Squeezed in and squeezed out: The effects of population ageing on the demand for housing

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Abstract

This paper examines how increasing longevity affects the housing choices of working age and retired people using a heterogeneous agent overlapping generations model that incorporates owner-occupier and rental sectors, credit constraints, detailed tax regulations, and a housing supply sector. Increasing longevity is predicted to increase the fraction of older households living in large houses, and reduce in home ownership rates among young people, who are squeezed out of the housing market because of higher taxes and house prices. The model suggests raising tax rates to provide pensions rather than relying on private provision can reduce the welfare of all agents, even those who are net beneficiaries over a lifetime, because they tighten credit constraints on agents when they are young.

JEL classification
H55

Keywords
Population ageing, tax policy, housing markets, home ownership rates, overlapping generation models, credit constraints.

Summary Haiku

The young pay taxes
So the old live in mansions
They wanted when young.

Contents

1 Extended Abstract

A key aspect of the evolution of New Zealand's society and economy in the first half of the 21st century will be the increasing number of older people. In part because of the large cohort born between 1946 and 1964, but more because life expectancy is expected to increase by 6 years, the fraction of the New Zealand population aged over 65 years is set to increase from 510 000 in 2006 to 1,350,000 in 2051, or from 12 percent of the population to 25 percent of the population.

As longevity increases, older people are likely to spend a greater fraction of their retirement in relatively high quality "ordinary" housing—houses comparable to those they lived in at the end of their working lives. In combination with the increase in the number of older people, increased longevity is likely to lead to a significant increase in the demand for high quality housing amongst retired people. Yet population ageing will also affect housing patterns among working age people, partly because they will face higher taxes to pay for the pensions and healthcare of older households, and partly because they anticipate living longer themselves. The overall effect of population on the demand for housing is therefore unclear.

This paper tries to identify how the overall pattern of housing demand is likely to change as the population ages. It does this by constructing a stylised model of the economy that attempts to capture how people who differ by age and income will be affected by their interactions in a common housing market and a common taxation and public expenditure system. The key conceptual framework underlying the model is the idea of a housing lifecycle or property ladder. Households start life with low incomes and wealth and are restricted in the amount they can borrow. In these circumstances they may live at home or rent a small flat. As their incomes and wealth increase, they may choose to purchase a small house. They can stop at this stage, or purchase a larger house as they get older and wealthier. In retirement they may continue to live in this house, or trade down to something smaller and more convenient. In broad terms, therefore, households can be characterized by their peak housing quality, the time they spend ascending the ladder, and whether or not they trade down. Since aggregate

housing demand in the economy will reflect all three characteristics, the model has been used to explore how different economic factors affect each aspect of a household's journey up the housing ladder.

The model is solved under the assumptions that households make sensible, forward looking decisions when they decide on their housing options, and that the government raises taxes if it increases its expenditure on pensions and healthcare as the number of older people increases. When these assumptions hold, the model has four key results. First, unless the supply of houses is extremely elastic, population ageing is likely to raise house prices, and a significantly larger fraction of the retired population will live in high quality houses. Secondly, the tax-advantaged status of housing means that there will be little change in the housing standards of most middle aged people, despite higher prices. Thirdly, as the population ages, younger people will spend more time climbing the housing ladder, home ownership rates will decline, and there will be a decline in the demand for better quality housing, Nonetheless, this decline will be less than the increase in the demand for better quality housing by older households, unless the supply of high quality houses is quite inelastic, so there will be a large increase in the total demand for better quality housing. Lastly, the welfare consequences of income taxes imposed to pay for the higher pension and medical expenses associated with population ageing will fall disproportionately on the youngest people in society, for they are the most affected by credit constraints and are likely to experience the largest changes in their desired housing status. It is possible that a majority of people in the economy, including a majority of low income people, would be better off if the government did not raise its pension and medical expenditure as the population ages, and did not raise taxes, but rather encouraged people to save more.

2 Introduction

“The conventional New Zealand housing model is a progression that starts with living in the parental home, moving to rental accommodation, buying a first home, and then trading up first homes as family situation and employment location change. Thereafter, people may trade down as people leave home or retirement nears. The later stage of this ‘housing career’ may include cashing up the housing asset to pay for retirement associated expenditure.”[1]

A key aspect of the evolution of New Zealand’s society and economy in the first half of the 21st century will be the increasing number of older people. Due to a combination of increasing longevity and the existence of a large cohort born between 1946 and 1964, the fraction of the New Zealand population aged over 65 years is set to increase from 510,000 in 2006 to 1,350,000 in 2051, or from 12 percent of the population to 25 percent of the population (Statistics New Zealand, 2007). The number of people aged over 85 years will increase even faster, from 1 per cent of the total population in 2006 to 6 percent in 2050.

The purpose of this paper is to explore how housing demand may change as a result of this forthcoming increase in the number of older and retired people. The changes comprise two separate components: a direct effect, or the change in housing demand that will occur because there will be more older people and because their housing patterns may change because of increasing longevity; and an indirect effect, as housing demand by younger people changes, both in response to the larger number of older people and because they anticipate being old for longer themselves. The direct and indirect effects will be interrelated, as both young and old members of societies interact in the same housing market. Indeed, because working age people will comprise a greater fraction of the population than elderly people throughout the period, it is possible that the indirect effects could be greater than the direct effects.

To explore how population ageing may affect the total demand for housing, this paper develops a model that calculates housing demand patterns in an economy consisting of households that differ by age, income, and wealth. The

[1] Davey (2006).

model is necessarily stylised, but it attempts to incorporate the major features of the housing market, including the way people can choose different size houses; the way they borrow and save; the ways their choices to rent or buy are affected by the tax, retirement income, and healthcare arrangements of the society; and the way these choices are affected by the cost of building new houses. The model is dynamic, both because it allows house prices to change through time and because the households are forward looking and at each stage of their lives they consider their future as well as current housing demands. The focus of the model is the way increasing life expectancy may affect the housing market in the long run, once changes in housing demand throughout a lifecycle are taken into account.

Two assumptions underpin this study. First, it is assumed that households make sensible, forward looking decisions about their housing arrangements at different stages of their lives, and that they respond in a rational manner to financial incentives when making these decisions. Thus households are assumed to save a deposit, to delay buying a house when young if this would mean they would have very little to spend on other things, and to take inflation into account when choosing between lending money or investing in property. Second,the paper assumes that people and governments face binding long run budget constraints. In particular, households cannot spend more than they earn over a lifetime, and governments are assumed to run balanced budgets. This means that if governments face higher expenses associated with population ageing such as higher retirement payments or medical care costs, they raise taxes to pay for them, and these taxes reduce the disposable income of working age people.

The models suggest there will be four main effects of increasing longevity on the housing market. First, there will be more people in the country, particularly more people over 65, and this will mean there will be a need for more houses. Secondly, there will be an increase in the demand for high quality housing by older people. This increase partially reflects the increase in the number of younger old people (people aged 65 – 84), for these people have higher than average wealth and typically live in high quality housing. However, it also reflects a change in the financial incentives facing older people to trade down to smaller houses, for any capital realised from the exchange of a large house for a small house (or a house in a more desirable area for a house in a less desirable area) is spread over a larger number of years and translates into a smaller annual increase in consumption, while the benefits of living in a better quality house extend over a longer period. Thirdly, there is likely to be an increase in house prices due the greater total demand for housing. While this increase is only likely to be in the order of the increase in population (say 15 – 20 percent), it will make it harder for young people to get a start on the housing ladder, leading to more renting and a substitution away from better quality houses while young. Fourthly, there is likely to be an increase in taxes to pay for longer retirement benefits and higher medical expenses. These taxes will reduce the after tax incomes of younger people, delaying the time when they can first purchase a house and then upgrade to a larger house. In turn, this causes an offsetting reduction in the number of better quality houses in the economy.

The model is used in two ways. First, some of the key parameters of the model are varied to ascertain the factors that are likely to be important in determining how housing patterns will change as the population ages. For example, the model can be used to explore how the cost structure of the building industry is likely to affect the change in housing patterns as the population ages. Secondly, the model can be used to explore how different policy options will affect the overall demand for housing as the population ages. For example, the model can be used to assess what happens if the government were to decide to fund a smaller fraction of retirement income through a state pension as the population ages, so that households would have to save more privately if they were wishing to smooth consumption flows. It is also used to explore what would happen if there were an increase in the availability and popularity of reverse mortgage products, so that older households can better access the equity in their homes.

The key question that the model is designed to address concerns the extent to which population ageing affects the demand for housing among younger households. While the results depend on the exact parameterisations studied, when interest rates and inflation are moderate most of the simulations suggest there will be a sizeable reduction in homeownership among young people as the population ages, and a considerable increase in the time taken to climb the housing ladder. It proves that the cost structure of the building industry is a particularly important factor in determining how long it takes most people to attain their “peak” house. If housing quality mainly concerns house size, and it is straightforward to build larger houses, population ageing is likely to mean that most new houses are high quality, for there will be a much larger demand for high quality houses amongst older people, and little offsetting demand among working age people. In contrast, if housing quality largely reflects factors that are expensive to produce, population ageing will mean that most new houses are lower quality, for younger households will be less able or less willing than older households to pay the necessary premiums to live in high quality housing. This would be the case, for instance, if housing quality largely reflected location and there was a premium paid to live in suburbs close to a city centre. In this case, the greater number of older people who wish to live in high quality housing will mean an increase in the time spent by working age people in less desirable areas, and most of the new housing that is constructed will be in these areas. The different implications of these two scenarios are potentially quite important, for if population ageing leads to the “graying” of inner suburbs, it may prove that there is a mismatch between the current location of public facilities such as schools and sport-fields and the future location of the young households who will primarily use them.

The model is not tested empirically. Nonetheless, in Appendix 2 various New Zealand data are used to analyse recent trends in housing patterns among older households. These data are broadly consistent with the predictions of the model. In particular, between 1996 and 2006 the fraction of older households living in households with at least three bedrooms increased by 9 percent, from 59 percent to 68 percent. This increase, which has not previously been documented in New Zealand, occurred amongst almost all demographic subgroups including couples, singles, and those aged over 80 years. This increase occurred at a time of increasing population, rising house prices, increasing tax rates, and sharply falling home ownership rates among young people, events that are all consistent with the major predictions of the model.

The paper is organised as follows. In section 3 of the paper the main components of the model are outlined. (The details are in Appendix 1.) The results are presented in section 4, while a discussion of the results and conclusions are offered in section 5. Appendix 2 contains a discussion of the major trends in population and housing demand among older households, making use of a variety of data from Statistics New Zealand.

3 A dynamic model of housing demand

The primary contention of this paper is that population ageing will have two effects on the housing market: a direct effect caused by an increase in the older proportion of the population, and by changes in their housing demands; and an indirect effect caused by changes in younger people's housing demand. Older people may change their demands because they are active longer, because they are living with a spouse for longer, or because a longer retirement makes them wish to economise on housing. Young people may change their demands because they anticipate living longer and wish to save more, because they pay more taxes to fund the pensions and healthcare expenditure of older people, or because they respond to changes in house prices. The theoretical framework developed in this paper, which is a version of the Modigliani-Brumberg overlapping generations model, attempts to unravel these competing effects by analysing how the interactions of households who differ by age and income determine house prices, and how these prices affect housing allocations.

The basic structure of the model is relatively straightforward, and the details are presented in Appendix 1. The model comprises a set of overlapping cohorts who are born at different times. Each cohort comprises N= 400 households who differ in terms of income. Each household passes through four distinct stages: two young stages, one middle-aged stage, and one stage in retirement. The household has a different income in each stage, and is allowed to choose a different type of housing. Households can share housing with their parents, rent a low quality (small) house, buy a small house or buy a high quality (large) house. Households are assumed to choose their most preferred houses, given their age, wealth and after-tax incomes, the cost (including interest charges) of renting or buying different houses relative to other goods, and their ability to raise a mortgage. For a given set of housing prices, housing demand for each of the households during their four stages of life are calculated. These 4N different housing demand functions are then added together so that the total demand for housing can be calculated. Because each life-stage can be a different length, the total population will not be 4N; rather, if the first two stages were ten years long (representing, say, ages 25 – 35 and 35 – 45), the third stage was 20 years long (45 – 65) and the last stage 12 years (65 – 77), aggregate housing demand comprises the demand of 52N households. The key issue the paper addresses concerns the way aggregate housing demand changes as the population ages. Population projections suggest that almost all of the increase in New Zealand's population over the next forty years will occur among those aged 65 or older. Therefore the model treats the population increase as being caused by an increase in longevity, that is, by a lengthening of the final period.

The above paragraph describes how aggregate housing demand is calculated for a particular set of house prices. Supply curves indicating the cost of supplying different quantities of houses are also specified, and prices are determined endogenously by equating the supply and demand for different types of houses. The prices are found using a complex numerical routine that calculates the demand for each of the 1600 different households for a set of prices, and then chooses a new set of prices until a set is found at which aggregate demand equals aggregate supply. Demand patterns are calculated at the equilibrium set of prices, including the number of young households that rent and the number of older households that live in high and low quality houses.

The model analyses the way households climb the housing ladder. Their ascent can be characterised by two factors: the ultimate height they reach and the speed at which they attain that height. The ultimate height is largely determined by life-time income. In this model there are only two housing qualities, and in the parameterisations studied most people can afford a high quality house in middle age[2]. The speed of ascent is mainly determined by (i) the steepness of the earnings profile (ii) inflation and interest rates (iii) the tax incentives facing households and property investors and (iv) the availability of credit from banks. Households

[2]In some sense this reflects the relatively modest quality and price of a high quality house in the parameterisations studied (say a nice three bedroom house). Nonetheless, when the price of these houses is raised, most middle aged people will choose to live in them. In part this result reflects that tax incentives that favour home-ownership over other investment classes.

ascend slowly when they have a steep earnings curve (implying relatively low incomes while young), when credit is hard to obtain, and when tax laws favour property investors.

In the model, a household can potentially pass through three stages before purchasing a high quality house. First, they can share housing with others – in this case, with their parents. If they do so, the number of houses in the model will be less than the number of people, so if housing is in short supply some sharing will be necessary[3]. Secondly, they can rent a low quality house. It is assumed that if they do this they get slightly lower utility than if they own the house, for they cannot shape it in their own image. Moreover, in New Zealand there are tax advantages to home ownership, as imputed rent is not taxed. Lastly, they can purchase a low quality house.

The focus on the speed with which households ascend the housing ladder means considerable attention is paid to various financial factors that influence the decision to buy, rent, or lease a house. Following Coleman (2008) the model includes a careful representation of the conditions imposed by banks on those obtaining mortgage finance to purchase a house, including realistic constraints on the minimum deposit and the maximum mortgage-repayment to income ratio. These constraints mean that young households may choose to rent rather than buy a house, even though the long term cost is the same, because they cannot obtain suitable financing. It also includes a careful consideration of the tax incentives facing landlords. In this case, because the New Zealand government taxes the inflation component of interest income but does not tax capital gains, competition between landlords means that landlords are prepared to offer artificially low rents when there is inflation in order to obtain tax free capital gains.

