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Golden years?

The impacts of New Zealand's ageing on wages, interest rates, wealth and macroeconomy

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Authorship

Each year NZIER devotes resources to undertake and make freely available economic research and thinking aimed at promoting a better understanding of New Zealand's important economic challenges. This paper was funded as part of this public good research programme.

This paper was prepared at NZIER by Kirdan Lees. The assistance of John Ballingall and John Stephenson is gratefully acknowledged.

This paper is the first of two papers on New Zealand's ageing funded from NZIER's Public Good programme. A second paper – "Hi ho silver lining?: What firms need to think about as New Zealand ages" follows up on the implications of New Zealand's ageing for industry.

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Key points

Ageing changes the structure of the economy

New Zealand is ageing. The number of old people will increase three-fold and will soon comprise a very large segment of society.

Ageing will shrink the labour supply relative to the size of the population and the existing supply of capital. That has implications for wages and interest rates. Increased longevity should also affect savings decisions and labour force participation.

In this paper we model these changes to put some numbers on their impact. While the population is ageing gradually, the impact on the mix of labour and capital that fuels the economy will be profound.

Wages increase and the cost of capital falls

Ageing will make labour scarce, so firms will bid up real wages to try to acquire the labour they need. This makes labour relatively more expensive than capital.

Our modelling work suggests:

- real wages are 16 percent higher than in the absence of ageing
- the real interest rate falls 160 basis points from 4.8 to 3.2 percent.

This change in the relative price of labour affects the investment decisions of firms, generally substituting capital for labour. This ultimately affects the structure of the economy. We model these effects on firms in a companion paper.

People retire later to fund longer lifespans

In recent years we have seen increased labour force participation by people past the age of eligibility for New Zealand superannuation. Retirement decisions in general are linked to health, life expectancy, past savings decisions, wages offered and a range of other factors.

Our modelling suggests increased longevity and rising real wages lead people to retire later, keeping the fraction of their life working about the same.

Because the real interest rate reduces, they will save a bit less in earlier years, but overall lifetime savings rise.

Assumptions about the health status of older people (or equivalently the extent to which workplaces accommodate older workers) affect these results; if people can expect to be healthy in later years, they will save less in their early years and stay in the workforce longer.

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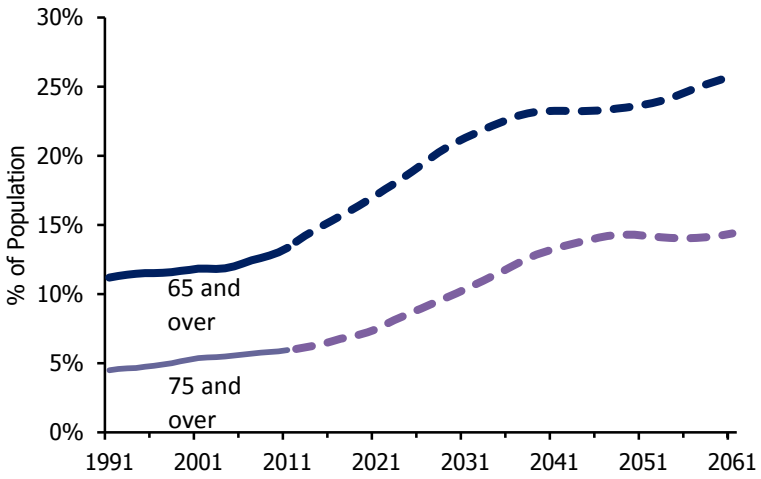
1. Overview

Most if not all of us are now very familiar with the fact that New Zealand is gradually ageing. In 50 years' time, more than a quarter of New Zealand's population will be aged 65+, according to Statistics New Zealand's projections (Figure 1).

Figure 1 Older people will form a larger segment of society

Dashed line denotes Statistics New Zealand projections



Source: Statistics New Zealand

The expected scale of change is unprecedented. While these changes will occur very gradually, the economic and social effects will be profound.

New Zealand's ageing means fewer workers for every retiree. If nothing changes, this suggests a significant increase in the demands retired people place on workers.

It is unlikely that nothing will change. Workers will command higher wages. Retired people will find that their savings won't go as far as they used to. At the same time, a lift in wages would see people delaying retirement and staying in the work force. This in turn puts downward pressure on wages.

This paper quantifies the net effects of these dynamics, putting numbers down on the impact of ageing on the economy. We gauge the extent to which the labour market, wages and people's wealth will be affected by population ageing. It draws on established modelling methods that allow for feedback loops between people and firms by responding to incentives like higher wages.

This paper is the first of two papers on New Zealand's ageing funded from NZIER's Public Good programme. A second paper – "Hi ho silver lining?: What firms need to think about as New Zealand ages" follows up on the implications of New Zealand's ageing for industry.

