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# Effectiveness of early retirement disincentives: individual welfare, distributional and fiscal implications


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# Effectiveness of early retirement disincentives: individual welfare, distributional and fiscal implications

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**Abstract:** In aging societies, information on how to reform pension systems is essential to policy makers. This study scrutinizes effects of early retirement disincentives on retirement behavior, individual welfare, pensions and public budget. We employ administrative pension data and a detailed model of the German tax and social security system to estimate a structural dynamic retirement model. We find that labor market participation and retirement behavior in general are strongly influenced by the level of disincentives. Further, disincentives come at the cost of increasing inequality and individual welfare losses. Still, net public returns are more than five times as high as monetarized individual welfare losses. Our estimates also suggest that similar levels of net public returns achieved by indiscriminating pension cuts are associated with individual welfare losses that are at least twice as high.

**Keywords:** dynamic discrete choice, retirement, tax and pension system, pension reform.

**JEL Classification:** C61, H55, J26

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## 1 Introduction

Aging populations exert increasing financial pressure on pension systems around the globe. Therefore, this central feature of modern welfare states is, and has been, subject to many fundamental reforms. Typical examples include increasing eligibility ages (Mastrobuoni, 2009; Staubli and Zweimüller, 2013; Ataly and Barret, 2015), pension level adjustments (Haan and Prowse, 2014), and pension system restructuring (Laun and Wallenius, 2013).[1] Apart from debates fueled by the Great Recession, the imminent retirement of baby-boomer cohorts calls for fundamental reforms of old age security in most welfare states in the near future. Thus, evaluations on different pension reforms are highly relevant when discussing future pension policy design.

The German case is an excellent example. Until the late 1970s, the German pay-as-you-go (PAYG) system was expanded, becoming one of the world's most generous programs, both in terms of replacement rates and early retirement provisions. Population aging, German reunification, and high unemployment rates since the late 1970s, however, caused a rising fiscal imbalance. Since the early 1990s, the eligibility age has been increased, replacement rates have been lowered, and subsidies stimulating private old-age provisions have been introduced (e.g. Bönke et al., 2010). These reforms have direct implications for the financial situation of Germany's current and future pensioners. They alter the legal framework under which individual labor supply, retirement, savings, and fertility decisions are made (e.g. Börsch-Supan, 2000; Blundell, 2002). The effects are vast as statutory pensions account for about 85% of the average household disposable income for the elderly population (Börsch-Supan and Reil-Held, 2001). While many of these reforms have been undertaken in other countries in a similar fashion, some reforms are not yet fully investigated and deserve further attention.

This study scrutinizes disincentives that lead to permanent pension deductions and increase with the distance between the actual/early and normal retirement age. Since individuals still have a (limited) choice, disincentives differ from indiscriminating pension cuts or raising the legal eligibility age for early retirement. Further, from a theoretical perspective, Diamond and Mirrless (1978) find similar reforms to reduce moral hazard problems in the pension scheme. We contribute to the existing literature with an analysis of both actual and potential behavior to provide a detailed overview on effects of retirement disincentives. At this, we contrast positive effects on public finances to negative effects on affected individuals. To provide comprehensive evidence on disincentives in general, we model a broad range of disincentive levels. This range includes pension deductions of 0.3% per month

[1] A broad overview of select reforms is provided by Gruber and Wise (2007).

of early retirement, which were actually introduced through a major pension reform in Germany in 1992 (Hanel, 2010; Lüthen, 2015). We analyze to what extent disincentives are able to steer retirement behavior and provide evidence on distributional, individual welfare and fiscal implications of reducing pensions for early retirees. Typically for pension reforms, the institutional changes were phased in, impacting birth cohorts to different degrees. Thus, evaluation is not trivial due to the lack of intra-cohort variation. We incorporate comprehensive dynamic incentives of labor market participation and retirement behavior by estimating a structural dynamic retirement model (e. g. Rust and Phelan, 1997; Gustman and Steinmeier, 2015). Then, we model forward-looking agents who consider option values of possible retirement decisions and, thus, recognize the impact of their choices on the accumulation of pension wealth and future consumption possibilities.

Retirement disincentives give individuals the choice to retire within a certain time period at the cost of actuarial adjustments. When modeling retirement behavior, dynamic incentives are particularly relevant because individuals account for the entire future stream of pension benefits (Coile and Gruber, 2007). For an accurate estimation, we model the German tax and social security system in great detail and utilize high quality German administrative pension data. This enables us to disentangle other changes in the tax and pension system from the introduction of the disincentives, which induce cohort specific dynamic incentives. The inter-cohort variation in dynamic incentives helps identifying the structural parameters of our retirement model (e.g. Manoli et al., 2014). Then, based on the estimated parameters, we simulate a variety of economic outcomes for a number of counterfactual scenarios with changing levels of retirement disincentives.

For working males and the disincentive level of the 1992 reform, we find a retirement entry delay of 5.5 months. Increasing the disincentives causes further delay; a tripling of the 1992 disincentive level encourages most individuals to completely abandon early retirement. We also find disincentives to increase inequality in expected consumption, to cause individual welfare losses, and to lead to positive net public returns. All three outcomes increase with the disincentive level, although with diminishing marginal returns. The welfare losses are heterogeneously spread across the earnings distribution and greatest for medium income earners. Still, at each disincentive level, the net public returns are more than five times as high as monetarized individual welfare losses. Further, depending on disincentive level, net public returns can correspond to up to 16% of total pension expenditure per individual. It follows that early retirement disincentives are able to substantially increase the pension system's financial stability. Comparing disincentives to indiscriminating pension cuts, we find that at similar levels of net public returns, pension cuts result in individual welfare losses that are more than twice as high.

The remainder of the article is structured as follows. The next section describes the institutional setting in Germany and the data. Section 3 illustrates the conceptual framework. The core of the paper is Section 4, where we present our estimation results and conduct a policy analysis. Section 5 concludes.

## 2 Institutional setting and data

### 2.1 German pension scheme

The German statutory pension system is a pay-as-you-go system of Bismarckian variety. The great majority of employees is mandatorily insured, contributing a percentage of their income up to a contribution ceiling based on their gross wage. For their contributions, the insurants acquire pension entitlements in form of earnings (or remuneration) points. Earnings points are calculated as ratio of employee's wage to average wage. Hence, the number of earnings points corresponds to one (per year) if the employee's yearly wage corresponds to the average yearly wage. Over their working life employees accumulate earnings points until retirement. At retirement the individual pension level is calculated on the basis of these accumulated earnings points ($EP$). Thus, the pension level mirrors the length of the working life and the average position in the earnings distribution. The *pension formula* (§ 64, Sozialgesetzbuch VI) provides the details on how to calculate the monthly pension $p_{n,t}$ for individual $n$: [2]

$$p_{n,t} = A_t \cdot RA_n \cdot Z_n \cdot EP_n$$

where $A_t$ corresponds to the *pension value*. Basically, the pension value is the amount of money that is multiplied with the sum of earnings points $EP$ to calculate the monthly pension. The value is adjusted every calendar year (for an overview see Table 2 below). $RA$ represents the pension type, which is 1 for old-age pensions. The factor $Z$ is introduced by the 1992 reform to reflect the retirement age and the deductions due to early retirement: $Z = (1 - deduction)$.

The pension scheme offers various retirement possibilities depending on the retiree's individual situation. We focus on agents who have a choice between continuing to work and retirement, therefore abstracting from previously unemployed or disabled individuals. The individuals considered are able to claim the *normal old-age pension* at age 65 or the *pension for long-term insured* after age

[2] Appendix A1 provides an overview on key institutional figures. For further details on the calculation of pensions in Germany see Lüthen (2015).

63, which is conditioned on having spent at least 35 years in the pension system.[3] Retiring before age 65 is viewed as early retirement. Women are excluded due to their diverging pension prospects and the low number of cases when conditioning on similar early retirement eligibility. In sum, we concentrate on men with a strong labor market attachment who are eligible to retire at age 63, even if they choose to work longer.

## 2.2 Introduction of early retirement disincentives

In 1992, Germany introduced a major pension reform to equalize different retirement ages monetarily. The aim was to balance the pension wealth of early retirees and normal retirees. However, the budget relief was also needed to ensure stable contribution rates (e.g. Schmähl, 2011). Since early retirees have a prolonged benefit period, one possibility was to reduce their pension wealth. Therefore, the reform implemented permanent pension deductions of 0.3% per month of early retirement. The deduction level results from the distance (in month times 0.3%) between the actual retirement age and normal retirement age of 65.[4] Still, all cohorts were allowed to retire at 63. The deductions were gradually phased in for the 1937 and 1938 cohorts, then fully affecting those born thereafter. At this, the maximum deduction starts at 0.3% for those born in January 1937 and increases by 0.3 % points per month of birth up to 7.2% for cohorts born after 1938. Thus, the individuals born during the phase-in are only partially affected by the reform. Table 1 provides an overview and exemplary date of birth examples.