[3]The model only allows young people to share with their parents. In Coleman (2009), "sharing" is modelled by allowing young people to share with each other, paying half rent and getting less utility than living by themselves. The latter model was used to analyse the effect of a capital gains tax on the housing market, not the effect of increasing longevity, and because it has a different although related solution technique, the effects of allowing young people to share with each other have not been explored in this paper. The results from Coleman (2009) suggest the higher taxes associated with increasing longevity would enhance the attractiveness of sharing rental accommodation and reduce homeownership rates. Since "sharing" allows higher consumption when young, some of the other results such as the welfare effects of tax increases may be softened, however.

The model also gives detailed attention to the role played by government. The government levies tax on labour and capital income, and imposes a goods and services tax. It grants special tax exemptions to housing assets. A key aspect of the model concerns what happens as the population ages and the government spends more on pensions and healthcare. In the basic version of the model, the government raises tax rates on labour income to pay for this expenditure. This lowers the after-tax income of working people, and reduces the amount they have to spend on housing and other goods when young. Other versions of the model examine the effect of different policies: for example, in one simulation the government reduces annual per capita pension payments as the number of older people increases to ensure total pension expenditure is constant, leaving it to individuals to fund their additional retirement years.

The model is dynamic and is solved under the assumption of rational expectations. Since house prices and rents are allowed to change through time, every housing price or rent comprises two parts: a price level at some base period (t = 0); and a price (or rent) appreciation rate. The property price appreciation rate is solved simultaneously with prices, and while the property price appreciation is normally the general inflation rate, it need not be. The agents are rational and in each period they choose housing taking into account their remaining length of life, their future income stream, their future housing patterns, and expected future prices. Thus when choosing housing in their first period, a young person takes into account not only their current income, current house prices, and interest rates and rents, but the fact that their income is likely to rise as they get older and more experienced, that they are likely to want a higher quality house when they have more money in the future, and that houses are likely to get more expensive. Depending on a variety of factors including taxes and the inflation rate, and bank imposed mortgage lending criteria, this may lead them to delay purchase, as they figure that it is better to spend money on other things when young and pay off a house when they have higher incomes later; but for different parameters it could lead them to purchase a higher quality house quickly because they realise inflation will erode the value of any deposit they save.

The model allows the housing supply functions to be varied. Three main variations have been examined. In the first, housing supply is almost perfectly elastic, meaning that there is no price response (other than an inflation adjustment) as the number of houses in the economy increases. This version is used to explore what happened when the main response to increasing longevity occurs because households live longer and pay more taxes, rather than because house prices change. In the second version, high and low quality house prices increase as the number of houses increase, by about 1 percent for each 1 percent increase in the population. This version is used to explore how price feedback effects (as well as increases in longevity and higher taxes) affect housing demand. In the third version, both high and low quality house prices increase as the number of houses increase, but high quality houses increase at a faster rate. This version is used to model what happens if location quality is an important component of housing quality, but high quality locations are in short supply. While various other parameterisations have been experimented with, these three prove to be most interesting for exploring the range of possible housing market outcomes as the population ages.

The model is related to several earlier papers. Its earliest form is the overlapping generations model of Modigliani-Brumberg (1980) that was used to analyse aggregate saving behaviour when agents differ according to their stage in the lifecycle. In terms of more recent literature, it extends the equilibrium lifecycle model of housing markets analysed by Ortalo-Magné and Rady (1998, 2006) and Coleman (2007, 2008). Compared to Ortalo-Magné and Rady, it has a significantly more sophisticated consumption side, it incorporates taxes and more realistic financial constraints, and it incorporates a construction sector. Compared to Coleman (2008), it includes a more elaborate government sector, a more complex treatment of inheritance, and it allows the lengths of different life-cycle stages to vary. Indeed, the latter modification proved most technically demanding as it alters much of the symmetry of the earlier models.

4 Results

4.1 Description of tables

The results show the ways that increases in longevity change tenure patterns and the composition of the housing stock. They are presented as a series of tables showing how equilibrium outcomes change as the length of the last period is increased from 10 to 20 years, approximately representing a change in life expectancy from 75 to 85. The first three tables show the results for three different housing supply functions. In table 1 (supply version 1), the supply of housing is almost perfectly elastic, with prices rising by only 1 percent for every 10 percent increase in the number of houses. In this case, the price of low quality houses is approximately three times the median income of middle-aged households, and high quality houses are approximately half as much again. In table 2 (supply version 2), house prices increase by approximately 1 percent for each percent increase in the number of houses, or by approximately 20 percent as the final period increases from 10 to 20 years. Prices in supply version 1 and 2 are the same when the length of the final period is 10 years. In table 3 (supply version 3), the supply curve for small houses is the same as supply version 2, but the supply curve for high quality houses is much less elastic to reflect the scarcity of premium location land.

Each table is divided into sections that show how different policy options affect the economy as the population ages. The first section shows what happens when taxes are raised to pay for higher expenditure on pensions, assuming that annual government pension paid to each retired person is constant in real terms. The second section shows what happens if taxes are increased further to pay for higher medical expenditure, as well as a longer pension entitlement. The increase in medical expenditure is approximately equal to 3 percent of GDP as the length of the final period is increased from 10 to 20 years. The third section of the table shows what happens when there is no change in total pension expenditure as longevity increases, and thus no change in taxes. This shows what would happen if the additional longevity was entirely funded by private saving, perhaps because the age of pension entitlement was raised one-for-one with longevity.

Tables 1 – 3 form the core of the results. The remaining tables show what happens when various parameters or policy options are changed. In tables 1 – 3, the annual inflation rate is 2 percent and annual real interest rates are 5 percent. Table 4 shows how the results for supply version 2 depend on inflation and interest rates. Table 5 shows how the results depend on the level of house prices, rather than the elasticity of the supply function. Lastly, table 6 shows what happens when households have the option of purchasing actuarially fair reverse mortgages.

4.2 The housing ladder.

In all the scenarios, the effects of increasing longevity can be largely described in terms of their effects on the three stages of the housing ladder: peak housing quality, the time taken to ascend to this peak, and the likelihood of a household trading down in retirement. For all of the parameterisations considered, the general principles are similar.

First, increasing longevity has small effects on peak housing quality for most households. While population ageing means that some poorer households are deterred from buying and living in a high quality house when they are middle aged, in most of the scenarios most households experience no change in their peak housing quality. This is because the tax laws generate large incentives to buy residential housing, rather than interest earnings assets. This means that most middle-aged households are better off if they hold their wealth as property. Since households save for retirement, because the pension level is much lower than an average income, the tax system means that most households choose to live in a high quality house in their middle age. As the population ages, however, households change the time spent in their peak quality houses.

The changes occur at both ends of the lifecycle. The model strongly suggests that longer life expectancy increases the number of older households in high quality housing. In the model the demand for high quality housing in later life represents a tradeoff between the benefits of living in a high quality house and the financial gain that may result from trading down. The financial gain is a one-time lump sum that must be spent over the remaining years of one's life. For each household there is a critical time period T_j^*, say six years before expected death, when households will be indifferent between remaining in a high quality house and trading down for financial reasons; if the length of the final period length is less than this value, it is advantageous to trade down, as the annual consumption value of the released housing equity exceeds the pleasure of staying in a large house. Thus in the model, the fraction of retired households living in high quality houses increases sharply as a function of the length of the last period, as the annual consumption benefits decrease, making it less attractive to sell. For example, in the first section of table 1, the fraction of older households living in high quality houses increases from 32 percent to 62 percent when the length of the last period is increased from 12 years to 20 years; a similar increase is found in all the parameterisations studied. It is worth recalling that New Zealand data is broadly consistent with this observation: between 1996 and 2006, the fraction of people over 65 living in small (1 or 2 bedroom) houses decreased by 9 percentage points to 42 percent.

The structure of the model means each household either lives in a high or a low quality house for their entire retirement. In real life, the choice is not so stark: rather, many households will live in one house type for a while, before moving to another type at the end of their lives, perhaps because of ill health or the death of a spouse. Indeed, financial reasons do not appear to be the main reason why people say they move in retirement. Nonetheless, if the decision to move for health or other reasons depends on the length of time before death, rather than the length of time since turning 65, the economic and social forces that determine the fraction of time retired households spend in high quality houses will have exactly the same effect as the forces in the model that give an incentive to trade down for financial reasons. Thus if health improves as life-expectancy increases, and this delays the shift from a high quality to a low quality house, households will spend more of their retirement in high quality houses. For this reason, summing up the fraction of households that spend their entire retirement in a high quality house (in the model), or summing up the fraction of each household's retirement that is spent in a high quality house (in the real world), is likely to generate a similar answer[4].

The model also suggests that increasing longevity is likely to increase the time taken to ascend the property ladder, because households have lower after-

[4] While it is possible to model the individual household's choice differently so that their retirement housing choices could reflect a period in different quality houses, the programme would be considerably more complicated. The core utility maximisation problem already has 48 Kuhn Tucker conditions, and for each of the households it is solved for 23 different housing permutations for every set of prices. Adding another period would mean a maximisation problem with 144 Kuhn-Tucker conditions and 46 housing permutations, increasing the size of the problem six-fold.

tax incomes and face higher property prices. Indeed, for most parameters analysed this is a much greater effect than the effect of population ageing on peak housing quality. While in some parameterisations population ageing accelerated the ascent of the property ladder, because households decided they needed to save more during their working life, this accelerated ascent only occurred in reasonably stringent conditions.

4.3 Core scenarios

4.3.1 Taxes increased to pay for pensions

The first section of tables 1 – 3 shows what happens when taxes are increased to pay for higher pension expenditure as the population ages.

Table 1 (supply version 1) indicates what happens when the construction section is very elastic and house prices change little as the population ages. The table is normalised so that the population is 1000 when the length of the final period is 10 years, increasing to 1200 when the final period is 20 years. As longevity increases and the population ages and increases in size, the total number of houses increases, although by slightly less than the increase in the number of households. (The total number of houses increases by 190, or 95 percent of the increase in population.) Approximately 80 percent of these new houses are high quality. The increasing demand for these new high quality houses largely comes from retired people, because as longevity increases there is a sharp increase in the number of older people who wish to live in a large house; or, to be more precise, there is a steep fall in the fraction of households trading down, because most people live in a high quality house in their middle age. As explained above, fewer households trade down as longevity increases because the annual consumption gain from such a move falls compared to the benefit gained from living in a large house.

The rise in taxes necessary to pay for higher pensions increases the average time it takes households to ascend the housing ladder. The increased delay represents two factors: delays leaving home and an increase in renting amongst the youngest cohorts, and thus a reduction in home ownership rates among this group (from 56 percent to 48 percent); and a reduction in the fraction of cohort 0 and cohort 1 households purchasing a large house (from 36 percent to

27 percent). Not all young households are affected, but the effects are felt up and down the income distribution. Some low income households delay leaving home rather than rent by themselves; some middle income households delay the purchase of a small house, choosing to rent instead; some relatively high income households wait to middle age before upgrading to a large house.

In the first section of table 2 (supply version 2) taxes are still raised to pay for additional pension expenditure as the population ages, but in addition house prices rise as the total number of houses increase. The results show small house prices rise in real terms by 23 percent (from $200,000 to $246,000) while large house prices rise by 16 percent (from $311,00 to $362,000.) The increase in house prices accentuates the outcomes in table 1. Three points should be noted. First, because both high and low quality house prices increase by a similar amount, there is little additional benefit for a retired household to trade down as the population ages. Thus the number of retired households living in high quality houses increases at the same rate as in table 1. Secondly, fewer new houses are built, because the higher prices induce more young cohorts to live with their parents. New houses are only built for 82 percent of the increased population, not 95 percent. However, a slightly greater fraction of these new houses are large because of the demand from older households. Thirdly, there is a significantly larger reduction in the fraction of cohort 0 that purchases a house, and the fraction of cohorts 0 and 1 that purchase a large house, as the population ages. As longevity increases from 10 to 20 years, home ownership among cohort 0 drops by 21 percentage points rather than by 8 percentage points, and the fraction of cohort 0 and 1 owning a large house drops by 12 percentage points rather than 9 percentage points. From these results, it would appear that the increase in house prices associated with population ageing will have its biggest effect on young households by making it more difficult for them to purchase a new house.

In the first section of table 3 (supply version 3) it is assumed that taxes are raised to pay for additional pension expenditure as the population ages, but in this case prices rise more sharply for high quality houses than low quality houses. This produces a twist in the results compared to supply version 2: while the increase in the total number of houses, and the decline in home ownership among cohort 0 is almost the same (for at the margin these households are affected by the price of low quality houses and this is the same in supply versions 2 and 3), there is a much smaller increase in the total demand for high quality houses. Only 25 – 30 percent of new houses are high quality, in contrast to the 85 – 90 percent figure in table 2. In turn, the fraction of high quality houses declines as the population ages. As longevity increases from 10 to 20 years, there is a smaller increase in the fraction of retired households living in large houses (up 30 percentage points rather than 43 percentage points) and a larger decrease in the fraction of cohorts 0 and 1 living in large houses (down 17 percentage points rather than 12 percentage points.) There is also a sharper reduction in the number of middle aged households living in high quality houses, down 13 percentage points rather than 5 percentage points. Even in this case, however, more than 80 percent of middle-aged households live in a high quality house.

4.3.2 Taxes increased to pay for pensions and medical care

The second sections of tables 1 – 3 show what happens when there is an increase in government funded medical expenditure as well as pension expenditure. Medical expenditure increases by 3 percent of GDP as longevity increases from 10 to 20 years, compared to a 5 percent increase in pension expenditure. The results are similar to those when pension expenditure increases, although home ownership rates among the young cohorts are slightly lower. The small effect of medical expenditure reflects differences in the way that the utility benefits of health care and pensions are modeled. In the model, health expenditure provides no income or utility in old age; rather it prevents large negative shocks to utility. Thus, unlike pension payments, medical expenditure does not alter the shape of the income or consumption profiles through time; rather the additional taxes that pay for higher medical expenditure merely lower lifetime disposable income, rather than tilt it towards older age. Consequently, these taxes do not intensify the effects of credit constraints on young households, and have very little effect on housing choices[5].

4.3.3 No changes in taxes or total pension expenditure as longevity increases

The third sections of tables 1 – 3 shows what happens if total pension expenditure and taxes are unchanged as longevity increases. In this scenario,

[5] Several variations with different values of the health expenditure variable were calculated. In all of the cases, the level of healthcare had very little effect on housing profiles.

households must save for their additional years of retirement if they wish to smooth consumption. This changes the results considerably, as the most tax efficient way of saving is to purchase a house. When the supply is nearly perfectly elastic (supply version 1) the increase in longevity leads to an increase in the total number of houses and the number of older people living in large houses, as before. In this case, however, the fraction of cohort 0 owning, and the fraction of cohorts 0 and 1 living in large houses scarcely changes as the population ages, because young households have tax incentives to buy; in fact it increases by l percentage point. In supply versions 2 and 3, the number of young people owning houses or purchasing large houses still decreases, because of the increase in house prices, but the decline is smaller than when the government raises taxes to pay for additional pensions. In table 2 the fraction of cohort 0 who own their own homes declines by 10 percentage points as longevity increases from 10 years to 20 years, not 21 percentage points, and the fraction owning large houses decreases by 6 percentage points rather than 12 percentage points.

