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## Health, longevity and pension reform

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*Health, Longevity and Pension Reform*

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## HEALTH, LONGEVITY AND PENSION REFORM

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# Health, Longevity and Pension Reform<sup>\*</sup>

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May 8, 2018

## Abstract

In this paper, we study alternative pension 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 pensions, (2) raising income taxes, (3) lowering pension benefits and (4) lowering pension and disability benefits. We find that, of the considered policies, proportionally lowering pension and disability benefits results in the highest average welfare and the lowest degree of inequality. It is also successful at boosting employment, particularly among the less educated.

*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, pension 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 homogenous 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 far less attention.<sup>1</sup>

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 whether or not there is a tradeoff 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

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<sup>1</sup>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.

heterogeneous agents who face health, mortality and income risk. Agents make decisions regarding consumption and saving, labor supply and if/when to claim old-age pension and disability benefits. We calibrate the model to Norwegian 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 pension reforms in the face of demographic change. In particular, we contrast different ways of making pension schemes robust to improvements in longevity. Examples include: (1) raising the early eligibility age for old-age pension benefits, (2) lowering benefits, and (3) raising income taxes. 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 incidence rates are high – despite good health and long life expectancy.

We find that simply increasing the early-access age for pension 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 stems in large part from high disability incidence among dropouts. To compare this policy with fiscally sustainable policies, notably raising income taxes and lowering benefits, we combine increasing the early access age for pensions to 67 with proportionally lowering pension benefits so as to achieve revenue neutrality. We find that, of the considered policy reforms, proportionally increasing taxes on labor and pension income results in the lowest employment outcomes for all education types. The tax increase also results in the greatest degree of inequality, as measured by the gini of labor or total income as well as the 90-10 income differential. This is due to an increase in the disability benefit claiming rate of high school dropouts relatively early in the life cycle. Moreover, the tax increase yields the lowest welfare of all reforms for all education

types. Proportionally lowering pension and disability benefits is the most effective policy reform for curbing disability incidence. As such, it results in the highest employment rates for dropouts. It is also the preferred policy measure from a welfare standpoint for all education types. Moreover, it results in the lowest degree of inequality of the considered policy reforms. However, it is of course the case that disability benefit recipients are made worse off by the reform. While employment rates for high school and college workers are highest when raising the early access age to 67 (and proportionally lowering pension benefits to balance the budget), this policy option results in high disability incidence for dropouts.

There is a large empirical literature on pension reform. The most relevant for us is Hernæs et al. (2016), which studies the latest Norwegian pension 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.

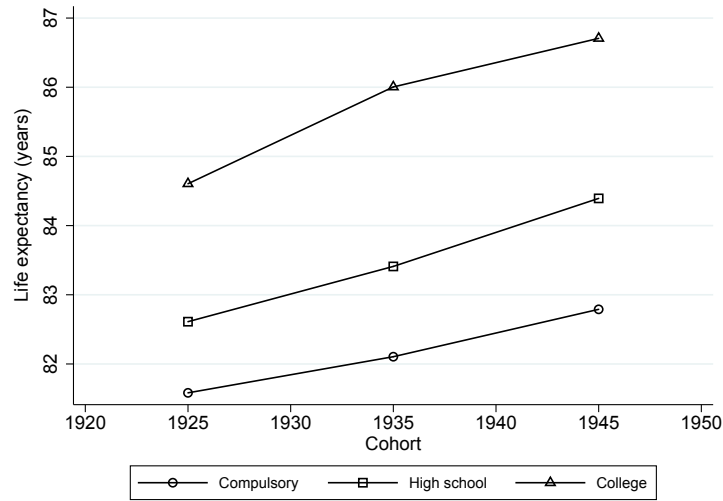
There is a large literature using life cycle models to study the effect of social security systems on labor supply, which we build on (see, e.g., Gustman and Steinmeier (1986), Stock and Wise (1990), Rust and Phelan (1997), French (2005), Coile and Gruber (2007) and French and Song (2014)). Perhaps the paper most similar to us is Haan and Prowse (2014), which studies how the German pension 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 pension reform. This is a point also recently emphasized by Laun and Wallenius (2016), Li (2018), and Galaasen (2017).

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, but also provide a comparison to the US.

Figure 1: Life Expectancy at Age 27 in Norway by Education and Birth Cohort



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

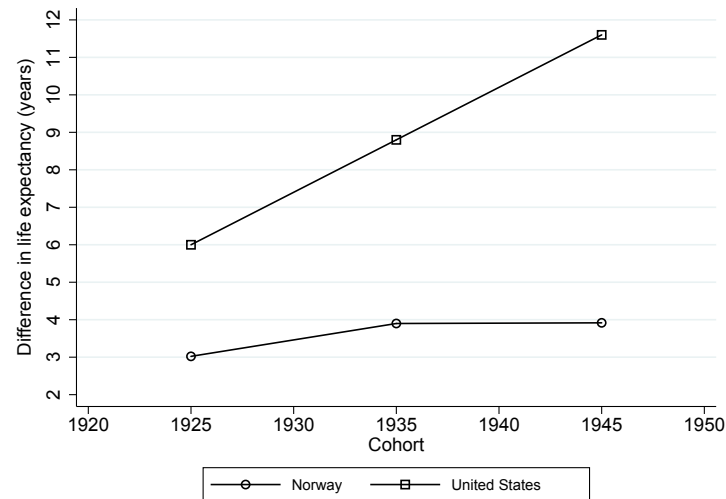
### *Longevity*

There have been substantial improvements in longevity over the last several decades. This is true for all education types. This is illustrated in Figure 1 for Norway. Longevity improvements have favored the highly educated somewhat more than the less educated. The divergence over education is, however, much more pronounced in the US than in



Norway.<sup>2</sup> These trends are summarized in Figure 2. All in all, we conclude that large gaps in longevity over education remain in Western economies.

Figure 2: Difference in Life Expectancy over Education: Norway and US



Difference in life expectancy between college educated and high school dropouts, at age 27 for Norway and at age 25 for US. For US, college category includes 'some college'. Estimates for Norway based on Norwegian registry data, years 1992-2015. Estimates for US from Krueger et al. (2015).

### *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. In Norway, the share of high school dropouts in bad health has risen, while the share of high school and college graduates in bad health has declined. In the US, the share of individuals in bad health has risen in all education groups, but much more so among the less educated. See Figure 3 for details.<sup>3</sup>

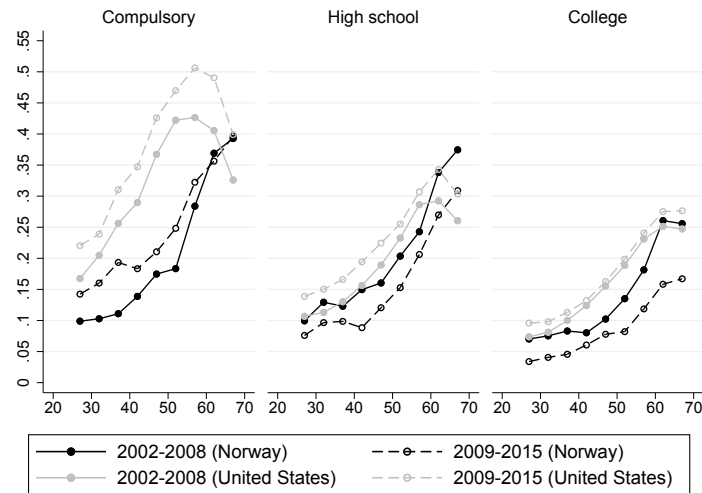
### *Disability*

The data on disability incidence mirrors the data on health and longevity. Disability incidence is declining in education. Moreover, in recent years disability incidence among high school and college graduates in Norway has declined, but the disability incidence of

<sup>2</sup>See Pijoan-Mas and Ríos-Rull (2014) and Chetty et al. (2016) for discussions of the US.

<sup>3</sup>US data from Behavioral Risk Factor Surveillance System, Atlanta, GA: US Department of Health and Human Services, CDC; 2016.

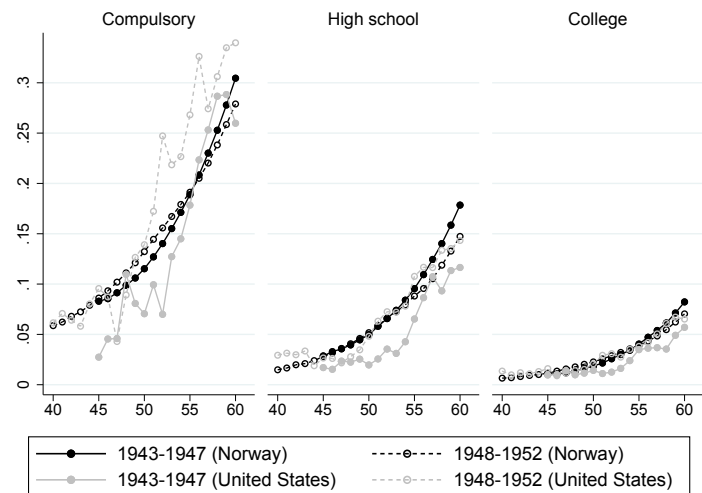
Figure 3: Share in Bad Health over Age, Education and Time: Norway and US



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

younger dropouts has risen. Disability incidence in the US has risen, especially among the less educated. These patterns are illustrated in Figure 4.<sup>4</sup>

Figure 4: Disability Incidence by Age, Education and Birth Cohort: Norway and US



Values for Norway computed from Norwegian registry data, years 1992-2015. US data from March CPS, 1992-2014. For US, college category includes 'some college'.