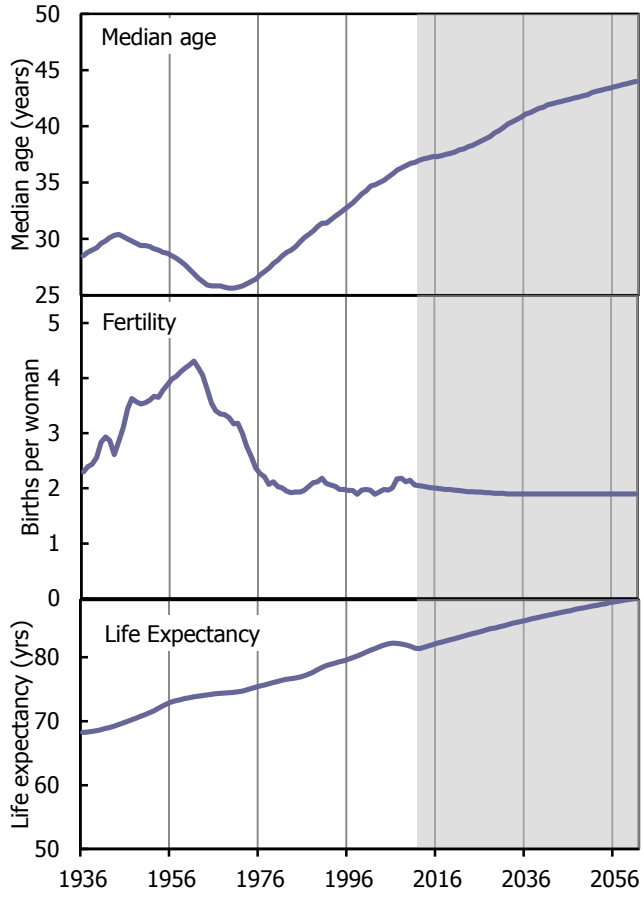
2. The drivers of ageing

Gradual change in New Zealand's ageing profile makes for pronounced demographic change in the long-run. This section documents these impacts.

Two big trends – a fall in fertility and an increase in longevity – drive New Zealand's ageing population. Figure 2 shows the median age has lifted from 25 in the mid-1960s and will hit 45 almost 100 years later according to Statistics New Zealand's projections.

Figure 2 Median age rises as fertility falls and longevity rises

Grey area denotes Statistics New Zealand projections



Source: Statistics New Zealand, NZIER

The sharp fall in fertility (after a dramatic rise in the forties and fifties) is a permanent change in behaviour. Given cross-country comparisons and our own short history, a sustained shift in fertility to the rates experienced in the 1950s seems unlikely.

In contrast, the increase in longevity has been relentless. The slow increase in our lifespan seems likely to grind higher. This is partly due to continuing improvements in living standards and technology but also lifestyle changes such as reducing smoking,

an improving diet and regular exercise. Increased longevity is one of the remarkable features of the twentieth century (United Nations 2010) and continues to confound expectations in this century (see National Research Council 2000 and Whitehouse 2009).

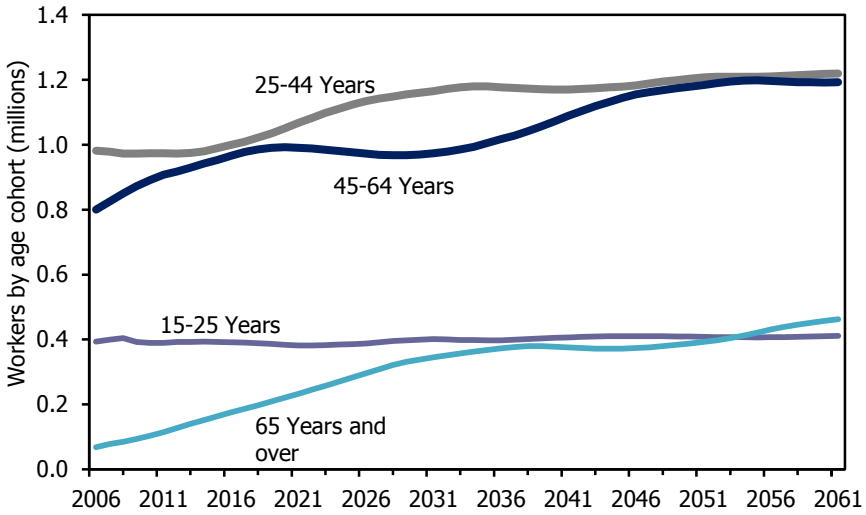
2.1 A threefold rise in older people

The baby boomer cohort is expected to dramatically increase the proportion of older (65+) workers, from about 115,000 today to just over 450,000 some fifty years later (see Figure 3).

Older people are less likely to engage formally in paid work. Just for this reason, as the population ages, the fraction of the population participating in the workforce – the participation rate – will fall. The Department of Labour projects our participation rate to decline from the current 69% to about 63% by 2050,[1] driven by the changing demographics (Department of Labour 2010).

Figure 3 There will be many more old people participating in the work force

Number of workers in each age group



Source: Statistics New Zealand National Labour Force Projections (2010)

Labour force participation may continue to rise in older age groups as health care improves and people continue to live longer. Regardless, older workers still tend to work fewer hours than those in the 25-54 age bracket. So aggregate labour force participation will slow in the future.

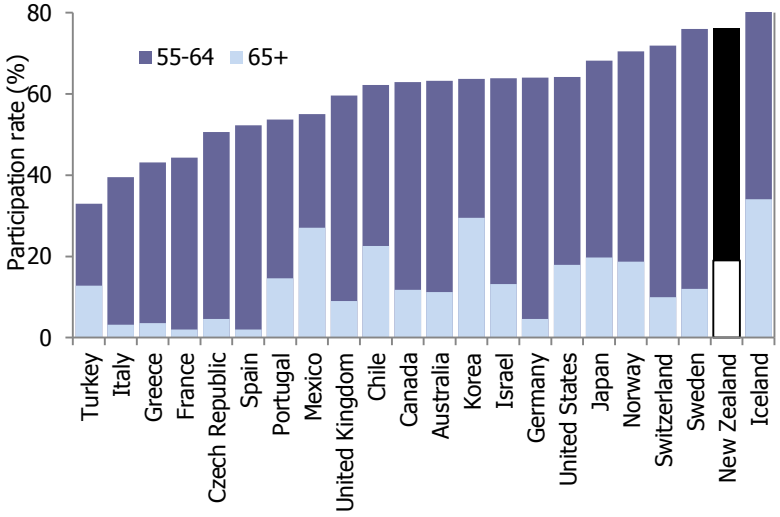
As a result, the size of the labour force relative to the total population will plateau and then fall.