These simulations suggest that the government's approaches to population ageing may have significant implications for young people's homeownership rates. If the government increases taxes on labour income to pay for population ageing, homeownership rates are likely to fall by more than if the government adopts policies that put more emphasis on private provision – for example, by increasing the age of entitlement, or by encouraging or making mandatory private saving, so long that this saving can be used to purchase a house. The "Kiwisaver" scheme, which allows households to use subsidised savings as a deposit on a house, is an example of a policy that could reduce the impact of population ageing on young people's home ownership rates.

Home ownership rates are not the only measure of welfare, and in fact are quite a poor measure. It is possible that a government tax-pension scheme makes low income people better off, because they pay fewer taxes than high income people but get the same pension. However, somewhat surprisingly, when the lifetime utility of each household is calculated, *everybody* would be better off saving for their own additional years of retirement rather than have a government increase their taxes when working and pay them a pension when retired. Middle and high income people are worse off because they pay more taxes than they get in additional pension, and some find they have to slow their ascent of the housing ladder. Low income people are worse off because when they are young the increase in taxes hurts them more than high income people (owing to their very low consumption levels at this stage) and they are also delayed climbing the housing ladder. The welfare loss for low income people is smaller than for high income people because the transfer element of the tax-pension policy means they have higher lifetime income. These results are not, of course, a serious argument against government pension schemes, for the international evidence strongly suggests that government pension schemes have been the major reason for the near elimination of elderly poverty for reasons that have not been included in this model. (See, for example, the discussion in Gruber 2004.) Nonetheless, they suggest that the incidence of the taxes used to raise funds to pay pensions may have important welfare consequences. Even small increases in the taxes on low lifetime income people when they are young can reduce welfare, even if they receive longer-lasting pensions when they are old.

4.3.4 Summary of the core results

There are four results that deserve emphasis. First, the model suggests that population ageing will have little effect on most households' peak quality housing. Most of the changes in the housing demand of working age households will reflect the amount of time they spend in their peak quality houses, rather than the size of their houses. Secondly, population ageing is likely to see a big increase in the demand for high quality housing among retired households. Thirdly, there is likely to be a fall in the number of young (25 – 45) households living in large houses. Fourthly, unless the supply elasticity of high quality houses is much less elastic than the supply elasticity of low quality houses, population ageing will mean most new houses will be high quality houses.

4.3.5 The effect of inflation and interest rates.

The results in tables 1–3 examine what happens when real interest rates are 5 percent and the inflation rate is 2 percent. Table 4 explores the effect of variations in interest rates and the inflation rate. The results are shown for the case that taxes are increased to pay for additional pension expenditure in supply version 2 (section 1 of table 2).

Inflation may be important because it reduces home ownership rates among the young. There are two reasons why this occurs. First, an increase in inflation raises real mortgage payments at the start of a mortgage and reduces them at the end of a mortgage, making it more difficult for young households to purchase a house (Modigliani 1977). Secondly, an increase in inflation attracts landlords into the rental market to take advantage of tax free capital gains. If the supply of houses is relatively inelastic, landlords bid up prices in order to take advantage of these capital gains; when the housing supply is relatively elastic (the case modeled here), landlords reduce rents to attract tenants and enter the property market (Coleman 2008). Either way, the interaction of inflation with the tax system tends to reduce homeownership rates among young households.

The effect of real interest rates is more complex. On the whole, declining real interest rates should be good for young households, for they are net borrowers and lower rates mean lower financing costs. However, lower real interest rates also make property a more attractive investment to landlords, particularly when inflation is moderate or high. Coleman (2007) suggests that the latter effect dominates, so that home ownership rates among cohort 0 decline as real interest rates fall[6]. Low real interest rates can also make it harder for households to accumulate funds for their retirement, which may affect their willingness to live in large houses when retired.

The simulations in table 4 suggest that although inflation has a large effect on the overall level of young households' ownership rates, increases in longevity reduce the home-ownership rates of young households irrespective of the inflation rate. The table shows that a reduction in the inflation rate from two percent to zero percent will increase homeownership rates among the youngest cohort by over 20 percentage points, will increase the fraction of cohorts 0 and 1 owning large houses by 8 percentage points, and will decrease the fraction of the older households owning large houses modestly. (The decrease occurs because

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[6] This aspect of the model is consistent with New Zealand data. Real interest rates declined steadily from 10 percent to 5 percent between 1990 and 2006, and homeownership rates fell among young people

when inflation is zero more households buy a house when young, but can't afford a large house at both ends of their lives.) These are level effects, occurring at all life expectancy values. In contrast, the change in the speed that young households reduce homeownership rates as longevity increases is not particularly large. For example, when longevity increases from 10 to 20 years, homeownership rates among cohort 0 decline by 16 percentage points when the inflation rate is 0 percent rather than 21 percentage points when the inflation rate is 2 percent. The change in the fraction of young households owning large houses as longevity increases is even smaller.

The effects of changing real interest rates are more complex. The effects of real interest rates on ownership patterns can also be split into level effects and the effects on rates of change. In level terms, the simulations suggest a decline in real interest rates have a positive effect on the total number of houses (because rents are lower, inducing less sharing), a small positive effect on the fraction of cohort 0 and 1 that owns a large home (because finance costs are lower), and a large negative effect on the fraction of cohort 0 that owns a home (because of competition from landlords). For example, a decline in real interest rates from 5 percent to 4 percent leads to an approximately 1.5 percent increase in the total number of houses, a 2 percent increase in the number of cohort 0 and 1 households owning a large house, and at least a 25 percent decrease in cohort 0 home ownership rate.

The simulations suggest that real interest rates have little effect on the rate at which the quality composition of the housing stock changes as the population ages. Irrespective of real interest rates, population ageing increases the demand for high quality houses by older people and reduces the demand by young people. The effect of real interest rates on the rate at which cohort 0 homeownership rates decline as the population ages is more complex. When the inflation rate is 2 percent and real interest rates are 5 percent, home ownership rates fall steeply as the population ages. When the inflation rate is 2 percent and real interest rates are 4 percent, homeownership rates among young cohorts are very low—under 10 percent—for all levels of longevity, and thus cannot fall by much. In this case, population ageing has very little effect on homeownership rates among young households because they are always low. When the inflation rate is 0 percent and real interest rates are either 4 percent or 5 percent, cohort 0 homeownership rates are high when the length of retirement is 10 years, and declines sharply as the population ages. In summary, if there is a decline in real interest rates as well as population ageing over the next forty years, it is likely that an increasing fraction of the housing stock will be leased.

4.4 Other supply scenarios

The results in tables 1 – 3 show that the ease with which new houses can be built is a crucial determinant of the effects of population ageing on the housing market. Table 5 shows the results for three additional housing supply functions. In each case, the slopes of the house supply functions are the same as supply version 2, but the price level have been increased. The first section of table 5 has the results when the prices of high and low quality houses are increased, keeping quality the same, by approximately $50000. In the second section, the price of low quality houses is unchanged, but the price of a high quality house is increased by $50000, again keeping quality unchanged. In the third section, both the price and the quality of large houses are increased to reflect what happens as high quality houses become better. In each section the table shows what happens if pension expenditure and taxes are increased as the population ages, so table 5 is directly comparable to section 1 of table 2.

The results are broadly similar to those described already. The easiest case to consider is when both the quality level and the price of high quality houses is increased. In this case there is almost no qualitative or quantitative change in the effect of population ageing on the patterns of homeownership: as before, population ageing causes an increase in the fraction of older households living in large houses, and an increase in the fraction of young households renting and living in small houses. The only major difference is an increase in the fraction of cohort 0 households owning houses (at all levels of longevity) as it cost more money and a larger deposit to purchase a high quality house, and than the most tax efficient way to save these funds is to start by buying a small house.

When high quality houses are simply more expensive (without a commensurate increases in quality) the effect of population ageing on housing demand is largely unchanged except far fewer households will own large houses in their retirement. The simulations suggest that the amount of money that can be made from trading down compared to the benefit of living in a larger house is so tempting that most older households will do it. In the real world a large fraction of households never trade down in retirement. This suggests that the parametres of the model may need to be modified to better reflect the desire of many (but by no means all) households to age in their long term homes even when the financial incentive to trade down is very large. Nonetheless, even though in this case the level effect may be wrong, the model still suggests that as the population ages there will be a large increase in the fraction of older households choosing to live in high quality houses, and a significant increase in the fraction of young households living in low quality houses.

The results when the prices of both types of houses are increased, keeping quality unchanged, are again similar to before, with one exception. In this case, homeownership levels among cohort 0 are significantly reduced, because more people live with their parents when they are young and because more households rent rather than take out a much bigger mortgage[7]. The simulations suggest that homeownership rates among cohort 0 are so low at all values of longevity that they scarcely decline as longevity increases, in contrast to the earlier result that increases in longevity reduce home ownership rates. Otherwise the fraction of older households who live in large houses, and the fraction of cohorts 0 and 1 who live in small houses, increase as the population ages at a very similar rate as suggested in supply version 2.

4.5 Reverse mortgages and inheritance

So far it has been assumed that the only way that a retired household can extract equity from housing is to sell a large house and buy a small house. However, retired households may be able to use reverse mortgages to extract some of the equity of their house and use the proceeds to increase consumption in the last period. If they were to do this, they could also reduce their saving in earlier periods in anticipation of taking out a reverse mortgage later on.

[7] The higher house prices mean both rents and mortgages will be higher. Nonetheless, a mortgage costs more than rent, and the increase in mortgage payments reduces consumption so low that many households choose to rent rather than accept a deep cut in consumption.

In table 11 the effect of older households obtaining a reverse mortgage equal to 20 percent of the value of the house is explored. The debt accumulates over time, and is paid off upon death out of the value of the household's estate. The interest rate on the loan is the standard (pre-tax) mortgage rate. The table shows the effect of these reverse mortgages when pensions and taxes are increased as the population ages, and supply version 2 is assumed (c.f. section 1 of table 2).

The main effect of a reverse mortgage is that a greater fraction of older households own high quality houses, for a reverse mortgage lets them have their house and eat it too. When life-expectancy is 10 years, the fraction of retired households owning a high quality house increases by 23 percentage points. When life expectancy is 20 years, so that more households want to own a high quality house in any case, the increase is 11 percentage points. The increase in the number of older households living in high quality houses means that the fraction of high quality houses in the economy increases.

The effect on working age households is mixed. This is because for some households (those that don't receive an inheritance) the availability of reverse mortgages will reduce the amount they need to save for retirement; while for other households (those who do receive an inheritance), the availability of reverse mortgages will increase the amount they need to save for retirement. The latter effect reflects the general equilibrium nature of the model: those receiving an inheritance receive a smaller inheritance because their parents took out a reverse mortgage, and this more than offsets the reduction in their need to save because they will take out a reverse mortgage. Overall there is a small increase in the fraction of cohort 0 households owning a house and a small decrease in the fraction of middle aged households living in large houses, but the effects on working age people are outweighed by the increase in the fraction of older households who live in large houses.

The issue of reverse mortgages raises a wider issue: how are important are inheritances in determining the effects of population ageing on the housing market? The model can be solved for several different assumptions about the way inheritances are passed on. As described in Appendix 1, the default rule assumes that half of the middle aged people in the economy get an inheritance (equal to the value of two houses, with the value of these houses depending on their place in the income distribution), while half get nothing[8]. The simulations suggest that the life-cycle housing patterns of most households depend on whether or not they inherit. Nonetheless, several other inheritance rules were explored, and while the effects on particular individuals of different inheritance allocations can be large, the effect on the aggregate economy is small. For example, if everyone inherits the house of the person in the same position in the income distribution in the cohort born before them, the aggregate effects of population ageing are almost the same as when half the people get nothing, although the identity of the people who live in large houses does change. In contrast, the timing of inheritances is very important. If people inherit when very young (from their grandparents, for example), they find it much easier to climb the housing ladder. For this reason, I have a maintained an assumption that inheritances are received in middle age. While this maximises the length of time people spend climbing the property ladder, the assumption is broadly consistent with the evidence and seems likely to become more so as the population ages.

5 Discussion and conclusions

The focus of the research has been to identify the main economic factors that will change housing demand for households at different stages of the housing lifecycle as longevity increases and the population ages. It proves that many of the factors considered in the model have large effects on housing patterns. Factors such as interest rates, inflation, tax rules, and building costs can dramatically change the level of homeownership at young ages, the speed with which households climb the housing ladder, and the overall fraction of high quality houses in the economy. Almost of these factors are important because of the way they affect the credit constraints on young households, or the incentives to invest in housing rather than other assets. While the effect of most of these factors on housing demand have been explored, the paper has focused on two factors which have particularly large effects on housing patterns as longevity

[8] To be precise, every odd numbered person in the income distribution gets nothing, while an even number person j receives the houses owned by person j-1 and j in the cohort born before them.

increases and the population ages. The first factor is the extent to which the government will increase taxes and its aggregate expenditure as the population ages, because it provides pensions and medical care to an increasingly large share of the population. If the government maintains the annual per capita value of pension expenditure, by 2050 population ageing will result in a large increase in government expenditure, by approximately 5 percent of GDP. Increases in medical expenditure will raise this amount further. In most versions of the model it is assumed that taxes will be increased on all households to raise these funds. As the increase in taxes reduces the disposable income of working age (and other) households, many young households will find it preferable to rent for longer and to delay their purchase of a large home. Consequently, population ageing is likely to lead to a reduction in aggregate housing demand by young households, and a substitution away from larger or better quality houses. The aggregate effect of this tendency to delay the purchase of a better quality house is relatively modest, however, unless house prices increase quite steeply as the total population increases. If house prices do not change, the model suggests that the tax increase needed to pay for expenses associated with a doubling of the older population will reduce homeownership rates and the fraction of younger households living in large houses by approximately 10 percentage points.

The role played by taxes on the changing patterns of housing demand as the population ages can be seen by examining what would happen if the government did not raise pension or medical expenditure, or taxes, as ageing occurs. In this case, again holding house prices constant, the aggregate demand for housing by young people scarcely changes as the older population doubles in size, in contrast to the situation when taxes are increased and homeownership rates decline by approximately 10 percentage points. The difference occurs because households have greater incentives to save for retirement and because housing is a tax advantaged asset class. It is possible that homeownership rates among the young could increase in these circumstances, although in the scenarios analysed most additional saving takes place during middle age due to the joint impact of credit constraints and a steeply rising life-cycle wage profile.