### Selection Concerns

Our analysis has centered around three education types, less than high school, high

<sup>4</sup>US data from March CPS Uniform Extracts, Version 1.0., Center for Economic and Policy Research, Washington, DC, 2016.

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 less than high school education is nearly unchanged from year 2000 (21.9%) to 2016 (20.8%).<sup>5</sup> 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 measure, such as government revenue.

These findings 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 incidence 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: less than high school, high school and college or more. All agents are initially

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<sup>5</sup>From Statistics Norway, Statistikkbanken, Table 09599.

in good health and endowed with zero assets. We assume people differ in their preference for leisure; in particular, we model a low and high type. Altogether, there are six combinations of education and preference for leisure, which we term types ( $s$ ).

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

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

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.<sup>6</sup> We assume that the disutility from working is also dependent on preference type (low or high disutility type), education and age (lower value below age 60, and higher value from age 60 onwards). The reason for introducing some preference heterogeneity is that variation in health and skill is not enough to generate the variation in retirement ages observed in the data. The preference heterogeneity can be viewed as capturing features not explicitly modeled here. 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 below age 60, and lower value from age 60 onwards) and health (greater value in good health and lower value in bad health).

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<sup>6</sup>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.

### *Budget Constraint*

Each period there are markets for consumption, labor and capital ( $k$ ). Labor income is the product of the wage,  $w_{a,s}$ , and labor supply,  $l_{a,s}$ .<sup>7</sup> 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,  $l_{a,s} \in \{0, \bar{l}\}$ . 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  $r$  denote the interest rate. The individual faces a sequence of budget constraints given by:

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

where  $y_{a,s}$  denotes taxable income,  $R_{a,s}$  retirement benefits and  $DI_{a,s}$  disability benefits. Note that social security benefits are part of taxable income.  $\tau_c$  denotes a proportional tax on consumption and  $\tau_l(\cdot)$  and  $\tau_b(\cdot)$  progressive taxes on labor income and retirement benefits, respectively.

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

### *Health and Mortality*

We assume two health states, good and bad. Health follows a two-state transition matrix, which is dependent on both age and education. Mortality rates depend on age, education and past health.

### *Social Security*

We model a stylized representation of the Norwegian social security system. The Norwegian pension system is quite complex, with different groups of the population facing

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<sup>7</sup>The price per efficiency unit of labor has been normalized to one.

<sup>8</sup>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.

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.<sup>9</sup> Also, since we rely on data for 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).<sup>10</sup>

The pension benefit depends on past earnings through pension points. Pension points are accumulated through work, as follows:

$$points = \min[\max(earnings - 1, 0), 5] + \max[\min((earnings - 6)/3, 2), 0] \quad (3)$$

In other words, one accrues full pension points on earnings up to 6 BA and then 1/3 points on income above 6 BA. Points are based on earnings from the 20 best years.

Pension points map into the retirement benefit as follows:

$$pension = 1 + 0.435 * points * [\min(yow/40, 1)] \quad (4)$$

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

<sup>9</sup>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.

<sup>10</sup>Equal to 92,576 NOK in 2016, which is slightly less than 12,000 USD.

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 60. This is to help match the age profile for disability receipt.

### *Taxes*

The government levies a proportional consumption tax ( $\tau_c$ ) and a progressive income tax ( $\tau_l$  on labor income and  $\tau_b$  on benefits). Note that pension and disability benefits are part of taxable income. The government uses the proceeds from these taxes to finance the retirement and disability insurance 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 type  $s$  to ease notation. The state  $x$  of an individual is given by age  $a$ , assets  $k$ , health  $h$ , pension capital  $pcap$ , pension status  $page$  (age at which started claiming pension 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). 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 pension/disability benefits (denoted by  $app^R$  and  $app^{DI}$ , respectively). Individuals claiming pension 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).

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. 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 1st Stage of Calibration

#### *Life Cycle Earnings Profiles*

Labor earnings are estimated using Norwegian administrative panel data, covering the full population. For consistency with the modeled social security system, we restrict the sample to men working in firms without access to early retirement schemes.<sup>11</sup> 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.

Labor earnings are comprised of a deterministic and a stochastic component. The deterministic component is estimated by regressing annual labor earnings on age, age

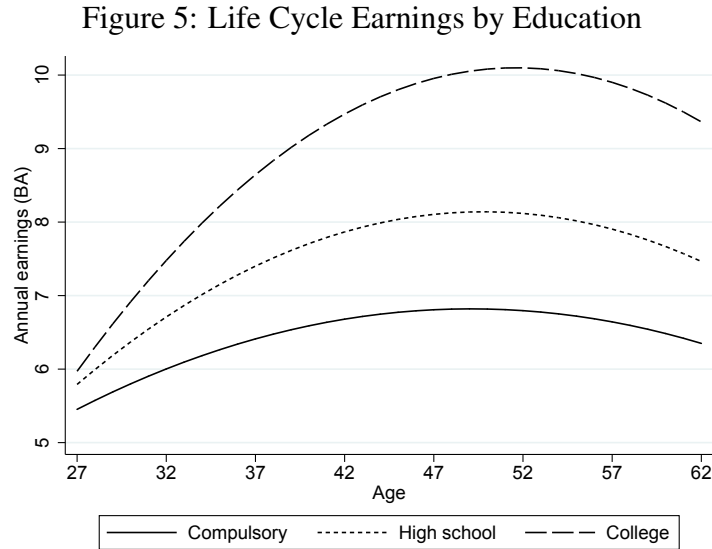
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<sup>11</sup>There are some data limitations that complicate making this distinction. See the Appendix for details on how we deal with them.



squared and an individual fixed effect. We run this estimation separately for each education type, dropouts, high school and college.<sup>12</sup> 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 5 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.



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 functions. To smooth out the data, we group incomes into bins of 0.1 BA and take the

<sup>12</sup>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 dropouts are defined as anything below level 4 (ISCED 1 and 2).

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 pension income. We take the consumption tax rate from McDaniel (2007). See Appendix for plots of the tax functions for labor and pension income.

### *Health Risk*

We use health data from the Norwegian Labor Force Survey. The health measure from the labor force survey is self-assessed and based on whether or not the individual feels that he/she suffers from physical or psychological health problems of a lasting nature which limit daily life. Recall that there are two health states in our model, good and bad. In order to construct transition probabilities for health, we must have two observations for each individual. Roughly 25% of the respondents in the survey have two consecutive observations.

For this sub-sample, we run a logit regression of the transition from good to bad (and bad to good) on age, age squared, education, gender, year and interaction terms of the aforementioned. The data on health is only available from year 2002. It is therefore not possible to follow a cohort. The calibration is based on data for 2009-15. We include women in the estimation to increase the sample size. However, we only use the predictions for men.

Figure A3, in the Appendix, plots the share of individuals in good health over age and education, as implied by the aforementioned transition probabilities. 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*

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:

$$\log(m_{a,t}) = \beta_a + \gamma_a k_t + \varepsilon_{a,t} \quad (7)$$

where  $m_{a,t}$  is the observed age-specific death rate at age  $a$  in year  $t$ ,  $\beta_a$  is the general age pattern for age  $a$ ,  $k_t$  is the time index for year  $t$  and  $\gamma_a$  is the age-dependent correction of the time index for age  $a$ . We estimate this model using data from years 1992-2015, for cohorts born 1895-1952.

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 estimated age-dependent mortality rates as weighted averages of the mortality rates of those in good and bad health and use that to back out the health-dependent survival probabilities.

Figure A4, in the Appendix, plots the share of individuals alive at each age, as implied by the aforementioned transition probabilities, separately for the three education types. As documented previously, life expectancy is increasing in education.

## 4.2 2nd Stage of Calibration

### *Preference Parameters*

The preference parameters that need to be assigned a value are the discount factor,  $\beta$ , the parameters governing the disutility from working,  $b(h,s,a)$ , and the utility cost, or stigma, of applying for disability benefits  $\psi(h,a)$ . We assume an annual interest rate equal to 3%.  $\beta$  is then chosen to match an asset to income ratio of 2.31. The parameters governing the disutility from working and the utility cost of applying for disability benefits are critical for matching the retirement age distribution and the incidence of disability insurance claiming over age. We assume two disutility from work types, low and high, and moreover allow the disutility from working to differ by health, age and education.

