

Kemptoner, Daniel; Haan, Peter; Prowse, Victoria

**Conference Paper**

## Lifetime income inequality with taxation and public benefits

Beiträge zur Jahrestagung des Vereins für Socialpolitik 2016: Demographischer Wandel - Session: Income, Social Security, and Consumption, No. E07-V2

**Provided in Cooperation with:**

Verein für Socialpolitik / German Economic Association

*Suggested Citation:* Kemptoner, Daniel; Haan, Peter; Prowse, Victoria (2016) : Lifetime income inequality with taxation and public benefits, Beiträge zur Jahrestagung des Vereins für Socialpolitik 2016: Demographischer Wandel - Session: Income, Social Security, and Consumption, No. E07-V2, ZBW - Deutsche Zentralbibliothek für Wirtschaftswissenschaften, Leibniz-Informationszentrum Wirtschaft, Kiel und Hamburg

This Version is available at:

<https://hdl.handle.net/10419/145564>

**Standard-Nutzungsbedingungen:**

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

**Terms of use:**

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*

# Lifetime income inequality with taxation and public benefits

Peter Haan<sup>\*</sup>

Daniel Kemptner<sup>†</sup>

Victoria Prowse<sup>‡</sup>

## Preliminary and Incomplete

February 15, 2016

### Abstract

In this paper, we show how taxation, unemployment insurance, welfare, disability benefits and public pensions affect the inequality of lifetime income. Using results from a dynamic life-cycle model estimated using German panel data, we show that taxation and public benefits combined reduce the inequality of lifetime income, measured by the Gini coefficient, by 22%. Pensions only slightly reduce inequality in lifetime income. Welfare benefits, meanwhile, make persistent transfers to individuals at the bottom of the distribution of lifetime income and, therefore, are highly effective at reducing the inequality of lifetime income. Welfare benefits and disability benefits have increasingly progressive effects on lifetime income as the persistence of employment shocks increases, suggesting that these program are particularly important for targeting lifetime inequality when labor market frictions are high.

**Key words:** Lifetime income inequality; lifetime earnings; unemployment insurance; pensions; welfare benefits; disability benefits; redistribution; life-cycle labor supply.

**JEL Classification:** D63; D91; H23; J22.

---

<sup>\*</sup>FU Berlin and DIW Berlin, phaen@diw.de

<sup>†</sup>DIW Berlin, dkemptoner@diw.de

<sup>‡</sup>Department of Economics, Cornell University, prowse@cornell.edu

# 1 Introduction

In this paper, we derive new results on the inequality of lifetime income, defined as lifetime earnings minus taxation plus public benefits including unemployment insurance, welfare, disability benefits and public pensions. Our interest in the inequality of lifetime income stems from its importance in determining the inequality of living standards. Owing to the powerful redistributive effects of taxation and public benefit programs, the inequality of individuals' economic outcomes is driven by the inequality of income, rather than earnings inequality. At the same time, to the degree that individuals save and borrow to moderate the impact of transitory income fluctuations, the distribution of lifetime income, rather than the distribution of annual income, is the key determinant of inequality in living standards.

We make three contributions to the inequality literature. First, we compare the effects of taxation and public benefit programs on the inequality of lifetime income to the effects of these programs on the inequality of annual income. Second, we offer new results on how taxation, unemployment insurance, welfare, disability benefits and public pensions affect the inequality of lifetime income. Third, we assess the insurance functions of taxation and public benefit programs by showing how changes in the persistence of employment shocks affect the inequality of lifetime earnings and the inequality of lifetime income.

Our results for Germany show that the inequality-reducing role of the taxation and public benefit programs is much smaller when considered on a lifetime basis than an annual basis: quantitatively, taxation and public benefits combined reduce the inequality of annual income by 46% but reduce the inequality of lifetime income by only 22%. These figures reflect that taxation and public benefits primarily reduce the inequality of annual income by redistributing within individual life-cycles rather than between individuals. Welfare benefits are the most effectively program at targeting the inequality of lifetime income and account for the majority of the effect of the overall public benefit system on the inequality of lifetime income. Despite the common presumption that unemployment insurance is not a strongly redistributive program, unemployment insurance accounts for almost 20% of the overall effect of the public benefit programs on the inequality of lifetime income. Pensions and disability benefit account for 7% and 15%, respectively, of the redistributive effect of all public benefit programs on the inequality of lifetime income.

The findings of this paper represent a valuable advance on the current understanding of income inequality. Reflecting the fundamental importance of lifetime income, the inequality literature has recently expanded from its traditional focus on annual outcomes and has started to explore the inequality of lifetime earnings. In this vein, Flinn (2002),

Bowlus and Robin (2004), Kopczuk et al. (2010), Bowlus and Robin (2012) and Corneo (2015) provide insights on the cross-country and cross-time dimensions of the inequality of lifetime earnings. Heathcote et al. (2005), meanwhile, decompose the sources of lifetime inequality and show that most of the inequality in lifetime earnings is due to differences established early in life. The inequality literature, however, still lacks a coherent body of evidence on the inequality of lifetime income, that is lifetime earnings adjusted for taxation and incremented for public benefits.

A small group of papers offers some important insights on the distribution of lifetime income. Notably, Conesa and Krueger (1999) and Huggett and Parra (2010) show how Social Security affects the distribution of lifetime income, but abstract from other public benefit programs. Brewer et al. (2012) study the effect of taxes and family-related benefits on the distribution of lifetime income, focusing on the female population prior to retirement, but not consider disability benefits, pensions or unemployment insurance. In this paper, we build on recent studies of the inequality of lifetime earnings and income by analyzing the inequality of a comprehensive measure of lifetime income. Relative to the previous literature of the inequality of lifetime earnings and lifetime income, our analysis offers a more complete picture of the inequality of lifetime living standards. Furthermore, because we separate out unemployment insurance, welfare, disability benefits and public pensions, our analysis makes a connection between the inequality of lifetime income and the design of a wide range of public benefit programs.

Our paper is also related to a large literature that documents the powerful distributional effects of taxation and public benefits on annual income, for example, Piketty and Saez (2007) and Heathcote et al. (2010).<sup>1</sup> In particular, our results suggest that the inequality-reducing effects of many public benefits programs are very different when viewed from a lifetime perspective rather than on an annual basis. Our comparison of the inequality of annual and lifetime income complements several studies that compare the inequality of annual and lifetime earnings. Corneo (2015) and Bowlus and Robin (2004), for example, find that the inequality of lifetime earnings is about 60%-70% of the size of inequality of annual earnings. Our analysis shows that the wedge between lifetime inequality and annual inequality is lower for income than for earnings.

We base our analysis around a dynamic structural life-cycle model to derive earnings and net income trajectories over the whole life-cycle, including the working phase and the retirement period. In more detail, the life-cycle model includes labor supply, retirement and savings decisions and incorporates a dynamic wage process with endogenous human

---

<sup>1</sup>The Handbook chapter by Katz and Autor (1999) surveys the extensive literature on the inequality of wages and annual earnings.

capital accumulation, labor market frictions, health shocks and a realistic specification of the systems of taxation and public benefits.<sup>2</sup>

This paper proceeds as follows. Section 2 provides a framework for understanding the relationship between the inequality of annual income and the inequality of lifetime income. Section 3 gives an intuitive overview of the model and describes the taxes and public benefits that are included in our analysis. Section 4 demonstrates that the model is able to replicate the levels of inequality in annual earnings observed in the sample and observed in an external administrative data source. Section 5 discusses effects of taxation and public benefits programs on the inequality of lifetime income.