Welfare analysis of these two cases suggests that for the same increase in longevity, policies in which taxes are raised to pay for additional pensions lowers welfare for almost all households compared to the alternative of letting people save for retirement themselves. It is by no means obvious that this result would hold for low income people, because low income people receive much higher pension benefits than the additional taxes they pay. (It is not surprising that it holds for high income people, because they pay more in taxes than they get in additional pensions.) In the model, however, the benefits come at the end of life, while the taxes fall on the beginning and the middle. Because people typically have much lower incomes when they are young, the model suggests the effect of higher taxes at young ages, including lower consumption and a delayed ascent of the housing ladder, offset the benefits of greater pension income in retirement.

The author does not recommend that pension expenditure should remain constant as the population ages, even though it would be simple to implement such a policy by raising the age of entitlement. The model is too stylised for make such a recommendation, excludes too many factors, and has a too simplistic assumption about the way taxes will be increased as the population ages. But the result does suggest that the structure of any tax changes that are implemented to pay for population ageing are very important. In particular, policies that increase taxes on people when they are young may induce quite large welfare losses. It is possible that age-specific as well as income specific taxes could mitigate these welfare losses.

The model suggests that changing the tax rate has little effect on the quality level of most households' peak quality houses--the houses in which people typically live when they are middle aged. This is because New Zealand's tax laws generate large incentives to buy residential housing rather than interest earnings assets and mean most middle-aged households are better off if they hold their wealth as property. Since there are incentives for households to save for retirement in the model (because the pension level is much lower that average income), the tax system means that most households choose to live in a large house in their middle age. This seems unlikely to change as the population ages.

The second factor that appears likely to have a major effect on the demand for housing as the population ages is the supply elasticity of the construction sector. Population ageing will lead to an increase in the total number of people in the country, and unless the housing supply is extremely elastic this will mean house prices will rise. The model indicates that these house price increases will choke off demand among young people, lowering home ownership and the fraction of young households living in large houses. These price effects reinforce the effects of higher taxes, and are quite large. When the elasticity of supply is approximately 1 percent--which seems likely to be the value in New Zealand--population ageing causes price feedback effects on young people that are similar in size to the effect of the tax increases[9]. Consequently, the total effect is about twice as large compared to the case for which supply is perfectly elastic. Again, there is very little effect on the peak housing quality attained by most people. When the supply elasticity for high and low quality houses is similar, the reduction in the demand for high quality houses by young people is much smaller than the increase in the demand for large houses by older people. Consequently, as the population ages the vast majority of new houses will be high quality.

This result need not occur. If the supply of high quality houses is less elastic than the supply of low quality houses, there is an additional feedback effect. In this case the price feedback effects have a much larger effect on the demand for high quality houses than the demand for low quality houses, as the higher rate of price increase for high quality houses acts to curtail demand for this type of house. The effect is much greater on young households (who are credit constrained) than older households (who are wealthier); indeed, the supply elasticity for high quality houses only needs to be half as big as the supply elasticity for low quality houses for the decline in the demand for high quality houses by young people to almost completely offset the increase in the demand for high quality houses by older people. In these circumstances, population ageing will mean most new houses in the economy will be low quality houses, and population ageing will cause a substantial change in ownership patterns. In particular, high quality houses will be increasingly inhabited by older people.

This scenario has an obvious interpretation. If the dominant feature of a high quality house is location, and the convenient access it provides to high quality facilities, it is quite likely that the supply elasticity for houses in nice suburbs is much lower than the supply elasticity for houses in far-away or less

[9] In New Zealand, for instance, the population increased by 54 percent between 1962 and 2002, while real house prices increased by 80 percent, implying an elasticity of 1.2.

desirable suburbs. In this case the housing ladder will be characterised by a shift from worse to better suburbs rather than from smaller to larger houses. As the population ages, the high quality suburbs will get "grayer", while younger households will increasingly live in newer, less desirable suburbs as they cannot afford the better locations. In turn, this may generate a mismatch between the current location of public facilities such as schools and sport-fields and the location of the young households who will primarily use them, and an increase in the use of transport services.

These two scenarios are quite different. If the main feature that distinguishes high and low quality houses is the size of the house, the model predicts that while there will be a decline in the fraction of young households owning houses, including a decline in the fraction owning large houses, overall population ageing will lead to a large increase in high quality large houses. In contrast, if the main feature that distinguishes quality is location, the model predicts that population ageing will squeeze young households out of the more desirable housing markets, that most new houses will be built in less desirable locations. In both cases, however, the tendency of middle-aged households to live in better quality houses is unchanged.

It remains to discuss some of the weaknesses of the model. First, for technical reasons it has proved difficult to incorporate the effect of income growth into the model. Nonetheless, earlier work shows that the effect of successive cohorts earning larger and larger incomes is similar to the effect of a decline in real interest rates (Coleman 2007). This intensifies the effect of credit constraints on young households, and is likely to reduce their home-ownership rates. However, in this model a 1 percent decline in real interest rates has relatively little effect on the way population ageing affects the housing demand, and only a modest effect on the mixture of large and small houses owned by young households, changing the ratio by 2 – 3 percentage points.

Secondly the model explicitly assumes households are forward looking and that they smooth consumption over their lifecycles. While to some extent this assumption is likely to be realistic, the amount of information that agents are assumed to have is unrealistically large. Nonetheless, it is not clear that this is a problem. In the model, the housing patterns chosen by households are determined by their budget constraints as well as their preferences. The model is very careful to capture the way that credit constraints limit the housing choices of young agents, and the way that pension programmes affect disposable income through taxation. Since most of the model's results are driven by the way households respond to taxes and house prices when they are credit constrained, it is likely that the results would change little if different assumptions about preferences and information sets were adopted.

References

Bridge, Catherine, Peter Phibbs, Hal Kendig, Mark Mathews and Brian Cooper. 2008. "The costs and benefits of using private housing as the home base for care for older people: secondary data analysis." Australian Housing and Urban Research Institute (AHURI) final report 115.

Coleman, Andrew. 2007. "Credit constraints and housing markets in New Zealand." Reserve Bank of New Zealand Discussion Paper 2007/11.

Coleman, Andrew. 2008. "Taxes, credit constraints, and the big costs of small inflation." Motu Economic and Public Policy Research Working Paper 2008/14.

Coleman, Andrew. 2009. "The long term effect of capital gains taxes in New Zealand." Motu Economic and Public Policy Research Working Paper 2009/13.

Coleman, Andrew, and John Landon-Lane. 2007. "Housing markets and migration in New Zealand, 1962-2006," Reserve Bank of New Zealand Discussion Paper 2007/12.

Cox, Mark and Simon Hope. 2006. "Health service needs and labour force projections." pp 221-251 in Boston, Jonathon and Judith Davey (ed) *Implications of Population Ageing: Opportunities and Risk*. (Wellington: Institute of Policy studies, 2006.)

Davey, Judith. 2006. "Housing." pp 253-273 in Boston, Jonathon and Judith Davey (ed) *Implications of Population Ageing: Opportunities and Risk*. (Wellington: Institute of Policy studies, 2006.)

Davey, Judith, Virginia de Joux, Ganesh Nana and Mathew Arcus. 2004. *Accomodation options for older people in Aotearoa/New Zealand* (Wellington: Centre for Housing Research, Aotearoa New Zealand).

De Nardi, Mariacristina, Eric French, and John B. Jones. 2009. "Life Expectancy and old age saving." NBER working paper 14653.

French, Eric and John B. Jones. 2004. On the distribution and dynamics of health care costs. *Journal of Applied Econometrics*, 19(6) 705-721.

Gray, Alastair. 2005. “Population ageing and health care expenditure.” *Ageing Horizons* 2 15-20.

Gruber, Jonathon (2004) *Public Finance and Public Policy* (New York: Worth Publishers.)

Joint Center for Housing Studies at Harvard University. (2000) *Housing America’s Seniors* (Cambridge: Harvard University)

Hermanson, Sharon and Jeremy Citro. 1999. *Progress in the housing of older persons.* (The Public Policy Institute.)

Modigliani, Franco. 1976. “Some economic implications of the indexing of financial assets with special references to mortgages.” pp 90–116 in Monti, M (ed), *The new inflation and monetary policy*, Macmillan, London and Basingstoke.

Modigliani, Franco, and R. Brumberg. 1980. “Utility analysis and aggregate consumption functions: an attempt at integration.” pp 128-197 in Abel, A. (ed), *The Collected papers of Franco Modigliani: Volume 2, The Life Cycle Hypothesis of Saving,* The MIT Press, Cambridge, MA.

Morrison, Philip S. 2007. *On the falling rate of homeownership in New Zealand.* (Wellington: Centre for Housing Research, Aotearoa New Zealand).

New Zealand Ministry of Health (2002) *Health Expenditure Trends in New Zealand, 1980 – 2000* (Wellington: New Zealand Ministry of Health.)

New Zealand Ministry of Health (2004) *Health Expenditure Trends in New Zealand, 1990 – 2002*. (Wellington: New Zealand Ministry of Health.)

Olsberg, Diana and Mark Winters. 2005. “Ageing in place: intergenerational and intrafamilial housing transfers and shifts in later life.” Australian Housing and Urban Research Institute (AHURI) final report 88.

Ortalo-Magné, F, and S Rady (1998), “Housing fluctuations in a life-cycle economy with credit constraints,” Research paper 1501, Graduate School of Business, Stanford.

Ortalo-Magné, F, and S Rady (2006), "Housing Market Dynamics: On the contribution of income shocks and credit constraints" *Review of Economic Studies*, 73(2), 459–485.

Schafer, Robert. 1999. "Determinants of the living arrangements of the elderly," Joint Center for Housing Studies at Harvard University Working Paper 99-6.

Statistics New Zealand. (2004) *Older New Zealanders – 65 and beyond*. (Wellington: Statistics New Zealand.)

Statistics New Zealand. (2007) *National Population Projections: 2006(base) - 2061*. (Wellington: Statistics New Zealand.)

Statistics New Zealand. (2008) *Period Life Tables: 2005-2007.* (Wellington: Statistics New Zealand.)

St John, Susan. 2006. The policy implications of decumulation in retirement in New Zealand. Mimeo, Department of Economics, University of Auckland.

U.S. Department of Housing and Urban Development. 2005. "Elderly Housing Consumption: historical patterns and projected trends. (Washington: U.S. Department of Housing and Urban Development.)

Wilson, Peter and Paul Rodway. 2006. "Ageing and the long-term fiscal position." pp 99 – 126 in Boston, Jonathon and Judith Davey (ed) *Implications of Population Ageing: Opportunities and Risk.* (Wellington: Institute of Policy studies, 2006.)

6 Appendix 1: An intergenerational model of housing demand.

6.1 Agents and period lengths

An agent lives for four periods labelled i = {0,1,2,3}. A period is T_i years long.

The periods can be any length, but in this model the periods 0 and 1 are chosen to be 10 years long, period 2 (middle age) is 20 years, and the last period is varied from 10 to 20 years to reflect the process of population ageing. It is useful to think of the model as consisting a forty year working life (ages 25 – 65) followed by a retirement period. Relatively short periods are needed at the beginning of life to capture life-cycle income changes and the effects of bank imposed borrowing constraints. 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. Agent 1 has the lowest lifetime income. In period t, agent j born in period t-i has real labour income

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

where ω_j = idiosyncratic factor affecting agent j relative to average cohort earnings;

g_i = factor reflecting the life-cycle earnings of the cohort in its i^{th} period; Y_{t-i}^0 = average income of cohort at time of birth; and τ_L reflects taxes on income. In period 3, income includes a government pension, G_t. that is the same for all people and constant in real terms through time.

Nominal income is $P_t Y_t^{i,j}$, where P_t is the pre-tax price of the good. An indirect goods and services tax is applied to goods other than housing at rate τ^g, so the post tax price of the good is $(1+\tau^g)P_t$. Incomes and the prices of goods are both assumed to increase at a constant inflation rate π, where $1+\pi = P_{t+1}/P_t$.

Agents obtain utility from the consumption of goods and housing. An agent chooses an annual flow of real consumption $c_t^{i,j}$, and has housing choices described by a vector of three indicator variables $\mathbf{I}_t^{i,j,h} = \left\{ I_t^{i,j,R}, I_t^{i,j,F}, I_t^{i,j,H} \right\}$ that equal one if the agent has housing tenure h in period i of his or her life at time t, 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). Age zero agents can live with their parents at zero cost, although they gain zero utility from doing so. In period t agents obtain utility

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

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. Agents born at time t choose consumption and housing paths to maximise discounted lifetime utility, weighting consumption each period by the number of years in the period:

$$U = \sum_{i=0}^{3} T_i \beta^{\left(\sum_{j=0}^{i} T_j - T_0\right)_i} u(c_{t+i,}^{i,j} \mathbf{I}_{t+i}^{i,j,h}) \qquad (3)$$

In the last stage of life, agents receive a health transfer H_t from the government that is spent on healthcare. In the main versions of the model, this does not raise utility, but it is assumed that if it was not received utility would fall. If the government does not make the transfer, it is assumed that in their last period of life agents spend their first H dollars on healthcare, leaving less to be spent on other goods and services.

6.1.1 Inheritance

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 3, 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; in this paper the weights are κ_i = (0,0,1) so that agents do not receive an inheritance until late in life. Two different inheritance assumptions have been analysed. In the first case, the house that the jth old agent lived in is left to the jth middle aged agent, thus preserving the intergenerational income ranking. In the second case, the houses of two adjoining old agents j and j+1 are left to middle aged agent j+1, while middle aged agent j gets nothing. The latter scheme, which is the preferred scheme, means that half the agents in an economy do not inherit any wealth, so all of their assets are accumulated from their own saving. In the utility maximisation equation below, Inheritt is the value of the inheritance left by the agents dying at the end of time t-1 and inherited at time t.

A version of the model is also solved where old agents can take out a reverse mortgage equal to 20 percent of the value of the house. They are assumed to spend this on consumption goods. When they die, this sum plus accumulated interest is deducted from the value of the house before it is passed on to the beneficiaries of the estate.

6.2 Taxes

In Coleman (2008) five features of the tax system were modelled; in this paper these features are retained and there is a further modification to capture the way income taxes may need to be raised to pay for additional government expenditure on pensions and medical care. First, interest and rent income is taxed at an agent's marginal tax rate. There are two marginal tax rates: τ_1 for agents with real income in period t less than τ^*; and $\tau_2 \geq \tau_1$ for agents with real income greater than or equal to τ^*. It is assumed that the tax threshold is automatically adjusted for inflation and thus constant in real terms. Secondly, the capital gains tax rate is zero. No property appreciation, either for an owner-occupied house or for a leased flat, is taxed. Thirdly, imputed rent is tax exempt. Fourthly, a landlord can deduct interest payments associated with a mortgage when calculating taxable income. Thus a landlord pays tax on rent net of interest payments, but no tax on any capital appreciation. Fifthly, there is a goods and services tax that is applied to consumption but not to rent or property. In the model, the goods and service tax rate is set endogenously at a rate that makes the total tax take (tax on capital income plus tax on goods and services) equal to a set fraction of labour income, in this case $\tau^{g^*} = 10$ percent. This ensures that any changes in the structure of capital incomes taxes do not have revenue implications for the Government.