[1] The Department of Labour (2010) refer to this decline in the participation rate as a projection that uses Statistics New Zealand's mid-range projection. Gardiner et al (2012) note this approach does not take into account changes in productivity or changes in income that we discuss in section 3.

This presents challenges for firms seeking labour, and the future fiscal position, as increased demands for publicly funded services are to be met from a relatively smaller work force. Retaining older workers will help with these challenges, but as Figure 4 shows, New Zealand already has relatively high participation amongst the elderly.

Figure 4 New Zealand has high participation among the elderly

Participation by selected age cohort



Source: OECD 2011

2.2 Physical health will be a key barrier to raising workforce participation

One of the challenges in retaining older workers will be how to manage the declining health status – through work place design, role assignments, technology, and flexible work patterns.

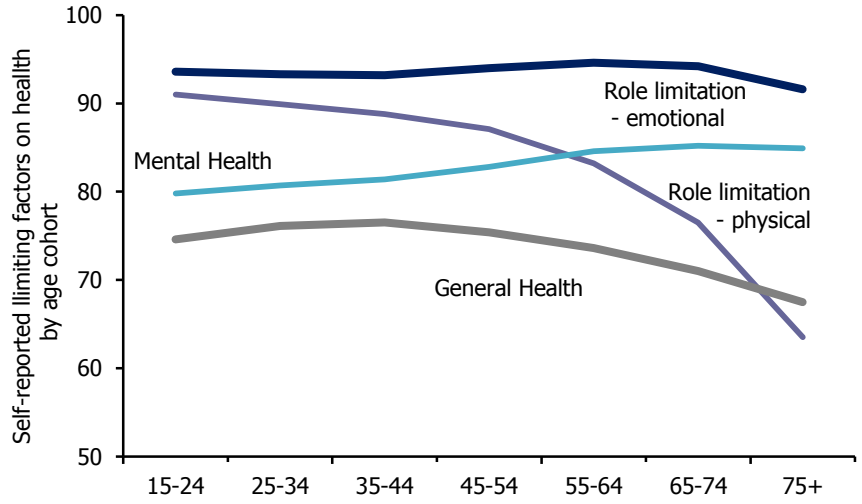
According to self-reported health status, physical health becomes the key factor limiting daily activities as people age, particularly from age 55 onward. This impacts on our ability to participate in the work force.

Figure 5 shows these self-reported health changes as we get older, where 100 represents the highest level of health and 0 represents the lowest level of health.[2]

[2] The SF-36 (Survey form-36) National Health Survey asks people to report on their own health to provide insights into the health of a population. Researchers use this method globally to identify factors that affect our health in a way that limit normal daily activities.

Figure 5 Deteriorating physical health drives role limitation

Health indicators over the cycle, 2006 SF-36 Survey



Source: Ministry of Health, NZIER

3. Our modelling framework

This section details the framework we use to model the impacts of the drivers of ageing identified in section 2 and how we match that model to New Zealand data.

3.1 Our model of choice: Overlapping generations models

Given the drivers of ageing identified in section 2, to work out the economy-wide impact of New Zealand's ageing we need a model that:

(i) captures the impacts of both changes in fertility and longevity

(ii) allows the behaviour of each cohort or year-group to respond to the incentives the fall in fertility and longevity generate

(iii) is flexible enough to distinguish between ageing in good and poor health.

Overlapping generations models (or OLG models for short) meet the first two features. OLG models combine individuals' decisions on when to consume and how much to work with simple models of how firms aggregate labour and capital to produce goods. Many argue that OLG models are the best vehicle for assessing the impact of demographic change and show how they can be used to make decisions on pension policy (see Miles 1999).

What makes OLG models particularly useful is the interaction between the behaviour of two types of people – young and old. That makes OLG models more appealing than standard macroeconomic models that have only a single decision-maker representative of all individuals. Modelling the interaction between the different savings decisions of young and old people in the model makes the OLG setup the macroeconomic workhorse model for understanding the implications of ageing.

OLG models split an individual's lifespan into two generations. The models assume people work in the first period of their life and do not work in the second period (childhood is usually ignored). Then households face two decisions:

(i) how much to consume from income in the first period and thus how much income to save for second period consumption

(ii) how much to work given the prevailing wage rate.

Firms put together labour supplied by the households with capital to produce goods for consumption. Firms face competition and pay wages that match the value provided by the labour they purchase. The cost to firms of purchasing additional capital is the real interest rate (adjusted for depreciation) and firms keep investing in capital until doing so would be counterproductive.

OLG models make a number of other simplifying assumptions. For example, there is typically no central bank and only one type of firm. That makes these models poor for forecasting (which usually have a horizon of up to three years). But they are useful for understanding the impact of ageing on cohorts or year-groups over longer time horizons.

