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Postprint version
This is a post-peer-review, pre-copyedit version of an article published in:

Journal of Economic Dynamics and Control

The definitive publisher-authenticated and formatted version:

Laun, Tobias, Simen Markussen, Trond C. Vigtel and Johanna Wallenius, 2019, Health, Longevity and Pension Reform, Journal of Economic Dynamics and Control, Vol 103, 123-157, DOI: 10.1016/j.jedc.2019.03.004.

is available at:

https://doi.org/10.1016/j.jedc.2019.03.004

Health, Longevity and Retirement Reform

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March 21, 2019

Abstract

In this paper, we study alternative retirement reforms designed to achieve fiscal sustainability in the face of demographic change. We are particularly interested in the heterogeneous effects across demographic groups, as improvements in health and longevity have not been uniform across the population. To this end, we develop a dynamic, structural life cycle model of heterogeneous agents who face health, mortality and income risk. We consider the following policy reform measures: (1) increasing the early access age to old-age retirement, (2) raising income taxes, (3) lowering old-age retirement benefits and (4) lowering old-age retirement and disability benefits. We find that, of the considered policies, proportionally lowering old-age retirement and disability benefits results in the highest average welfare for all education categories. It is also the most successful at boosting employment.

JEL classification: E24; J22; J26

Keywords: Life cycle; Retirement; Disability insurance; Health

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1 Introduction

Population aging places enormous pressure on traditional pay-as-you-go (PAYG) social security programs, where taxes levied on current workers are used to fund benefits to current retirees. In many countries, solvency of social security in the future will require that people work longer, benefits are cut, or social security contributions (taxes) are increased. Correspondingly, retirement reform, aimed at improving solvency, is on the policy agenda in a number of countries (OECD (2012)). Population aging is largely driven by improvements in longevity. However, there is substantial heterogeneity in the life expectancy, and also health, of older people. More educated individuals enjoy better health, and can also expect to live longer, than their less educated counterparts. Moreover, improvements in health and longevity over the last several decades have not affected workers in a uniform manner. In fact, more educated workers have benefitted more from improvements in health and longevity over the last few decades than less educated workers. Yet, in most countries these heterogeneous workers face homogeneous social security rules.

The large and growing gap in life expectancy is well documented, particularly for the US (see, e.g., Waldron (2007), Pijoan-Mas and Ríos-Rull (2014) and Bound et al. (2015)). This issue has also been brought to the attention of the general public, thanks to recent well-publicized studies by Case and Deaton (2015) and Chetty et al. (2016). Yet, the impact of this on government programs, such as old-age retirement and disability insurance, has received less attention.[1]

The aim of this paper is to evaluate alternative policy measures for achieving solvency of social security in the face of population aging. We evaluate policies along two key dimensions, efficiency and equity, in order to shed light on the trade-off between the two. By design, this type of policy question necessitates the use of a structural model. In this paper, we develop a dynamic, structural life cycle model of heterogeneous agents who

[1] There is one notable exception, a recent paper by Auerbach et al. (2017). Note, however, that in that paper all of the transitions – including those into retirement – are driven by transition probabilities, rather than the choices of optimizing agents.

face health, mortality and income risk. Agents make decisions regarding consumption and saving, labor supply and if/when to claim old-age retirement and disability benefits. We calibrate the model to Norwegian panel data and the Norwegian institutional setting, but our findings are general. We use the model to study the labor supply and redistributionary effects of alternative retirement reforms in the face of demographic change. In particular, we contrast different ways of making retirement schemes robust to improvements in longevity. Examples include: (1) raising the early eligibility age for old-age retirement benefits, (2) raising income taxes, (3) lowering old-age retirement benefits, and (4) lowering old-age retirement and disability benefits. We are particularly interested in the differential effects of the alternative reforms for agents who differ in terms of productivity, health and life expectancy. It is important to include disability insurance in the model, since restricting the access to old-age retirement may have the unintended consequence of increasing the flow into disability. The endogeneity of disability claiming in our model reflects the fact that disability is utilized as a pathway into early retirement. This is particularly relevant for Norway, where disability benefit claiming rates are high – despite good health and long life expectancy.

We find that simply increasing the early-access age for old-age retirement benefits is not a very effective policy tool. Increasing the early access age from 62 to 67 (the age at which individuals are transferred from disability to old-age retirement in Norway) is not enough to achieve revenue neutrality. This is driven by increased disability benefit claiming. To compare this policy with fiscally sustainable policies, notably raising income taxes and lowering benefits, we combine increasing the early access age for old-age retirement benefits to 67 with proportionally lowering old-age retirement benefits so as to achieve revenue neutrality. We find that, of the considered policy reforms, proportionally increasing taxes on labor and social security income results in the lowest average employment outcomes, whereas proportionally reducing old-age retirement and disability benefits results in the highest. This is true for all education types. Moreover, the tax increase yields the lowest average welfare of all reforms for all education types, while the cut in old-age retirement and disability benefits yields the highest. The other policy reform scenarios yield intermediate outcomes. It is of course the case that disability benefit recipients are made worse off by a reduction in old-age retirement and disability benefits. This is reflected in the fact that the gini of welfare is higher under this policy scenario than some of the others. The combined policy of increasing the early access age to old-age retirement and scaling down old-age retirement benefits results in the lowest welfare inequality of the considered reforms. Thus, there is an equity-efficiency trade-off to retirement reform.

There is a large empirical literature on retirement reform. The most relevant for us is Hernæs et al. (2016), which studies the latest Norwegian reform carried out in 2011. They find that removing the earnings test, which implied a doubling of the average net take-home wage, led to an increase in average labor supply of 30% at age 63 and 46% at age 64, demonstrating that economic incentives matter greatly (also) for this age group.

There is a large literature using life cycle models to study the effect of social security systems on labor supply, which we build on (see, e.g., Gustman and Steinmeier (1986), Stock and Wise (1990), Rust and Phelan (1997), French (2005), Coile and Gruber (2007) and French and Song (2014)). Perhaps the paper most similar to us is Haan and Prowse (2014), which studies how the German retirement system could be reformed to achieve fiscal stability in the face of increasing longevity. Yet, their focus is not on the heterogeneous effects across demographic groups or on the redistributionary implications of various policy alternatives. There are relatively few studies that focus on the redistributionary consequences of alternative social security reforms. Gustman and Steinmeier (2001) and Coronado et al. (2002) are notable examples. Note, however, that these studies do not focus on how redistribution might change as the gap in life expectancy and health increases.

We stress the importance of including a disability channel in analyses of retirement reform. This is a point also recently emphasized by Laun and Wallenius (2016), Li (2018), and Galaasen (2017). Moreover, our paper touches on the recent literature suggesting that non-health related motives also influence the use of disability benefits among older workers. See Johnsen and Vaage (2015), Bratsberg et al. (2013), Kostøl and Mogstad (2014) and Dahl et al. (2014), who also, incidentally, all use data on Norway.

Our paper is also related to the literature studying the redistributive power of retirement benefits and heterogeneity in life expectancy. A recent Consensus Study Report studies the impact the growing gap in life expectancy has on the present value of lifetime benefits that people with higher or lower earnings will receive from major entitlement programs in the US, namely Medicare, Medicaid and Social Security.[2] Brown (2002) studies the value of individual account retirement annuities in the face of differential mortality. In related work, Fuster et al. (2003) study the heterogeneity in value households assign to the insurance role of social security due to differential mortality risk.

The remainder of the paper is structured as follows. Section 2 outlines the stylized facts that emerge from the data. Section 3 presents the model, while Section 4 outlines the calibration procedure. Section 5 presents the results from the policy analysis. Section 6 concludes.

2 Stylized Facts

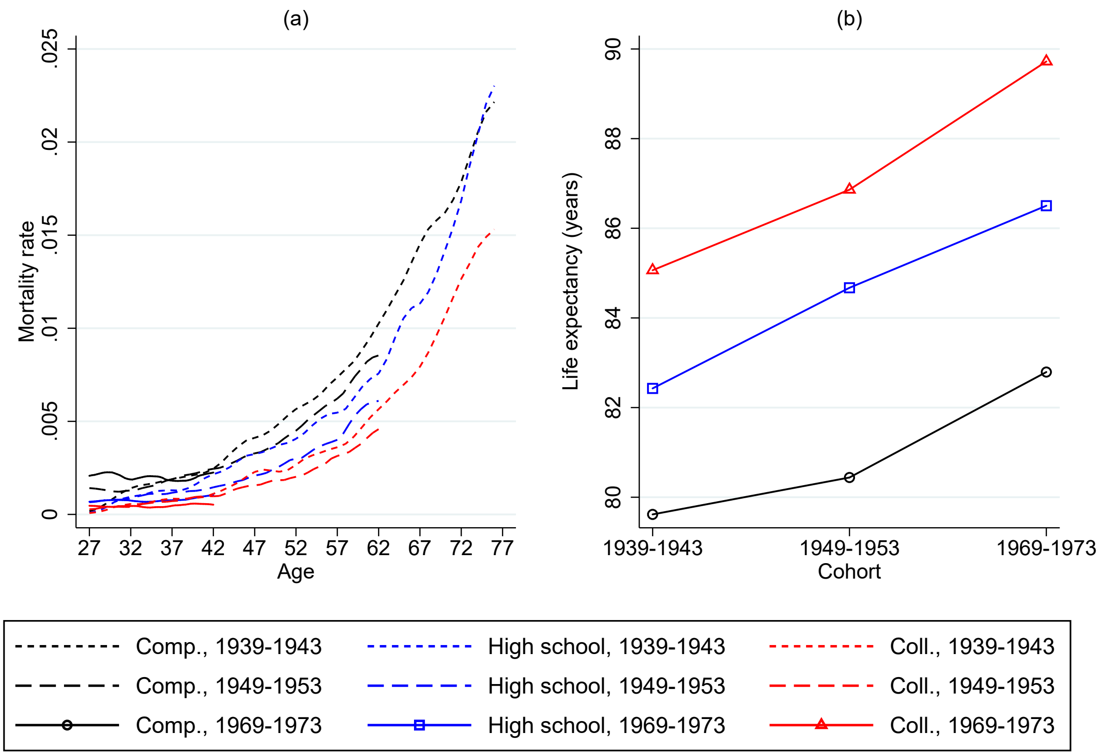
Health and longevity are important for understanding the labor supply behavior of older individuals. In this Section, we document some key facts concerning the heterogeneity in health and longevity across individuals and the evolution of these measures over time. We use Norwegian data for our analysis. However, as noted previously, many of the facts hold also for other Western economies, including the US. All data are for men.

Longevity

There is a strong education gradient to longevity. While all education types have benefitted from substantial improvements in longevity over the last several decades, the

[2] National Academies of Sciences, Engineering, and Medicine (2015).

Figure 1: Mortality and Life Expectancy by Education and Birth Cohort



Panel (a) displays mortality rates by age and cohort (smoothed). In Panel (b) these mortality rates are used to construct life expectancy at birth, conditional on being alive at age 27. We employ a Lee-Carter model to construct the survival probabilities. This procedure is explained in the Calibration Section. While the mortality rates in Panel (a) are smoothed, we use the unsmoothed values when estimating the survival probabilities. Data source: Norwegian registry data, years 1967-2015.

improvements have favored the more educated somewhat more than the less educated.[3] These patterns are summarized in Figure 1.

Health

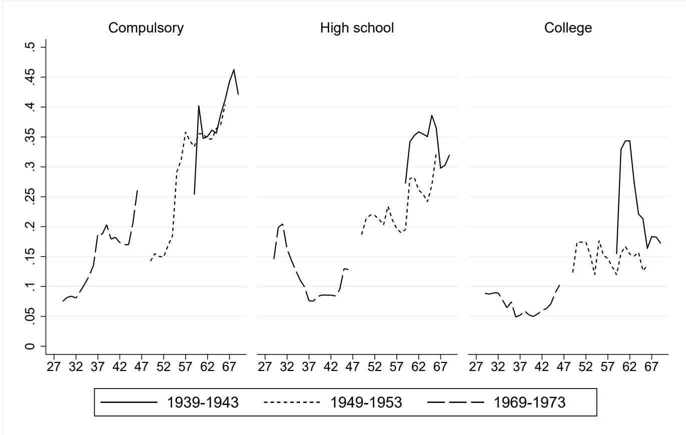
Similar to longevity, there are substantial differences in health over education. There has also been a divergence in health over education in recent years. The share of compulsory educated individuals in bad health has risen, while the share of high school and college graduates in bad health has declined. See Figure 2 for details.

Disability

The data on disability benefit claiming mirrors the data on health and longevity. Dis-

[3] Note, however, that the divergence over education is much more pronounced in the US than in Norway. See Pijoan-Mas and Ríos-Rull (2014) and Chetty et al. (2016) for discussions.

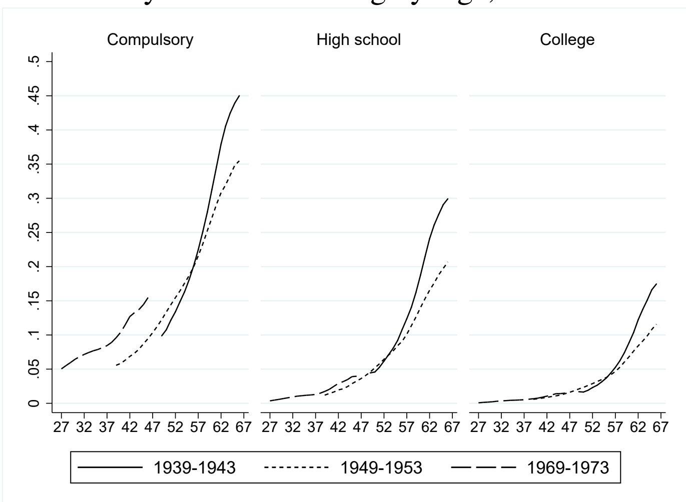
Figure 2: Share in Bad Health by Age, Education and Cohort



Bad health defined as functional limitations on daily life, self-assessed. Data from Norwegian Labor Force Survey, years 2002-2015.

ability benefit claiming is declining in education. Moreover, in recent years disability benefit claiming among high school and college graduates has declined, but the disability benefit claiming of younger individuals with only compulsory education has risen. These patterns are illustrated in Figure 3.

