Institute for Fiscal Studies

Should generations differ in their wealth accumulation?

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Abstract

In the UK, those born between the 1930s and 1950s have seen generation-on-generation increases in wealth, while those born more recently appear to have accumulated no more wealth than their predecessors had done by the same age. There is debate over the drivers, and therefore implications, of these trends. We use a heterogeneous agents lifecycle model to quantify the potential importance of changing economic and demographic circumstances for the wealth accumulation of generations. Using generation-specific inputs to our model, we examine the impact of differences in earnings, household composition, life expectancy, retirement ages, the tax and benefit system, the state pension system and rates of return on assets. Several of these factors have quantitatively important implications for the level and distribution of wealth, saving rates and replacement rates. We find that changing circumstances alone could generate a picture of stalling wealth accumulation among later generations – one does not need to appeal to differences in preferences between generations. Furthermore, our simulations indicate that given the circumstances they face, later born generations would need higher saving rates even to achieve lower replacement rates in retirement than their predecessors.

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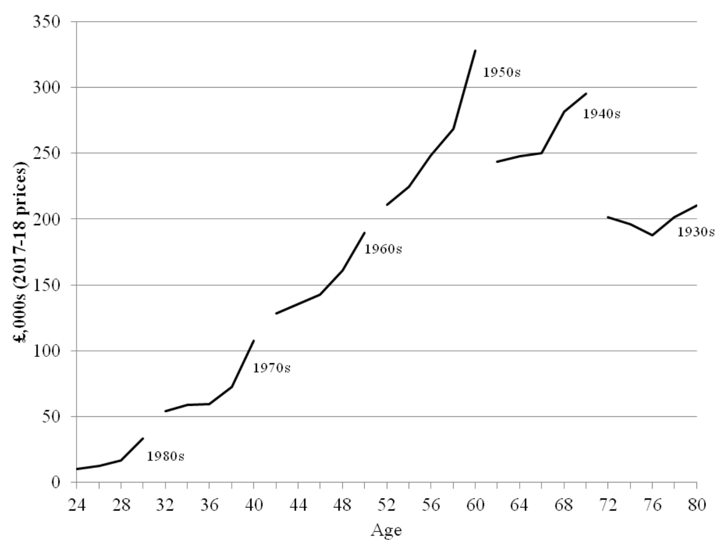
1 Introduction

There is an important debate on the drivers of wealth accumulation, and how these might differ between different generations. In the UK, those born between the 1930s and 1950s have seen generation-on-generation increases in wealth levels, while those born more recently look to have accumulated no more wealth than their predecessors had done by the same age (Hood and Joyce (2013), Cribb et al. (2016), and D'Arcy and Gardiner (2017)). This pattern can be seen in Figure 1, which summarises wealth holdings for different generations. This apparent 'stalling' of wealth accumulation has prompted much discussion. Some argue that the lower wealth accumulation of younger generations is due to lower preferences for saving and higher luxury consumption – the stereotypical image of millennials breakfasting on avocado toast and chai latte, rightly or wrongly, has gained some traction.[1] Others argue that changing economic circumstances, such as levels of earnings, returns from the stock market, and the nature of the housing market, are the main force at play.[2]

Figure 1: Median wealth by age for selected generations



Note: Household wealth per person, composed of net housing wealth, private pension wealth, physical wealth, and net financial assets. Wealth and Assets Survey, 2006-2016

Understanding what factors are driving wealth levels, and how these differ between generations, is important. One policy concern arising from the comparison of wealth between generations is that today's young people are not saving enough to enjoy a good standard of

[1]See, for example, https://www.theguardian.com/lifeandstyle/2017/may/15/australian-millionaire-millennials-avocado-toast-house.

[2]See, for example, https://www.theguardian.com/money/2019/may/11/dont-believe-the-hype-about-millennials-and-money-data-suggests.

living in retirement. However, without knowing whether lower wealth accumulation is driven by circumstances, preferences or behavioural biases, it is impossible to justify, or appropriately design, any policy intervention aimed at addressing this (or any other) concern.

In this paper, we quantitatively evaluate the potential importance of changing economic and demographic circumstances for wealth accumulation of different generations. We use a heterogeneous agents lifecycle model to simulate how individuals would be expected to save, given the circumstances they face, assuming they are rational agents seeking to maximise expected lifetime utility from consumption. We solve and simulate our model, varying circumstances individually in order to quantify the importance of each element for wealth accumulation. We then use generation-specific inputs, which capture the environment faced by those born in different decades, to simulate how the wealth accumulation of different generations would be expected to compare given the different circumstances they have faced. In doing so we demonstrate how far it is possible to replicate the observed patterns of wealth differences between generations without needing to appeal to differences in preferences or behavioural biases.

Our work relates, in terms of the question we address, to Kapteyn et al. (2005) who seek to explain differences in wealth holdings between generations in the Netherlands. They employ a reduced form empirical approach, and argue that all cohort differences in observed wealth levels can be explained by differences in productivity growth and social security provision. Our approach differs in that rather than simply assessing whether observed empirical differences in wealth are *associated* with changing economic circumstances, we explicitly model the impact of different circumstances on savings choices, allowing us to ask whether patterns in wealth accumulation are *expected*, given changing circumstances. Further, we consider a wider range of circumstances than the two (productivity growth and social security) examined by Kapteyn et al. (2005). Gale et al. (2019) consider the prospects for the adequacy of the retirement incomes and wealth accumulation of millenials in the US, and how their circumstances and outcomes may compare to older generations. They consider a similar set of changing circumstances to those analysed in this paper, including, earnings, rates of return, the tax and benefits system and the timing of children, but rather than quantify the impact of each factor in a model, they describe and discuss the implications of each qualitatively. Our approach of simulating saving behaviour using a lifecycle model is most similar to that taken by Scholz et al. (2006) and Crawford and O'Dea (2018). However rather than comparing the simulations produced with empirical wealth levels for one particular generation, as those papers do, our focus is on how the simulations we produce vary across generations.

We find that changes in the conditions in which different generations have saved would be expected to drive large differences in both the size and timing of saving and wealth accumulation. Levels of earnings, the rate of return on assets, and the generosity of the public pension system have quantitatively large impacts on simulated saving behaviour. Life expectancy and retirement timing have smaller, but still non-negligible, impacts. Taking all these circumstances together, our simulations suggest a general pattern of increasing wealth levels at retirement for each generation, as compared to those born earlier, driven largely by increased earnings but also by falling state pension generosity and falling average tax rates among later-born generations. However, the relative position of cohorts changes with age. When viewed at ages 30, 40 and 50 respectively, the 1980s, 1970s and 1960s cohorts have the same or less wealth than their immediate predecessors. One of the main reasons for this is the low rates of return, and poor earnings performance that each cohort has experienced in the period during and following the financial crisis.

The qualitative patterns observed in empirical data can therefore be replicated without allowing preferences or behavioural biases to differ between generations: the different economic and demographic circumstances faced result in no generation-upon-generation increases in wealth accumulation among those born since the 1960s, at the ages they are observed. Furthermore, our results reveal that while those born in the 1960s, 1970s and 1980s would be expected to have lower gross replacement rates in retirement than those born between the 1930s and 1950s, these still require higher saving *rates* than previously. This highlights that the retirement income replacement achieved by previous generations should not be used as a benchmark against which to assess the likely adequacy of retirement saving by younger generations. This may be holding younger generations to an inappropriately high ideal, even if there are no differences in preferences between generations.

The paper is organised as follows: in section 2 we give a brief overview of our structural lifecycle model. In section 3 we discuss the circumstances that have differed between generations, and use our model to simulate the impact that each of these circumstances would individually be expected to have had on saving behaviour. We examine, in turn, earnings, the tax and benefit system, the state pension system, the return on saving, life expectancy, the number and timing of children, and retirement ages. In section 4 we bring together these different circumstances to simulate how one might expect saving behaviour to differ between generations even if preferences were identical. Section 5 summaries and concludes.

2 A lifecycle model of saving

We use a simple heterogeneous agents lifecycle model to quantitatively illustrate the effects of different economic and demographic circumstances on private savings behaviour. Here we provide a brief description of the model.

2.1 Model overview

The agent in our lifecycle model is an individual who lives from age 26 until death, and in each period chooses how much to save in a risk-free asset. Agents make this choice in the context of circumstances that potentially differ between generations: earnings, public pension provision, the tax and benefit system, the return on saving, the number and timing of children, life expectancy and the retirement age. They face uncertainty in terms of their future earnings and their future mortality. We describe all these features in more detail below.

2.1.1 Preferences and the environment

Lifetimes Individuals are modelled from the age of 26 until death, with each period, t, in the model representing one year. From the age of 65 onwards, individuals face an age-varying probability of death each year, with death occurring at age 110 at the latest.

Preferences and equivalisation Utility in each period is a constant relative risk aversion function (with CRRA parameter γ) of equivalised consumption (where $\theta_t \geq 1$ is an age-specific equivalisation factor):

$$u(c_{i,t}) = \frac{(c_{i,t}/\theta_t)^{1-\gamma} - 1}{1-\gamma} \tag{1}$$

Note that there is no utility gained from wealth left at death, i.e. no bequest motive. Individuals aim to maximise expected lifetime utility, with discount factor β, and probability of survival to age t of S_t:

$$U = \sum_{t=0}^{T} \beta^t S_t u(c_{i,t}) \tag{2}$$

Employment and earnings Individuals are assumed to start working at age 26 and to remain in the labour force each year until the known retirement age K. Earnings, $e_{i,t}$, are given by an education-specific process that is a function of age:

$$\begin{aligned} \ln(e_{i,t}) =& \; f_{ed}(age_{i,t}) + v_{i,t} \quad \forall t < K \\ v_{i,t} =& \; m_{ed}(v_{i,t-1}) \qquad (3) \\ e_{i,t} =& \; 0 \qquad\qquad\qquad \forall t \geq K \qquad (4) \end{aligned}$$

Where $f_{ed}(age_{i,t})$ represents the deterministic component of earnings, which is the same for all individuals of a given age and education level, and $m_{ed}(v_{i,t-1})$ represents the the stochastic (uncertain) component of earnings, which is mean zero and follows a first-order Markov process that is age- and education-specific.

Public pensions From the retirement age K, individuals receive a public pension payment. This is assumed to be an education-specific deterministic function of individuals' final earnings:

$$\begin{aligned} p_{i,t} =& \; 0 \qquad\qquad\quad \forall t < K \\ p_{i,t} =& \; g_{ed}(e_{i,K-1}) \quad \forall t \geq K \qquad (5) \end{aligned}$$

Taxes and benefits Individuals face a tax and benefit system which is specific to their age. Taxes are levied on earnings and state pension income less savings, $s_{i,t}$ (equivalently plus asset drawdown i.e. negative savings), and there is no tax on the return to savings i.e. taxation of savings follows an "exempt-exempt-taxed" system. The only benefit is an income floor. If an individual's post-tax level of income is lower than some age-specific floor, then it is increased to this level. We denote this system with the following function:

$$\tau_t(e_{i,t} + p_{i,t} - s_{i,t}) \qquad (6)$$

Choices Each period individuals decide how much to save in a risk-free asset and consume their after-tax income, according to a budget constraint:

$$c_{i,t} = \tau_t(e_{i,t} + p_{i,t} - s_{i,t}) \qquad (7)$$

The risk-free asset has an age-specific rate of return over the agent's life, yielding an asset accumulation equation:

$$a_{i,t+1} = (a_{i,t} + s_{i,t})(1 + r_t) \qquad (8)$$

Borrowing is not allowed at any age:

$$a_t \geq 0 \tag{9}$$

2.1.2 Model solution

The maximisation problem faced by individuals (with subscript i suppressed for ease of notation) is:

$$V_t(a_t, v_t; ed) = max_{s_t}\big[u(c_t) + \beta s_{t+1} \int_{v_{t+1}} V_{t+1}(a_{t+1}, v_{t+1}; ed)\big]$$

$$\begin{aligned} s.t.\ c_{i,t} =& \tau_t(e_{i,t} + p_{i,t} + db_{i,t} - s_{i,t}) \\ a_{i,t+1} =& (a_{i,t} + s_{i,t})(1 + r_t) \end{aligned}$$

There is no analytical solution to this maximisation problem. We solve the model recursively to obtain the 'decision rule'. In other words, we work out for every possible state of the world that an individual could end up in, what the expected consequence of any savings choice would be and therefore what the best decision they could make is (in expectation). We can then use this to simulate the lifecycle of different individuals, starting in the first period and making the best savings choice given realised circumstances until the end of each individual's life.

2.2 Parameterisation

We use our model to (i) quantify how wealth accumulation is affected by varying different economic and demographic conditions individually (i.e. while holding all else equal), and then (ii) quantify how different generations' wealth holdings may be expected to vary when we simultaneously vary all economic and demographic conditions between generations but continue to hold preferences constant.

Individual preferences are therefore held constant in all our simulations. There are two preference parameters: the discount factor β and the coefficient of relative risk aversion γ. The assumed level of patience is pivotal, and has an overriding impact on the wealth levels individuals would be simulated to hold. We set the discount rate equal to the (baseline) risk free interest rate (so that the discount factor, β, is equal to $1/(1 + r) = 0.971$). We set the coefficient of relative risk aversion to 3, in line with Crawford and O'Dea (2018) and Scholz et al. (2006).

The other parameters in our model - those relating to part of the earnings process (the deterministic function $f_{ed}(age_t)$), the risk free rate of return (r_t), the state pension system (the function $g_{ed}(e_{i,K-1})$), the tax system (the function $\tau(.)$), the number and timing of children (the equivalisation factor θ_t, survival probabilities, (S_t), and the retirement age, (K) - are ones we vary to examine their impact on saving behaviour. The values used for these, the empirical data on which they are based, and the simulated effects of varying these on saving behaviour are discussed in section 3.

2.3 Simulation

We solve the model for each of three education groups, for each permutation of circumstances we examine. We then simulate the model 10,000 times for each education-circumstance permutation. Each of these simulations is an individual, with savings choices (and hence wealth) differing across individuals because of different realisations of earnings uncertainty. By simulating multiple times we generate a distribution of experiences for each parametrisation of the model.

The output of the model is 30,000 simulated life histories for each parametrisation of the model, detailing earnings and savings (and therefore wealth) at each age. When describing our results we focus on (i) average (mean) wealth by age, (b) average saving rate (mean saving divided by mean gross income) by age, and (c) the "gross income replacement rate" – defined as gross income in the first year of retirement divided by mean gross income over the final 15 years of working life. These represent three of the most common metrics that are used by those making comparisons of the wealth, savings or preparedness for retirement of different generations.

3 The effect of economic and demographic circumstances on saving behaviour

We turn now to illustrating how various economic and demographic circumstances have differed between generations, and use our model to simulate the impact that each of these circumstances could have in isolation (i.e. holding all else equal) on saving behaviour and wealth accumulation. The 'baseline' parameterisation, from which we vary one aspect at a time, holds the rate of return at 3% in working life and 0% in retirement, and all other circumstances at the parameters appropriate for the 1950s generation.[3] In the Appendix, we show the results of changing circumstances with different assumed levels of preference parameters, demonstrating the robustness of our main qualitative and quantitative findings to different preference assumptions.