## 2 Connecting inequality of lifetime income and inequality of annual income

In this paper, we analyze the inequality of lifetime income and we contrast the effects of taxation and public benefits on the inequality of lifetime income and the inequality of annual income. We organize our discussion around the following decomposition, which formalizes the distinction between the inequality of annual income and the inequality of lifetime income (this decomposition also applies to earnings, and holds for any entropy-based inequality metric):

$$\text{Inequality of annual income} = \text{Inequality of lifetime income} + \text{Average inequality within the life cycle} . \quad (1)$$

The above decomposition provides five important insights that inform on the subsequent empirical analysis:

1. In the benchmark case where income is constant over the life cycle at the individual level, there is no inequality within the life cycle and inequality in annual income coincides with inequality in lifetime income; inequality within the life cycle at the individual level leads inequality in annual income to exceed inequality in lifetime income.
2. Shocks that affect the distribution of income within the life cycle at the individual level but that do not affect total lifetime income per person, e.g., employment shocks that average out over many years, do not affect inequality in lifetime income but

---

<sup>2</sup>Bowlus and Robin (2004), Bowlus and Robin (2012) or Flinn (2002) apply a similar simulation strategy.

contribute to inequality in annual income via their impact on inequality within the life cycle.

3. The share of inequality in annual income due to inequality in lifetime income increases as heterogeneity in endowments, such as education and ability, increases and as the persistence of employment shocks increases.
4. Public benefits with a lifetime value that is proportional of lifetime income, such as a pension system that pays benefits in proportion to lifetime earnings, do not affect inequality in lifetime income; such benefits reduce inequality in annual income entirely via their impact on inequality within the life cycle.
5. Public benefit programs that concentrate lifetime benefit income on particular groups of individuals, such as disability benefits and social assistance benefits, are relatively effective at reducing inequality in lifetime income. Meanwhile, public benefits with low cross-individual variance of lifetime benefit income, such as unemployment insurance, are relatively effective at reducing inequality in income within the life cycle.

### **3 Empirical approach**

Our study requires detailed information about gross income in each year of the life cycle and information about taxes and public benefits. We obtain the required information from a standard life-cycle model of labor force status (employed, retired, disability benefit claimant or unemployed) and consumption. The model includes income and capital taxes and four distinct public benefit programs. The solution to the model provides individual-level life-cycle trajectories for labor force status, market wages and wealth. We focus our discussion on the channels that give rise to inequality in gross income and on the modeled taxes and public benefit programs that mitigate income inequality. A full description of the model is provided in Appendix A.

#### **3.1 Model overview**

The model includes three key sources of heterogeneity: 1) individuals are endowed with two skills, human capital and innate ability, and both skills are heterogeneous in the population; 2) health status evolves stochastically over the life cycle; and 3) job offers arrive stochastically over the life cycle. These three sources of heterogeneity combine together to generate heterogeneous individual-level life-cycle trajectories of wages, employment, and wealth. In particular, the individual's market wage depends on skills and

on experience accumulated through previous employment. Employment outcomes reflect individual choice subject to employment shocks that limit work opportunities and subject to disability benefit eligibility. The likelihood of employment shocks depends on skills and health status, and disability benefit eligibility is restricted to individuals with poor health status. Wealth reflects the accumulated effects of the individual's previous savings choices, which depend on past income and thus on skills and health status.

We combine the life-cycle trajectories of employment, wages and wealth to form annual gross income in each year of an individual's life between leaving education and death. We then obtain annual net incomes by applying taxes and public benefits to the annual gross incomes. Finally, summing over the individual-level life-cycle trajectories of gross income and net income provides measures of lifetime gross income and lifetime net income at the individual level.

## 3.2 Public benefits

We consider four public benefit programs: unemployment insurance; disability benefits; pension benefits; and social assistance benefits. We base our models of these programs on the public benefits system in Germany; however, the social safety net most countries contains elements of some or all of these four programs.

### 3.2.1 Unemployment insurance benefits

Unemployment insurance benefits (UI) are paid to individuals in their first year of unemployment after employment. UI benefits have a value of 60% of the individual's previous post tax wage and are not means-tested. If an unemployed individual is not eligible for UI he might receive Social assistance benefits, which are described below.

### 3.2.2 Pension benefits

Pension benefits are paid to retired individuals, and are based on the age of retirement (60-65 years) and on prior earnings over the whole working life. Annual pension benefits for an individual retiring at age  $R$  are given by:

$$\text{Annual pension benefits (OAP)} = \alpha \times \text{Penalty}(R) \times \text{Exp}_R \times \overline{W}_R, \quad (2)$$

where:  $\text{Penalty}(R)$  is an early retirement penalty that reduces annual pension benefits by 3.6% for each year that the individual retires before age 65;  $\text{Exp}_R$  is years of working experience at the age of retirement;  $\overline{W}_R$  is the individual's average qualifying earnings

over all years of employment<sup>3</sup>; and  $\alpha$  is an institutional parameter that controls pension generosity.

### 3.2.3 Disability benefits

Disability benefits are paid to individuals who permanently leave the labor force due to poor health, and have a maximum value that is based on the age that disability benefits are first received and on prior earnings. Maximum annual disability benefit for an individual who first receives disability benefits at age  $D$  is given by:

$$\begin{array}{l} \text{Maximum annual} \\ \text{disability benefit (DB)} \end{array} = \alpha \times \text{Penalty}(D) \times [\text{Exp}_D + (60 - D)_+] \times \overline{W}_D, \quad (3)$$

where  $\text{Penalty}(D)$  is a penalty that reduce the maximum annual disability benefit by 3.6% for each year that the individual receives disability benefits before age 63, up to a maximum penalty of 10.8%. Individuals under the age of 60 receive the full maximum annual disability benefit. Meanwhile, individuals aged 60 and above receive an annual disability benefit equal to the difference between the maximum annual disability benefit and annual pension benefits.

### 3.2.4 Social assistance benefits

Social assistance (SA) guarantees wealth-poor individuals a minimum level of income,  $\mu$ . SA is means-tested against all other sources of income including unemployment benefits, pension and disability benefits. Annual social assistance benefits for an individual with less than 10,000 Euros in assets are given by:

$$\text{SA} = \max\{\mu - W - \text{UI} - \text{OAP} - \text{DB} + \text{Tax}, 0\}, \quad (4)$$

## 3.3 Taxation

The model includes three annual taxes: a progressive tax on earnings and pension benefits; a progressive tax on capital income; and a Social Security tax. The Social Security tax comprises a flat rate tax for unemployment and pension benefits that is levied on earnings (up to a maximum amount), and a flat rate tax for health insurance that is levied on earnings and pension benefits (again up to a maximum amount). Figures 1(a)-1(c) in SWA.1 illustrate the tax schedules.

---

<sup>3</sup>Only annual earnings below a cap of X Euros are pensionable.



### 3.4 Estimation sample and methodology

For the estimation of our structural life cycle model, we use an unbalanced panel sample of men covering the years 2004 to 2012 inclusive taken from the German Socio-Economic Panel. Section SWA.2 in the Supplementary Appendix describes the sample in more detail and provides definitions and descriptive statistics for the variables used in our analysis. In Section SWA.3 of the Supplementary Appendix we describe the Maximum Likelihood estimation method and report the parameter estimates.

## 4 Model Implications

Before proceeding to our analysis of lifetime inequality, we assess the quality of the model for our research question in two ways. First we, validate the model with respect to internal and external information on the inequality of annual earnings. Second, we show that the model is able to capture accurately the persistence of employment observed in the sample, which is necessary for the model to provide a realistic picture of inequality in lifetime outcomes.

We examine the internal and external validity of our model by comparing the distribution of annual earnings in the simulated data with the respective outcomes that are (1) directly observed for the estimation sample (Ginis of pooled cross section outcomes) and (2) with recent findings of a study by Bönke et al. (2015) that is based on administrative data from the German pension insurance, VSKT, (Ginis of pooled cross sections and of life-cycle outcomes). Table 2 displays the estimates of the Gini coefficients. The model is successful in reproducing the patterns of inequality observed in the SOEP sample and in the German administrative data.

We examine the model's ability of generate accurate patterns of persistence in two ways: in Figure 1 we compare the distribution on unemployment durations observed in the estimation sample with the corresponding distribution implied by the estimated model; and in Figure 2 we compare the distribution of experience observed in the estimation sample with the corresponding distribution implied by the estimated model. The model is able to accurately replicate the distributions of unemployment durations and experience observed in the estimation sample.