Figure 3: Disability Benefit Claiming by Age, Education and Cohort



Values computed from Norwegian registry data, years 1992-2014.

Selection Concerns

Our analysis has centered around three education types, compulsory, high school and college or more. Over time, the population has become more educated. This raises the concern of selection. Namely, is the divergence in outcomes over education that we have documented driven by selection? Moreover, how interesting is the group with less than a high school education, if it is shrinking rapidly? While we cannot ignore these concerns entirely, we would argue that the patterns documented above are by no means driven exclusively by selection. The share of native born Norwegians aged 30-34 with only compulsory education is nearly unchanged from year 2000 (21.9%) to 2016 (20.8%).[4] This illustrates that while the education level in the population is rising, a substantial share of young people are still without a high school degree today. Note also that in our quantitative analysis we adjust for changes in education shares when computing aggregate measures, such as government revenue.

These stylized facts are also mirrored in recent papers studying trends in social mobility. Markussen and Røed (2017) show a gradual worsening over time in the performance of young adults born to parents in the lowest earnings ranks in Norway. This group has experienced a substantial increase in disability benefit claiming and stable adult mortality, despite substantial reductions among the rest of the population. Chetty et al. (2016) find similar results for mortality in the US based on income ranks of young adults. Thus, the increasing polarization across education groups documented in this paper is not just driven by selection, but is also present when applying methods where selection plays no role.

3 Model

We develop a discrete time life cycle model with heterogeneous agents who face health, mortality and income risk. Agents enter the model at age 27 endowed with a given education level e, as well as initial assets k_0 and initial health h_0. We allow for three education categories: compulsory, high school and college or more. All agents are initially in good health and endowed with zero assets.

A model period is a year. Agents live for at most 69 periods. Agents face a positive

[4] From Statistics Norway, Statistikkbanken, Table 09599.

mortality risk at the end of each period. The survival probability $p_{a,e,h}$ from age a to $a+1$ is dependent on age, education and health.

Preferences

Agents have preferences over consumption (c_a), labor supply (l_a) and health (h_a), where the period utility function is given by:

$$U(c_a, l_a, h_a) = \ln(c_a) - b(h_a, e)l_a - \psi(h_a, a) \quad (1)$$

Preferences are assumed to be separable and consistent with balanced growth, thereby dictating the $\ln(c)$ choice. Health enters utility indirectly through the disutility from work. We assume that working is more unpleasant the worse one's health.[5] We assume that the disutility from working is also dependent on education. The agent incurs a utility cost or stigma from applying for disability benefits denoted by $\psi(\cdot)$. The utility cost is dependent on age (higher value up to age 56, and lower value from then onwards) and health (greater value in good health and lower value in bad health).

Budget Constraint

Each period there are markets for consumption, labor and capital (k). Labor income is the product of the wage, $w_{a,e}$, and labor supply, $l_{a,e}$.[6] The wage process is uncertain, consisting of a persistent and a transitory component. We assume labor supply is a discrete choice, i.e., the individual either works full-time or not at all, $l_{a,e} \in \{0, \bar{l}\}$.[7] We assume everyone is retired at age 72. This is also the age until which employment protection extends in Norway; after that employers are free to fire workers without just cause. Let r

[5]This is an alternative to assuming that productivity (or the wage) is health dependent, since both result in a distribution of retirement ages. French (2005) finds surprisingly little difference in the wages of healthy and unhealthy individuals in the United States. Kemptner (2013) also finds that the coefficient for health is small and insignificant when estimating a wage equation for Germany.

[6]The price per efficiency unit of labor has been normalized to one.

[7]The prevalence of part-time work among men is very low. Figure A1 in the Appendix shows the concentration of male weekly hours at full-time work.

denote the interest rate. The individual faces a sequence of budget constraints given by:

$$(1+\tau_c)c_{a,e}+k_{a+1,e}-(1+r)k_{a,e}=(1-\tau_l(y_{a,e}))w_{a,e}l_{a,e}+(1-\tau_b(y_{a,e}))(DI_{a,e}+R_{a,e}) \quad (2)$$

where $y_{a,e}$ denotes taxable income, $R_{a,e}$ old-age retirement benefits and $DI_{a,e}$ disability benefits. Social security benefits are part of taxable income. Note that individuals cannot collect disability and old-age retirement benefits simultaneously. At age 67, disability benefit recipients are transferred automatically to old-age retirement benefits. τ_c denotes a proportional tax on consumption and $\tau_l(\cdot)$ and $\tau_b(\cdot)$ progressive taxes on labor income and social security benefits, respectively.

We impose a no-borrowing constraint, $k_{a,e} \geq 0$. This is a way of ensuring that people work when young, even at a low wage.[8] We assume that any accidental bequests are taxed at a confiscatory rate of 100%.

Health and Mortality

We model two health states, good and bad. As noted previously, all agents start out in good health. The agent then faces an age and education dependent probability of transitioning from good to bad health, where bad health is assumed absorbing. Mortality rates depend on age, education and past health.

Social Security

We model a stylized representation of the Norwegian social security system.[9] The Norwegian social security system is quite complex, with different groups of the population facing different schemes. Moreover, due to changes in recent years, different birth cohorts also face different rules. The scheme we model here is the one in place for private sector employees without access to early retirement.[10] Also, since we rely on data for

[8]In the absence of a borrowing constraint, and with exogenous wages and individuals choosing the timing of work, people would choose not to work when young but rather at a higher wage later on. This is contrary to what we observe in the data.

[9]In the paper, we use social security to refer to both old-age retirement and disability benefits.

[10]This scheme covers approximately a third of the workforce. For simplicity, we abstract from occupational pensions. They are relatively small, and similar across education groups, for our sample. On average, occupational pensions only constitute roughly 2.5% of the total wage bill.

people currently in retirement or nearing retirement, we use the scheme for the cohort born 1953 or earlier. All benefits are indexed to so-called base-amounts (BA).[11]

The old-age retirement benefit depends on past earnings through so called average pension points. The pension points accrued in a given period depend on earnings in that period:

$$points_{a,e} = \min[\max(w_{a,e}l_{a,e} - 1, 0), 5] + \max[\min((w_{a,e}l_{a,e} - 6)/3, 2), 0] \quad (3)$$

In other words, one accrues full pension points on earnings up to 6 BA and then 1/3 points on income above 6 BA. The average over pension points from the 20 best years form the basis for computing the old-age retirement benefit. Keeping track of the best 20 years would imply keeping track of all possible combinations of wage shocks, which is infeasible. Instead, given the labor supply choice and the realization of the wage shock, we compute the pension points accrued in the current period according to the formula above. We then update average pension points. When the worker has worked fewer than 20 years, average points increase unambiguously. If the worker has worked more than 20 years, average pension points only increase if pension points in the current period exceed average points. For simplicity, we throw out an average year of pension points, instead of the lowest year. This is in line with French (2005).

Average pension points then map into the retirement benefit as follows:

$$R_{a,e} = 1 + 0.435 \times avepoints_{a,e} \times [min(yow_{a,e}/40, 1)] \quad (4)$$

The full old-age retirement benefit is awarded with 40 years of work (*yow*). Benefits are reduced proportionately for missing years of work. There is a supplementary benefit for people with low benefits. The resulting minimum benefit is equal to twice the BA. The earliest claiming age for old-age retirement benefits is 62. There is an adjustment for

[11] Equal to 92,576 NOK in 2016, which is slightly less than 12,000 USD.

delayed claiming.

Disability benefits equal 66% of the last income before going on disability. Maximum income for this calculation is 6 BA. There is a minimum benefit of 2 BA. Disability recipients are transferred to old-age retirement benefits at age 67. One accrues pension points while on disability, as if one had continued to work at the last wage.

The collection of disability insurance benefits is contingent on applying for benefits. We assume that there is a utility cost associated with applying for disability insurance benefits, which is dependent on age and health. Specifically, we assume that the cost is greater if one is in good health as opposed to bad health, and that the cost is higher below age 57. This is to help match the age profile for disability receipt. While assuming everyone who applies for disability benefits is granted them is a simplifying assumption, rejection rates in Norway are low, particularly at older ages. The initial rejection rate for applicants aged 61-65 is only 6%, and half of those are granted permanent disability benefits within 5 years of first applying (see Kornstad and Skjerpen (2010)). Nevertheless, we discuss the implications of this assumption in the Sensitivity Analysis Section.

In actuality, the first step to obtaining disability benefits is sick leave. Sick leave is certified by a doctor and lasts up to one year. If one does not return to work after sick leave, one can apply for temporary disability. The requirement is the same as for sick leave – reduced work capacity due to health problems, fairly broadly defined. Since this entry condition is already fulfilled from the sick leave certificate, the transition to temporary disability insurance is rather automatic. In the temporary disability insurance program, the goal is to be rehabilitated, re-trained and/or re-oriented, and then return to work. The time spent in temporary disability varies, both across persons and over time. The norm is 3-4 years. According to Markussen and Røed (2014), 48% return to work (highly dependent on age). If one does not return to work, one can apply for permanent disability insurance. In our model, we abstract from temporary disability.

Taxes

The government levies a proportional consumption tax (τ_c) and a progressive income tax (τ_l on labor income and τ_b on benefits). Note that old-age retirement and disability benefits are part of taxable income. The government uses the proceeds from these taxes to finance social security benefits. We assume that the remaining tax revenue is thrown away. This is equivalent to assuming that the additional tax revenue is spent on government consumption which the agent values, as long as the government consumption does not affect the marginal utility of private consumption.

Recursive Formulation

The individual's decision problem can be written in recursive form. We suppress the dependence on education e to ease notation. The state x of an individual is given by age a, assets k, health h, average pension points $avepoints$, years of work yow, last wage shock $dshck$, benefit status $bage$ (age at which started claiming old-age retirement benefits, if claiming), disability status $dage$ (age at which started claiming disability benefits, if claiming), and work status $rage$ (age at which stopped working, if no longer working). We keep track of average pension points and years of work in order to compute the old-age retirement benefit. The last wage shock is necessary for computing the disability benefit. We need to keep track of the employment status, since retirement is an absorbing state.

Every period, individuals face uncertainty with respect to health, survival and earnings. Individuals know x at the beginning of the period and decide how much to consume, how much to save, whether or not to work, and, if applicable, whether or not to apply for old-age retirement/disability benefits (denoted by app^R and app^{DI}, respectively). Individuals claiming old-age retirement benefits can work, whereas individuals collecting disability benefits cannot. Moreover, we assume that benefit claiming and retirement are absorbing states (i.e, once the individual stops working, he/she cannot return to work).[12]

[12] In the data, disability benefit claiming is perfectly absorbing. This is related to the fact that it is possible to combine partial disability with working. However, very few individuals actually do so. Only 2.7% of disability benefit claimants above age 60 combine working and disability benefit receipt. In general, retirement is highly absorbing in the data. Of those aged 62 and older who did not work in a given year, only 2.6% worked the following year. Moreover, only a small fraction of these individuals returned to full-time

The value of state x is:

$$V(x) = \max_{\substack{c,k',l,\\ app^{DI},app^{R}}} u(c,l,h) + \beta p(x) EV(x') \quad (5)$$

$$s.t. \quad (1+\tau_c)c + k' - (1+r)k = (1-\tau_l(x))w(x)l + (1-\tau_b(x))(DI(x)+R(x)) \quad (6)$$

4 Calibration

In this Section we discuss the process of parameterizing the model. We calibrate the model to Norwegian data and institutions. Where data allows, we calibrate the model to the cohort born 1949-53. We also generate predictions of health and survival probabilities for the cohort born 1969-73 for the subsequent policy analysis. Note that all data are for males. The parameterization of the model is a two-stage process. In the first stage, we assign values to parameters that can be estimated outside our model. These include the earnings process and the probabilities governing health transitions and survival. In the second stage, we use the model to calibrate the remaining parameters, namely the preference parameters.

4.1 First Stage of Calibration

Life Cycle Earnings Profiles

Labor earnings are estimated using Norwegian administrative panel data on annual earnings, covering the full population from 1967 to 2015. For consistency with the modeled social security system, we restrict the sample to men working in firms without access to early retirement schemes.[13] We include workers with earnings above 3.5 BA in our sample. Subsequently, this also serves as our definition of employment. We top-code incomes at 25 BA. We follow individuals from age 27 to age 62.

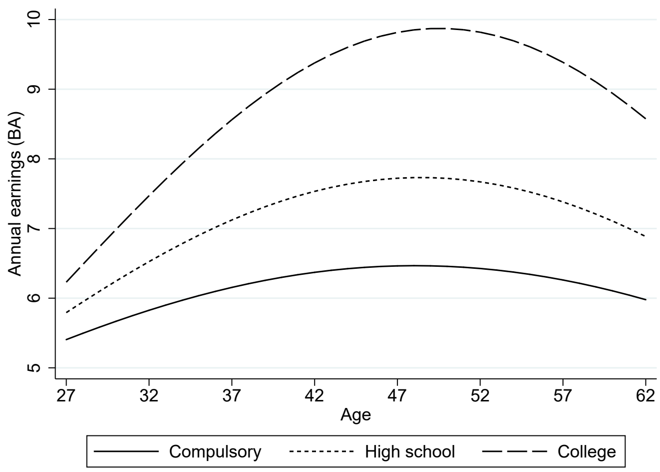
work.

[13] There are some data limitations that complicate making this distinction. See the Appendix for details on how we deal with them.

Labor earnings are comprised of a deterministic and a stochastic component. The deterministic component is estimated by regressing annual labor earnings on age, age squared and an individual fixed effect. We run this estimation separately for each education type, compulsory, high school and college.[14] Due to selection issues, we hold the deterministic component of earnings constant after age 62. The residuals from the above regression represent the stochastic component of earnings. As is standard in the literature, we follow Storesletten et al. (2004) and assume that this process can be represented by a time-invariant process with a persistent and a transitory component. We discretize the persistent stochastic component with a five-state Markov-process using Tauchen's method. For the transitory shock we assume two states.

Figure 4 plots the life cycle earnings profiles for the three education types. They exhibit the usual hump-shaped profile, with the earnings of more educated workers rising more over the life cycle and peaking later in the life cycle than the earnings of less educated workers.

