this maximum price for investors would be found by rearranging the relationship equating the returns obtained from leveraged acquisition of rental property, with contributed equity $(1 - \omega_a)Pp_a\Delta a$, where $\Delta a = h_{z-1}$, with that from holding an amount of bonds equal to this contributed equity, as shown earlier in (10), to obtain an expression for p_a (15).

$$p_a = R^*/[i - m(1 - m(1 - \omega_a) - (\dot{p}^e + \pi + \dot{p}^e \pi)] \tag{15}$$

Since the young households in cohort $z - 1$ are bidding against the potential property investors amongst their elders, the maximum price the investors are willing to pay is also the price that the young households end up paying, conditional on them succeeding in entering into home ownership. Thus p_a would then also be the price that enters into the repayment and downpayment constraints on the young households.

All households are subject to the borrowing constraints, however, which puts a limit on the amount of rental housing assets that older households can accumulate in any period. For example, suppose cohort $z + 1$ borrowed the maximum allowed by the repayment constraint when they first became homeowners at age z. Then, allowing for nominal income growth $(1 + \pi)(1 + w) - 1$ and the principal repayment of their original debt, this cohort could borrow an amount equal to $\Delta a_{z+1} Pp$, as shown in (16). Therefore the actual relative price of housing p may be lower than the expression for p_a shown in (15).

$$\Delta a_{z+1} = \frac{W_{z+1}\psi(\pi + w + \pi w)}{Pp} \frac{(1+i)^T - (1+i)}{i(1+i)^T} \tag{16}$$

Because of the complexities of the interaction between the borrowing constraints and households' optimising behaviour, an analytic solution for the equilibrium outcome will not be presented here. In the next section, the qualitative effects of a disinflation are discussed, both in steady state and during the transition.

[10] This involves a normalisation of initial average wage rates to unity, with no meaningful implications for the results.

4.2 Effects of a disinflation

If households were not subject to borrowing constraints along the lines of (6) and (7), then a permanent, credible disinflation (fall in π) would have little effect on outcomes. In perfect foresight equilibrium, where the relative price of housing is expected to remain constant $(\dot{p}^e = 0)$, the (unconstrained) price the older households are willing to pay for investment property simplifies to (17), using the Fisher identity to relate the nominal interest rate to the real interest rate r and inflation π, $i = (1 + r)(1 + \pi) - 1$. The role of the inflation rate in (17) is clearly of second-order importance, and is frequently ignored in approximated definitions of the nominal interest rate. Nonetheless, provided $r > \dot{p}^e = 0$, a disinflation does slightly increase the relative price that investors are willing to pay for housing assets, at the expense of the amount of housing services consumed by homeowners, at least initially at age z.

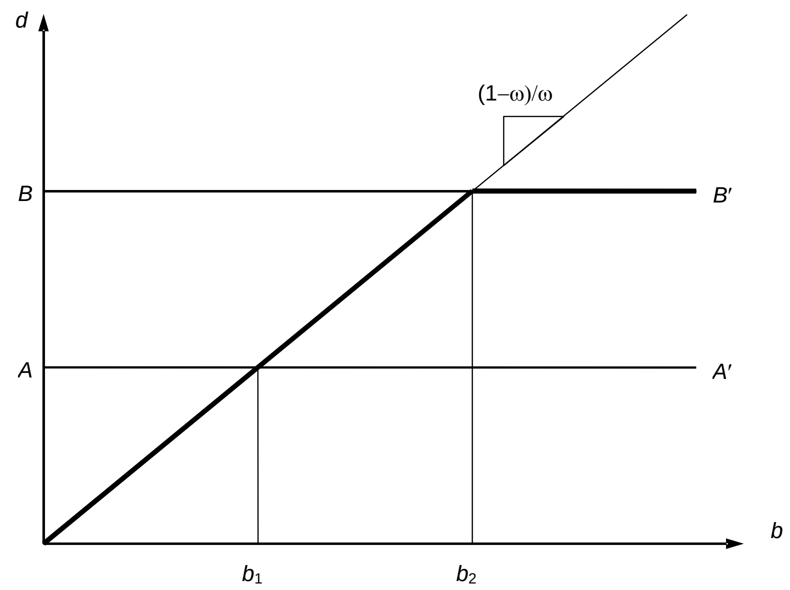
$$p_a = R^*/[(1+r)(1+\pi) - 1 - m(1-\omega_a) - \pi] = R^*/[r + r\pi - m(1-\omega_a)] \quad (17)$$

