# Disability insurance, pension reforms and retirement behavior

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**Abstract**

Retirement through the disability insurance system accounts for a large share of labor force exits in Norway. By age 66 more than 40 percent receive disability insurance. In this paper, a life-cycle model with endogenous retirement is developed to study the interplay between the disability insurance (DI) and old-age pension (OA-pension) systems, and the macroeconomic effects of OA-pension reforms. The key contribution is that I, in contrast to standard macro pension models, include DI as another margin of retirement. I show that failure to account for this margin might severely bias the outcome of pension reforms.

## 1 Introduction

Pension reform is on the agenda in most developed countries. The predicted increase in life-expectancies are putting public finances under pressure. A key target in most reforms is to increase labor supply. Despite this fact, little is known about macroeconomic labor supply elasticities of pension rules. In this paper I bridge this gap by studying pension reforms in a standard heterogenous agent life-cycle model of consumption, savings and income uncertainty, augmented with health risk, public disability insurance and endogenous retirement. Agents in poor health have the option to retire early with disability insurance (herafter DI). By including this dimension, I allow for an important alternative retirement route. As noted in Iskhakov (2010), one third of Norwegian 50-year-olds retire with DI before old-age pension (herafter OA-pension) becomes an option, and 11 percent of working-age population were DI-recipients in 2009 (more than twice the US fraction, see Low and Pistaferri, 2011). Neglecting this dimension might bias the labor supply response of pension reforms upwards. Consider a pension reform that reduces old-age pension benefits. Agents typically respond by increasing their savings and postponing retirement. However, policy makers face a trade off when deciding how to treat those on DI. Unhealty individuals cannot easily postpone retirement, and there are potentially good reasons to protect them from the benefit cuts. On the other hand, if those on DI are protected, the incentive to retire through the DI system goes up, inducing an increased flow of workers to DI, offsetting the initial labor supply increase. Policy makers thus face the trade off between maintaining insurance and limiting retirement incentives. The importance of this trade-off can be motivated by the findings in Börsch-Supan et.al (2005). Using the 'Survey of Health, Ageing and Retirement in Europe' (SHARE), they find that the large variation in disability take-up across countries is not due to demographics or health, and conclude that institutional differences must be a key explanation. Considering that Norway has one of the highest DI take up in the OECD, it thus seems appropiate to focus on the institutional design of the Norwegian system.

These issues have indeed been a major concern when designing the Norwegian pension reform (implementation started January 2011). The main goal of the reform is to make the government's expected pension bill of any cohort independent of retirement age and life-expectancy. This is done by linking OA-benefits directly to a cohort's average life-expectancy. Upon retirement, a yearly pension benefit is calculated by dividing a pension wealth by (roughly) the expected number of years in retirement. This feature of the reform is equivalent to pure cohort-specific reductions, i.e. if retirement age is constant while life-expectancy goes up, the yearly benefit goes down to keep expected life-time OA-pension constant. More than 40 percent of the population is, however, transferred from DI to OA-pension at age 67[1]. A key discussion point has been if the OA-pension cut should be extended to these individuals. Due to the large fraction of Norwegians on disability, the trade off between maintaining insurance and limiting retirement incentives has been a source of conflict. A temporary compromise has been reached, in which DI recipients are partly protected from benefit cuts.[2]

The offsetting effect will be determined by the degree of substitutability between the DI- and OA-program. By including endogenous disability retirement in a macroeconomic pension model, I am able to focus the analysis on this issue. The main mechanism in the paper is as follows: The model features an exogenous first-order Markov process for health, and poor health increases the disutility of work. Unhealthy agents are eligible for DI if they retire, and retirement is permanent (cannot return to work). In the benchmark model, calibrated to Norwegian economy, there are unhealthy individuals choosing not to retire with DI. When a OA-pension reform increases the incentive to claim DI, some of these individuals will substitute OA-pension with DI. As an alternative, I also consider the naive modelling approach, that is, a model where by assumption there is no substitution going on; all DI retirement is exogenous (poor health forces the agent to retire). It turns out that the offsetting effect is quantitatively important. In a reform scenario where OA-pension is reduced with 20 percent from age 67, but those coming from DI are protected from cuts, the exogenous DI model delivers large fiscal gains. When DI retirement

[1] See White Paper No. 5, Ministry of Labour, 2006, page 31

[2] See Government Proposition 130 L, 2011. In 2018, the government will re-evaluate the design.

is endogenous, individuals substitute into DI to such extent that the fiscal gain turns into a loss.

The lack of panel data for health status in Norway precludes external calibration of the health process. I therefore adopt the health transition matrix in French(2005) estimated on US self-reported health status from the PSID.[3] The use of self-reported health data in life-cycle models are also found in e.g. Blau and Gilleskie (2008), Low and Pistaferri (2010), Rust and Phelan (1997).

A key parameter in these kind of models is the wage-offer profile among older agents. Due to selection I cannot use observed wages as the estimated profile. However, since participation is endogenous in the model, I can consistently estimate the wage offers, providing a structural adjustment of the selection bias in the data. Even though selection is potentially acute, looking at one particular dimension of the wage data indicates that it is not. When comparing the labor income at age 57 for all individuals, with the income at age 57 for the highly selected group who also works at age 68, it turns out that the latter group only has 5 percent higher labor income. In the model, it turns out that preference heterogeneity provides a straightforward way to account for this wage premium. In a calibrated version without preference heterogeneity the wage premium is 23 percent. I therefore augment the model with heterogeneous disutility of work, and identify the degree of heterogeneity by targeting precisely this feature of the wage data.

In addition to preference heterogeneity, the model features another non-standard perference parameter: Retirement with DI comes with a utility cost labled stigma, a reduced form for all costs related to DI, including pure social stigma, cost of application, cost of going to the doctor etc. This friction makes the transition into DI less smooth, and is needed for the model to be consistent with the large employment drop following the introduction of an early-retirement program we see in the data. To quantify the magnitude of this cost, I exploite the observed old-age employment in Norway, before and after an early-retirement reform in the 1990s.

An implicit assumption is that there is an economic margin among disabled individuals. Assuming that the unhealthy can work is in line with the life-cycle models of French (2005) and Low et.al. (2010). The former study has an explicit two-state health process, but no DI-program, while the latter models DI eligibility as a negative income shock.[4] The importance of economic incentives is confirmed in Bratberg (1999). Using Norwegian registry data to estimate a multinomial logit model, the study finds that income opportunities is a significant determinant of labor force status, even after controlling for measures of health status. Bratsberg et.al. (2010) concludes that job loss more than doubles

[3] The health measure is the respons to the question: 'Do you have any physical or nervous condition that limits the type or amount of work you can do?". The estimation is found in French (2001, mimeo) and used in French (2005).

[4] A clear physical medical diagnosis among the disabled, could cast doubt on the relevance of economic factors. In many cases, however, the health condition is self-perceived without any observable physical illness, making it harder to determine the true work limitation. Official medical diagnosis from 2000-2003 reveals that disability insurance was granted on mental, muscular and skeletal disorders in 60 percent of the cases (see Mykletun and Knudsen, 2009).

the risk of permanent disability and accounts for three out of ten new DI claims in Norway.

The paper proceeds as follows. The next section goes through related literature. Section 3 outlines the life-cycle model, while section 4 presents the calibration. Section 5 goes through the benchmark model and policy experiments. Section 6 concludes.

## 2 Related literature

The paper contributes to the macroeconomic literature on social security reforms, and is the first attempt to focus on the interaction between the DI and OA systems. The pioneering work by Auerbach and Kotlikoff (1987) has been succeeded by a vast number of papers on macroeconomic and welfare implications of social security reforms in large-scale overlapping-generations model. Retirement behavior has nevertheless received little attention. In recent years, however, a few contributions have been made. To the best of my knowledge, Hirte (2002) is the first study to include optimal retirement in the standard Auerbach-Kotlikoff model. This study was followed up by Fehr et.al. (2003) and Eisensee (2005). Eisensee builds a life-cycle model with optimal retirement to study the effects of U.S. social security reforms. There is no wage uncertainty, but type-heterogeneity with respect to skills and immigration is introduced to explain heterogeneous retirement behavior. The main finding is that a benefit reduction of 42 percent delays retirement with 3-4 years, and puts U.S. fiscal policy on a sustainable path. Díaz-Giménez and Díaz-Saavedrac (2009) and Imrohoroglu and Kitao (2012) are the ones most closely related to the present study.[5] The former study explores the effect of delaying first retirement age in Spain in a model with optimal retirement, as well as disability and idiosyncratic wage uncertainty. Each period the agents face a probability of becoming permanently disabled. Unlike the present study, DI retirement is treated as a pure exogenous process. The second study include both optimal retirement and benefit claiming, as well as health and medical expenditure risks, in a US macroeconomic model. Health risks are quantified using self reported health status and medical expenditures from the Medical Expenditure Panel Survey. Employer provided health insurance and Medicare provide partial coverage for health expenditures. The US disability program (SSDI) is however not modelled.