3.1 Earnings

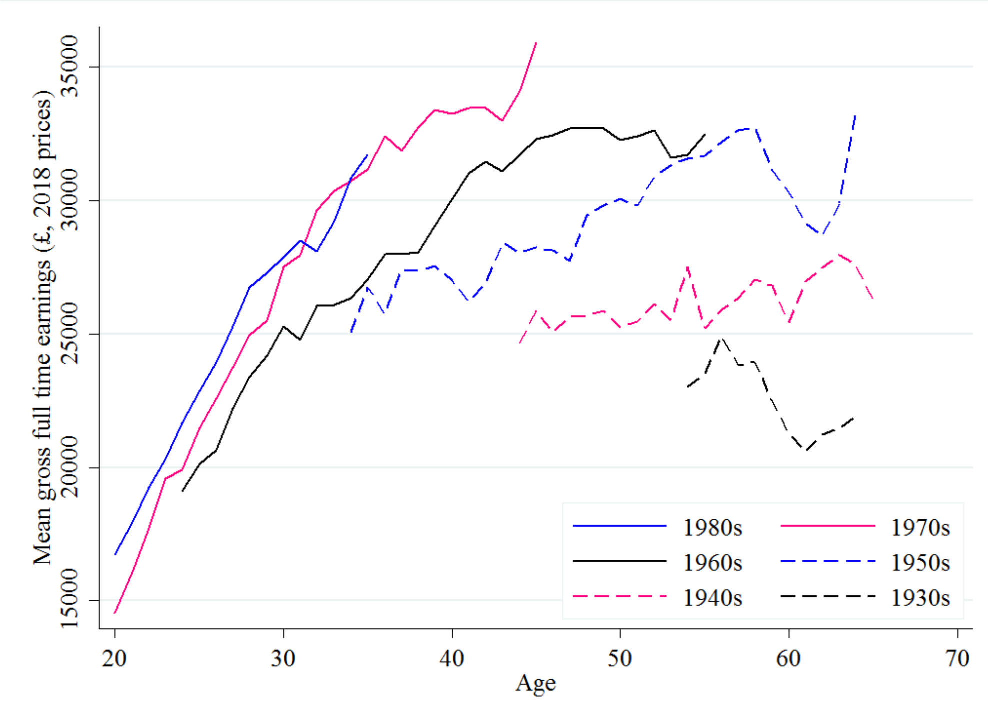
Earnings from work are, for almost all individuals, the primary resource that they have to fund their spending during working life and retirement. The earnings circumstances that an individual faces are therefore likely to be an extremely important driver of their retirement savings decision-making.

Figure 2 shows mean gross earnings for individuals working at least 30 hours per week, at different ages, for each of our cohorts. Due to data availability, we cannot compare all cohorts at the same age. However, comparing adjacent cohorts, we can see that those born later have generally earned more at the mean than the preceding cohort. The 1970s and 1980s cohorts have similar levels of mean earnings, when compared at the same age. In part this represents a genuine slowing of earnings growth across cohorts. But in part it is because only those born earlier in the 1980s have moved into full-time work within our data period, particularly when looking at older ages.

When considering the earnings environment faced by an individual of a given cohort, it is important to consider not only average earnings for that cohort, but also inequalities in earnings. These may feed through to inequalities in wealth accumulation. These inequalities may vary across cohorts as, for example, levels of education, or the returns to education in terms of earnings, vary, or structural changes in the economy take place.

[3]The rate of return on assets is held constant at a rate of 3% in working life and 0% in retirement, rather than using the interest rates we calculate for the 1950s generation, as the 1950s cohort enjoyed particularly high interest rates. As discussed in section 3.4, the outputs of the model are particularly sensitive to the interest rates faced by agents. We use a version of the 1950s earnings process that removes cyclical fluctuations, resulting in smoother profiles for savings and wealth that make it easier to interpret the impact of changing circumstances.

Figure 2: Mean gross full time individual earnings, by age and cohort



Source: UK Household Longitudinal Study, all waves.

It is also important to consider the uncertainties that individuals face in their future earnings, and the potential for 'shocks' to move them up and down the earnings distribution. These can have large implications for saving behaviour, particularly motivating the accumulation of wealth to insulate consumption from periods of transitory low income. The frequency and permanence of 'shocks' to earnings will also determine the extent to which the inequalities in earnings seen at any one point in time reflect significant inequalities in individuals lifetime earnings, and therefore inequalities in resources from which to make savings.

3.1.1 Earnings process estimation

To quantify the earnings processes, and its dependence on age, time, and education, and the uncertainties faced by individuals, we employ canonical models of earnings from the labour economics literature (see, for example, Meghir and Pistaferri (2010)). In selecting our method for estimating individual earnings processes, we faced a trade-off between using a dataset with a longer time period but only cross-sectional data (such as the Family Expenditure Survey or Living Costs and Food Survey) or a panel data set covering a more limited time period (the UK Household Longitudinal Survey (UKHLS), composed of both the British Household Panel Survey and its successor, Understanding Society). Many of the techniques for estimating stochastic earnings processes rely on the availability of panel data. Exceptions to this are the techniques that use changes in the variances of earnings and consumption to identify pass-through of earnings or income changes to consumption and so infer properties of the earnings process (see Blundell et al. (2013)). In the context of individual earnings (as opposed to household income) and in the presence of a progressive tax system, identification requires strong assumptions and obtaining precise estimates of earnings process parameters proved challenging. We therefore decided to exploit panel data techniques using the UKHLS.

We assume that the log earnings process takes the following form:

$$\ln(y_{i,t}) = \delta_t + \sum_{k=1}^{18} DP_{i,t}^{k} + \sum_{c=30s}^{80s} \sum_{ed=1}^{3} \beta_{c,ed} cohort_i \times ed_{it} + \sum_{a=16}^{64} \sum_{e=1}^{3} \gamma_{a,ed} age_{i,t} \times ed_i + v_{i,t} \quad (10)$$

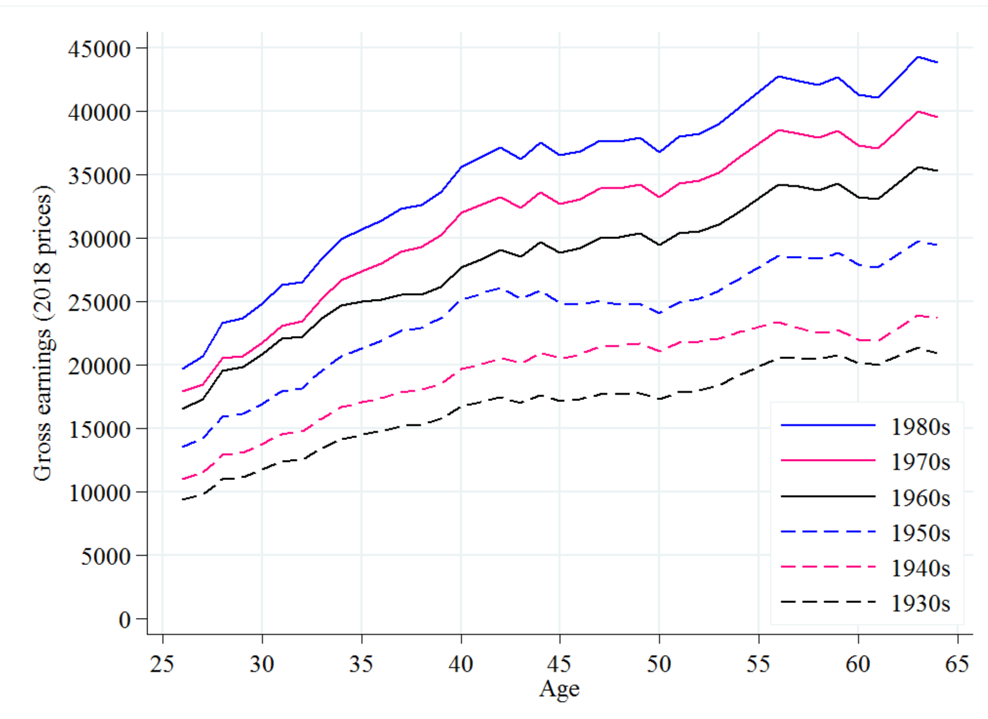
Where δ_t is a linear time trend and $\sum_{k=1}^{18} DP_{i,t}^{k}$ are a series of time effects constrained to sum to zero (see Deaton and Paxson (1994)). We control for the interaction of education and cohort dummies as well as the interaction of a full set of age dummies with education dummies. The interpretation is that the average level of earnings can vary across cohort-education groups and that earnings are assumed to vary with age in a way which is specific to the individual's education level, but does not depend on their cohort.

This form allows us to control flexibly for the effects of age, while allowing the returns to different levels of education to vary across cohorts. Separation of time effects into a linear time trend and a cyclical fluctuations around this means that we can extrapolate to years outside our data period under the assumption of a continuing time trend and no cyclical fluctuations. We attempted to estimate a specification whereby age effects could vary across cohorts, but given the window of observation for some cohorts, this was not a credible approach.

The evolution of the residual component of earnings is modelled as a discretized first-order Markov process (see De Nardi et al. (2019)). We assign individuals to quintiles of the residual distribution for their age and education group. We then calculate a quintile-to-quintile transition matrix for each age- and education-group. We carried out this estimation for each cohort separately and did not find significant differences in either (i) the distribution of residuals or (ii) the quintile-to-quintile transition matrixes. We therefore assume that the residual follows the same education-specific process for each cohort and carry out the estimation with data pooled across cohorts.

Figure 3 shows the profiles for mean earnings for each cohort that result from this estimation process. Each cohort is predicted to earn more, on average, at each age, than did its predecessors. However, the growth rate of average earnings across cohorts is diminishing. Whereas average earnings for those born in the 1940s are 16% higher than for those in the 1930s, and the 1950s are 23% higher than for the 1940s, the subsequent cohort-on-cohort growth rates are 18%, 12% and 11% respectively. Differences in the shape of the earnings profiles reflect differences in when each cohort has experienced recessions or booms, with the period of low wage growth following the financial crisis most prominent.

Figure 3: Predicted mean gross full time individual earnings, by age and cohort



3.1.2 Results of varying the earnings process

We solve and simulate our model using the earnings process estimated for each generation in turn.[4] Figure 4 shows the simulated mean asset holdings and savings rates. We see that mean assets at retirement rise when moving through the cohorts, though this increase in assets-holdings is smaller in percentage terms for the latter three cohorts. This reflects the trends in the levels of median earnings across cohorts seen in Figure 2 and Figure 3.

[4]We use the 1950s tax and benefit system and state pension system and scale this up or down with average earnings so that tax thresholds and benefit levels are the same percentage of average earnings for each cohort.

Savings rates are similar across cohorts, reflecting the fact that, given we assume the same age-profile of earnings, differences between cohorts are primarily level shifts in earnings, which lead to a proportionate rise in consumption and savings, and therefore the same savings decisions when expressed in percentage terms. The reason that the savings rates are not exactly the same across cohorts in our simulations is due to the fact that cyclical movements in wages affect all cohorts in the same years, but therefore at different ages. For example, we see the effects of the drop in real wages that occurred following the financial crisis in the late 2000s affect the 1940s cohort in their early-to-mid-60s, the 1950s cohort in their early-to-mid-50s, the 1960s cohort in their early-to-mid-40s, and so on, as it results in a relatively low savings rate for these cohorts at those ages. It is notable that this timing of the economic cycle means that the wealth accumulation of those born in the 1970s does not exceed that of those born in the 1960s until they reach age 39.

Figure 4: Wealth and saving profiles - effect of different earnings processes

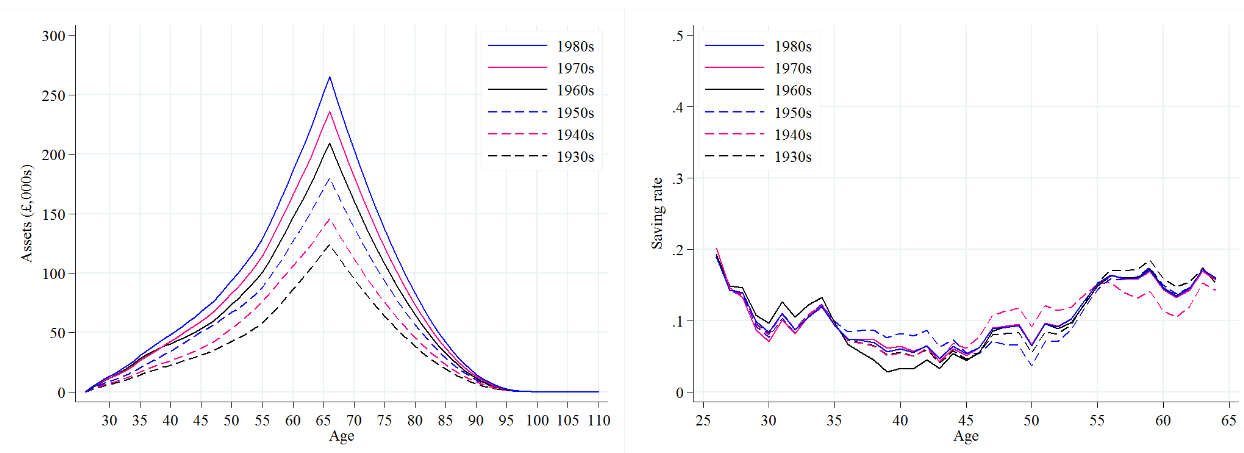


Table 1: Wealth and replacement rates - effect of different earnings processes

Scenario	Wealth at 50		Wealth at retirement		Gross income	Average
	£,000s	Relative to 1950s	£,000s	Relative to 1950s	replacement rate	savings rate
1930s	42.7	63.8	124.1	68.9	80.1	10.6
1940s	53.7	80.2	145.8	81.0	80.6	10.6
1950s	66.9	100.0	180.1	100.0	80.4	10.6
1960s	73.7	110.2	209.4	116.2	80.3	10.5
1970s	83.1	124.2	236.0	131.0	80.2	10.6
1980s	94.0	140.4	265.1	147.2	80.0	10.7

3.2 Taxes and benefits

The tax and benefit system that an individual faces has the potential to effect their optimal savings decisions by changing both the total financial resources that they have available and by changing the rate at which they can move consumption between periods by saving.

There are many aspects to the tax and benefit system that could impact upon savings decisions. In line with our focus on individuals whose income comes from paid employment, we look at taxation of earnings and the minimum level of income that is effectively guaranteed for an individual by the social security system. We therefore focus on Income Tax, National Insurance and Unemployment Benefit/Jobseeker's Allowance.[5]

We model the tax treatment of savings as an "exempt-exempt-taxed" (EET) system, in line with the treatment of private pension savings in the UK over the period we are examining. (This means that the amount saved is exempt from income tax at the point at which it is saved, returns are exempt from taxation, but that the withdrawals are taxed as income when the wealth is accessed.) In reality, other forms of savings are treated differently – for example, savings into many other types of assets must be made out of post-tax earnings and have returns that are subject to taxation. Furthermore, there are annual and lifetime limits to the amount of pension saving that can be made from pre-tax earnings. We are therefore abstracting from these details in modelling a simple "EET" system. This is necessary given that we are working within a model with one type of asset only. Nevertheless, we believe this treatment of savings to be most appropriate given our focus on retirement savings and our aim of capturing the most important quantitative changes across cohorts.

3.2.1 The tax and benefit system over time

The tax and benefit system has been under near-constant change over the past half-century, meaning that individuals born at different points in time have experienced different tax and benefit systems. For a comprehensive account of the changes in the tax and benefit system over time see Pope and Waters (2016). Here, we briefly describe the most important trends in tax rates and benefit provision over time.

Taxe rates on earned income have been on a decreasing path since the late 1970s. As documented in Table 2, the basic rate of income tax was 30% in 1975-76 and now stands at 20%. A reduction in higher rates culminated in the consolidation, in 1988-89, of a range of higher rates between 40% and 60% into one 40% band. These sharp falls in income tax rates have been partly offset by increasing rates of National Insurance contributions (NICs) where

[5] Of course, the economic incidence of these taxes may not be 100% on earnings. Likewise other taxes, such as corporation tax and employer social security contributions, may be partly incident on individual earnings and therefore relevant to our analysis. We abstract from these issues here.

the main rate for employees has risen from 5.5% in 1975 to 12% today. The rates shown in the table are far from an exhaustive description of the tax system. In addition to the rates shown, a lower Income Tax 'starting' rate was in place from 1992-93 to 2007-08 and a higher 'additional' rate has existed since 2010-11. The structure of NICs has changed over time and multiple different rates are payable depending on whether someone is employed or self-employed and has opted in or out of certain systems.

