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**Working Paper**

## Natural population ageing and the aggregate stock of human capital in New Zealand

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TE TAI ŌHANGA  
THE TREASURY

WORKING PAPER

# Natural population ageing and the aggregate stock of human capital in New Zealand

Tim Ng

New Zealand Treasury Working Paper 25/03

October 2025

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**Te Kāwanatanga o Aotearoa**  
New Zealand Government

**NZ TREASURY  
WORKING PAPER 25/03**

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Natural population ageing and the aggregate stock of human capital  
in New Zealand

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**MONTH/YEAR**

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# Abstract

I quantify the implications of projected natural population ageing for the value of the New Zealand aggregate human capital stock, using the Jorgenson/Fraumeni framework and Mincer equations. Using the framework, I compare quantitatively the impact of natural population ageing with that of other key influences on aggregate human capital, such as net immigration, real wage growth and educational attainment. The results suggest that the impact of projected natural ageing is substantial when considered in light of the changes that would be needed in the other influences to have a quantitatively equivalent offsetting impact.

## **JEL CLASSIFICATION**

J1, J3, O1, O4

## **KEYWORDS**

human capital; ageing population; New Zealand

## Disclaimer

These results are not official statistics. They have been created for research purposes from the Integrated Data Infrastructure (IDI) which is carefully managed by Stats NZ.

For more information about the IDI please visit <https://www.stats.govt.nz/integrateddata/>

Access to the data used in this study was provided by Stats NZ under conditions designed to give effect to the security and confidentiality provisions of the Data and Statistics Act 2022 (New Zealand). The results presented in this study are the work of the author, not Stats NZ or individual data suppliers.

# Executive Summary

This paper is one of a series aiming to inform policy priorities for improving human capital in New Zealand. New Zealand faces complex economic and fiscal choices that impact human capital. Achieving value for money in these choices over the medium term, while taking into account broad outcomes, will be important.

The paper looks at the implications for the value of the New Zealand aggregate human capital stock of projected natural population ageing. It compares quantitatively the impact of natural population ageing with that of other key influences on aggregate human capital, such as net immigration, real wage growth and educational attainment.

Using current New Zealand population estimates and prediction equations for lifetime earnings based on sex, educational attainment and age, the paper projects earnings for individuals in the working age population. These projected earnings are discounted and then aggregated to produce a current human capital valuation for New Zealand as a whole. The paper shows that projected natural population ageing implies net retirement of people out of the working age population and an increase in the average age of workers, substantially reducing the earning capacity of the workforce, measured in terms of aggregate human capital.

Other scenarios with higher real wage or productivity growth, increased immigration, or improved educational attainment suggest that while these influences could help offset the impacts of natural population ageing, none of them alone is likely to be feasible as a full offset. This result suggests that a range of policy approaches will instead be needed.

The paper is exploratory. The aggregate human capital results should be seen as rough orders of magnitude, rather than precise estimates. Several limitations are important to note. For tractability, the model simplifies the complex relationships involved in labour market dynamics and focuses on a small number of factors, and is an all-else-equal (i.e. non-equilibrium) approach. It does not account for how the economy might adjust (for example, in terms of wages or participation in education or the labour market), or for the costs and feasibility of implementing any interventions associated with the scenarios.

Despite these simplifications, the results are suggestive about the factors likely to have the biggest impact on New Zealand's human capital in the future. The paper also points to key areas for further research, such as growing labour market participation at older ages. These insights can help inform more detailed policy analysis and planning.

The other papers in the series

- set out a broad definition of human capital and the main related outcomes of interest, review the evidence on the theoretical underlying relationships, and discuss the implications of New Zealand's unusual circumstances for policy research on human capital here (Schaer, 2025), and
- analyse and discuss the historical trends and drivers of human capital in New Zealand (Reid, 2025).

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# Natural population ageing and the aggregate stock of human capital in New Zealand

## 1 Introduction

Human capability – health, education, skills and know-how – is widely recognised as fundamental for economic growth and performance, and for human wellbeing more generally. Research literature across various disciplines has enhanced understanding about the nature of human capability, its determinants and its relation to a range of important life outcomes.<sup>1</sup> In economics, a growing body of research focuses on human *capital*, defined as aspects of human capability that directly support labour market outcomes such as employment status, productivity, and earnings (Abraham and Mallatt, 2022; Blair, 2011; Deming, 2022). This research is of great interest to policymakers due to its implications for sustainable economic growth and for individual and community wellbeing.

Defining human capital as an individual's ability and likelihood to earn labour income allows for the individual's human capital to be valued in monetary terms as the discounted present value of the individual's expected stream of future labour earnings (Jorgenson and Fraumeni, 1992), taking into account likely wages, future employment status and mortality. Such an approach enables the national stock of human capital to be calculated as the aggregate of individual human capital values. The national aggregate human capital stock (or its investment flow) can then be compared with those for physical and financial capital, which are already measured in monetary units, and those for natural capital, for which monetary valuation techniques are also advancing. Evaluating a nation's stocks of these major types of capital and their trajectories in a common unit allows for more comprehensive assessments of sustainability than simply looking at economic growth, consumption or physical capital alone (see e.g. Arrow et al., 2012; World Bank, 2021, 2024; The Treasury, 2022).

This paper presents results from a valuation model of the aggregate human capital of New Zealand as derived from its working age population (WAP), using this approach. The valuation model derives expected lifetime incomes for individuals in the current WAP conditional on sex, age and educational attainment using Mincer equations (Mincer, 1974) estimated on New Zealand data, and aggregates them using the Jorgenson/Fraumeni approach.

The Jorgenson/Fraumeni/Mincer approach allows a range of scenarios for New Zealand human capital prospects to be explored by varying the assumptions for the conditioning variables. I consider first the potential effects on aggregate human capital of the projected natural ageing of the population (i.e. a “no migration” population projection) through to the year 2050, and its impact on the WAP count and its age structure. I compare the aggregate human capital result from that scenario to that from scenarios involving increased real wage growth, net immigration and increased educational attainment. The comparison provides a sense of the magnitude of the impact of projected natural population ageing on aggregate human capital, in terms of other key influences on it that may be potential offsets.

It should be emphasised that the scenario comparisons are on an “all else equal” basis, and should not be interpreted as general equilibrium results. That is, they do *not* take account of behavioural changes and second-round effects in the economy that would likely accompany the different scenarios (such as wage, price or investment adjustments), nor of implementation considerations, including costs of bringing about the changes imagined in the scenarios. They are instead in the spirit of “accounting exercises” (Sianesi and Reenen, 2003), rather than behaviourally and

<sup>1</sup> The term “capability” as used here is a narrower sense than its usage in the “capabilities approach” literature of Amartya Sen and Martha Nussbaum, which emphasises the extent to which individuals have opportunities to live the lives they value and thus considers institutional features external to the individual such as the legal and rights environment, infrastructure, political voice, etc.

causally rich depictions of future economic states and dynamics. Nevertheless, assuming the missing behavioural adjustments and forces are quantitatively second-order, the comparisons can be interpreted as broad relative magnitudes.

The comparisons highlight that the impact of natural population ageing on aggregate human capital is likely to be substantially adverse, and that offsetting policy responses are likely to have to be multi-pronged across a range of policy areas in order to compensate quantitatively. Such insights may inform policymakers about fruitful areas for more detailed policy analysis and planning.

The rest of the paper proceeds as follows. Section 2 sets out the logic of the Jorgenson/Fraumeni/Mincer aggregate human capital valuation model. Section 3 presents the current (baseline) New Zealand aggregate human capital valuation using the model. Section 4 presents results for the natural population ageing, real wage growth, immigration and education scenarios. Section 5 discusses the results overall and notes the limitations of the analysis.

## 2 Measuring national aggregate human capital

The discounted lifetime labour income approach developed by Jorgenson and Fraumeni (1992), drawing on seminal work by Schultz (1961) and Becker (1962), has been increasingly applied to measure and analyse human capital in different countries (e.g. World Bank, 2021, 2024; Liu, 2011). Le et al. (2006) produced national human capital estimates for New Zealand, and an update was subsequently produced to support the Treasury’s Wellbeing Report (2022; see Galt, 2023 for details on the estimates).