Table 1: Phase-in of disincentives

| Date of birth | Retirement age without deductions | Maximal deduction (month) | Maximal deduction (share) |
|---|---|---|---|
| Before 1937 | 63 | 0 | 0% |
| January 1937 | 63+1 month | 1 | 0.3% |
| June 1937 | 63+6 month | 6 | 1.8% |
| January 1938 | 64+1 month | 13 | 3.9% |
| June 1938 | 64+6 month | 19 | 5.7% |
| After 1938 | 65 | 24 | 7.2% |

Note: The maximal deduction (share) determines the age factor $Z$ in the pension formula. Source: SUFVSKT2002, 2004-12.

[3] We disregard individuals claiming old-age pensions for previously unemployed or disabled persons. These can be claimed at age 60 under different eligibility criteria like time spend in the pension system. These “waiting periods” consist of periods of contributions, wage replacement benefits (unemployment, sick-pay, invalidity), child-raising and times of education. A detailed overview on eligibility and pension types is provided in Lüthen (2015).

[4] See Lüthen (2015) for further details. The reform also introduces a pension bonus of 0.5 % per month retiring after 65, but this affects only a negligible amount of individuals. Due to dominance of collective bargaining for cohorts considered, most contracts force workers to retire at 65.

## 2.3 Data

To calculate pension entitlements as described above, the pension insurance collects information on all contributors' earnings biographies. The dataset we use, the Insurance Account Sample (*Versicherungskontenstichprobe*, VSKT), is a stratified random sample of these records. Each wave contains information on individuals aged between 30 and 67 in the reference year.[5] From age 14 through age 65, the VSKT provides a monthly history of employment, unemployment, sickness, and earnings points. The latter are used to compute monthly gross earnings. The total sum of earnings points provides the foundation for calculating gross pensions. To obtain net incomes, we subtract taxes and social security contributions. We account for all regulations and changes affecting monthly disposable income and pensions. An additional scenario that implements the regulations of the first year considered in this study, 1998, for all later years is also estimated. This allows the disentanglement of other changes in the tax and pension system from changes induced by the disincentives. For further details, see Figure 2 and Appendix A.

To ensure early retirement eligibility, we restrict the sample to those who have spent at least 35 years in the pension system before turning 63. This also ensures that the sample does not include individuals with substantial labor market earnings unnoticed by the Federal Pension Insurance (i.e. self-employed, civil servants, or long-term emigrants). Further, we exclude individuals who have worked in the German Democratic Republic (GDR; the former East Germany). For the cohorts considered, neither the labor market situation nor working life is comparable to the West German context.[6] The final sample contains 945 individuals (Table 2).

While German social security data records earnings very accurately, one major drawback is the top coding of earnings information at the contribution ceiling. For a better approximation of true distribution of earnings above the ceiling, we impute earnings of all individuals affected by top coding. The imputation method is based on the assumption of Pareto-distributed earnings in the upper tail of the distribution.[7] Further, the VSKT lacks information on other income sources, wealth or household context. A comparison with survey data reveals that these limitations are not harmful. The considered

[5] We use the scientific use files for on-site-use (waves SUFVSKT2002 and SUFVSKT2004 to SUFVSKT2012), provided to researchers by the Data Research Center of the German Federal Pension Insurance. We use all 10 waves in our analysis (see Appendix B for further information).
[6] West-East migration only affects an empirically negligible share of the population (Schündeln and Schündeln, 2009).
[7] Bönke et al. (2015) provide a detailed description of the imputation procedure in Online Appendix III.3. They find that, on average, top coding affects 7 % of all West German men in the VSKT.

group of individuals receives income almost exclusively from statutory pensions and wages.[8] This income also accounts on average for more than 90% of their total household income (Table A4). Nearly 80% are married. Accordingly, we assume a married single-earner household and joint taxation. For robustness, we also calculate a scenario assuming only single households (Tables B1 and B2). Our results are robust to this assumption.

Table 2 provides key descriptives of the sample. Column 1 shows that the observed average retirement entry age increases by about 8 months across cohorts. Column 2 reveals declining average pensions in real terms, although pension entitlements remain stable across cohorts (column 3). Columns 4 and 5 add further insights to this development by showing the pension value and the average amount of disincentives. At age 65, the pension value slightly increases up to cohort 1937 and then decreases for later cohorts (calendar years 2000-2010).[9] The column "disincentives" gives the average deduction on the monthly pension realized by each cohort. For fully affected cohorts, the average deduction fluctuates between 2.6% and 4.3%. All changes are accounted for when modeling the institutional background.

Table 2: Sample descriptives

| Cohort | Entry age | Monthly pension | Earnings points | Pension value at age 65 | Disincentives in % | Number of observations |
|---|---|---|---|---|---|---|
| 1935 | 63.55 | 1680.97 | 57.73 | 28.91 | 0.00 | 53 |
| 1936 | 63.67 | 1660.76 | 55.98 | 28.71 | 0.00 | 43 |
| 1937 | 63.61 | 1636.40 | 55.72 | 29.18 | 1.06 | 50 |
| 1938 | 63.75 | 1565.26 | 54.42 | 29.03 | 3.70 | 72 |
| 1939 | 63.89 | 1607.84 | 56.33 | 28.70 | 4.28 | 84 |
| 1940 | 64.03 | 1558.46 | 54.84 | 28.27 | 3.77 | 93 |
| 1941 | 64.06 | 1564.30 | 55.85 | 27.83 | 3.69 | 77 |
| 1942 | 64.32 | 1580.62 | 56.08 | 27.28 | 2.67 | 95 |
| 1943 | 64.36 | 1574.17 | 55.01 | 26.81 | 2.56 | 122 |
| 1944 | 64.31 | 1555.39 | 54.57 | 27.18 | 2.73 | 115 |
| 1945 | 64.23 | 1562.70 | 55.82 | 27.20 | 3.08 | 141 |

Note: The average pensions and the pension values are in 2010 Euro values. The numbers of observations represent the final sample. Source: SUFVSKT2002, 2004-12, Deutsche Rentenversicherung (2014), (own calculations).

[8] Tables A3 and A4 provide information on the relevance of different income sources and marital status. For the overall population, Bönke et al. (2015) document that the VSKT represents about 80% of the total male labor force in West Germany and that its cross-sectional earnings distributions are similar to those found in survey data.

[9] Figure 1 and Appendix A provide estimations on the effect of these changes.

# 3 Model and estimation

## 3.1 Dynamic retirement model

In the following we introduce our theoretical framework step by step. The model aims to explain retirement behavior in a time frame of 24 months, namely between age 63 and age 65. Still, implications for future years spent in retirement are also accounted for and correspond to individuals' particular choices. We rely on a theoretical framework where agents' utility in period $t$ depends on consumption $c$ and disutility of labor $l$. The total number $N$ of individuals is indexed by $n$. Discrete time is measured in months $t$, running up to age 100 (period $T$). Then, $t$ also expresses individual age, where $t = 0$ corresponds to the month an agent turns 63. Consumption in $t$ for individual $n$ equals net income flow from earnings, pensions or social security transfers, and disutility of labor depends on working or not in $t$. Agent $n$'s utility in month $t$ is then:

$$u(c_{nt}, l_{nt}) \quad (1)$$

Further, we assume risk averse agents. Current and future consumption possibilities in month $t$ depend on earnings biography and choices until the current period, whereas disutility of labor is allowed to vary in age $t$. Equation (1) becomes:

$$u(c(\boldsymbol{s}_{nt}, d_{nt}), l(d_{nt}, t_n)) \quad (2)$$

where $\boldsymbol{s}_{nt}$ denotes a vector of state variables (age, birth cohort, accumulated pension points, gross wage, and previous period's choice) and $d_{nt} \in \{0,1\}$ is a dummy variable indicating the retirement choice. Hence, $c(\boldsymbol{s}_{nt}, d_{nt})$ denotes the level of consumption associated with state $\boldsymbol{s}_{nt}$ and choice $d_{nt}$. Due to our short time frame of two years, we abstract from private savings. Thus, individual disposable income corresponds to consumption in the respective period.[10] Disutility of labor $l(d_{nt}, t_n)$ is both a function of $d_{nt}$ (since there is no more disutility of labor after retirement) and age $t_n$. For the explicit form, we assume a time separable random utility model representing individual preferences that satisfy our assumptions on consumption and disutility of labor:

[10] Before retirement, individuals earn a gross wage. In case of early retirement, some monthly wages between ages 63 and 65 are unobserved. We impute the counterfactual wage relying on the last real wage observed in the respective month of the previous year. This corresponds to the wage observed 12 or 24 month before the imputation. This accounts for monthly wage volatility.