The new tax is an additional tax on labour income. As the population ages, represented by an increase in the length of the last period, government expenditure on the elderly is allowed to increase. The labour tax is imposed at a rate that raises exactly enough to pay for any additional government expenditure associated with increases in longevity: if age increases by ΔT3 years, and the government gives each retired person a pension size G and healthcare H, the labour tax τL solves

$$\Delta T_3(G_t + H_t)N = \tau_L \sum_{i=0}^{2}\sum_{j=1}^{N} Y_t^{i,j} T_i$$

In essence, this assumption means that even though agents face different marginal tax rates, both taxes rates are increased by the same percentage to pay for additional government expenditure[10]. The result is a direct intergenerational transfer from working age members of the population to the elderly generation. The tax-pension scheme also transfers income from high income members of the economy to low income members, as the increase in the pension is assumed to be the same for all agents whereas the taxes are proportional to income.

In the main parameterisations modelled, expenditure on pensions increases one for one with the increase in the length of the last period. In the main alternative variation, there is no increase in total government expenditure on pensions; in essence, the age of eligibility is increases one for one with the increase in longevity, as happened in New Zealand in the 1990s. In addition, medical expenditure on the elderly can be increased, by approximately 3 percent of GDP.

6.3 The housing market

Low quality houses (flats) and high quality houses (houses) cost P_t^F and P_t^H to purchase. Low quality houses can also be leased, at price P_t^R that 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 of their lives. The number of landlords is endogenous; an indicator variable $I_t^{i,j,R*}$ indicates whether or not

[10] To minimise computation complexity, it proved easier to raise taxes on labour income than labour and capital income. This means there is a small wedge between labour and capital taxes. Until recently in New Zealand, capital and labour taxes have been the same, unlike the situation in many other countries where social security taxes are levied on labour income but not capital income. In the last few years, however, capital taxes have been lower than labour taxes. Thus it is not inconceivable that in the future taxes could be raised on labour rather capital income as longevity increases.

the j[th] agent owns a rental property[11]. Because there is no uncertainty, the after-tax return from purchasing a flat in period *t*, leasing it, and selling it in period *t+1* is equal to the after-tax return from lending money. As such, the relationship between rent, tax rates, flat prices, and interest rates is

$$P_t^R(1-\tau_2)(1+r_t(1-\tau_2))^T + P_{t+1}^F = P_t^F(1+r_t(1-\tau_2))^T \qquad (4)$$

or

$$P_t^R = P_t^F\left(\frac{(1+r_t(1-\tau_2))^T-(1+\pi_t^F)}{(1-\tau_2)(1+r_t(1-\tau_2))^T}\right) \qquad (5)$$

where π_t^F is the rate of price appreciation for flats. The right hand side of equation 4 is the after-tax return in period *t+1* from investing P_t^F in interest earning bonds. The left hand side is the after-tax return at *t+1* from using the same sum to purchase a rental flat at time *t*. It comprises the after-tax rent paid at time *t* and reinvested at interest, plus the untaxed proceeds from selling the rental unit at time *t+1*. Since interest payments by landlords are fully tax deductible, the return to a landlord is independent of their level of gearing. It is assumed that the landlords are high income agents in period 2 of their lives, so after-tax returns are calculated using the top marginal tax rate τ_2[12].

In each period, agents choose between one of the three housing options, or not having housing. Consequently, there are potentially 256 different ways to climb the housing ladder. Rather than calculate the utility of each of these patterns, I only let agents choose from a much smaller set of patterns, $\mathcal{H}$. To reduce the number of possible patterns, I impose a series of restrictions on the lifetime housing options available to an agent. The three restrictions are: (i) only 0 period agents may choose no housing; (ii) only period 0 and period 1 agents may choose to rent; and (iii) except in the last period, agents' housing choices must not worsen through time. By this means, the set $\mathcal{H}$ is reduced to 23, $\mathcal{H}$={0RFF,

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[11] If there is demand for *f* flats, the $f\, T_0/T_2$ highest income individuals are assumed to own one flat each for all T_2 years of the second period. This adjustment is needed to ensure that the aggregation in the model is done correctly.

[12] If there is a high demand to rent property, it is possible that the last landlord in the model is on the low marginal tax rate. Nonetheless, it is assumed that competition between high income landlords determine rents, so the top marginal rate is used.

0RHF, 0RHH, 0FFF, 0FHF, 0FHH, 0HHF, 0HHH, RRFF, RRHF, RRHH, RFFF, RFHF, RFHH, RHHF, RHHH, FFFF, FFHF, FFHH, FHHF, FHHH, HHHF, HHHH}. 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.

It should be noted that these set of options do not allow agents to rent in their last period. While in reality some people do rent in retirement, this restriction is probably not particularly important for three reasons. First, as an empirical matter, in New Zealand (and in Australia and the United States) a large majority of retired people own their own houses. Those who don't tend to have low incomes, or have been subject to shocks such as ill health or divorce that are outside the confines of this model. Since in the model the long term costs of renting are similar to the long term costs of owning a house, there is no long term financial advantage to be gained by renting rather than owning; indeed, the tax advantages to home ownership mean it is usually cheaper than renting in the long run. Consequently, in this model there is no reason why households are unable to own in the long term, although they may choose to rent while young in order to smooth consumption. One would have to incorporate a degree of short-sightedness or irrationality in the model to explain why people can afford to rent rather than own, or posit the existence of rent subsidies, perhaps by local government.

Secondly, from an aggregate position, the total number of high and low quality houses is largely unchanged whether people own their own homes or rent them. Consequently, in the long run, there will be little difference in house prices and thus little difference in the indirect effects on other cohorts. A modelling change that would make a significant difference would be to allow older cohorts to move in with their families, which would reduce the total number of houses demanded in the same way that letting young people live with their parents changes housing demand. At the moment, this is not a common arrangement in New Zealand or Australia, and it is unlikely to be a common arrangement in the future either (Olsberg and Winters 2005). It is possible that this will become a more popular arrangement in the future, particularly among non-Pakeha New Zealanders, but this possibility has not been modelled.

The third reason to ignore the rental market among older people concerns the type of financial services that are available in New Zealand. In the model, the costs of renting and owning are similar, meaning that over a lifetime if one can afford to rent then one can afford to buy. Nonetheless, in the model if people chose to rent rather than own in the last period they could choose to leave a smaller inheritance and consume more. In principle, this could induce people to rent instead of living in a large house, so that they could spend the difference on consumption. I have chosen to ignore this option for two reasons. First, there is little evidence that many elderly wish to people do this. Australian evidence strongly suggest that older people prefer to retain ownership of their homes as it provides them with options to realise their wealth in the event that bad shocks occur. Secondly, in most countries including New Zealand, the absence of a well defined annuities market means it is not possible to sell up and obtain an actuarially fair annuity that would enable a household to guarantee they could cover their rent given uncertainty over life expectancy (St John 2006).

It is assumed that there is a construction sector that builds new flats and houses, or converts house from one quality into another. Consequently the quantity of each type of property is determined in equilibrium along with rents and prices. Linear supply functions are specified:

$$\begin{aligned} P_t^F &= \alpha_0^F + \alpha_1^F \left(Q_t^F + Q_t^H \right) \\ P_t^H &= P_t^F + \alpha_0^H + \alpha_1^H Q_t^H \end{aligned} \qquad (6)$$

In this specification the price of flats is an increasing function of the total number of properties (to reflect the possible scarcity of land), while the price of houses is determined as a variable premium supply over the price of flats. In the first parameterisation the price of flats is very elastic, with house prices increasing by 0.1% for a 1 percent increase in the number of houses $(\alpha_0^F = 18000; \alpha_1^F = 1;$ $\alpha_0^H = 10000; \alpha_1^F = 1.5)$. In the second parameterisation, a 1 percent increase in the number of properties leads to a 1 percent increase in prices $(\alpha_0^F = -8000;$ $\alpha_1^F = 15;$ $\alpha_0^H = 10000; \alpha_1^F = 1.5)$. In the third parameterisation, a 1 percent increase in the number of properties leads to a 1 percent increase in the price of small houses, but prices of large houses increase three times as fast. $(\alpha_0^F = -8000; \alpha_1^F = 15;\ \alpha_0^H = 22500; \alpha_1^F = 30)$.

6.4 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. The economy can either be closed, in which case the interest rate is determined endogenously and aggregate deposits equal aggregate loans, or open, in which case real interest rates are determined exogenously and the net foreign asset position can be non-zero. There are no restrictions on the deposit contract, and interest on a deposit made at time *t* is paid at time *t+1*. Agents pay tax on this interest at their marginal tax rate, but do not get a tax deduction for interest paid on borrowed funds unless they borrow to fund a rental property[13]. An agent's positive funds are labelled $B_t^{i,j}$.

The mortgage contract is subject to three restrictions[14].

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 $D_t^{i,j-}$ cannot exceed the value of property multiplied by the loan to value ratio θ: that is

$$D_t^{i,j-} \leq \sum_{h \in F,H} \theta P_t^h I_t^{i,j,h} \tag{7}$$

(Note $D_t^{i,j-} > 0$ 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.

Banks only issue η-year table mortgages, and require a "cash payment" in the period the mortgage is issued. This restriction is imposed to mimic a standard condition of a table mortgage, namely that a customer is required to make regular

[13] To reduce computational complexity, the marginal tax rate is calculated on the basis of labour income, not total income. Otherwise the marginal tax rate is determined endogenously.
[14] Note that banks impose these restrictions even though there is no uncertainty in the model

cash repayments CP of equal size throughout the life of the mortgage rather than a large repayment at its terminal date. The payment size CP is chosen to ensure the mortgage is retired at the end of the term: if D^{0-} is initially borrowed, the annual payment is

$$CP = D^{0-} r \left[\frac{(1+r)^{\eta}}{(1+r)^{\eta} - 1} \right] \qquad (8)$$

and η is assumed to be 25 years[15].

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 $D_t^{i,j-}$ is required to open up a separate account with the bank and make a deposit of size

$$D_t^{i,j*} = D_t^{i,j-} \frac{r_t}{1+r_t} \left[\frac{(1+r_t)^{\eta/T}}{(1+r_t)^{\eta/T} - 1} \right] \qquad (9)$$

into this account. This deposit earns (untaxed) interest at rate r_t. This means the net borrowing position of a borrowing agent, $D_t^{i,j} = D_t^{i,j-} - D_t^{i,j*}$, is less than the gross borrowing position. Without this "cash payment" feature, many agents 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 to ensure the mortgage repayment given by equation 8 is smaller than a fraction δ of income:

$$D_t^{i,j-} \frac{r_t}{1+r_t} \left[\frac{(1+r_t)^{\eta/T}}{(1+r_t)^{\eta/T} - 1} \right] \le \delta P_t Y_t^{ij} \qquad (10)$$

[15] Until recently, this has been the standard term for a table mortgage in Australia and New Zealand.

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

The mortgage conditions are only imposed on agents in periods 0 and 1 of their lives in order to simplify the solution algorithm. In period 2 agents can borrow unrestricted amounts. The absence of a restriction in period 2 has little effect because agents are in their peak earning years, receive their inheritance at this time, and are actively saving or reducing debt to finance their retirement.

6.5 Utility maximisation

An agent born at time *t* solves the following constrained maximisation problem (the jth superscript is omitted):

$$Max_{\{c_{t+i},\mathbf{I}_{t+i}^{i,h}\}} \quad U=\sum_{i=0}^{3} T_i \beta^{\left(\sum_{j=0}^{i} T_j - T_0\right)_i} u(c_{t+i,}^{i,j}\mathbf{I}_{t+i}^{i,j,h}) \tag{11}$$

$$-\lambda_0 \quad \left(P_t T_0 Y_t^0 - B_t^0 + D_0^t - (1+\tau^g) T_0 P_t c_t^0 - \sum_h P_t^h I_t^{0,h} \right)$$

$$-\sum_{i=1}^{3} \lambda_i \left(\begin{array}{l} (1+\pi)^i T_i P_t Y_{t+i}^i + B_{t+i-1}^i (1+r_{t+i-1}(1-\tau^i)) - D_{t+i-1}^i (1+r_{t+i-1}) - B_{t+i}^i + D_{t+i}^i \\ -(1+\pi)^i (1+\tau^g) T_i P_t c_t^i - \sum_h P_{t+i}^h I_{t+i}^{i,h} + \sum_{h=F,H} P_{t+i}^h I_{t+i-1}^{i-1,h} + \kappa_i Inherit_{t+i} \\ +\left[P_{t+i}^R (1-\tau^i) I_{t+i}^{i,R*} + (P_{t+i}^F - P_{t+i-1}^F (1+r_{t+i-1}(1-\tau^i)) I_{t+i-1}^{i-1,R*} \right] \end{array} \right)$$

$$-\sum_{i=0}^{1} \chi_i \left(D_{t+i}^{i,-} - \sum_h \theta P_{t+i}^h I_{t+i}^{i,h} \right)$$

$$-\sum_{i=0}^{1} \phi_i \left(D_{t+i}^{i,-} \frac{r_{t+i}}{1+r_{t+i}} \left[\frac{(1+r_{t+i})^{\tau/T}}{(1+r_{t+i})^{\tau/T} - 1} \right] - \delta Y_{t+i}^i \right)$$

$$-\sum_{i=0}^{3} \varsigma_i \left(B_{t+i}^i \right) - \sum_{i=0}^{3} \nu_i \left(D_{t+i}^i \right)$$

The first line of equation 11 is the utility maximisation equation, equation 3. Lines 2 and 3 of equation (11) are the budget constraints facing the agent in the four periods. Note the budget constraints as well as the utility function have an adjustment for the number of years in each period. Lending and borrowing are entered separately as there are different after tax interest rates, and there are terms to reflect inheritance and rental income. Lending and borrowing in period 3 are restricted to equal zero, and τ^i is the marginal tax rate applying in period *i* of the agent's life. 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 Kuhn-Tucker conditions in line 6 reflects the requirement that non-negative amounts are lent and borrowed. The agent solves the problem by calculating the maximum utility for each housing pattern in the set $\mathcal{H}$, 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 48 parts corresponding to the 48 possible combinations of Kuhn-Tucker conditions[16].