Table 1: Ginis of gross earnings

|                               | <b>Own calculations</b> |                           | <b>Bönke et al. (2015)</b> |
|-------------------------------|-------------------------|---------------------------|----------------------------|
| Sample                        | Simulated data          | Estimation sample (SOEP)  | Admin. data (VSKT)         |
|                               | 10000 life-cycles       | Survey years 2005 to 2012 | Cohorts 1935 to 1949       |
| Cross-section (no retirees)   | 0.286                   | 0.272                     | 0.262–0.336                |
| Cross-section (with retirees) | 0.323                   | 0.31                      | –                          |
| Lifetime                      | 0.187                   | –                         | 0.156–0.212                |

## 5 Taxation, public benefits and the distribution of income

### 5.1 Lifetime tax payments and transfer receipt

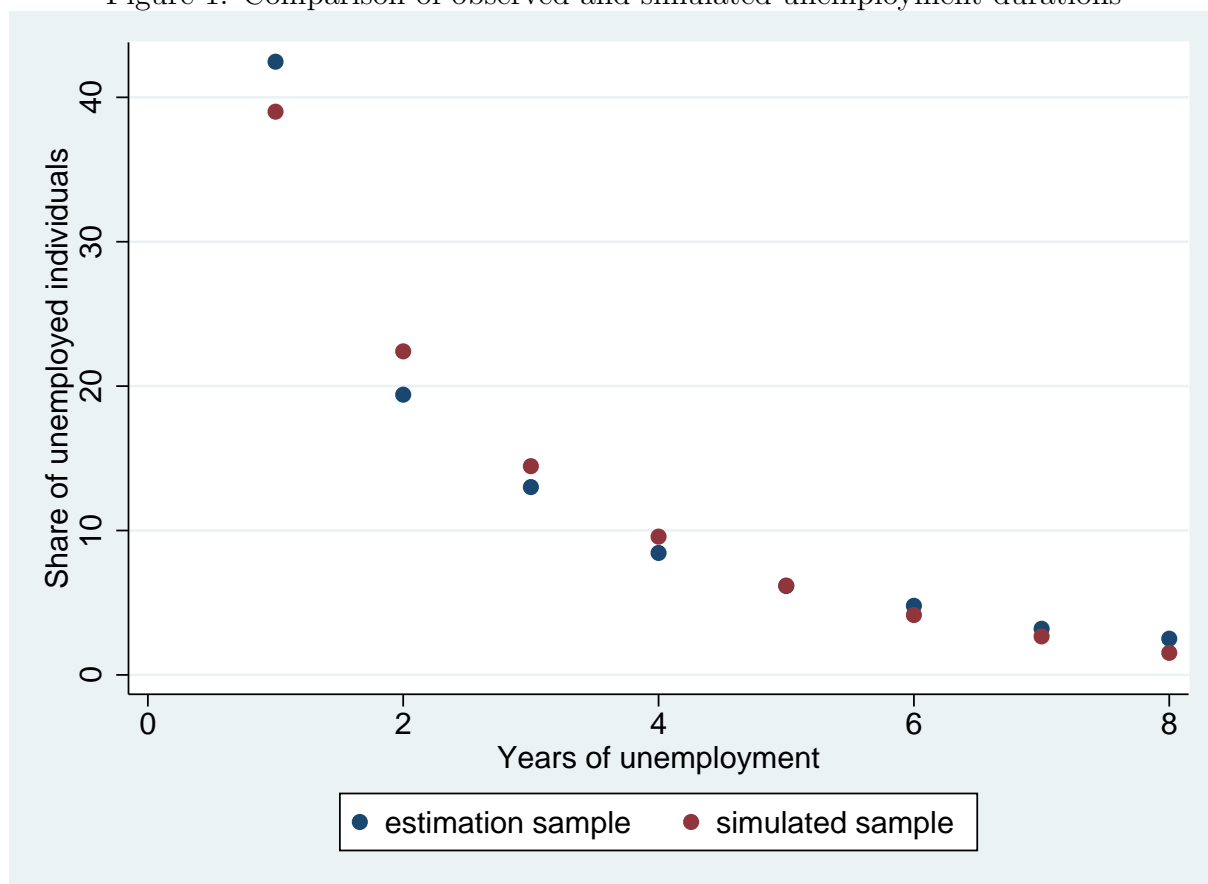
Table 2 shows how average total lifetime gross income (earnings+capital income) is divided between taxes, transfers, and disposable income. Taxation is around 40% of gross lifetime income. Transfers are around 40% of the value of income taxation, giving government a surplus of around 300,000 Euros per person.

Table 2: Composition of lifetime gross income

|                       | Gross Income | Taxation | Public benefits | Disposable Income |
|-----------------------|--------------|----------|-----------------|-------------------|
| Mean (1000s Euros)    | 1149         | 470      | 209             | 888               |
| Share of Gross Income | -            | 0.41     | 0.18            | 0.77              |

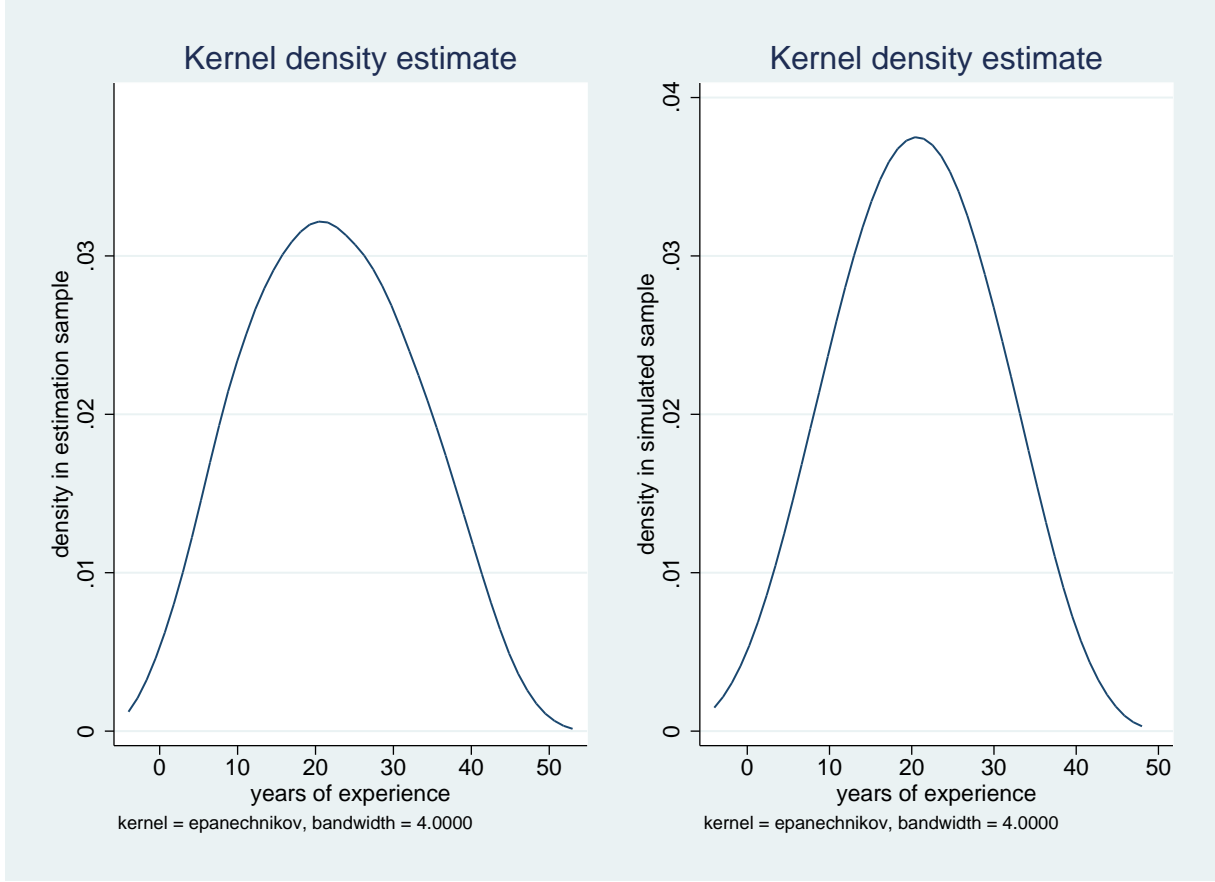
Table 3 displays the composition of lifetime transfer income. Unemployment insurance (UI), social assistance (SA), and disability pension (DP) are similarly sized programs: UI accounts for 8%, SA for 10%, and SB for 9% of total transfers. Aggregating over lifetime, SA is spread less equally than UI (fewer people ever receive benefit, but benefits are received longer than from UI). Disability benefits are claimed by fewer individuals than SA benefits, but individuals who claim DB receive the benefits for a longer period of time: 33% of individuals receive DB and on average claimants receive the benefits for 6.9 years, compared to 67% of individuals receiving SA benefits on average for 3.9 years.