Figure 4: Life Cycle Earnings by Education



Data source: Norwegian registry data for cohort born 1949-53.

Taxes

We use income registry data for year 2014 to construct the progressive income tax

[14]College graduates correspond to NUS categories 6, 7 and 8 (ISCED 6, 7 and 8). High school refers to NUS categories 4 and 5 (ISCED 3, 4 and 5), whereas compulsory is defined as anything below NUS level 4 (ISCED 1 and 2).

functions. To smooth out the data, we group incomes into bins of 0.1 BA and take the median tax rate for each bin. We then regress the median tax rates on a second order polynomial of income. This is done separately for labor and social security income.[15] For social security income, only income above 2 BA and below 10 BA is taxed. The estimated coefficient values are summarized in Table 1. Plots of the tax functions for labor and social security income can be found in the Appendix, see Figures A2 and A3. We take the consumption tax rate from McDaniel (2007).

Table 1: Estimated Tax Function Coefficients

Coefficient	Labor	Retirement
Constant	0.0984	-0.1111
Income	0.0321	0.0897
Income^2	-0.0008	-0.0047

Tax function coefficients, estimated using second order polynomial. Labor: tax function on labor income. Retirement: tax function on social security benefits.

Health Risk

Recall that there are two health states in our model, good and bad, and that bad health is absorbing. We use health data from the Norwegian Labor Force Survey. The health measure in the survey is self-assessed and based on whether or not the individual feels that he suffers from physical or psychological health problems of a lasting nature which limit daily life. The data on health is only available from year 2002 onward. It is therefore not possible to obtain complete life cycle profiles when following specific cohorts. Instead, we estimate a logit model for bad health in which we include interaction terms for calendar time (year) and age. The model takes the following form:

$$bad\ health_{i,t} = F\left(\beta_0 + \beta_1 a_{i,t} + \beta_2 a_{i,t}^2 + \beta_3 e_i + \beta_4 t + \beta_5 (t \times e_i) + \beta_6 (t \times a_{i,t})\right) \quad (7)$$

[15] The tax function for social security income is based on taxes levied on old-age retirement income. We apply the same tax function to disability benefits.

where a is age, e is education and t is year. This model allows us to predict out of sample and to obtain predictions both for ages above 67 and for future years not covered by the data. These predictions are then used as inputs in the model. We anchor this fit to the calibration cohort, which corresponds to the prediction for 2012. Hence, when we consider earlier and later cohorts, the time-intervals for health predictions are similar to the time intervals between cohorts (i.e. for the 1939-43 cohorts we use health predictions for 2002).[16]

Figure A4 in the Appendix plots the share of individuals in good health over age and education, as implied by the aforementioned transition probabilities, for the calibration period, namely the cohort born 1949-53. As documented previously, the share of workers in good health is higher the better educated the individuals. Moreover, the differences over education become more pronounced with age.

Survival Risk

We use Norwegian population panel data containing records for the full population from 1967 to 2015. For individuals born in 1949 (1953), we observe actual mortality rates up to age 66 (62). Given that we need survival probabilities up to the terminal age of 97, we need to predict the survival probabilities at older ages using historical data. To do so, we estimate the following Lee-Carter model using the singular value decomposition method:

$$log(m_{a,t}) = \beta_a + \gamma_a k_t + \varepsilon_{a,t} \tag{8}$$

where $m_{a,t}$ is the observed age-specific death rate at age a in year t, β_a is the general age pattern for age a, k_t is the time index for year t and γ_a is the age-dependent correction of the time index for age a. We use the estimated model to forecast the value of the time index up to year 2070 using a random walk with drift. This allows us to construct full cohort life tables for all cohorts up to 1973.[17]

[16]See the Appendix for details.
[17]See the Appendix for details.

Figure A5 in the Appendix plots the share of individuals alive at each age, as implied by the aforementioned transition probabilities, for the cohort born 1949-53, separately for the three education types. As documented previously, life expectancy is increasing in education.

It is, however, natural to think that health also impacts longevity. We would therefore like to condition the survival probabilities on health. Due to data limitations we are not able to do this directly. Instead, we use disability status as a proxy for bad health, and compute the difference in average mortality by age and disability status. We then think of the age-dependent mortality rates estimated above as the weighted averages of the mortality rates of those in good and bad health and use that to back out the health-dependent survival probabilities.

Combining the health and average survival probabilities outlined above, it is possible to compute healthy life expectancy over education. From Table 2 it is apparent that, not only do more educated men live longer than their less educated counterparts, they can also expect to spend a larger share of their life in good health. The values in the first column of the table are for the calibration cohort, men born 1949-53. The second column reports predicted values for a younger cohort, men born 1969-73. While all education groups in the younger cohort are expected to benefit from improvements in longevity, only high school and college educated workers can expect to spend a larger share of their life in good health relative to their counterparts in the older cohort.

4.2 Second Stage of Calibration

Preference Parameters

The preference parameters that need to be assigned a value are the discount factor, β, the parameters governing the disutility from working, $b(h,e)$, and the utility cost, or stigma, of applying for disutility benefits $\psi(h,a)$. We assume an annual interest rate equal

Table 2: Life Expectancy and Healthy Life Expectancy by Education and Cohort

	1949-53		1969-73	
	LE	HLE	LE	HLE
Compulsory	80.4	60.8	82.8	54.9
High school	84.8	68.1	86.5	77.8
College	87.0	74.6	89.7	84.8

Life expectancy (LE) and healthy life expectancy (HLE) at birth, conditional on being alive at age 27, for cohorts born 1949-53 and 1969-73. Data sources: Norwegian registry data and Norwegian Labor Force Survey. Life expectancy is derived as the sum of cumulative survival probabilities from age 27 to age 97. Healthy life expectancy is derived as the sum of cumulative survival probabilities from age 27 to age 97, scaled by the fraction in bad health at each age.

to 3%. β is then chosen to match an asset to income ratio of 2.36.[18] The parameters governing the disutility from working and the utility cost of applying for disability benefits jointly pin down retirement entry (stop work) and disability benefit claiming. We target these moments by age and education, and also report the fit over health.[19] In the calibration, we minimize the sum of squared deviations between model outcomes and data counterparts. We weight employment and disability benefit claiming equally. Moreover, for disability benefit claiming we weight each age bin equally, whereas for employment we only target employment for the last two age bins, 62-66 and 67-71.[20] To match these moments, we allow the disutility from working to differ by health and education. Allowing for variation over age proved unnecessary. The weights for the different education types are taken from the data. We allow the utility cost of applying for disability benefits to depend on health and age. There is a strong education gradient to disability claiming, which we feel it is important to match. Yet, it turns out that it is not necessary to allow stigma to vary by education in order to match this, since disutility from work varies by education. To match the steeply rising age profile for disability claiming, stigma needs to vary over age. All calibrated preference parameters are summarized in Table 3.

[18]This is with censoring on assets at 30 million NOK (or roughly 3.8 million USD).

[19]The data moments for employment and disability claiming are from administrative data and follow specific cohorts. They are also linked to the earnings process. This data does not have health, since health is available only for the labor force survey sample. As such, the health data is cruder.

[20]The data on employment for ages 67-71 is based on a projection using data on the exit rates of preceding

Table 3: Calibrated Parameter Values

Parameter		Target	Value
Disutility from work			
$b(g,0)$	good health, compulsory	employment by age and education	10.2
$b(b,0)$	bad health, compulsory		39.2
$b(g,1)$	good health, high school		10.5
$b(b,1)$	bad health, high school		45.4
$b(g,2)$	good health, college		11.2
$b(b,2)$	bad health, college		19.3
Stigma of applying for DI			
$\psi(g,y)$	good health, young	DI by age and education	10.0
$\psi(g,o)$	good health, old		3.5
$\psi(b,y)$	bad health, young		7.0
$\psi(b,o)$	bad health, old		0.5
Discount factor			
β		asset/income ratio	0.9753

Young refers to ages 27-56, old to ages 57+.

4.3 Calibrated Economy

In this Section we discuss the fit of the model to the data. We are particularly interested in how well we are able to replicate the labor supply behavior of older workers.

Figure 5 shows the employment rates of men by age and education relative to the data. Our model does a good job of matching the employment data.[21] The model slightly overpredicts employment at younger ages, but does a very good job of matching the decline in employment from the late 50s on. Similarly, Figure 6 shows the disability benefit claiming rates of men by age and education relative to the data. Our model matches the data on disability benefit claiming quite well. In particular, the model generates the strong education gradient to disability benefit claiming.[22] Also, the model generates a strong increase in disability benefit claiming with age, although it somewhat overpredicts this relative to the data.

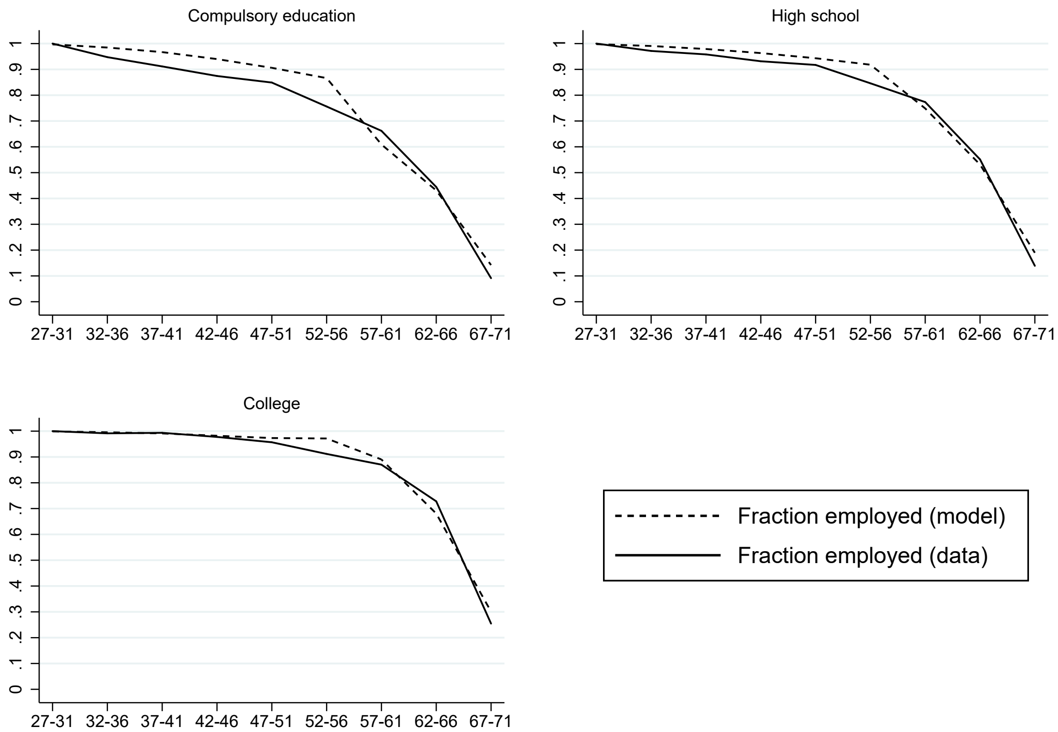
cohorts, since we do not observe employment for ages 67-71 for our cohort.

[21]Note that the employment and disability insurance rates are conditioned on everyone working at age 27. As such, we abstract from people who are born with disabilities or become disabled early in life.

[22]We find that differences in wages and health and survival probabilities are important for generating the education gradient in disability benefit take up. For generating the difference between high school and college educated individuals, differences in wages are somewhat more important than differences in health/survival probabilities, whereas for generating the differences between individuals with a compulsory and a high school education the two are of roughly equal importance.

The model is calibrated to match the average asset to income ratio. The model also matches the life cycle asset profiles for each education type quite well until about age 60. After that the profiles diverge, since, in the absence of a bequest motive, agents in the model start running down their assets.

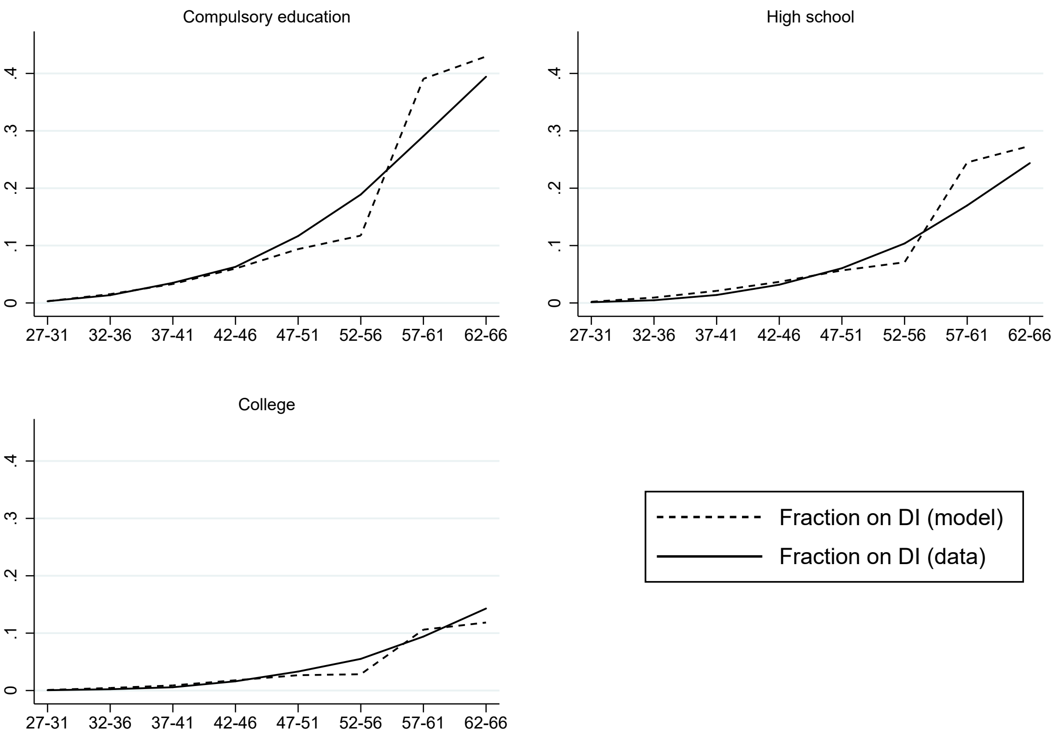
Figure 5: Model Fit for Employment by Age and Education



Data source: Norwegian administrative data, cohort born 1949-53.