6.6 Equilibrium conditions

In the simulations, the steady state equilibrium is found for an open economy in which agents borrow or lend at the world interest rate. In the steady state, the following price relationships hold:

$$(1+r_t)/(1+\pi_t) = r \tag{12a}$$

$$\frac{P_{t+1}^F}{P_t^F} = 1+\pi^F \tag{12b}$$

$$\frac{P_t^H}{P_t^F} = \rho^H \tag{12c}$$

$$\frac{P_t^R}{P_t^F} = \left(\frac{(1+r_t(1-\tau_2))^T - (1+\pi_t^F)}{(1-\tau_2)(1+r_t(1-\tau_2))^T} \right) = \rho^R \tag{12d}$$

Equation (12a) states that real interest rates are constant. In the open economy model, the rate *r* is the foreign real interest rate. Equation (12b) states that flat prices appreciate at a constant rate[17]. Equation (12c) states that the ratio of house prices to flat prices is constant. Equation (12d) restates equation 5, linking rents to interest rates and the flat price appreciation rate.

[16] In the periods 0 and 1, the financial asset position can be positive, zero, negative, or equal to the borrowing constraint; in period 2, the financial asset position can be positive, zero or negative; and in period 3 it is zero.

[17] If the number of flats and houses is determined exogenously, an equilibrium can be found in which incomes in the economy grow at a constant rate, and in this case the steady state equilibrium will have property prices growing at a faster rate than the rate of inflation. If the number of properties is determined endogenously and the income growth rate is positive, the only possible steady states occur when all people live in large houses, or when the quality of flats and houses steadily improves. This paper does not analyse these cases.

For a set of parameters $\left\{N, T, T_{i,} Y_t^0, \omega_j, g_i, \pi, \beta, v_h, \kappa_i, \mathcal{H}, n^H, n^F, \eta, \theta,\right.$ $\left.\delta, \tau^{g*}, \tau_1, \tau_2, \tau^*\right\}$, pension expenditure G, medical expenditure H, and labour taxes τ_L, and housing parameters $\left\{\alpha_0^F, \alpha_1^F, \alpha_0^H, \alpha_1^H\right\}$ the steady state equilibrium is described by a set of prices $\left\{r, \pi^F, \rho^H, \rho^R\right\}$, a GST rate τ^g, a set of housing and consumption demands $\{c_{t-i+s,}^{s,j} \mathbf{I}_{t-i+s}^{s,j,h}\}_{s=0,\ldots,3}$ for each agent j in each cohort born in period *t-i*, and a net foreign asset position B_t^{net} such that all agents have maximal utility and

$$\sum_{i=0}^{3}\sum_{j=1}^{N} T_i c_t^{i,j} = (1-\tau^{g*})\sum_{i=0}^{3}\sum_{j=1}^{N} y_t^{i,j} - \left(\frac{r-\pi}{1+\pi}\right) T_i B_t^{net} \tag{13a}$$

$$\sum_{i=0}^{3}\sum_{j=1}^{N} (B_t^{i,j} - D_t^{i,j}) - P_t^F \sum_{j=1}^{N} I_t^{2,j,R*} = B_t^{net} \tag{13b}$$

$$\begin{aligned} &\tau^{g*}\sum_{i=0}^{3}\sum_{j=1}^{N} y_t^{i,j} = \\ &\tau^{g}\sum_{i=0}^{3}\sum_{j=1}^{N} T_i c_t^{i,j} + \sum_{i=0}^{3}\sum_{j=1}^{N} T_i B_{t-1}^{i,j} r \tau_t^{ij} + \sum_{j=1}^{N} P_t^R \tau_t^{2,j} I_t^{2,j,R*} - \sum_{j=1}^{N} P_{t-1}^F r \tau_t^{3,j} I_{t-1}^{2,j,R*} \end{aligned} \tag{13c}$$

and

$$\Delta T_3 (G_t + H_t) N = \tau_L \sum_{i=0}^{2}\sum_{j=1}^{N} Y_t^{i,j} T_i \tag{13d}$$

$$\sum_{i=0}^{3}\sum_{j=1}^{N} T_i (I_t^{i,j,R} + I_t^{i,j,F}) = Q^F \tag{13e}$$

$$\sum_{i=0}^{3}\sum_{j=1}^{N} T_i I_t^{i,j,H} = Q^H \tag{13f}$$

where Q^F and Q^H are the number of houses produced when the supply of properties is elastic,

$Q^H = \dfrac{P^H - P^F - \alpha_0^H}{\alpha_1^H}$ and $Q^F = \dfrac{P^F - \alpha_0^F}{\alpha_1^F} - Q^H$.

Equation (13a) requires that total consumption plus tax plus real earnings on the net bond position in each period equals total production. Equation (13b) is the net supply of foreign bonds, given that landlords are assumed to borrow 100 percent of the price of a flat. This will change through time if there is economic growth or inflation. Equation 13c is the equation for tax revenues excluding the labour tax surcharge needed to pay for the additional health and pension expenditure incurred as the population ages. The total tax take is equal to total GST revenue plus tax on interest and rent minus the tax deduction for landlords. Note that while it has been assumed landlords borrow 100 percent of the value of the property, tax revenue would not change if landlords had different gearing as the tax rate on positive balances is the same as the tax deduction they get when they borrow. Equation (13d) is the labour tax surcharge that pays for the additional expenditure associated with increased longevity. Equations (13e) and (13f) require that the total demand for flats equals the supply of flats, and that the total demand for houses equals the supply of houses.

6.7 Parameterisation

The set of baseline parameters[18]. are nearly the same as those used by Coleman (2008) and have been chosen to approximate features of the New Zealand economy[19]. These are listed in table 8. Except for 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, after tax income in the first period is assumed to be uniformly distributed over the range $20,000 to $80,000.

In the baseline model, the discount rate is 3 percent, the real interest rate is 5 percent (assumed equal to the world rate), and banks impose borrowing restrictions that limit households to borrow up to 80 percent of the value of a property and to pay no more than 30 percent of their income in debt servicing.

The tax rates also reflect New Zealand tax settings in 2000. In the baseline model, the marginal tax is 20 percent for households with incomes less

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[18] $\left\{N,T,Y_t^0,\omega_j,g_i,\pi,\beta,v_h,\kappa_i,\mathcal{H},n^H,n^F,\eta,\theta,\delta,\tau^{g*},\ \tau_1,\tau_2,\tau^*\right\}$

[19] Coleman (2007) uses 5 cohorts, not 4, and the parameters have been slightly modified.

than \$50,000, and 33 percent for households with incomes above that level. The model is also solved for a set of tax rules that exclude the inflation component of interest income from tax, and which only allow landlords to deduct real interest payments from their taxable income[20]. The GST rate was chosen to ensure that capital income taxes and consumption taxes total to 10 percent of labour income.

The parameters $(\upsilon^R, \upsilon^F, \upsilon^H) = (0.33, 0.35, 0.45)$ mean (approximately) that at the margin a household would be prepared to spend a third of their income on rent rather than have no accommodation; the benefit from living in an owner-occupied flat rather than a rented flat is 2 percent, and the additional benefit from living in a large house a further 10 percent. Housing supply parameters were chosen so that that the quantity of flats would increase by approximately one percent for a one percent increase in prices, but that the number of houses and flats would be approximately the same in the elastic and inelastic cases.

6.8 Solution technique

The solution is found numerically. The algorithm searches for a set of prices $\left\{\tau^g, P_t^R, P_t^F, P_t^H\right\}_{t=-3,..0,...3}$ so that when each agent *j* born in period *t-i, i= 0,…3* is consuming a sequence of goods and tenure options $\{c_{t-i+s,}^{s,j} \mathbf{I}_{t-i+s}^{s,j,h}\}_{s=0,...,3}$ that solves their constrained utility problem given by equation (11), the aggregation conditions 13a–13f applied at time *t* are satisfied. In the steady state, the vector $\left\{\tau^g, P_t^R, P_t^F, P_t^H\right\}_{t=-3,..0,...3}$ can be calculated from the vector $P^* = \{\tau^g, P_0^F, \pi^F, \rho^H\}$ and the parameters $\left\{r, \tau_2\right\}$.

The basic structure of the algorithm is as follows.

a) Let the vector $P^{*,k} = \{\tau^g, P_0^F, \pi^F, \rho^H\}^k$ 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 who are born at *t=0* by searching over the different possible tenure paths in the set $\mathcal{H}$.

[20] In this case the constraints in equation 11 and the aggregation condition (13c) are modified accordingly.

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 13a–13f.

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-Rhapson method. A set of quasi-derivatives is calculated by recalculating the set of excess demand functions at the prices $\{\tau^{g}+\Delta_1, P^{F}, \pi^{F}, \rho^{H}\}$, $\{\tau^{g}, P^{F}+\Delta_2, \pi^{F}, \rho^{H}\}$, $\{\tau^{g}, P^{F}, \pi^{F}+\Delta_3, \rho^{H}\}$ and $\{\tau^{g}, P^{F}, \pi^{F}, \rho^{H}+\ \Delta_4\}$. These quasi derivatives are used to calculate the updated price vector using Broyden's method. The process is continued until the sequence of estimates $P^{*,k}$ converges.

7 Appendix 2. Population and housing trends amongst older people.

7.1 Population trends.

New Zealand's population is ageing. According to the 2006 National Population Projections (Statistics New Zealand 2007), the number of people aged over 65 will increase from 510 000 to 1 350 000 between 2006 and 2051, or from 12 percent of the population to 25 percent of the population[21]. This increase will reflect two main factors: a greater number of births in the 30 years to 1985 than the thirty years to 1940; and a likely increase in longevity, from 78 years for males and 82 years for females in 2006 to 84 for males and 88 for females in 2051. After 2041 the lagged effect of fluctuating birth rates will be minimal, and the increase in the number of people aged at least 65 years will mainly reflect changes in longevity. The number of births has already largely stabilized, meaning that the population aged less than 65 will increase by little between 2006 and 2051, from 3 700 000 to 4 100 000. Consequently, the increase in the total population will be dominated by the increase in people aged at least 65 years.

7.2 Housing demand by older people: general considerations

There is an extensive literature examining housing demand by older people, including a dedicated journal "Journal of Housing for Elderly." This section provides a brief review of some of the key features of this literature that are relevant to the model developed in the paper. The review is primarily focused on literature from New Zealand with supporting material from Australia and the USA, as these countries have institutional frameworks similar to those in New Zealand.

The demand for housing by older people is fashioned by six major factors. First, older people tend to have more assets, in large part because of their ownership of residential property. Secondly, older people often have long-term roots in an area – friends, relatives, acquaintances, familiar relationships with commercial firms – and are thus have greater attachment to a location than younger people. Thirdly, older people do much less paid work than younger

[21] This is their central projection based on assumptions of medium birth rates, medium increases in longevity, and medium inward migration.

people, have lower incomes, and are less likely to move for work related reasons. Fourthly, particularly at older ages (over 80) older people are subject to worse health, and are less able to undertake some physical activities. This means they need more low-level and sometimes acute healthcare. Fifthly, older people are often subject to the death or long-term incapacitation of a partner. Lastly, older people are sometimes subject to personal incapacitation requiring acute nursing attention.

Subject to some qualifications, the first three factors have meant that housing demand among older people has been characterized by a demand to "age in place" – to live in the same location, and oftentimes the same house as they have always lived (Schafer 1999; Olsberg and Winters 2005; Davey et al 2004.) This may be the home in which one lived while working and raising children, or it may be a smaller house that the person or couple moved to at the beginning of retirement, but which has been lived in for several years. Despite the popular impression that older people tend to live in nursing homes, rest homes, retirement homes, or communities in sunny locations, most older people live in ordinary housing in ordinary locations. In part this is because most older people are aged 65 – 80, active, and ordinary participants in the community. While a sizeable fraction of older people do spend some of their final years in a specialized retirement home or rest home, the fraction of most people's lives spent in such places is small.

Statistics from the United States and Australia demonstrate this clearly. According to the National Institute of Ageing's "Asset and Health Dynamics Among the Oldest Old" survey, 75 percent of people aged over 70 in the U.S. live in conventional single family housing, with a further 15 percent living in conventional housing with other family members or non-related adults (Schafer 1999). According to the American Housing survey, 70 percent of those aged 62–84 live in single family detached housing, as do 61 percent of those aged at least 85 (U.S. Department of Housing and Urban Development, 2005). In Australia, 83 percent of people aged over 60 live in single detached housing (Bridge et al 2008). Moreover, a study that tracked 1000 healthy people who lived in Melbourne and were over 65 in 1994 showed that only 20 percent had entered a residential care facility by 2006, leading them to conclude there was a "growing body of evidence that the majority of older people remain in the community throughout later life and never enter residential care for very long periods.” (Bridge et al, 2008, 23)

While most older people live in ordinary housing, in terms of understanding the effect of population ageing on aggregate housing demand, two important questions arise. First, do many older people move houses? Secondly, if they move, do they tend to move to small houses? The evidence from Australia and the United States is somewhat conflicting on these questions, with Australians appearing more mobile than Americans. In Australia, for example, 33 percent of people aged over 65 had moved in the previous five years (Olsberg and Winters 2005), whereas in the United States, only 40 percent of people older than 60 have moved at least once (Joint Center for Housing Studies of Harvard University 2000). These differences make it useful to analyse New Zealand data separately. While the motives for these moves are unclear, most surveys and studies suggest they often occur when there is a major change in health status, or when a spouse dies, or when it gets to difficult or time consuming to manage a large property. Few people suggest they “trade down” in order to free up financial resources, although of course financial resources are often freed up when a move occurs.

7.3 Ageing in place in New Zealand.

Tables 8 – 12 present some detailed statistics compiled from census returns about the extent to which older people in New Zealand “age in place.” The data indicate the extent to which older people move, and the size of the houses in which they live. The data are based on three census questions from the 1991 – 2006 censuses: a question asking the number of years a person has lived in their current house; a question about the size of their house; and a question asking where they lived five years previously.

There are two ways of examining how frequently older people move. First, a “snapshot” can be taken in a particular year of the number of years people have lived in the same house. Secondly, people in a particular year can be traced through successive censuses. Both techniques suggest that only a minority of the population do *not* move after retirement. For instance, table 8 presents a snapshot of census data from 2006 and shows that 30 percent of households aged 65 or older had been in their current house for fewer than 5 years, and that at least 42%

of those aged 75-84 and at least 69% of those aged over 85 had moved at least once after they were 65. The data do not indicate whether these moves involve a shift to a less expensive house. The data also show that 33 percent had been in their house for at least 20 years.

Similar results are found when the cohort that was aged between 65 and 69 in 1991 is traced through successive censuses. Table 9 shows the distribution of the population who were 65-69 in 1991 by the length of time they subsequently stayed in the same house. The table suggests the population can be usefully divided into two subgroups: those who move frequently, and those who do not. Of the quarter of those aged 65-69 in 1991 who had moved in the previous five years, 62% remained in that house after five years, 51% remained in it after 10 years, and 33% were still there after 15 years. (Of those who moved between 1991 and 1996, 38% moved again within the next five years.) In contrast, of those who had not moved in the previous five years in 1991, 79% were still there in 1996, 63% were there in 2001, and 48% were there in 2006. These data provide further evidence that while a large fraction of New Zealand's older population age in place, a sizeable fraction move at least once after retirement. The data do not indicate whether these moves involve a shift to a less expensive house. Nonetheless, those who moved within the previous five years were 50 percent more likely to live in 1 or 2 bedroom houses than those who stayed, although a majority (58 percent) moved to houses with at least three bedrooms.