Figure 1: Comparison of observed and simulated unemployment durations



Earnings-related old age pension is the largest transfer program, accounting for 72% of overall transfers.

Figure 2: Comparison of observed and simulated experience distribution



## 5.2 Effects of taxation and transfers on inequality in lifetime and annual income

Table 4 shows that the Gini coefficient for annual income is more than double the Gini for lifetime income. Similarly, inequality in annual income measured by the squared coefficient of variation (SCV) is about 6 times higher than inequality in lifetime income. Taxation and public benefits reduce the inequality in lifetime income, measured by the squared coefficient of variation, by around 46% (26% for Gini). The combined tax and transfer system eliminates about 50% more of inequality in annual income than of inequality in lifetime income (robust to Gini). This is due to the fact that a large share of the inequality reducing effect of the tax and transfer system on cross sectional inequality is driven by variation over the life-cycle in within-individual taxation and transfers.

Taxation accounts for 65% of the effect of combined effects of taxation and public benefit programs on the inequality of lifetime income, which is about the same as the share of taxation in total tax and transfers flows (robust to Gini), i.e., size adjusted, taxation and public benefits are equally effective at reducing inequality in lifetime income. The

Table 3: Composition of lifetime income from public benefit programs

|   | UI    | Welfare | Earnings-related<br>pension | Disability<br>benefits |
|---|-------|---------|-----------------------------|------------------------|
| Average benefit per person (1000s Euros)  | 17    | 22      | 150                         | 19                     |
| Share of total public benefit expenditure | 0.08  | 0.11    | 0.72                        | 0.09                   |
| Share of pop. receiving benefit           | 0.03  | 0.07    | 0.27                        | 0.12                   |
| Share of pop. that ever receives benefit  | 0.85  | 0.67    | 1.00                        | 0.33                   |
| Av years of benefit receipt               | 1.56  | 3.85    | 16.04                       | 6.93                   |
| Av years benefit received for recipients  | 1.85  | 5.77    | 16.04                       | 20.73                  |
| Share of population/Share of benefits     | 10.30 | 6.31    | 1.39                        | 3.68                   |

Table 4: Effects of taxation and public benefits

|  | Gini<br>lifetime | Gini<br>annual | SCV<br>lifetime | SCV<br>annual | SCV within<br>individual |
|--|------------------|----------------|-----------------|---------------|--------------------------|
| Lifetime earnings                            | 0.198            | 0.499          | 0.060           | 0.400         | 0.340                    |
| Lifetime income                              | 0.153            | 0.269          | 0.035           | 0.113         | 0.077                    |
| Level effect of taxation and public benefits | -0.045           | -0.230         | -0.025          | -0.287        | -0.262                   |
| Prop effect of taxation and public benefits  | -0.228           | -0.461         | -0.414          | -0.718        | -0.772                   |
| Level effect of taxation                     | -0.029           | -0.084         | -0.016          | -0.082        | -0.066                   |
| Share due to taxation                        | 0.653            | 0.366          | 0.623           | 0.286         | 0.253                    |
| Level effect of public benefits              | -0.016           | -0.146         | -0.009          | -0.205        | -0.196                   |
| Share due to public benefits                 | 0.347            | 0.634          | 0.377           | 0.714         | 0.747                    |

Notes: Lifetime earnings includes interest income from wealth.

importance of taxation relative to public benefits is larger for lifetime income than for annual income.

Table 5 shows the distributional effects of the individual transfer programs. As expected SA benefits are most successful in reducing lifetime inequality, making up 56.4% of the overall effect of the transfers (in terms of SCV). UI and DB account for 16.9% and 19.3%, respectively. The redistributive effect of the earnings-related pension, however, is rather small. This follows from the strong proportional link between gross lifetime earnings and pension claims. Considering annual outcomes, the earnings-related pension is the most redistributive program (72.7% of the overall effect in terms of SCV). UI, SAB, and DB exert smaller relative effects on annual than on lifetime inequality. The magnitude of these effects is robust to using the Gini as measure of inequality.

Table 5: Effect of individual transfer programs

|                                 | Gini<br>lifetime | Gini<br>annual | SCV<br>lifetime | SCV<br>annual | SCV within<br>individual |
|---------------------------------|------------------|----------------|-----------------|---------------|--------------------------|
| Pre tt lifetime income          | 0.198            | 0.499          | 0.060           | 0.400         | 0.340                    |
| Level effect of transfers       | -0.016           | -0.146         | -0.009          | -0.205        | -0.196                   |
| Share of transfer effect due to |                  |                |                 |               |                          |
| UI                              | 0.180            | 0.086          | 0.169           | 0.064         | 0.059                    |
| SAB                             | 0.599            | 0.124          | 0.564           | 0.095         | 0.072                    |
| Pension                         | 0.069            | 0.707          | 0.073           | 0.727         | 0.759                    |
| Disability benefits             | 0.153            | 0.083          | 0.193           | 0.114         | 0.111                    |

# Appendix

## A Description of life-cycle model

### A.1 General framework

Individual  $i$  is endowed with a level of education  $\text{Educ}_i \in \{7, \dots, 18\}$ , corresponding to years of schooling, and an unobserved type  $\eta_i \in \{0, 1\}$ , where type probabilities are given by  $\gamma$  and  $1 - \gamma$ , respectively. An individual enters the labor force after completing education and military service. We assume that this is at  $\max(20, \text{Educ}_i + 8)$  and that individuals are in good health at this time. In each year after entering the labor force, individuals make choices about consumption ( $c$ ), labor supply ( $l$ ), and retirement ( $r$ ) by maximizing expected lifetime utility

$$U(c, l, r) + \beta V_{t+1} \quad (5)$$

where  $U(c, l, r)$  is the per-period utility flow and  $V_{t+1}$  captures the expected future lifetime utility.  $\beta$  is a subjective time discount factor that is set to be 0.97. We assume the following time-separable function to represent an individual's preference over consumption and leisure time:

$$U(c, l, r) = (\alpha_1 + \alpha_{2\eta} \text{work}(l, r)) \times \frac{c^{(1-\rho_\eta)} - 1}{(1 - \rho_\eta)} + \epsilon(c, l, r) \quad (6)$$

where  $\epsilon(c, l, r)$  is assumed to be type 1 extreme value distributed.  $\alpha_{2\eta}$  reflects type-specific unobserved heterogeneity in the disutility for work.  $\rho_\eta$  is a type-specific coefficient of relative risk aversion. In line with e.g., Attanasio and Weber (1995) we account for non-separability between consumption and leisure time. The vector  $\boldsymbol{\theta}_U = (\alpha_1, \alpha_{21}, \alpha_{22}, \rho_1, \rho_2)$  contains the parameters of the utility function.

Individuals' beliefs about future states are captured by a Markov transition function  $q(\mathbf{s}_{t+1}|\mathbf{s}_t, c, l, r)$  that indicates the transition probabilities. In particular,  $q(\mathbf{s}_{t+1}|\mathbf{s}_t, c, l, r)$  captures expectations about the transitions of the health status and the expectations of unemployed individuals to receive a job offer and of employed individuals to face a job separation in the following period (see below). The value function  $V_t$  can be represented recursively as

$$V_t = \max_{\{c, l, r\} \in \mathbb{D}(\mathbf{s}_t)} U(c, l, r) + \beta \int_{\epsilon} \left[ \sum_{\mathbf{s}_{t+1}} V_{t+1}(\mathbf{s}_{t+1}) q(\mathbf{s}_{t+1}|\mathbf{s}_t, c, l, r) \right] g(\boldsymbol{\epsilon}_{t+1}) \quad (7)$$

where  $g(\cdot)$  is the probability density function of the unobserved random components of the utility function.  $\mathbb{D}(\mathbf{s}_t)$  is the choice set available to individual  $n$  in period  $t$ . The

choice set is restricted by eligibility requirements for early retirement and by job offer and separation rates.