In contrast to the macro literature, many microeconometric life-cycle models has been developed to study social security and endogenous retirement. Some contributions are the abovementioned studies by Rust and Phelan (1997) and Blau and Gilleskie (2008). French (2005) estimates a full structural life-cycle model with retirement, benefit claiming and health risk, and confirms a rather robust result in the literature: Retirement is quite insensitive to the level of

[5] Erosa et.al (2011) builds on Imrohoroglu and Kitao (2012), to study cross country differences in labor suply late in the life cycle. The study includes disability retirement as an exogenous event.

benefits. A 20 percent reduction delays retirement by only three months in the model. The study also finds that actuarial unfairness and work disincentives seem to explain the U.S. retirement pattern well. Removing the earnings test causes individuals in the model to spend an extra year in the labor force. Few studies have, however, focused on retirement through disability. Recent exceptions are Low et.al (2010) and Low and Pistaferri (2011) focusing on the insurance value and efficiency effects of DI over the life cycle. However, these studies treat old-age retirement as exogenous at age 62.[6] Bound et.al. (2010) and Iskhakov (2010) estimates DP-models with latent health indicators, assuming consumption equals income every period. Precisely as this paper, these studies focus on different modes of retirement. Bound et.al (2010), conjecture that the coming increase in the normal retirement age in the US will have a modest impact on disability applications, while Iskhakov (2010) concludes through simulations that removing the Norwegian early-retirement program[7] increases disability take-up by 4-7 percent in age group 64-66.

# 3 Model

The economy is populated by $J$ overlapping generations. A model period corresponds to a calendar year. Each cohort is a constant fraction of total population, which grows at a constant rate. Cohorts consist of a continuum of bachelor households starting their economic life at age $j = 22$. Lifetimes are uncertain; agents survive to age $j$ with probability $p_j$ and die before age $j = J$. At the beginning of their economic life, agents are of different types, characterized by: education (no college, college), preferences towards work and income levels. Education heterogeneity maps into education specific life-cycle profiles for earnings and preference heterogeneity maps into idiosyncratic disutility of work. Different income types are represented by a fixed effect in earnings realized at age $j = 22$. Moreover, two kinds of risk generate within-type heterogeneity over the life-cycle. First, at each age $j$ individuals are either in good or bad health, and health condition follows a two-state first order Markov process. Finally, agents face idiosyncratic shocks to earnings represented by an AR(1) process. Agents choose how much to consume and save, and labor supply along the extensive margin. Retirement is an absorbing state and an option only for those eligible for public pension, either through disability pension or through old-age pension[8]. Eligibility ages are $R$ and $D < R$ in the old-age pension and disability insurance program respectively. Once entitled to OA-pension at age $R$, disability insurance is no longer an option and all DI-recipients are transferred to OA-pension. The benefit rules are the same in both programs, but OA-pension is subject to

[6] Kitao (2012) develops a life cycle model of unemployment and disability , building on these studies. However, also this paper assumes mandatory old-age retirement. In contrast, my paper focuses explicitly on the interaction between DI and OA-pension retirement.

[7] The reform in Iskhakov (2010) increases the eligibility age for roughly 60 percent of the work force from 62 to 67.

[8] This is not a restrictive assumption. Allowing for self-financed retirement does not change the agent's allocation.

an earnings test if working, while disability pension is received conditional on retirement. Health condition is observable and only unhealthy agents can retire with disability pension. When claiming DI, there is zero rejection probability, and eligibility is not reassessed if health condition improves in the future.

The value function while employed is

$$V_j^W(a_j, m_j, e_j, I_j^b) = \max_{a_{j+1}, c_j} \left\{ u(c_j, I_j^w = 1, I_j^b) + \beta s_{j+1} E_j V_{j+1}(a_{j+1}, m_{j+1}, e_{j+1}, I_{j+1}^b) \right\}, \tag{1}$$

where $s_{j+1} = \frac{p_{j+1}}{p_j}$ is the conditional survival probability, and expectation is taken over next period earnings and health condition, conditional on information available at age $j$. State variables are current asset, pension wealth, earnings and health condition $(a, m, e, I^b)$, and $I^w$ is an indicator function, taking value 1 if working and 0 otherwise while $I^b$ is an indicator for bad health. The value function during retirement is

$$V_j^{NW}(a_j, m_j, I_j^b) = \max_{a_{j+1}, c_j} \left\{ u(c_j, I_j^w = 0, I_j^b) + \beta s_{j+1} E_j V_{j+1}^{NW}(a_{j+1}, m_{j+1}, I_{j+1}^b) \right\}, \tag{2}$$

and the unconditional value function is

$$\begin{aligned} V_j(a_j, m_j, e_j, I_j^b) &= \max\left(V_j^W(a_j, m_j, e_j, I_j^b), V_j^{NW}(a_j, m, I_j^b)\right), \text{ if eligible for retirement} \\ V_j(a_j, m_j, e_j, I_j^b) &= V_j^W(a_j, m_j, e_j, I_j^b), \text{ if not eligible for retirement.} \end{aligned}$$

Period utility of consumption and leisure is given by

$$u = \ln(c) - \delta_w I^w - \delta_b I^b I^w, \tag{3}$$

with $\delta_w$ denoting the disutility of work (heterogenous across agents), and $\delta_b$ the disutility of bad health if working (common to all agents).

Stigma is attached to receiving DI, interpreted as a reduced form capturing all cost related to DI retirement. The cost is parameterized as addative cost of claiming, $z_1$, and a flow cost, $z_2$ incured every period receiving DI (until one is transferred to OA-pension at age $R$). These two costs can be combined to form an age-specific fixed cost of DI-retirement at age $j$, $\widehat{z}_j$, increasing in the number of years expected to be on DI:

$$\widehat{z}_j = z_1 + z_2 \sum_{i=j}^{R-1} \beta^{i-j} \frac{p_i}{p_j}, \tag{4}$$

where the second term is the value of current and future flow cost, discounted back to age $j$. Formally, this cost is included in equation 3 upon claiming DI.

Health risk is age-dependent and health condition is either good or bad. Let $h_{j, I_j^b, I_{j+1}^b}$ denote the probability of a transition to health condition $I_{j+1}^b$ next period, given health condition $I_j^b$ at age $j$. The health condition parameter if healthy is $I^b = 0$, otherwise $I^b = 1$.

At age $j$ the agent receives an endowment of efficiency units per hour of $\log(n_j) = q_j + e_j$. The first component captures the deterministic age-earnings profile, normalized to one at age $j = 22$, and the second component the stochastic endowment process, governed by:

$$\begin{aligned} e_j &= \alpha + z_j \\ z_j &= \eta z_{j-1} + \varepsilon_j \ , \ z_{21} = 0, \end{aligned} \tag{5}$$

where $\alpha \sim N(0, \sigma_\alpha^2)$ is a fixed effect obtained age $j = 22$, and $z$ is an AR(1) with innovation $\varepsilon \sim N(0, \sigma_\varepsilon^2)$. Given a wage rate, $w$, per efficiency unit, annual pretax labor income is (full time work corresponds to $H = 1725$ hours per year)

$$y_j = w \exp(q_j + e_j) H. \tag{6}$$

Both the age component and the stochastic component of earnings will be estimated separately for each education group.

Pension wealth is a function of yearly pension claims over the working periods:

$$m_{j+1} = \begin{cases} m_j + \frac{M(y_j)}{20} & if \ \ j \leq 20 \\ m_j + \frac{\max(0, M(y_j) - m_j)}{20} & if \ j > 20 \end{cases} , \tag{7}$$

where pension claim $M$ is a progressive function of labor income. In the actual Norwegian system total pension entitlements is the average of the twenty best earnings years. It is computationally infeasible to keep track of twenty years of earnings history. Hence, the function is an approximation in which pension wealth is revised upwards only if the pension claim is above average pension claims (as in French 2003 and 2005). Upon retirement a pension benefit is calculated from $b = B(m_j)$.