We use the OLG model from Kulish, Kent and Smyth (2010). One of the nice features of that model is the timing of the retirement decision (the transition from "young" to "old") is endogenous. That is, it responds to higher wage rates, lower interest rates and increases in longevity. Kulish, Kent and Smyth (2010) also show how to use that model to assess the impact of ageing in good versus poor health by varying the level of assumed health or productivity when we age. So that model meets our third modelling requirement.

3.2 Key drivers of individual behaviour

For the full derivation of the model, we refer the reader to Kulish, Kent and Smyth (2010). We now focus on two critical relationships that underpin individuals' behaviour within the model.

First, equation (1) governs how in a particular year ($year\ t\ in\ the\ model$) individuals make choices about how much to consume in each subsequent year of their life ($year\ s\ in\ the\ model$) Each year's consumption is optimal so that workers cannot make themselves better off by saving or consuming additional units of consumption given the rate of return to capital (R_t), how workers discount the future (the discount rate β) and the intratemporal elasticity of substitution for consumption (ρ), that is:

Deciding when to consume

$$\underbrace{c_{s+1,t+s}}_{\substack{consumption\ at\ time\ t+s \\ of\ a\ person\ s+1\ years\ old}} = \beta R_{t+s}^{1/\rho} \underbrace{c_{s,t+1-s}}_{\substack{consumption\ at\ time\ t+s-1 \\ of\ a\ person\ s\ years\ old}} \qquad s = 1,2,\dots,T \quad (1)$$

Increases in the return to capital increase the incentive for workers to save. But if workers have a high discount rate, they prefer to consume today rather than in future years and save little wealth for retirement.

Deciding how much to work

Equation (2) governs how much to work and how much to consume at a point in time. At a point in time, agents decide how much to work (l) in each year of their life, taking into account their distaste for work and their productivity (and hence wages) as they age.

$$\underbrace{l_{s,t+s-1}}_{\substack{labour\ at\ time\ t+s \\ of\ a\ person\ s+1\ years\ old}} = \left[\underbrace{v(s,T)}_{\substack{disutility\ from \\ working}} / \underbrace{e_s w_{s,t+s-1}}_{\substack{age-specific \\ productivity\ wages}} \right]^{1/\rho} \qquad s = 1,2 \dots T \quad (2)$$

Within the model, the disutility or reduction in well-being from working depends on the health of workers. The health of workers deteriorates as they age (s) and in our baseline case increases with life expectancy (T). That means a worker aged 50 with life expectancy of 80 has better health than a worker aged 50 with a life expectancy of 60.

Workers' income streams also depend on productivity. We allow for an age specific productivity term that comes from the expertise (*human capital)* workers develop over their careers. We estimate age specific human capital using wage data for New Zealand, following a similar method to Kulish, Kent and Smyth (2010).

3.3 Calibrating the model to New Zealand

To make sure the impacts of the ageing reported in that model hold for New Zealand we calibrate the model to match New Zealand data. In particular we:

- increase the discount rate relative to Kulish, Kent and Smyth (2010) while keeping the relative risk aversion parameter at 3.5. This helps produce a lower real interest rate and a lower capital-to-output ratio
- increase the capital depreciation rate to be more consistent with the assumption that underpins the NZIER CGE model and the observation that New Zealand's capital depreciates slightly more rapidly relative to Australia's
- use a slightly higher total factor productivity consistent with labour's share of income (as measured by wages relative to output) in New Zealand
- use New Zealand's long-run historical experience of population growth. Over the past fifty years, New Zealand's population growth has averaged about 1.5 percent per annum and we use this for the steady-state population growth rate.

We detail the model calibration in the table below relative to Kulish, Kent and Smyth (2010) and note some differences are required to match the New Zealand data.

Table 1 Our model calibration to match New Zealand data

Parameter	Description	NZ calibration	Australia calibration
β	Discount rate	0.98	0.97
ρ	Relative risk aversion	3.5	3.5
δ	Capital depreciation rate	0.075	0.052
$(1-\alpha)$	Labour share of income	0.50	0.55
n	Steady-state Population growth rate	1.5 % pa	1.2 % pa
TFP	Steady-state Total Factor Productivity	0.5 %	0.4 %

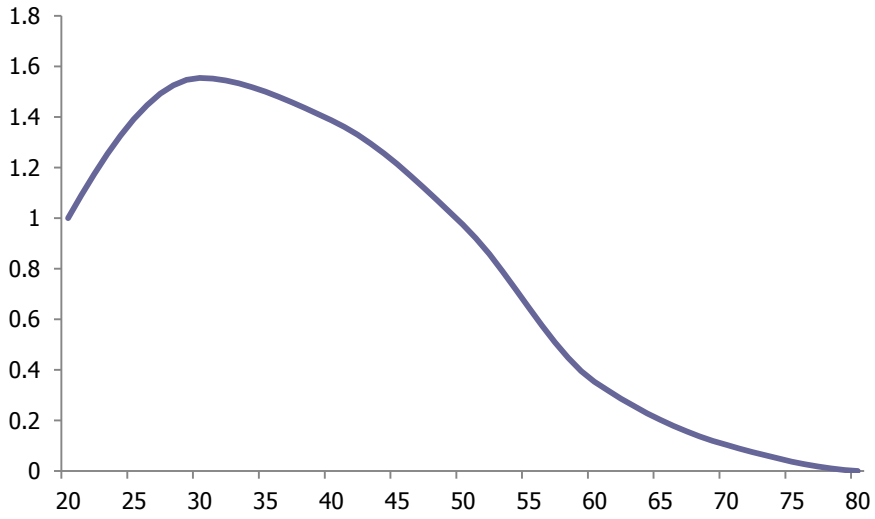
Source: NZIER

We also use an age specific profile for human capital within the model based on estimating wage regression. Figure 6 shows that profile.