The individual's working decisions and income in each year are shaped by employment and health shocks and by retirement rules:

**Employment shocks** A job offer arrives with probability  $\Gamma_{i,t}^1$  if the individual was employed in the previous year and probability  $\Gamma_{i,t}^0$  if the individual was unemployed in the previous year.

**Health shocks** If in good health the individual has a probability  $\Lambda_t^1$  of receiving a negative health shock that leads to a transition into bad health. Similarly, if in bad health the individual has a probability  $\Lambda_t^0$  of being subject to a positive health shock that leads to a transition back into good health. Being in bad health reduces the job offer probabilities for employed and unemployed individuals. Age-specific transition probabilities are computed by estimating local polynomial regressions of health status on age first using the sample of individuals in good health status and, then, using the sample of individuals in bad health status. We do this separately for the high and the low educated.

**Retirement** Normal retirement is allowed from age 60 and is compulsory at age 65. An exception is the disability pension where individuals are allowed to retire at any age if they meet the eligibility criteria (sufficiently severe health condition).

The job offer and separation rates are estimated differentially by level of education (high/low), health status, and age ( $50 \geq \text{Age} < 60$ , and  $\text{Age} \geq 60$ ):

$$\begin{aligned}\Gamma_{i,t}^1 &= \Lambda(\phi_1 + \phi_2 \text{Educ}_i^{\text{high}} + \phi_3 \text{Health}_{i,t} + \phi_4 \text{Age}_{i,t}^{50+} + \phi_5 \text{Age}_{i,t}^{60+}) \\ \Gamma_{i,t}^0 &= \Lambda(\phi_6 + \phi_7 \text{Educ}_i^{\text{high}} + \phi_8 \text{Health}_{i,t} + \phi_9 \text{Age}_{i,t}^{50+} + \phi_{10} \text{Age}_{i,t}^{60+})\end{aligned}\tag{8}$$

where  $\Lambda(\cdot)$  is the logistic distribution function. The parameters for the job offer and separation rates are contained by the vector  $\boldsymbol{\phi} = (\phi_1, \phi_2, \phi_3, \phi_4, \phi_5, \phi_6, \phi_7, \phi_8, \phi_9, \phi_{10}, )$ .

## A.2 Gross earnings

Employed individuals receive a wage  $W_{i,t}$  that is modeled as a function of education, work experience, and unobserved type. Hence, gross earnings are given by

$$\text{Gross earnings}_{i,t} = \text{Employed}_{i,t} \times W_{i,t}(\text{Educ}_i, \text{Exper}_{i,t}, \eta_i)\tag{9}$$

and for  $\log(W_{i,t})$ , we assume the following functional form:

$$\begin{aligned}\log(W_{i,t}) &= \delta_1 \text{Educ}_i + (\delta_2 \text{Exper}_{i,t} + \delta_3 \text{Exper}_{i,t}^2) \times (\text{Educ}_i < 12) + \\ &\quad (\delta_4 \text{Exper}_{i,t} + \delta_5 \text{Exper}_{i,t}^2) \times (\text{Educ}_i \geq 12) + \kappa_\eta + \mu_{i,t}\end{aligned}$$



where  $\text{Educ}_i$  is years of education,  $\text{Exper}_{i,t}$  is years of work experience,  $\kappa_\eta$  is time-constant unobserved heterogeneity, and  $\mu_{i,t}$  is i.i.d.  $(0, \sigma_\mu)$ . It is due to the DPDC framework that individuals take into account the human capital accumulation process when making their employment choice. Hence, work experience is an endogenous variable in the model. In the interaction terms between work experience and education account for heterogeneous returns to work experience for the high and the low educated (as reflected by the diverging wage profiles). The correlation between individual-specific leisure preferences and the unobserved component,  $\kappa_\eta$ , in the wage equation accounts for selection into the labor market. When computing gross labor earnings, I assume that individuals work the median number of hours, which is 40 in the sample. The vector  $\boldsymbol{\theta}_w = (\delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \kappa_1, \kappa_2, \sigma_\mu)$  contains the parameters of the wage equation.

### A.3 Budget constraint

Individuals face a budget constraint when making their saving/consumption choice. The constraint comprises three equations:

$$\begin{aligned} c &= \text{Government}(\mathbf{s}_t, l, r) - \text{Savings} \\ \text{Wealth}_{t+1} &= (1 + r_t)(\text{Wealth}_t + \text{Savings}) \\ \text{Wealth}_t &> 0 \end{aligned} \tag{10}$$

where  $\text{Government}(\cdot)$  indicates net income by applying the rules and regulations of the German tax and transfer system and of the statutory pension insurance. The budget constraint's first equation defines the possible levels of consumption in period  $t$ , the second equation describes the wealth accumulation process, and the third equation is a non-negativity constraint. We assume that the forward looking individuals do not expect future changes in the institutional framework.  $\text{Wealth}_t$  is period  $t$ 's net wealth and  $r_t$  is the real interest rate that is set to be 0.02. Pension claims are a deterministic function of retirement age, work experience, and past wages.

### A.4 Solving the model

Given the finite horizon of the individual's optimization problem, it can be solved recursively. The expected value functions,  $v_t(\mathbf{s}_{nt}, c, l, r)$ , for periods  $t = T, \dots, 1$  are given

by:

$$\begin{aligned}
v_T(\mathbf{s}_t, c, l, r) &= u(\mathbf{s}_{nt}, c, l, r) \\
v_t(\mathbf{s}_t, c, l, r) &= u(\mathbf{s}_t, c, l, r) + \beta \times \sum_{\mathbf{s}_{t+1}} \log \\
&\quad \left[ \sum_{\{c, l, r\} \in \mathbb{D}(\mathbf{s}_{t+1})} \exp(v_{t+1}(\mathbf{s}_{t+1}, c, l, r)) \right] q(\mathbf{s}_{t+1} | \mathbf{s}_t, c, l, r) \\
&\quad \forall t = 1, \dots, T - 1
\end{aligned}$$

The computation of the expected value functions for periods  $t=65, \dots, T$  is comparatively simple because individual choices are only modeled for  $t=1, \dots, 64$ . Rust (1987) shows that under the assumptions of additive separability and conditional independence, the conditional choice probabilities have a closed form solution (mixed logit probabilities):

$$\Pr(c, l, r | \mathbf{s}_t) = \frac{\exp(v_t(\mathbf{s}_t, c, l, r))}{\sum_{j \in \mathbb{D}(\mathbf{s}_t)} \exp(v_t(\mathbf{s}_t, j))}$$

When computing choice probabilities, we take into account that the choice of employment is restricted by the job offer and separation probabilities. The expected value functions are computed for a discretized state space in order to save computational time (Keane, 1994). As a consequence, interpolation methods must be used to approximate the functions at the observed values of the state variables. For each of these variables, we define five grid points. The results are insensitive to an increase in the number of these grid points or the choice of interpolation function.