In the presence of borrowing constraints, however, the effect of a disinflation is potentially much greater. The effect of a disinflation on the two borrowing constraints is shown in Graph 5. The repayment constraint imposes a maximum total amount of debt d, while the downpayment constraint requires that this debt can be no larger than $(1 - \omega)/\omega$ times the deposit, or accumulated financial assets at the time of first-home purchase, b. For low levels of accumulated assets, the downpayment constraint binds but the repayment constraint does not. The combination of the two constraints results in a set of possible combinations of d and b that permit home purchase, represented by the area between the x-axis and the thick piecewise linear frontier between the origin and point B'. Unless the households' rate of time preference is noticeably below the real interest rate, or their preferred level of housing services dramatically different from the constrained level of finance, they will not generally choose to accumulate more financial assets than is necessary to meet the downpayment constraint, conditional on the repayment constraint being binding. Therefore the constrained equilibrium outcome will normally be the corner solution where both constraints are just binding. For example, the debt-asset combination consistent with point b_1 is the likely outcome of a repayment constraint that permits a maximum loan size of A.

A reduction in inflation, and thus nominal interest rates, results in the repayment constraint being consistent with a higher total level of debt. This is represented in Graph 5 by an upward shift in the horizontal part of the constraint frontier, say from AA' to BB'. The downpayment constraint is therefore the binding constraint over a wider range of possible levels of accumulated assets, up to b_2.

Graph 5

Effect of disinflation on borrowing constraints for cohort *z*



With borrowing constraints eased, households will clearly prefer to spend more on housing. If, however, the physical supply of housing is fixed, at least as a first approximation, this tendency will completely manifest in the price in steady state. Even if there is some supply response, prices will still rise to some extent, assuming an upward-sloping supply curve for the flow of new housing, as discussed above. The comparative statics result is therefore for higher *p* and *z*, which translates into a lower home ownership rate, but a higher debt/income ratio $\Sigma d_j / \Sigma W_j P$.

In the transition, the downpayment constraint binds by even more, because the young households, who had previously expected a lower price of housing assets, did not accumulate savings sufficient to meet the downpayment constraint given the higher new relative price of housing. In the first period after the disinflation, these households are priced out of the market and must continue to rent. Moreover, older households are not bound by the downpayment constraint to the same extent, because their equity increases disproportionately when *p* rises. Thus they can both increase their own consumption of housing services *h* and their holdings of rental properties.[11] This serves to bid up the price of housing assets, but not by as much as would occur if cohort *z* were not temporarily priced out of the market and were thus adding their demand to the total. The older households therefore expect that, over time once cohort *z* can return as first-home buyers, the relative price of housing will rise $(\dot{p}^e > 0)$. From (17), this implies that these older households perceive a sufficiently high return from ownership of rental properties that they are willing to hold the extra rental properties in the transition period.

Facing a permanently higher relative price *p*, the younger households still renting must accumulate sufficient financial assets *b* to meet the downpayment constraint. If the age at first-home purchase *z* rises, renting households by definition have longer to accumulate these assets. However, the externality between returns from renting and owning suggests that they will also have some behavioural response in order to minimise the increase in the time spent renting. Depending on the effects of the discontinuity arising from the fact that *z* must be integer-valued, this adjustment will come from a combination of lower consumption of consumption goods *c* and (rented) housing services *h*, as well as lower leisure *l*.