An important test of the model is its ability to match moments which were not explicitly targeted. Key among them is health by employment/disability status. The model slightly underpredicts the share of employed workers in bad health. Specifically, the model predicts that on average 2% of compulsory educated, 2% of high school educated and 1% of college educated individuals who are employed are in bad health, compared with 5%, 5% and 3%, respectively, in the data. The model does a good job of matching the average health of disability claimants. The model predicts that on average 86% of compulsory educated, 86% of high school educated and 90% of college educated individuals collecting disability benefits are in bad health, compared with 84%, 87% and 92%,

Figure 6: Model Fit for Disability Benefit Claiming by Age and Education



Data source: Norwegian administrative data, cohort born 1949-53.

respectively, in the data. While the model does a good job matching health over employment/disability status on average, it struggles somewhat to match the life cycle profiles. See Figures A6 and A7 in the Appendix for the full age-health profiles.

It is rather striking that the disability benefit claiming rate in Norway is so high, yet life expectancy is very long. To put things in perspective, note that disability benefit claiming in the US and most of Continental Europe is much lower than in Norway, with disability benefit claiming rates among 50-64 year olds below 10%. It is well recognized that disability is partly utilized as a pathway into early retirement in Norway; see, e.g, Hernæs et al. (2016). Our model captures this phenomenon.

Old-age retirement benefit claiming in the data occurs on average earlier than in the model. Based purely on the benefit formula, it would be optimal for someone with average life expectancy to claim benefits at age 67. This is what we see in the model. In the data, the average age for claiming benefits is 65. This discrepancy has been previously documented; see Brinch et al. (2018) for a study on the role of private information regarding life expectancy in accounting for this phenomenon. The coordination of retirement across spouses is another potential contributing factor that our model abstracts from; see Kruse (2018).

4.4 Model Evaluation

As a further test of the calibration, we use our model to study the Norwegian retirement system in place before the last reform. We compare the optimal life cycle behavior of two groups of individuals who differ with respect to health and life expectancy, and the retirement schemes that are applied to them. Each individual in the first group faces the age- and education-specific health and survival risk associated with the cohort born 1949-53. This is our calibrated economy. Each individual in the second group faces the age- and education-specific health and survival risk associated with the cohort born 1939-43. All probabilities governing health and survival risk are computed as outlined in the previous section. As documented in the Stylized Facts Section, the older cohort exhibits worse health and lower life expectancy relative to the newer cohort. The notable differences in the retirement system in place for the 1939-43 cohort relative to our benchmark are: (1) no claiming of old-age retirement benefits before age 67, and (2) a severe earnings test on benefits when combining work and claiming of old-age benefits.[23] Disability insurance eligibility has remained the same across these cohorts.

In the data we observe lower employment for the cohort born 1939-43 than for the cohort born 1949-53. Our model can account for this. In particular, the model predicts a difference in average employment of 1.6 pp across the two cohorts, compared with a difference of 1.8 pp observed in the data. The difference in employment arises largely due to differences in disability benefit claiming. The model predicts a difference of 3.9 pp in the average disability claiming rates of men aged 50-66 between the two cohorts,

[23]For simplicity, in this exercise we tax old-age retirement benefits at 100% when working, since the earnings test was large enough to discourage combining work and benefit claiming.

compared with 4.5 pp in the data. Figures A8 and A9 in the Appendix plot life cycle profiles for employment and disability. The lower employment for the older cohort is driven by demographic factors as well as the fact that, in the absence of early retirement via old-age benefit claiming, disability insurance claiming is higher.

All in all, we feel that this exercise is a good test of our calibrated model.

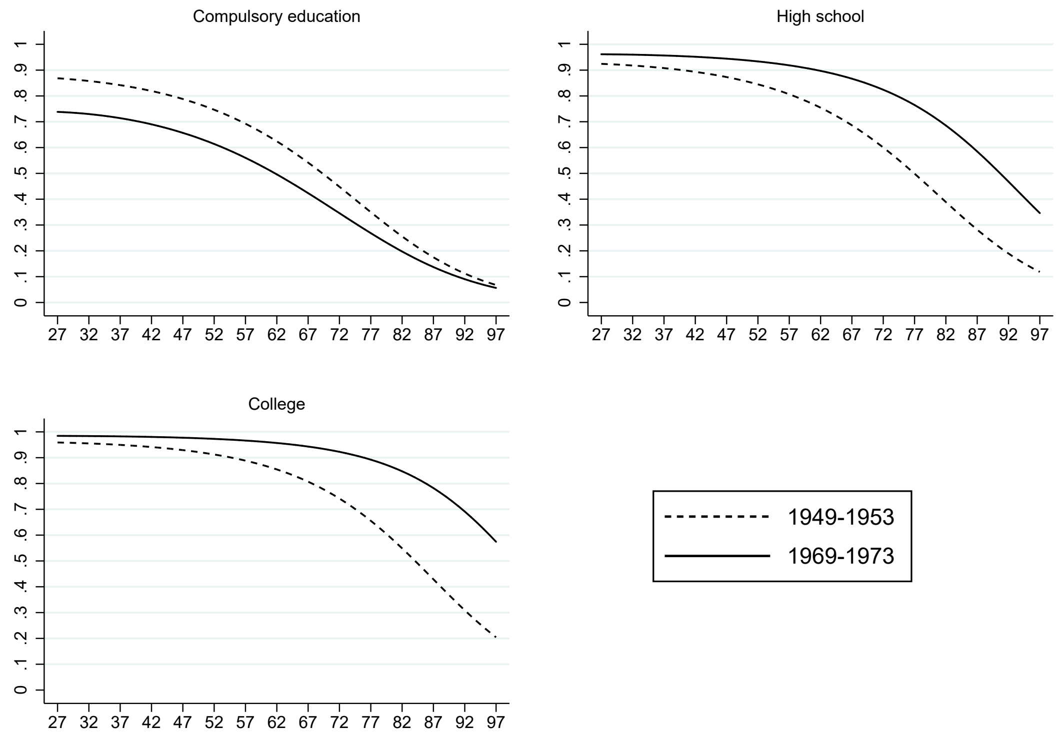
5 Policy Analysis

Having calibrated the model, we now turn to the policy analysis. Increasing longevity threatens the solvency of social security programs. Our goal is to study alternative retirement reform measures that are fiscally sustainable in the face of demographic change. We are particularly interested in the differential effects of the alternative reform scenarios for individuals who differ in terms of productivity, health and life expectancy. To this end, we study the labor supply effect as well as the redistributionary implications of the different policy measures.

To study the effects of increasing longevity, we compare the optimal life cycle behavior of two groups of individuals who differ with respect to health and life expectancy. Each individual in the first group faces the age- and education-specific health and survival risk associated with the cohort born 1949-53. This is our calibrated economy. Each individual in the second group faces the estimated age- and education-specific health and survival risk associated with the cohort born 1969-73. The probabilities governing health and survival risk for the cohort born 1969-73 are a mix of data and projections, as detailed in the Calibration Section. We predict a widening of the education-gap in health and survival. See Figures 7 and 8 for details on the predicted changes in health and survival across cohorts born 1949-53 and 1969-73.

In addition to facing different health and survival risk, the cohort born 1969-73 is also more educated relative to the cohort born 1949-53. We adjust the education shares across

Figure 7: Predicted Share of Men in Good Health by Age and Education: Cohort Comparison



Data source: Norwegian Labor Force Survey, 2002-15.

cohorts when computing aggregate measures such as government revenue to reflect this.[24]

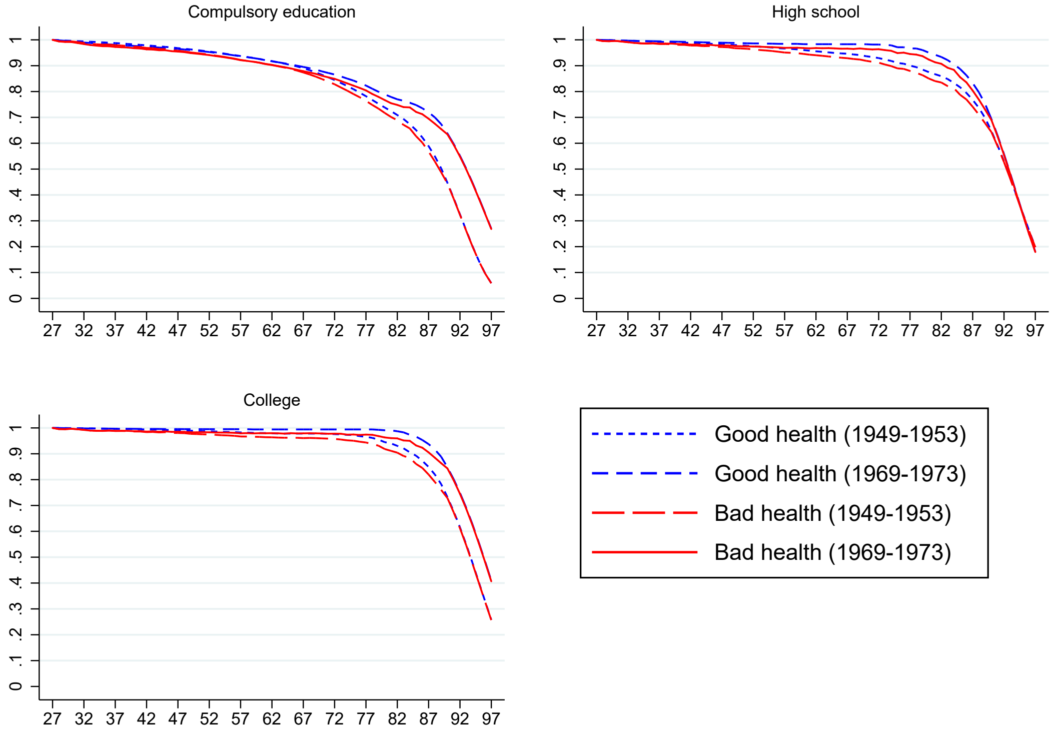
With the exceptions of health and survival probabilities, the parameters governing retirement policies, and the education shares, we hold all parameters fixed across the two groups.[25] To facilitate comparisons across policy regimes, we consider revenue neutral policy measures.[26]

[24]The education shares are based on forecasts used by Statistics Norway for constructing the built-in longevity adjustment in the retirement benefit formula.

[25]We hold wages fixed across cohorts, since due to data limitations we are not able to construct complete life cycle profiles for the younger cohorts.

[26]Note that we do not compute transitions. Rather, we are comparing two cohorts that face different but invariant policy regimes.

Figure 8: Predicted Share of Men Alive by Age and Education: Cohort Comparison



Data source: Norwegian registry data, years 1992-2015.

5.1 Effects of Demographic Change

Before analyzing how social security systems can be reformed to achieve financial stability, we must first understand the behavioral and fiscal implications of forecasted changes to health and life expectancy. Therefore, as a first step, we use our model to study the implications of changes in health and longevity under the current retirement benefit scheme. In other words, we feed in the predicted survival and health shock probabilities for the cohort born 1969-73, holding the institutional features constant at the benchmark. Note that the current Norwegian retirement scheme already includes a longevity adjustment, which means that future cohorts with higher life expectancy face lower benefits. Specifically, the annual benefit is reduced by 4.8% for the later cohort relative to the earlier cohort.

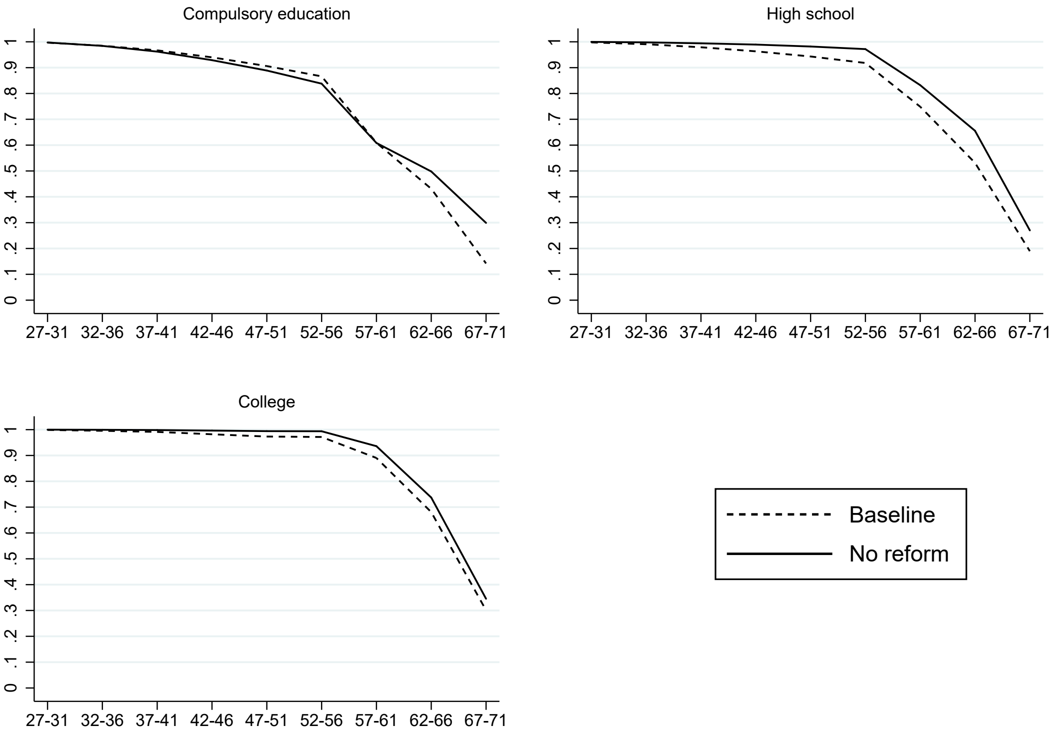
According to our model, however, the built in longevity adjustment is not sufficient to achieve revenue neutrality. Our model predicts a 7.9% decline in government revenue relative to the benchmark economy. This despite the fact that the model predicts an increase in the average employment rate of 50-66 year old men of 6 pp. The increase is most pronounced for high school graduates who exhibit an increase of 8 pp, compared with an increase of 4 pp for college graduates and no change for individuals with only compulsory education. The increase in employment at older ages is mirrored in a decline in disability benefit claiming, with the disability benefit claiming rate of men aged 50-66 falling by 4 pp. See Figures 9 and 10 for details on the model predicted changes in life cycle employment and disability benefit claiming across cohorts. The decline in government revenue is driven by a worsening of the old-age dependency ratio. The built-in longevity adjustment, changes in health and survival probabilities and changes in the educational composition all increase government revenue. Specifically, the built-in longevity adjustment increases government revenue by 3.9%, while changes in health and survival probabilities increase revenue by 0.2% and changes in the educational composition increase revenue by 11.6%. Changes in the dependency ratio decrease government revenue by 20.2%. Note that simply adjusting life expectancy across cohorts in our model does not accurately capture the change in the old-age dependency ratio implied by the data, since we abstract from changes in fertility. To correct for this, we weight the share of people aged 27-66 relative to the share of people aged 67 and above according to the data when computing aggregate measures such as revenue.[27]

5.2 Comparing Revenue Neutral Policies

We now turn our attention to alternative retirement reform scenarios. All workers in each scenario face the age- and education specific health and survival probabilities associated with the cohort born 1969-73, but different retirement benefit schemes. For comparability across exercises, each policy reform generates the same government consumption as the

[27] The decline in revenue results from an 8.2% decline in tax revenue and a 1.7% increase in the payout of retirement benefits. The payout of disability insurance benefits declines by 32.1%. Note that disability recipients are transferred into old-age retirement at age 67, so after that age their benefits are counted as part of the retirement benefit payout.