## References

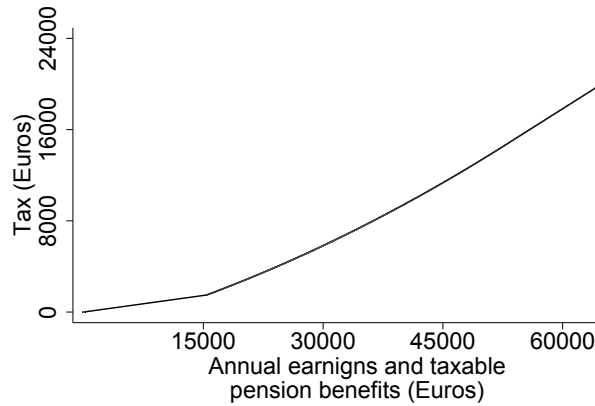
- Arcidiacono, P.** and **Jones, J.B.** (2003). Finite mixture distributions, sequential likelihood and the em algorithm. *Econometrica*, 71(3): 933–946
- Attanasio, O.P.** and **Weber, G.** (1995). Is consumption growth consistent with intertemporal optimization? evidence from the consumer expenditure survey. *Journal of Political Economy*, 103(6): 1121–57
- Bönke, T., Corneo, G., and Lüthen, H.** (2015). Lifetime earnings inequality in germany. *Journal of Labor Economics*, 33(1): 171 – 208
- Bowlus, A.J.** and **Robin, J.M.** (2004). Twenty years of rising inequality in u.s. lifetime labor income values. *Review of Economic Studies*, 71(3): 709–743
- Bowlus, A.J.** and **Robin, J.M.** (2012). An international comparison of lifetime labor income values and inequality. *Journal of the European Economic Association*, 10(6): 1236–1262
- Brewer, M., Dias, M.C., and Shaw, J.** (2012). Lifetime inequality and redistribution. Technical report, IFS Working Papers
- Conesa, J.C.** and **Krueger, D.** (1999). Social security reform with heterogeneous agents. *Review of Economic dynamics*, 2(4): 757–795
- Corneo, G.** (2015). Income inequality from a lifetime perspective. *Empirica*, 42(2): 225–239
- Flinn, C.** (2002). Labour market structure and inequality: A comparison of italy and the u.s. *Review of Economic Studies*, 69: 611–645
- Heathcote, J., Perri, F., and Violante, G.L.** (2010). Unequal we stand: An empirical analysis of economic inequality in the united states, 1967–2006. *Review of Economic dynamics*, 13(1): 15–51
- Heathcote, J., Storesletten, K., and Violante, G.L.** (2005). Two views of inequality over the life cycle. *Journal of the European Economic Association*, 3(2-3): 765–775
- Huggett, M.** and **Parra, J.C.** (2010). How well does the us social insurance system provide social insurance? *Journal of Political Economy*, 118(1): 76–112

- Katz, L.F.** and **Autor, D.** (1999). Changes in the wage structure and earnings inequality. *Handbook of Labor Economics*, 3: 1463–1555
- Keane, M.P.** (1994). A computationally practical simulation estimator for panel data. *Econometrica*, 62(1): 95–116
- Kopczuk, W., Saez, E., and Song, J.** (2010). Earnings inequality and mobility in the united states: Evidence from social security data since 1937. *Quarterly Journal of Economics*, 125(1): 91–128
- Low, H.** and **Pistaferri, L.** (2010). Disability risk, disability insurance and life cycle behavior. Technical report, National Bureau of Economic Research
- Piketty, T.** and **Saez, E.** (2007). How progressive is the u.s. federal tax system: A historical and international perspective. *Journal of Economic Perspectives*, 21(1): 3–24
- Rust, J.** (1987). Optimal replacement of gmc bus engines: An empirical model of harold zurcher. *Econometrica*, 55(5): 999–1033

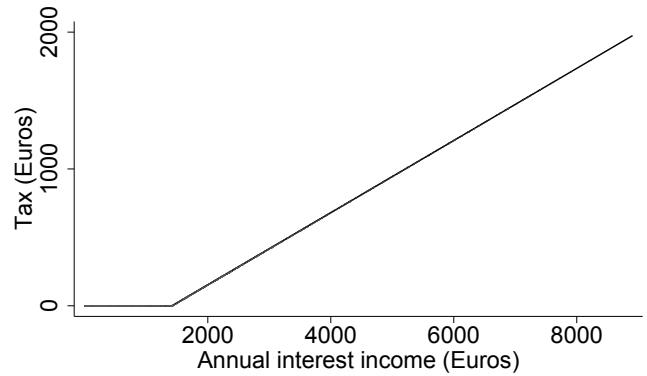
# **Supplementary Web Appendix**

(Intended for Online Publication)

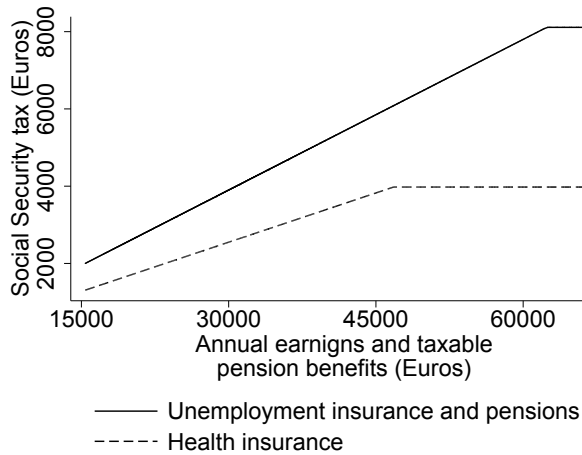
## SWA.1 Tax schedules



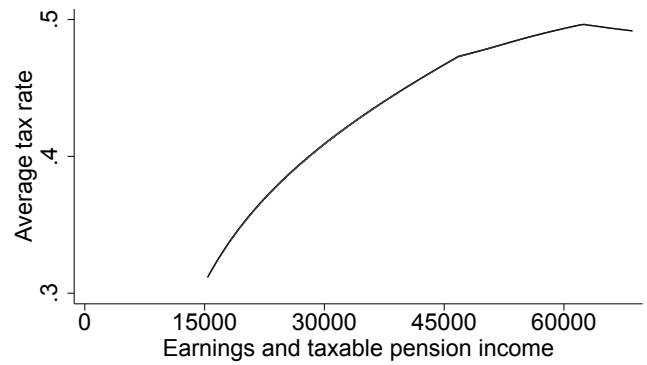
(a) Progressive tax on earning and taxable pension benefits.



(b) Progressive tax on capital income.



(c) Social Security tax.



(d) Average tax on earning and pension benefits (progressive tax plus Social Security tax).

Notes: Only 50% of pension benefit income is subject to the progressive tax shown in Figure 1(a), and only 50% of pension benefit income is subject to the Social Security tax for health insurance. All pension benefit income is exempt from the Social Security tax for unemployment and pension benefits.

Figure SWA.1: Tax schedules.

## SWA.2 Data and descriptive statistics

The sample is restricted to males aged 20-64 years in West Germany and excludes self-employed and civil servants. We consider the age cohorts 20 to 64 because the individuals' behavior is only modeled until the statutory retirement age of 65 years. The final sample consists of 14,552 observations on 3,128 individuals.

Table SWA.1: Descriptive statistics

| Variable                         | Mean        |               |                | Median | Std.    |
|----------------------------------|-------------|---------------|----------------|--------|---------|
|                                  | Full sample | Low education | High education |        |         |
| Age                              | 44.8        | 46.3          | 43.4           | 44     | 9.6     |
| Employed                         | 0.87        | 0.83          | 0.91           | 1      | 0.34    |
| Retired                          | 0.05        | 0.07          | 0.03           | 0      | 0.22    |
| Hourly wage (€)                  | 16.7        | 14.4          | 18.7           | 15.5   | 6.3     |
| Years of education               | 12.3        | 10.5          | 14             | 12     | 2.47    |
| Good health                      | 0.84        | 0.8           | 0.88           | 1      | 0.37    |
| Work experience                  | 21.7        | 24.6          | 19             | 22     | 10.3    |
| Savings before retirement (€)    | 4,334       | 3,303         | 5,289          | 3,101  | 6,263   |
| Net wealth before retirement (€) | 105,639     | 92,283        | 118,000        | 52,102 | 123,540 |

For our analysis, we use information on employment (full-time or non-employment),<sup>4</sup> retirement status, gross wages, work experience, years of education, binary health status, net wealth, and savings. Education is measured as years of education and we use this variable to define two groups: years  $\geq 12$  and years  $< 12$ .<sup>5</sup> Work experience is defined as years of full-time experience, where one year of pre-sample part-time experience is counted as half a year of full-time experience. Wealth information is contained in the SOEP only every 5 years. In 2007, the information comprises market values of real estates, financial assets, building loan contracts, private insurances, business assets, tangible assets, consumer debts, and overall debts. We compute net wealth by combining the information on gross wealth and debts. The variable is imputed for the other survey years when it is unobserved.<sup>6</sup>

We follow the approach of Schündeln (2008) defining total savings are defined as the sum of financial and real savings. The SOEP participants indicate their financial savings annually by answering a question about the “usual” amount of monthly savings.<sup>7</sup> Real

<sup>4</sup>Employment is defined as working at least 20 hours per week and median hours of work for the employees is 40. Note, only very few men work part-time and they are considered to be non-employed.