The first step in the valuation model is to predict labour earnings for individuals in the WAP, conditional on education, age as a proxy for experience, survival and being employed at all future ages, until the ends of their working lives. To obtain predicted earnings I use sex-specific specifications of the Mincer equation very similar to those in the World Bank’s 2021 and 2024 *Changing Wealth of Nations* (CWON) reports. As in those studies, I allow for effects on earnings of still being in school or post-school formal education and of status as an employer or as self-employed. The reference worker in the specification is an employee who is neither at school nor in formal post-school education:

$$\begin{aligned}
 y_i = & \text{const} + \alpha \cdot \text{edu}_i + \beta_1 \cdot \text{exp}_i + \beta_2 \cdot \text{exp}_i^2 \\
 & + \gamma_1 \cdot \text{at\_school}_i + \gamma_2 \cdot \text{in\_formal\_ed}_i \\
 & + \gamma_3 \cdot \text{is\_self\_employed}_i + \gamma_4 \cdot \text{is\_employer}_i + u_i
 \end{aligned} \tag{1}$$

where, for individual  $i$  within each sex,  $y_i$  is log average weekly earnings (unadjusted for hours worked per week),  $\text{edu}_i$  is years of education,  $\text{exp}_i$  is years of experience,  $\text{at\_school}_i$  is a dummy variable for being at school (=1) or not (=0),  $\text{in\_formal\_ed}_i$  is a dummy variable for being in non-school formal education (=1) or not (=0),  $\text{is\_self\_employed}_i$  is a dummy variable for being self-employed (=1) or not (=0),  $\text{is\_employer}_i$  is a dummy variable for being an employer (=1) or not (=0),  $\text{const}$  is a (cross-sectional) constant and  $u_i$  is the error term.  $\text{exp}_i$  enters both untransformed and squared, which allows for an increasing or decreasing effect of extra experience on earnings as the worker ages. This specification allows for the effects on average weekly earnings of education, experience, school enrolment, post-school formal education enrolment, self-employed status, employer status and the constant to differ by sex, while constraining the effects of education ( $\alpha$ ) and experience ( $\beta_1$  and  $\beta_2$ ) to be the same for all groups within a given sex.

All data are sourced from the Household Labour Force Survey (HLFS) and New Zealand Income Survey (NZIS).  $\text{edu}_i$  is derived by mapping HLFS highest-qualification codes onto years of education as set out in Table 1.

Following World Bank (2021, 2024),  $\text{exp}_i$  is measured as age less 15 years, rather than directly (some studies using this approach apply the label “potential experience” accordingly). Using age

**Table 1 – HLFS highest-qualification to years of education mapping**

HLFS qualification	Years of education
No qualification	10
NCEA 1 or equivalent	11
NCEA 2 or equivalent	12
NCEA 3 or equivalent	13
1-year sub-degree diploma	14
2-year sub-degree diploma	15
Bachelor's degree	16
Masters degree	18
PhD	21

as a proxy for (market-wage-relevant) experience has the obvious limitation that it assumes that time in and out of the formal workforce has identical impacts on earnings.

For the effects of education and age in the earnings predictions, I use sex-stratified weighted OLS estimates of the above specification using HLFS/NZIS unit record data for 2024, for employees, self-employed and employer individuals between the ages of 15 and 74 inclusive, where the weights are the HLFS sampling weights.<sup>2</sup> I exclude from the estimation sample individuals with earnings above the 99th percentile and below the 1st percentile of the distributions by sex in each year, to reduce the impact of extreme outliers in the upper tail and clusters of very small earnings observations in the lower tail.

Expected lifetime earnings of the current WAP need to take account of expected employment rates and survival rates. For expected employment rates at future ages, I use the 2013-2022 average observed sex-, education- and age-specific employment rates for all working-age individuals. For comparability with the CWON human capital estimates, I set expected employment rates to zero for age 65 and older for both sexes. In the New Zealand (and several other developed countries) contexts, this assumption is increasingly unrealistic, as labour force participation and earnings after age 65 are already substantial and increasing (which is a reason to include data for 65-74 year olds in the sample for estimating the Mincer equations, assuming, as I do here, that the effects of the explanatory variables are the same for that age group as for 15-64 year olds). The assumption does not much affect the magnitude of differences between the scenarios and baseline, which are the main focus in this work. I discuss the assumption further in Section 5.

I use Stats NZ's life tables for the sex-specific probability of survival at each age. I assume future average annual real wage growth for all groups of 1.0% per annum (the average over the past decade), and discount expected future earnings back to the present at a real rate of 2.7% (also the average over the past decade).

This process yields sex-, age- and education-specific valuations of human capital for working-age individuals in 2024. Pre-working age and retired (age 65+) individuals are assigned zero human capital in this approach.<sup>3</sup> WAP individuals who are not currently employed still have positive human capital because they have a positive probability of survival and employment over the rest of their working lives. In the baseline and scenario modelling, I assume that all workers (people who are in employment) are employees who are not at school and not in post-school formal education, for simplicity and since this group forms the bulk of the WAP in employment.<sup>4</sup>

<sup>2</sup> Andradá and Galassi (2009) note that Mincer estimates based on observational data may be biased because of self-selection into the labour force. In the context of this paper, which focuses on the differences between scenarios and baseline, any such bias should not matter much because it will be "differenced out".

<sup>3</sup> This approach conforms with the World Bank 2021 and 2024 approaches. Although it is probably reasonable for the purposes of this study to assign currently retired people human capital of zero, it is perhaps less reasonable to do so for those who are born but yet to enter the workforce, since they have positive probabilities of survival and of becoming employed once they enter the WAP. To include them in the analysis would significantly complicate it but make little difference to the relative magnitudes of the scenario-minus-baseline results. If instead the ultimate interest was in estimating the *level* of aggregate human capital given the total population it would be arguably more important to include pre-working age individuals.

<sup>4</sup> Given the Mincer equation estimates, this assumption slightly overstates aggregate human capital, since the small proportions of the WAP who are in school or post-school formal education or are self-employed tend to earn less than

To obtain the aggregate human capital stock valuation in 2024, I multiply the individual human capital valuations by sex, age and educational attainment by the corresponding numbers of individuals in each group in that year, estimated in the HLFS.

The following equation summarises the above steps. Aggregate human capital  $HK_t$  is the population-weighted sum of individual sex-, education- and age-specific human capital:

$$HK_t = \sum_s \sum_e \sum_a w_{s,e,a} \cdot \left[ y_{s,e,a} + \sum_{p=a+1}^{a_R} \delta^{p-a} \cdot y_{s,e,p}^f \right] \quad (2)$$

where  $w_{s,e,a}$  is the population count of individuals of sex  $s$ , education level  $e$  and age  $a$ ;  $y_{s,e,a}$  is the (observed) current earnings of an individual of sex  $s$ , education level  $e$  and age  $a$ ;  $y_{s,e,p}^f$  is an individual's expected earnings (given the Mincer estimates, probabilities of survival and employment, and assumed real wage growth) at future age  $p$  where  $p$  is less than retirement age  $a_R$  (set to 65 as noted), and  $\delta$  is the real discount rate.

## 3 Current (baseline) aggregate human capital valuation

### 3.1 Estimated Mincer equations

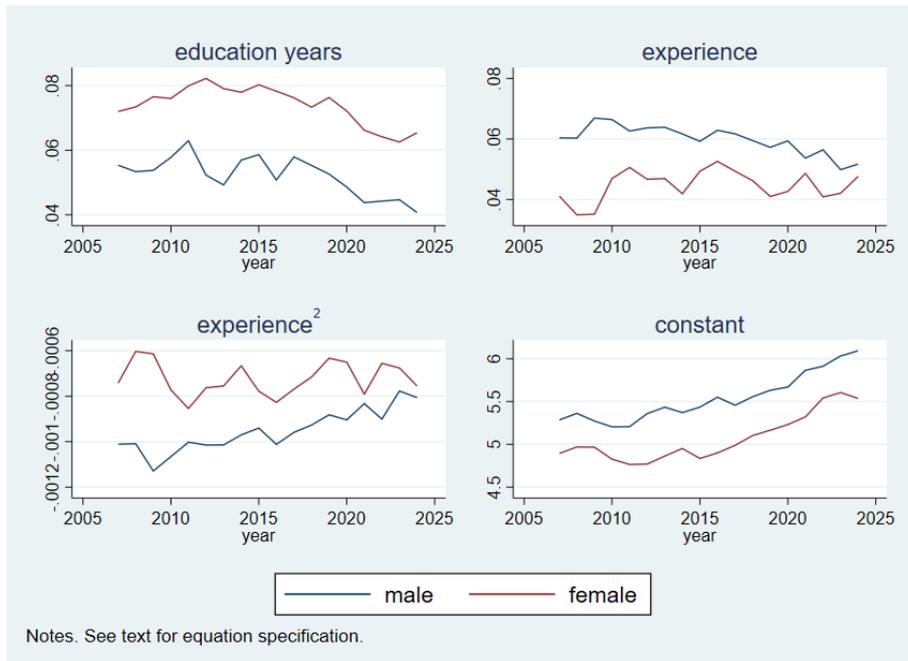
Figure 1 shows the coefficients of the Mincer specifications estimated separately for each sex, cross-sectionally on each year of the HLFS/NZIS from 2007 to 2024. Since these are simple cross-sectional OLS estimates, they should be interpreted as statistical associations only, rather than causal effects of the explanatory variables on earnings. The relationship between education and earnings, for example, is likely to be more complex than suggested by the Mincer equation, and the underlying causality requires careful econometric identification beyond the scope of this paper (see e.g. Card, 1999).