Table 1: Preference Parameter Values

	$b(h,s,a)$						$\psi(h,a)$
	Dropout		High School		College		
	Low	High	Low	High	Low	High	
Good health, young	0	5	0	6	0	9	10
Good health, old	6	17	6	11	5.5	11	4
Bad health, young	12.7	15	15	22.5	4	17.5	7
Bad health, old	13.5	24.2	17	22.5	7	17.5	1

The weights for the different education types are taken from the data. We assume equal weights for the low and high disutility types. We allow the utility cost of applying for disability benefits to depend on health and age. The preference parameter values can be found in Table 1.

### 4.3 Calibrated Economy

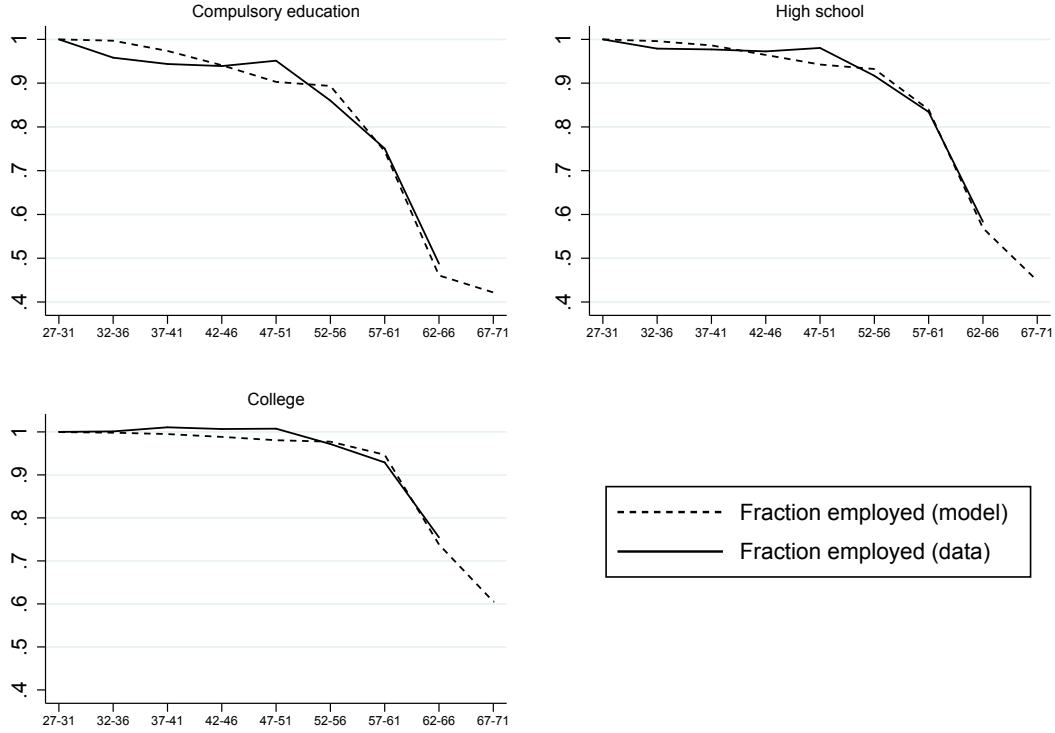
In this Section we discuss the fit of the model to the data. We are particularly interested in how well we are able to replicate the labor supply behavior of older workers.

Figure 6 shows the employment rates of men by age and education relative to the data. Our model does a very good job in matching the employment data.<sup>13</sup> Similarly, Figure 7 shows the disability incidence rates of men by age and education relative to the data. Our model matches the data on disability incidence well, although it does struggle a bit with matching the exact timing of disability benefit claiming. In particular, our model predicts somewhat too high disability incidence when young and struggles to fully match the steep rise in disability incidence in the 50s.

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 incidence 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%. Our model captures the fact that disability is partly utilized as a pathway into early retirement.

<sup>13</sup>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.

Figure 6: Model Fit for Employment by Age and Education



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

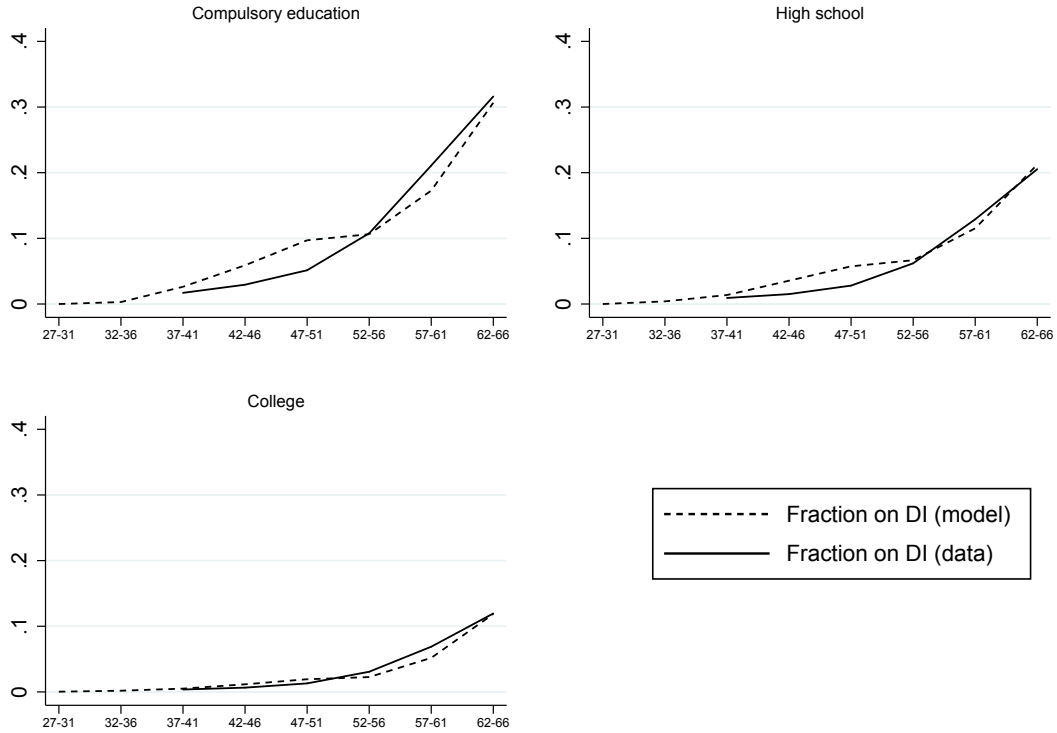
The asset to income ratio generated by the model is 2.32, compared with 2.31 in the data.<sup>14</sup>

#### 4.4 Model Evaluation

As a test of the calibration, we use our model to study the Norwegian pension 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 pension 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

<sup>14</sup>This is with censoring at 30 million NOK (or roughly 3.8 million USD).

Figure 7: Model Fit for Disability Incidence by Age and Education



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

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 pension system in place for the 1939-43 cohort relative to our benchmark are: (1) no claiming of old-age pension benefits before age 67, and (2) a severe earnings test on pension benefits when combining work and claiming of old-age benefits.<sup>15</sup> Disability insurance has remained the same across these cohorts.

In the data we observe much lower employment for the cohort born 1939-43 than for the cohort born 1949-53. Our model does a good job of accounting for this. In fact, our model accounts for essentially all the difference in employment rates across cohorts for dropouts and high school graduates. While it accounts for less of the difference for college graduates, the model still generates a sizable difference in employment across cohorts for

<sup>15</sup>For simplicity, in this exercise we tax pension benefits at 100% when working, since the earnings test was large enough to discourage combining work and pension claiming.

this group. The lower employment for the older cohort arises in large part from higher disability incidence. Our model is largely able to account for this. In fact, the model slightly overpredicts the disability incidence for the high school graduates in the earlier cohort. See Figures A5 and A6, in the Appendix, for details. 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.

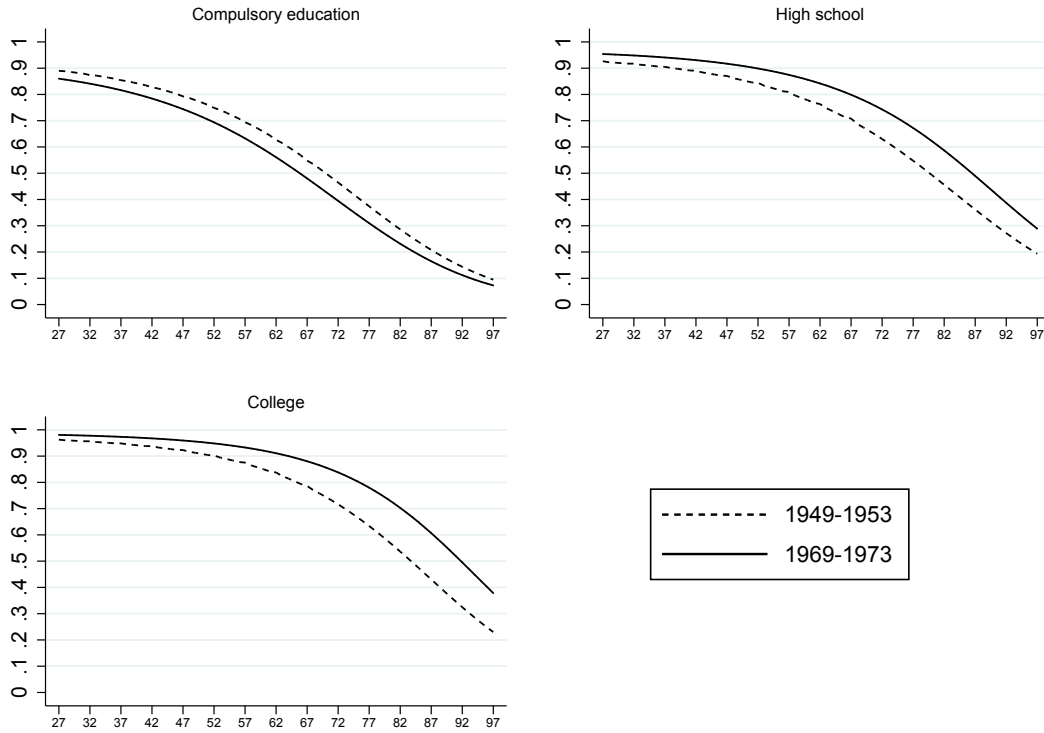
All in all, we feel that this exercise is a good test of our calibrated model.