The overall amount of tax that an individual pays depends on tax rates and the income thresholds above which these apply. Tax thresholds have generally increased over time in real terms. For example, the personal allowance threshold (below which an individual is not liable for income tax) has increased from £4,000 to £11,000 between 1975-76 and 2015-16 (when expressed in 2016 prices).

Table 2: Personal tax rates on earned income for selected years (%)

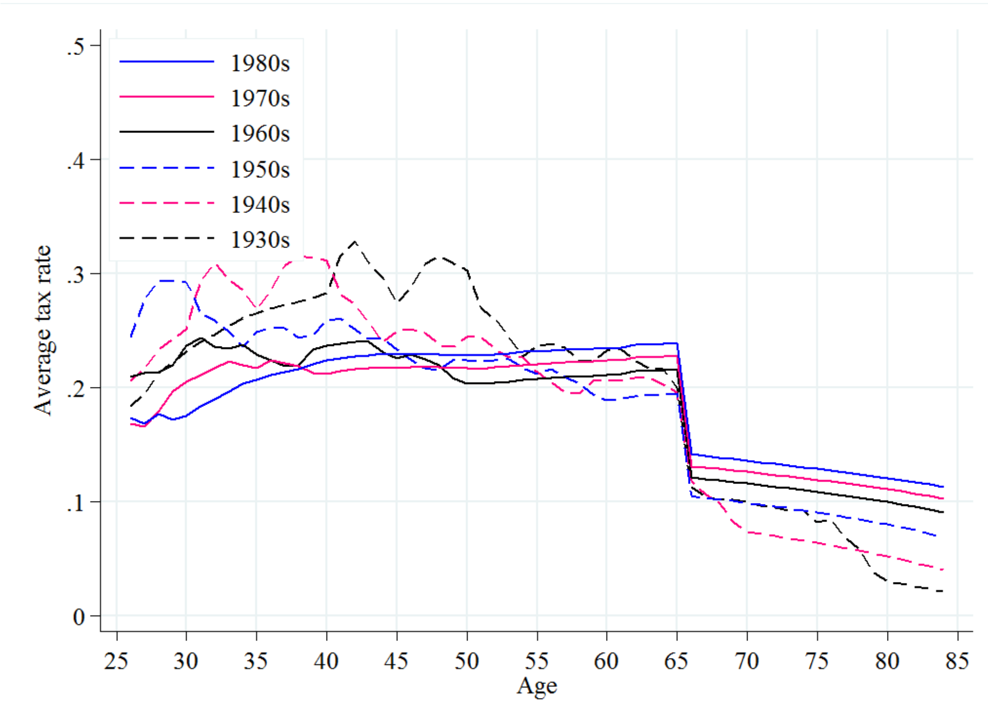
Year	Income Tax		National Insurance contributions
	Basic Rate	Higher rate(s)	Main rate (Employee, Class 1)
1975	35	40-75	5.5
1985	30	40-60	9
1995	25	40	10
2005	22	40	11
2015	20	40	12

The welfare system includes a number of benefits payable to those who are unable to work or to find work, or who have low incomes. The design and take-up of benefits has varied dramatically across cohorts in ways that are outside the scope of this analysis. Given that we do not extensively model ill-health, we restrict our examination to the main benefit for those looking for work: unemployment benefit or, since 1996-97, job-seeker's allowance (JSA). The value of the benefit has typically varied between amounts equivalent to £3000 to £4000 per year.

Direct comparison of tax and benefit systems over time is complicated by the fact that, while tax rates that are set in percentage terms are to a degree comparable across cohorts, comparisons of allowances and benefit levels in real terms across cohorts may be misleading, as the same real-terms threshold will sit at a different point in the distribution of earnings at different points in time. Furthermore, an individual's tax rate is the combined impact of the extensive system of rates and thresholds.

Given this, we scale tax thresholds in line with the ratio of average cohort earnings to average 1950s cohort earnings. We solve and simulate our model for the 1950s cohort, subject to each of the constructed tax and benefit systems, and calculate average tax rates. The resulting average tax rates are plotted in Figure 5. There is a mild tendency for average tax rates to rise in early life and fall in later life, due to the progressive nature of the systems (we see this by looking at the 1980s cohort who by construction are assumed to face a time-invariant system). Tax reduces at retirement as individuals no-longer pay employee National Insurance contributions. Looking across cohorts, those born in the 1930s, 1940s and 1950s have seen substantial falls in average tax rates over the course of their lives.

Figure 5: Average personal income tax rates by age and cohort



3.2.2 Results of changing the tax and benefit system

We now examine the consequences for savings rates and wealth accumulation of the changing tax and benefits system, by simulating and solving our model for different tax and benefit systems. Figure 6 and Table 3 show the results.

The earlier cohorts, who experience higher taxation of their working-life income relative to their retirement income, hold slightly less wealth into retirement; on average when facing the tax system of someone born in the 1930s individuals choose to hold 91% of the average amount of wealth that they would choose to hold when facing the 1950s tax system. Correspondingly, savings rates rise slightly as we move to later tax systems. The gross replacement rate of those facing the tax system of later cohorts is marginally higher due to lower average tax rates on the whole, across their lives. Figure 7 demonstrates that these patterns are replicated at different points of the asset distribution, illustrating that the change in tax systems has had a similar effect for those with different levels of earnings.

Figure 6: Wealth and saving profiles - effect of different tax and benefit systems

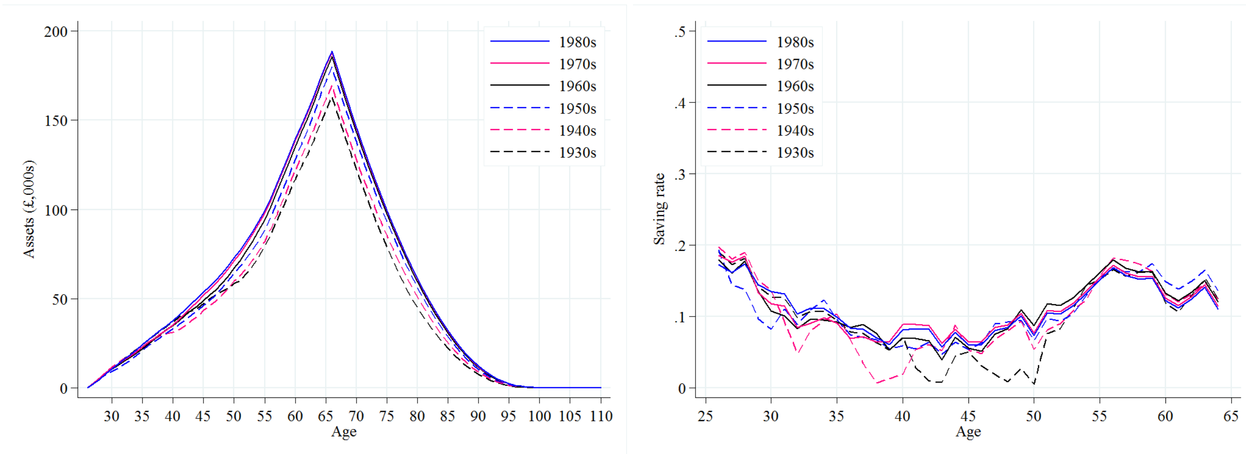


Table 3: Wealth and replacement rates - effect of different tax and benefit systems

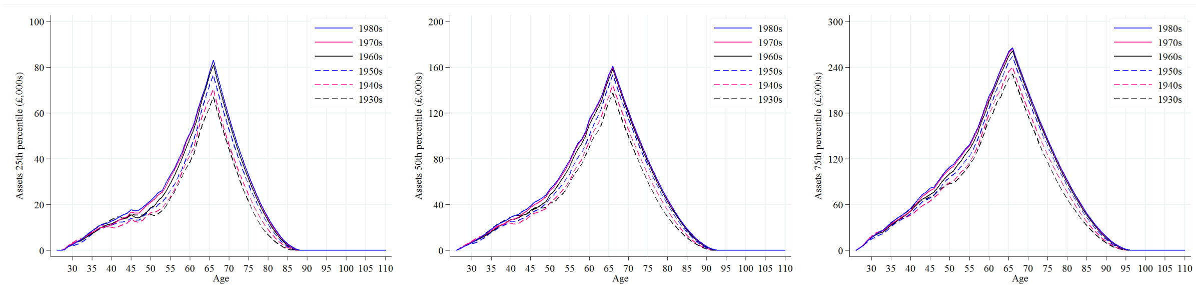
Scenario	Wealth at 50		Wealth at retirement		Gross income	Average
	£,000s	Relative to 1950s	£,000s	Relative to 1950s	replacement rate	savings rate
1930s	58.3	90.7	163.4	90.8	79.7	9.7
1940s	59.7	92.9	169.7	94.3	81.4	10.1
1950s	64.2	100.0	179.9	100.0	80.0	10.7
1960s	67.0	104.2	185.8	103.3	80.6	11.0
1970s	71.2	110.8	188.3	104.6	80.9	11.0
1980s	72.8	113.4	188.9	105.0	81.0	11.0

By modelling individuals' choices subject to the actual tax and benefit system faced, we are implicitly assuming that individuals anticipated tax changes that were to come and make their saving plans accordingly. This is unrealistic but we do not have data on what tax rates individuals expected that they would face in the future and modelling individuals with changing expectations about the tax system would be an involved, if not infeasible, approach.

If individuals in earlier cohorts did not anticipate, or only partially anticipated, that tax rates would fall over time, then their optimal savings rates would have been higher than those shown in our simulations, over their working life.

Figure 7: Wealth profiles - effect of different tax and benefit systems at different points of the wealth distribution

(a) 25th percentile (b) 50th percentile (c) 75th percentile



3.3 Public pensions

The amount that an individual will choose to save for their retirement will depend on the income that they expect to receive from a publicly provided pension. Roughly speaking, the more generous the public pension provision, the less an individual will save privately in order to achieve a smoothed path of living standards over their lifetime.

3.3.1 The changing public pension system

The UK public pension system - known as the 'state pension' system - is complex, with different components having existed at different points in time, and the rules for accrual of benefits from each component also changing over time.[6] Different generations have therefore faced different circumstances for their accrual of public pension benefits.

To give an extremely simplified summary, the state pension began as a relatively flat rate system (where entitlement depended on years of activity but not earnings). A significant earnings related component was added in 1978, but the generosity of accrual to this component was gradually eroded over time. From 2016 onwards, the state pension has been entirely flat rate again - there is no longer any earnings related component. Furthermore, the activity requirements have been broadened such that entitlement to the full flat rate amount will be near universal.

There are therefore two important aspects of the public pension system that have varied between generations that would be expected to influence wealth accumulation: the average generosity and how related benefits are to earnings (or, equivalently, how the average generosity varies with lifetime income).

Another parameter of the public pension system that has changed over time is the age

[6]For a comprehensive history of the UK state pension system, see Bozio et al. (2010)

from which public pension benefits can be received. This is discussed separately, in section 3.7.

3.3.2 Modelling public pension entitlements

In this section, we describe the way in which we capture the public pension system experienced by different generations within our model. We model a simplified version of the public pension – in part because computational feasibility limits the complexity of the system that we can model, but also because, given the illustrative nature of our modelling, it is instructive to reduce the complex rules into a reduced set that can therefore be compared and whose implications can be more fully explained.

As described in 2, we model the state pension system experienced by an individual as a function of their final working-life earnings. Specifically, we assume that the pension system is of the form:

$$\begin{aligned} p_{i,t} &= 0 && \forall t < K \\ p_{i,t} &= \alpha_{ed} + \beta_{ed} e_{i,K-1} && \forall t \geq K \end{aligned} \tag{11}$$

i.e. an individual's state pension entitlement is equal to some fixed amount plus some percentage of their final earnings.

Table 4 shows the estimated pension system parameters for each cohort- and education-group. We express α as a percentage of average earnings at the end of working life, to abstract from changes in the real-terms generosity of the pension system that reflect state pensions keeping pace with rising average earnings.[7] Note this captures not just the 'flat rate' component of the pension, but also the amount of earnings-related component that is not 'explained' by final earnings.

Table 4: Pension system parameters by cohort- and education-group

Scenario	α (as a % of mean final earnings)			β (%)		
	Low-ed	Mid-ed	High-ed	Low-ed	Mid-ed	High-ed
1930s	37.1	38.4	43.7	4.4	5.6	3.9
1940s	42.8	45.9	50.0	2.0	2.0	1.3
1950s	38.3	39.3	41.4	0.2	0.5	0.5
1960s	31.6	31.8	31.9	0.1	0.0	0.1
1970s	35.8	35.8	35.8	0.0	0.0	0.0
1980s	35.8	35.8	35.8	0.0	0.0	0.0

[7] Note that average earnings is the average across all individuals in the cohort, such that percentages are comparable across education groups.

The average generosity of the state pension system is highest for those born in the 1940s, and declines for the two subsequent cohorts (who experienced less generous earnings-related pension systems), before rising slightly for the 1970s and 1980s cohorts (due to an increase in the generosity of the flat rate component of the pension from 2016 onwards).

Within each cohort from 1930s to 1960s, those with higher earnings have higher pension entitlements – reflected in the higher α and positive β parameter. However, the degree to which pension entitlements are related to earnings becomes weaker moving through cohorts, seen both by comparing the difference in α between education groups and when looking at the magnitude of the β parameters. For the 1970s and 1980s cohorts, entitlements are fully flat rate as these generations no longer accrue any earnings related component, and entitlement to the flat rate component is now near universal.

3.3.3 Results of changing the state pension system

We solve and simulate our model using each state pension system, varying the parameters α and β across the six cohort scenarios in Table 4, while maintaining all other parameters unchanged. The implications of varying the pension system for the mean wealth holdings and savings rate are shown in Figure 8.

Changing the state pension system has a large impact on wealth accumulation and savings rates. Table 5 shows that wealth accumulation at the point of retirement is 14% lower for those subject to the 1940s pension system as compared to the 1950s pension system, and 18% higher for those subject to the 1960s system. These relative wealth and savings trajectories reflect the relative generosity of each pension system. This is also reflected in the gross income replacement rate: the more generous is the state pension system, the lower are savings during working life and the higher is consumption at all points in the lifecycle. In terms of overall wealth accumulation and savings rates, 1970s and 1980s cohorts are set to experience pensions systems that lie between that of the 1950s and 1960s cohorts.[8]

Changing the pension system has different impacts for those at different points on the earnings distribution. We illustrate these in Figure 9 by showing profiles, for each cohort, that show the level of wealth held by individuals at different points in the wealth distribution at that age. We can see that while changing the state pension system has a bigger impact on the absolute amount of wealth held at higher points in the wealth distribution (as changes in the earnings-related component of state pensions lead to greater changes in entitlements for these individuals), the impact in proportional terms is higher at lower points in the wealth distribution (as the flat-rate component of state pension entitlement means it makes up a

[8]Note that the 1970s and 1980s pension systems are identical and so simulated paths for these groups overlap.