Agents are born with zero assets and have access to a capital market yielding a risk-free rate of return on savings, denoted $r$. A zero borrowing constraint is imposed and a competitive annuity market provides a survivors premium denoted $1/s_j$. Assets then evolves according to the sequence of budget constraints

$$\begin{aligned} a_{j+1} &= (1 + \widehat{r}(1 - \tau^a)) a_j + T(j, y_j, b_j) - (1 + \tau^c) c_j \\ a_j &\geq 0, \end{aligned} \tag{8}$$

where $\tau^a$ and $t^c$ are capital gains and consumption tax rates, $T(j, y, b)$ after tax labor and pension income, and $\widehat{r} = r/s_j$ the interest rate adjusted for fair annuities. The maximization problem in equations 1 and 2 is constrained by equations 7 and 8.

A single aggregate consumption good is produced by a representative firm employing efficiency labor units ($L_t$) and capital ($K_t$). Output in period $t$ is given by a constant returns to scale Cobb-Douglas production function

$$Y_t = K_t^\alpha ((1 + g)^t L)^{1-\alpha}, \tag{9}$$

with labor augmenting technological growth, $g$. Capital mobility is perfect and equilibrium requires equalization of domestic and global rate of return,

$$r = \alpha \left( \frac{K_t}{(1 + g)^t L_t} \right)^{\alpha - 1} - \delta, \tag{10}$$

where $\delta$ is annual depreciation rate. Competitive labor markets pin down the wage rate

$$w_t(1+\tau^p) = (1+g)^t (1-\alpha) \left( \frac{K_t}{(1+g)^t L_t} \right)^{\alpha-1}. \tag{11}$$

A wage tax ($\tau^p$) is levied on the firm (corresponds to the employer's contribution to the social security payroll tax). The combination of perfect capital mobility, a constant global rate of return and constant technological progress, implies that real wage grows at rate $g$ over time. In order to transform the economy to a stationary one, I write all non-stationary variables as growth adjusted and replace the left-hand side of equation 8 with $a(1+g)$.

The government collects taxes on capital, labor and pension income to finance pension outlays and unproductive consumption $X$. In the benchmark calibration, it runs a balanced budget by adjusting $X$. Later, when computing long-run effects of the reforms, the government uses the consumption tax rate to close the budget.

The equilibrium conditions of this small open economy are simple to characterize. Factor prices are constant, and when exogenous public consumption closes the budget, tax rates are constant as well. When the consumption tax rate is made endogenous, equilibrium requires that maximizing individual behavior is consistent with the tax rate that balances the government budget.

## 3.1 Solution algorithm

Decision rules are found by backwards recursion. Since the retirement decision is absorbing I solve it in two steps. First I solve the retirement problem. Since there is no uncertainty when retired except for stochastic age, the problem is a simple consumption-savings problem with one endogenous state variable (asset) and one exogenous (pension benefit). This gives me the retirement value function. Due to the discrete nature of labor supply, the value function is not necessarily globally concave (see e.g. Low and Pistaferri, 2010), and working with the first-order condition might lead to local and not global optima. The value function for an employed agent is therefore solved by straightforward discretization of the state and control space. Health status is by definition discrete. For current and next period asset I use the same non-equally spaced grid, with denser grids for lower asset levels. The auto-regressive part of the income process is approximated by a two-state first order Markov process, following Tauchen and Hussey (1991). Fixed effects are represented by two types, a low and high income type, and the magnitude of $\alpha$ is set to match $\sigma_\alpha^2$. The pension wealth is discretized using a linear grid. When next period pension wealth is between grid points, it is determined by a lottery over the two neighboring grid points. Number of grid points are set to 200 and 15 for asset and pension wealth respectively. The model is simulated with 40000 individuals for each pair of income-type and education.

## 4 Calibration

Parameters are calibrated to male observations. One period corresponds to a calender year and age is capped at 102.Total population size is normalized to one, and grows at a yearly rate of one percent. Survival probabilities are taken from Statistics Norway life-tables for males in 1987. The social security rules reflect the sytem in place in the 1980s, and preference parameters will be calibrated to match male employment in 1987. Calibration of stigma will exploit the introduction of an early retirement program in the 1990s, and match the change in male employment from 1987 to 2005.

Capital's share of output is set to $\alpha = 1/3$, annual depreciation rate to $\delta = 0.06$, global interest rate to $r = 0.04$ and technological growth to $g = 0.015$. I set capital gains tax rate, $\tau^a$ ,equal to 28 percent, which is the current flat rate in Norway. The payroll tax rate, $\tau^p$, is 13 percent. To obtain the consumption tax rate, $\tau^c$, I compute the average rate based on the 2006 National Account. Total household indirect taxes divided by total household consumption gives $\tau^c = 0.19$. Labor and pension income is taxed according to the function $T$.

**Social security**

The pension-claim function $M$ in equation 7 is given by:

$$M(y) = \left\{ \begin{array}{c} \max(0, \frac{y-G}{G}) \text{ if } y < 8G \\ 7 + \frac{y-8G}{3G} \text{ if } 8G \leq y < 12G \\ 8 + 1/3 \text{ if } y > 12G \end{array} \right. ,$$

where $G$ is the basic amount in the Norwegian social security system (to be calibrated below). Upon retirement, the function $B$ transforms pension wealth to a constant pension benefit by:

$$B(m) = G\left(1 + \max(0.79, 0.45m)\right).$$

Eligibility age in the OA-system is set to $R = 67$ and in the DI-system it is set to $D = 51$, and the pension is determined by the same set of rules. However, those eligible for OA-pension are allowed to work and receive benefits and if younger than 70, benefits are tested against earnings. If the sum of pension benefit and labor earnings exceed 80 percent of previous earnings (denoted $y^{prev}$), benefits are reduced such that the constraint holds. In the true Norwegian system previous earnings is the average of the previous three years. For computational reasons I simplify by assuming that previous earnings is the average of deterministic labor earnings, i.e. $y_j^{prev} = wH\frac{1}{3}\sum_{i=j-3}^{j-1}\exp(q_i)$.(see appendix ?? for more details about how this relates to the actual social security system in the 1980s).

**Tax function**

The tax function $T(age, y, b)$ takes into account the progressivity in the Norwegian system and special tax rules for retirees. In general, the system differentiate between a general income tax and a social security tax. The income tax consists of a marginal tax rate scheme with three brackets. Income in the first bracket is taxed at a marginal rate of 0.28, whereas income in the second

| | No college | college |
|---|---|---|
| $\rho$ | 0.736 | 0.676 |
| $var(\alpha)$ | 0.049 | 0.0716 |
| $var(\varepsilon)$ | 0.003 | 0.005 |
| $var(u)$ | 0.008 | 0.009 |

Table 1: Income process estimates

and third bracket is taxed at rates 0.37 and 0.40. The threshold levels are $6G$ and $9.8G$, respectively. In addition, an (income-dependent) amount roughly between $0.5G$ and $1.46G$ is made tax exempt. The social security tax is levied on total labor and pension income, and is 0.078 on labor income and 0.03 on pension income. Finally, special tax rules applies for individuals who receive pension income. They can deduct an additional earnings-tested amount of $0.25G$. If total earnings and pension income is below a threshold of roughly $2.1G$ , then no tax is paid, and total income tax is limited to 55 percent of income above this threshold. As a consequence, a retiree who receives only the minimum pension pays no income tax. The tax-favorable treatment of pension income contributes to an even more redistributive pension system, but also to a further weakening of work incentives, especially among low-income households.

**Income process**

I define two education groups, those with at least college degree and those with no college degree, and estimate the income process separately for each group. The stochastic component of the process in equation 5 is estimated using a 1997-2008 panel of hourly wage for Norwegian males in age group 30-50 with annual labor income above $1G$. The sample age restriction is chosen to avoid the most severe selection problems. In the estimated income equation, log of wages are determined by a time effect, age, and a stochastic part. Let $(i, j, t)$ index individual $i$ of age $j$ in period $t$. The income process is

$$\ln(y_{i,j,t}) = \gamma_t + age_j + \omega_{i,j,t}, \tag{12}$$

where $y_{i,j,t}$ is hourly wage, $\gamma_t$ is a time dummy and $age_j$ age dummies. The disturbance term $\omega_{i\,j,t}$ is

$$\begin{aligned} \omega_{i,j,t} &= \alpha_i + z_{j,i} + u_{j,i} \\ z_{j,i} &= \rho z_{j-1,i} + \varepsilon_{j,i}\ ,\ z_{21,i} = 0, \end{aligned} \tag{13}$$

which is the empirical analog to the idiosyncratic income component in equation 5. In addition to the fixed effect and the AR(1) shock, an i.i.d transitory shock $u$ is added. When simulating the model the transitory shock is set to zero, which is consistent with interpreting the shock as measurement error. Parameter estimates are obtained by first running OLS on equation 12 and then fit the income process to match the covariance structure of the residuals. See appendix ?? for details.