## 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 pension 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 based on the changes in health and survival risk across cohorts born 1939-43 (model validation period) and 1949-53 (calibration period). We predict a widening of the education-gap in health and survival. See Figures 8 and 9 for details on the predicted changes in health and survival across cohorts born 1949-53 and 1969-73.

Figure 8: Predicted Share of Men in Good Health by Age and Education: Cohort Comparison



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

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 cohorts when computing aggregate measures such as government revenue to reflect this.<sup>16</sup>

With the exceptions of health and survival probabilities, the parameters governing pension policies, and the education shares, we hold all parameters fixed across the two groups.<sup>17</sup> To facilitate comparisons across policy regimes, we consider revenue neutral policy measures.<sup>18</sup>

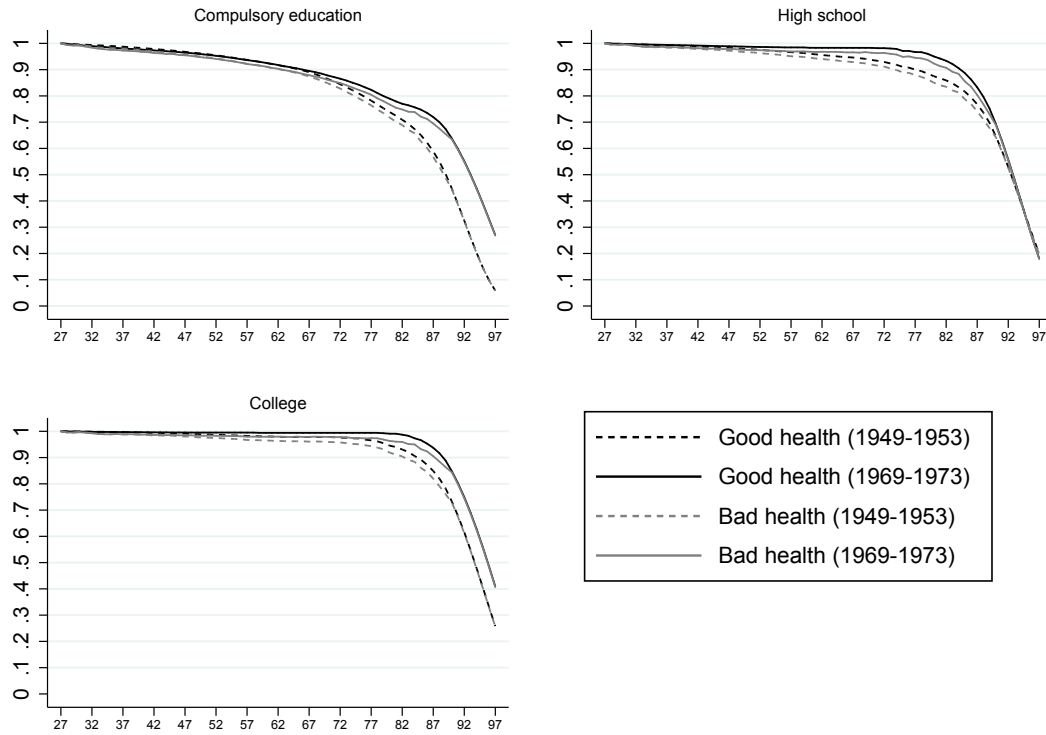
<sup>16</sup>The education shares are based on forecasts used by Statistics Norway for constructing the built-in longevity adjustment in the pension formula.

<sup>17</sup>Due to data limitations it is not possible to vary wages across cohorts.

<sup>18</sup>Note that we do not compute transitions. Rather, we are comparing two cohorts that face different but invariant policy regimes.



Figure 9: 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 public pension 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 pension 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 pension 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 7.2% decline in government revenue

relative to the benchmark economy.<sup>19</sup> This despite the fact that our model predicts an increase in the employment rate of older high school educated workers, and, to a lesser extent, also college educated workers in the younger cohort relative to those in the older cohort. Specifically, the average employment rate of men aged 50-66 rises by 8 pp for high school and 2 pp for college educated individuals. This is mirrored in a decline in disability benefit claiming for these groups. The disability incidence rate among 50-66 year old men declines by 9 pp for high school and 3 pp for college educated people. While the model predicted employment rates for dropouts in their 60s are similar across the two cohorts, the employment rates of dropouts in their 40s and 50s are lower for the cohort born 1969-73 relative to the cohort born 1949-53. This is due to an increase in disability incidence for the later cohort. Disability incidence among dropouts aged 50-66 rises by 9 pp. This in turn results in the predicted decline in government revenue. These diverging employment outcomes across demographic groups reflect the divergence in health and longevity across said groups. See Figures 10 and 11 for details on the model predicted changes in employment and disability incidence across cohorts.

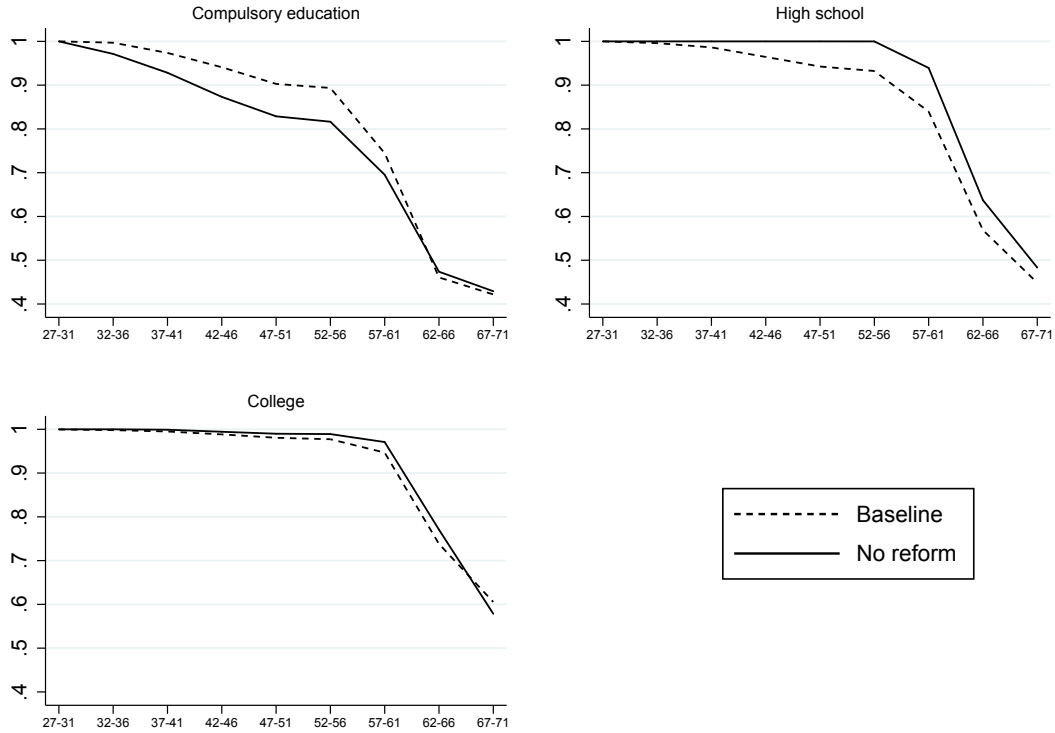
## 5.2 Comparing Revenue Neutral Policies

We now turn our attention to alternative pension 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 pension schemes. For comparability across exercises, each policy reform generates the same government consumption as the benchmark economy. The policy alternatives we consider are: (1) raising the early access age to old-age pension, (2) increasing the longevity adjustment for pension benefits (i.e., lowering pension benefits), (3) proportionately increasing taxes on labor and pension income, and (4) lowering both pension and disability benefits. Table 2 provides a summary of

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<sup>19</sup>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.