Even if the stock of housing is fixed only in the short run, and eventually expands to meet the increased demand, the transitory effects will still apply. These effects could be quite persistent; it will take at least *z* years before the *z*-aged cohort have experienced only the low-inflation state, and saved accordingly. In addition, the housing stock could take a long time to adjust. In the long run, however, if the housing stock adjusts, the rental rate *R* and price of housing assets *p* will return to (approximately) the levels prevailing before the disinflation. Therefore the relative (but not actual) price of a dwelling of constant quality will return to its pre-disinflation level. However, the median transacted price that is commonly used in housing price series will rise because the average quality of dwellings will rise.

5. Conclusion

The results presented in this paper depend entirely on the interaction of the repayment and downpayment, or deposit, constraints in intermediaries' lending decisions. These constraints were assumed to be a result of intermediaries' responses to imperfections in capital markets, particularly information asymmetries affecting the assessment of credit risk. If these imperfections are ameliorated at the same time as inflation falls, the effect on ownership rates could be reduced. Indeed, if there was no downpayment constraint at all, such that intermediaries were willing to lend 100% of valuation, the effect on home ownership rates disappears entirely.

The balance sheets of Australian households have been clearly affected by the consequences of disinflation. Debt/income ratios have risen rapidly since the early 1990s disinflation, with little sign as

[11] This kind of reallocation of housing services amongst cohorts assumes that, even though the stock of housing is fixed, it is freely divisible. In reality, households will tend to upgrade to a higher-quality home, or renovate the one they currently reside in; an easing in borrowing constraints should be expected to result in an increase in the average quality of dwellings. However, explicitly tracking the occupation of dwellings of specific quality by different households would require adding another dimension of heterogeneity to the model, making it even more complex than it already is.

yet that this process has completed. This expansion in credit has been associated with strong construction activity, both in the construction of new dwellings and in substantial renovation activity. As would be expected from the model presented in this paper, the average quality of new homes is also rising quite rapidly. Strong growth in ratios of household credit to income has also been observed in other countries with relatively deregulated financial sectors once they experience a sustained disinflation. Disinflation interacts with income-linked constraints on borrowing to increase housing indebtedness. This effect works in the same direction as the effects of financial deregulation in easing borrowing constraints. But the ensuing upward shift in housing prices implies that downpayment-type constraints on borrowing become more binding, not less. Thus although financial deregulation would be thought to increase home ownership rates by making finance more accessible, disinflation may actually reduce home ownership rates for younger age groups, at least in the short run until the housing stock adjusts fully. This effect via deposit constraints is in addition to any effect on ownership rates due to a reduction in the tax advantages of home ownership as inflation falls. Moreover, even if the increase in the relative price of housing is temporary, the transition can take considerable time to work through. This is because the housing stock takes time to adjust and young households take time to accumulate savings sufficient for a larger deposit.

Discerning these effects in Australian data is not easy, however. Ownership rates have certainly fallen for younger age groups, according to Census data, with the overall population ownership rate remaining constant because of population ageing. However, most of this decline occurred through the late 1970s and 1980s, rather than after the early 1990s disinflation in Australia.

The implications of these changes for intergenerational welfare are mixed. In the United States, at least, there is evidence that young households are relying more on gifts from their elders than on their own savings in accumulating the downpayment on their first home (Mayer and Engelhardt (1996)). As with transfers between generations, direct government subsidies to first-home buyers would also offset the increasing importance of the deposit constraint as inflation falls. Intergenerational transfers might seem like an understandable response in the transition period, when the older households bought their homes when inflation was high, and have thus experienced an unexpected windfall gain in housing wealth. But if the current growth in the relative price of housing is simply a transition to a new, higher equilibrium level, then currently young households will not have the same windfall gains to redistribute once they are old. Inheritances will be larger than when housing prices are low, but given population growth, they will account for only a constant fraction of the required downpayment for any given relative price level of housing. This suggests that younger households of subsequent generations might have to save more on their own behalf, relative to their incomes, in order to meet the downpayment constraint. This has obvious implications for the intergenerational distribution of consumption and leisure further into the future.

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