Fot the deterministic age component of efficiency units, $q$, I take equation 12 and regress it on the same panel of hourly wage for males, for the broader age group 22-69. Due to selection I cannot take realized wages as the estimated profile. True wage growth is confounded with spurious wage growth caused by differences in the level and growth rate of wages between those who exit and remain in the labor market. However, the fact that retirement is endogenous allows me to consistently estimate the offered wage profile using the model, providing a structural adjustment of the selection bias in the data (as in French, 2005). When calibrating the model I set efficiency units in age group 51-69 such that the model delivers the same average wage profile among workers as in the data.[9] Efficiency units are set to zero for individuals older than 69, implicitly assuming that agents do not work after reaching age 70. A relatively small fraction (7 percent) are observed participating at that age and an even smaller fraction work full time. Appendix ?? deals with details about the data, estimation strategy and identification. When aggregating over education types I use the empirical education distribution in 1987 (see figure A1, appendix A).

To pin down the social security replacement rate, the basic amount ($G$) is set such that the average yearly income among agents in age-group 40-44 is $6.6G$. From 1997 to 2008, the average full-time monthly wage in units of $G$ among male workers in age-group 40-44 has fluctuated between 0.55 and 0.56[10][11].

**Health**

Figure 1 displays the conditional probability being unhealthy over the life cycle, taken from French (2005). The estimation accounts for both mearurement error and individual heterogeneity.[12] I assume that the health process starts at age 51, prior to this age, all agents are in good health. The probability of becoming unhealthy at age 51 is set equal to the unconditional probability of bad health at age 51, $h_{50,good,bad} = 0.16$. For age 51 to 69 the transition probabilities are taken directly from figure 1. All individuals age 70 and above are assumed to be unhealthy. When adopting the US health process for Norway, one possible concern is the large cross-country variation found in surveys of self-assessed health status. These stuides typically ask the respondent to rate their own health according to a 5 point scale, ranging from "very good" to "very poor". However, using the European SHARE survey, Jurges (2007) finds that, after accouning for more objective measures of health,[13] most of the variation comes from reporting style, i.e. the connotation of the health categories differs across countires. The health measure used in French (2005) is based on the

[9] The social security rules reflect the policy environment in the 80s. The use of data from 1997-2008 as emprical targets in the wage calibration creates certain inconsistencies since an early retirement program (AFP) was implemented in the 90s. By 1997 the retirement age for those eligibel for AFP (approximately 60 percent of the work force) was 62, as opposed to 67 in the 80s. Hence, the policy environment in the model does not correspond to the policy environment that created the empirical wage target. I use 97-08 observations since this, at the present moment, the only way I can control for hours worked. This will be handled in a future version of the paper.

[10] I calculated yearly wage as 12*(monthly wage).

[11] Source: Table 05218 in Statbank, http://statbank.ssb.no/. Full-time equivalent monthly pay, part-time and full-time working males, age 40-44.

[12] The figure corresponds to the smoothed versions in figure 1 in French (2005).

[13] These (quasi-) objective measures are 15 different physical conditions reported by the respondents

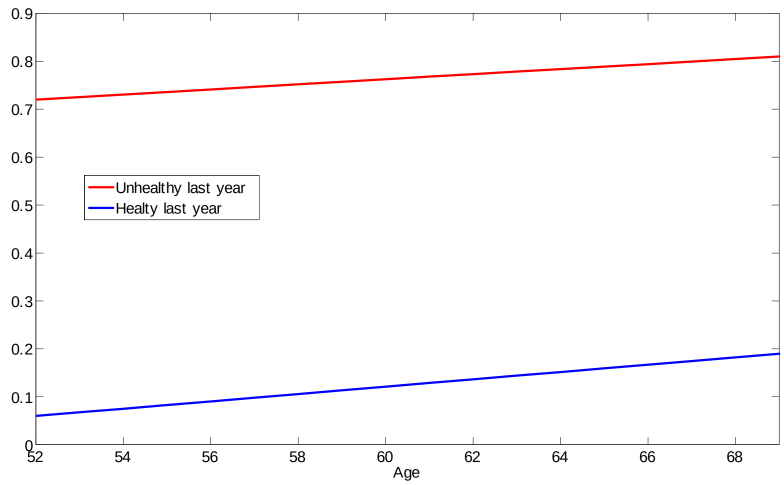


Figure 1: Probability of being in bad health at age j, conditional on health status at age j-1.

respons to the question: Do you have any physical or nervous condition that limits the type or amount of work you can do?. It is likely that this measure is more in line with objective health measures than the conventional 5 point scale.

**Discount rate, disutility of work and bad health**

The discount rate $\beta$ is pinned down by matching the ratio of aggregate wealth to earnings in age group 30-64. I use the ratio 2.15 which corresponds to the empirical ratio for males in 1993. Due to difference between the actual 1993 male population structure and the stationary model population, the actual 1993 population is used when aggregating the corresponding model moment.

Disutility parameters are set to match employment rates. The empirical employment moments are calculated using the 1987 cross section of male yearly labor income, collected from an administrative record covering all residents in Norway. Individuals are classified as retired when income is below the unit amount $G$ (roughly equal to 5300 USD in 1987). Income is defined as *pension effective income* and includes all income contributing to pension claims. In particular, it consists of all labor income, as well as unemployment insurance and sickness absence pay. When calculating the moments I normalize with age 50 employment, thereby leaving out individuals classified as not participating at age 50 (roughly 10 percent). Dropping them is in line with this paper's focus on old-age employment, that is, the model does not attempt to explain retirement during prime-age working life. The parameters are the disutility of bad health if working $\delta_b$ (common to all agents) and the distribution of disutility of work

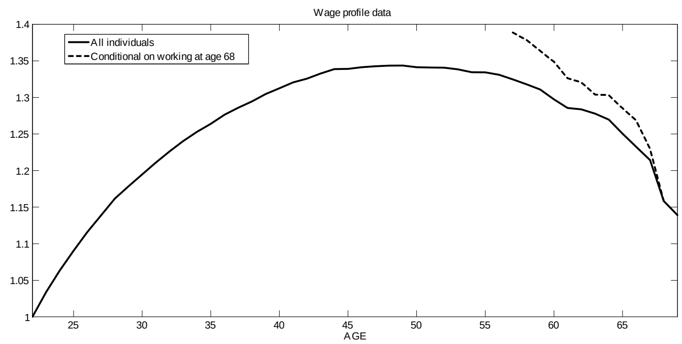


Figure 2: Data Wage profile, no college degree

$\delta_{w.}$ To quantify $\delta_b$ I target employment rate at age 66 (0.58).

To illustrate the identification and motivation behind introducing heterogeneous preferences, consider two versions of the model, with and without heterogeneity. The first version has no preference heterogeneity and $\delta_w$ is calibrated by matching employment rate at age 68 (0.21). A striking feature of this model is that is creates huge participation selection on income. Figure 2 displays two data wage-profiles for individuals with no college degree. The solid line is the age-wage profile estimated above. The dashed line is the age-wage profile (starting at age 57) estimated on the sub-sample of individuals observed working at age 68 (i.e. yearly income above 1G from the administrative record). In other words, the difference between these two profiles at age 57 is that the former is the mean wage among all individuals working at age 57, while the latter includes only those who also work at age 68. The selected group of 57-year-olds observed working at age 68 has a 5 percent higher mean wage. In contrast, the same selected group of 57-year-olds in the calibrated model without preference heterogeneity has a wage premium of 23 percent. Consequently, the model creates too much selection on income relative to data, indicating that income explains too much of retirement. The model needs something that makes low income individuals retire late, and this paper considers preference heterogenity as a solution[14]. With heterogeneity, some agents will, despite low income and high social security replacement rates, choose to retire late simply because they don't dislike working quite as much, compared to other agents. It is a natural extension of the model, and the wage data provides a clear identification. The degree of heterogeneity is calibrated by reducing the model selection on income to levels observed in the data for the low education group.[15]

[14] One possible explanation for the low selection observed in the data, could be that low income individuals only qualify for partial pension , i.e. they don't have a full history of years with earnings above 1G, (a requirement for full pension). However, if I redo the calculation using only individuals with full eligibility, the wage premium is roughly unchanged.