<sup>5</sup>The SOEP constructs the years of education variable from respondents’ information on the obtained level of education and adds some time for additional occupational training.

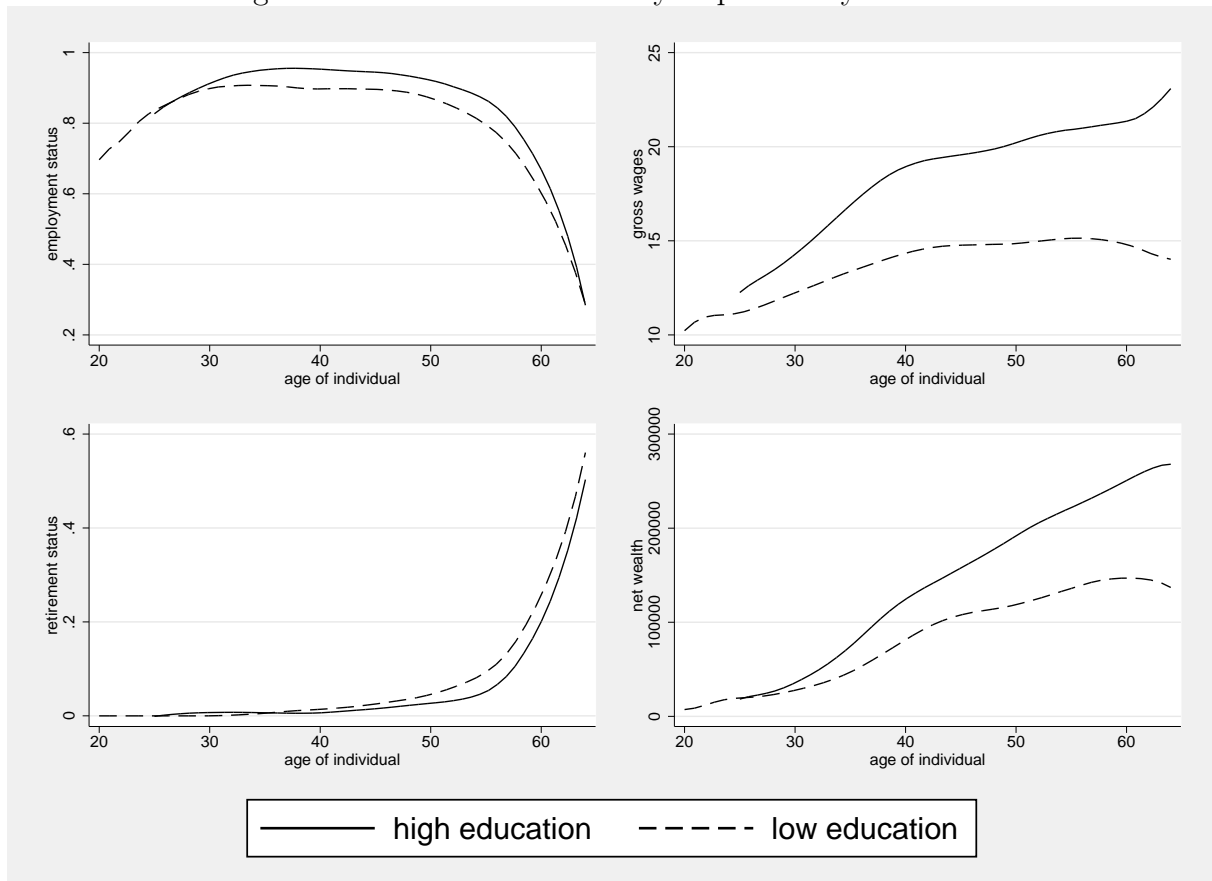
<sup>6</sup>This is done by using information on saving behavior and carrying forward net wealth under some assumptions from the year 2007 to the other survey years. We assume that individuals borrow at a real interest rate of 6% and receive a real interest rate of 2% on both their financial and real savings. Moreover, we take into account observed capital losses. In order to make the wealth measure consistent with our model assumptions, we introduce a censoring such that individuals always have non-negative wealth and can have at most as much wealth as they could possibly have accumulated within our life cycle model until their respective ages.

<sup>7</sup>Question: “Do you usually have an amount of money left over at the end of the month that you can save for larger purchases, emergency expenses or to acquire wealth? If yes, how much?”

savings are defined as annual amortization payments.<sup>8</sup> Since saving information in the SOEP is left-censored (dissavings are unobserved), we assume that working individuals aged 20 to 64 have non-negative net savings over the period of a whole year and make assumptions on the dissavings of the unemployed and retirees. In particular, unemployed individuals are assumed to dissave in the case that they are not eligible for unemployment insurance benefits and fail the means test required for social assistance benefits.<sup>9</sup> Retirees are assumed to annuitize their accumulated net wealth.

In Figure SWA.2 we present employment and retirement rates, gross hourly wages and accumulated net wealth by age. We present these statistics by education. As expected the high educated have higher employment rates, higher wages and higher accumulated assets.

Figure SWA.2: Estimated life cycle profiles by education



<sup>8</sup>Since the SOEP question asks for the sum of amortization and interest payments, the share of interest payments must be derived from information on the amount of debts.

<sup>9</sup>These individuals receive an income at the minimum income level (social assistance benefits) that is deducted from their net wealth, where €10,000 are exempted from the means test that is required for social assistance benefits. The exemption level of €10,000 is assumed because the actual rules are very complicated and enforcement of these rules is unobserved.



### SWA.3 Estimation method and parameter estimates

We estimate our model by the method of maximum likelihood. In a first step, we implement a sequential and inefficient Expectation-Maximization algorithm in order to obtain good starting values for a subsequent full information maximum likelihood (FIML) procedure (as proposed by Arcidiacono and Jones, 2003). Using good starting values, the maximum of the log-likelihood function can be found easily by conventional optimization routines supplying a numerical gradient and a BHHH Hessian (see Appendix for details). Table SWA.2 shows the estimates obtained from the efficient FIML estimation procedure.