It also should be noted that the earnings measure is weekly earnings (consistent with the measure in World Bank, 2021, 2024), and so its variance combines the variances of hours worked per week and of hourly wages. Over the period, hours per week for females and hourly wages for both sexes (as measured by the Quarterly Employment Survey) have trended up. Ideally, the measure of earnings would be hourly earnings (as in e.g. Andrada and Galassi, 2009), but the HLFS has the limitation that it does not survey hourly earnings directly (only "actual" and "normal" hours worked, from which hourly earnings measures could be derived). Other New Zealand data sources with hourly earnings include the Quarterly Employment Survey. I leave for future work the disentanglement of the relative contributions of hours worked per week and hourly earnings, which would be interesting in light of the recent New Zealand literature on the gender wage gap (e.g. Sin et al., 2022).

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employees not in school or post-school formal education. Since the scenarios do not involve varying the incidence of school or post-school formal education enrolment status or of the different employment types, the overstatement cancels out in scenario minus baseline terms.

**Figure 1 – Mincer equation coefficients**  
**Dependent variable: log(average weekly earnings)**



Source: Author's calculations.

For both sexes, the coefficient on education, measuring the association between earnings and education all else equal, has trended down since the early 2010s. This decline is consistent with the decline in the educational wage premium documented by Maré (2018). The education coefficient estimates suggest that an additional year of education in 2024 was associated with about an extra 4% and an extra 6.5% average weekly earnings for males and females respectively, all else equal. As also noted by Maré (2018), these estimates of the “return to education” in New Zealand are rather low by international standards (see e.g. Montenegro and Patrinos, 2014; Patrinos, 2016; Lemieux, 2006). The lower premium for males is also consistent with other New Zealand and international evidence.<sup>5</sup>

The estimates for the association of earnings with experience are more stable. The negative coefficient on the square of experience indicates the intuitively reasonable pattern that an extra year's experience is associated with a smaller percentage increase in earnings as a worker ages. The upward trend evident in the constant term for both sexes shows, as expected, positive average nominal wage growth over the period.

Overall, the Mincer equation specification seems to capture from the data estimates of reasonable magnitudes. I use the 2024 estimates for the predictions of income at future ages by sex and education, since 2024 was the most recent year of data at the time of this analysis.

Table 2 shows the 2024 estimates in detail, with selected specification changes to test robustness. The “Benchmark” columns (first two from left) show the weighted-OLS estimates used in the valuation modelling, from the sample of employed individuals aged 15 to 74 with observations below the 1st and above the 99th percentiles of log average weekly earnings excluded. This benchmark sample consists of 9,141 males and 9,087 females<sup>6</sup>, representing population counts of about a million individuals in each case. Being at school or in post-school formal education while employed is unsurprisingly associated with much lower earnings, as it effectively proxies for part time status (since the average weekly earnings measure does not adjust for hours worked per week). Being self-employed is also associated with markedly lower (reported) earnings for both sexes, while being an employer is associated with slightly lower earnings (but the sign of the

<sup>5</sup> Montenegro and Patrinos (2014) estimate the returns to an extra year of schooling for males and females at 9.5% and 11% respectively for high-income countries for the period 1970-2013. For the period of sample overlap (2007-2013), their estimates are around 10% for a sample including all countries and both sexes.

<sup>6</sup> sample sizes have been random-rounded to base 3 consistent with Stats NZ confidentialisation requirements

estimate is not robust across the specifications).

For a specification that is fairly simple (for example, with no adjustment for the quality of education, the extent of work-relevant experience or time out of the formal labour force, individual ability, socioeconomic background, etc.), the cross-sectional variance in earnings explained by the benchmark specification is quite substantial, with  $R^2$  statistics just under 0.3.

For robustness checks, I run the same specifications but on a sample that includes the 1% and 99% tails (“No trim”), which produces higher estimates of the association between education and earnings, particularly for males. Restricting the estimate to individuals aged 25-64 (“Core working age”) and dropping the school dummy, but keeping the other features of the Benchmark specification, also leads to a higher estimate of the association between education and earnings for males, but much less so for females. Finally, estimating the Benchmark specification with 1%/99% trim and on 15-74 year olds but without using weighting results in essentially identical estimates.

**Table 2 – Mincer equation specifications**  
**Dependent variable: log(average weekly earnings)**

Explanatory variable	Model							
	Benchmark		No trim		Core working age		Unweighted	
	M	F	M	F	M	F	M	F
education years	0.041 (0.000)	0.065 (0.000)	0.053 (0.000)	0.069 (0.000)	0.054 (0.000)	0.066 (0.000)	0.041 (0.002)	0.066 (0.003)
experience	0.052 (0.000)	0.048 (0.000)	0.059 (0.000)	0.053 (0.000)	0.045 (0.000)	0.035 (0.000)	0.052 (0.002)	0.048 (0.002)
experience <sup>2</sup>	-0.00081 (.00000)	-0.00075 (.00000)	-0.00091 (.00000)	-0.00085 (.00000)	-0.00066 (.00001)	-0.00055 (.00001)	-0.00081 (.00003)	-0.00076 (.00003)
in post-school formal education	-0.34 (.00)	-0.38 (.00)	-0.35 (.00)	-0.40 (.00)	-0.21 (.00)	-0.14 (.00)	-0.33 (.03)	-0.34 (.03)
in school	-1.02 (.00)	-1.06 (.00)	-1.11 (.00)	-1.06 (.00)	-	-	-1.01 (.05)	-1.01 (.05)
is employer	-0.10 (.00)	-0.03 (.00)	0.00 (.00)	0.12 (.00)	-0.02 (.00)	0.11 (.00)	-0.10 (.02)	-0.07 (.04)
is self-employed	-0.49 (.00)	-0.47 (.00)	-0.50 (.00)	-0.55 (.00)	-0.46 (.00)	-0.54 (.00)	-0.49 (.02)	-0.49 (.02)
const.	6.1 (.00)	5.5 (.00)	5.8 (.00)	5.4 (.00)	6.0 (.01)	5.7 (.01)	6.1 (.04)	5.5 (.04)
<i>N</i>	9141	9087	9498	9255	7740	7650	9141	9087
<i>R</i> <sup>2</sup>	0.28	0.28	0.25	0.26	0.11	0.11	0.28	0.27

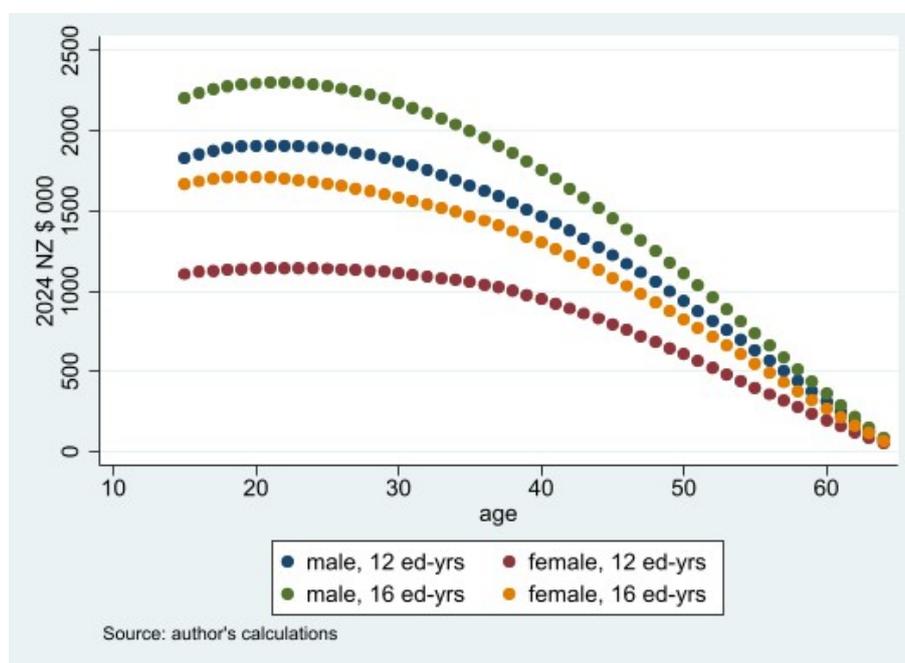
**Notes.** OLS estimates on 2024 HLFS data. Standard errors in parentheses. See text for full details of specifications.