[15] Adjusting also for the high education group would not change the results much, since the

To be precise, I assume that $x = \exp(-\delta_w)$ is distributed according to a Beta distribution $x \backsim Be(\eta_m, \eta_s)$ with support $x \in (0, 1)$. Note that $-\delta_w$ is measured as disutility, hence $-\delta_w < 0 \Leftrightarrow 0 < \exp(-\delta_w) < 1$. The value of $x$ can be interpreted as follows: $(1 - x)$ is the utility cost of working measured as percentage of consumption. The utility function in equation 3, conditional on working, can be rewritten in terms of $x$,

$$u = \ln(cx) - \delta_b I^b.$$

In addition to $\delta_b$ the utility function is now parameterized by the mean $(\eta_m)$ and the scale $(\eta_s)$ of the Beta distribution, i.e. including preference heterogeneity adds one extra parameter to the model.[16] The mean is calibrated as before by matching age 68 employment and the model selection on income is reduced to levels observed in the data by calibrating the scale to match the mean wage at age 57 conditional on being employed at age 68 (for those with no college degree).[17]

**Stigma**

Figure 3 displays to employment profiles for Norwegian males, in 1987 and 2005, normalized with age 50 employment. Over that time period, two large changes has been made to the OA-pension system. In 1989, the opportunity to retire at age 66 with OA-pension was introduced for some employees in the private sector and everyone employed in the public sector, in a program named AFP. The following decade, the eligibility age was further reduced, until it reached it 62 in 1998. Today, roughly 60 percent of the work force is entitled to early retirement (Holmøy and Stensnes, 2008). In addition, there has been a weakening of the pension earnings-test for age group 67-69. As of 2002 benefits are reduced with 40 percent of earnings above 2G, a clear improvment of work incentives relative to the earnings test in 1987. Someone earning a constant income of $5.5G$,[18] gains 27 percent on their after-tax income. In the model, on average, after-tax income at age 67 goes up with 40 and 18 percent for low and high education types, respectively.

The motivation for stigma is that, in a model without such cost, the employment effect of implementing these two changes is not consistent with the data. In fact, the simulated employment lies above the 1987 profile. Two things are going on. First, given the underlying health risk, 87 percent of all agents has at least one year in bad health by age 67, and at one point have had the opportunity to retire with DI. Many of those who do not choose this option, will not choose to retire through the early-retirement program either. Second, many of those who do retire, are close to being indifferent, hence the earnings-test reform

no-college group is by far the largest group. Roughly 90 percent of all 68 year olds have no college degree (in 1987)

[16] The standard parameterization of the Beta distribution is in terms of two shape parameters $s_1$ and $s_2$. I have chosen to reparameterize in terms of the mean and scale, where these are related to the two shape parameters via $s_1 = \eta_m \eta_s$ and $s_2 = (1 - \eta_m)\eta_s$

[17] In the numerical implementation the Beta distribution is discretized using Gaussian quadrature with 4 nodes.

[18] This is the median male yearly income in 2009 in Norway, conditional on working full-time.

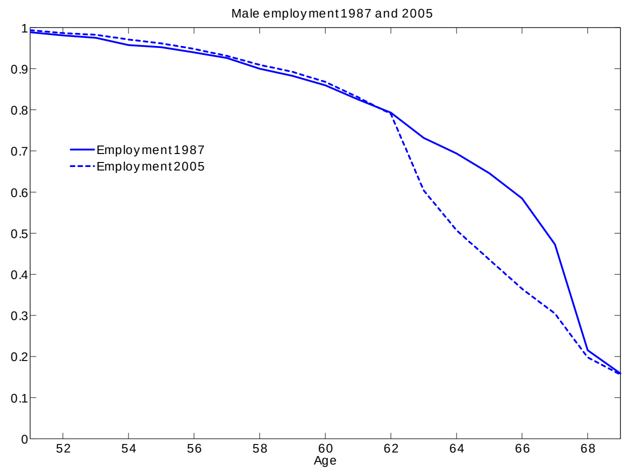


Figure 3: Male employment 1987 and 2005, normalized with age 50 employment

induces a large increase in labor supply. Overall, the early-retirement program is clearly not very popular among the agents in the model. This changes when introducing stigma cost. In addition to extending the early retirement option to healthy agents, an early-retirement program also offers a way for unhealthy to bypass this cost.

The fixed cost of applying ($z_1$) is calibrated to match aggregate employment at age 63 in 2005, while the per-period cost ($z_2$) is set to match age 57 employment in 1987. The reason I model stigma with two parameters is twofold. First of all, if all stigma comes from the fixed cost $z_1$, then simulated retirement prior to age 67 will tend to concentrate around the age group 51-59. If, alternatively, sitgma is entirely due to the flow cost $z_2$, most agents will retire in the age group 60-66. Both of these scenarios are inconsistent with the observed 1987 employment profile, which shows a more smooth decline in employment until age 66. By mathing age 57 employment, the calibration routine balances these two forces. Secondly, as shown in equation 4, this parameterization incorporates the reasonable assumption that the total stigma cost of DI is a decreasing function of age ($\widehat{z}_j$).

**Summary of calibration**

This section summarizes the calibration. The following parameters are calibrated externally: The health process, the (education specific) age-income profile $q_j$ for age $j \in [22, 50]$ and income shock process, the survival probabilities, tax and pension system. The following parameters are calibrated internally (targets in parenthesis): $\beta$ (wealth/earnings ratio=2.15), $\delta_b$ (employment at age 66=0.58), $\eta_m$ (employment at age 68=0.21), $\eta_s$ (mean age 57 wage conditional on age 68 employment=1.39), the age-income profile $q_j$ for age $j \in [51, 69]$ (data observed mean wage age 51-69), and the stigma parameters $z_1$ and $z_2$ (1987 age

57 employment and 2005 age 63 employment). The fixed effect in the income process is approximated by 2 types (low and high income) and the distribution of preference heterogeneity is approximated by 4 types. Consequently, the ex-ante heterogeneity is summarized by $2 * 2 * 4 = 16$ types, and each type is born with a particular combination of education level, fixed effect and disutility of work.

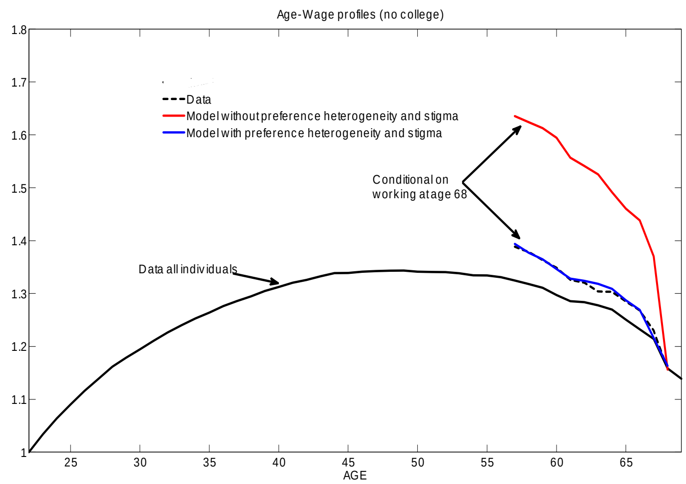


Figure 4: Wage profiles conditional on working at age 68, data and model with and without preference heterogeneity. No college degree

# 5 Results

## 5.1 The benchmark economy

The benchmark model is the version with preference heterogeneity and stigma, and it will be used when running the policy experiments. However, when presenting the calibrated economy it will be compared the no-heterogeneity, no-stigma model to illustrate the effect of including these two dimensions.

Figure 4 is the same as figure 2, with the conditional wage profiles for the two calibrated models added. Although the calibration routine only matches the age 57 wage premium target, the model with preference heterogeneity is successful in bringing selection on income closer to data levels, even for ages 58-67.