(3) $$u(c_{nt}, l_{nt}) = \alpha \frac{c(\boldsymbol{s}_{nt}, d_{nt})^{(1-\rho)} - 1}{(1-\rho)} + l(d_{nt}, t_n) + \epsilon_{nt}(d_{nt})$$

We assume the random component $\epsilon_{nt}(d_{nt})$ to be type 1 extreme value distributed. The random component represents individual utility shocks not observed by the researcher. $\rho$ depicts the coefficient of relative risk aversion and $\alpha$ a consumption weight. To allow the disutility of labor to vary in age, age enters $l(d_{nt}, t_n)$ as a linear spline function. The function is allowed to change the slope every three months of age to ensure a flexible specification:

(4) $$l(d_{nt}, t_n) = \delta_1[1 - d_{nt}] + [1 - d_{nt}] \begin{Bmatrix} & \delta_2\, min(t\ \ ,3) & if\ t > 0 \\ + & \delta_3\, min(t - \ 3,3) & if\ t > 3 \\ + & \delta_4\, min(t - \ 6,3) & if\ t > 6 \\ \vdots & \vdots & \vdots \\ + & \delta_9\, min(t - \ 21,3) & if\ t > 21 \end{Bmatrix}$$

When timing retirement decisions, agents are forward looking and maximize their expected lifetime utility according to their preferences constrained by the institutional setting. Here, for each month between ages 63 and 65, agents decide between continuing to work or retirement. When continuing to work, utility stems from consumption only, but individuals experience disutility of labor. After retirement, agents receive utility from consumption only. In line with the rules and regulations of the pension system, working individuals accumulate pension claims proportional to real wages. This creates dynamic incentives for individuals taken into account by the dynamic choice framework. Retirement is an absorbing state and agents are not allowed to return to work, making utility maximization an optimal stopping problem. Earliest possible retirement choice is at $t = 1$ in the month following the 63rd birthday, latest possible early retirement decision is at age 64, month 12 ($t = 24$). Each month $t$, individual $n$ observes state variables $\boldsymbol{s}_{nt}$ and makes retirement choice $d_{nt}$ to maximize expected lifetime utility $E$. We define $D(\boldsymbol{s}_{nt})$ to be the choice set available to individual $n$ in period $t$ and to contain the choice between employment and retirement:

(5) $$\max_{d_{nt} \in D(s_{nt})} E\left[\sum_{j=0}^{T-t} \theta_{bt+j}\, \beta^j u\big(c_{nt+j}, l_{nt+j}\big)\right]$$

with $\beta$ denoting a monthly subjective time discount factor, which we derive from a yearly discount factor of 0.96 (Gourinchas and Parker, 2002). To accommodate our monthly setting, we implement $\beta = \sqrt[12]{0.96}$ . $\theta_{bt+j}$ indicates individual probabilities of being alive in period $t + j$, conditional on survival until period $t$ and belonging to cohort $b$. Cohort specific mortality rates ensure a realistic setup and also help identifying parameters in the estimation procedure by inducing cohort-specific heterogeneity in dynamic incentives.[11]

We further define a Markov transition function $q(\boldsymbol{s}_{nt+1}|\boldsymbol{s}_{nt}, d_{nt})$ to capture individual beliefs about future states. Since $\boldsymbol{s}_{nt+1}$ evolves from state variables and agents are assumed to have perfect foresight about future states, $q(\boldsymbol{s}_{nt+1}|\boldsymbol{s}_{nt}, d_{nt})$ is a deterministic function. The only function not evolving deterministically is the utility shock $\epsilon_{nt}(d_{nt})$, which is not regarded as a state variable. Therefore, agents' maximization problem corresponds to the following value function $v(\boldsymbol{s}_{nt})$:

$$v_t(\boldsymbol{s}_{nt}) = \max_{d_{nt} \in D(\boldsymbol{s}_{nt})} \Bigg\{ u(c_{nt}, l_{nt}) + \theta_{bt+1}\beta \int_{\epsilon} \Bigg[ \sum_{S(\boldsymbol{s}_{nt})} v(\boldsymbol{s}_{nt+1}) q(\boldsymbol{s}_{nt+1}|\boldsymbol{s}_{nt}, d_{nt}) \Bigg] g(\boldsymbol{\epsilon}_{nt+1}) \Bigg\} \quad (6)$$

where $g(\cdot)$ represents a multivariate probability density function of the random components. $S(\boldsymbol{s}_{nt})$ contains all possible different states in $t+1$ given state $\boldsymbol{s}_{nt}$. The difference in the expected discounted future utility between working and not working reflects option values of respective choices.

## 3.2 Choice probabilities and estimation

This section features the model estimation. Given the finite horizon of the individuals' optimization problem, it can be solved recursively. Starting point is the expected value function $V(\cdot)$ for particular choice options in the last period $T$. $V(\cdot)$ needs to be computed for all possible choices. In the last period $T$, it corresponds to

$$V(\boldsymbol{s}_{nT}, d_{nT}) = E[u(c_{nT}, l_{nT})] \quad (7)$$

By Bellman's principle of optimality, the individual's optimization problem can be written as a two-period problem for all other time periods $t$, which take into account the optimal decision for $t+1$. Due to the type 1 extreme value distribution of utility shock $\epsilon_{nt}(d_{nt})$, the expected value function has a closed form solution (Rust, 1987):

[11] To account for increasing life expectancy, we use official mortality tables supplying cohort-specific projections (Statistisches Bundesamt, 2006).

$$V(\boldsymbol{s}_{nt}, d_{nt}) = E[u(c_{nt}, l_{nt})]$$

(8)
$$+\theta_{bt+1}\beta \sum_{\boldsymbol{s}_{nt+1}} \log\left\{ \sum_{d_{nt+1}\in D(\boldsymbol{s}_{nt+1})} exp\big(V(\boldsymbol{s}_{nt+1}, d_{nt+1})\big)\right\} q(\boldsymbol{s}_{nt+1}|\boldsymbol{s}_{nt}, d_{nt})$$

Computation of expected value functions between mandatory retirement (age 65) and $T$ is comparatively simple as individual choices are limited until age 65. Thereafter, real net income streams remain constant. Rust (1987) shows that when assuming additive separability and conditional independence of utility shocks, conditional choice probabilities have a closed form solution (here mixed logit probabilities):

(9)
$$Prob(d_{nt}|\boldsymbol{s}_{nt}) = \frac{exp\big(V(\boldsymbol{s}_{nt}, d_{nt})\big)}{\sum_{j\in D(\boldsymbol{s}_{nt})} exp\big(V(\boldsymbol{s}_{nt}, j)\big)}$$

The model is estimated by maximum likelihood. The log-likelihood function of the sample is given by

(10)
$$\sum_{n=1}^{N}\sum_{t=1}^{T} \log\left\{\sum_{d_{nt}} Prob(d_{nt}|\boldsymbol{s}_{nt}, \boldsymbol{\lambda}) \times I(d_{nt})\right\}$$

with $I(d_{nt})$ indicating the individual choice observed in period $t$ and the vector $\boldsymbol{\lambda} = (\alpha, \rho, \delta_1, .., \delta_9)$ containing all parameters of the utility function. The likelihood contributions then correspond to the respective conditional choice probabilities, abstracting from random transitions of state variables. For robustness, we also estimate a model specification allowing for unobserved heterogeneity in $\delta_1$ (Heckman and Singer, 1984). We further include a robustness test where unobserved types are modeled as a function of lifetime earnings until age 63 to account for a possible correlation between leisure preferences and employment history (Wooldridge, 2005). Still, neither the central preference parameter $\rho$ nor any of our postestimation outcomes are sensitive to these extensions.[12]

## 3.3 Parameter estimates and model fit

An overview on parameter estimates is displayed in Table 4. Our estimate of the relative risk aversion, $\rho = 1.5$, is in line with previous studies (see e.g. Chetty, 2006), although our identification is based on retirement choices only. The estimates of the spline function $l(\cdot)$ indicate the results typically found in the literate: a spiking retirement hazard at early eligibility and normal retirement age that cannot

[12]Although we can identify two types, the second type is estimated to make up only a small fraction of the population and precision of the respective type-specific parameter is low. Initial conditions exert no significant effect on type probabilities. See Appendix B for results and details on the estimation.

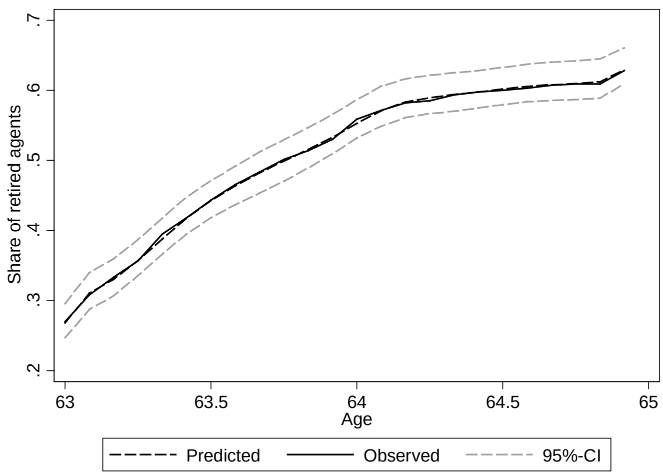
be explained entirely by incentives but rather mirrors institutional constraints (e.g. Coile and Gruber, 2007). Here, this is reflected by the high negative estimate for $\delta_1$ (mitigated by $\delta_2$ when continuing to work) and the high positive estimate for $\delta_9$. All estimates are independent of their starting values and the small standard errors indicate precise estimation. In the following, confidence intervals of postestimates are computed by applying a parametric bootstrapping method. Based on the inverse of the Hessian of the log-likelihood function, the procedure relies on 200 draws from the asymptotic sampling distribution of the estimated model parameters. Figure 1 compares predicted and observed shares of retirees by age and shows a very good internal validity.