We estimate the human capital stock with wage data using the lifetime income approach used by the OECD detailed in Liu (2011) in its current human capital project.

The base year for our estimates is 2006 – the most recent New Zealand census of population and dwellings which is our primary data source.

Figure 6 Our estimated human capital profile: Ages 20-80



Source: NZIER

3.4 Our three scenarios

We explore three scenarios relative to our baseline to show how ageing changes the structure of the economy. To simulate the fall in fertility we reduce the long-run population growth rate from 1.5 to 0.5 percent.[3]

Then to simulate the rise in longevity we extend the lifespan of every individual by ten years, mimicking the expected increase in life expectancy over the next 50 years. To show the impact of a rising longevity we assume that there is a permanent increase in people's life expectancy. We assume that the increase in life expectancy comes with no deterioration in health so that people can work for longer if they want to. To make concrete the change, we assume that people face an unanticipated lift in longevity that increases their lifespan by ten years.[4]

Finally, we put the fall in fertility together with the increase in life expectancy in a joint scenario. Then in turn, we look at the impact of the scenarios on real wages, the cost of capital, the individual retirement decision and consumption and savings.

Table 2 below shows the parameter settings for the scenarios we explore.

[3] A population growth rate of 1.5 percent is consistent with population growth over the past 50 years. A population growth rate of 0.5 percent is close to the growth rate projected by Statistics New Zealand over the next fifty years.

[4] From a modelling perspective, we can assume people either have perfect foresight about the increase in longevity or are surprised by the increase in longevity. Here we adopt the latter assumption that produces a spike in figure 11 in response to the new information. This approach is consistent with both the theoretical literature (see Kotlikoff 1989 and Kulish, Kent and Smyth 2010, for example) and empirical findings that lifespan extension tends to be under predicted – even by professionals (see the discussion in Llewellyn and Chaix-Vero 2008).

Table 2 Ageing assumptions for model scenarios

See Appendix for more details on the model calibration

Scenario	Population growth rate		Lifespan	
	period one	period two	period one	period two
1 Baseline	1.5 %	1.5 %	80 years	80 years
2 Permanent fall in fertility	1.5 %	0.5 %	80 years	80 years
3 Rise in longevity	1.5 %	1.5 %	80 years	90 years
4 Falling fertility & longevity rise	1.5 %	0.5 %	80 years	90 years

Source: NZIER

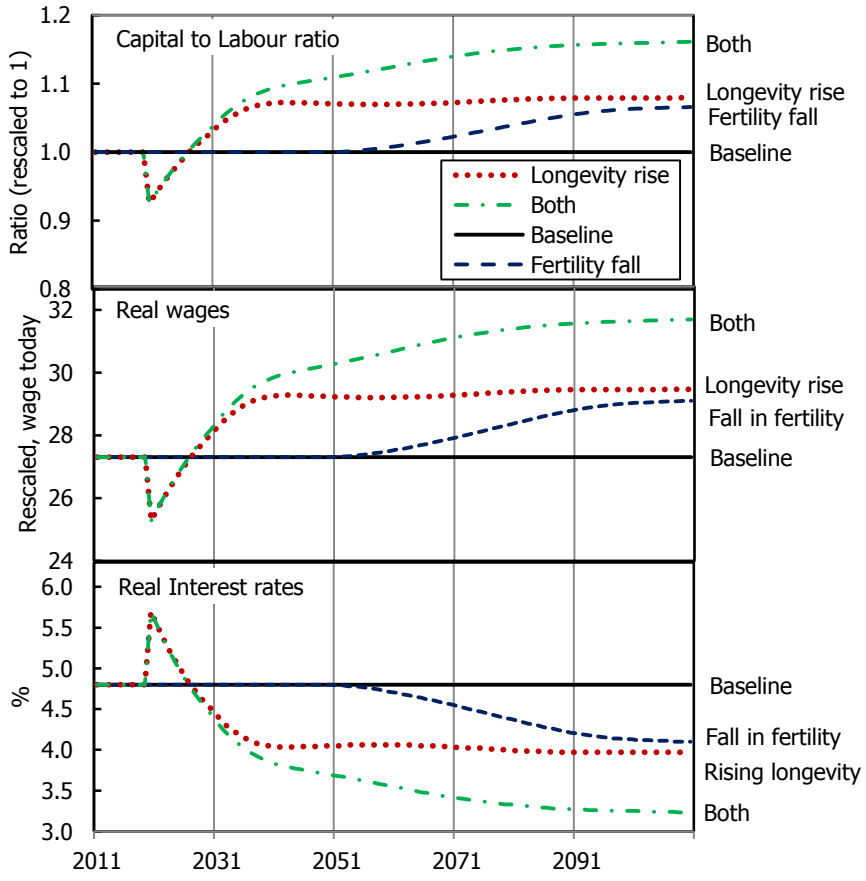
The scenarios isolate what we might expect from the key drivers of ageing from other economic factors that clearly have an influence.

4. Our results

This section documents what we find when we use our modelling framework to look at the three scenarios. We also show that ageing in good health matters.

Figure 7 shows the macroeconomic impacts on the capital-to-labour mix, real wages and real interest rates. We rescale the capital-to-labour ratio to one in the base period and scale the real wage to the current average QES hourly earnings (including overtime).