Figure 10: Employment by Age and Education: Baseline vs. No Reform



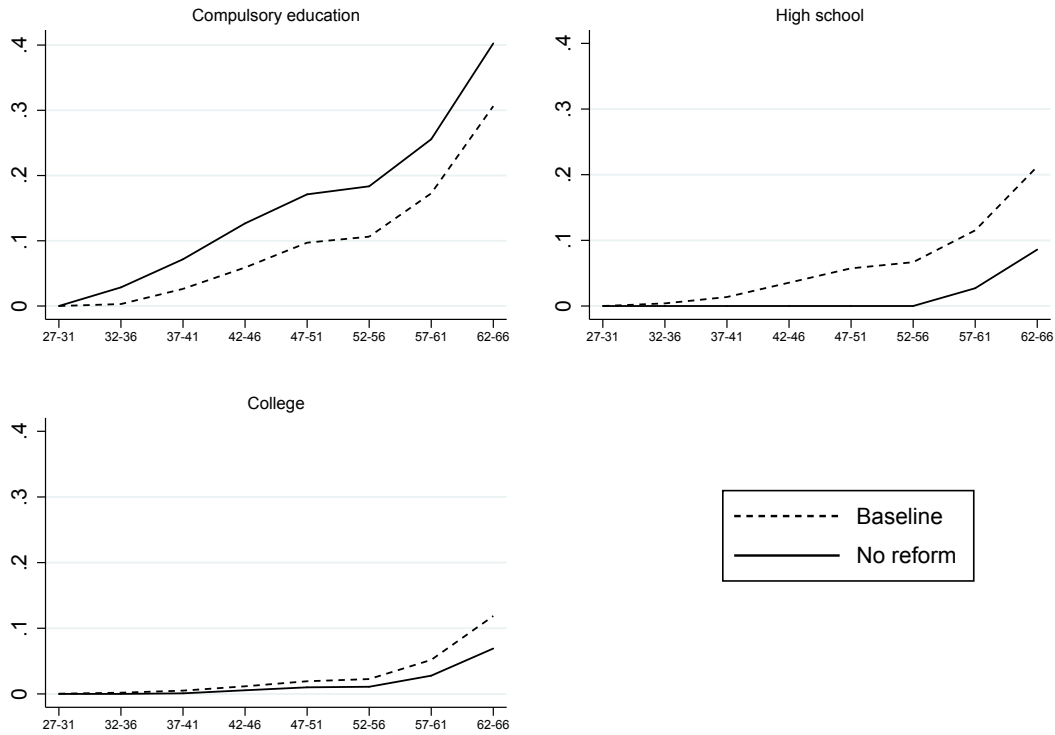
Baseline is the cohort born 1949-53 that the model is calibrated to. No reform is the cohort born 1969-73, which faces different health and survival risk but the same pension scheme as the older cohort.

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*

We find that only increasing the early access age for old-age pension 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 old-age retirement) is not enough to achieve revenue neutrality vis-a-vis the benchmark economy. Specifically, government consumption is 6.2% lower than in the calibrated economy. Raising the early access age for pension benefits does raise the employment rate of older high school and college educated men. However, the disability incidence of dropouts rises, resulting in the decline in government revenue. This exercise highlights

Figure 11: Disability Incidence 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 pension scheme as the older cohort.

the importance of including the disability channel in analyses of pension reform.

In order to achieve revenue neutrality, we combine increasing the early access age to 67 with lowering the pension benefit. We then compare this policy reform with the other revenue neutral policy reforms. Figure 12 plots the employment rates by age and education across the four policy reform scenarios, while Figure 13 plots the incidence of disability insurance by age and education across the aforementioned reforms.

We find that a proportional increase in taxes on labor and pension 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 3-5 pp lower with the tax reform than with the other pension reforms. The proportional increase in income taxes needed for revenue neutrality is 7.0%.

Reducing pension and disability benefits proportionately results in the highest average

Table 2: Comparison of Revenue Neutral Pension Reforms

	EAA	LPB	RTX	PDI
Average discounted lifetime labor income	1	0.998	0.980	1.011
Average discounted lifetime utility	1	0.996	0.971	1.014
Average Employment (50-66)	1	0.994	0.962	1.021
Average DI (50-66)	1	0.967	1.032	0.678
Gini discounted lifetime labor income	1	0.974	1.056	0.855
Gini discounted lifetime total income	1	0.984	0.998	0.976

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

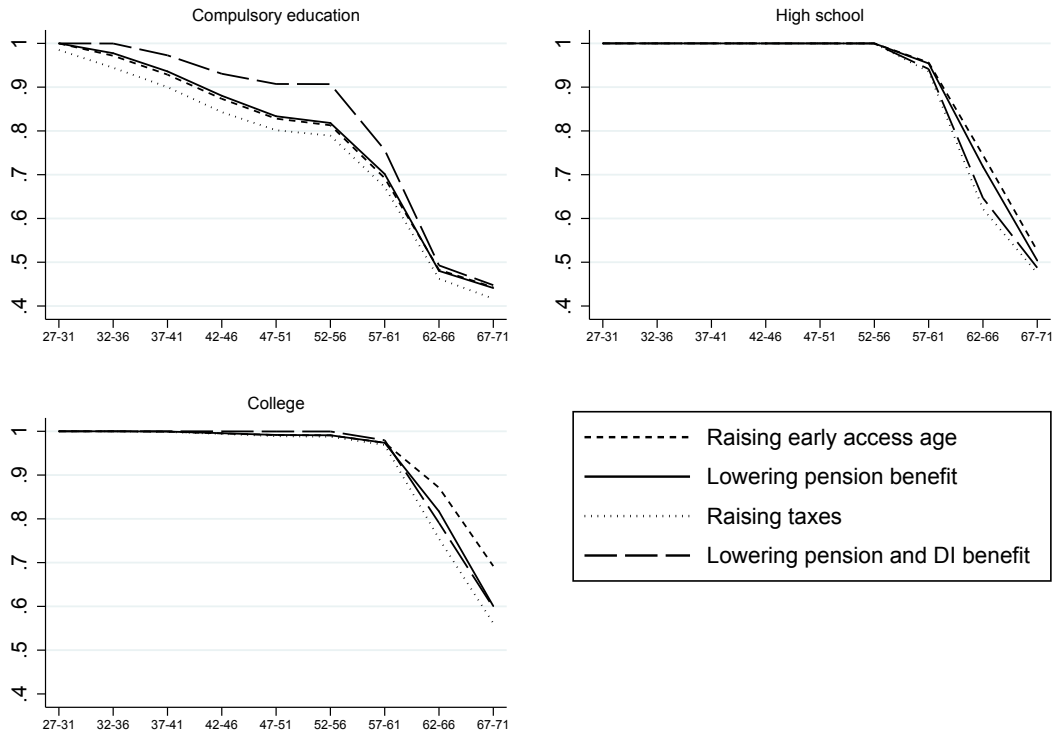
employment rate for older people. This stems from the fact that this policy is most effective at curbing disability benefit claiming and boosting employment among dropouts.<sup>20</sup> The model predicted disability benefit claiming rate among dropout men aged 50-66 is between 8 and 10 pp lower in this policy scenario compared with the other reforms. Note that revenue neutrality is achieved by scaling down pension and disability benefits by 8.0%.

The employment rates for high school and college educated individuals are highest under the reform where the early access age is raised to 67 in combination with a scaling down of pension benefits. The disability incidence among dropouts, however, is high in this policy scenario, resulting in lower average employment relative to the scenario where pension and disability benefits are scaled down proportionately. Note that revenue neutrality requires pension benefits to be scaled down by 22.6% in connection with raising the early access age to pensions. Similar employment outcomes for high school men are also achieved when only scaling down pension benefits, keeping the early access age fixed at 62. In this scenario, revenue neutrality requires pension benefits to be reduced by 27.3%.<sup>21</sup>

<sup>20</sup>The results presented here are from the scenario where we lower pension and disability benefits proportionately, but keep pension accrual while on disability unaffected. We considered a scenario where we also lower pension 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.