## 3.2 Current (baseline) aggregate human capital valuation

As noted in Section 2, for the current (baseline) aggregate human capital valuation and scenarios, the reference individual in the WAP is not in school or post-school formal education, and if employed, is an employee, not self-employed or an employer. Using the benchmark Mincer estimates and projected survival and employment rates, I project the expected lifetime income of individuals in the WAP treating them all as reference individuals. Such individuals constitute the bulk of the WAP, so the Mincer estimates for them are likely to be the most accurate. This assumption implies a slight overstatement of aggregate human capital since the estimates of earnings conditional on education and age of those still in education, and of the self-employed and employers (slightly), are lower than employees not in education (Table 2). Since this overstatement is in both the baseline and the scenario aggregate human capital values, it does not materially affect the baseline-scenario comparisons reported below.

Applying the approach set out in Section 2, Figure 2 shows the age profile in 2024 of individual human capital by sex for individuals with 12 and 16 years of education (an NCEA2 school leaver and a Bachelor's degree holder, respectively), as examples. In all cases shown, individual human capital peaks in an individual's 20s and then converges down to zero by the end of working life (by construction, because of the assumption of zero employment rates after age 65), as a result of the fall in remaining earning years as the individual ages. The curvatures of the lines depend on the balance of effects of the projected aggregate real wage, the discount rate, and the age profiles of earnings-if-employed and of the employment rate. The age-specific mortality rate has very little effect, since mortality is uniformly very low between the ages of 15 and 64. The sizeable gap between male and female individual human capital, even controlling for education, is evident. According to the estimates here, a male in his early 20s with NCEA2, for example, has estimated human capital of around \$1.7 million, slightly above that of a female in her early 20s with a Bachelor's.

**Figure 2 – Individual human capital**

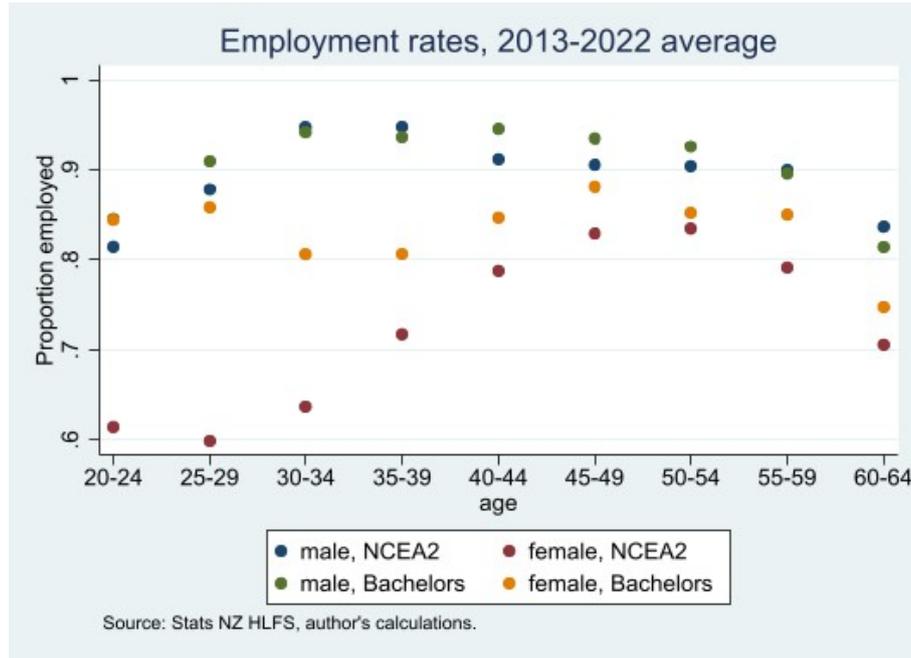


Source: Author's calculations.

The bulk, if not all, of the male-female individual human capital gap in the figure is in favour of males is due to the lower female employment rates for both education levels at almost all ages, and especially for individuals with NCEA2-level education (Figure 3). A dip in employment rates during the child-rearing ages of 30-45 is evident for females with Bachelor's but not for those with NCEA2 only, and not for males of either education level.<sup>7</sup>

<sup>7</sup> The age profiles of employment rates for females with Bachelor's compared to with NCEA2 only are consistent with graduate females bearing children later than non-graduate females. My thanks to Patrick Nolan for pointing this out.

**Figure 3 – Employment rate**



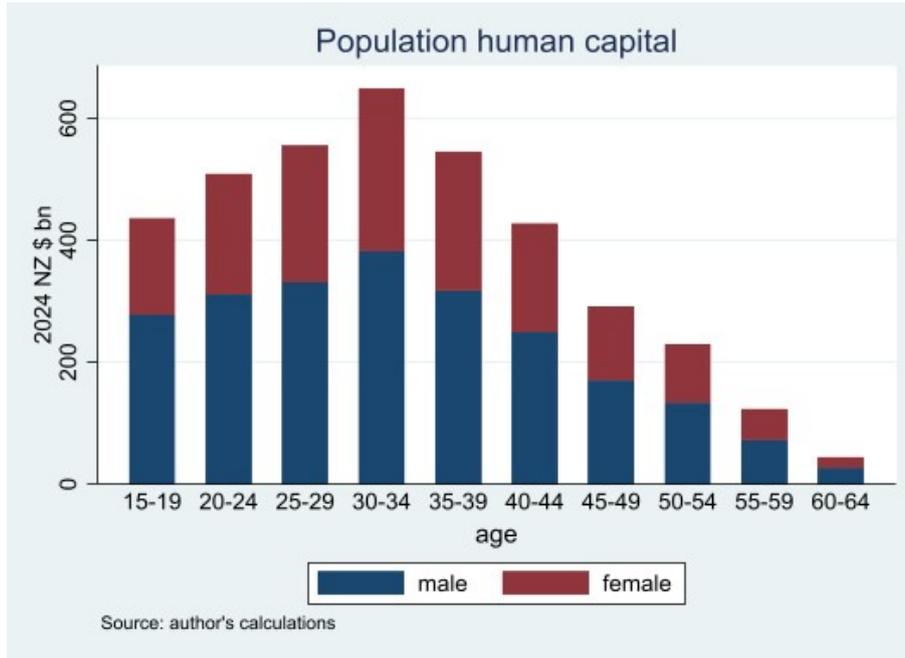
Source: Author's calculations.

Scaling up the individual human capital estimates by sex, age and education using the 2024 population counts for each group produces an estimate for the New Zealand aggregate human capital stock in 2024 of NZ\$3.8 trillion (in 2024 dollars).<sup>8</sup>

The bulk of human capital in 2024 is in the age groups immediately post-formal education (Figure 4). The hump shape of aggregate human capital by age group is more pronounced than the age profile for individual human capital, reflecting that the aggregate measure contains larger proportions of middle-aged groups than younger age groups (see Figure 6), and that employment rates and average education levels are lower among older age groups currently. These compositional effects at the aggregate level accentuate the effect of diminishing remaining years of working life for older individuals.

<sup>8</sup> This estimate may be compared to Trinh Le's recent estimate (discussed in Galt, 2023) of \$1.9 trillion (in 2018 dollars). Considering nominal wage inflation and population growth since 2024, and that Le used a different data source (Census), somewhat smaller WAP definition (18-64) and different method (different discount rate and projected real wage growth assumptions) for projecting an individual's lifetime labour income (using observed income of older aged individuals as a proxy for younger individuals' expected incomes when they reach older ages), the two figures appear in a similar neighbourhood.