Figure 8: Wealth and saving profiles - effect of different pension systems

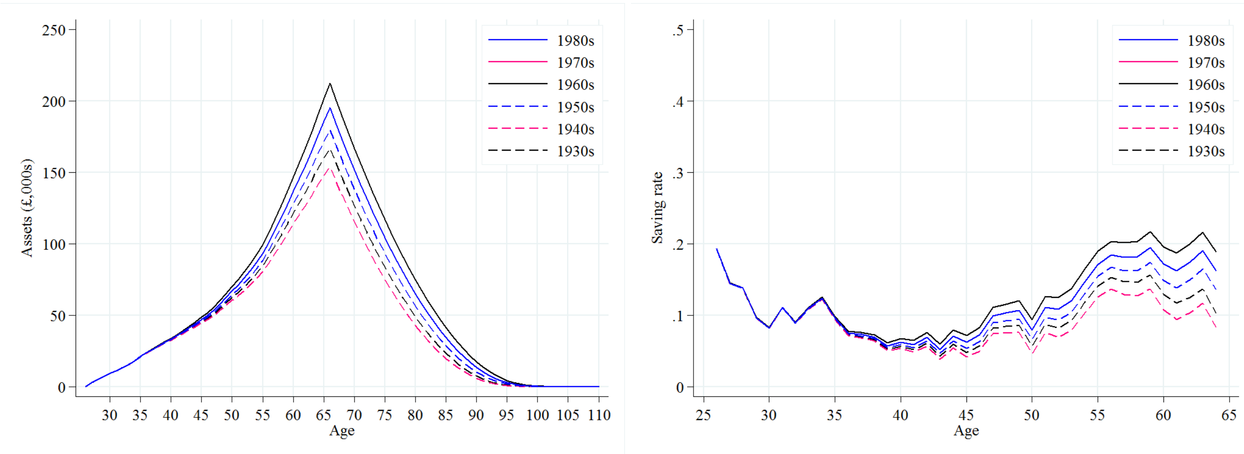


Table 5: Wealth and replacement rates - effect of different pension systems

Scenario	Wealth at 50		Wealth at retirement		Gross income	Average
	£,000s	Relative to 1950s	£,000s	Relative to 1950s	replacement rate	savings rate
1930s	62.4	97.2	167.0	92.8	82.7	9.8
1940s	60.5	94.1	153.9	85.6	84.8	9.0
1950s	64.2	100.0	179.9	100.0	80.0	10.7
1960s	70.0	109.0	212.3	118.0	75.1	12.8
1970s	66.8	104.0	195.3	108.6	77.5	11.7
1980s	66.8	104.0	195.3	108.6	77.5	11.7

larger share of the lifetime wealth of those with lower earnings).

3.4 Rates of return on assets

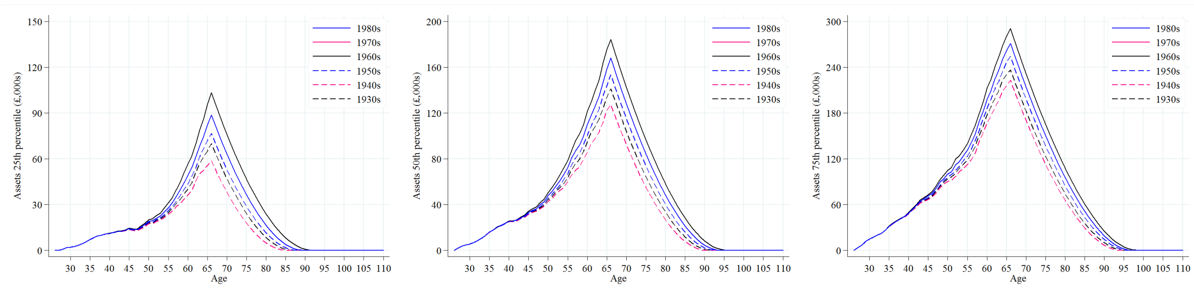
An important determinant of individuals' savings decisions is the return that they expect to receive on their savings. For individuals who will always hold net positive assets – as the individuals we consider always will – an increase in interest rates increases the real value of an individual's lifetime income while increasing the rate at which current consumption can be exchanged for future consumption. The former effect should act to increase consumption at all ages (i.e. decrease savings rates at all ages), whereas the latter effect should act to shift the timing of consumption to later in life i.e. saving happens earlier in life. The net effect is that consumption later in life is increased, whereas consumption earlier in life may rise or fall, depending on the individual's preferences and the income process they face.

The rate of return that individuals receive on their assets can vary substantially over time, across different asset types and even across individuals.[9] Comprehensively assessing and

[9]See, for example, Fagereng et al. (2019) for evidence on individual-level heterogeneity in asset returns.

Figure 9: Wealth profiles - effect of different pension systems at different points of the wealth distribution

(a) 25th percentile (b) 50th percentile (c) 75th percentile



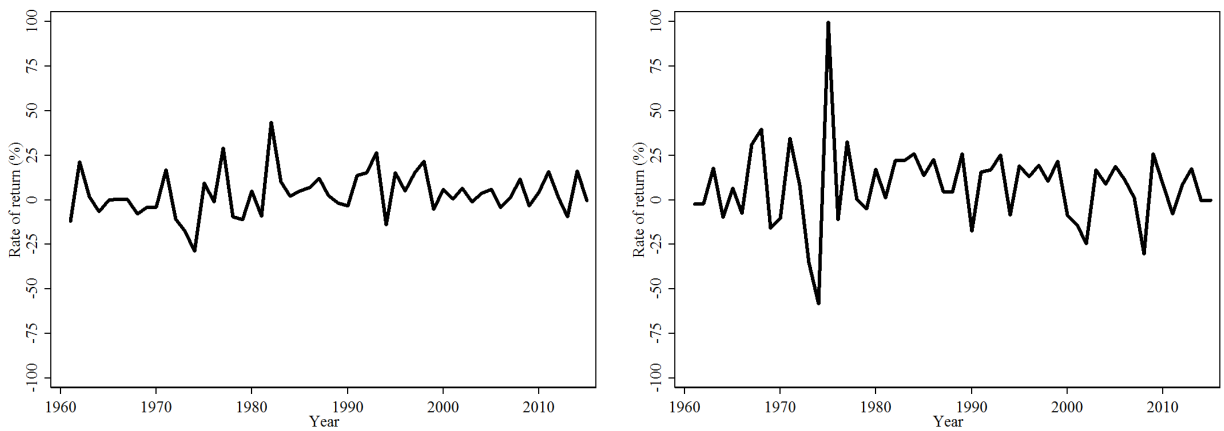
quantifying the different rates of return faced by different generations is therefore challenging. In what follows we focus on three main sources of heterogeneity in returns. The first is differences in rates of return across different assets classes. The second is variation in returns, within asset classes, over time. The third is variation in portfolio composition with age.

We first document variation over time in selected measures of the return on different asset classes. Figure 10 shows the annual real rate of return for UK gilts and UK equities over time. In both cases, the return is composed of both the capital appreciation and any income, and is deflated by inflation. The portfolio of gilts has an average maturity of 20 years (15 years from 1992) and the return on equities is for the FTSE All-Share index. More details can be found in Barclays (2016), from which these data are taken. These two series might be thought to capture, respectively, the rates of return on holdings of risk-free and risky financial assets. Looking at these measures, we can see that returns vary considerably from year-to-year.

A large proportion of household wealth is held in owner-occupied housing. The 'direct' financial return on this asset is composed of the capital appreciation in the value of the house, net of any mortgage interest payments. In addition, the owner receives a flow of housing services, which can be seen as a financial return in so far as they mean that the owner avoids having to make the rental payments that would required to rent an equivalent property. Figure 11 shows the annual increase in an index measuring the value of properties sold, a measure of capital appreciation, as well as an measure of typical mortgage interest rates. Fluctuations in house prices have been large in some years, though the dynamics from year-to-year are less volatile than for financial assets. Mortgage interest rates have varied only modestly over time, as compared to other components of the rates of return. Having fluctuated during periods of elevated inflation in the 1970s, there has been a general decline in rates since the early 1980s, interrupted by the financial crisis.

Figure 10: Real rates of return for UK Gilts and Equities

(a) Long-dated gilts (b) Equities (FTSE All-Share Index)



Note: Rates of return on gilts and equities include both income and capital appreciation. Gilt rates are based on a portfolio of UK gilts designed with an average maturity of 15-20 years. Equity returns are based on the FTSE All-Share index. For more details, see Barclays' *Equity Gilt Study* (2016).

To calculate an overall rate of return for an individual in a specific year, we combine the above information on returns to different asset types with information on the share of wealth held in different assets. For individuals of working age, we use data from the UK Wealth and Assets Survey to estimate the proportion of mean net household wealth per person held in net housing wealth, as a function of age.[10] This yields a share of wealth held in housing that declines from 55% at age 26 to 29% at age 64. We assume that wealth not held in housing is composed 70% of equities and 30% of gilts until age 50 and that the share in equities then declines linearly to reach 20% by age 75. In order to calculate the rate of return on housing wealth, we require information on how net housing wealth is composed of gross housing wealth and mortgage debt. We take the composition implied by the leverage ratio function estimated and reported in Crawford and O'Dea (2018), which calculates an average leverage ratio as a function of age in a way analogous to our calculation for the housing share of net wealth.[11] We assume a service flow of housing implied by the OECD's historical series for the UK house price to rent ratio.[12] Finally, we assume that on retirement, the housing share of

[10]Specifically, we use OLS to estimate a specification for the percentage of net household wealth per person that is held as net housing wealth, with a constant, age and age squared as explanatory variables. The estimated coefficients on these variables are 0.6291, -0.0016 and 0.00006 respectively.

[11]According to this function, the leverage ratio (mortgage debt divided by gross housing wealth) declines from 55% at age 26 to 6% at retirement. See Crawford and O'Dea (2018) for more details of estimation.

[12]The implied service flow falls from around 2% of gross housing wealth to 1% over the period 1969 to 2018.

Figure 11: Annual increase in UK house prices and UK mortgage interest rate

(a) Annual increase in house prices (Nationwide) (b) Mortgage interest rate (Bank of England)

Note: The change in house prices is the annual change in the Nationwide Building Society index of all house prices. The mortgage interest rate is the "Effective Mortgage Rate" series taken from the Bank of England "Millennium of Macroeconomic Data for the UK" spreadsheet. Both series are deflated by the RPI.

wealth falls to zero. While this is a major simplification, it is consistent with agents moving into lower risk assets and beginning to draw on their wealth (including housing wealth) in retirement.

To produce illustrative scenarios for rates of return for each cohort, we use the above method and the data shown in Figure 10 and Figure 11 which cover the years up to 2015. For rates of return from 2016 onwards we use the mid-point of assumed future real rates of return for gilts and equities produced by the Financial Conduct Authority (FCA). These are -0.5% and 4.0%, respectively. For growth in house prices and the mortgage rate, we use Oxford Economics' long-term forecasts, which are 1.6% and 1%, respectively.[13] The OECD rent-to-price ratio has stabilised at around 1% in recent years and we assume that it remains at that level in future years. Table 6 summarises the return that each cohort experiences, as an annualised rate, both by asset type and as a total return given the portfolio we assume.

These average rates of return suggest that cohorts born later have experienced, and will continue to experience, lower rates of return than those born earlier. This is driven in part by the particularly high rates of return on equities in the 1980s, that benefited the 1930s, 1940s and 1950s cohorts, but not those born later, and the significant negative returns experienced

[13]The Oxford Economics long-term house price growth assumption is reported as a 3.6% nominal increase in FCA (2016). We deflate this to 1.6% real growth, by assuming 2% CPI inflation in future years. The mortgage rate is taken from the Oxford Economics report 'Forecasting UK House Prices and Home Ownership'.

by the 1950s, 1960s and 1970s cohorts during the early 2000s and the financial crisis of 2008-09. Also very important is the strong growth in house prices seen from the early 1980s until the financial crisis, which drove high returns to housing wealth for the 1940s and 1950s cohorts. Those born later didn't benefit fully from this growth but did share in the real-terms decline in house prices in 2010 and 2011 and then the weak growth since. The high returns to equities and to housing of the past are not expected in future years. The FCA's assumed future rates of return for gilts and equities, which we use in our modelling, assume that rates of return persist at lower rates than the average experienced over the post-war period - in particular, that annual total real returns on UK equities will average between 3.5% and 4.5% in future, compared to an annualised real return of 5.2% between 1960 and 2015.[14] The equivalent figures for gilts are -1% to 0% and 2.7%, respectively. The picture is similar for house price growth where Oxford Economics' long-term forecast for house prices increases of 1.6% in real terms compares to an annualised increase of 2.6% in the Nationwide index over the period 1960 to 2017.

Table 6: Annualised real rates of return

	Working life				Retirement		
Cohort	Equities	Gilts	Housing	Total	Equities	Gilts	Total
1930s	6.7	2.6	5.3	5.9	3.2	0.8	1.2
1940s	5.4	3.4	5.2	5.5	4.0	0.0	0.9
1950s	6.9	5.0	3.2	4.8	4.0	-0.5	0.5
1960s	4.9	3.1	3.3	3.7	4.0	-0.5	0.5
1970s	3.2	0.7	3.8	3.1	4.0	-0.5	0.5
1980s	4.0	-0.1	3.2	2.7	4.0	-0.5	0.4

Note: Rates of return are the geometric mean of returns over the relevant years for an individual born in the middle year of each cohort. Equity and Gilt returns are taken from Barclays' Equity Gilt Study (years up to 2015) and the midpoint of FCA assumed rates of return for 2016 onwards. Housing returns are based on the Nationwide House Price Index and Bank of England Effective Mortgage Rate series for the years up to 2016, and use Oxford Economics' house price and mortgage rate forecasts thereafter. Imputed rent is given by the OECD price to rent ratio.

There is substantial uncertainty around both future rates of return, and how different generations have invested in the past. We therefore show the results of solving and simulating our model with six illustrative interest rate scenarios. In each scenario, there is a 0% real rate of return in each year in retirement. In working life, the interest rate is time-invariant and varies between 1% and 6% across the 6 scenarios. Figure 12 shows the simulated wealth and savings rate profiles.

[14]FCA and Barclays' Equity Gilt Study

Relative to other circumstances considered, plausible differences in the real rate of return on savings lead to large percentage changes in wealth accumulation, replacement rates and savings rates. Individuals who face a higher interest rate hold more wealth at all ages as the higher rate of interest more that offsets their lower savings rate at younger ages. For example, when individuals face a 4% real interest rate they hold on average 13.8% more wealth at the start of their retirement than when facing a 3% real interest rate. Higher interest rates also translate into substantially higher gross income replacement rates as the fact that individuals are effectively made wealthier by a higher real interest rate means that they can afford higher consumption both in working life and in retirement and so their pension income plus asset drawdown in retirement makes up a larger percentage of their average working life earnings.

Figure 12: Wealth and saving profiles - effect of different rates of return

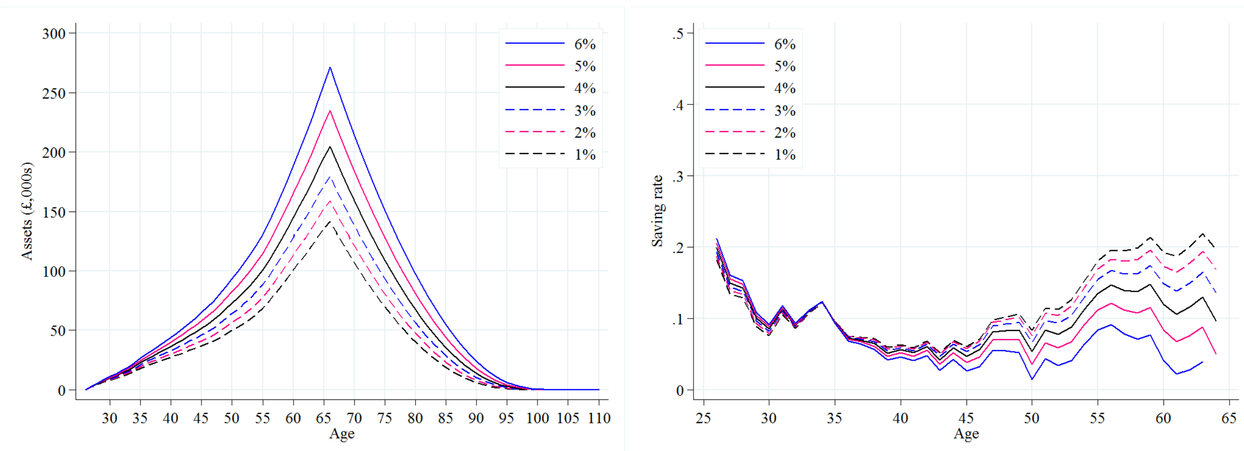


Table 7: Wealth and replacement rates - effect of different real rates of return in working-life

Scenario	Wealth at 50		Wealth at retirement		Gross income	Average
	£,000s	Relative to 3%	£,000s	Relative to 3%	replacement rate	savings rate
1%	50.0	77.9	141.8	78.8	73.8	12.2
2%	56.7	88.2	159.2	88.5	76.6	11.6
3%	64.2	100.0	179.9	100.0	80.0	10.7
4%	72.9	113.4	204.8	113.8	83.9	9.6
5%	82.6	128.5	235.0	130.6	88.6	8.2
6%	93.3	145.3	271.3	150.8	94.1	6.5

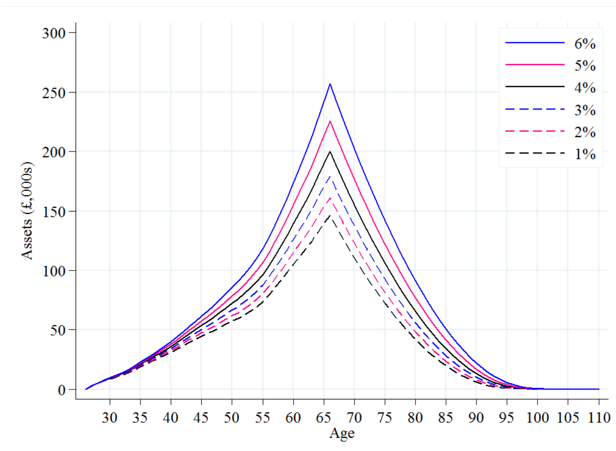
Note: in all 6 scenarios, the real rate of return on assets during the retirement years is 0%.