Figure 9: Employment by Age and Education: Baseline vs. No Reform



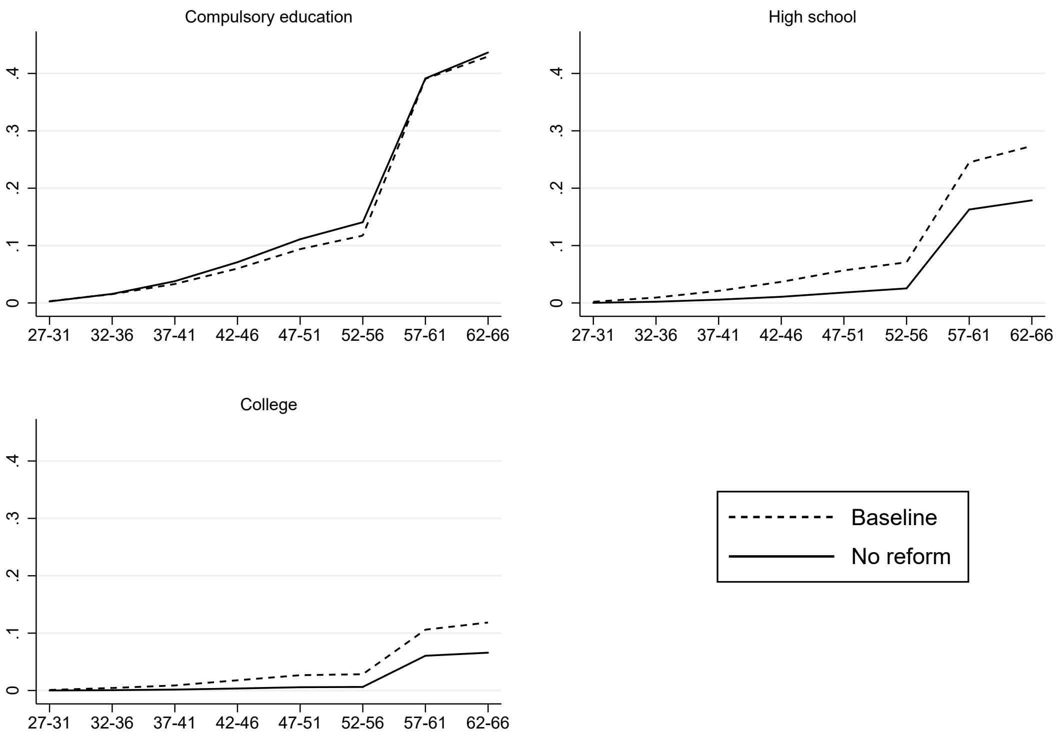
Baseline is the cohort born 1949-53 that the model is calibrated to. No reform is the cohort born 1969-73, which faces different health and survival risk but the same retirement benefit scheme as the older cohort.

benchmark economy. The policy alternatives we consider are: (1) raising the early access age to old-age retirement benefits, (2) increasing the longevity adjustment for old-age retirement benefits (i.e., lowering old-age retirement benefits), (3) proportionately increasing taxes on labor and social security income, and (4) lowering both old-age retirement and disability benefits. Table 4 provides a summary of the results from the alternative policy reforms. Below we draw attention to what we feel are the most interesting results, with a particular focus on comparing policies from the perspective of both equity and efficiency.

Employment and Disability

We find that only increasing the early access age for old-age retirement benefit claiming is not a very effective policy tool. In fact, according to our model, raising the early access age from 62 to 67 (the age at which disability benefits recipients are transferred to

Figure 10: Disability Benefit Claiming by Age and Education: Baseline vs. No Reform



Baseline is the cohort born 1949-53 that the model is calibrated to. No reform is the cohort born 1969-73, which faces different health and survival risk but the same retirement benefit scheme as the older cohort.

old-age retirement) is not enough to achieve revenue neutrality vis-a-vis the benchmark economy. Specifically, government consumption is 9.6% lower than in the calibrated economy. The reason for this is that, when we restrict access to old-age retirement benefits, disability benefit claiming rises. This is true for all education types. This exercise highlights the importance of including the disability channel in analyses of retirement reform.

In order to achieve revenue neutrality, we combine increasing the early access age to 67 with lowering the old-age retirement benefit. We then compare this policy reform with the other revenue neutral policy reforms. Figure 11 plots the employment rates by age and education across the four policy reform scenarios, while Figure 12 plots the incidence of disability insurance by age and education across the aforementioned reforms.

To achieve revenue neutrality by increasing taxes, a 6.0% increase in taxes on labor

Table 4: Comparison of Revenue Neutral Retirement Reforms

	EAA	LPB	RTX	PDI
Average discounted lifetime labor income	1	1.003	0.992	1.008
Average discounted lifetime utility	1	1.010	0.975	1.022
Average employment (50-66)	1	1.000	0.960	1.037
Average DI (50-66)	1	0.899	1.010	0.664
Share of DI recipients in bad health	1	1.022	0.926	1.099
Gini discounted lifetime labor income	1	1.004	0.997	0.959
Gini discounted lifetime total income	1	1.002	0.992	1.011
Gini discounted lifetime utility	1	1.337	1.091	1.314

EAA: early access age for old-age retirement benefit claiming raised to 67 and benefit scaled down. LPB: all old-age retirement benefits scaled down proportionally. RTX: taxes on labor and social security income increased proportionally. PDI: all old-age retirement and disability benefits scaled down proportionally. Results reported relative to the EAA policy scenario. Gini computed based on net of tax income.

and social security income is needed. We find that such a proportional increase in taxes on labor and social security income yields the lowest employment outcomes of all four policy alternatives. This is true for all education types. Model predicted average employment among people aged 50-66 is 3-6 pp lower with the tax reform than with the other retirement reforms.

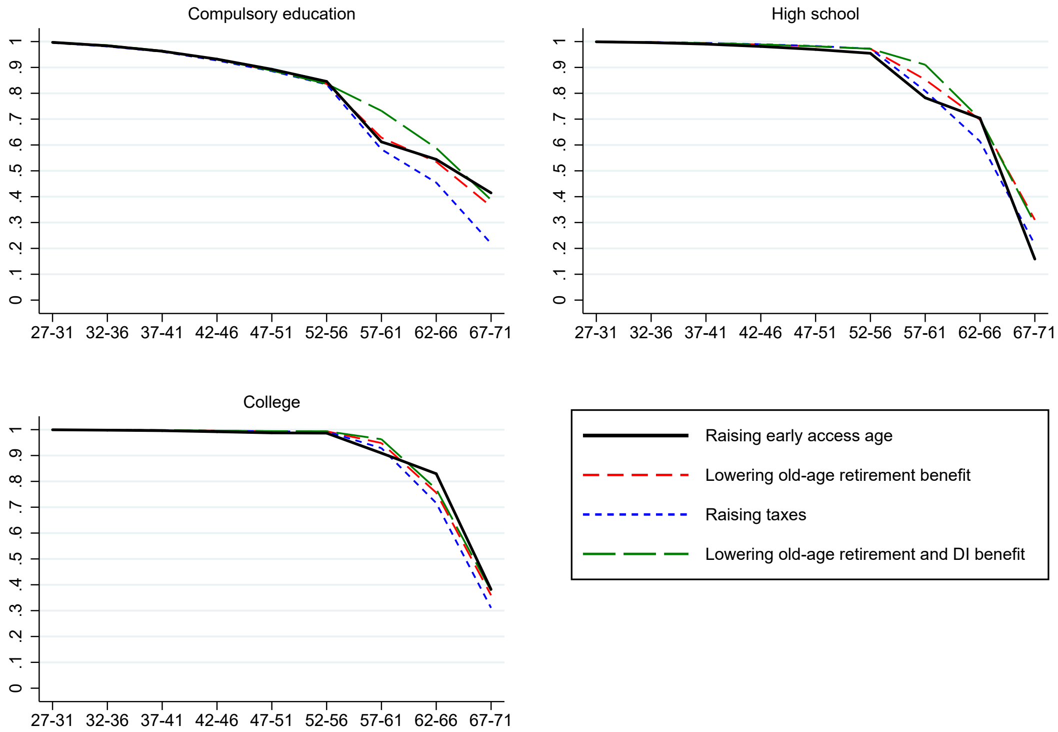
Scaling down old-age retirement and disability benefits by 12% results in revenue neutrality. This proportional reduction in old-age retirement and disability benefits results in the highest average employment rate for older people. This stems from the fact that this policy is most effective at curbing disability benefit claiming and boosting employment, especially among individuals with compulsory education only.[28] The model predicted average disability benefit claiming rate among men aged 50-66 is between 5 and 7 pp lower in this policy scenario compared with the other reforms.

The other two policy reform scenarios, namely increasing the early access age to 67 in combination with lowering old-age retirement benefits and lowering only old-age retire-

[28]The results presented here are from the scenario where we lower old-age retirement and disability benefits proportionately, but keep benefit accrual while on disability unaffected. We considered a scenario where we also lower old-age retirement benefit accrual while on disability in the same proportion as benefits. Revenue neutrality is then achieved with a slightly smaller decline in benefits. The results are very similar to the ones presented here.

ment benefits keeping the early access age fixed at 62, require old-age retirement benefits to be scaled down by 30% and 27%, respectively, in order to achieve revenue neutrality. These two policy reform scenarios yield intermediate outcomes for employment and disability benefit claiming.[29]

Figure 11: Employment by Age and Education Across Revenue Neutral Retirement Reforms



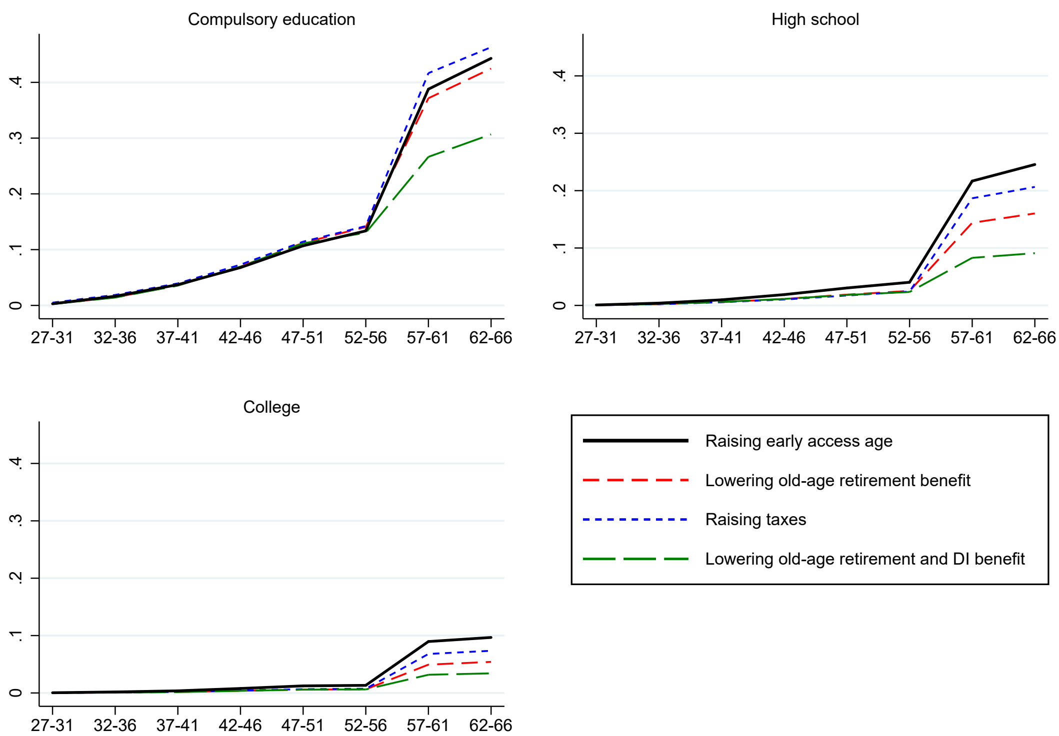
Raising early access age: early access age for old-age retirement benefits raised to 67 and benefit scaled down. Lowering old-age retirement benefit: all old-age retirement benefits scaled down proportionally. Raising taxes: taxes on labor and social security income increased proportionally. Lowering old-age retirement and DI benefit: all old-age retirement and disability benefits scaled down proportionally.