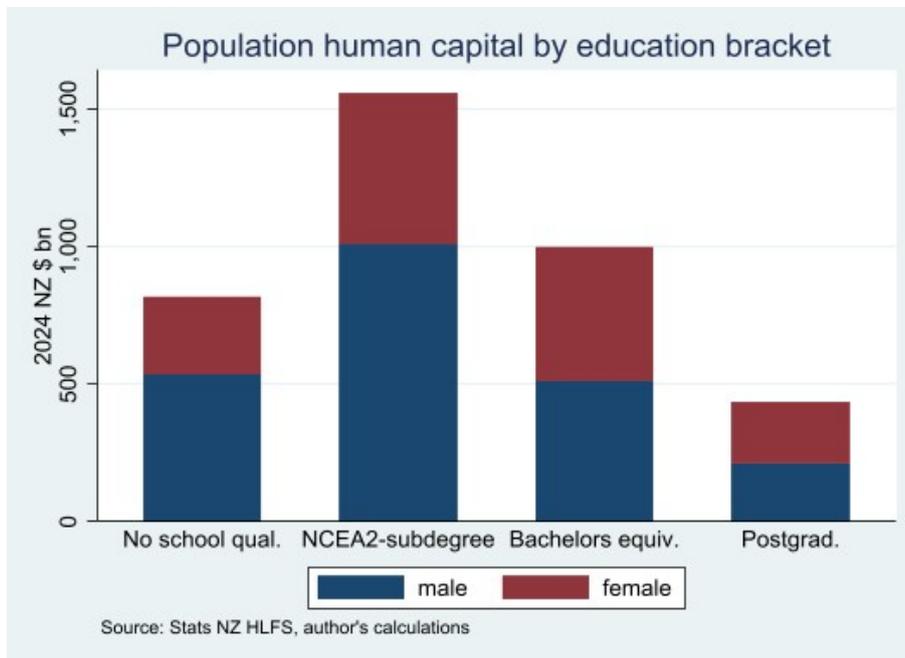
**Figure 4 – Components of aggregate human capital by age bracket**



Source: Author's calculations.

By education level, the bulk of the aggregate human capital stock is attributable to those with NCEA2 to Bachelor's levels of attainment (Figure 5).

**Figure 5 – Components of aggregate human capital by educational attainment**



Source: Author's calculations.

## 4 Aggregate human capital scenarios

This section compares the baseline aggregate human capital valuation for 2024 to valuations in scenarios in which assumptions about some of the key factors influencing human capital are varied.

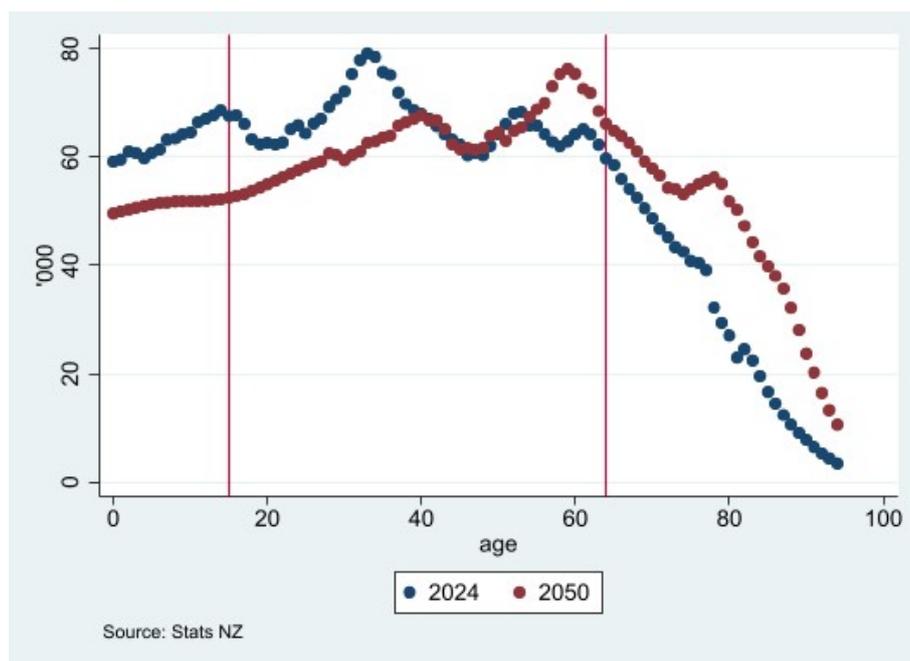
## 4.1 Natural population ageing

The ageing of the population in New Zealand and in most of the rest of the world, and its major social and economic implications at the global, national, community and household levels, is well-recognised as one of the fundamental challenges facing society. A facet of the challenge is what population ageing means for labour force dynamics and national income, and in turn the capacity of the earnings of the working age population to support the living standards of the population as a whole.

The aggregate human capital valuation model based on the concept of lifetime labour income is well-suited to providing quantitative insight into the scale of the national earnings capacity issue as it relates to natural population ageing. Since it explicitly recognises the finite nature of working life, the value of aggregate human capital can be viewed as a summary statistic linking national labour earning capacity to the age structure (given the other parameters in the valuation model).

The blue dots in Figure 6 show the 2024 population in New Zealand. The baseline aggregate human capital valuation discussed in Section 3 uses the WAP (of all employment and in-education statuses), between the vertical lines in the figure, from this population. For the natural ageing scenario, I assume instead a WAP using the population age structure shown by the red dots in the figure, which are Stats NZ's median projection for 2050 from a 2022 base assuming no migration. Such a projection constitutes the projected natural ageing of the population based on the current population age structure and projected birth and death rates.<sup>9</sup>

**Figure 6 – Population age structure, current and no-migration projected**

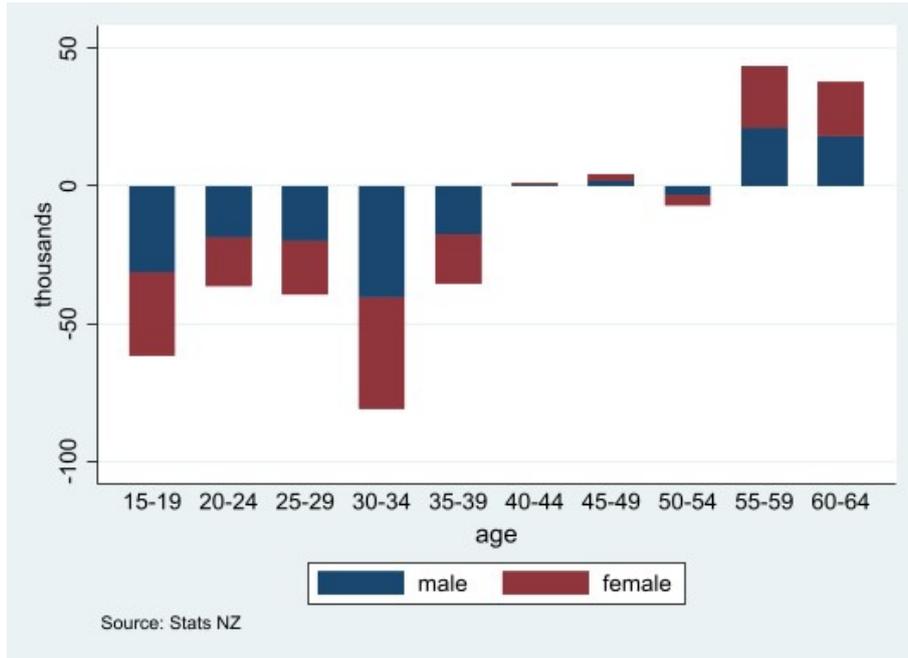


Source: Stats NZ.

Figure 7 shows the scenario-baseline difference in WAP count at each age. This difference is the measure of natural population ageing used to calculate the effects on aggregate human capital in the scenario. It is evident from both figures that the total WAP is projected to drop, and on average get older, in the absence of migration. The count in the WAP below age 40 is projected to drop by around 240,000 in total, while the count above age 55 is projected to increase by around 70,000.

<sup>9</sup> The Stats NZ projection assumes a fertility rate of 1.65 per female and a continued gradual decline in mortality rates in line with recent trends. The no-migration projected population curve begins to decline in the 2040s as the effects on the population of the low birth rate start more than offsetting the effects of decreasing mortality.