In these scenarios we assume that individuals are aware of the rate of return that they will receive on saving – in other words, the expected and actual rate of return are the same.[15]

[15] A similar assumption is in play with the other circumstances that we examine – we assume individuals are perfectly aware of future tax rate changes, for example.

This is clearly a strong assumption, with potentially important implications for how much we might expect wealth accumulation to differ with changes in the rate of return. Figure 13 and Table 18 therefore illustrate our simulations under the assumption that in each scenario individuals expect a real rate of return of 3% in each year, but experience an actual rate of return that may be higher or lower than this. We see that in this case, the impacts of changing the rate of return on wealth are smaller, but not dramatically so. The main effect of different rates of return is therefore the mechanical one of increasing (or decreasing) the stock of wealth held, rather than by influencing individuals' decisions over how much to save.

Figure 13: Wealth and saving profiles - effect of different rates of return when 3% return expected



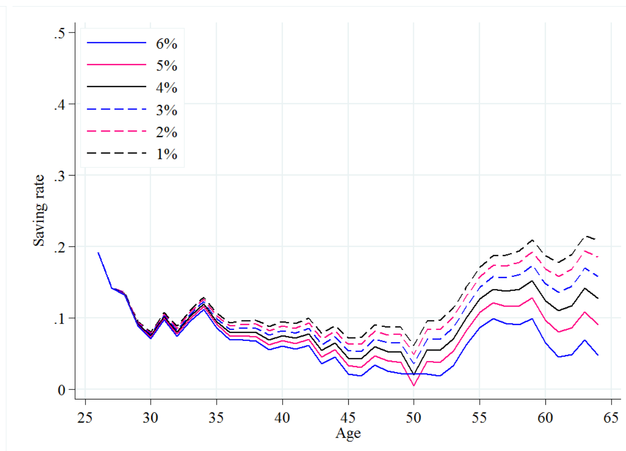


Table 8: Wealth and replacement rates - effect of different real rates of return when 3% return expected

Scenario	Wealth at 50		Wealth at retirement		Gross income	Average
	£,000s	Relative to 3%	£,000s	Relative to 3%	replacement rate	savings rate
1%	57.4	86.0	146.3	81.7	75.2	12.6
2%	61.8	92.6	161.3	90.1	77.7	11.6
3%	66.8	100.0	179.1	100.0	80.6	10.6
4%	72.3	108.3	200.3	111.8	83.9	9.4
5%	78.6	117.7	225.9	126.1	87.9	8.0
6%	85.7	128.3	256.9	143.5	92.7	6.5

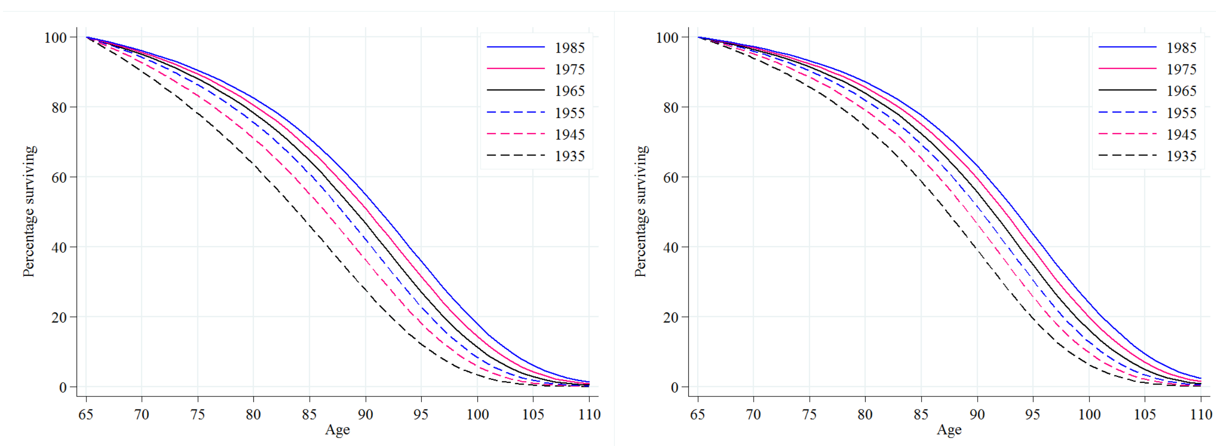
The effect of changing the rate of return on assets is sensitive to the assumed value for the coefficient of relative risk aversion. This parameter determines the willingness of individuals to shift consumption across time periods in response to financial incentives. In Appendix A.2 we show the impact of varying the rate of return under the assumption of a coefficient of relative risk aversion of 1.5 i.e. greater willingness to shift consumption over time.

3.5 Survival probabilities

In the UK as in many countries around the world, longevity at older ages has increased substantially for those born later, and is this trend is expected to continue. Figure 14 shows Office for National Statistics 'survival curves' for 65-year-old men and women born in the middle year of each decade.[16] The differences across generations are substantial. For example, whereas a man born in 1935 who attained the age of 65 had, on average, a 28% chance of surviving to age 90 or older, for those born in 1985, this figure is projected to be 55%. While it is projected that 19% of women born in 1935 who survived to age 60 will go on to survive to age 95 or older, for those born in 1985 this figure is projected to be 44%.

Figure 14: ONS survival curves for men and women born in different decades

(a) Men (b) Women



We explore the impact of this increasing longevity, assuming that individuals retire at the same fixed age (66), but allowing the probability of survival to each older age to vary. We show six scenarios – taking the ONS survival curve for a man born in the middle year of each cohort. With the same time spent in work, but a longer expected time spent in retirement, individuals in our model need to save more, and accumulate a larger amount of assets at the point of retirement, if they are to avoid a drop-off in their living standards in retirement.

Figure 15 shows the asset and savings rate profiles that result from simulating our model with different survival probabilities. Indeed wealth accumulation is greater, and savings rates are higher (mainly at the end of working life when earnings are greater) for later generations, compared to those born earlier.

[16] We use cohort survival curves for England and Wales as UK cohort survival curves are not available for cohorts born before 1951.

Figure 15: Wealth and saving profiles - effect of different survival probabilities

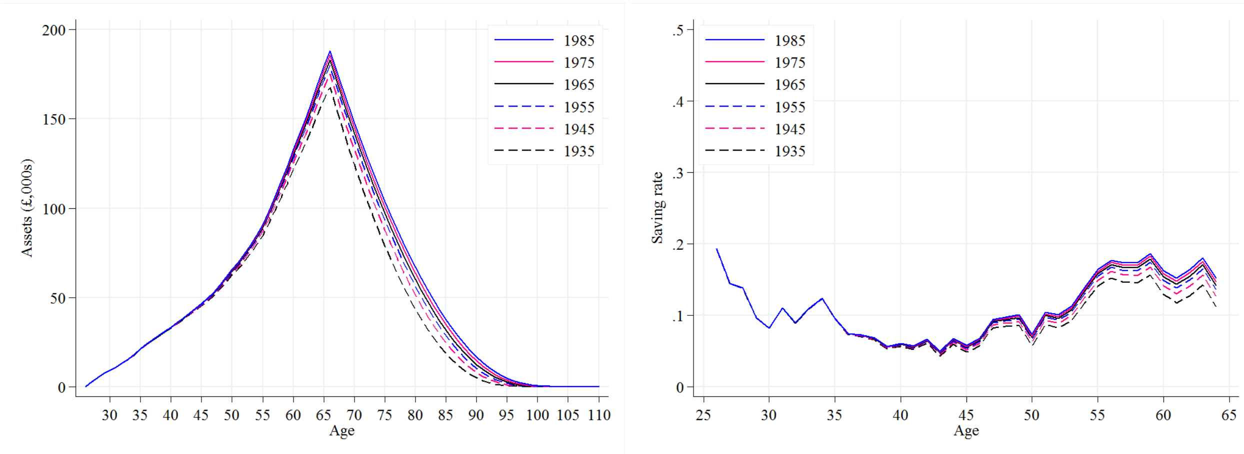


Table 9 shows the impact of changing survival probabilities on the amount of wealth and held at the point of retirement and on replacement rates and the average savings rate. Longer-lived individuals must spread fixed resources over a greater number of years and so consume less in each year, implying a lower replacement rate. For example, an individual facing the 1985 survival curve begins retirement with 5% more wealth, on average, than an individual who faces the 1955 survival curve, but has a lower replacement rate of gross income (78.6% as compared to 80.0%). This demonstrates that these two measures of retirement resources can move in opposite directions in response to a change in circumstances. Appendix A.1 shows the equivalent set of results but using the survival curves for women. Qualitatively and quantitatively the results are very similar. Women live longer on average and so savings rates are slightly higher, and replacement rates slightly lower than for men in all scenarios. Female life expectancy has not increased by the same degree as for men across the cohorts we examine and so the difference between the different survival scenarios for women is slightly smaller, proportionally, than for men.

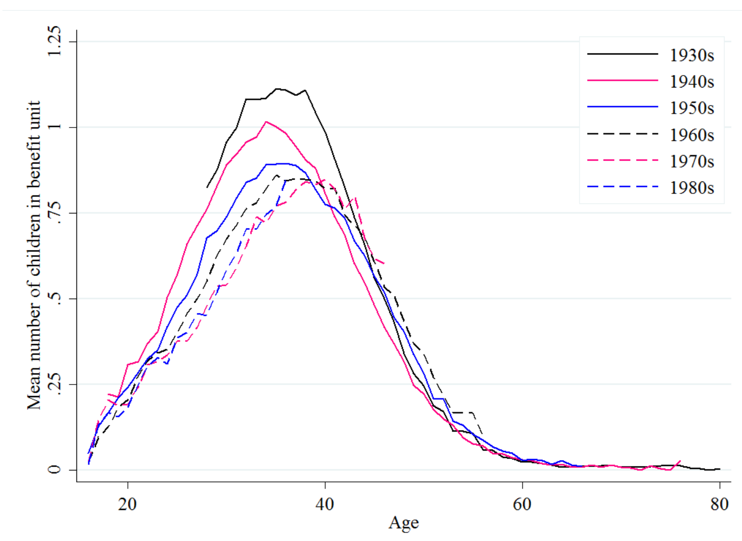
Table 9: Wealth and replacement rates - effect of different survival probabilities

Scenario	Wealth at 50		Wealth at retirement		Gross income	Average
	£,000s	Relative to 1950s	£,000s	Relative to 1950s	replacement rate	savings rate
1930s	62.5	97.3	167.8	93.3	81.9	9.9
1940s	63.6	98.9	175.2	97.4	80.7	10.4
1950s	64.2	100.0	179.9	100.0	80.0	10.7
1960s	64.7	100.7	183.0	101.7	79.5	10.9
1970s	65.1	101.4	185.8	103.3	79.0	11.1
1980s	65.5	102.0	188.3	104.7	78.6	11.3

3.6 Number of children

If an individual expects to face different costs of living at different points in their life, then this may impact the way in which they optimally time their savings. One of the main ways in which costs of living may vary over an individual's lifetime is if they need to support dependants, particularly children. Figure 16 shows the mean number of children that an individual has in their "benefit unit" (i.e. within their immediate family that they live with). We can see that, averaging over all individuals, including those in couples and those who are single, those born in the 1930s had on average between 1 and 1.1 children in their benefit unit between the ages of 31 and 39. This 'peak' number of children is progressively lower amongst later-born cohorts, and was 0.85 for the 1970s cohort (as some of the 1980s cohort are still in prime child-bearing age it is too early to give equivalent figures, but they look to be following a similar pattern to the 1970s cohort). Later cohorts also look to be having their children later in life with the 'peak' in the average number of children coming at age 35 for those born in the 1930s, as compared to 40 for those born in the 1970s.

Figure 16: Mean number of children per benefit unit, by age and cohort



Source: FES/EFS/LCFS, all years

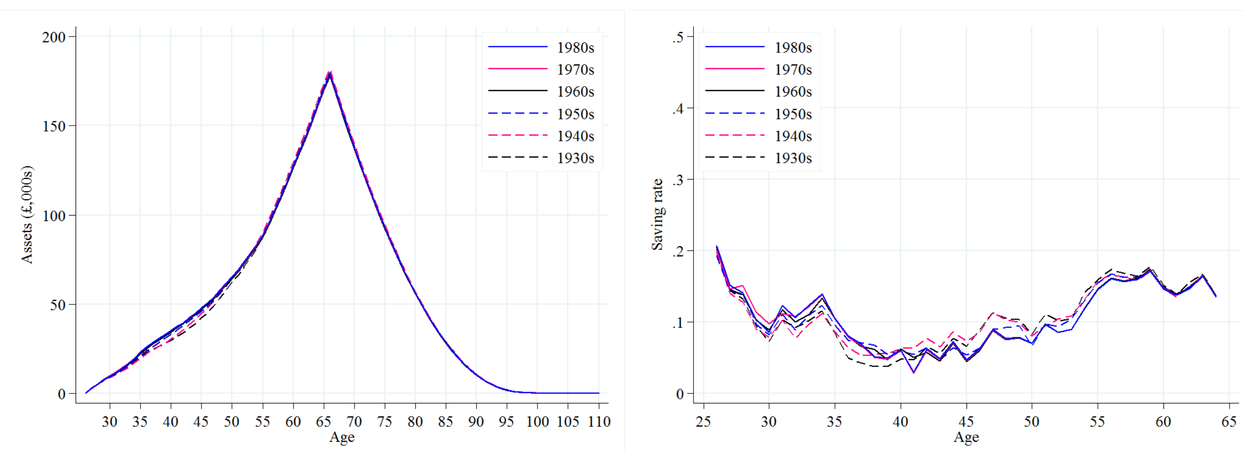
We attempt to quantify the importance of these changing patterns in child-bearing for retirement savings.[17] To do this, we calculate age- and cohort-specific equivalisation factors. We take the average number of children (both 14+ and under 14) per adult at each

[17]While our model is one of an individual, and spending on dependants is usually considered within a household or benefit unit context, we believe that it is meaningful and instructive to consider the average number of children that any one individual will have in their benefit unit at each age.

age for each cohort and construct the implied OECD modified equivalisation factor.[18] For cohort-age-groups where we do not have data, we assume that the growth rate with age of the component of the equivalisation factor attributable to children is the same as for the preceding cohort.