7.4 House size in New Zealand

Table 10 shows the number of people aged at least 65 who lived in different size houses in 2006. Houses are categorized according to whether they have one, two, or three or more bedrooms. The data were provided on request from Statistics New Zealand. Housing patterns are shown for men and women; singles and couples; and people aged 65-84 and 85 and over.

The data indicate that only a minority of people aged at least 65 live in houses with 2 or fewer bedrooms: 68% of people aged over 65 live in houses with at least three bedrooms, 26 percent live in houses with two bedrooms, and 6 percent live in houses with 1 bedroom. There are clear differences by age and household size. People aged at least 85 are twice as likely as people aged 65-84 to live in one bedroom houses (10% versus 5%) while singles are seven times as likely as couples to live in one bedroom houses (15% versus 2%). Indeed, more than 75% of couples aged 65-84 live in houses with at least three bedrooms, compared to just 43% of singles. These data clearly suggest that a majority of older people live in standard housing, although there is a tendency for older singles to live in smaller one or two bedroom houses. These fractions are very similar to those reported in the United States (Hermanson and Citro 1999 p20.)

Table 11 shows the same data for 1996. While the overall pattern is similar in 1996 and 2006, between 1996 and 2006 there was a big increase in the fraction of older people who were living in houses with at least three bedrooms, and a commensurate reduction in those living in one and two bedroom houses, primarily two bedroom houses. Overall, the fraction of older people living in three or more bedroom houses increased by 8.5 percent between 1996 and 2006, from 59% to 68%. The increase was largest amongst couples aged 65-84 (+9.3%) but occurred across all age and demographic groups. The fraction of the population living in one bedroom houses declined by 1.5 percentage points, from 7.1% to 5.9% despite the numbers of people aged 85 and over increasing three times as quickly as the numbers aged 65-84.

It is not known why the fraction of older people living in three or more bedroom houses increased sharply between 1996 and 2006. The increase, which occurred amongst all demographic sub-groups, could reflect a nationwide trend towards larger houses. Alternatively, it could reflect rising life-expectancy and improving health amongst older people. There is little reason to expect this trend to change. Even though the increase in longevity is expected to lead to an increase in the proportion of older people who are over 85, it is also expected lead to an increase in the fraction of the elderly who are living as couples, as male life expectancy is expected to increase faster than female life expectancy.

Table 12 shows how house size in 1996 and 2006 differed according to household mobility. The table shows the distribution of house size for those who had moved in the previous five years, and those who lived in the same house. The overall patterns are similar in both years, but once again the data shows that a much higher fraction of people lived in houses with at least three bedrooms in 2006 than in 1996. In both cases the data are consistent with the hypothesis that some older people “trade down” when they move. In each year, people who had moved in the previous five years were more likely to live in 1 bedroom houses and less likely to live in three or more bedroom houses. Nonetheless, the data show that even when they move, most older people prefer to live in houses with at least three bedrooms. In 2006, 58 percent of people who had moved in the previous five years lived in houses with three or more bedrooms, while only 12 percent lived in 1 bedroom houses. Of those aged at least 85, only 20 percent of those that had moved in the previous 5 years moved into a house with only one bedroom, versus 37 percent who moved to a house with at least 3 bedrooms.

The census data also indicate that most older people own the property in which they live, or own it jointly with a partner. Using census data, Morrison (2007) estimates that over 90 percent of couples aged 60-80 in New Zealand owned their own home, as did 80 percent of singles. For this reason, the model developed in this paper makes the assumption that people own their own homes in their retirement years. Consequently, it does not tackle the issues facing the small minority of people who rent in retirement, although it does analyse the implications of population ageing on the decision to rent or buy when younger. It should be noted that whether one owns or rents proves to be one of the most important predictors of whether a retired household is satisfied with their housing, in part because people who own their own house tend to be wealthier than those that do not, and this wealth gives them the opportunity to change their housing choices should they wish to do so (Olsberg and Winters 2005). People who do not own their own home typically have less wealth, spend a larger fraction of their income on rent, and often find they cannot afford to move to change some of their housing characteristics if they no longer suit (for instance, if they have a health problem that makes their housing unsuitable.)

7.5 Medical Care, Housing and Taxes.

Changing health needs are one of the main reasons why older people move houses. Many older people find it inconvenient to live in locations without an adequate supply of medical and hospital services, and will often move from poorly serviced locations to towns and cities, or suburbs within cities, where these services are adequately provided. Similarly, some people move, often within a city, because their existing house proves awkward to live in because of some low level disability, or because they find it difficult to maintain their property. Even in these circumstances, however, most older people live in “ordinary” housing, even if sometimes it is modified to make it easier to live in for those with low level health problems.

The interaction of housing and health needs may prove to be a major factor in determining future housing demand. This issue is particularly complex, and it is difficult to predict how technological advances will affect housing demand. There are four main issues. First, technological advances *may* improve health in older age, making it easier for older people to live in traditional housing. Since the life expectancy of men has been increasing faster than that of women, an increasing fraction of elderly people will live with a spouse, making it easier to cope with low level physical disabilities[22]. Secondly, technological changes may make it easier to provide non-acute medical care within homes (through a greater use of pharmaceuticals, for instance.) This will also make it easier for older people to “age in place,” although may lead to an enhanced demand to live in locations where these services are available, typically cities. Thirdly, medical advances may increase the length of time people can stay alive while severely incapacitated and needing specialized housing or hospital facilities. If so, there will also be an increase in demand for this type of facility. Lastly, greater levels of medical care will have to be paid for. The way this is financed may have important implications for housing demand.

If healthcare is financed privately, there will be a reduction in expenditure on other items, presumably including housing. Whether older people will pay for these services by saving more while young, living in smaller houses when old, or using sophisticated financial contracts to withdraw equity from their homes (for example reverse mortgages) is unclear. Alternatively, if most of the care is financed through the government, tax levels will change and this will have reverberations throughout the economy and property markets.

[22] In 2006, 57 percent of singles but only 25 percent of couples aged 65-84 lived in houses with 2 or fewer bedrooms.

The extent to which health care costs are likely to increase as the population ages is a hotly contested subject. On one hand, it is clear that medical expenses are much higher for people aged over 65 than those under 65; for those aged 65-74, medical expenditure is approximately 4 times as high as for those aged 25-65, while for those aged over 75 it is are 8 times as high. (New Zealand Ministry of Health 2002, 2004.) Currently in New Zealand, three-quarters of medical expenditure is spent on those aged over 65. As the fraction of the population that aged 65 or older is set to double by 2050, it seems not unreasonable to expect medical expenditure to rise sharply as a fraction of gross domestic product. Yet the extent to which healthcare costs will rise depends on four major factors: (a) whether *annual* health care costs per older person remain constant, so total healthcare costs increase linearly with the number of older people; (b) whether *lifetime* health care costs per older person (i.e. for the period between 65 and death) remain constant, because the onset of expensive medical conditions are delayed to later in life, in which case total medical expenditure will increase by little; (c) whether lifetime health care costs per older person fall because chronic illness is delayed until closer to death, in which case total expenditure could fall; and (d) whether the government responds to greater demand for medical care (should it occur) by increasing expenditure. The evidence on this issue is by no means clear: many experts think it is reasonable to expect relatively modest increase in medical expenditure because most expense occurs in the last two years of someone's life (Gray 2005) while others expect medical expenditure to increase rapidly (Wilson and Rodway, 2006; Cox and Hope 2006). In the modelling I have adopted a position close to that of Gray and have simulated the effect of increasing medical expenditure by approximately 3 percent of GDP as the elderly population doubles. In these simulations, taxes are raised to pay for the additional medical expenditure.

Table 1. Supply curve 1: both curves very elastic

Length of last period	10	12	15	17	20
Total population	1000	1040	1100	1140	1200
	Taxes raised to pay additional pension expenses				
Number small houses	405	415	422	434	443
Number big houses	565	593	643	668	717
Total number houses	970	1008	1064	1102	1160
% new houses large		74%	83%	78%	80%
Price small house	199,000	200,000	201,000	202,000	203,000
Price large house	317,000	318,000	321,000	323,000	325,000
% cohort 0 owning	56%	54%	52%	49%	48%
% cohorts 0-1 large	36%	34%	32%	30%	27%
% cohort 2 large	95%	95%	94%	93%	90%
% cohort 3 large	19%	32%	48%	53%	62%
% total large	58%	59%	60%	61%	62%
	Taxes increased to pay additional medical and pension expenses				
Number small houses	405	418	438	446	467
Number big houses	565	588	624	652	686
Total number houses	970	1006	1062	1098	1152
% new houses large		63%	64%	68%	66%
Price small house	199,000	200,000	201,000	202,000	203,000
Price large house	317,000	318,000	320,000	322,000	324,000
% cohort 0 owning	56%	54%	50%	47%	43%
% cohorts 0-1 large	36%	34%	29%	27%	25%
% cohort 2 large	95%	94%	93%	91%	88%
% cohort 3 large	19%	32%	46%	53%	59%
% total large	58%	58%	59%	59%	60%
	Taxes constant, no increase in total pension payment				
Number small houses	409	412	414	420	430
Number big houses	562	599	656	690	741
Total number houses	970	1011	1070	1110	1171
% new houses large		91%	95%	92%	89%
Price small house	200,000	200,000	202,000	202,000	204,000
Price large house	317,000	319,000	322,000	323,000	326,000
% cohort 0 owning	56%	55%	56%	57%	57%
% cohorts 0-1 large	36%	36%	37%	37%	37%
% cohort 2 large	95%	95%	94%	92%	89%
% cohort 3 large	18%	31%	45%	52%	60%
% total large	58%	59%	61%	62%	63%

In section 1, taxes are increased as the population ages to pay for higher aggregate pension expenditure. When the elderly population doubles, pension expenditure increases by approximately 5% of GDP

In section 2, taxes are increased as the population ages to pay for higher aggregate pension and medical expenditure. When the elderly population doubles, expenditure increases by approximately 8% of GDP.

In section 3, pension expenditure is maintained at initial levels and taxes are unchanged.

Table 2. Supply curve 2: both curves upward sloping

Length of last period	10	12	15	17	20
Total population	1000	1040	1100	1140	1200
	Taxes raised to pay additional pension expenses				
Number small houses	409	416	423	422	428
Number big houses	556	582	624	658	700
Total number houses	965	998	1047	1080	1128
% new houses large		77%	82%	88%	88%
Price small house	200,000	209,000	223,000	233,000	246,000
Price large house	311,000	321,000	336,000	347,000	362,000
% cohort 0 owning	52%	47%	40%	37%	31%
% cohorts 0-1 large	35%	32%	27%	25%	23%
% cohort 2 large	95%	94%	93%	92%	91%
% cohort 3 large	18%	33%	48%	56%	61%
% total large	58%	58%	60%	61%	62%
	Taxes increased to pay additional medical and pension expenses				
Number small houses	405	417	425	435	442
Number big houses	559	580	619	639	677
Total number houses	964	997	1044	1074	1119
% new houses large		65%	75%	73%	76%
Price small house	199,000	209,000	222,000	231,000	244,000
Price large house	311,000	321,000	336,000	345,000	359,000
% cohort 0 owning	52%	46%	38%	33%	29%
% cohorts 0-1 large	35%	31%	26%	23%	21%
% cohort 2 large	95%	94%	93%	91%	89%
% cohort 3 large	20%	34%	49%	53%	59%
% total large	58%	58%	59%	59%	60%
	Taxes constant, no increase in total pension payment				
Number small houses	409	413	404	402	410
Number big houses	556	588	648	685	730
Total number houses	965	1000	1052	1087	1140
% new houses large		89%	105%	105%	99%
Price small house	200,000	210,000	225,000	235,000	250,000
Price large house	311,000	322,000	339,000	350,000	366,000
% cohort 0 owning	52%	48%	43%	43%	42%
% cohorts 0-1 large	35%	33%	32%	31%	29%
% cohort 2 large	95%	95%	93%	93%	90%
% cohort 3 large	18%	32%	49%	57%	64%
% total large	58%	59%	62%	63%	64%

In section 1, taxes are increased as the population ages to pay for higher aggregate pension expenditure. When the elderly population doubles, pension expenditure increases by approximately 5% of GDP

In section 2, taxes are increased as the population ages to pay for higher aggregate pension and medical expenditure. When the elderly population doubles, expenditure increases by approximately 8% of GDP.

In section 3, pension expenditure is maintained at initial levels and taxes are unchanged.

Table 3. Supply curve 3: high quality supply curve steeply upward sloping

Length of last period	10	12	15	17	20
Total population	1000	1040	1100	1140	1200
	Taxes raised to pay additional pension expenses				
Number small houses	398	424	460	480	517
Number big houses	567	574	588	599	610
Total number houses	965	998	1047	1079	1127
% new houses large		22%	25%	29%	27%
Price small house	199,000	209,000	223,000	232,000	246,000
Price large house	309,000	323,000	345,000	361,000	381,000
% cohort 0 owning	52%	47%	39%	35%	30%
% cohorts 0-1 large	36%	31%	25%	23%	19%
% cohort 2 large	96%	94%	92%	87%	82%
% cohort 3 large	21%	32%	41%	47%	51%
% total large	59%	58%	56%	56%	54%
	Taxes increased to pay additional medical and pension expenses				
Number small houses	398	424	461	470	517
Number big houses	567	573	584	599	603
Total number houses	964	997	1044	1069	1120
% new houses large		20%	21%	31%	23%
Price small house	199,000	209,000	222,000	229,000	244,000
Price large house	309,000	322,000	342,000	358,000	374,000
% cohort 0 owning	52%	46%	38%	41%	25%
% cohorts 0-1 large	36%	30%	24%	22%	18%
% cohort 2 large	96%	94%	91%	86%	81%
% cohort 3 large	21%	33%	41%	50%	52%
% total large	59%	58%	56%	56%	54%
	Taxes constant, no increase in total pension payment				
Number small houses	398	424	461	487	524
Number big houses	567	576	592	601	616
Total number houses	965	1000	1052	1088	1140
% new houses large		26%	28%	27%	28%
Price small house	200,000	210,000	225,000	235,000	250,000
Price large house	310,000	325,000	349,000	364,000	388,000
% cohort 0 owning	52%	47%	45%	41%	40%
% cohorts 0-1 large	36%	32%	27%	26%	24%
% cohort 2 large	95%	94%	90%	87%	80%
% cohort 3 large	21%	30%	41%	45%	50%
% total large	59%	58%	56%	55%	54%

In section 1, taxes are increased as the population ages to pay for higher aggregate pension expenditure. When the elderly population doubles, pension expenditure increases by approximately 5% of GDP

In section 2, taxes are increased as the population ages to pay for higher aggregate pension and medical expenditure. When the elderly population doubles, expenditure increases by approximately 8% of GDP.