Figure 7 Ageing scenarios: macroeconomic outcomes

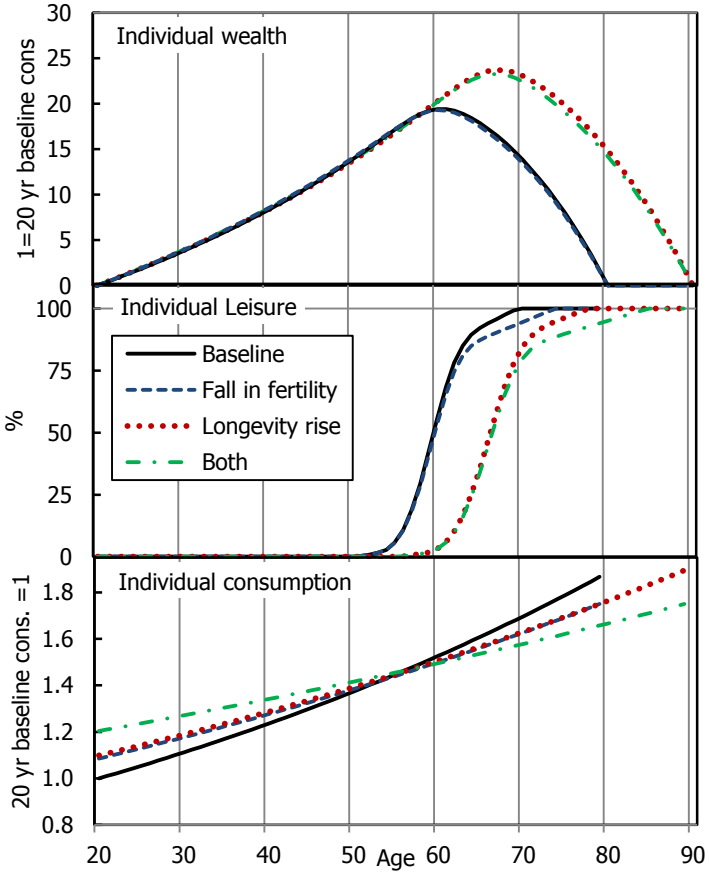


Source: Statistics New Zealand, NZIER

Figure 8 shows lifetime outcomes for individuals in terms of wealth, leisure and consumption. Leisure is expressed in terms of working life. Implicitly, 0 percent leisure equates to the average 37.5 hour working week while 100 percent leisure implies no formal paid work.

Figure 8 Ageing scenarios 2011-2100: individual outcomes

Capital-to-Labour rescaled to baseline and real wages rescaled to current QES wage



Source: NZIER

4.1 Real wages

The dashed lines (dark blue) show the impact of the fall in fertility relative to the solid baseline (in black). The fall in fertility shrinks the labour supply relative to the size of the population and existing supply of capital. That changes the mix of labour and capital that fuels the economy. With labour in short supply, firms bid up real wages to try to acquire the labour inputs they need.

Similarly, the dotted line (red) in Figure 7 shows the impact of the increase in longevity on the macroeconomy. To begin with, the increase in longevity increases the relative size of the labour supply at least partly because workers need to save for an unexpected increase in lifespan. Initially this reduces real wages.

We also put together both the fall in fertility scenario and increase in longevity scenario in a joint scenario titled 'both' in Figure 7 depicted with a dot-dash line

(green).[5] Under that scenario the economy shifts to the new equilibrium labour-capital mix, real wages are 16 percent higher than in the absence of ageing.

4.2 The cost of capital

Turning to the cost of capital, a fall in fertility leaves firms with too much capital for too few workers and the cost of capital, the real interest rate (adjusted for depreciation), falls.

But when longevity increases, initially interest rates spike higher and the labour supply increases since with increased longevity people retire later all else equal. As a result wages fall and firms will want to increase capital, bidding up the cost of capital.

But households must save for the longer period of retirement. That depresses the real interest rate or cost of capital, in turn reversing the fall in real wages. Ultimately, substitution from labour to capital increases the capital-to-labour mix, real wages increase and the real interest rate falls.

Putting both the fall in fertility and the rise in longevity together the real interest rate falls 160 basis points from 4.8 to 3.2 percent.

4.3 The retirement decision

One of the key features of the Kulish, Kent and Smyth (2010) model is that it allows individuals to change the timing of their retirement decision in response to the macroeconomic environment.

The middle panel of Figure 8 shows the impact of each scenario on the retirement decision. When fertility falls, higher wages boost incomes. So workers can afford to retire earlier. But high wages make the price of each additional year of retirement more costly. On balance, the model suggests that workers choose to retire slightly later, or at least work some more hours in later years, relative to the baseline.

Under the increasing longevity scenario, when life expectancy increases by ten years, workers retire later in life. Workers enjoy more years in retirement in absolute terms but work about the same fraction of their lifespan as in the baseline case (to be precise, 68.2 percent of their lifetime).

Combining the increase in longevity with the fall in fertility means workers retire later than the baseline case and retain some work between the ages of 70 and 80. This is due to the strong incentive from higher wages from the fall in fertility.

4.4 Saving for consumption

To retire, workers need to save over their lifetime. The top panel of Figure 8 shows that in the baseline case savings peaks at about 60 before being drawn down to fund consumption until the age of 80.

[5] The joint scenario extends both the long-run or steady-state population growth rate and longevity. Over a transition period of several decades, the increase in longevity temporarily extends the population growth rate beyond the long-run growth determined by fertility.