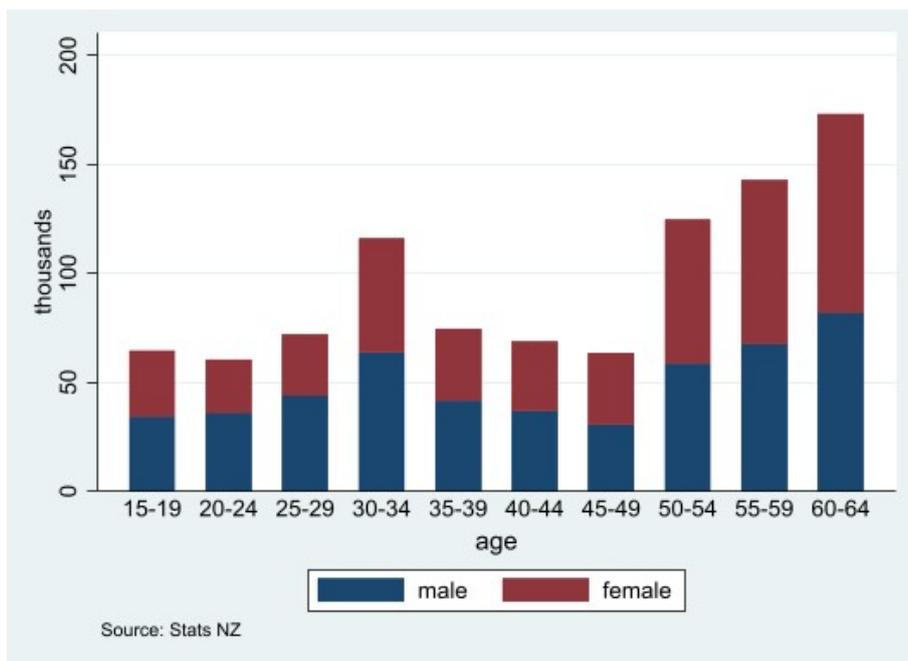
**Figure 7 – No-migration projected working age population change**



Source: Author's calculations.

The projected overall reduction in the WAP in the scenario is 174,000, equivalent to 5.3% of the baseline (2024) WAP. The reduction is also equivalent to about a fifth of the *increase* in the WAP between 1996 and 2023 (which includes the effect of net migration as well as natural change), a length of time the same as the time horizon in the scenario. Figure 8 shows that the WAP not only increased substantially over recent decades, but also that the increase was more evenly spread across the age groups (albeit with a slight skew towards older age groups). Using this recent trend as a benchmark indicates that the projected reduction and ageing of the WAP due to natural ageing is substantial.

**Figure 8 – Working age population change, 1996-2023**



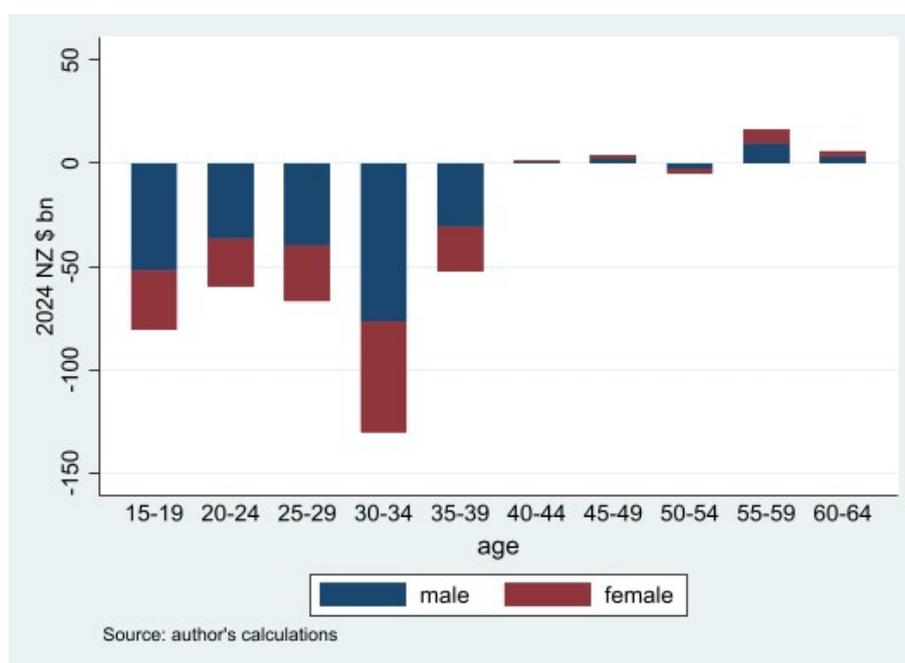
Source: Author's calculations.

### 4.1.1 Scenario results

Plugging the WAP counts by age and sex in the scenario into Equation 2 (keeping sex-specific education proportions the same) and then subtracting the baseline provides the difference in aggregate human capital under the scenario assumptions compared to baseline. The difference measures the effect on aggregate human capital in 2024 of the natural ageing projected to 2050, keeping all else unchanged at the baseline assumptions. This difference combines the effects of the natural-ageing-related reduction in the WAP count and increase in its average age, and is \$368 billion, or 9.7% of baseline.

Figure 9 shows the difference in aggregate human capital by age bracket. The by-age contribution to the difference is heavily concentrated in the younger (less than 40) age groups (more so than the change in population counts by age), because higher individual human capital at younger ages (Figure 2) compounds the concentration of the projected fall in the WAP in younger age groups (Figure 7).

**Figure 9 – Natural ageing scenario: difference in aggregate human capital**



Source: Author's calculations.

Most of the difference in aggregate human capital is attributable to males, despite the changes in the male and female counts in each WAP age group being similar (Figure 7). The greater male contribution to the aggregate human capital decrease is due to the higher individual human capital profile for males compared to females, especially at younger ages (Figure 2).

\$200 billion (5.3% of baseline) – slightly more than half – of the overall difference in aggregate human capital is due to the reduction in the overall WAP count, as natural ageing implies the death or retirement of workers out of the WAP, without complete replacement by young workers ageing into the WAP, given the relatively low counts in pre-WAP age groups in the current population. The projected increase in average age of the WAP, and the consequent effect of fewer average remaining years of working life, accounts for the other \$168 billion (4.3% of baseline). The effect on aggregate human capital of the substantial projected reduction in the WAP count is thus materially exacerbated by WAP ageing.

## 4.2 Increased aggregate real wage growth

The valuation model can be solved for the additional real wage growth that would have an equivalent magnitude of aggregate human capital impact to that in the natural population ageing scenario. Running such a thought experiment through the model indicates that the aggregate human capital

impact of ageing (\$368 billion) is equivalent in magnitude to an additional 0.65 percentage points of projected annual real wage growth compared to baseline (which already assumes 1.0% growth p.a.), for each year of the current WAP's remaining working life (i.e. up to 50 years for 15 year olds). 0.65 percentage points is two thirds of the annual real wage growth rate achieved in New Zealand over the past decade. Real wage growth supported by productivity growth (whether through innovation or capital deepening) is, of course, a key source of offset to the human capital effects of natural population ageing (Guest, 2013), but New Zealand's "disappointing" productivity performance in recent years (Nolan et al., 2018) and slowing productivity growth in New Zealand and elsewhere (Cook et al., 2024) highlight the magnitude of the task of improving productivity if it were to be relied on as the sole means of alleviating the natural ageing effect.<sup>10</sup>

### 4.3 Increased net immigration

Immigration is another means of offsetting the aggregate human capital effects of natural population ageing (albeit easier for a small country, and even then with some limits given that natural WAP ageing is a worldwide phenomenon). It has the potential to address both a reduction in the WAP count as well as WAP ageing, since the age of immigrants can be influenced by policy settings.

To explore the aggregate human capital effects of immigration, I implement a scenario with an immigration inflow of 10,000 into the WAP. Such an inflow is quite small compared to typical swings in gross immigration flows. The small size of the assumed inflow in the scenario reflects that the focus of this paper and the aggregate human capital valuation model is on long-run labour supply and demographic channels. Large immigration flows may involve shorter-run macroeconomic effects that would complicate the analysis.