Welfare and Inequality

To evaluate the welfare implications of the alternative policy reforms, we compute changes in average discounted lifetime utility relative to the no-reform scenario. From

[29]The results presented here are from the scenario where we lower old-age retirement (and disability) benefits proportionately for all education types. We also considered a scenario where the longevity adjustment is education-specific. In other words, given that more educated individuals can expect to live longer, and thereby collect benefits longer, we lower their retirement benefits more relative to those of less educated individuals. We find that making the longevity adjustment education-specific does not have a big effect on the results.

Figure 12: Disability Benefit Claiming by Age and Education Across Revenue Neutral Retirement Reforms



Raising early access age: early access age for old-age retirement benefits raised to 67 and benefit scaled down. Lowering old-age retirement benefit: all old-age retirement benefits scaled down proportionally. Raising taxes: taxes on labor and social security income increased proportionally. Lowering old-age retirement and DI benefit: all old-age retirement and disability benefits scaled down proportionally.

an average welfare perspective, proportionately raising taxes on labor and social security income is the worst reform scenario, whereas proportionately lowering old-age retirement and disability benefits is the best. Specifically, raising income taxes lowers average discounted lifetime utility by 7.0% relative to the no-reform scenario, while lowering old-age retirement and disability benefits lowers it by only 2.6% (recall that the no-reform scenario results in a budget deficit). The welfare ordering of reforms is the same for all education types; for details see Table 5.

To judge the effect of the alternative retirement reforms on income inequality, we compute the gini of both labor income and total income (labor plus social security income). All measures are after taxes. The inequality of labor income is lowest with the cut in old-age retirement and disability benefits, and the greatest with the cut in old-age

Table 5: Welfare over Education in Revenue Neutral Retirement Reforms

	EAA	LPB	RTX	PDI
Compulsory	-5.4	-4.6	-7.8	-3.6
High school	-5.0	-3.7	-6.9	-2.3
College	-3.7	-2.8	-6.2	-1.5
Average	-4.7	-3.8	-7.0	-2.6

EAA: early access age for old-age retirement benefit claiming raised to 67 and benefit scaled down. LPB: all old-age retirement benefits scaled down proportionally. RTX: taxes on labor and social security income increased proportionally. PDI: all old-age retirement and disability benefits scaled down proportionally. Results reported as change (%) relative to no-reform scenario.

retirement benefits alone. The same observation holds if one compares the 90-10 income differentials instead of the ginis. Conversely, inequality of total income is lowest with the increase in taxes, and highest with the decrease in old-age retirement and disability benefits. These differences are not terribly large, however, with the gini of after-tax total income 1.9% higher with the cut in old-age and disability benefits than with the tax increase. To gauge inequality of welfare, we also computed the gini of welfare. Welfare inequality is lowest under the combined policy of increasing the early access age and scaling down old-age retirement benefits, and greatest with the cut in old-age retirement benefits.

Summary

To summarize, proportionally lowering old-age retirement *and* disability benefits is the best policy reform from the point of view of maximizing the average welfare of agents. It also results in the highest average employment, and thereby highest average labor earnings, of all policy experiments. However, cutting old-age retirement and disability benefits results in a greater degree of inequality of welfare than some of the other considered policy scenarios.

So, while the average welfare of all education types is highest under the policy reform where old-age retirement and disability benefits are lowered, disability benefit recipients are of course worse off than in the other policy scenarios. In our model, we assume that all workers are able to work – regardless of their health. Work is simply more unpleasant when one is in bad health. Our framework captures the fact that disability is utilized as a pathway into early retirement. Recall that the starting point for the policy reforms is an economy with very high disability benefit claiming. Moreover, disability benefits are very generous in the baseline. When disability becomes less attractive, the average health of disability recipients declines, implying that the reduction in disability benefit claiming comes from relatively healthier individuals working instead of receiving benefits. In fact, the share of disability benefit recipients who are in bad health is between 6 and 18 pp higher with the cut in old-age retirement and disability benefits than with the other policy reform scenarios. Our findings highlight the importance of including disability in models of retirement reform, as reducing the generosity of old-age retirement benefits can have the unintended consequence of increasing disability benefit claiming.

6 Sensitivity Analysis

While there is an education gradient to health and survival in Norway, and the improvements in both are expected to favor the more educated in coming decades, the projected differences over education – and income – are less pronounced in Norway relative to many other countries, for example the US. It is, therefore, of interest to ask whether any of our policy conclusions would be different in an economy where the changes in health and survival would favor the more educated more starkly than in Norway. In order to assess this, we re-do our policy analysis for an economy where the differences in health over education are amplified. Specifically, for individuals with a compulsory education we scale the transition probabilities from good to bad health up by 10% and for individuals with a college education we scale the transition probabilities from good to bad down by 10%. We leave the high school types unchanged. Note that we do not directly alter survival probabilities, but as health impacts survival, those are affected as well. We term this the pessimistic scenario.

We find that the results from the alternative policy reforms for the pessimistic scenario look similar to the baseline one. See Table 6 for a summary of the results. The employment and disability claiming patterns are plotted in Figures 13 and 14.

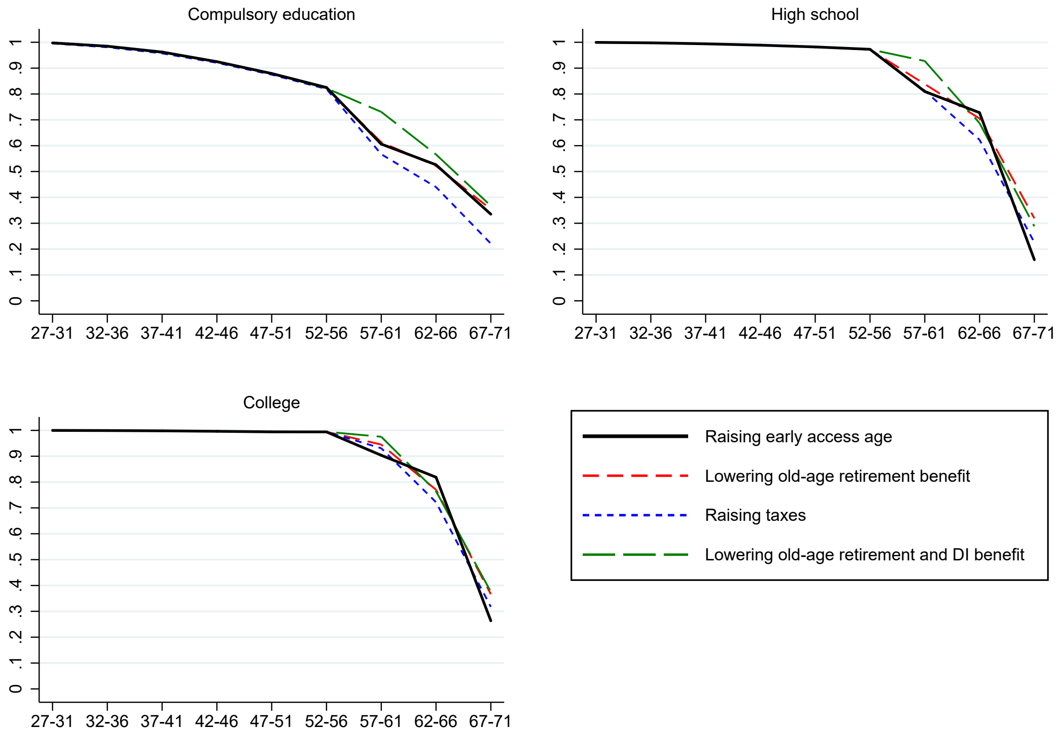
Table 6: Comparison of Revenue Neutral Retirement Reforms: Pessimistic Scenario

	EAA	LPB	RTX	PDI
Average discounted lifetime labor income	1	1.002	0.992	1.008
Average discounted lifetime utility	1	1.008	0.990	1.019
Average employment (50-66)	1	1.000	0.960	1.037
Average DI (50-66)	1	0.929	1.018	0.638
Share of DI recipients in bad health	1	1.014	0.943	1.136
Gini discounted lifetime labor income	1	1.021	1.027	0.982
Gini discounted lifetime total income	1	1.015	1.013	1.029
Gini discounted lifetime utility	1	1.130	1.080	1.077

EAA: early access age for old-age retirement benefit claiming raised to 67 and benefit scaled down. LPB: all old-age retirement benefits scaled down proportionally. RTX: taxes on labor and social security income increased proportionally. PDI: all old-age retirement and disability benefits scaled down proportionally. Results reported relative to the EAA policy scenario. Gini computed based on net of tax income.

The data on disability insurance claiming rates and health together imply that a substantial share of disability claimants in Norway must be in relatively good health. In Norway, temporary disability is easy to obtain and acts as a pathway into permanent disability. In our model, we abstract from temporary disability and only model permanent disability. While it is clear that some healthy people are claiming disability benefits this need not mean that all healthy people have the option of claiming them. To gauge the bias resulting from our assumption that anyone can get disability benefits, we recalibrate the model to a world in which people in bad health face an 80% probability of being granted disability benefits and people in good health face a 50% probability of being granted disability benefits. We then re-run all of our policy experiments. The results are summarized in Table 7. A comparison with Table 4 shows that the results are similar to the baseline. In particular, the ranking of policies according to average employment and average welfare remains unchanged. The only notable difference is in the ordering based on the gini of welfare. Here, lowering old-age retirement benefits results in the lowest degree of welfare

Figure 13: Employment by Age and Education Across Revenue Neutral Retirement Reforms – Pessimistic Scenario



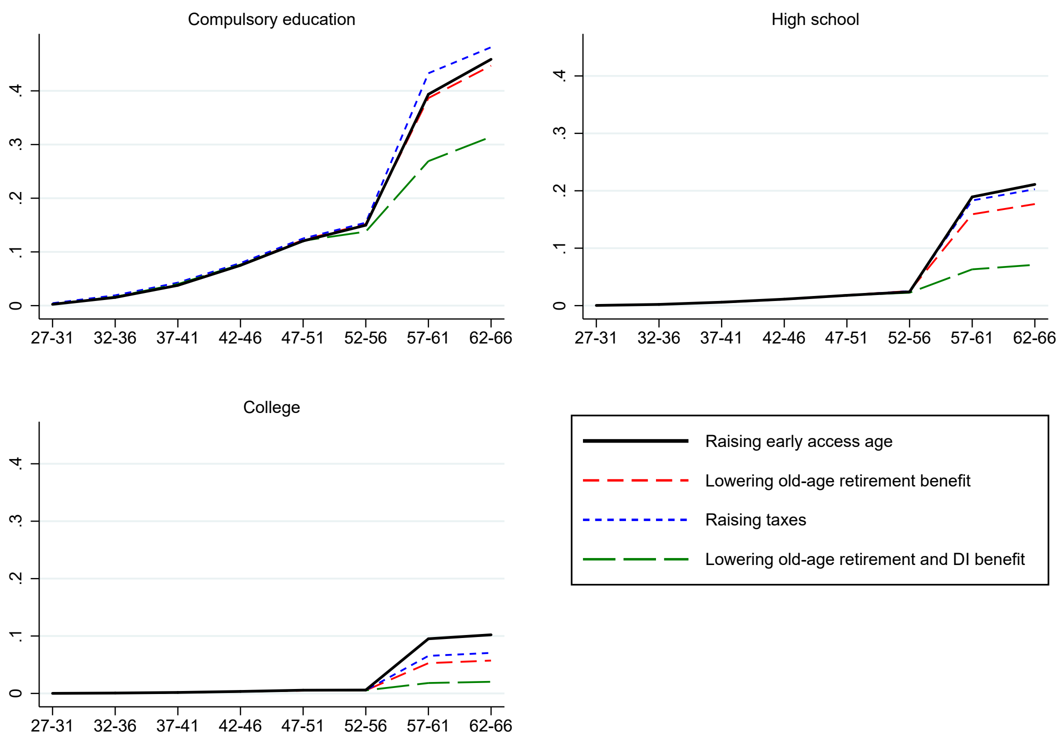
Raising early access age: early access age for old-age retirement benefits raised to 67 and benefit scaled down. Lowering old-age retirement benefit: all old-age retirement benefits scaled down proportionally. Raising taxes: taxes on labor and social security income increased proportionally. Lowering old-age retirement and DI benefit: all old-age retirement and disability benefits scaled down proportionally.

inequality.

7 Conclusions

Faced with aging populations, many governments the world over are grappling with social security reform. In this paper, we study alternative ways to reform retirement systems to achieve fiscal sustainability in the face of demographic change. A notable feature of improvements in longevity is that these improvements have not benefitted the population in a uniform manner, rather they have favored the more educated. The same is true of improvements in health. Our focus is on the differential effects of alternative retirement reforms in the face of widening education-gaps in health and survival.

Figure 14: Disability Benefit Claiming by Age and Education Across Revenue Neutral Retirement Reforms – Pessimistic Scenario



Raising early access age: early access age for old-age retirement benefits raised to 67 and benefit scaled down. Lowering old-age retirement benefit: all old-age retirement benefits scaled down proportionally. Raising taxes: taxes on labor and social security income increased proportionally. Lowering old-age retirement and DI benefit: all old-age retirement and disability benefits scaled down proportionally.

To this end, we develop a heterogeneous-agent life cycle model featuring health, survival and income risk. Agents make decisions regarding consumption, savings, labor supply and benefit claiming. An important feature of our framework is the inclusion of a disability insurance channel alongside regular old-age retirement. Changes to old-age retirement schemes can have the unintended consequence of increasing the flow into disability. As such, abstracting from this channel can bias the policy conclusions.