The bottom panel of Figure 8 shows the consumption profile of workers who have to make a trade-off between saving to maintain some living standard in retirement and consumption today. (That profile also shows consumption increases steadily over a worker's lifetime, as wealth increases.)

When fertility falls, individuals save about the amount of wealth over their lifetime as in the baseline case. Wealth peaks at about age 60. But when fertility falls interest rates fall. That reduces the savings incentive and, relative to the baseline case, workers consume more today foregoing some future consumption.

But when longevity increases workers must accumulate enough wealth over their lifetime to fund ten additional years of consumption. The dotted (red) line shows that workers save about 20 percent more wealth over their lifetime compared with the baseline case. After the increase in life expectancy, workers only start to draw down on their wealth at about 66 years of age – 6 years later than in the baseline case. Since interest rates are a bit lower than the baseline, workers tilt consumption a little bit towards consuming earlier in life.

Under the joint scenario, workers increase their savings to about the same level as the increased longevity case to fund consumption in retirement. Since interest rates are now lower from both the fall in fertility and increased longevity, consumption becomes much more tilted toward consuming earlier than either the baseline.

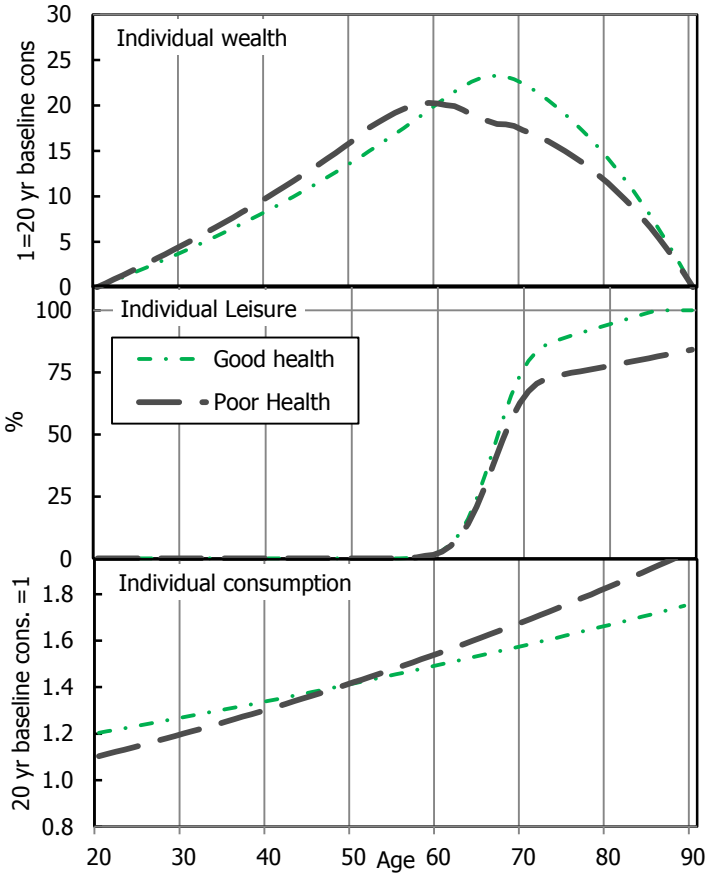
4.5 Good health improves individual and macroeconomic outcomes

The extent to which ageing is healthy and extends the working life is critical. Healthy ageing enables longer workforce participation, extending the number of years over which savings can occur to allow individuals to take wealth into retirement. We model and contrast ageing in good health and ageing in poor health scenarios to show the different impacts on individuals.

Our scenario (see Figure 9) shows that, when longevity increases and health does not improve, people need to finance ten years of additional consumption. Rather than reducing consumption and saving more throughout their career to fund the longer retirement period, households work for much longer, delaying, if not 'foregoing', retirement since in our model their health reduces their productivity (human capital) and thus the returns from working.

But people must save more for the longer number of years spent in the retirement period. The additional savings increases the aggregate capital stock, in turn increasing the marginal product of labour. This increases wages but reduces the return on capital. The real interest rate falls.

Figure 9 Good health improves macroeconomic outcomes



Source: NZIER

4.6 How do our results compare with other studies?

Broadly, Kulish, Kent and Smyth (2010) report similar results to the scenarios presented here although differences in our estimated profile for human capital make some impact. While the intensity and magnitudes are different, real interest rates fall and real wages increase after a fall in fertility and increase in longevity.

The increase in the capital-to-labour ratio squares with the simple model in Kotlikoff (1989) and the projections in Martins et al (2005) that show longevity increases capital-to-labour ratios for key OECD countries as the real interest rate falls.

Hanel and Riphahn (2006) use Swiss retirees to show that financial incentives do influence the timing of the retirement decision. Gorman, Scobie and Towers (2012) find both health status and financial incentives matter for the retirement decision.

Using Australian data, Cai and Kalb (2006) find that disability or poor health is associated with a lower probability of labour force participation. Enright and Scobie (2010) report a similar finding using New Zealand data.

Bloom and Canning (2006) note that if longevity increases possible lifetime income then savings need to compound for a longer period, enhancing the need for assets to carry wealth through to retirement.

While our modelling work shows the types of consumption decisions individuals should make, Creedy and Guest (2006) note that if people have different needs that vary by age, individual consumption decisions can easily vary from the decisions a social planner might make. That matters for the thinking about the tax policies that might make society better off.