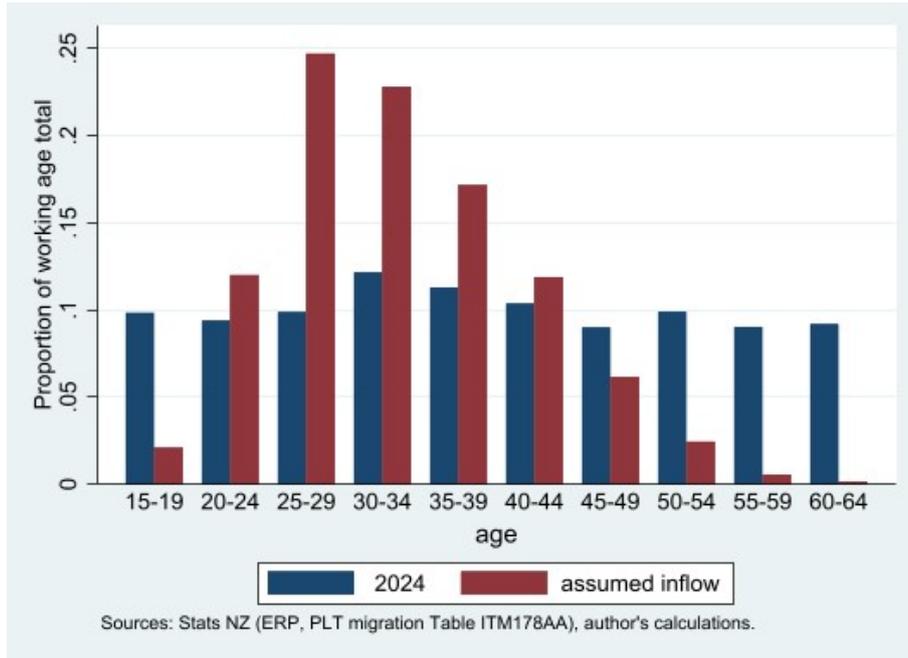
In this scenario, I assume that the inflow of 10,000 people into the WAP has the same age structure as observed for the inflow of PLT work visa holders of working age in 2023 (Figure 10). All other characteristics – sex and education level proportions, expected employment rates, mortality rates and applicable Mincer coefficients – for the inflow are assumed to be the same as in the baseline population, so they do not contribute to the difference in aggregate human capital.

This approach isolates the impact of the age structure of recent immigration inflows. As the figure shows, a greater proportion of incoming individuals on work visas falls in the "prime working age" groups (20s and 30s) than the existing population, reflecting policy settings in recent years. Immigration being concentrated in younger age groups has contributed to the relatively flat distribution of WAP change by age over recent decades (Figure 8), in effect leaning against the natural ageing effect. (Emigration can of course lean in the opposite direction, given that movement in general is typically concentrated in younger age groups; Brabyn and Jackson, 2019.)

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<sup>10</sup> In order to represent an increase in earnings capacity for the economy as a whole, an increase in average real wages across the WAP would have to be supported by a similar increase in labour productivity of the same magnitude, otherwise the increase in wages would have to come at the expense of the returns to capital, leaving the overall economy no larger.

**Figure 10 – Age structure, current population and assumed immigration inflow**



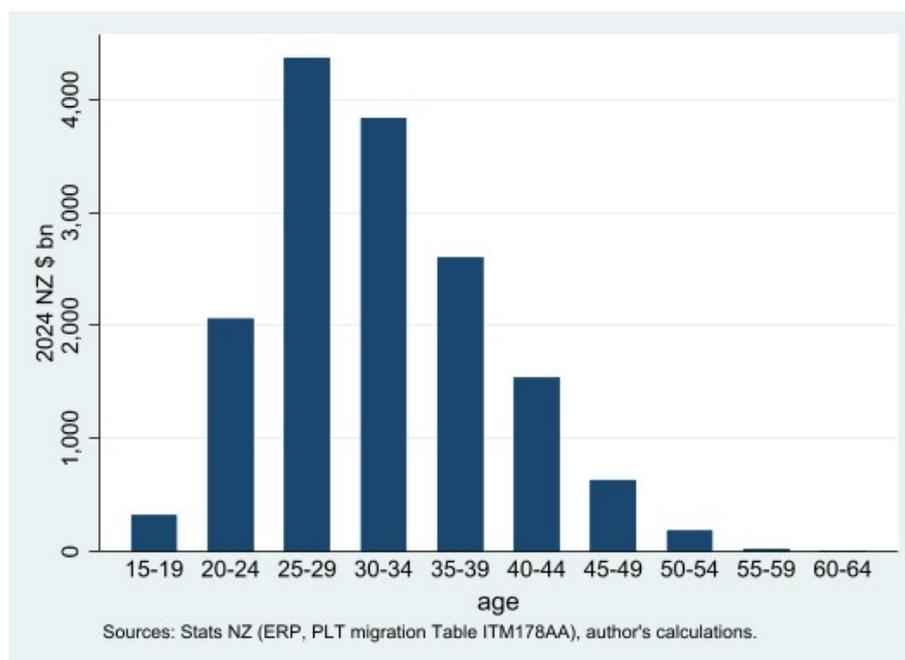
Source: Author's calculations.

Sex proportions in typical immigrant inflows tend to be similar to those in the baseline population, and mortality rates are also likely to be similar. However, assuming that the typical employment rates and education levels of immigrants are the same as those in the current population is probably an understatement given the work visa rules around those characteristics. For the same reason, educational enrolment rates for younger immigrants on work visas are probably also lower than those for residents. On the other hand, assuming that earnings of recent immigrants conditional on age, sex and education are the same as in the baseline population is almost certainly an overstatement in the short term (Stillman and Maré, 2009). Better characterising these differences and exploring their implications for human capital and labour market dynamics more generally (building on e.g. Maré and Stillman, 2009; New Zealand Productivity Commission, 2021) would be a worthy subject for further research.

### 4.3.1 Scenario results

Figure 11 shows the difference in aggregate human capital in this scenario. The curvature of individual human capital by age reinforces the shape of the inflow age structure, so the vast bulk of the contribution to the difference in human capital is from the younger part of the inflow.

**Figure 11 – Immigration scenario: difference in aggregate human capital**



Source: Author's calculations.

The difference in aggregate human capital in this scenario, with a 10,000 inflow, is an increase of about \$16bn (0.4% of baseline). A little over a quarter of that increase is due to the relative youth of the inflow compared to the baseline population, with the rest due to the increase in the WAP count.

Applying a simple scale-up, the model thus suggests that the effect of projected natural population ageing on aggregate human capital (\$368 billion) is equivalent in magnitude to a substantial immigration inflow of 230,000 extra people, if the inflow were age-structured similarly to the 2023 work-visa inflow. For comparison, net immigration for 2024 was around 30,000, so any net 230,000 inflow would have to be spread over several years (not least because of macroeconomic spillovers, from which this exercise abstracts, as noted). Notably, this equivalent inflow count is larger than the projected 170,000 fall in the WAP count in the natural ageing scenario, indicating that the youth-skew of the fall in the WAP in the latter is greater than that in the 2023 observed immigrant inflow. Given that immigration settings already substantially prioritise prime working age groups (Figure 11), there are likely to be limits to how much more a youth priority in immigration can be relied upon to counteract the natural ageing effect.

#### 4.4 Increased educational attainment

The final thought experiment in this paper relates to educational attainment, a key driver (alongside age) of earnings in the Mincer equation and hence of human capital in the valuation model. Much of education policy focuses on lifting achievement. To illustrate the potential implications of increased achievement for aggregate human capital in the model framework, I look at a scenario involving individuals with very low levels of school achievement. Among other things, this allows the aggregate human capital effects of natural population ageing to be scaled against educational achievement as a potential offset.

It should be emphasised that this exercise abstracts from the feasibility and costs of lifting school achievement by the various interventions which could be contemplated. Such analysis requires careful identification and causal inference work, and is the subject of a vast empirical literature, and hence beyond the scope of this paper.<sup>11</sup>

<sup>11</sup> The same remark could be made in respect of the thought experiment on real wage / productivity growth, the lifting of which is also the subject of a massive literature. The immigration thought experiment is easier to conceive as a feasible and cost-effective policy scenario, since the quantity and age structure of immigration can be relatively tightly controlled by policy. The question of "what works" when it comes to education and economic growth, on the other

Individuals with no school qualifications have substantially lower expected employment rates and are much more likely to be not in employment, education or training (NEET), compared to those with NCEA2 as their highest qualification. The lower expected employment rates of those with no school qualifications compound the effect of their lower wages as captured in the Mincer equations.