Table 3: Parameter estimates

| | | | | | |
|---|---|---|---|---|---|
| $\alpha$ | 0.215 | $\delta_3$ | -0.164 | $\delta_7$ | 0.255 |
| | (0.0241) | | (0.0665) | | (0.1281) |
| $\rho$ | 1.506 | $\delta_4$ | 0.032 | $\delta_8$ | -0.232 |
| | (0.0716) | | (0.0647) | | (0.1411) |
| $\delta_1$ | -3.015 | $\delta_5$ | 0.080 | $\delta_9$ | 1.212 |
| | (0.2476) | | (0.0733) | | (0.1343) |
| $\delta_2$ | 1.057 | $\delta_6$ | -0.261 | | |
| | (0.1182) | | (0.0916) | | |
| Log-likelihood | -1942.31 | | | | |

Note: Standard errors in parenthesis.

Figure 1: Comparison of predicted and observed shares of retirees




Source: SUFVSKT2002, 2004-12

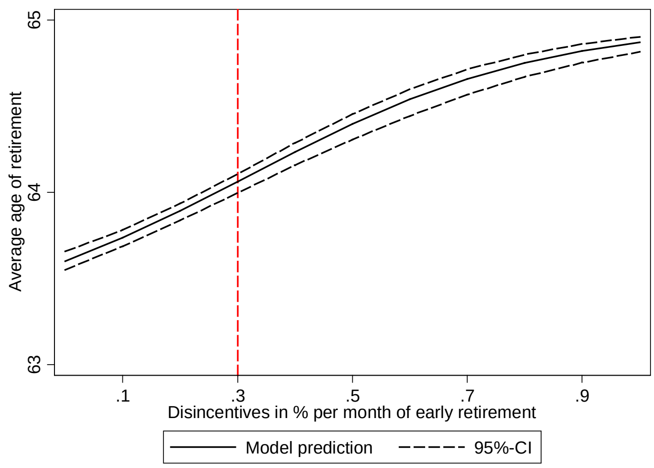
## 4 Results and policy analysis

To analyze the economic effects of retirement disincentives in general, we simulate scenarios for different disincentive levels. Those levels range from 0% to 1% per month of early retirement. We set the distance between each disincentive level to 0.1%, resulting in 10 counterfactual scenarios. Unless stated otherwise, the results are based on cohorts 1939 to 1945 which are fully affected by the 1992 reform. This ensures meaningful comparisons among counterfactual scenarios. We present predominantly graphical results; the actually implemented disincentive level of 0.3% per month is marked with a vertical dashed line. In sum, this section sheds light on the "dose-response" relationship between disincentive level and outcome measure and still includes a full analysis of the 1992 reform.

## A. Labor market effects

Here we look at the effects of disincentives on labor market exit timing. Figure 2 displays a concave relationship between average retirement age and disincentive level. This suggests that disincentives can be used to steer retirement behavior. While low disincentive levels lead to small postponements in retirement, high levels induce most individuals to retire at age 65 such that hardly any penalties are actually realized ("prohibitive effect"). The actually implemented level causes a postponement of about 5.5 months, whereas the highest disincentive level would have delayed retirement by about 15 months.

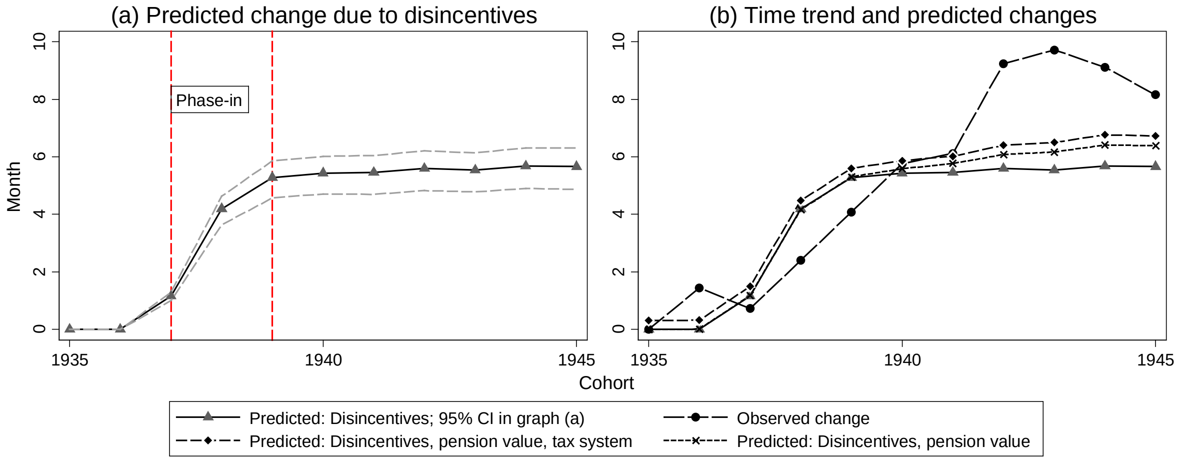
Figure 2: Expected retirement age by disincentive level




Source: SUFVSKT2002, 2004-12

To look more closely at the labor market effect, Figure 3 provides changes in expected retirement age by birth cohort. We focus on the 0.3%-disincentive level introduced by the 1992 reform and show how much of the cohorts' retirement postponement can be attributed to the reform. Panel (a) displays predicted changes due to the introduction of disincentives. Panel (b) additionally shows observed changes from cohorts 1935 to 1945 as well as predicted changes attributed to disincentives, the pension value and the tax system. Panel (a) indicates that the disincentives delay average retirement entries by 5.5 months. This finding is stable across the fully affected 1939 to 1945 cohorts. We identify smaller effects for cohorts 1937 and 1938, which were affected by the reform's phase-in. Comparing observed entries and predictions across cohorts, the introduction of disincentives explains 68% of the observed change in retirement patterns. Panel (b) demonstrates that changes in tax system and pension value delay retirement by an additional month. In total, the model explains about 80% of the average increase in retirement age between the 1935 and 1945 cohorts. This total predicted change relies on a counterfactual where tax and pension legislation from 1998 hold for all agents. This mirrors the institutional setting of agents born in 1935 at age 63, which is the point of their first decision about early retirement.

Figure 3: Reform effects on expected retirement age by birth cohort




Source: SUFVSKT2002, 2004-12

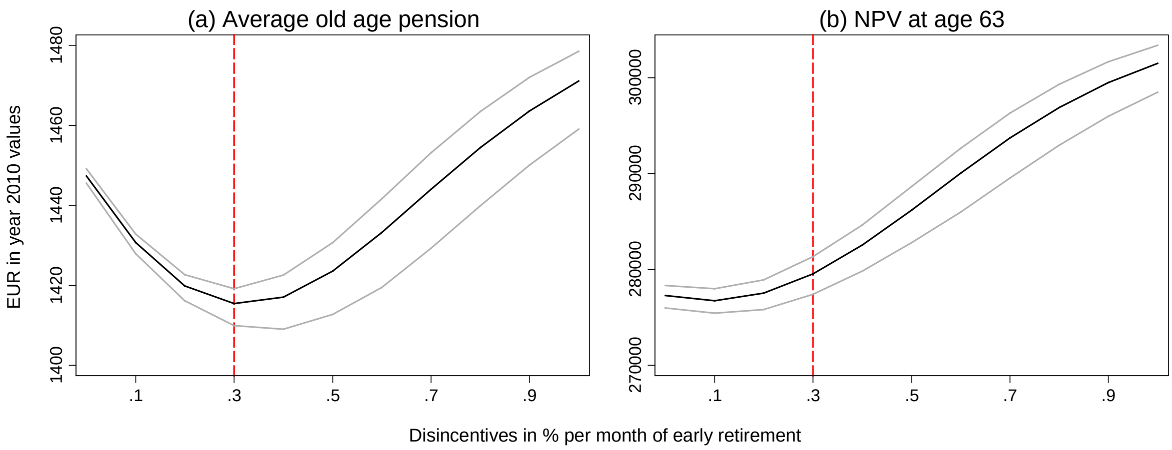
## B. Financial implications

Here we analyze disincentive effects on pension level and NPVs of remaining lifetime consumption.[13] The individual pension level is affected by two countervailing effects induced by the reform. First, early retirement entails a penalty on pension benefits. Second, individuals delay exiting the labor market and receive labor earnings for a longer period of time (notice that wages exceed pension benefits in most cases). More contributions then translate into higher pension claims. Thus, the behavioral effect of delayed retirement is able to counteract the disincentive effect at some point. With that in mind, it is not surprising that Figure 4 shows a u-shaped relationship between pension and disincentive level. The actually implemented disincentive level of 0.3% per month yields the lowest average pension — both reducing and enhancing the disincentive level increases average retirement income. When decreasing the disincentive level, the behavioral reactions are small but pensions still rise. When

[13] The NPV constitutes the sum of the discounted expected consumption stream at age 63.

increasing, the behavioral effect outweighs the penalty effect and pensions increase. For the actually implemented level of the 1992 reform, we find that pensions decrease by €32 per month. Put another way, the average individual loses a bit more than the equivalent of one year of average pension entitlements (i.e. one earnings point). Figure 6 also shows a similar relationship between disincentive level and remaining lifetime consumption. Interestingly, the lowest NPV realized is associated with a disincentive level of 0.1%. At a level of 0.2%, the increases in labor market earnings start to outweigh the decreases in pension level.