Calibrated mean wage offers are also affected by preference heterogeneity. Figure 5 shows the calibrated age-wage profiles for the low education type, in both model versions. In both cases the wage offers are calibrated such that the

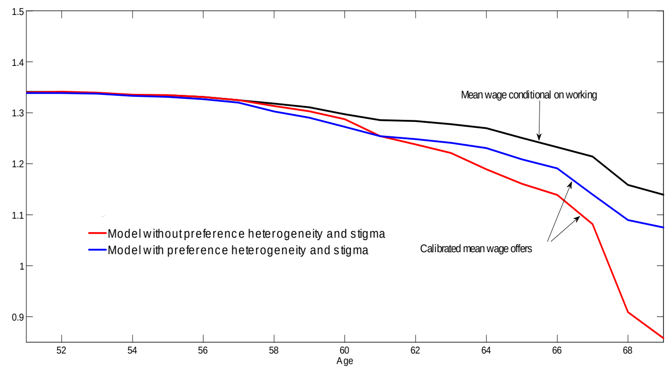


Figure 5: Calibrated wage profile, with and without preference heterogeneity. No college degree.

induced participation selection on wages creates an age-wage profile, conditional on employment, that corresponds to the observed data profile. By including preference heterogeneity in the model, the large drop in wage offers from age 66 to 68 is reduced. This means that the large drop in employment from age 66 to 68 is *not* caused simply by a corresponding drop in the age-wage profile. A negative adjustment is, however, needed for the model to be consistent with wage data, illustrating that selection on income still goes on.

The simulated employment profile is displayed in panel A of figure 6. When aggregating across education types I use the empirical education distribution in 1987. Although only matching employment rates at ages 57, 66 and 68, the simulated model fits data employment at age 51 to 65 well both in terms of level and curvature.[19] Figure A2 (appendix A) shows the employment profiles by education. The effect of 1) lowering the OA-pension eligibility age to 62 for 60 percent of the population and 2) reforming the earnings-test for age 67-69 for everyone, is displayed in panel B of figure 6. The calibration routine matches age 63 employment in 2005, and the model is able to capture the steady decline for older ages as well.[20] As a further evaluation of the model, consider the group of males still working at age 61 *and* eligible for the early-retirement program.

[19] The model misses age 67 employment moment in the data. I did not include this moment in the calibration since the data employment at age 67 is most likely too high. This is due to the way I classify individuals as employed. If an individual is earning more than 1*G in the calender year he reaches 67 he is defined as employed even if he reitres as soon as he turns 67.

[20] Before age 62, however, the model underpredicts retirement. Agents eligible for early-retirement postpone retirement to avoid the stigma cost. Recall that the stigma cost $z_2$ is incurred every year on DI, i.e. until the agent is transferred to OA-pension at age $R = 67$ (even though the early-retirement reform in Norway reduced the OA-pension eligibilty age $R$ to 62, those on DI is not transferred to OA-pension until age 67). Re-doing the simulation assuming that stigma for those eligible for early retirement only goes on until age 62, eliminates this underprediction, while keeping employment at older ages unchanged.

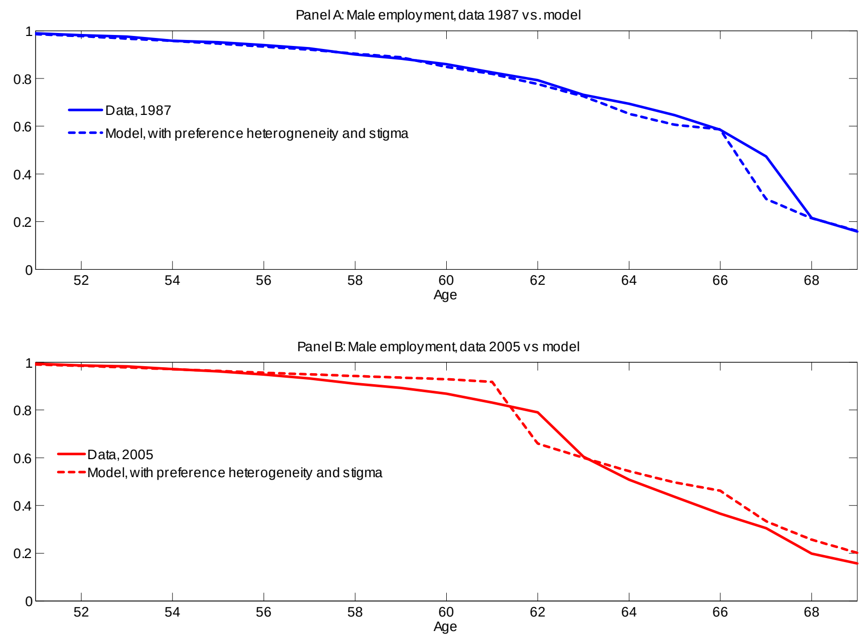


Figure 6: Panel A) aggregate employment, data 1987 vs model. Panel B) aggregate employment data 2005 vs model with simulated with early retirement program and earnings-test reform

By age 66, 71.3 percent of these individuals received early-retirement pension in 2005 in the data[21]. The corresponding model moment is 70.7 percent.

The mean and scale of the Beta distribution is calibrated to $\eta_m = 0.81$ and $\eta_s = 8.3$, and the disutility of bad health to $\delta_b = 0.64$. Expressed in terms of percentage of consumption this corresponds to a mean utility loss of 19.0 and 57.3 from working in good and bad health, respectively, with a standard deviation of 12.4. The stigma costs are calibrated to $z_1 = 0.35$ and $z_2 = 0.26$. The calibrated disutility of bad health $(\delta_b)$ is small enough to prevent DI-retirement from being, de facto, an exogenous event. If $\delta_b$ was very large, agents would retire as soon as they could, i.e. as soon as they receive a negative health shock. Then the exogenous health process would in effect determine employment. It follows from the health transition probabilities that 87 percent of all individuals have at least one year in bad health by age 66. The employment rates would be too low, compared to data, if a negative health shock immediately induced retirement. In fact, 31 percent of the agents working

[21] See Government White Paper no. 5 (2006-2007), p. 49. Among those retiring with early-retirement pension in 2005, 85 percent had full pension (i.e. full retirement)

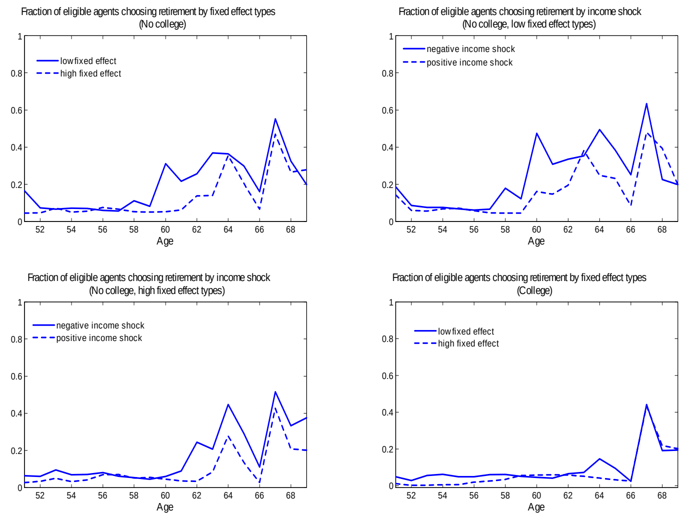


Figure 7: Retirement rates among individuals eligible for pension (DI or OA), by age.

at age 66 have poor health (and thus eligibel for DI).

Since health alone is not enough to induce job exit, the distribution in retirement age must be explained by other factors too. The model generates moderate participation selection based on wages, explaining the (small) negative wage adjustment needed in figure 5. Focusing on those with no college degree, the top-left panel of figure 7 shows the fraction of eligible agents choosing retirement at each age, by fixed effect types.[22] As noted in section 3, poor health is required for DI-eligibility. Even though different income groups (fixed effect types) face the same health process, early retirement is dominated by low-income (low fixed effect) types. Average retirement age is 64.2 and 65.7 for the low and high income type, respectively. Within both income groups there is also selection on current idiosyncratic income shocks, shown in top-right and bottom-left panel. Those with a negative income shock is much more likely to retire. Finally, the bottom-right panel illustrates the huge effect of education. There is a low, but steady, exit and as many as 38 percent of them work until they are forced to retire at age 70. However, this has little impact on aggregate employment, since only about 10 percent of individuals above age 65 has a college degree.