The aggregate human capital framework allows simple calculations of the difference in aggregate human capital if those with no school qualifications instead had achieved NCEA2 as their highest educational qualification (again, holding all else equal, including the applicable Mincer coefficients for those individuals). In 2024, around 9,000 individuals left school without a qualification. I implement a scenario in which a third (3,000) of those are assumed instead to have achieved NCEA2.<sup>12</sup> The scenario could be interpreted as the result of an intervention that increases the educational attainment of 3,000 individuals from a single cohort, and models the difference in aggregate human capital as a result of their higher expected lifetime trajectories of earnings and employment rates. I distribute the 3,000 individuals 50:50 male:female, and 2:1 employed:not employed in the baseline, to roughly match the proportions observed in recent cohorts of school leavers with no school qualification.

#### 4.4.1 Scenario results

The difference in aggregate human capital in this scenario relative to baseline is \$1.1bn, or \$376,000 for each individual in the 3,000 whose qualification level is changed in the scenario. The difference in *individual* human capital is substantial, and of course would contribute positively to those individuals' life circumstances. However, \$1.1bn is only a tiny fraction – about a third of 1% – of the aggregate human capital difference in the natural population ageing scenario. Clearly, if increased educational attainment is to contribute materially to offsetting the effect of natural population ageing, it would have to be sustained well beyond a single cohort and across the spectrum of educational attainment (not just concentrated in low achievers). This too is a topic worthy of further research, especially in light of the trend *decrease* in NCEA2 attainment rates seen recently (Nicol-Williams, 2024).

## 5 Discussion

The scenario results reported in this paper suggest that projected natural population ageing is likely to be associated with a substantial loss of aggregate human capital, partly due to net exit of people from the WAP and partly due to an increase in the average age of the WAP. This loss needs to be offset somehow in order for the earning capacity of the WAP to continue to support overall living standards at current levels. Population ageing dynamics of course also imply, as is well-known, a large projected increase in the old-age dependency ratio, compounding the issue.

The other scenarios illustrate the magnitude of the issue by scaling the impacts of population ageing against the impacts of other major influences on aggregate human capital: real earnings (productivity) growth, immigration and educational attainment. Those scenarios suggest that none of those channels by themselves are likely to be an easy fix to fully offset the impact of natural ageing.

### 5.1 Limitations and potential future work

The intent of this paper is relatively modest and exploratory, to illustrate the rough orders of magnitude of aggregate human capital change associated with various thought experiments about its drivers. The results are subject to important limitations that would need to be addressed in any future work intended to make stronger causal claims about the contributions of the drivers to human capital dynamics.

First, the model heavily simplifies the relationship between human capital and its influences, starting from the very simple specification of the Mincer equations. Among other things, the specification

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hand, is much more situation-specific.

<sup>12</sup> To implement this scenario, I change the educational achievement of 3,000 19 year olds to 12 years (NCEA2) instead of 10 years (no school qualifications). I use 19 year olds to avoid conflation with the effects on earnings of still being at school, which is more likely for younger ages, and which as noted is not modelled in the current version of the model. The scenario further assumes that the 19 year olds are not in post-school formal education.

limits the role of skills in earnings to educational qualifications, when evidence suggests a strong role for skill formation on the job. Also, the Mincer equation estimates use cross-sectional samples to proxy for the lifetime trajectories of earnings and employment rates. Using (increasingly available) true longitudinal data would be an improvement. As well, the estimates of the effects of education and experience, and sex differences in earnings, are held fixed in the valuation modelling, which given the trends evident in the data deserves more sophisticated modelling. More fundamentally, the modelling leaves the structural behavioural relationships and assumptions about causality and equilibrium relations implicit, and ignores dynamics, including important equilibrating responses of prices and other variables such as investment in physical capital. For example, the scenarios include no adjustment effects in labour markets (e.g. wages responding to changed aggregate labour supply, or to changes to education levels or occupational structures, which may depend on age).

Second, the implications of the scenarios extend beyond aggregate human capital effects. All the scenarios, except the real wage/productivity scenario, are thought experiments about labour supply. In a long-run general equilibrium analysis, investment responses to labour supply shocks would be expected, meaning that changes in labour income would be accompanied by changes in capital income, both of which contribute to the earning capacity of the economy.<sup>13</sup>

Finally, the model does not incorporate any structure to represent the cost or feasibility of any interventions needed to achieve the shifts contemplated in the scenarios. The differences in aggregate human capital in the scenarios should therefore be interpreted as gross differences, that do not take account of the costs of the interventions themselves and any associated unintended consequences.

Given these limitations, simplifications and uncertainties, the results should be interpreted as order-of-magnitude indications rather than precise predictions. Nevertheless, the model's simplicity and tractability has allowed quite diverse scenarios to be explored in terms of their implications for aggregate human capital. This can identify particular influences that would be relatively impactful for human capital, and therefore worthy of further, more detailed, analytical investigation.

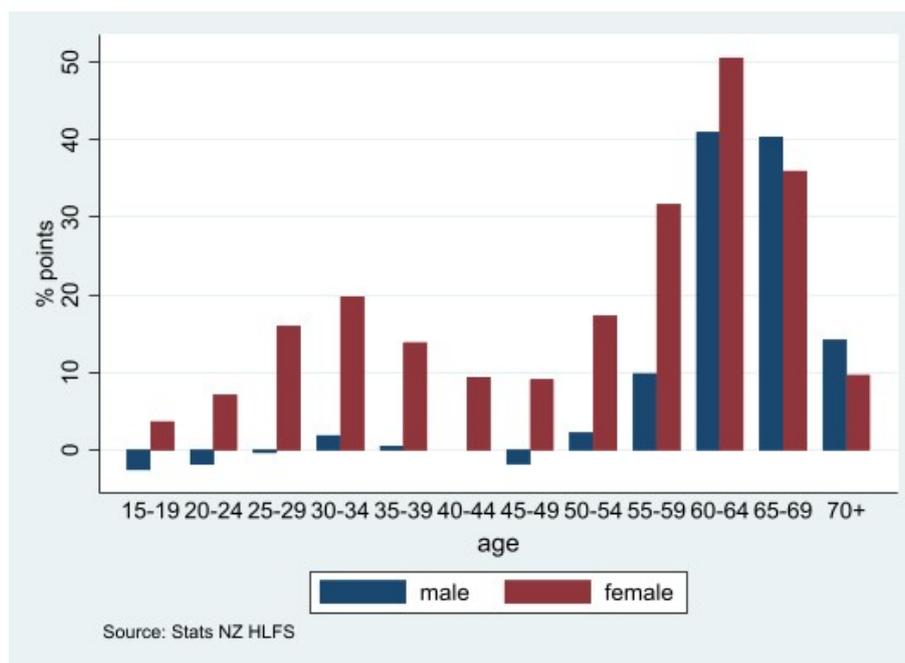
A range of structural refinements to the model could improve its accuracy and relevance. These include investigating different or more comprehensive data sources from the Census and personal tax data, introducing the probability of continued participation in school or formal education, incorporating hourly rather than average weekly earnings to capture hours-per-week differences (and perhaps modelling caring work as a driver of part-time status as well as education enrolment), incorporating the impact of health status on labour force participation and earnings (which plenty of evidence shows is empirically important) and perhaps on education, looking at improvements in educational attainment across a broader spectrum of skill levels, incorporating demographic influences beyond age and sex such as ethnicity, and extending the end of working life to recognise the increasing number of people working past age 65.

The last is particularly pertinent given current trends. In the current version of the model, as noted, the age of retirement (after which labour income is assumed to be zero) is set at 65 for comparability with other work, but this is increasingly unrealistic. It materially understates both individual and aggregate human capital (but without substantially affecting the scenario-minus-baseline results). As shown in Figure 12, labour force participation in older age groups has grown very strongly over the past three decades, particularly for females. It is showing little sign of slowing. Current average incomes of 65-74 year olds are not dissimilar to those of individuals in their 20s. The positive aggregate human capital implications of these trends in older age labour force participation deserve exploration and further work. Scenarios exploring the impact of living longer and healthier lives and of declining fertility on participation would also be worth considering in extensions of the model.

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<sup>13</sup> If the labour share of income is unaffected in equilibrium, then operating surplus must increase in proportion to labour income.

**Figure 12 – Participation rate increase, 1993 to 2024**



Source: Author's calculations.

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