<sup>21</sup>The results presented here are from the scenario where we lower pension (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

Figure 12: Employment by Age and Education Across Revenue Neutral Pension Reforms



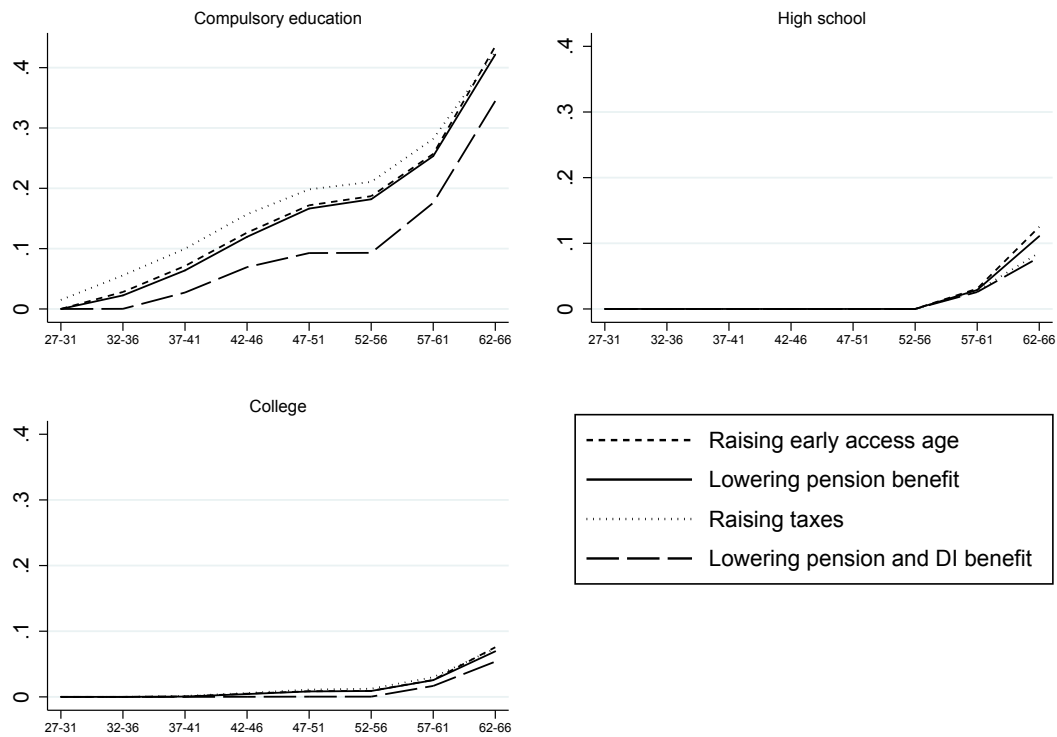
Raising early access age: early access age for pension claiming raised to 67 and benefit scaled down. Lowering pension benefit: all pension benefits scaled down proportionally. Raising taxes: taxes on labor and pension income increased proportionally. Lowering pension and DI benefit: all pension and disability benefits scaled down proportionally.

### *Welfare and Inequality*

To judge the effect of the alternative pension reforms on inequality, we compute the gini of both labor income and total income (labor plus pension income). Inequality is greatest with the proportional tax increase and lowest with the proportional cut in pension and disability benefits. This is true of both labor income and total income. To gauge the magnitude of the differences across policies, note that the gini of after-tax labor income is 19.1% lower with the cut in pension and disability benefits than with the tax increase. We also supplement the gini calculations with a comparison of the 90-10 income differential. Also by this metric tax increases result in the most inequality, while pension and disability

thereby collect benefits longer, we lower their pension 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 13: Disability Incidence by Age and Education Across Revenue Neutral Pension Reforms



Raising early access age: early access age for pension claiming raised to 67 and benefit scaled down. Lowering pension benefit: all pension benefits scaled down proportionally. Raising taxes: taxes on labor and pension income increased proportionally. Lowering pension and DI benefit: all pension and disability benefits scaled down proportionally.

benefit cuts result in the least.

To judge the welfare implications of the alternative policy reforms, we compute changes in average discounted lifetime utility relative to the no reform scenario. From a welfare perspective, proportionately raising taxes on labor and pension income is the worst reform scenario. This is true for all education types. Conversely, lowering pension and disability benefits proportionately is the best for all education types. Specifically, raising income taxes lowers average discounted lifetime utility by 5.1% relative to the no reform scenario, while lowering pension and disability benefits lowers it by only 0.8% (recall that the no reform scenario results in a budget deficit).

### Summary

To summarize, proportionately lowering old-age pension *and* disability benefits is the

best policy reform both from the point of view of minimizing inequality and maximizing the average welfare of agents. It also results in the highest average employment, and thereby highest average labor earnings, of all policy experiments. Thus, there is no equity-efficiency tradeoff across the considered policy experiments. Note that while other policy measures, such as increasing the early access age to old-age pensions in connection with lowering pension benefits, result in higher employment rates for more educated workers, they result in high disability insurance claiming among dropouts, and thus lower average employment. Our findings highlight the importance of including disability in models of pension reform, as reducing the generosity of old-age pension benefits can have the unintended consequence of increasing disability benefit claiming.

While the average welfare of all education types is highest under the policy reform where pension 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 incidence. 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 incidence comes from relatively healthier individuals working instead of receiving benefits.

## **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 dropouts we scale the transition probabilities from good to bad health up by 10%, and the transition probability from bad to good health down by the corresponding factor. For the college types we do the opposite, namely scale the transition probability from good to bad down and from bad to good up 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.

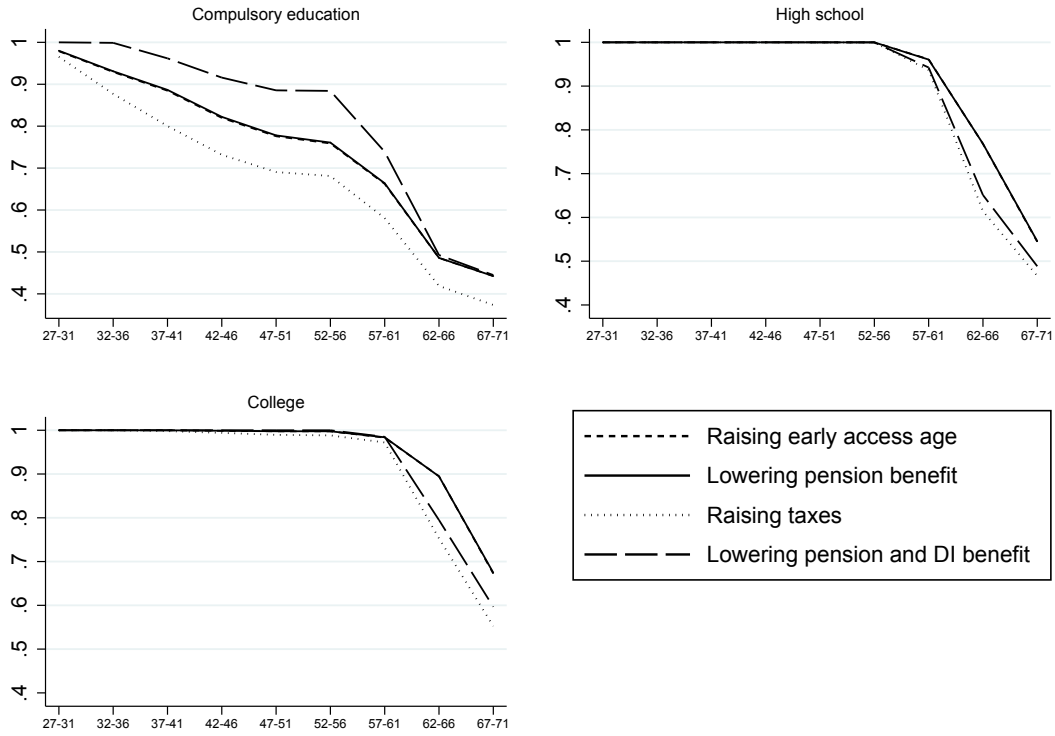
We find that the results from the alternative policy reforms for the pessimistic scenario look similar to the baseline one. The differences across policies are, however, amplified relative to the baseline. See Figures 14 and 15 for details.

## 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 pension 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 pension reforms in the face of widening education-gaps in health and survival.

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 pension claiming. Changes to old-age pension schemes can have the unintended consequence of increasing the flow into disability. As such, abstracting from this channel can bias the policy conclusions.

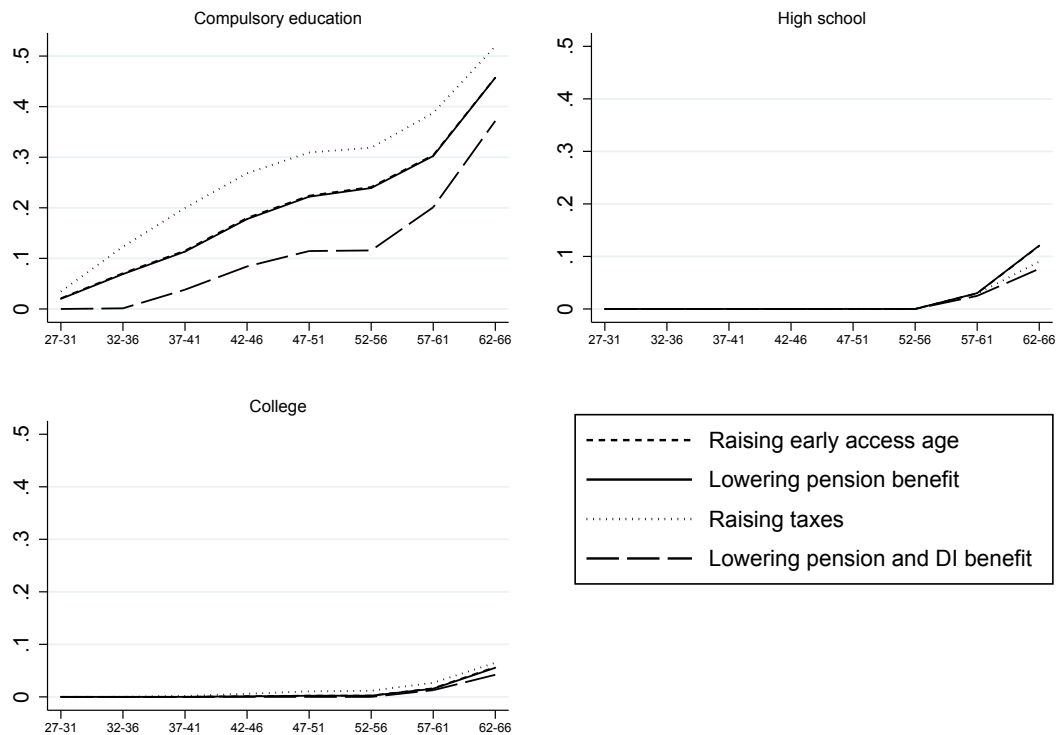
Figure 14: Employment by Age and Education Across Revenue Neutral Pension Reforms – Pessimistic Scenario



Raising early access age: early access age for pension claiming raised to 67 and benefit scaled down. Lowering pension benefit: all pension benefits scaled down proportionally. Raising taxes: taxes on labor and pension income increased proportionally. Lowering pension and DI benefit: all pension and disability benefits scaled down proportionally.