Individuals in our model seek to smooth the marginal utility of equivalised consumption and so having more children at a given age will mean that there is relatively more consumption, and less saving at that age. Therefore we would expect that those cohorts that have fewer children and have them later will save slightly more during working life and do this saving earlier. We do indeed see this qualitative pattern in Figure 17, although the quantitative differences are very small, in comparison to the impact of other factors. For example, the largest difference in simulated savings rate between any two cohorts is a difference of 3 percentage points, that occurs at age 36, comparing the 1930s and 1980s cohorts. Consequently, wealth at retirement and replacement rates vary only very slightly across cohorts (at most by around 1 percentage point). The exact quantitative implications of the model do depend on our choice for the coefficient of relative risk-aversion, but as demonstrated by the sensitivity analysis in Appendix A, for any plausible choice of value, the impact of changing the number and timing of children is not large.

Figure 17: Wealth and saving profiles - effect of different equivalisation factors



3.7 Retirement age

In our model individuals leave work and start to claim their public pension at an exogenous age K. In the UK, the age at which individuals can claim the public pension has been

[18]Under the OECD modified scale, a single adult has an equivalisation factor of 1 and each additional child aged 14 or older adds an additional 0.5 to this and a child 13 or under adds an additional 0.3 to this equivalisation factor.

Table 10: Wealth and replacement rates - effect of different equivalisation factors

Scenario	Wealth at 50		Wealth at retirement		Gross income	Average
	£,000s	Relative to 1950s	£,000s	Relative to 1950s	replacement rate	savings rate
1930s	62.1	96.7	179.9	100.0	80.0	10.8
1940s	64.9	101.0	181.8	101.0	80.3	10.8
1950s	64.2	100.0	179.9	100.0	80.0	10.7
1960s	64.3	100.1	178.0	99.0	79.7	10.6
1970s	65.1	101.4	178.9	99.4	79.8	10.6
1980s	65.3	101.7	179.1	99.6	79.8	10.6

increasing. For those born in the 1930s the 'state pension age' for women was 60 and for men was 65, but between 2010 and 2018 the state pension age for women was increased from 60 to 65. Since November 2018 the male and female state pension age has been increasing further. Current government policy is that this will reach age 68 (for both men and women) for those born in the 1970s - with further increases expected for generations born more recently.

Increases in the age from which the public pension is received would, all else equal, increase wealth accumulation during working life. This is because with retirement ages unchanged there would be a period of time with no income (earnings or public pension) which would need to be funded entirely from private saving. However, in practice, the average age of retirement would also be expected change, driven by credit constraints among low lifetime income individuals, the signalling effect of the state pension age, social norms, and the income effect associated with lower lifetime public pension income. Empirically this has been shown to be the case in the UK (Cribb et al., 2016). Furthermore, there is a general trend in the UK, as well as in a number of advanced economies, towards longer working at older ages. This may be a response to increasing longevity (as we have seen, individuals will see their average living standards drop if they do not respond to increasing longevity, all other circumstances being equal) or to improved health, and therefore ability to work, at older ages.

In our model labour supply is exogenous and individuals in different generations cannot respond to the different economic and demographic circumstances they face by changing the timing of retirement. However, to illustrate both the effects of the changing state pension age and the possibility of generations responding to their circumstances by changing their retirement timing rather than just their savings behaviour, we illustrate the effect on wealth accumulation if we exogenously vary K.

Figure 18 and Table 11 show the results of our simulations when we vary K between 65 and 70. By working longer, individuals in our model increase their lifetime resources from work while at the same time expecting to spend fewer years in retirement. They are able to sustain a higher level of consumption across their lifecycle and hence savings at each age fall while the gross income replacement rate increases. The effect is to reduce assets held at any given age during working life. Table 11 shows, for example, that an individual who retires at age 70 will hold 3% less wealth at age 50 than someone who retires at age 67, whereas someone retiring at age 65 will hold 2.5% more wealth than someone retiring at age 67. The effect on assets at the beginning of retirement is theoretically ambiguous – it depends on how earnings in the extra period of work compare to those earlier in working life, and on how quickly assets are run down in retirement (a more risk-averse individual holds onto assets for longer in retirement). However, we find that in our main model specification and in all sensitivities presented in section A, later retirement increases wealth held at retirement.

Figure 18: Wealth and saving profiles - effect of different retirement ages

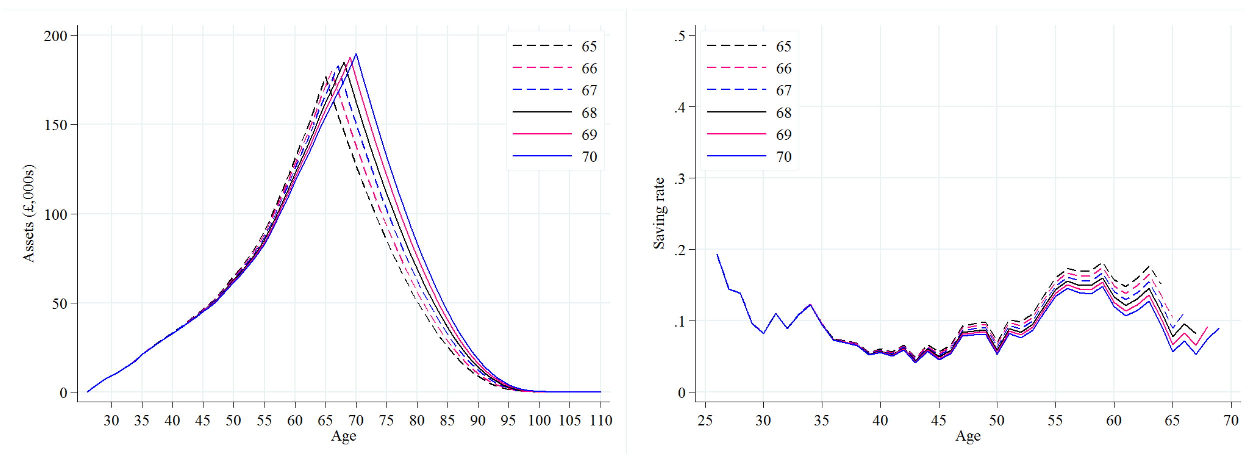


Table 11: Wealth and replacement rates - effect of different retirement ages

Scenario	Wealth at 50		Wealth at retirement		Gross income	Average
	£,000s	Relative to 67	£,000s	Relative to 67	replacement rate	savings rate
65	65.1	102.5	176.9	96.6	78.8	11.1
66	64.2	101.2	179.9	98.3	80.0	10.7
67	63.5	100.0	183.1	100.0	81.2	10.4
68	62.8	98.8	185.2	101.2	82.4	10.0
69	62.1	97.9	187.7	102.6	83.7	9.6
70	61.6	97.0	190.0	103.8	85.1	9.2

Given that later retirement is partly a response to increased longevity, it is interesting to consider the combined effect of increased longevity and later retirement on savings and wealth. To do this we vary survival probabilities and retirement ages together, setting the retirement age equal to the actual or planned State Pension Age for a man someone born in the relevant year, adding for illustrative purposes an additional increase in the State Pension Age for the 1985 born individual to age 69. This means that for the 1935 and 1945 born individuals, the retirement age is 65, and for each subsequent cohort thereafter, it increases in one year steps. The results, presented in Figure 19 and Table 12 show that within our model, the increases in retirement age that occur for the generations after the 1940s almost exactly offset their increased longevity, in terms of their impact on savings rates and gross income replacement at retirement.

Figure 19: Wealth and saving profiles - effect of different survival probabilities and retirement ages

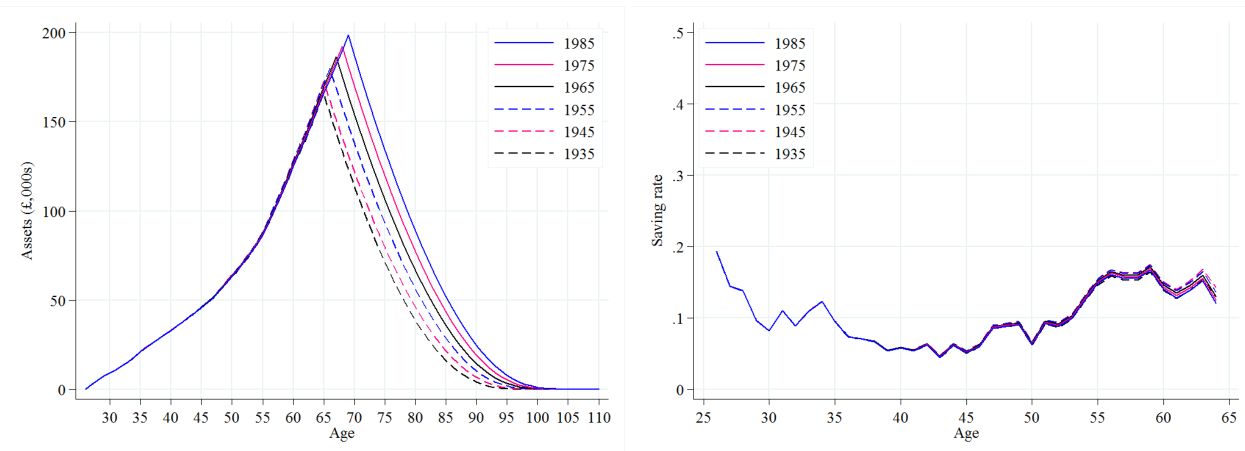


Table 12: Wealth and replacement rates - effect of different survival probabilities and retirement ages

Scenario	Wealth at 50		Wealth at retirement		Gross income	Average
	£,000s	Relative to 67	£,000s	Relative to 67	replacement rate	savings rate
1930s	63.3	98.5	165.9	92.2	83.9	10.3
1940s	64.4	100.2	172.6	96.0	82.7	10.8
1950s	64.2	100.0	179.9	100.0	80.0	10.7
1960s	63.9	99.5	186.5	103.7	80.8	10.6
1970s	63.6	99.1	192.3	106.9	81.5	10.4
1980s	63.4	98.6	198.7	110.5	82.4	10.2

4 Simulations for different generations

We turn now to examining how generations' wealth holdings and saving behaviour might be expected to differ given the different economic and demographic conditions they have faced over their lifetimes. We do so by varying all the aforementioned conditions simultaneously, while still holding preferences unchanged between generations.

Table 13 summarises the circumstances in question, and the parameterisation for each generation. In essence we pick the most applicable input for each generation, taken from the data sources and estimation discussed in Section 3. In the case of the real interest rate, we use the series that we construct as described in Section 3.4 to simulate the model. When we solve for agents' decision rules, we assume that agents expect the mean rate of return that is given in Table 13 to obtain each year. We do this because it is unrealistic to assume that agents anticipate all year-to-year changes in rates of return and adjust their behaviour accordingly and this would result in savings rates that fluctuated dramatically from year to year. However, we do assume that individuals are aware of the overall level of rates of return that they will face over their lifetime.

Table 13: Generations' circumstances: summary of inputs

	1930s	1940s	1950s	1960s	1970s	1980s
Earnings	Education-generation specific earnings process, estimated using the UK Household Longitudinal Study					
Tax system	Year-specific income tax and National Insurance rates and thresholds and Unemployment Benefit/Jobseeker's Allowance rates					
Public pension	Education-generation specific function, estimated using UK state pension system calculator					
Rate of return						
– Working life	5.9%	5.5%	4.8%	3.7%	3.1%	2.7%
– Retirement	1.2%	0.9%	0.5%	0.5%	0.5%	0.4%
Survival	ONS 2014-based cohort male survival curves (England & Wales)					
Children	Age varying equivalisation factor (implied by av. number children, Family Expenditure Survey)					
Retirement age	65	65	66	67	68	69

Note: Expected rates of return, listed here, are the geometric average of the age-specific rates of return used when simulating the model.

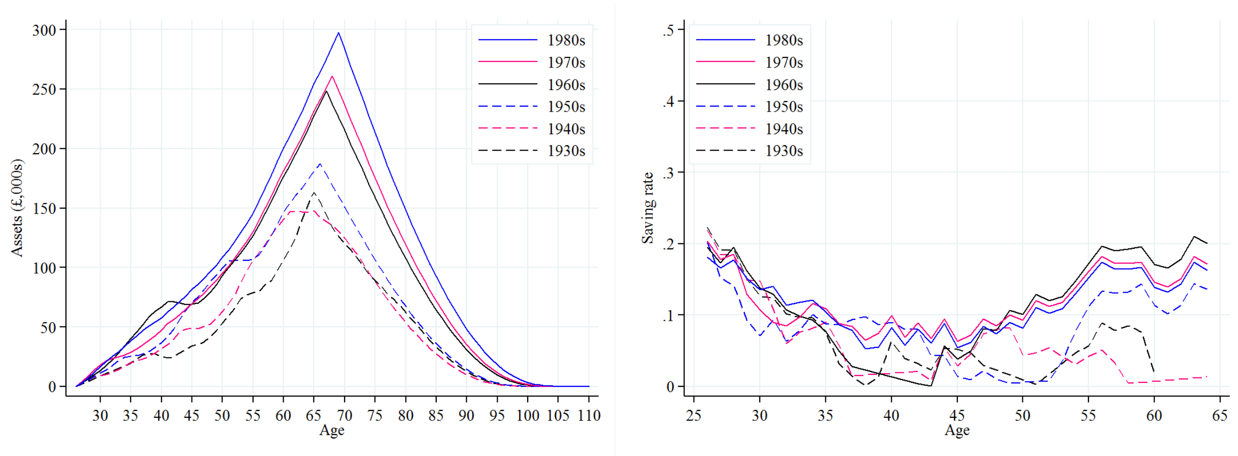
Figure 20 and Table 14 present the main results. First, in terms of *levels* of wealth, patterns look different when comparing generations at different ages. By retirement, each cohort has accumulated more wealth than its predecessors (with the exception of the 1940s cohort where wealth falls just before retirement) because of the different circumstances they face. If we look at earlier ages and the later-born generations, however, there is a 'stalling' – or even reversal – of generation-on-generation wealth increases. At age 50, the 1960s and 1970s generations are simulated to hold slightly less wealth than the 1950s generation, and the 1980s generation holds just 9% more wealth. At age 40, the 1970s and 1980s generations hold less wealth than the 1960s generation (though more than the 1950s). At age 30, the 1970s and 1980s generations are simulated to hold the same level of wealth.

In terms of saving *rates*, our simulations indicate that those born in the 1930s and 1940s would choose to save similar proportions of their income on average over their working lives (around 5%), but simulated saving rates are higher for the 1950s generation (around 8%) and then increase to around 11-12% for those born in the 1960s, 1970s and 1980s. Despite saving at twice the rate, or more, of the 1930s and 1940s generations, it is interesting to note that the 1960s, 1970s and 1980s generations have gross replacement rates of 74-77%, compared to 104% and 95% for the 1930s and 1940s generations, respectively.

What is driving these results? The most significant change in circumstance between the generations that we model is the difference in rates of return – specifically, the low rates of return experienced, and expected in future, for the 1960s, 1970s and 1980s generations, and the particularly high rates of return experienced by the 1930s and 1940s generations. The 1930s cohort gained from the high returns to equities in the 1980s, and to housing up until the mid-2000s, but avoided the worst of the effects of the financial crisis on returns. The 1940s and 1950s cohorts gained from most of the high return years but also experienced the negative returns of the financial crisis years while approaching the peak of their earnings and wealth accumulation. As we move through the cohorts, each experienced fewer of the 'good' years of returns before the financial crisis, but each also held less wealth at the point that the crisis struck. The 1980s cohort began to accumulate wealth in the period of the financial crisis and so experienced this period of relatively poor returns in their first few years of working life. As illustrated in section 3.4, higher rates of return both increase the gross income replacement rate (since lifetime resources are greater and therefore the smoothed level of consumption is greater, while earnings are unchanged) and reduce the savings rate (since the return is greater, a given level of retirement wealth can be achieved with lower savings).