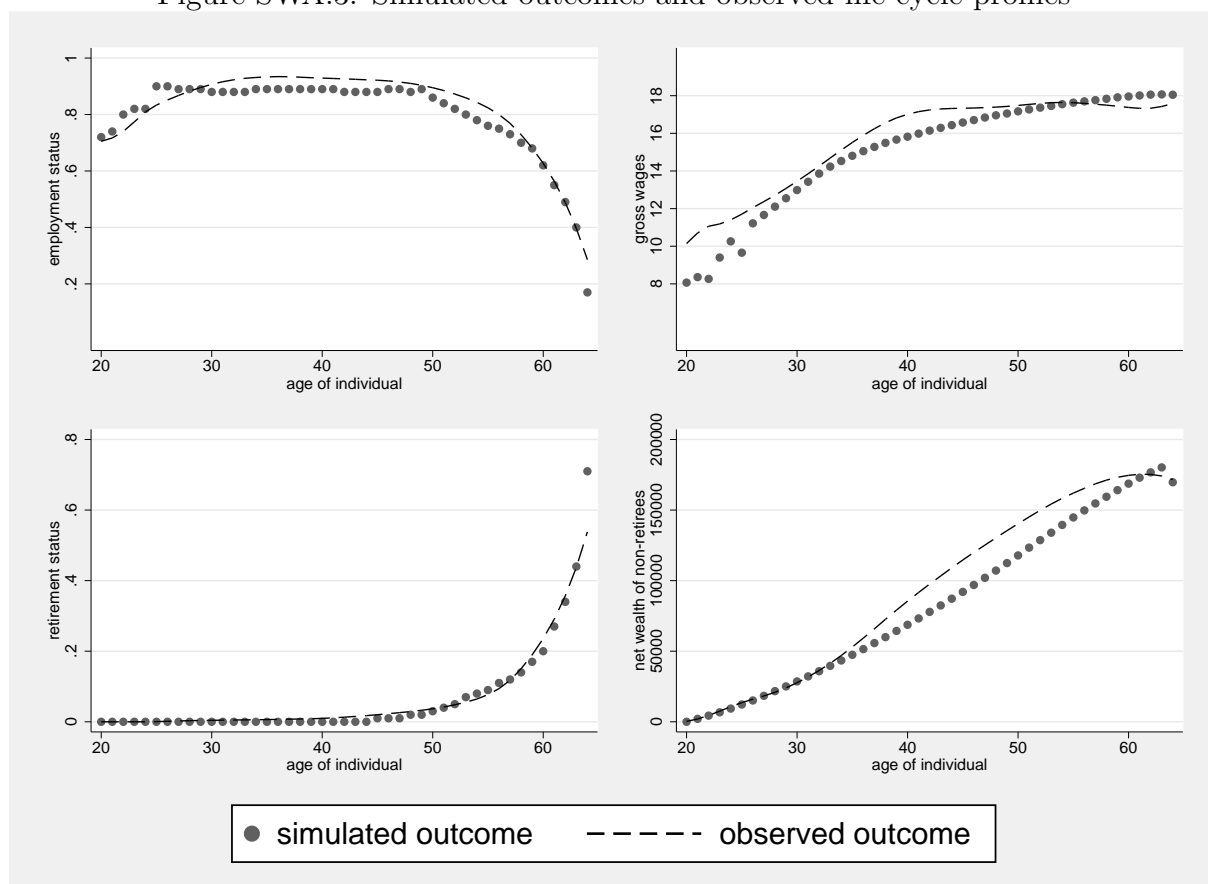
Table SWA.2: Parameter estimates of FIML estimation

|  | Estimates | St.e.    |
|--|-----------|----------|
| $\alpha_1$ (scaling factor)                    | 3.911     | (0.0694) |
| $\alpha_{21}$ (work, type 1)                   | -2.638    | (0.0662) |
| $\alpha_{22}$ (work, type 2)                   | -1.564    | (0.0573) |
| $\rho_1$ (crra, type 1)                        | 0.424     | (0.0298) |
| $\rho_2$ (crra, type 2)                        | 0.641     | (0.0241) |
| <b>Wage equation:</b>                          |           |          |
| $\kappa_1$ (constant, type 1)                  | 1.925     | (0.0103) |
| $\kappa_2$ (constant, type 2)                  | 1.475     | (0.0102) |
| $\delta_1$ (years of education / 10)           | 0.566     | (0.0063) |
| $\delta_2$ experience*(educ<12)                | 0.194     | (0.0055) |
| $\delta_3$ experience <sup>2</sup> * (educ<12) | -0.026    | (0.0012) |
| $\delta_4$ experience*(educ≥12)                | 0.273     | (0.0058) |
| $\delta_5$ experience <sup>2</sup> * (educ≥12) | -0.039    | (0.0013) |
| $\sigma_\mu$ (standard deviation)              | 0.23      | (0.0008) |
| <b>Job offers and separations:</b>             |           |          |
| $\phi_1$ (separation, constant)                | -2.464    | (0.0888) |
| $\phi_2$ (separation, high educ)               | -0.22     | (0.0678) |
| $\phi_3$ (separation, good health)             | -0.901    | (0.088 ) |
| $\phi_4$ (separation, age≥50)                  | 0.63      | (0.0932) |
| $\phi_5$ (separation, age≥60)                  | 1.151     | (0.1155) |
| $\phi_6$ (offer, constant)                     | -2.006    | (0.1031) |
| $\phi_7$ (offer, high educ)                    | -0.846    | (0.0624) |
| $\phi_8$ (offer, good health)                  | 2.155     | (0.1264) |
| $\phi_9$ (offer, age≥50)                       | -1.785    | (0.0966) |
| $\phi_{10}$ (offer, age≥60)                    | -0.822    | (0.2012) |
| <b>Type probabilities:</b>                     |           |          |
| $\gamma_1$ (prob. of type 1)                   | 0.517     | (0.0106) |

The estimates suggest significant unobserved heterogeneity in both the coefficient of

relative risk aversion and the disutility of work. The more productive individuals of type 1 (larger constant in the wage equation) are estimated to be less risk averse. The returns to one additional year of education are 5.7% and the high educated are estimated to have larger returns to work experience than the low educated. Health status strongly affects the job offer and separation rates while education only exerts a significant effect on the probability of receiving a job offer. For individuals with age  $\geq 50$  and even more for age  $\geq 60$ , the probability of job separations rises and the probability of job offers decreases. The estimated probability of being of type 1 suggests that about half of the individuals in the population are of type 1, while the other half is of type 2.

Figure SWA.3: Simulated outcomes and observed life cycle profiles



Using the point estimates of the parameters, we simulate a sample of 10,000 synthetic individuals. The simulations start between age 20 and 26 (depending on education). Initial conditions are drawn from the empirical distribution of education and the estimated distribution of unobserved types. Individuals are assumed to be in good health status before entering the labor force. Choices and random transitions of state variables are based on the respective probabilities and pseudo-random draws from the uniform distribution.

Life cycle paths of state variables, social security contributions, tax payments, and received benefits are saved.

## **SWA.4 Additional consistency checks**

### **SWA.4.1 Behavioral responses**

Similar to Low and Pistaferri (2010) we show that the implications of the model are consistent with previous literature exploiting pension reforms directly for identification. Table SWA.3 shows the simulated effects of five counterfactual scenarios. These simulation outcomes allow checking the model's consistency with respect to the behavioral margins that are most relevant for our analysis. We consider two behavioral outcomes: the change in (a) retirement age and (b) accumulated net wealth at age 60.

First, we simulate the abolishment of early retirement disincentives that penalize individuals who opt for early retirement by up to 18 % of their annual pension benefits (0.3% reduction per month of early retirement). This induces substantial behavioral responses (composed of a substitution and income effect). Second, we simulate the pure income effect of the abolishment of the early retirement disincentives by giving individuals a lump sum increase on their pension benefits that equals the average rise in pension benefits that individuals would have enjoyed without behavioral responses to the abolishment of the disincentives (average income effect: +439€ p.a.). The income effects on individual behavior appear to be fairly small in comparison to the substitution effect. This finding is consistent with credible reduced form evidence by Manoli et al. (2011). Relying on policy changes for identification, they estimated social security wealth and accrual elasticities in individuals' retirement decisions in Austria.

In the third scenario, the statutory pension age is raised by one year from age 65 to 66 while other threshold values are kept constant. This induces an average postponement of retirement by 0.63 years. The predictions are in line with findings by Mastrobuoni (2009). Mastrobuoni exploits a policy change in the U.S. that increased the national retirement age (NRA) from 65 to 67 and raised the penalty for claiming retirement benefits before the NRA. He estimates that an increase in the NRA by 2 months delays effective retirement by around 1 month. At last, we simulate an increase in individuals' life expectancies by five years. The simulations suggest that individuals postpone retirement by about 2 months and build up a larger wealth stock.

Table SWA.3: Simulated treatment effects

| Outcome                             | Abolishment of early retirement disincentives |                                 |
|-------------------------------------|---|---------------------------------|
|                                     | Income & substitution effect                  | Pure income effect (€ 439 p.a.) |
| $\Delta E(\text{retirement age})$   | -0.46   | -0.06                           |
| $\Delta E(\text{wealth at age 60})$ | € +1,331                                      | € -209                          |
|                                     | Pension age +1 year                           | Life expectancy +5 years        |
|                                     |   |                                 |
| $\Delta E(\text{retirement age})$   | 0.63  | 0.17                            |
| $\Delta E(\text{wealth at age 60})$ | € -1,180                                      | € +1,346                        |