Figure 4: NPVs of expected consumption and retirement income by disincentive level




Note: Euro in 2010 real values. Source: SUFVSKT2002, 2004-12

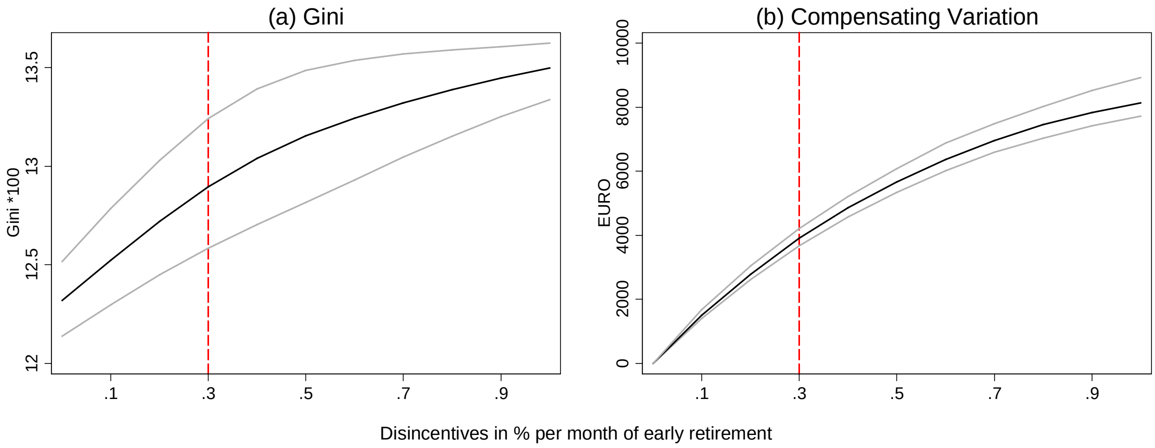
## C. Individual welfare effects

Figures 5 displays potential costs associated with the considered range of disincentive levels. Panel (a) provides estimates on increasing inequality in remaining lifetime consumption (Gini coefficient). Without disincentives retirement behavior is more heterogeneous, which offsets some initial inequalities in pension claims at age 63. Panel (b) assesses expected individual welfare losses (compensating variations, CV). [14] The variations refer to NPVs at age 63 that are annuitized over the remaining lifetime. Obviously, individuals who would have worked until age 65 even without disincentives are unaffected. The estimates provide quantifications for the average decline in individual welfare and further allow a disaggregated analysis of individual welfare losses along the income distribution.

[14] A compensating variation (CV) indicates the amount of money that an individual would have to receive at age 63 to be fully compensated for a particular reform. Here, to compute CVs, we employ an iterative algorithm targeting the expected remaining lifetime utilities at age 63 without retirement disincentives. The algorithm converges when the differences in individuals' expected utilities under both scenarios (disincentives and no disincentives) are very small. The payment is then annuitized over the remaining lifespan.

Both Gini and CV show a concave relationship to the level of disincentives. Increases at low disincentives levels cause large increases in Gini and CV. Increases at higher disincentive levels have smaller effects since at high disincentive levels, the average retirement age is close to 65 already (see Figure 2). We find that the relationship flattens out around a disincentive level of 0.7%. For the highest considered disincentive level, the overall effects amount to twice the effects attributed to the actually implemented reform (vertical dashed line) – a 10% increase in the Gini and a CV of about €8000.

Figure 5: Gini and CVs by disincetive level

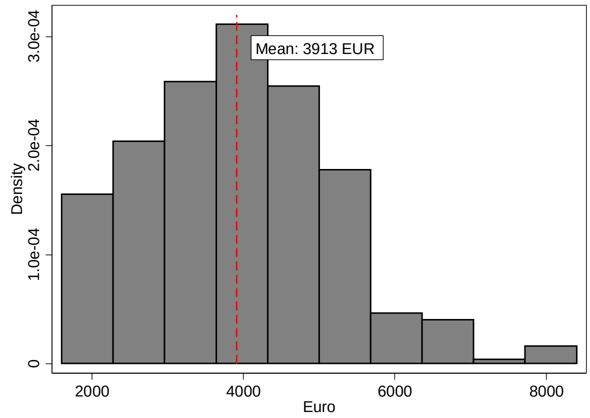



Note: Euro in 2010 real values. Source: SUFVSKT2002, 2004-12

For a detailed analysis, we again focus on the 0.3% disincentive level implemented by the 1992 reform. Figure 6 concentrates on the CV and reveals that individual welfare losses are heterogeneously distributed in the sample population, ranging from negligible amounts up to almost €9,000. This complicates compensation through e.g. saving subsidies because such a scheme may not allow for the targeting of individuals according to their specific losses.[15] Figure 7 shows a non-parametric regression of estimated compensating variations on NPVs of expected consumption. The results suggest that medium income earners lose most through the introduction of retirement disincentives. This is driven by earnings-level heterogeneity in the expected retirement age. Low and high income individuals tend to retire closer to age 65 regardless, which is due to low pension claims and high opportunity costs of retirement, respectively.

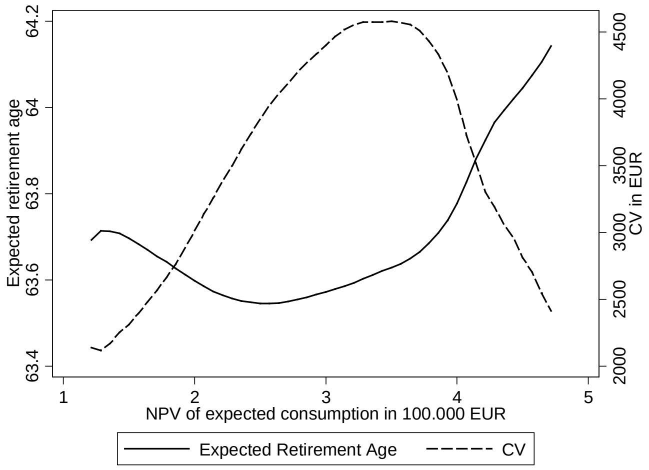
[15] Indeed, in 2002 Germany introduced subsidies for private pension plans to compensate employees for lower levels of expected PAYG-pensions due to various reforms. For a distributional analysis and further details see Corneo et al. (2015).

Figure 6: Distribution of compensating variations




Note: Euro in 2010 real values. Source: SUFVSKT2002, 2004-12

Figure 7: Predicted CVs and expected retirement age by NPVs of consumption




Note: Euro in 2010 real values. Source: SUFVSKT2002, 2004-12

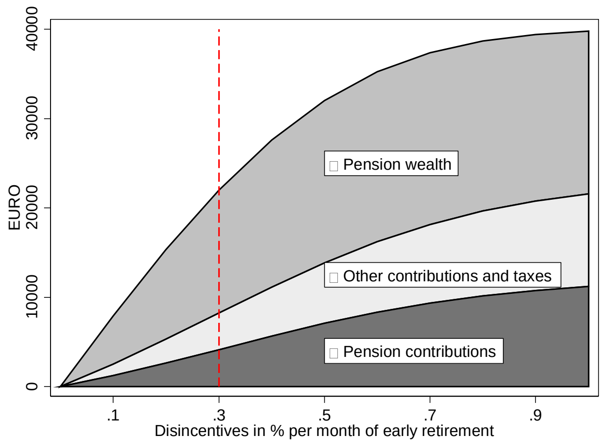
## D. Fiscal implications

Figure 8 displays the (fiscal) benefits of introducing disincentives − the net public returns at varying levels. We again find the relationship to be concave. Although the returns are diminishing, increasing disincentives beyond the implemented level (vertical dashed line) would further foster the pension system's financial sustainability. At each disincentive level, about half of the net public returns are generated by reduced pension wealth, while the remainder is divided into increases in pension contributions and increases in tax payments and other contributions.

The net public returns can be linked to pension expenditures under a no disincentive scenario. This reveals that net public returns correspond to about 9% of average pension wealth under the actually implemented 0.3%-scenario (€ 21,994; vertical dashed line) and to 16% at the 1%-disincentive level. These fiscal implications are substantial. Resorting to aggregate data of the German pension insurance, we find that our sample population corresponds to 424,286 individuals for the 1939 to 1945 cohorts affected by the 1992 reform (Deutsche Rentenversicherung, 2014). We assess that the simulated public returns per capita at the 0.3% disincentive level translate into overall public gains of 424,286 × € 21,994 ≈ € 9.33 billion for these cohorts.