To study the effects of changes in longevity, we compare the optimal life cycle behavior of two groups of individuals who differ with respect to health and life expectancy. The individuals in the first group face the age- and education-specific health and survival risk associated with the cohort born 1949-53. This is our calibrated economy. The individuals in the second group face the estimated age- and education-specific health and survival risk

Table 7: Comparison of Revenue Neutral Retirement Reforms: Stricter Screening

	EAA	LPB	RTX	PDI
Average discounted lifetime labor income	1	1.003	0.991	1.002
Average discounted lifetime utility	1	1.009	0.966	1.015
Average employment (50-66)	1	0.993	0.951	1.004
Average DI (50-66)	1	0.970	1.038	0.719
Share of DI recipients in bad health	1	1.012	0.996	1.125
Gini discounted lifetime labor income	1	1.004	0.988	0.978
Gini discounted lifetime total income	1	1.007	0.991	1.028
Gini discounted lifetime utility	1	0.769	0.937	0.987

EAA: early access age for old-age retirement benefit claiming raised to 67 and benefit scaled down. LPB: all old-age retirement benefits scaled down proportionally. RTX: taxes on labor and social security income increased proportionally. PDI: all old-age retirement and disability benefits scaled down proportionally. Results reported relative to the EAA policy scenario. Gini computed based on net of tax income.

associated with the cohort born 1969-73. For comparability across policy regimes, we focus on policy measures that generate the same government consumption for the economy populated by the cohort born 1969-73 as the benchmark economy populated by the cohort born 1949-53. We consider the following policy reforms: (1) raising the early access age for old-age retirement benefits, (2) raising taxes on labor and social security income, (3) lowering old-age retirement benefits, and (4) lowering old-age retirement and disability benefits.

We find that just raising the early access age for old-age retirement benefits is not a very effective policy tool. Even a substantial increase in the early access age, from 62 to 67 (the age at which disability claimants are transferred to old-age retirement benefits), is not enough to balance the budget for the economy with the life expectancy of the 1969-73 cohort. This is largely due to the fact that our model predicts high disability benefit claiming with this policy scenario. To achieve revenue neutrality, and thereby comparability with the other policy measures, we combine raising the early access age for old-age retirement benefits to 67 with a proportional lowering of old-age retirement benefits.

We find that, of the studied policy reforms, proportionally increasing income taxes yields the lowest employment outcomes for all education types. The tax increase also results in the lowest average welfare for all education types. According to our framework, proportionally lowering old-age retirement and disability benefits is the most effective policy reform for boosting average employment (and average labor earnings). This is largely due to the fact that this policy measure is the most effective at curbing disability benefit claiming and boosting employment in all education categories. It is also the preferred policy measure from an average welfare standpoint for all education types. The other two policy reforms result in intermediate outcomes, both in terms of employment and welfare. Although reducing old-age retirement and disability benefits results in the highest average welfare, it does make disability benefit recipients worse off. One should of course bear in mind that the starting point is an economy with high disability benefit claiming and generous disability benefits, and the proposed cut to benefits is rather modest. Nevertheless, this policy does result in a greater degree of inequality in welfare than the combined policy of increasing the early access age and lowering old-age retirement benefits and the policy of raising taxes.

Acknowledgements

We thank seminar participants at the Uppsala University Workshop on Aging and Health, the Norwegian Ministry for Labor and Social Affairs and Statistics Norway for their comments. This research has received support from the Norwegian Research council, grant no. 238203. Data made available by Statistics Norway have been essential for the research project. Laun and Wallenius also gratefully acknowledge support from the Riksbankens Jubileumsfond, grant no. P14-0477:1.

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Data Appendix

Sample Selection

The aim is to produce a data set which follows male workers in firms with no early retirement scheme (henceforth called non-ER firms) employed at age 27 throughout their lives. This is however not fully possible, mainly due to three limiting features of the data:

1. We cannot observe the employment relation (only the income) before 1992. Hence, we do not know whether a worker was employed in a non-ER firm or in another firm before 1992.

2. The data stops in 2015/16 such that we cannot follow workers longer than that.

3. There is no income information available prior to 1967.

4. There is no DI information available prior to 1992.

There is no way to deal with the second limitation, part from inferring later cohorts' behavior from the behavior or earlier cohorts. The third limitation implies that we cannot identify whether or not a person is employed at age 27 for earlier cohorts than 1940. For 1939 we instead condition on employment at age 28. The first limitation is dealt with in the following way:

(i) Make a data set of workers from the relevant cohorts conditional on being employed in a non-ER firm at age 50. If age 50 occurs before 1992 we find the firm in which he was employed in 1992. If age 50 is after 2014 we use 2014. The reason we use age 50, and not 1992, is to make the conditioning as symmetric as possible across cohorts.

(i) Make another data set of workers from the relevant cohorts unconditional of employment at age 50. This data set includes the data set in (i) but also much more. We can divide this data set in three parts:

1. Those included in (i): Employed at age 50 in a non-ER firm

2. Those employed at age 50, but in an ER firm

3. Those not employed at age 50 (but who was employed at age 27).

(iii) We now want to include a fraction of the observations in (3) such that the data set we use also includes workers who have left the workforce between age 27 and age 50. However, since only a fraction of workers belong to the non-ER group we cannot include everyone on (3). To determine the fraction we want to include we compute the fraction of those employed at age 50 that works in a non-ER firm (this is approximately 35-45%, depending on cohort and education). If this fraction is e.g. 44% in a certain education/cohort group we simply include a random draw of 44% of (3) into the sample.

Health Transitions

Using data from the Norwegian Labor Force Survey for the years $t = 2002$-2015 covering the ages $a = 22, 27, \ldots, 67$, the following logit model is estimated:

$$bad\ health_{i,t} = F\left(\beta_0 + \beta_1 a_{i,t} + \beta_2 a_{i,t}^2 + \beta_3 e_i + \beta_4 t + \beta_5 (t \times e_i) + \beta_6 (t \times a_{i,t})\right) \quad \text{(A1)}$$

Here $bad\ health_{i,t}$ is an indicator variable for individual i reporting bad health in year t, e_i is an indicator variable for three education levels for individual i (compulsory, high school and college) and $F(\cdot)$ is the logistic function $\exp(\cdot)/(1+\exp(\cdot))$. The estimated model in Equation (A1) is then used to predict the outcome for all years $t = 2002, \ldots, 2030$ and all ages $a = 22, \ldots, 97$.

We then let the cross-sectional distribution in 2002 correspond to the validation cohorts 1939-1943, 2012 correspond to the calibration cohorts 1949-1953 and 2030 correspond to the prediction cohorts 1969-1973. Using this, we then find the fraction in bad health for each of these three cohort groups, separately for each education level and age.

In order to create the transition probabilities, we use the fractions in bad health estimated above and define the transition rate gb_i (from good to bad health) for each cohort group and education level separately as follows:

$$P(gb_a) = [P(bad\ health_a) - P(bad\ health_{a-1})] \times \frac{1 - P(deathbh_a)}{[1 - P(bad\ health_{a-1})][1 - P(deathbh_a)]} \tag{A2}$$

Here $P(deathbh_a)$ is the probability of not surviving from age $a-1$ to age a (meaning death at age $a-1$) for individuals in bad health, while $P(deathbh_a)$ is the probability of not surviving from age $a-1$ to age a (meaning death at age $a-1$) for individuals in good health.

Mortality Rates

For the validation cohorts (1939-1943), calibration cohorts (1949-1953) and prediction cohorts (1969-1973), Table A1 shows the ages where we observe the actual mortality rates in our data.

We want a full cohort life table (covering ages 27-97) for all cohorts in Table A1, which means we must predict the "missing" mortality rates using historical data. To do so, we estimate a Lee-Carter model on the observed mortality rates for all cohorts leading up to the last cohort in each cohort group. The predicted mortality rates are then used to create the complete (hybrid) cohort life tables for each cohort in Table A1.

For each cohort group, a Lee-Carter model is estimated using the singular value decomposition method:

$$\log(m_{a,t}) = \beta_a + \gamma_a k_t + \varepsilon_{a,t} \tag{A3}$$

Here $m_{a,t}$ is the observed age-specific death rate at age a in year t, β_a is the general age pattern for age a, k_t is the time index for year t and γ_a is the age-dependent correction of

Table A1: Observed Mortality Rates by Cohort

Cohort	Validation	Calibration	Prediction
1939	Ages 27-76		
1940	Ages 27-75		
1941	Ages 27-74		
1942	Ages 27-73		
1943	Ages 27-72		
1949		Ages 27-66	
1950		Ages 27-65	
1951		Ages 27-64	
1952		Ages 27-63	
1953		Ages 27-62	
1969			Ages 27-46
1970			Ages 27-45
1971			Ages 27-44
1972			Ages 27-43
1973			Ages 27-42

the time index for age a. The model in Equation (A3) is estimated using the samples for the different cohort groups shown in Table A2.

Table A2: Estimation Sample by Cohort

Sample	Validation	Calibration	Prediction
Ages (a)	73-97	63-97	43-97
Years (t)	1992-2015	1992-2015	1996-2015
Cohorts (c)	1895-1942	1895-1952	1899-1972
Forecast years (2016 to $\bar{t}$)	2016-2040	2016-2050	2016-2070

Having fit the model in Equation (A3) using the observed death rates, we forecast k_t for $t \in \{2016, \ldots, \bar{t}\}$ (see Table A2 for $\bar{t}$) using a random walk with drift parameter θ:

$$k_t = \theta + k_{t-1} + \upsilon_t \tag{A4}$$

Starting the dynamic forecasts from $\hat{t}$, Equation (A4) gives the values for k_t for $t > \hat{t}$ as:

$$\begin{aligned} \hat{k}_t &= \hat{\theta} + \hat{k}_{t-1} \\ \hat{k}_{t+1} &= \hat{\theta} + \hat{k}_t \end{aligned} \tag{A5}$$

Using the forecasted values of $k_{2016 \leq s \leq \bar{t}}$ from Equation (A4), the forecasted log mortality rates ($\widehat{\log(m_{a,s})}$) for $2016 \leq s \leq \bar{t}$ are found by inserting into the estimated version of Equation (A3):

$$\widehat{\log(m_{a,s})} = \hat{\beta}_a + \hat{\gamma}_a k_s \tag{A6}$$

Finally, the forecasted mortality rates are given by $\hat{m}_{a,t} = \exp\left[\widehat{\log(m_{a,t})}\right]$. These forecasted mortality rates are then used to construct complete (hybrid) life tables for all cohorts in Table A1. This procedure is repeated for each education group separately.

Life Expectancy

For each cohort in Table A1, we also calculate the implied life expectancy at birth as follows. Starting from age $a = 27$, the following survival probability is constructed:

$$P(surv_a) = P(surv_{a-1})\left[1 - P\left(\widehat{death_a}\right)\right] \tag{A7}$$

$P(surv_a)$ is the probability of survival from age $a-1$ to age a, while $P\left(\widehat{death_a}\right)$ is the probability of not surviving from age $a-1$ to age a (meaning death at age $a-1$). Ages run from to $a = 27$ to $a = 97$. From Equation (A7), the life expectancy at birth is then finally calculated as:

$$LE = 26 + \sum_{a=27}^{97} P(surv_a) \tag{A8}$$

Healthy Life Expectancy

For each cohort in Table A1, we also calculate the implied healthy life expectancy at birth as follows. Starting from age $a = 27$, the following survival probability is constructed:

$$P(surv_a) = P(surv_{a-1})\left[1 - P\left(\widehat{death_a}\right)\right] \tag{A9}$$

$P(surv_a)$ is the probability of survival from age $a-1$ to age a, $P\left(\widehat{death_a}\right)$ is the probability of not surviving from age $a-1$ to age a (meaning death at age $a-1$), and ages run from to $a = 27$ to $a = 97$. We augment the survival probability in Equation (A9) with the fraction in bad health at each age a ($bad\ health_a$). From this, we derive the healthy life expectancy in a similar manner to that done in Equation (A7):

$$HLE = 26 + \sum_{a=27}^{97} (1 - P(bad\ health_a))\, P(surv_a) \tag{A10}$$

The life expectancy (LE) and healthy life expectancy (HLE) by cohort group and education level is shown in Table A3.

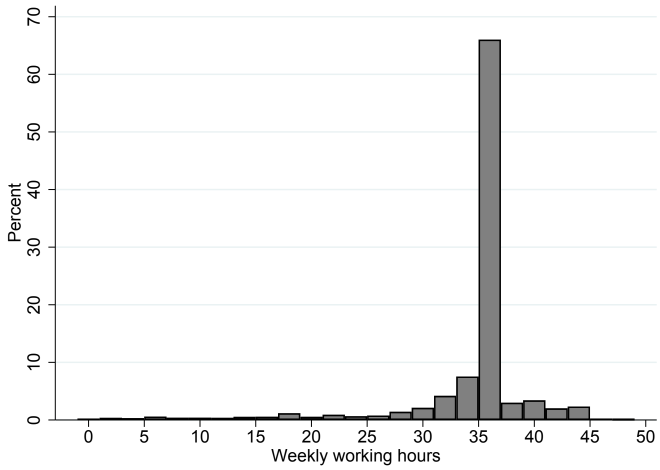
Table A3: Healthy Life Expectancy by Cohort and Education

	Validation (1939-1943)		Calibration (1949-1953)		Prediction (1969-1973)	
	LE	HLE	LE	HLE	LE	HLE
Compulsory	79.6	63.4	80.4	60.8	82.8	54.9
High school	82.5	62.0	84.8	68.1	86.5	77.8
College	85.1	67.6	87.0	74.6	89.7	84.8

Life expectancy (LE) and healthy life expectancy (HLE) at birth, conditional on being alive at age 27, by cohort and education level.

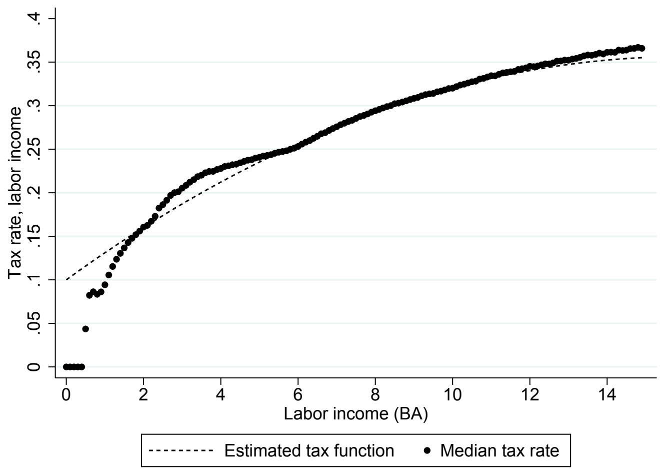
Figures

Figure A1: Distribution of Male Weekly Working Hours



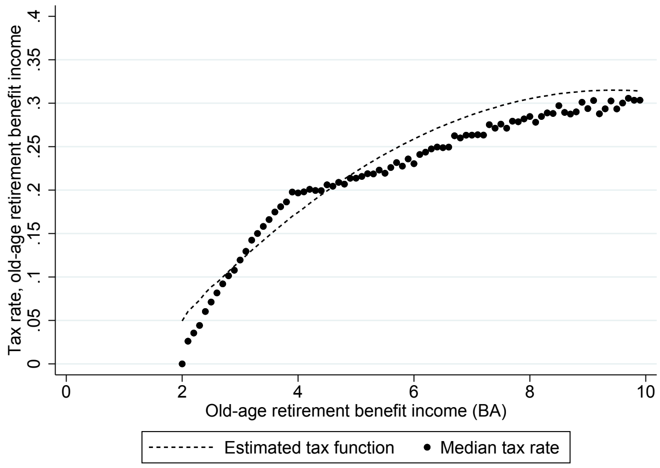
Men aged 27-62, conditional on working. Data source: Norwegian registry data, 2015.