A characterizing feature of the model is that it fits the drop in employment

[22] For example, consider the group defined by low-education, LA-type, age 58, with low fixed income effect who has 1) not yet retired and 2) is in poor health. The top left panel shows that among these agents 10.2 percent choose retirement.

| | |
|---|---|
| Total public expenditures, % of GDP | 46.7 |
| DI and OA-pension, % of total public expenditures | 19.1 |
| Consumption tax, % of total public expenditures | 21.4 |

Table 2: macroeconomic variables

around the OA eligibility age. This is not a surprise considering the fact that the model is calibrated to match the drop from age 66 to 68. It is, however, interesting to understand why I get a peak in retirement exactly at age 67. Since most of the action takes place among the low-education type I will focus on this group. No-college employment in fact drops from 0.56 to 0.28, hence 28 percent retire at the OA eligibility age. Apart from a drop in the age-wage profile of 4.3 percent, the work incentives does not change much from age 66 to 67, given poor health. But at age 67 unhealthy can retire with OA-pension and thus avoid stigma cost of DI. This is indeed the most important explanation. Simulating the model with stigma extended to age 69,[23] reduces the fraction retiring at age 67 from 28 to 9 percent.

The main macroeconomic variables of the benchmark stationary economy are summarized in table 2. Note that I set exogenous government expenditures $X$ to close the government's budget, and assume a constant education distribution, with 25 percent of each cohort having a college degree.

## 5.2 Experiments

The calibrated model is used to analyze macroeconomic implications of pension reforms, justified by increased life expectancy at age 67, with a factor of $1/0.8 = 1.25$, from 13.9 years to 17.4.[24]. The new balanced growth paths, both in the benchmark and reform scenarios, are solved assuming the demographic transition has settled down and that consumption tax rate adjust to close the government's budget.[25] If no pension reform is undertaken, the consumption tax rate must increase with 4.8 percentage points, from 19.0 to 23.8. Two qualitatively different reforms are considered, one in which OA-benefits are reduced, and one in which OA eligibility age is increased. As noted in section 3, the two social security programs are equal in the benchmark economy, i.e. at any given age, the agent is indifferent between retiring with OA and DI benefits. What kind of benefit to receive is, however, not a choice. Prior to age 67 DI-benefit is the only option, and, upon reaching 67, all DI recipients are transferred to OA benefit.

**Reducing Old-Age pension benefits**

In the first reform OA benefits are reduced with 20 percent. The expected life-time, pre-tax pension bill of someone who receives OA-pension from age

[23] I add a cost of $z_1 + z_2$ to the value of choosing retirement at age 67, 68 and 69.

[24] Even though an agent's life-expectancy improves it is assumed no changes in health or productivity. The new survival probabilities are taken from Statistics Norway's projection for 2014 (male cross section)

[25] Exogenous government expenditures $X$ are taken from the initial steady state

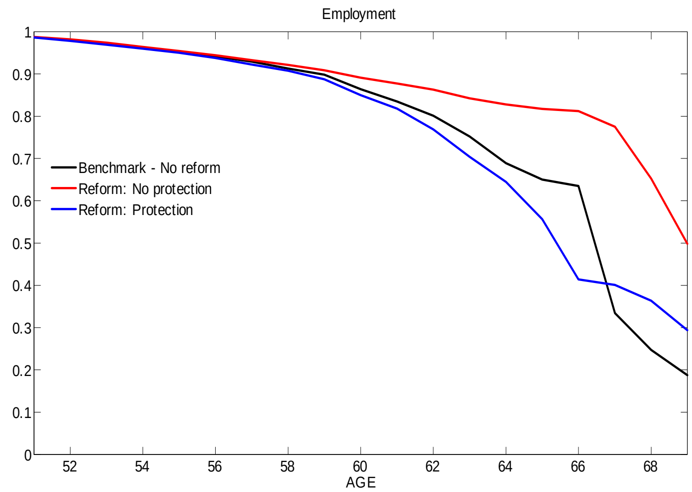


Figure 8: Employment effects of reform 1: Reducing OA-pension and removing earnings test

67 is therefore unchanged,[26] despite increased life-expectancy. Moreover, the OA-pension earnings test is completely removed, so that agents can work full time *and* receive full OA-pension. Finally, individuals transferred from DI to OA-pension at age 67 are protected from benefit cuts. While the benefit cut and earnings-test removal create an incentive for the everyone to delay retirement, the protection creates an incentive for the unhealthy to retire with DI prior to age 67. This reform captures the trade-off in the Norwegian pension reform between maintaining insurance and increasing labor supply. A potential increase in DI take up will counteract any delayed retirement respons, and apriori it is not clear what the sign of the total labor supply effect will be. To single out the effect of substitution between the two social security programs, I also run a reform whith no protection for DI-recipients.

Figure 8 shows the labor supply responses. When there is no protection, the aggregate labor supply response is positive. In age group 51-69, labor supply goes up with 9.3 percent and the consumption tax rate is 18.5 percent (compared to 23.8 percent in the no-reform scenario). These effects are large, but it is worth noting that the reform is quite drastic. In addition to a benefit cut of 20 percent, we go from a system where most agents keep 0 percent of OA-benefits if working, to a system where everyone keep 100 percent. This completely removes the high implicit tax rate caused by the earnings test. As it turns out, this has large effects on labor supply.

When protecting those coming from DI, the substiution between DI and OA

[26] This holds exactly if wage growth rate is used as discount factor (which is the discount factor chosen by Norwegian government in the actual pension reform)

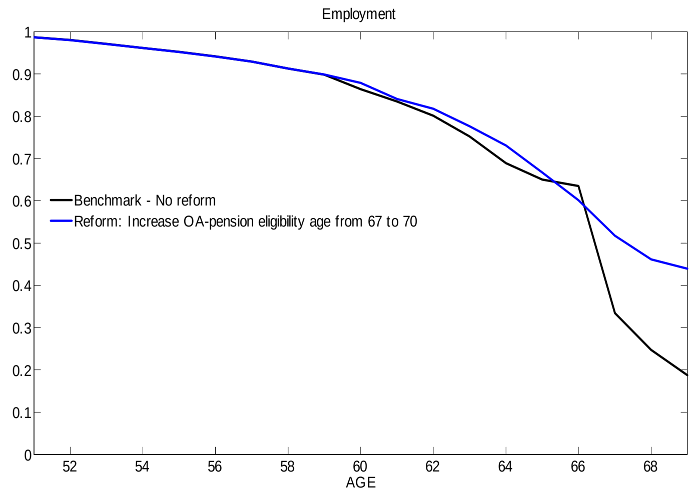


Figure 9: Employment effects: Increase OA eligibility age from 67 to 70

program is so large that the outcome it a fiscal loss. Aggregate labor supply now decreases with 1.4 percent, while the consumption tax rate is 24.3 percent. Unhealthy individuals who previously chose to work are now retiring to such extent that it outweighs the increased participation by healthy individuals, and as a result, the consumption tax rate must go up.

**Increasing eligibility age**

In this reform the eligibility age for OA-pension is raised by three years, from 67 to 70, justified by the same increase in life-expectancy as in the previous reform. Consider the following *static* response for 67-year-old agents. All healthy agents are now forced to work, while all unhealthy who previously retired with OA-pension just switch to DI pension. The immediate effect is therefore a jump in aggregate labor supply by the magnitude of healthy 67-year-olds who previously retired. The *dynamic* response comes from forward looking agents. Consider an unhealthy 66-year-old agent who previously chose participation. Conditional on bad health, the budget constraint remains unchanged, i.e. retirement with DI at age 67 is still an option. If health status changes the agent is, however, no longer eligible for OA-pension. This might encourage DI retirement at age 66. On the other hand, when raising the OA eligibilty age, the number of years on DI goes up, causing the discounted sum of stigma costs to go up (follows from equation 4), and thereby discourage DI retirement.

Figure 9 shows that age 66 employment falls, allthough negligible, and employment at younger ages goes up. In total, the reform actually cause less DI retirement prior to age 67. Of course, at age 67-69 unhealthy agents will now switch from OA-pension to DI, while healthy agents must work. The overall labor supply goes up by 3.9 percent, while the consumption tax rate falls by 1.8

| | Endogenous DI-retirement | Exogenous DI-Retirement |
|---|---|---|
| Reduce benefits | $(-1.4\%\ ,\ 1.9\%)$ | $(2.3\%\ ,\ -6.3\%)$ |
| Increase eligibility age | $(3.9\%\ ,\ -7.6\%)$ | $(2.4\%\ ,\ -4.9\%)$ |

Table 3: Reform effects, percentage change in (aggregate labor supply age 51-69 , consumption tax rate), relative no-reform scenario. In the exogenouse DI model, the no-reform consumption tax rate is 24.0

percentage points.