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 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 pension reforms: (1) raising the early access age for pension benefits, (2) raising taxes on labor and pension income, (3) lowering pension benefits, and (4) lowering pension and disability benefits.

Figure 15: Disability Incidence by Age and Education Across Revenue Neutral Pension Reforms – Pessimistic Scenario



Raising early access age: early access age for pension claiming raised to 67 and benefit scaled down. Lowering pension benefit: all pension benefits scaled down proportionally. Raising taxes: taxes on labor and pension income increased proportionally. Lowering pension and DI benefit: all pension and disability benefits scaled down proportionally.

We find that just raising the early access age for pension 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 pension 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 incidence for dropouts in this policy scenario. To achieve revenue neutrality, and thereby comparability with the other policy measures, we combine raising the early access age for pensions to 67 with a proportional lowering of pension 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 greatest degree of inequality and the lowest welfare (for all education types)

of all considered reforms. According to our framework, proportionally lowering pension 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 incidence and boosting employment among dropouts. It is also the preferred policy measure from a welfare standpoint for all education types, and results in the lowest degree of inequality of all the modeled policy reforms. Thus, there is no equity-efficiency tradeoff among the considered policy measures. It is worth noting that, although this policy results in the highest average welfare, it does make disability benefit recipients worse off. One should, however, bear in mind that the starting point is an economy with high disability incidence and generous disability benefits, and the proposed cut to benefits is rather modest. Moreover, while employment rates for high school and college workers are highest when raising the early access age to 67 in combination with proportionally lowering pension benefits to achieve revenue neutrality, this policy option results in high disability incidence for dropouts.

## References

- AUERBACH, A. J., K. K. CHARLES, C. C. COILE, W. GALE, D. GOLDMAN, R. LEE, C. M. LUCAS, P. R. ORSZAG, L. M. SHEINER, B. TYSINGER, D. N. WEIL, J. WOLFERS, AND R. WONG (2017): “How the Growing Gap in Life Expectancy May Affect Retirement Benefits and Reforms,” Working Paper 23329, National Bureau of Economic Research.
- BOUND, J., A. T. GERONIMUS, J. M. RODRIGUEZ, AND T. A. WAIDMANN (2015): “Measuring Recent Apparent Declines In Longevity: The Role Of Increasing Educational Attainment,” *Health Affairs*, 34(12), 2167–2173.
- CASE, A., AND A. DEATON (2015): “Rising morbidity and mortality in midlife among white non-Hispanic Americans in the 21st century,” *Proceedings of the National Academy of Sciences*, 112(49), 15078–15083.
- CHETTY, R., M. STEPNER, S. ABRAHAM, S. LIN, B. SCUDERI, N. TURNER, A. BERGERON, AND D. CUTLER (2016): “The Association Between Income and Life Expectancy in the United States, 2001-2014,” *JAMA*, 315(16), 1750–1766.
- COILE, C., AND J. GRUBER (2007): “Future Social Security Entitlements and the Retirement Decision,” *The Review of Economics and Statistics*, 89, 234–246.
- CORONADO, J., D. FULLERTON, AND T. GLASS (2002): “Long-Run Effects of Social Security Reform Proposals on Lifetime Progressivity,” in *The Distributional Aspects of Social Security and Social Security Reform*, ed. by M. Feldstein, and J. B. Liebman. University of Chicago Press, Chicago.
- FRENCH, E. (2005): “The Effects of Health, Wealth, and Wages on Labour Supply and Retirement Behaviour,” *The Review of Economic Studies*, 72(2), 395–427.
- FRENCH, E., AND J. SONG (2014): “The Effect of Disability Insurance Receipt on Labor Supply,” *American Economic Journal: Economic Policy*, 6(2), 291–337.

- GALAASEN, S. (2017): “Pension Reform Disabled,” SSRN Scholarly Paper ID 3057983, Social Science Research Network, Rochester, NY.
- GUSTMAN, A., AND T. STEINMEIER (1986): “A Structural Retirement Model,” *Econometrica*, 54, 555–584.
- GUSTMAN, A. L., AND T. L. STEINMEIER (2001): “How effective is redistribution under the social security benefit formula?,” *Journal of Public Economics*, 82(1), 1–28.
- HAAN, P., AND V. PROWSE (2014): “Longevity, life-cycle behavior and pension reform,” *Journal of Econometrics*, 178, 582–601.
- HERNÆS, E., S. MARKUSSEN, J. PIGGOTT, AND K. RØED (2016): “Pension reform and labor supply,” *Journal of Public Economics*, 142, 39–55.
- KEMPTNER, D. (2013): “Health-Related Life Cycle Risks and Public Insurance,” Discussion Paper 1320, DIW Berlin, German Institute for Economic Research.
- KRUEGER, P., M. TRAN, R. HUMMER, AND V. CHANG (2015): “Mortality Attributable to Low Levels of Education in the United States,” *PLoS ONE*, 10(7).
- LAUN, T., AND J. WALLENIS (2016): “Social insurance and retirement: A cross-country perspective,” *Review of Economic Dynamics*, 22, 72–92.
- LI, Y. (2018): “Paradoxical effects of increasing the normal retirement age: A prospective evaluation,” *European Economic Review*, 101, 512–527.
- MARKUSSEN, S., AND K. RØED (2017): “Egalitarianism under Pressure: Toward Lower Economic Mobility in the Knowledge Economy?,” Discussion Paper 10664, Institute for the Study of Labor (IZA).
- MCDANIEL, C. (2007): “Average Tax Rates on Consumption, Investment, Labor and Capital in the OECD 1950-2003,” Mimeo.
- OECD (2012): “Pensions Outlook 2012,” OECD Publishing.

- PIJOAN-MAS, J., AND J.-V. RÍOS-RULL (2014): “Heterogeneity in Expected Longevities,” *Demography*, 51(6), 2075–2102.
- RUST, J., AND C. PHELAN (1997): “How Social Security and Medicare Affect Retirement Behavior in a World of Incomplete Markets,” *Econometrica*, 65, 781–832.
- STOCK, J., AND D. WISE (1990): “Pensions, the Option Value of Work and Retirement,” *Econometrica*, 58, 1151–1180.
- STORESLETTEN, K., C. TELMER, AND A. YARON (2004): “Cyclical Dynamics in Idiosyncratic Labor Market Risk,” *Journal of Political Economy*, 112(3), 695–717.
- WALDRON, H. (2007): “Trends in Mortality Differentials and Life Expectancy for Male Social Security-Covered Workers, by Socioeconomic Status,” *Social Security Bulletin*, 67(3), 1–28.

# Data Appendix

## Sample Selection

The aim is to produce a dataset which follows male workers in 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 of 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 dataset 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 dataset of workers from the relevant cohorts unconditional of employment at age 50. This dataset includes the dataset in (i) but also much more. We can divide this dataset in three parts:

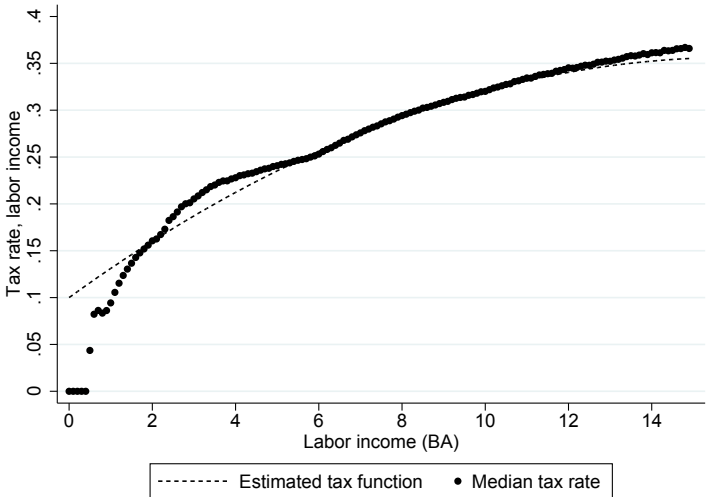


1. Those included in i): Employed at age 50 in a non-ER firm
2. Those employed at age 50, but in an ER firm
3. Those not employed at age 50 (but who was employed at age 27).