Relating costs (Figure 5) and benefits (Figure 8) demonstrates that this increase in financial stability comes at the cost of increasing inequality and non-negligible individual welfare losses within the population of retirees. Still, at each disincentive level, net public returns are about five times as high average individual welfare losses.

Figure 8: Net public returns by disincetive level

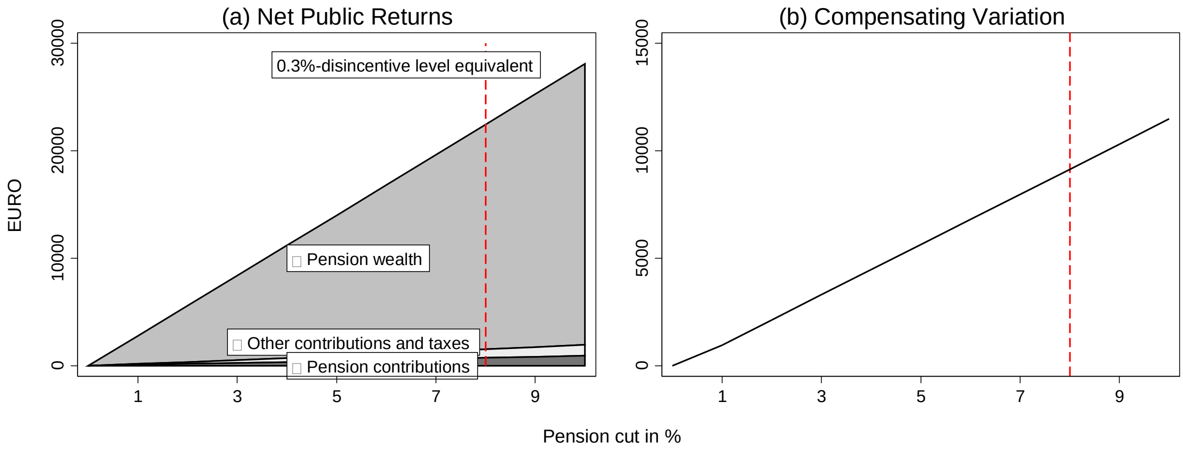



Note: Euro in 2010 real values. Source: SUFVSKT2002, 2004-12

## E. Alternative reforms

To set the welfare losses into perspective, we simulate scenarios where we indiscriminately cut all pensions by a certain amount, ranging from 1% to 10% (Figure 9). It turns out that to yield equal net public returns to introducing a 0.3%-disincentive level, all pensions would have to be lowered by about 8%. However, pension cuts more than double the individual welfare losses. This holds also true for higher levels of net public returns. Since individuals barely adjust their retirement behavior when confronted with a pension cut, nearly all the net public returns stem from decreased pensions: €113 per month instead of €32 under the 0.3% disincentive level. These findings suggest that disincentives realize financial gains at lower individual costs than pension cuts.

Figure 9: Pension cuts – costs and benefits




Note: Euro in 2010 real values. The red line indicates the level of pension cuts that correspond to the net public returns under a 0.3%-disincentive level. Source: SUFVSKT2002, 2004-12, own calculations

## 5 Conclusion

This study evaluates the effectiveness of early retirement disincentives and its distributional, individual welfare and fiscal implications. We focus on disincentives leading to permanent pension deductions that increase with the distance between actual/early and normal retirement age. We model different disincentive levels and analyze to what extent disincentives are able to steer retirement behavior. Our range of disincentive levels includes the level actually implemented by the 1992 pension reform in Germany, which introduced permanent pension deductions of 0.3% per month of early retirement. For the actually implemented level, we estimate an increase in retirement age of 5.5 months. This implies that the reform is responsible for 68% of the observed change in retirement patterns across cohorts. Further simulations demonstrate that tripling the actually implemented level would essentially prevent individuals from opting for early retirement at all. Dose response reveals that disincentives increase inequality in expected consumption, cause individual welfare losses, and lead to positive net public returns. All three show a concave relationship with the disincentive level. The individual welfare losses are largest for medium income earners and difficult to compensate due to their heterogeneous distribution. However, at each disincentive level, the net public returns are more than five times as high as the individual welfare losses. Overall welfare in the economy may increase regardless, given that longer life expectancies and demographic change requires a reform of either the contribution scheme or the level of pension benefits.

Contrary to many public claims, disincentives do not correspond to an indiscriminating pension cut. In fact, at equal levels of net public returns, disincentives cause individual welfare losses that are less than half as large as those under a pension cut. Concerning future implications, Germany introduced various major pension reforms, two of which can be directly related to our results. The first reform increases the normal retirement age to 67 while the early retirement age remains at 63. This increases the disincentives for early retirees. Here, our results suggest that average retirement age increases and average pensions adjust slightly for individuals still employed at 62. The second reform introduces an exception to the rule by abolishing disincentives for pensioners with very long employment histories. According to our results, this will cause a substantial decline in average retirement age for eligible individuals. A more detailed analysis is left for future research.

# Appendix

## Appendix A: Taxation, social security contributions and sample selection

The income from PAYG-pensions and employment constructed from the available information provided in the VSKT is gross. To obtain net incomes, we subtract social security contributions and personal income taxes from gross earnings and pensions. Because the burden of taxes and social security contributions heavily depends on whether being an employee or retiree, a concise overview of the procedure and underlying assumptions to obtain net incomes is provided in subsections A.1 and A.2.

### A.1 Social security contributions

The calculation of social security contributions is straightforward. Regular employees considered in our sample must contribute to the pension, unemployment, health and long term care insurance. Pensioners only have to contribute to the health and long term care insurance. Note that rates for pensioners and regular employees differ. Assessment basis is insurable income up to the respective contribution ceiling. Tables A1 and A2 list the key determinants used for calculating statutory social security contributions for the 1998 to 2011 assessment years. Displayed contribution rates are annual averages. In case of the statutory health insurance, actual contribution rates differ between insurance providers. Our calculation assumes the average contribution rates published by Deutsche Rentenversicherung (2014). Further, employees with earnings above the compulsory insurance exemption limit may opt for a private health insurance instead of the statutory. We disregard this possibility.

Between 1998 and 2011, employees face a joint burden on gross earnings from contributions of roughly 23%, not including the employer's share. Social security contributions are usually almost evenly split between employee and employer. Gross earnings are net of employer's contribution and therefore only the employee's contributions need to be deducted. The burden differs with total remuneration. Low income earners and those receiving incomes above the respective contribution ceilings of the various branches of the social security system are subject to a lower relative burden. Social security contributions are calculated on hypothetical gross annual earnings and then deducted from gross monthly earnings. In contrast to employees, pensioners are subject to a combined average burden of 8 - 10%, which is deducted from the monthly pension.

Table A1: Pension and unemployment insurance

| Year | Average social security income | Contribution ceiling | Contribution rate | |
|---|---|---|---|---|
| | | | Pension insurance | Unemployment insurance |
| 1998 | DM 52925 | DM 100800 | 10.15 | 3.25 |
| 1999 | DM 53507 | DM 102000 | 9.85 | 3.25 |
| 2000 | DM 54256 | DM 103200 | 9.65 | 3.25 |
| 2001 | DM 55216 | DM 104400 | 9.55 | 3.25 |
| 2002 | € 28626 | € 54000 | 9.55 | 3.25 |
| 2003 | € 28938 | € 61200 | 9.75 | 3.25 |
| 2004 | € 29060 | € 61800 | 9.75 | 3.25 |
| 2005 | € 29202 | € 62400 | 9.75 | 3.25 |
| 2006 | € 29494 | € 63000 | 9.75 | 3.25 |
| 2007 | € 29951 | € 63000 | 9.95 | 2.1 |
| 2008 | € 30625 | € 63600 | 9.95 | 1.65 |
| 2009 | € 30506 | € 64800 | 9.95 | 1.4 |
| 2010 | € 31144 | € 66000 | 9.95 | 1.4 |
| 2011 | € 32100 | € 66000 | 9.95 | 1.5 |

Note: Values until 2001 in DM and in Euro thereafter. One Euro corresponds to 1.95583 DM. Contribution rates are annual averages for employees, contributions for employers differ slightly. Pensioners are not subject to pension or unemployment insurance contributions. Source: Deutsche Rentenversicherung (2014) (own calculations).