**Exogenous disability**

To evaluate the quantitative importance of endogenous DI retirement it is usefull to compare the above results to a model economy with exogenous DI retirement. In this world, bad health is an absorbing state and the disutility of working with poor health ($\delta_b$) is infinity. The probability of a bad health shock at age t, conditional on good health at age t-1, is calibrated to match data employment age 51-66 for each education group separately, with linear extrapolation for age 67-69. The parameters of the $\delta_w$-distribution, $Be(\eta_m, \eta_s)$, and $\beta$ are calibrated as before. With exogenous DI, the stigma cost is irrelevant and set to zero.

Table 3 summarizes the results. In the exogenous DI model, reform effects are limited by the fact that many are not able to respond to incentives. Roughly 40 percent have no ability to work at age 66, and with linear extrapolation of health risk, almost 60 percent at age 69. Nevertheless, the consumption tax rate goes down, and labor supply goes up in both reforms. With endogenous DI, the gains tum to losses in the benefit-reduction reform, while the gains are actually larger in the eligibility-age reform.

**Welfare effects**

High stigma cost of DI implies that there might be a scope for early retirement programs to improve welfare. These programs offers a easy and quick way of leaving the labor force, without the effort and social stigma attached to the DI route. In this respect, an early retirement program works a lot like removing the stigma cost. Clearly, if I introduce a universal early retirement program, with no effect on retirement age (that is, only effect is that DI-recipients switch to early retirement pension), welfare improves. However, the behavioral respons (that is, reduced retirement age), triggers a tax increase which might outweigh the reduced stigma cost. This is indeed the outcome. With an early-retirement program, granting universal access to OA-pension from age 62 ($R = 62$), all agent-types are made worse off in the new stationary equilibrium. The consumption tax rate goes up with 5.2 percentage points and the type-dependent welfare loss varies between 1.6 and 4.2 percent of yearly consumption.

Welfare effects of protecting disabled retirees from OA-pension cut. [TO BE COMPLETED]

## 6 Conclusion

This paper studies the interaction between DI and OA-pension retirement, in a quantitative life-cycle model calibrated to the Norwegian economy. This interaction is an important dimension, considering the large fraction (roughly 40 percent) of the Norwegian population transferred from DI to OA-pension at the official retirement age (67). Motivated by the ongoing Norwegian pension reform I ask the question: What are the macroeconomic effects of protecting DI-recipients from the reform? I look at two stylized reforms, one in which OA-pension is reduced and earnings test removed, and one in which the eligibility age is increased. I consider two modeling approaches, one in which DI-retirement is exogenous and one in which it is endogenous. The key result is that with exogenous DI-retirement there are large fiscal gains in both reforms. When DI-retirement is endogenous, however, individuals substitute into DI to such an extent that the fiscal gain in the benefit-cut reform turns into a loss. [TO BE COMPLETED]

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# 7 appendix

[TO BE COMPLETED]

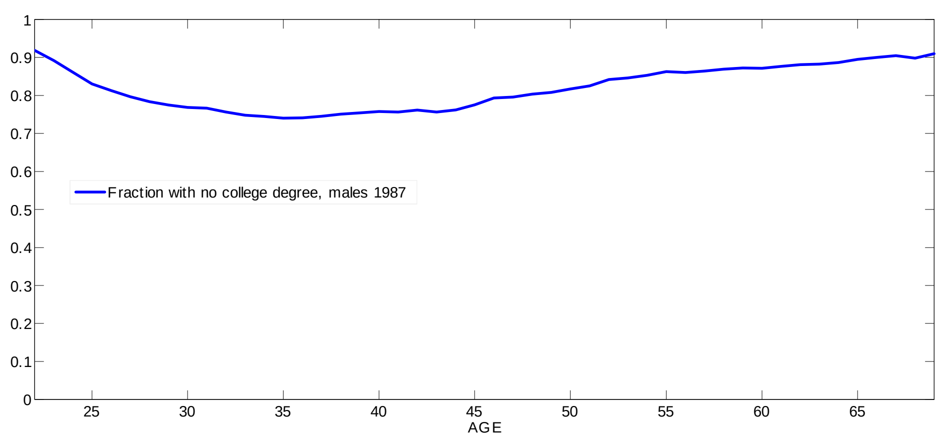
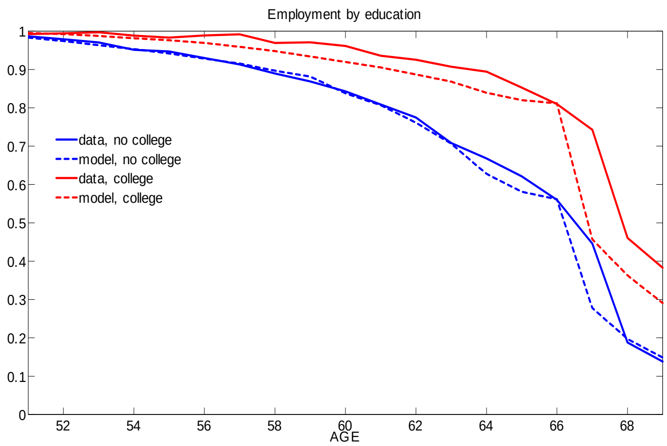



Figure 10: A1: Empirical education distribution by age, males 1987

The data set used in estimating the age-wage profiles and the income process consists of monthly earnings (consisting of basic salary, fixed and variable additional allowances, bonuses and commisions, and overtime pay) and contractual monthly working hours from 1997-2008. Data is collected once a year during the 3rd quarter. Hourly wage is computed as the ratio of monthly earnings (excluding overtime pay) to monthly hours. The data set covers all employees in the public sector and large private sector firms (100-150 employees, depending on industry), while employees in small and medium sized firms are sampled each year with a sampling rate between 10-40 percent, depending on industry (see Statistics Norway, 2005).




The parameters of the income process is estimated by fitting the observed covariance structure of residuals $\omega$ obtained from running OLS on equation 12. Let $j$ denote age, the empirical income process used in the model (eq 13) is

$$\begin{aligned} \omega_j &= \alpha + z_j + u_j \\ z_j &= \rho z_{j-1} + \varepsilon_j \ , \ z_0 = 0 \end{aligned}$$

The vector of parameters to be estimated is $\theta = \{var(\alpha), var(u), var(\varepsilon), \rho\}$. Taking variances and covariances gives

$$\begin{aligned} var(\omega_j) &= var(\alpha) + var(z_j) + var(u_j) \\ cov(\omega_j,\omega_{j+k}) &= var(\alpha) + \rho^k var(z_j) \\ cov(\omega_j,\omega_{j+1}) - cov(\omega_j,\omega_{j+k}) &= \rho(1-\rho^{k-1})var(z_j), \end{aligned}$$

where $var(\omega_j)$ and $cov(\omega_j,\omega_{j+k})$ are the age $j$ variance of the residuals and the covariance of residuals of age $j$ and $j+k$. For a given $k$, the identification of $\rho$ is given by

$$\frac{1-\rho^{k-1}}{1-\rho} = \frac{\sum_j \left[cov(\omega_j,\omega_{j+1}) - cov(\omega_j,\omega_{j+k})\right]}{\sum_j \left[cov(\omega_j,\omega_{j+1}) - cov(\omega_j,\omega_{j+2})\right]}$$

where the summation is over all ages $j \in [30, 50-k]$. The variance $var(u)$ is given by

$$var(u) = \frac{1}{N_k} \sum_j \left[var(\omega_j) - cov(\omega_j,\omega_{j+k}) - (1-\rho^k)var(z_j)\right]$$

where $N_k = 50 - k - 30 + 1$ and

$$var(z_j) = \frac{cov(\omega_j,\omega_{j+1}) - cov(\omega_j,\omega_{j+2})}{\rho\,(1-\rho)}$$

Identification of $var(\alpha)$

$$var(\alpha) = \frac{1}{N_k} \sum_j [var(\omega_j) - var(z_j)] - var(u)$$

Identification of $var(\varepsilon)$

$$var(\varepsilon) = \frac{1}{N_k} \sum_j \left[var(\omega_{j+1}) - var(\omega_j) + (1 - \rho^2) var(z_j)\right]$$

I do this for $k = 3, .., 9$, giving 7 values for $\theta$ (one for each $k$). I take the mean over all $k's$ to obtaine estimates of $var(\alpha)$, $var(u)$, $var(\varepsilon)$, and $\rho$.