(iii) We now want to include a fraction of the observations in 3) such that the dataset 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 approx. 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.

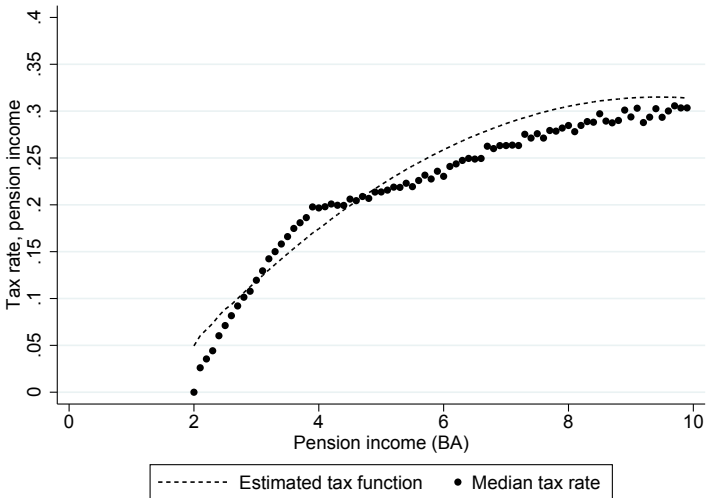
# Figures

Figure A1: Tax Function for Labor Income



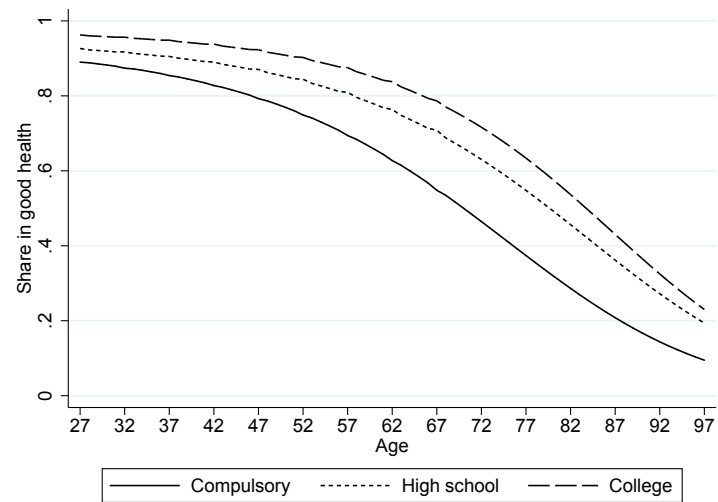
Data source: Norwegian income registry, year 2014. Income measured in base-amounts.

Figure A2: Tax Function for Pension Income



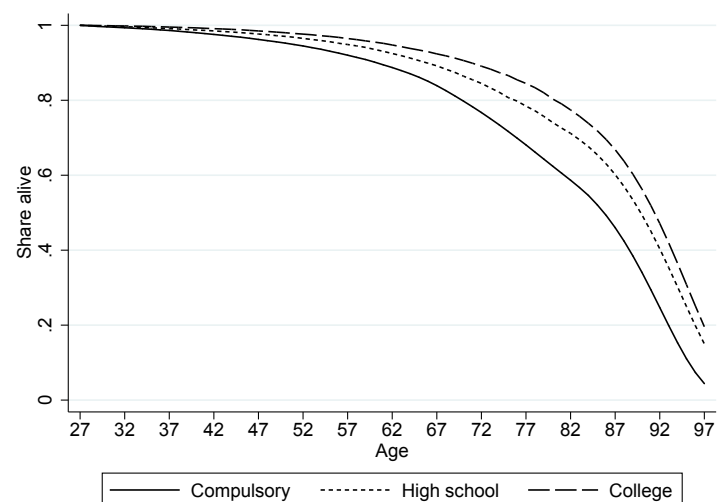
Data source: Norwegian income registry, year 2014. Income measured in base-amounts.

Figure A3: Predicted Share of Men in Good Health by Age and Education



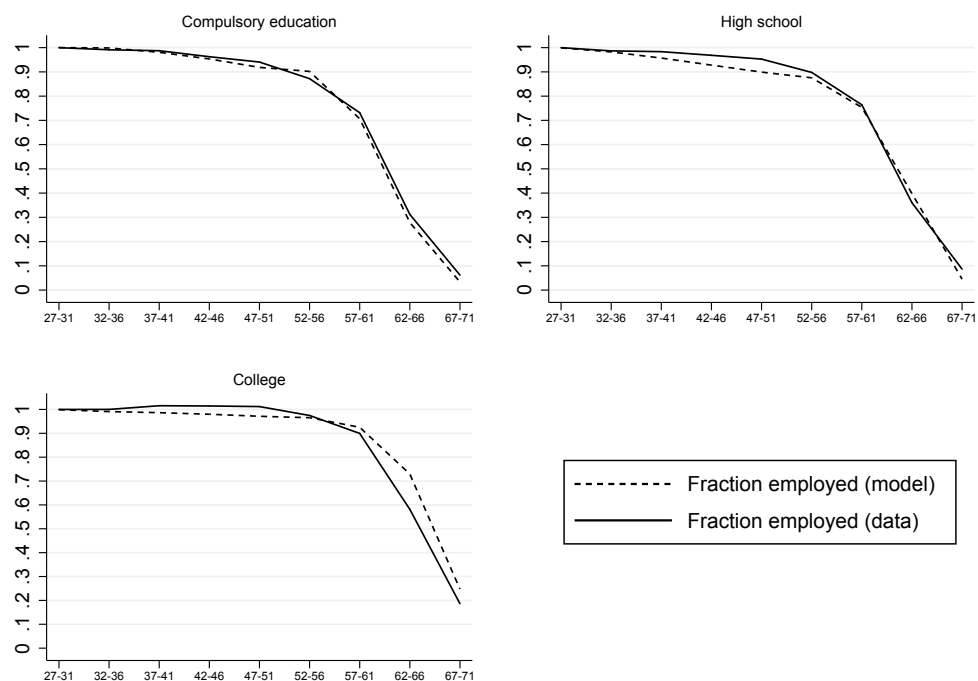
Data source: Norwegian Labor Force Survey, years 2002-15.

Figure A4: Predicted Share of Men Alive by Age and Education



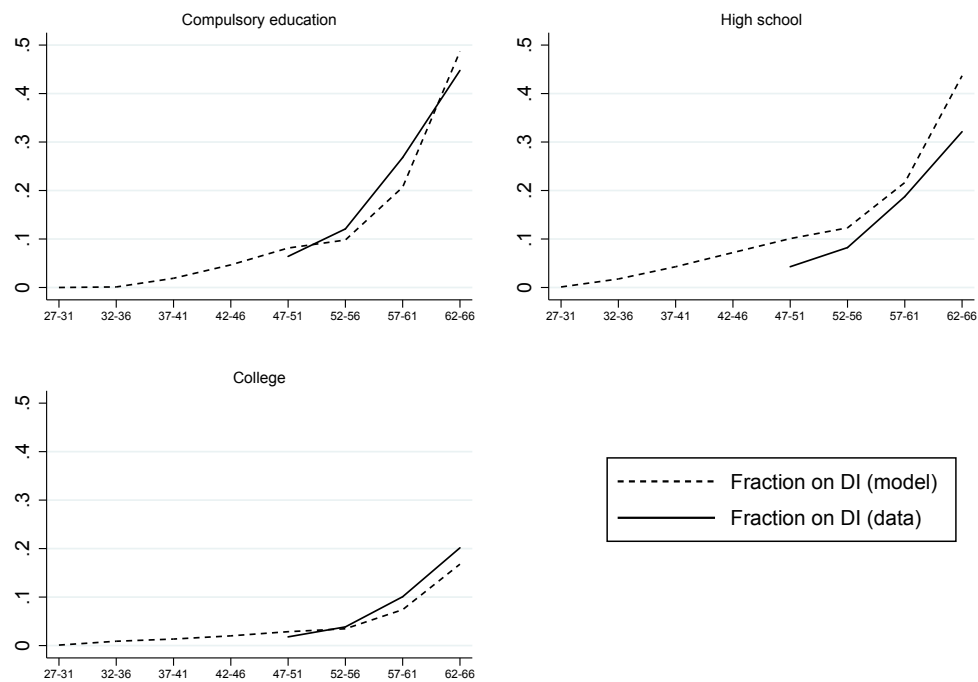
Data source: Norwegian registry data, years 1992-2015.

Figure A5: Model Fit for Employment by Age and Education – Earlier Cohort



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

Figure A6: Model Fit for Disability Incidence by Age and Education – Earlier Cohort



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