5. Conclusion

New Zealand is ageing. There will be many more old people and they will make up an increasingly large segment of society. The number of people that work relative to our total population will shrink, and this ultimately has profound effects on wages, interest rates, and savings and retirement decisions.

The mix of labour and capital that fuels the economy will tilt away from labour. With labour in short supply, firms bid up real wages to try to acquire the labour inputs they need. Real interest rates will fall compared to the baseline. On balance, older workers will respond to both increased wages and increased longevity to increase their participation in the labour force.

This paper identifies the broad orders of magnitudes of these changes.

These changes in the relative price of labour and capital will affect the investment decisions of firms over time. This will impact on the structure of the economy. Similarly, the changing demographics will affect the domestic market for goods and services. Our next paper "Hi ho silver lining?: What firms need to think about as New Zealand ages" shows what this means for firms.

6. References

Cai, L and G Kalb (2006) "Health Status and Labour Force Participation: Evidence from Australia", *Health Economics*, 15: 241-261.

Enright, James and Grant Scobie (2011) Healthy, Wealthy and Working: Retirement Decisions of Older New Zealanders. Treasury Working Paper 10/02, New Zealand Treasury.

Creedy, John and Ross Guest (2008) Population ageing and intertemporal consumption: Representative agent versus social planner, *Economic Modelling*, Elsevier, vol. 25(3), pages 485-498, May.

Department of Labour (2010) Labour Force Participation in New Zealand: Recent Trends, Future Scenarios and the Impact on Economic Growth, Wellington, New Zealand

Gardiner, Pete, Matthew Bell and Paul Rodway (2012) "Long-term fiscal projections under alternative labour force scenarios", paper presented to NIDEA/Motu Population Ageing and the Labour Market workshop, Hamilton.

Gorman, Emma, Grant M Scobie and Andy Towers (2012) Health and Retirement of Older New Zealanders. Treasury Working Paper Series 12/02, New Zealand Treasury.

Hanel, Barbara and Regina T. Riphahn (2006) Financial Incentives and the Timing of Retirement: Evidence from Switzerland. IZA Discussion Paper 2492, Institute for the Study of Labor (IZA).

Kotlikoff, L. (1989) "Some Economic Implications of Life-Span Extension", in *What Determines Savings?* Cambridge MA: MIT Press Books, Ist edition volume 1, no. 1.

Kulish, Mariano, Christopher Kent and Kathryn Smith (2010) "Aging, Retirement, and Savings: A General Equilibrium Analysis," *The B.E. Journal of Macroeconomics*, 10(1):18.

Liu, G. (2011) Measuring the Stock of Human Capital for Comparative Analysis: An Application of the Lifetime Income Approach to Select Countries. OECD Statistics Working Paper 2011/06, OECD Paris.

Llewellyn, John and Camille Chaix-Vero (2008) *The Business of Ageing*. Nomura Equity Research.

Martins, Joaquim Oliveira, Frédéric Gonand, Pablo Antolín, Christine de la Maisonneuve and Kwang-Yeol Yoo (2005) The Impact of Ageing on Demand, Factor Markets and Growth. Economics Working Paper 420, OECD Paris.

National Research Council (2000) *Beyond Six Billion: Forecasting the World's Population*. Panel on Population Projections, John Bongaarts and Rodolfo A. Butatao (eds), Committee on Population, Commission on Behavioural and Social Sciences and Education, Washington, D.C.: National Academy Press.

United Nations (2010) *World Population Ageing 2009*. Population Division, Department of Economic and Social Affairs, New York: United Nations.

Whitehouse, Edward (2009) Life-Expectancy Risk and Pensions: Sharing the Burden. OECD Social Employment and Migration Working Paper, OECD Paris.

Appendix A Estimating age specific human capital

The model used for constructing our estimates is composed of three stylised life-cycle stages: (1) those in both study and work between ages 15-30 (inclusive); (2) those in work between ages 31 and 64 (inclusive); (3) those 65 and over who are considered outside the workforce. The first two of these categories differ from the categories used in the OECD human capital project in so far as the first category is considered by us to end at 30 rather than 40 as used in the OECD project.

Lifetime income for people 65 and over is assumed to be zero. Lifetime income for the other two categories is calculated as:

$$LIN\ {}^{edu}_{age} =$$

$$EMP\ age\quad edu\ .\ AIN^{edu}_{age} + \left\{1 - \sum_{edu} ENR^{edu-edu^*}_{age}\right\}.\ SUR_{t+1}\ .\ LIN\ {}^{edu}_{age\ t+1}\ \left\{\frac{1+r}{1+\delta}\right\} +$$

$$\sum_{edu} ENR^{edu-edu^*}_{age} \left\{\frac{\sum_{t=1}^{t\ edu-edu^*} SUR_{age+t} . LIN^{edu^*}_{age+t} \left\{\frac{1+r}{1+\delta}\right\}^t}{t_{edu-edu^*}}\right\} \text{ for ages 15-30, and}$$

$$LIN\ {}^{edu}_{age} = EMP\ {}^{edu}_{age}\ .\ AIN^{edu}_{age} + SUR_{t+1}\ .\ LIN\ age\ t+1\quad edu\ \left\{\frac{1+r}{1+\delta}\right\} \quad \text{for ages 31-64.}$$

Where *LIN* is lifetime income, by age and education and gender, *EMP* is employment rate, *AIN* is current annual income, *ENR* is rate of enrolment in study and t_{edu} is the time taken for an individual in study to transition from their current level of educational attainment *edu* to the next level of attainment edu^*, *SUR* is the probability of surviving one more year.