In section 3, pension expenditure is maintained at initial levels and taxes are unchanged.

Table 4. Variations in interest rates and inflation rates for supply curve 2

Length of last period	10	12	15	17	20
Total population	1000	1040	1100	1140	1200
	inflation = 0, real interest rates = 5				
Number small houses	389	397	408	416	430
Number big houses	573	598	637	662	695
Total number houses	962	995	1045	1077	1125
% new houses large		74%	77%	77%	75%
Price small house	199,000	208,000	222,000	232,000	246,000
Price large house	311,000	321,000	336,000	346,000	361,000
% cohort 0 owning	75%	72%	67%	64%	59%
% cohorts 0-1 large	43%	40%	36%	33%	28%
% cohort 2 large	94%	93%	92%	91%	94%
% cohort 3 large	12%	27%	43%	50%	52%
% total large	60%	60%	61%	61%	62%
	inflation = 0, real interest rates = 4				
Number small houses	411	427	447	457	488
Number big houses	564	583	614	639	658
Total number houses	975	1010	1061	1096	1145
% new houses large		55%	58%	62%	55%
Price small house	203,000	212,000	227,000	237,000	251,000
Price large house	314,000	325,000	340,000	351,000	366,000
% cohort 0 owning	51%	46%	35%	27%	22%
% cohorts 0-1 large	45%	42%	38%	35%	30%
% cohort 2 large	95%	95%	94%	93%	93%
% cohort 3 large	3%	15%	30%	38%	42%
% total large	58%	58%	58%	58%	57%
	inflation = 2, real interest rates = 4				
Number small houses	434	438	438	442	450
Number big houses	545	575	624	654	696
Total number houses	979	1013	1062	1096	1146
% new houses large		87%	95%	93%	90%
Price small house	204,000	213,000	227,000	237,000	251,000
Price large house	315,000	325,000	341,000	351,000	367,000
% cohort 0 owning	9%	6%	2%	0%	0%
% cohorts 0-1 large	37%	34%	31%	28%	26%
% cohort 2 large	96%	96%	95%	94%	93%
% cohort 3 large	6%	24%	41%	48%	55%
% total large	56%	57%	59%	60%	61%

In each section, taxes are increased as the population ages to pay for higher aggregate pension expenditure. When the elderly population doubles, pension expenditure increases by approximately 5% of GDP

Table 5. Additional variations in supply curves, inflation = 2.

Length of last period	10	12	15	17	20
Total population	1000	1040	1100	1140	1200
	Both house prices increased				
Number small houses	403	400	397	411	412
Number big houses	528	563	613	633	678
Total number houses	931	963	1010	1044	1090
% new houses large		109%	108%	93%	95%
Price small house	266,000	275,000	289,000	299,000	312,000
Price large house	377,000	387,000	402,000	412,000	427,000
% cohort 0 owning	22%	21%	20%	21%	19%
% cohorts 0-1 large	27%	25%	23%	21%	18%
% cohort 2 large	94%	93%	92%	91%	90%
% cohort 3 large	21%	38%	52%	54%	62%
% total large	57%	58%	61%	61%	62%
	High quality house prices increased				
Number small houses	550	592	631	644	655
Number big houses	416	407	419	437	474
Total number houses	966	999	1049	1081	1129
% new houses large		-25%	4%	19%	36%
Price small house	200,000	209,000	224,000	233,000	247,000
Price large house	355,000	364,000	379,000	389,000	404,000
% cohort 0 owning	45%	42%	38%	35%	27%
% cohorts 0-1 large	23%	21%	19%	17%	15%
% cohort 2 large	81%	79%	76%	74%	70%
% cohort 3 large	0%	3%	13%	22%	33%
% total large	43%	41%	40%	40%	42%
	High quality house prices increased and quality improved				
Number small houses	375	377	389	391	390
Number big houses	588	620	656	687	736
Total number houses	963	996	1045	1077	1125
% new houses large		96%	83%	86%	91%
Price small house	199,000	208,000	222,000	232,000	246,000
Price large house	359,000	370,000	385,000	395,000	410,000
% cohort 0 owning	63%	60%	55%	52%	44%
% cohorts 0-1 large	36%	33%	28%	26%	24%
% cohort 2 large	96%	95%	94%	93%	92%
% cohort 3 large	30%	45%	56%	62%	68%
% total large	61%	62%	63%	64%	65%

In each section, taxes are increased as the population ages to pay for higher aggregate pension expenditure. When the elderly population doubles, pension expenditure increases by approximately 5% of GDP

Table 6. Reverse mortgages and inheritances; supply curve 2, inflation = 2.

Length of last period	10	12	15	17	20
Total population	1000	1040	1100	1140	1200
	Supply curve 2: standard inheritance, no reverse mortgage				
Number small houses	409	416	423	422	428
Number big houses	556	582	624	658	700
Total number houses	965	998	1047	1080	1128
% new houses large		77%	82%	88%	88%
Price small house	200,000	209,000	223,000	233,000	246,000
Price large house	311,000	321,000	336,000	347,000	362,000
% cohort 0 owning	52%	47%	40%	37%	31%
% cohorts 0-1 large	35%	32%	27%	25%	23%
% cohort 2 large	95%	94%	93%	92%	91%
% cohort 3 large	18%	33%	48%	56%	61%
% total large	58%	58%	60%	61%	62%
	Supply curve 2: standard inheritance, reverse mortgage				
Number small houses	368	377	400	407	406
Number big houses	596	622	649	674	724
Total number houses	964	998	1049	1081	1130
% new houses large		75%	62%	67%	77%
Price small house	199,000	209,000	224,000	233,000	247,000
Price large house	312,000	322,000	338,000	348,000	363,000
% cohort 0 owning	54%	48%	44%	42%	40%
% cohorts 0-1 large	35%	32%	27%	25%	24%
% cohort 2 large	94%	93%	90%	88%	85%
% cohort 3 large	41%	52%	60%	65%	72%
% total large	62%	62%	62%	62%	64%
	Supply curve 2: different inheritance, no reverse mortgage				
Number small houses	386	382	395	405	414
Number big houses	577	614	650	673	713
Total number houses	963	995	1044	1077	1127
% new houses large		114%	90%	84%	83%
Price small house	200,000	209,000	223,000	232,000	247,000
Price large house	312,000	322,000	337,000	348,000	363,000
% cohort 0 owning	56%	53%	46%	42%	35%
% cohorts 0-1 large	35%	32%	27%	26%	24%
% cohort 2 large	97%	97%	95%	93%	90%
% cohort 3 large	25%	42%	54%	58%	65%
% total large	60%	62%	62%	62%	63%

In each section, taxes are increased as the population ages to pay for higher aggregate pension expenditure. When the elderly population doubles, pension expenditure increases by approximately 5% of GDP

Table 7. Key model parameters.

Parameter	Description	Value	Source/Rationale
Ti N	Length of period Population of cohort	(10, 10, 20, 10-20) years 400	To approximate work history from age 25 – 75 Arbitrary; initial population = 2000
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, 0.1+25000}	NZ Census, 1966- 2001. Based on real lifecycle earnings of cohort turning 20 in 1946, 1961.
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	{0,0,1,0}	Arbitrary
H	Mortgage term	25 years	Standard mortgage term
Δ	Maximum debt service-income ratio	30%	Reflects NZ banking conditions
Θ	Maximum loan to value ratio	80%	Reflects NZ banking conditions
τ^{g*}	GST rate	0.10	Tax take equals 10% of labour income; arbitrary, but close to NZ rate.
τ_1, τ_2, τ^*	Income tax rates and threshold	20%, 33% $50000	Reflects NZ rates in 2000.
α_0^F, α_1^F α_0^H, α_1^H	Housing supply parameters	(10, 180000 15, 100000) (150, -80000 10, 100000) (150, -80000 300, -225000)	Supply version 1. Supply version 2 Supply version 3

Table 8. Length of time in current house: fraction of each age group, 2006.

	65-74	75-84	85+	65+	
	%	%	%	%	cumulative
0-4 years	30%	27%	37%	30%	30%
5-9	17%	15%	15%	16%	46%
10-14	13%	13%	10%	12%	58%
15-19	9%	10%	7%	9%	67%
20-24	6%	7%	6%	6%	73%
25-29	5%	5%	5%	5%	79%
30+	21%	23%	20%	21%	100%

Source: Statistics New Zealand, 2006 census.

Table 9. Fraction of people aged 65-69 in 1991 by length of time remaining in the same house.

	<5 years in house, 1991	5+ years in home, 1991		<5 yrs in house, 1996
Fraction in house x years later				
5 years	62%	79%		62%
10 years	51%	63%		42%
15 years	33%	48%		

Source: Statistics New Zealand, 1991 - 2006 census.

Table 10. House size for people over 65, 2006.

	Number of bedrooms					percentages		
	1	2	3	All		1	2	3
All 65-84	20,289	98,055	274,035	392,379		5.2%	25.0%	69.8%
All 85+	3,918	15,504	17,760	37,182		10.5%	41.7%	47.8%
All 65+	24,207	113,559	291,795	429,561		5.6%	26.4%	67.9%
Couples 65-84	4,236	45,639	173,205	223,080		1.9%	20.5%	77.6%
Couples85+	393	4128	6933	11,454		3.4%	36.0%	60.5%
Single M 65-84	6,543	10,617	14,832	31,992		20.5%	33.2%	46.4%
Single M 85+	777	2064	1809	4,650		16.7%	44.4%	38.9%
Single F 65-84	8,988	33,075	34,518	76,581		11.7%	43.2%	45.1%
Single F 85+	2703	8301	5073	16,077		16.8%	51.6%	31.6%
All couples	4,629	49,767	180,138	234,534		2.0%	21.2%	76.8%
All singles	19,011	54,057	56,232	129,300		14.7%	41.8%	43.5%
All M 65-84	9,144	38,244	135,774	183,162		5.0%	20.9%	74.1%
All M 85+	1,035	4,968	7,152	13,155		7.9%	37.8%	54.4%
All F 65-84	11,148	59,808	138,264	209,220		5.3%	28.6%	66.1%
All F 85+	2,883	10,536	10,608	24,027		12.0%	43.9%	44.2%

Source: Statistics New Zealand census data, 2006, special tables.

Table 11. House size for people over 65, 1996.

	Number of bedrooms					percentages		
	1	2	3	All		1	2	3
All 65-84	22,842	111,813	206,637	341,292		6.7%	32.8%	60.5%
All 85+	3,165	10,668	10,686	24,519		12.9%	43.5%	43.6%
All 65+	26,007	122,481	217,320	365,808		7.1%	33.5%	59.4%
Couples 65-84	4,896	54,231	126,039	185,166		2.6%	29.3%	68.1%
Couples85+	303	2778	3801	6,882		4.4%	40.4%	55.2%
Single M 65-84	6,312	10,122	10,815	27,249		23.2%	37.1%	39.7%
Single M 85+	564	1326	1032	2,922		19.3%	45.4%	35.3%
Single F 65-84	11,106	37,776	28,617	77,499		14.3%	48.7%	36.9%
Single F 85+	2247	5550	2721	10,518		21.4%	52.8%	25.9%
All couples	5,199	57,009	129,840	192,048		2.7%	29.7%	67.6%
All singles	20,229	54,774	43,185	118,188		17.1%	46.3%	36.5%
All M 65-84	9,213	42,720	100,788	152,721		6.0%	28.0%	66.0%
All M 85+	771	3,378	4,074	8,223		9.4%	41.1%	49.5%
All F 65-84	13,629	69,090	105,849	188,568		7.2%	36.6%	56.1%
All F 85+	2,394	7,287	6,612	16,293		14.7%	44.7%	40.6%

Source: Statistics New Zealand census data, 1996, special tables.

Table 12. House size by mobility, 1996 and 2006.

	Number of bedrooms					**percentages**		
	1	2	3	All		1	2	3
	2006							
All 65-84	18,669	91,443	252,111	362,223		5.2%	25.2%	69.6%
All 85+	3,672	14,454	16,257	34,383		10.7%	42.0%	47.3%
All 65+	22,341	105,891	268,368	396,600		5.6%	26.7%	67.7%
Same 65-84	9,066	56,859	186,183	252,108		3.6%	22.6%	73.9%
Same house 85+	1,869	10,491	12,921	25,281		7.4%	41.5%	51.1%
Same house 65+	10,935	67,347	199,104	277,386		3.9%	24.3%	71.8%
Moved 65-84	9,603	34,584	65,928	110,115		8.7%	31.4%	59.9%
Moved 85+	1,803	3,963	3,336	9,102		19.8%	43.5%	36.7%
Moved 65+	11,406	38,544	69,264	119,214		9.6%	32.3%	58.1%
	1996							
All 65-84	21,699	107,691	195,822	325,212		6.7%	33.1%	60.2%
All 85+	3,045	10,287	9,864	23,196		13.1%	44.3%	42.5%
All 65+	24,744	117,978	205,686	348,408		7.1%	33.9%	59.0%
Same 65-84	12,606	75,456	157,314	245,376		5.1%	30.8%	64.1%
Same house 85+	2,031	8,280	7,929	18,240		11.1%	45.4%	43.5%
Same house 65+	14,640	83,736	165,243	263,619		5.6%	31.8%	62.7%
Moved 65-84	9,093	32,235	38,508	79,836		11.4%	40.4%	48.2%
Moved 85+	1,014	2,007	1,935	4,956		20.5%	40.5%	39.0%
Moved 65+	10,104	34,242	40,443	84,789		11.9%	40.4%	47.7%

Source: Statistics New Zealand census data, 1996 and 2006, special tables.

8 Appendix 3: Data references

Statistics New Zealand. "House size by age: special data from Statistics NZ, 1996-2006," obtained by Motu Research in March 2009. Unrestricted dataset 9963. Details online at http://www.motu.org.nz/building-capacity/datasets.

Statistics New Zealand. "Housing tenure by age, census 2006," obtained by Motu Research in March 2009. Unrestricted dataset 9964. Details online at http://www.motu.org.nz/building-capacity/datasets.

Statistics New Zealand. "New Zealand's 65+ population 2007 chapter 6: housing," obtained by Motu Research in March 2009. Unrestricted dataset 9966. Details online at http://www.motu.org.nz/building-capacity/datasets.

Statistics New Zealand. "New Zealand's 65+ population 2007 chapter1 - population," obtained by Motu Research in March 2009. Unrestricted dataset 9967. Details online at http://www.motu.org.nz/building-capacity/datasets

Statistics New Zealand. "Years at Usual Residence Age Group and Sex for the Census Usually Resident Population Count 1991 1996 2001 2006," obtained by Motu Research in March 2009. Unrestricted dataset 9965. Details online at http://www.motu.org.nz/building-capacity/datasets.

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08-02 Lock, Kelly and Suzi Kerr. 2008. “Nutrient Trading in Lake Rotorua: Overview of a Prototype System”.

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