Table A2: Health and long-term care insurance

| Year | Contribution ceiling | Contribution rate | | |
|---|---|---|---|---|
| | | Health insurance – employees | Long-term care insurance – employees | Health and long term care insurance – pensioners |
| 1998 | DM 75600 | 6.8 | 7.575 | 0.85 |
| 1999 | DM 76500 | 6.8 | 7.6253 | 0.85 |
| 2000 | DM 77400 | 6.8 | 7.6 | 0.85 |
| 2001 | DM 78300 | 6.8 | 7.6 | 0.85 |
| 2002 | € 40500 | 7 | 7.725 | 0.85 |
| 2003 | € 41400 | 7.2 | 7.925 | 0.85 |
| 2004 | € 41856 | 7.2 | 8.27505 | 0.85 |
| 2005 | € 42300 | 8 | 9.05 | 1.1 |
| 2006 | € 42756 | 7.4 | 9.25 | 1.1 |
| 2007 | € 42756 | 7.7 | 9.4 | 1.1 |
| 2008 | € 43200 | 7.8 | 9.7 | 1.1 |
| 2009 | € 44100 | 7.9 | 10 | 1.225 |
| 2010 | € 45000 | 7.9 | 9.85 | 1.225 |
| 2011 | € 44550 | 8.2 | 10.15 | 1.225 |

Note: Values until 2001 in DM and in Euro thereafter. One Euro corresponds to 1.95583 DM. Contribution rates are annual averages for employees/pensioners, contribution rates for employers/pensions insurance differ slightly. Source: Deutsche Rentenversicherung (2014) (own calculations).

## A.2 Personal income tax

In Germany, personal income tax depends on several characteristics of the tax unit not available in our data. For our calculation we assume that all taxable income solely stems either from employment and/or PAYG pensions. Other sources of income are not recorded in our data. In Table A3 and A4 we provide an overview of the actual composition of household and individual incomes for the considered population according to the SOEP. The population depicted in Tables A3 and A4 mirrors our sample regarding age, region, employment status, earnings biography and gender. For our sample, household and individual incomes are predominantly comprised of earnings from employment and PAYG-pensions, which can be observed in our data. Other pensions, transfers or asset income are negligible small.

Table A3: Composition of individual income and marital status

| Age | Employment | | | | Pensions | | | | Unempl. benefit | | Married | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Employed | | Self | | PAYG | | Other | | | | | |
| | Share | (Sd) | Share | (Sd) | Share | (Sd) | Share | (Sd) | Share | (Sd) | Share | (Sd) |
| 62 | 96 | (16) | 0 | (2) | 3 | (14) | 0 | (0) | 1 | (7) | 78 | (48) |
| 63 | 92 | (24) | 1 | (10) | 7 | (21) | 0 | (0) | 1 | (7) | 76 | (48) |
| 64 | 83 | (32) | 1 | (9) | 16 | (31) | 0 | (3) | 0 | (4) | 70 | (47) |
| 65 | 58 | (46) | 0 | (3) | 41 | (46) | 1 | (7) | 0 | (2) | 73 | (48) |
| 66 | 36 | (41) | 0 | (6) | 64 | (41) | 0 | (1) | 0 | (1) | 72 | (47) |
| 67 | 10 | (22) | 1 | (8) | 89 | (23) | 0 | (0) | 0 | (0) | 72 | (44) |
| 68 | 8 | (21) | 1 | (7) | 92 | (22) | 0 | (0) | 0 | (0) | 76 | (44) |

Note: Income shares of total individual income in percent. Standard deviation (Sd) in parentheses. Sample comprised of West German males born between 1935 and 1945 in regular insurable employment at age 62. Source: SOEP waves 1984-2012.

Table A4: Composition of household income

| Age | Labor income | | PAYG Pensions | | Asset income | |
|---|---|---|---|---|---|---|
| | Share | (Sd) | Share | (Sd) | Share | (Sd) |
| 62 | 87.81 | (18.69) | 6.10 | (15.83) | 4.18 | (8.96) |
| 63 | 84.65 | (22.48) | 8.77 | (19.01) | 3.53 | (6.82) |
| 64 | 75.71 | (28.65) | 17.23 | (25.31) | 3.90 | (8.40) |
| 65 | 56.69 | (38.86) | 32.22 | (34.73) | 5.12 | (8.72) |
| 66 | 39.22 | (35.40) | 47.93 | (32.81) | 4.58 | (7.59) |
| 67 | 20.24 | (25.77) | 63.67 | (28.14) | 6.37 | (10.38) |
| 68 | 17.54 | (26.69) | 67.73 | (28.65) | 5.57 | (9.05) |

Note: Income shares of total household income in percent. Standard deviation (Sd) in parentheses. Sample comprised of households with a West German male born between 1935 and 1945 in regular insurable employment at age 62. Source: SOEP waves 1984-2012.

Table A3 shows that roughly three-quarters of the individuals are married. Because the martial status is not recorded in the data, we assume all tax units to be married and eligible for joint assessment.[16] For robustness, we also calculate a scenario where the tax units are assumed to be single. Due to the ages considered, we do not regard the case of tax relevant children.

In general, after deductions of e. g. social security, the income tax schedule is applied. The income tax is calculated on yearly taxable income (earnings and pensions). To obtain the monthly income tax, the yearly tax burden is distributed according to the monthly share of taxable income on yearly taxable income. From 1998 to 2011, the code was subject to several changes, e.g: top marginal tax rates were reduced from 53% to 45%; taxation of pensions was reformed by the introduction of deferred taxation and changes in the deductibility of social security contributions. In addition, there were some minor alterations like changes in lump sum deductions. All these changes occur regularly between 1998 and 2011, impacting the birth cohorts accordingly and influencing their retirement decisions. To disentangle the impact from changes in the income tax law from changes in the pension system, we simulate a counterfactual assuming the governing law of 1998 (see Appendix C). Concerning the taxation of income from employment and PAYG-pensions, our tax model in particular includes the following regulations:[17]

- Income from employment: In order to obtain the taxable portion of income, gross earnings are reduced by a lump sum deduction for work related expenses (*Werbungskostenpauschale*).
- Income form PAYG-pension: In case of pensions, the return portion (*Ertragsanteil*) is taxable only if the pensioner retired before 2005. For our sample, the return portion varies between 27% and 29%, depending on retirement age. Beginning with 2005, the taxable portion (*Besteuerungsanteil*) depends on the year of retirement and ranges from 50% in 2005 to 62% in 2011. Further, the lump sum deduction for pensions is subtracted.
- Special expenses (*Sonderausgaben*): The modelling concerning the deduction of social security contribution from taxable income (*Vorsorgeaufwendungen*) accounts for all changes between 1998 and 2011. Further, the lump sum deduction for special expenses (*Sonderausgabenpauschbetrag*) is subtracted.

[16] Married couples profit from a splitting rule (Bönke and Eichfelder, 2010). We assume joint assessment and a single earner/pensioner without spousal income.
[17] For a detailed description of work related deduction and special expenses see Bönke und Eichfelder (2010).

## A.3 Data

The dataset consists of the waves of SUFVSKT of calendar years 2002 and 2004-2012. Each SUF is a 25% stratified random sample of the VSTK of the respective year and includes the same information. Since we need completed biographies to clearly identify the timing of old-age retirement, we focus on cohorts aged 66 or 67 in the respective year only. This means that usable observations for cohorts 1938-1945 appear in two different waves, once aged 66 and once aged 67. Due to the sampling structure it is possible to match those two waves for each of these cohorts and enhance the number of observations. Since there is no unique identifier across all waves, we identify duplicates (whom appear in both waves) on the basis of their employment biographies. For the selected cohorts, those biographies consist of monthly earnings points observations included from age 14 onwards up to the age of 66. Therefore, we draw on a large number of data points for the matching procedure and do not have to make any assumptions. For identification we use all of the at least 420 month (35 years) history as well as the year and month of birth. Verification checks further confirm the correctness of our procedure. Certainly, the matching procedure might be problematic for individuals without a strong labor market attachment - but those are not the persons we focus on.

# Appendix B: Robustness

## B.1 Inclusion of type-specific preference heterogeneity

We implement preference heterogeneity in disutility of work by assuming two unobserved types[18] $m \in \{1,2\}$ that comprise a fixed proportion of the population (Heckman and Singer, 1984). We assume that the constant in the spline function of the disutility of work $\delta_1$ is heterogeneous for the unobserved types. Hence, equation (4) becomes:

$$l(d_{nt}, t_n) = \delta_{1m}[1 - d_{nt}] + [1 - d_{nt}] \begin{Bmatrix} & \delta_2 \, min(t, 3) & if \ t > 0 \\ + & \delta_3 \, min(t - \ 3,3) & if \ t > 3 \\ + & \delta_4 \, min(t - \ 6,3) & if \ t > 6 \\ \vdots & \vdots & \vdots \\ + & \delta_9 \, min(t - \ 21,3) & if \ t > 21 \end{Bmatrix}$$

The results suggest that the second type with lower disutility comprises only about 9% of the population. The specification yields unprecise estimates for the parameter related to this type ($\delta_{12}$). Still, central parameters remain stable, the model fit improves only slightly, and postestimation

[18]For more than two unobserved types, the optimization algorithm did not converge.

outcomes are almost unaffected. Therefore, we conclude that our results are insensitive to the inclusion of preference heterogeneity and do not add it to the baseline specification.