Since the impact of returns is so substantial, we find it instructive to also show the overall impact on generations' wealth and savings if we vary all economic and demographic circumstances *except* rates of return. The results of this exercise (holding rates of return constant at 3% for all generations) are shown in Figure 21 and Table 15. In these scenarios, we see that wealth accumulation is greater for each cohort than its predecessor. However, the rate of increase across cohorts, in percentage terms, slows for the most recent cohorts.

Figure 20: Wealth and saving profiles - cohort scenarios



The increase in wealth at any given age for successive generations is driven by higher earnings and declining state pension generosity, while the further increase in wealth by the eve of retirement (which is assumed to happen later for subsequent generations) is driven by increasing longevity.

Interestingly, even when we hold rates of return the same for all generations, it is still the case that we simulate a higher savings rate for the latter four generations than the earlier two, and a lower replacement rate – although the differences between generations are now less stark. These remaining differences are driven mainly by declines in the generosity of the public pension for later born generations. The effects of increased longevity among later born generations are largely offset by the assumed later retirement.

These results demonstrate that changing rates of return are quantitatively very important for the savings decision of different generations. However, while they are responsible for a large proportion of the lack of growth in wealth levels, declines in replacement rates, and increase in saving rates of later born generations, they are not the only circumstance that differs between generations or that matters. Even without across-generation differences in rates of return, the net effect of the other circumstances that we study would also imply a slow down in the difference in wealth accumulation between later born generations.

Table 14: Wealth and replacement rates - cohort scenarios

Scenario	Wealth at 30		Wealth at 40		Wealth at 50	
	£,000s	Relative to 1950s	£,000s	Relative to 1950s	£,000s	Relative to 1950s
1930s	11.1	77.4	24.8	58.3	53.5	53.7
1940s	10.5	72.9	35.6	83.8	63.3	63.5
1950s	14.4	100.0	42.5	100.0	99.6	100.0
1960s	18.0	125.4	69.7	164.3	93.7	94.0
1970s	21.2	147.7	52.4	123.4	95.4	95.8
1980s	21.2	147.3	62.5	147.2	108.6	109.0

Scenario	Wealth at Retirement		Gross income replacement rate	Average savings rate
	£,000s	Relative to 1950s		
1930s	163.5	87.3	104.0	5.3
1940s	147.8	78.9	95.3	4.9
1950s	187.2	100.0	81.7	8.3
1960s	248.7	132.8	74.4	11.4
1970s	261.3	139.6	76.7	12.2
1980s	297.5	158.9	77.3	11.9

Wealth levels reported for ages 30 and 40 are the mean of wealth at ages 30-32 and 40-42, respectively.

Figure 21: Wealth and saving profiles - cohort scenarios with rate of return constant across scenarios

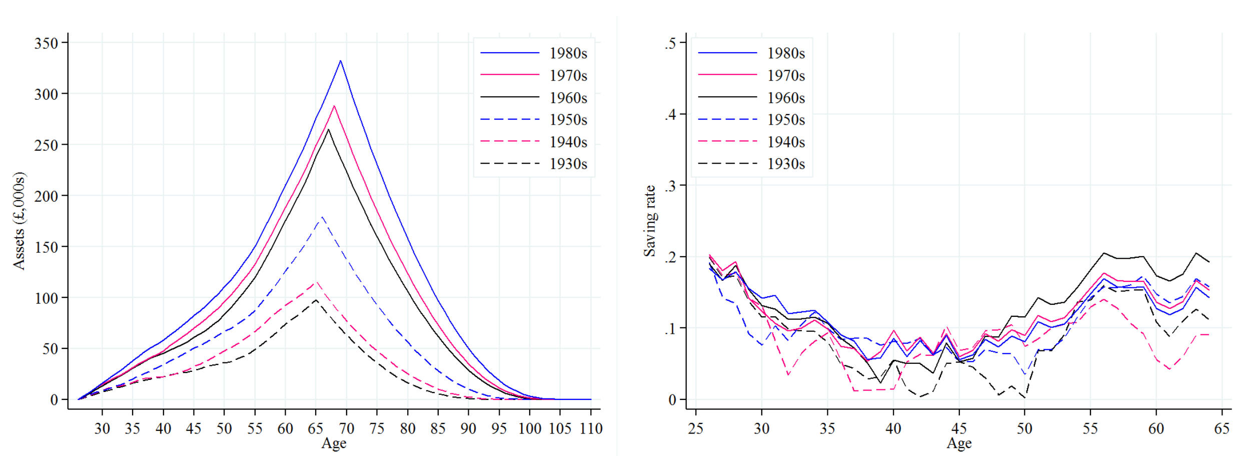


Table 15: Wealth and replacement rates - cohort scenarios with rate of return constant across scenarios

Scenario	Wealth at 30		Wealth at 40		Wealth at 50	
	£,000s	Relative to 1950s	£,000s	Relative to 1950s	£,000s	Relative to 1950s
1930s	9.2	85.6	23.9	63.9	36.2	54.2
1940s	11.0	101.9	23.7	63.4	47.9	71.8
1950s	10.7	100.0	37.4	100.0	66.8	100.0
1960s	17.0	158.5	48.2	128.9	83.8	125.5
1970s	18.1	168.7	52.4	140.1	96.2	144.2
1980s	20.4	189.5	62.8	168.0	110.8	165.9
Scenario	Wealth at Retirement		Gross income replacement rate		Average savings rate	
	£,000s	Relative to 1950s				
1930s	98.0	54.7	86.6		8.7	
1940s	115.9	64.7	88.8		8.7	
1950s	179.1	100.0	80.6		10.6	
1960s	265.0	148.0	76.4		12.8	
1970s	288.1	160.9	79.8		11.7	
1980s	332.7	185.8	81.0		11.5	

Wealth levels reported for ages 30 and 40 are the mean of wealth at ages 30-32 and 40-42, respectively.

5 Discussion and conclusions

Much attention has been given to the empirical observation that generation-on-generation increases in wealth seems to have stalled among generations born since the 1960s. There has been some debate as to whether this is the result of different preferences for saving, or differences in the economic environment.

We have demonstrated, using a heterogeneous agents lifecycle model, that the changing economic and demographic circumstances facing different generations are important. The exact quantitative conclusions of the model are sensitive to the parametrisation chosen. However, we have shown that is possible to generate the lack of generation-on-generation growth in wealth, for specific cohorts at specific ages, that is seen in the data, without incorporating any difference in preferences between generations. Specifically, the 1960s, 1970s and 1980s cohorts do not accumulate more wealth the their immediate predecessors by ages 50, 40 and 30, respectively. This being said, there are differences the relative wealth holdings we simulate and those seen in the data. For example, we do not simulate larger wealth holdings in retirement for the 1940s generation as compared to the 1930s generation. Given that our model is a drastic simplification of reality, such differences are no surprise. It is therefore notable that incorporating only the circumstances we examine, we simulate patterns in relative wealth levels across recent generations that accord reasonably well with the wealth data.

Furthermore, our simulation results indicate that not only would we expect younger generations to choose lower gross replacement rates in retirement than their predecessors given the circumstances they face, but that to achieve these they would still have higher average saving rates over their working lives. This is largely driven by a less generous state pension system and lower average rates of return. The implication of this is that caution must be used when seeking to make inferences about younger generations preparedness for retirement by comparing their wealth levels or projected retirement replacement rates with those of previous generations. Using previous generations as a benchmark may be holding younger generations to an inappropriately high ideal.

Our results do give some cause for optimism for those lamenting the stalling of wealth accumulation, however. Our simulations suggest that the poor relative performance of later born cohorts over recent years is partly due to the impact of the financial crisis, which has resulted in stagnant real earnings and low rates of return. While most analysis of these trends does not suggest a complete return to the levels of earnings growth and rates of return seen over the decades preceding the crisis, our simulations do suggest that even with subdued rates of return and earnings growth, younger generations will emerge from the shadow of the great recession and eventually accumulate more wealth than their predecessors.

There are, of course, limitations to our model and simulations, and there are three areas in particular that we feel are worth highlighting as important for future research. The first is obtaining better empirical evidence on the asset return experience of different generations. The rates of return in our model are estimated using data on average UK gilts, equities, house prices, mortgage rates and rent-to-price ratios. While we have allowed portfolio composition to vary with age, the patterns in portfolio composition are assumed to be unchanging across cohorts. Given the importance of rates of return in driving wealth accumulation, it would be interesting to re-simulate our model if better data on the portfolio composition and actual investment performance of individuals at different ages in different generations became available.

Second, a substantial part of many individuals' retirement portfolio in the UK is defined benefit (DB) pension income. These pensions were often very generous, at least to those who remain a pension member for a long while. For example, a scheme offering a pension income in retirement of 1/80 of final salary for each year of service and a lump sum of 3/80 of final salary for each year of service, in exchange for employee pension contributions of 6% of gross earnings each year of working life, would be equivalent to a rate of return of around 8-9% a year for the generations we consider. We use our model to examine the effect of introducing such a DB pension (membership of which is compulsory), and find that (all else equal) individuals hold more wealth - both because of the high rate of return and because individuals can only choose to be 'in' or 'out' of the scheme, which might lead them to save more than they would choose if they had a flexible choice of how much to save with an equivalent rate of return. The effect is substantial – wealth at retirement would be over twice as large if everyone had access to such a pension (in our baseline specification), and the replacement rate achieved from retirement income would be 120% rather than 80%.

The availability and generosity of DB pensions has declined substantially in recent decades, with private sector schemes in particular largely closing to new members (and sometimes to new accrual). Cribb (*forthcoming*) highlights the decline in active membership of DB pensions both within and between generations over the past two decades. Unfortunately, the extent of the decline in DB pensions for different generations is difficult to simulate, even if pension membership is modelled as exogenous, as one needs to know how pension tenure has changed (affected by schemes closing and labour turnover) and how pension scheme rules have changed. However, undoubtedly, the reduction in DB scheme availability will have reduced the incentive to accumulate wealth for retirement among more recently born generations. Given the likely importance of this effect, further research yielding empirical evidence on scheme availability, tenure and generosity would be valuable.

Finally, our model also abstracts from many important facets of the purchasing and use of housing. Housing is an important asset in the UK, and different generations have experienced very different housing markets, in terms of house price to earnings ratios, the growth of house prices over time, the price and availability of mortgages, and the cost of not being a homeowner (i.e. renting). We have sought to incorporate some of these aspects by assuming that households hold a certain fraction of their wealth as housing, paying off their mortgage as they age, and by constructing series for the resulting rates of return to housing which vary by time and by age. By incorporating housing wealth into our single, composite asset and allowing individuals to choose their level of asset holdings continuously in each year, we have abstracted from the fact that individuals buy a property or move house only infrequently, and that purchases of property are also subject to deposit requirements and maximum loan-to-value ratios, which have varied substantially over time. Modelling the impact of these effects on wealth accumulation would require a more complex model, with housing as a separate asset class, and further assumptions about individual preferences (in particular, for non-housing consumption versus housing consumption) and the inflexibility of housing wealth. This is beyond the scope of the current work, but would be a worthwhile direction for future research.

These limitations of our simulations and model notwithstanding, our findings do make an important contribution. One does not need to appeal to differences in preferences to explain an absence of greater wealth accumulation among younger generations compared with their predecessors - demographic changes, public pension reforms, and an economic environment that is less favourable to wealth accumulation could be sufficient to drive such behaviour. Given the uncertainties involved in our simulations, it is possible that changing preferences or 'under saving' do drive patterns in wealth accumulation. However, the observed patterns of wealth alone are not evidence of this. Those concerned with the living standards, and retirement preparedness, of today's young people should therefore give at least as attention to the problem of low productivity and consequent low investment returns than to the supposed breakfast choices of the young people in question.

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A Additional results

A.1 Changing survival probabilities: female survival curves

This section shows the equivalent set of results to those in section 3.5 in the case where we use female rather than male ONS survival curves.

Figure 22: Wealth and saving profiles - effect of different survival probabilities (female)

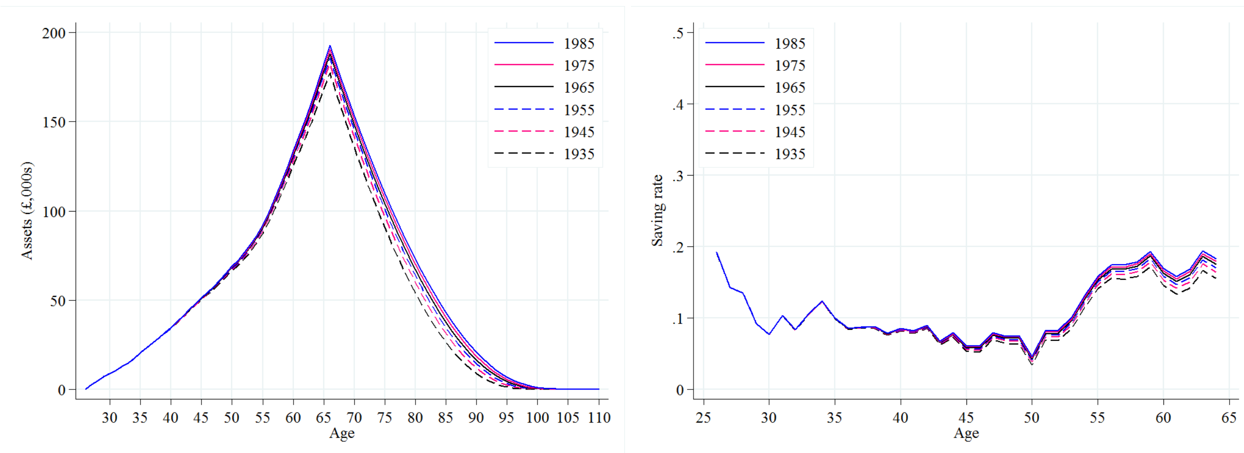

Table 16: Wealth and replacement rates - effect of different survival probabilities (female)

Scenario	Wealth at 50		Wealth at retirement		Gross income	Average
	£,000s	Relative to 1950s	£,000s	Relative to 1950s	replacement rate	savings rate
1930s	66.5	98.1	177.5	95.5	80.8	10.5
1940s	67.3	99.2	182.5	98.2	80.0	10.8
1950s	67.8	100.0	185.8	100.0	79.5	11.0
1960s	68.2	100.6	188.3	101.4	79.1	11.2
1970s	68.6	101.1	190.6	102.6	78.8	11.3
1980s	68.9	101.7	192.8	103.8	78.4	11.5

A.2 Sensitivity of interest rate results to CRRA parameter

In this section, we show the sensitivity of some of our results about the impact of changing interest rates to the value assumed for the coefficient of relative risk aversion. In Figure 23 and Table 17 we show the results of varying the interest rate when we assume a coefficient of relative risk aversion of 1.5 (rather than 3 as in the main model). In Figure 24 and Table 18 we show the results of varying the interest rate, with individuals always expecting an interest rate of 3%, again assuming a coefficient of relative risk aversion of 1.5.