Figure A2: Tax Function for Labor Income



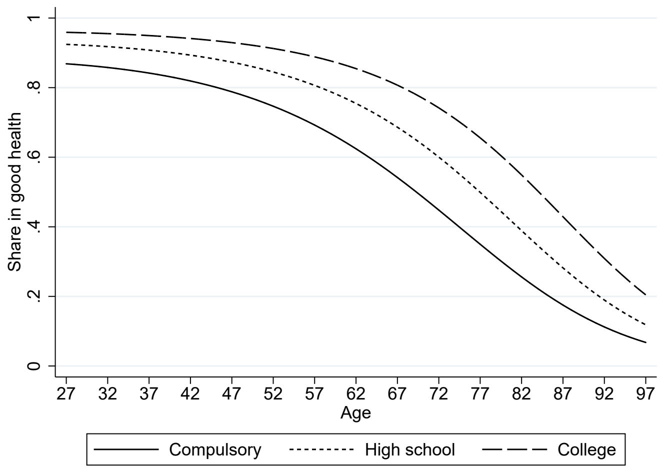
Data source: Norwegian income registry, year 2014. Income measured in base-amounts.

Figure A3: Tax Function for Retirement Benefit Income



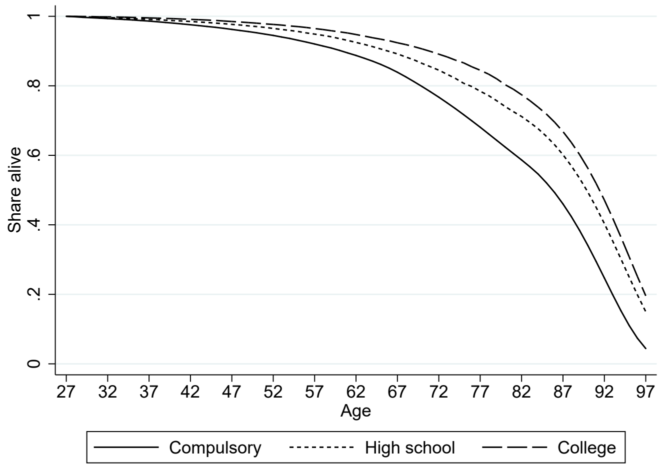
Data source: Norwegian income registry, year 2014. Income measured in base-amounts.

Figure A4: Predicted Share of Men in Good Health by Age and Education



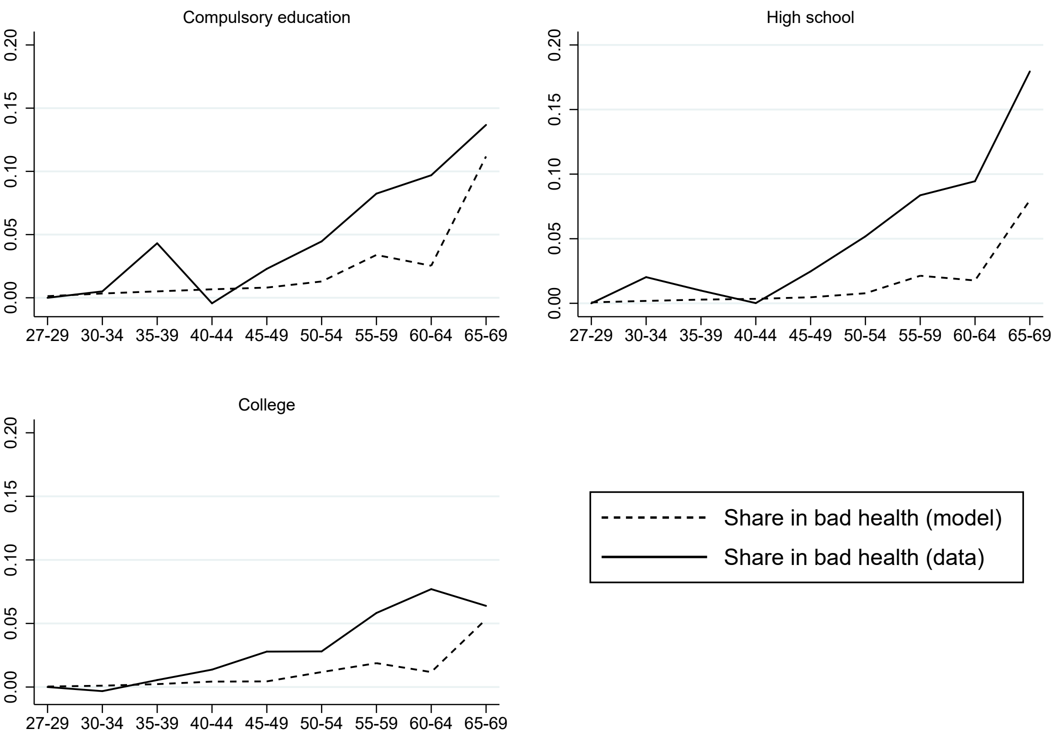
Data source: Norwegian Labor Force Survey, years 2002-15.

Figure A5: Predicted Share of Men Alive by Age and Education



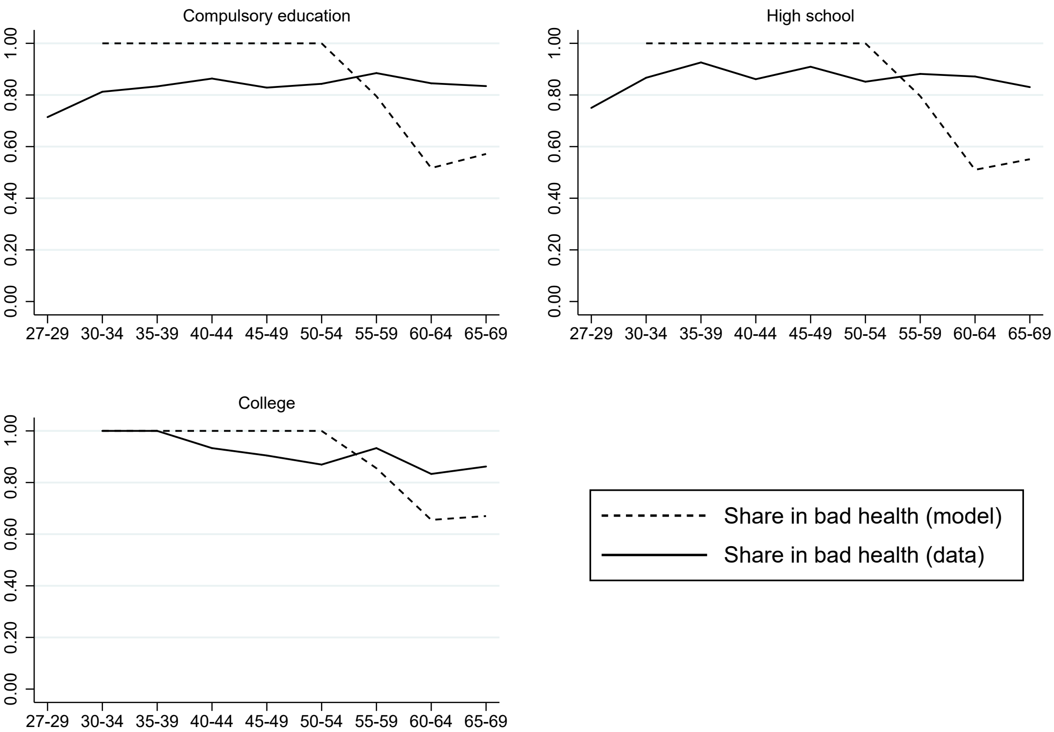
Data source: Norwegian registry data, years 1992-2015.

Figure A6: Model Fit for Age-Health Profile of Employed



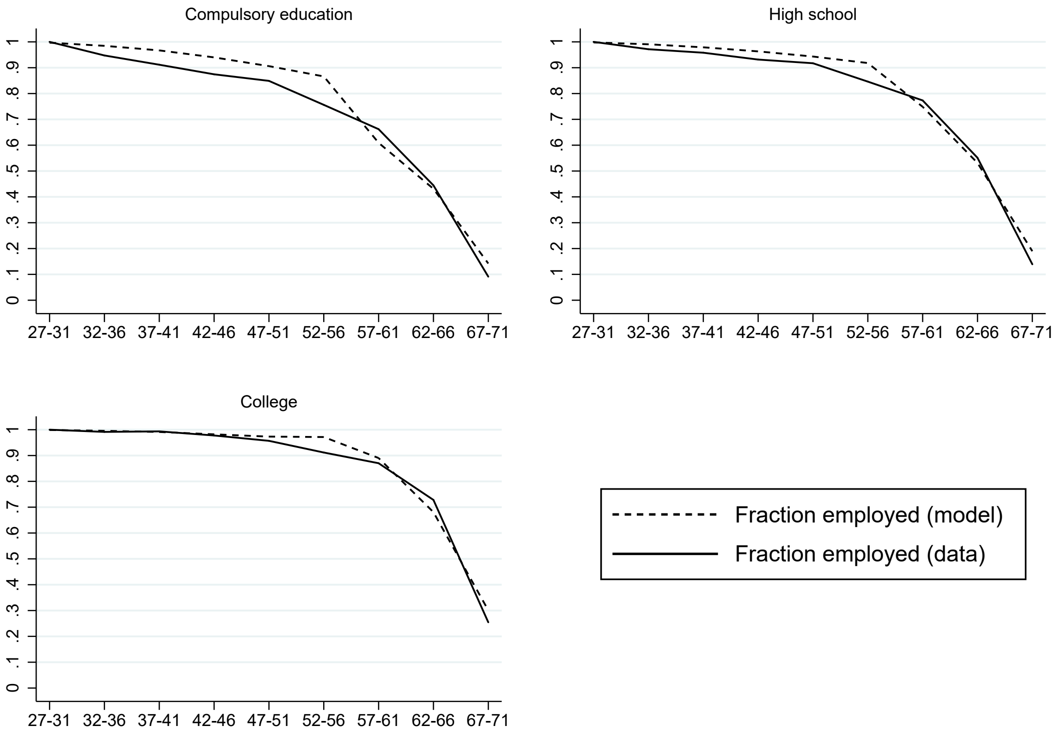
Data source: Norwegian Labor Force Survey, years 2002-15.

Figure A7: Model Fit for Age-Health Profile of Disability Claimants



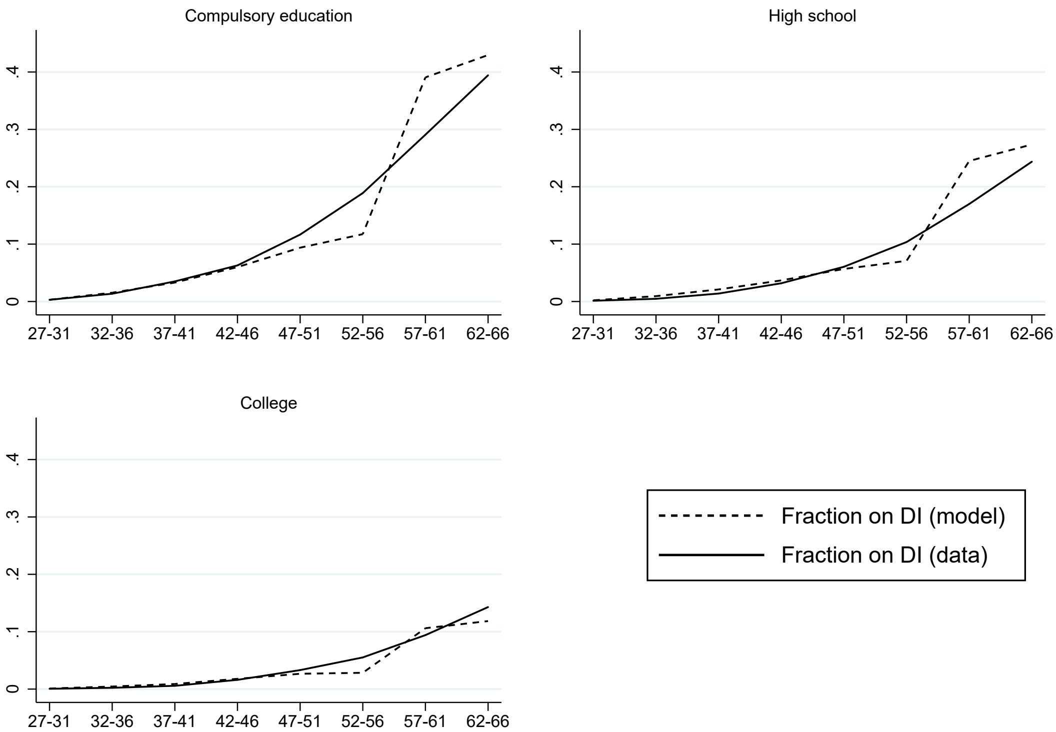
Data source: Norwegian Labor Force Survey, years 2002-15.

Figure A8: Model Fit for Employment by Age and Education



Data source: Norwegian administrative data, cohort born 1939-43.

Figure A9: Model Fit for Disability Benefit Claiming by Age and Education



Data source: Norwegian administrative data, cohort born 1939-43.