## B.2 Type probabilities (unconditional and conditional on initial conditions)

The probability that individual $n$ is of type $m$ is given by $\pi_{nm}$, where $\pi_{nm}$ is assumed to be logistic and can be modeled conditional on initial conditions at age 63. For the unconditional specification we assume:

$$\pi_{nm} = \frac{\exp(\gamma_1)}{1 + \exp(\gamma_1)}$$

For the conditional specification we assume:

$$\pi_{nm} = \frac{\exp(\gamma_1 + \gamma_2 Lifetime\ earnings_n^{63}/10)}{1 + \exp(\gamma_1 + \gamma_2 Lifetime\ earnings_n^{63}/10)}$$

In the conditional specification, the probability that individual $n$ is of type $m$ is modeled as a function of the employment history at age 63. Thereby, we use real accumulated lifetime earnings (Bönke et. al., 2015) as a summary measure because it reflects both wage history and employment pattern over the working life cycle.

By making the type probabilities a function of the employment and wage history at age 63, we account for non-random initial conditions at age 63. This approach follows Wooldridge (2005) and only requires the assumption that the initial condition is random conditional on real accumulated lifetime earnings at age 63. The log-likelihood function of the sample is then given by

$$\sum_{n=1}^{N} \log \left\{ \sum_{m=1}^{2} \pi_{nm} \prod_{t=1}^{T} \left[ \sum_{d_{nt}} Prob_m(d_{nt} | \boldsymbol{s}_{nt}, \boldsymbol{\lambda}) \times I(d_{nt}) \right] \right\}$$

with $I(d_{nt})$ indicating the individual choice observed in period $t$.

## B.3 Results

Table B1: Parameter estimates and robustness

| | Baseline | Single | Unobserved Heterogeneity w/o init. cond. | Unobserved Heterogeneity with init. cond. |
|---|---|---|---|---|
| α (consumption) | 0.21516 | 0.2024 | 0.3203 | 0.32503 |
| | (0.024108) | (0.026465) | (0.035013) | (0.040995) |
| ρ (CRRA) | 1.5065 | 1.5 | 1.5661 | 1.5784 |
| | (0.071666) | (0.087501) | (0.065832) | (0.079646) |
| $\delta_1$, $\delta_{11}$ (disutility, constant) | -3.0154 | -2.9948 | -3.0742 | -3.0743 |
| | (0.24757) | (0.23875) | (0.25671) | (0.23648) |
| $\delta_{12}$ (disutility, constant) | | | -1.5747 | -1.5228 |
| | | | (2.3507) | (2.384) |
| $\delta_2$ (disutility, spline) | 1.0568 | 1.0577 | 1.0561 | 1.0561 |
| | (0.11822) | (0.11174) | (0.12249) | (0.11377) |
| $\delta_3$ (disutility, spline) | -0.16413 | -0.16571 | -0.16444 | -0.16443 |
| | (0.066455) | (0.062373) | (0.071532) | (0.070221) |
| $\delta_4$ (disutility, spline) | 0.032382 | 0.038399 | 0.032745 | 0.032774 |
| | (0.064722) | (0.064915) | (0.072272) | (0.070505) |
| $\delta_5$ (disutility, spline) | 0.080143 | 0.077559 | 0.078887 | 0.078822 |
| | (0.073298) | (0.072578) | (0.078636) | (0.07622) |
| $\delta_6$ (disutility, spline) | -0.26074 | -0.26343 | -0.25952 | -0.2594 |
| | (0.091609) | (0.093278) | (0.099041) | (0.091424) |
| $\delta_7$ (disutility, spline) | 0.25537 | 0.2551 | 0.24973 | 0.2493 |
| | (0.12815) | (0.13244) | (0.14189) | (0.11686) |
| $\delta_8$ (disutility, spline) | -0.23207 | -0.22357 | -0.21365 | -0.21193 |
| | (0.14114) | (0.14541) | (0.15405) | (0.13698) |
| $\delta_9$ (disutility, spline) | 1.2119 | 1.2055 | 1.1328 | 1.1277 |
| | (0.13425) | (0.13741) | (0.15709) | (0.15359) |
| $\gamma_1$ (constant, type) | | | 2.2783 | 2.4235 |
| | | | (0.36287) | (0.71499) |
| $\gamma_2$ (initial condition, type) | | | | -0.0088864 |
| | | | | (0.031546) |
| Log-likelihood | -1942 | -1947 | -1930 | -1930 |

Source: SUFVSKT2002, 2004-12, own calculations.

Table B2: Exemplary robustness results for a disincentive level of 0.3%

| | Baseline | Single | Unobserved Heterogeneity w/o init. cond. | Unobserved Heterogeneity with init. cond. |
|---|---|---|---|---|
| ΔE[retirement age] (months) | 5.54 | 5.07 | 5.80 | 5.77 |
| ΔE[NPV of consumption] | 2,271 | € -783 | € 3,369 | € 3,249 |
| ΔE[NPV of consumption] (%) | 0.65 | -0.40 | 1.07 | 1.04 |
| ΔGini coefficient (%) | 4.68 | 3.6 | 5.09 | 4.81 |
| ΔMonthly retirement income | € -31.92 | € -35.13 | € -30.60 | € -30.74 |
| Average compensating variation | € 3,913 | € 3,561 | € 4,615 | € 4,604 |
| Average equivalent variation | € 3,754 | € 3,453 | € 4,296 | € 4,297 |
| NPV of net public returns | € 21,994 | € 22,825 | € 22,784 | € 22,650 |
| ΔE[NPV of pension benefits] | € 13,754 | € 13,450 | € 13,851 | € 13812 |
| ΔE[NPV of pension contributions] | € 4,137 | € 3,762 | € 4,381 | € 4345 |
| ΔE[NPV of other contr. & taxes] | € 4,103 | € 5,613 | € 4,552 | € 4493 |

Note: Euro in 2010 real values. Source: SUFVSKT2002, 2004-12, own calculations

## Appendix C: Effects of different institutional changes

Here we document the effects of various alternative reforms apart from the introduction of disincentives. Tables C1 shows the effects of certain tax/pension parameters on retirement age. These effects are measured by assuming the values from 1998 (the first year of this study) for all other years. Figure C1 presents an alternative reform-scenario, which implements a pension cut of a various levels. Panel (a) shows how much the pensions would have to decrease to yield a certain amount of net public returns. Panel (b) provides estimates on the corresponding individual welfare losses. Table C2 shows further results of this counterfactual scenario.

Table C1: Predicted effects of various reforms

| | Predicted effect on retirement age in month | | | |
|---|---|---|---|---|
| Cohort | Disincentives | Pension value constant | Tax system constant | Total predicted change |
| 1935 | 0 | -0.0037798 | 0.3086298 | 0.30485 |
| 1936 | 0 | 0.010305 | 0.306345 | 0.31665 |
| 1937 | 1.1605 | 0.0136 | 0.3205 | 1.4946 |
| 1938 | 4.1914 | -0.0299 | 0.3171 | 4.4786 |
| 1939 | 5.2811 | 0.0228 | 0.2984 | 5.6023 |
| 1940 | 5.4339 | 0.1542 | 0.2788 | 5.8669 |
| 1941 | 5.4546 | 0.3112 | 0.2548 | 6.0206 |
| 1942 | 5.597 | 0.4855 | 0.3239 | 6.4064 |
| 1943 | 5.5353 | 0.6321 | 0.3298 | 6.4972 |
| 1944 | 5.6771 | 0.7385 | 0.3522 | 6.7678 |
| 1945 | 5.6608 | 0.7227 | 0.3398 | 6.7233 |

Note: Euro in 2010 real values. Pension value and tax system constant refer to scenarios where both are constant at the 1998 level, the first year of this study. Source: SUFVSKT2002, 2004-12, own calculations.

Table C2: Effects of pension cuts

| Pension cut | Net public returns | CV | Δ Retirement age (month) | Δ Gini | Δ NPV of expected lifetime consumption | Δ Monthly pension benefits |
|---|---|---|---|---|---|---|
| 1% | 2792 | 959 | 0.11033 | 0.21055 | -2279 | -14 |
| 2% | 5589 | 2132 | 0.224 | 0.42715 | -4551 | -28 |
| 3% | 8389 | 3303 | 0.34041 | 0.64724 | -6815 | -42 |
| 4% | 11193 | 4476 | 0.45975 | 0.87447 | -9070 | -56 |
| 5% | 14001 | 5642 | 0.58111 | 1.1089 | -11318 | -71 |
| 6% | 16813 | 6813 | 0.70536 | 1.3496 | 13557 | -85 |
| 7% | 19629 | 7979 | 0.83244 | 1.5997 | -15788 | -99 |
| 8% | 22451 | 9147 | 0.96449 | 1.848 | -18007 | -113 |
| 9% | 25278 | 10313 | 1.1001 | 2.1045 | -20218 | -127 |
| 10% | 28111 | 11483 | 1.239 | 2.3701 | -22419 | -141 |

Note: Euro in 2010 real values. Source: SUFVSKT2002, 2004-12, own calculations.

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