Figure 23: Wealth and saving profiles - effect of different rates of return with coefficient of relative risk aversion of 1.5

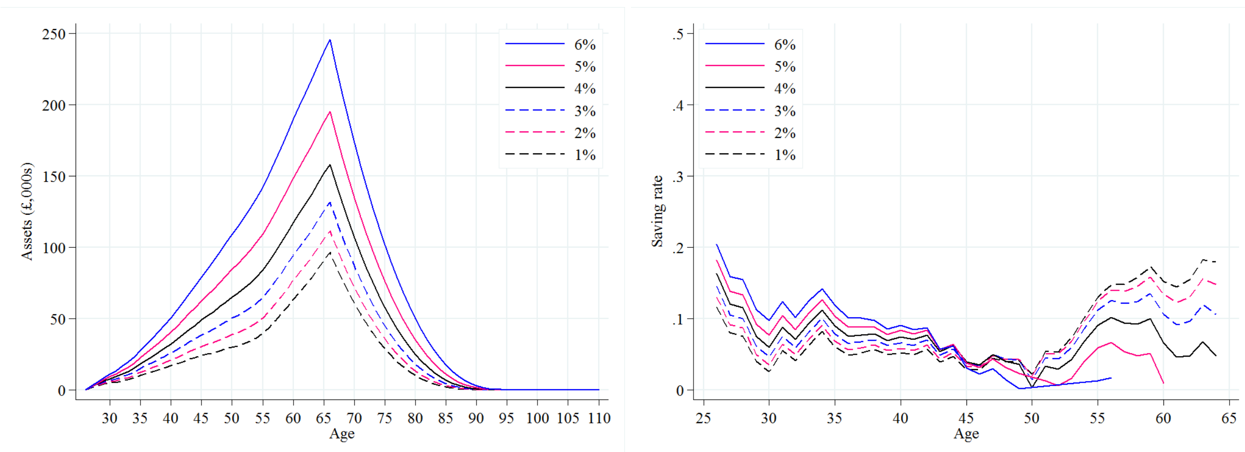

Table 17: Wealth and replacement rates - effect of different real rates of return with coefficient of relative risk aversion of 1.5

Scenario	Wealth at 50		Wealth at retirement		Gross income	Average
	£,000s	Relative to 3%	£,000s	Relative to 3%	replacement rate	savings rate
1%	41.8	87.2	110.8	83.7	79.7	9.6
2%	44.7	93.2	120.7	91.3	82.0	8.7
3%	48.0	100.0	132.3	100.0	84.7	7.8
4%	51.6	107.6	145.8	110.2	87.8	6.8
5%	55.6	116.0	161.8	122.3	91.5	5.7
6%	60.2	125.6	180.8	136.7	95.7	4.4

A.3 Sensitivity to discount rate

In the main specification of the model, the discount rate is set to 1/1.03. We here produce the summary tables of results in the case where the discount rate is equal to 0.95 and where it is equal to 0.99.

Figure 24: Wealth and saving profiles - effect of different rates of return when 3% return expected, with coefficient of relative risk aversion of 1.5

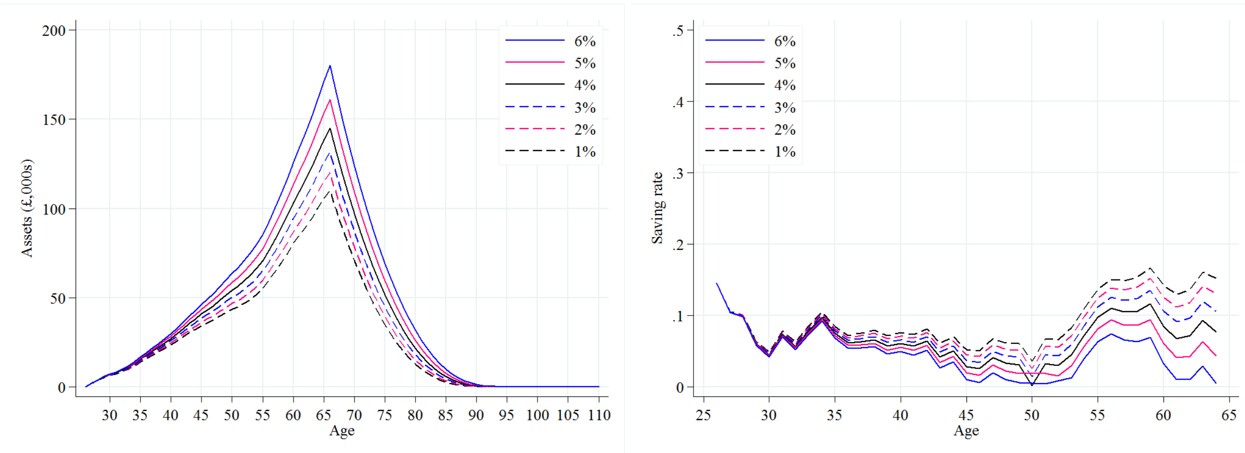

Table 18: Wealth and replacement rates - effect of different real rates of return when 3% return expected, with coefficient of relative risk aversion of 1.5

Scenario	Wealth at 50		Wealth at retirement		Gross income	Average
	£,000s	Relative to 3%	£,000s	Relative to 3%	replacement rate	savings rate
1%	43.5	86.7	110.2	83.7	80.2	9.5
2%	46.6	93.0	120.1	91.2	82.6	8.6
3%	50.2	100.0	131.6	100.0	85.4	7.7
4%	54.1	107.8	145.2	110.3	88.5	6.7
5%	58.5	116.6	161.2	122.5	92.2	5.5
6%	63.4	126.5	180.5	137.1	96.5	4.2

A.4 Sensitivity to coefficient of relative risk aversion

In the main specification of the model, the coefficient of relative risk aversion (CRRA) parameter is equal to 3. We here produce the summary tables of results in the case where the CRRA parameter is equal to 1.5 and where it is equal to 4.5.

Table 19: Wealth and replacement rates - results when discount rate equals 0.95

Scenario	Wealth at 50		Wealth at retirement		Gross income	Average
	£,000s	Relative to 3%	£,000s	Relative to 1950s	replacement rate	savings rate
Survival probabilities						
1930s	47.4	98.6	132.7	94.5	81.2	7.9
1940s	47.8	99.4	137.4	97.8	80.3	8.2
1950s	48.1	100.0	140.4	100.0	79.7	8.4
1960s	48.3	100.4	142.3	101.3	79.4	8.6
1970s	48.4	100.7	143.9	102.5	79.1	8.7
1980s	48.6	101.0	145.4	103.5	78.8	8.8
Retirement age						
65	48.6	101.9	138.3	96.8	78.8	8.8
66	48.1	100.9	140.4	98.3	79.7	8.4
67	47.7	100.0	142.8	100.0	80.7	8.2
68	47.3	99.2	144.3	101.1	81.7	7.8
69	47.0	98.5	146.1	102.3	82.7	7.5
70	46.7	97.9	147.9	103.6	83.8	7.2
Equivalisation factors						
1930s	46.7	97.0	140.8	100.3	79.8	8.5
1940s	48.8	101.3	141.9	101.0	80.0	8.5
1950s	48.1	100.0	140.4	100.0	79.7	8.4
1960s	48.1	100.0	138.9	98.9	79.4	8.3
1970s	48.7	101.1	139.4	99.2	79.5	8.4
1980s	48.8	101.5	139.5	99.4	79.5	8.4
Earnings						
1930s	30.3	60.6	105.9	75.9	80.3	9.4
1940s	37.9	75.7	116.7	83.6	79.9	8.7
1950s	50.1	100.0	139.6	100.0	80.3	8.3
1960s	60.5	120.8	169.2	121.2	79.9	8.4
1970s	70.3	140.5	191.4	137.1	80.3	8.6
1980s	79.3	158.4	211.6	151.6	81.1	8.5
Tax and benefits						
1930s	43.6	90.5	128.4	91.4	79.4	7.7
1940s	44.8	93.2	132.8	94.6	81.2	8.0
1950s	48.1	100.0	140.4	100.0	79.7	8.4
1960s	49.4	102.6	144.3	102.8	80.2	8.6
1970s	52.4	108.9	145.6	103.7	80.3	8.6
1980s	53.6	111.4	146.0	104.0	80.4	8.6
State pension						
1930s	47.2	98.1	129.6	92.2	82.6	7.7
1940s	46.2	96.0	119.2	84.9	84.8	7.0
1950s	48.1	100.0	140.4	100.0	79.7	8.4
1960s	51.2	106.4	167.2	119.0	74.5	10.3
1970s	49.5	102.9	153.1	109.0	77.1	9.3
1980s	49.5	102.9	153.1	109.0	77.1	9.3

Table 20: Wealth and replacement rates - results when discount rate equals 0.99

Scenario	Wealth at 50		Wealth at retirement		Gross income	Average
	£,000s	Relative to 3%	£,000s	Relative to 1950s	replacement rate	savings rate
Survival probabilities						
1930s	83.0	95.8	212.8	92.0	82.8	12.4
1940s	85.2	98.3	224.0	96.9	81.3	13.1
1950s	86.7	100.0	231.2	100.0	80.3	13.6
1960s	87.8	101.3	236.3	102.2	79.7	13.9
1970s	88.8	102.4	240.9	104.2	79.1	14.2
1980s	89.7	103.5	245.2	106.1	78.6	14.5
Retirement age						
65	88.0	102.9	227.3	96.6	78.9	14.0
66	86.7	101.4	231.2	98.3	80.3	13.6
67	85.5	100.0	235.3	100.0	81.9	13.1
68	84.4	98.7	238.2	101.3	83.4	12.6
69	83.3	97.5	241.3	102.6	85.0	12.1
70	82.3	96.3	244.2	103.8	86.7	11.7
Equivalisation factors						
1930s	83.5	96.3	230.3	99.6	80.2	13.6
1940s	87.2	100.6	233.3	100.9	80.6	13.7
1950s	86.7	100.0	231.2	100.0	80.3	13.6
1960s	86.8	100.2	229.1	99.1	80.0	13.4
1970s	88.1	101.6	230.4	99.7	80.2	13.5
1980s	88.4	101.9	230.7	99.8	80.3	13.5
Earnings						
1930s	57.7	64.2	172.3	74.7	81.0	14.8
1940s	70.8	78.7	194.1	84.1	81.0	14.1
1950s	90.0	100.0	230.8	100.0	81.0	13.4
1960s	106.1	118.0	276.3	119.7	80.4	13.6
1970s	123.7	137.5	315.4	136.6	80.9	13.9
1980s	141.8	157.6	353.9	153.3	82.0	13.9
Tax and benefits						
1930s	79.0	91.1	209.3	90.5	80.1	12.2
1940s	80.4	92.7	217.9	94.3	81.7	12.9
1950s	86.7	100.0	231.2	100.0	80.3	13.6
1960s	91.5	105.5	239.8	103.7	81.3	14.0
1970s	97.0	111.9	243.6	105.4	81.7	14.1
1980s	99.3	114.5	245.0	106.0	81.8	14.1
State pension						
1930s	83.7	96.6	216.1	93.5	83.0	12.6
1940s	80.2	92.5	199.8	86.4	84.9	11.5
1950s	86.7	100.0	231.2	100.0	80.3	13.6
1960s	95.9	110.7	269.5	116.6	75.8	16.0
1970s	91.0	104.9	249.5	107.9	78.1	14.7
1980s	91.0	104.9	249.5	107.9	78.1	14.7

Table 21: Wealth and replacement rates - results when CRRA equals 1.5

Scenario	Wealth at 50		Wealth at retirement		Gross income	Average
	£,000s	Relative to 3%	£,000s	Relative to 1950s	replacement rate	savings rate
Survival probabilities						
1930s	46.4	96.7	120.7	91.2	86.6	7.0
1940s	47.3	98.7	127.7	96.5	85.5	7.5
1950s	48.0	100.0	132.3	100.0	84.7	7.8
1960s	48.3	100.8	135.1	102.1	84.3	8.0
1970s	48.7	101.5	137.5	103.9	83.9	8.2
1980s	49.0	102.1	139.6	105.5	83.5	8.3
Retirement age						
65	48.5	102.3	131.2	98.2	83.8	8.2
66	48.0	101.1	132.3	99.1	84.7	7.8
67	47.4	100.0	133.6	100.0	85.8	7.5
68	47.0	99.1	134.0	100.4	86.8	7.1
69	46.5	98.0	134.7	100.8	87.9	6.7
70	46.1	97.2	135.2	101.2	89.0	6.4
Equivalisation factors						
1930s	46.3	96.5	132.6	100.2	84.8	7.9
1940s	48.6	101.4	133.7	101.1	85.1	7.9
1950s	48.0	100.0	132.3	100.0	84.7	7.8
1960s	47.9	100.0	130.8	98.9	84.4	7.7
1970s	48.6	101.3	131.3	99.3	84.5	7.7
1980s	48.8	101.7	131.5	99.4	84.5	7.7
Earnings						
1930s	32.0	63.7	93.5	71.0	84.4	8.0
1940s	40.6	81.0	109.2	83.0	84.7	7.9
1950s	50.2	100.0	131.6	100.0	85.4	7.7
1960s	55.1	109.8	156.1	118.6	84.8	7.8
1970s	62.3	124.1	175.9	133.7	84.7	7.9
1980s	70.1	139.8	195.4	148.5	84.8	7.9
Tax and benefits						
1930s	42.8	89.3	121.1	91.5	83.9	7.2
1940s	44.1	92.0	124.9	94.4	85.9	7.4
1950s	48.0	100.0	132.3	100.0	84.7	7.8
1960s	50.0	104.2	136.3	103.0	85.4	8.0
1970s	53.3	111.2	137.7	104.0	85.7	8.0
1980s	54.7	114.0	138.1	104.4	85.9	8.0
State pension						
1930s	46.6	97.1	121.5	91.8	87.3	7.1
1940s	45.3	94.5	112.1	84.7	89.3	6.4
1950s	48.0	100.0	132.3	100.0	84.7	7.8
1960s	51.8	108.0	157.3	118.9	80.1	9.5
1970s	49.7	103.6	144.3	109.0	82.4	8.6
1980s	49.7	103.6	144.3	109.0	82.4	8.6

Table 22: Wealth and replacement rates - results when CRRA equals 4.5

Scenario	Wealth at 50		Wealth at retirement		Gross income	Average
	£,000s	Relative to 3%	£,000s	Relative to 1950s	replacement rate	savings rate
Survival probabilities						
1930s	75.4	97.8	199.1	94.4	79.8	11.7
1940s	76.5	99.2	206.4	97.8	78.6	12.2
1950s	77.1	100.0	210.9	100.0	77.9	12.5
1960s	77.6	100.6	214.2	101.5	77.4	12.7
1970s	78.0	101.2	217.1	102.9	77.0	12.9
1980s	78.4	101.7	219.8	104.2	76.5	13.1
Retirement age						
65	78.0	102.2	206.7	96.0	76.7	12.9
66	77.1	101.1	210.9	98.0	77.9	12.5
67	76.3	100.0	215.3	100.0	79.2	12.1
68	75.5	99.0	218.8	101.6	80.5	11.7
69	74.8	98.1	222.5	103.3	81.9	11.3
70	74.2	97.2	226.0	104.9	83.3	11.0
Equivalisation factors						
1930s	74.7	96.8	210.7	99.9	77.9	12.6
1940s	77.7	100.7	213.0	101.0	78.2	12.6
1950s	77.1	100.0	210.9	100.0	77.9	12.5
1960s	77.2	100.1	208.9	99.0	77.6	12.4
1970s	78.1	101.3	209.9	99.5	77.8	12.4
1980s	78.4	101.6	210.2	99.6	77.8	12.4
Earnings						
1930s	51.9	64.9	148.0	70.4	77.4	12.6
1940s	64.9	81.2	174.5	83.0	77.9	12.6
1950s	79.9	100.0	210.2	100.0	78.5	12.4
1960s	89.2	111.7	248.2	118.1	77.9	12.4
1970s	100.4	125.7	279.7	133.1	77.8	12.6
1980s	112.9	141.3	310.9	147.9	77.9	12.5
Tax and benefits						
1930s	70.8	91.8	191.3	90.7	78.0	11.3
1940s	72.1	93.5	199.1	94.4	79.4	11.8
1950s	77.1	100.0	210.9	100.0	77.9	12.5
1960s	80.3	104.2	218.0	103.3	78.6	12.8
1970s	84.9	110.1	220.9	104.7	78.9	12.9
1980s	86.9	112.7	222.1	105.3	79.0	12.9
State pension						
1930s	75.2	97.5	197.3	93.5	80.8	11.6
1940s	72.8	94.4	181.8	86.2	82.9	10.5
1950s	77.1	100.0	210.9	100.0	77.9	12.5
1960s	84.0	108.9	247.4	117.3	72.9	14.9
1970s	80.2	104.0	228.3	108.2	75.4	13.6
1980s	80.2	104.0	228.3	108.2	75.4	13.6