Pension Reform with Variable Retirement Age – A Simulation Analysis for Germany‡

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Abstract

Germany has introduced in 2007 a pension reform which increases the normal retirement age between 2012 and 2029 from currently 65 to 67 years. The present study aims to quantify the macroeconomic, welfare and efficiency consequences of this reform by means of a computable general equilibrium model with overlapping generations. Our model features the most recent demographic projections for Germany and distinguishes three skill classes with different life expectancies within generations. Most importantly, individuals chose their effective age when they exit from the labor market and start receiving pension benefits.

Our quantitative analysis indicates three central results: First, the previously implemented pension reductions are not able to stabilize long-run contribution rates and increase old-age poverty rates in Germany considerably. Second, the considered reform of 2007 will increase effective retirement by about 11 months and redistribute towards future cohorts. However, it will also further increase old-age poverty since rich people are more flexible in adjusting retirement. Overall, the efficiency gains of the reform are very modest. Third, reform packages which aim to reduce old-age poverty may even harm future cohorts and come with significant efficiency cost.

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1 Introduction

Almost all countries of the Western world are confronted with a rapidly ageing population which places considerable pressure on the sustainability of pay-as-you-go financed social security systems. With respect to the pension system, the financial problems are exacerbated by the fact that despite the rise in life expectancy, the effective age of retirement has been steadily decreasing for decades. Within OECD countries, pension ages for men have declined by 2.5 years between 1958 and 1999 to just under 62 on average. While the decline was smaller for women, their pension age was some 1.5 years lower than that for men in 1999. Due to earlier retirement and longer lives the average amount of time spent in retirement in OECD countries increased by 5.6 years between 1958 and 1999, see OECD (2009).

At least partly, the described trend towards early retirement was due to the fact that governments had implemented generous early retirement schemes as a means to fight unemployment during the 1980s and 1990s. However, the cost of these programs rose quite dramatically in an ageing society since they increase pension-related spending while at the same time reduce tax revenues to finance retirement.[1] As a consequence, the positive view of early retirement has changed considerably in recent years. Nowadays it is a key policy objective in many countries to encourage labor force participation and employment of older workers through increases in the normal retirement age (NRA) and reductions in early retirement incentives. On theoretical grounds it has been even argued that such a policy may yield a double dividend since it may – if designed properly – improve the resource allocation between and within generations and increase economic efficiency, see Cremer and Pestieau (2003).

The purpose of the present paper is to analyze the most recent pension reform in Germany intended to increase future retirement ages. The situation in Germany is of particular interest for at least three reasons. First, in contrast to other countries, Germany's pension system features a tight tax-benefit linkage so that labor supply distortions at the intensive margin are relatively small. Second, various pension reforms implemented in the recent past have reduced early retirement incentives and introduced adjustment factors for early and delayed retirement. As a consequence, distortions at the extensive labor supply margin have decreased considerably and the effective retirement age has increased in recent years. Third, due to fairness considerations the most recent reform is very unpopular among the German population. There is a widespread fear that especially those with physically demanding and often low-paid jobs are the main losers since they are not able to adjust their

[1] Herbertsson and Orzag (2003) estimated an early retirement burden which amounts to 10 percent of GDP in year 2010 within the OECD.

retirement behavior.[2]

The present reform is the last of four major pension reforms which can be described by three central elements: higher retirement ages, significant benefit cuts and the introduction of tax-favored funded private pensions. Already the reform of 1992, which became fully effective after the year 2004, introduced an actuarial reduction for early and an actuarial increase for deferred retirement. The adjustment factors are 3.6 per cent for each year (or 0.3 per cent per month) of retirement before normal retirement age 65 and 6 per cent for each year (or 0.5 per cent per month) of retirement after age 65. These adjustments are in addition to reductions (increases) due to fewer (longer) contribution years.[3] It should be highlighted that the applied adjustment factors are still heavily disputed. Breyer and Kifmann (2002) show that with actuarially fair benefit adjustment (i.e. the present value of pension benefits is independent of retirement age) a delay in retirement age will increase long-run contribution rates. Berkel and Börsch-Supan (2004) argue that actuarially fair adjustment may distort the participation decision at the end of working life. They propose to increase the adjustment factors in order to facilitate an undistorted retirement age. Finally, Breyer and Hupfeld (2010) criticize the whole concept of neutrality or "marginal fairness" by referring to the fact that income and life expectancy are correlated. Before the discussion came to an end and the adjustment factors were fully implemented, the pension reform of 2001 brought a radical change in the pension provision paradigm from a defined benefit towards a defined contribution scheme. It introduced ceilings for future contribution rates (20 per cent up to 2020 and 22 per cent up to 2030) which should be achieved by adjustments in the pension indexation formula. In order to compensate for future cuts in public pensions, the reform introduced heavily subsidized (and regulated) individual retirement accounts ("Riester pensions"). Soon it became clear that the adjustment of the indexation formula would not suffice to stay within the contribution rate limits. Consequently, the reform of 2004 introduced the so-called sustainability factor which links the current pension benefit to the ratio of pensioners and contributors. As a consequence, the future rise in the dependency ratio will partially translate into a lower replacement rate and a higher contribution rate depending on a weighting factor which is build into the system. This should insure that the system stays within the contribution rate limits specified above.[4] In order to stabilize the system in years after 2030, the latest pension reform of 2007 introduced an announced and gradual

[2]For example, Scheubel, Schunk and Winter (2009) report of opinion polls which show that about 80 to 90 per cent of the population oppose this reform.

[3]For a more detailed discussion of the implementation and special provisions see Berkel and Börsch-Supan (2004).

[4]For a more detailed description and analysis of these reforms see Fehr and Habermann (2006) and Börsch-Supan, Reil-Held and Schunk (2008).

increase of the normal retirement age from 65 to 67. Starting in 2012 and the birth cohort 1947, the NRA will increase initially by one month per year and birth cohort and later by two months per year and birth cohort. Consequently, the birth cohort of 1958 faces a NRA of 66, while cohorts born 1964 and later face a NRA of 67.

Of course, the reform will dampen the increase in future contribution rates. This will alter the intergenerational distribution and generate positive efficiency effects from improved labor supply incentives. However, the quantitative results crucially depend on the induced changes in retirement behavior within and across generations, since they determine the future structure of benefits. If, for example, the cohort born in 1964 would retire in year 2029 (i.e. at age 65) it has to accept a benefit reduction of 7.2 percent, while a deferral of retirement by two years would yield full pension benefits.[5] In addition, with differing life expectancies the benefit adjustment cannot be actuarially fair and the higher NRA will affect retirement behavior of different types of individuals within a cohort quite differently. Not surprisingly, Berkel and Börsch-Supan (2004) estimate that the considered reform will increase average retirement ages of men by nine months while women will even retire one month earlier.

Such differential changes in retirement behavior also indicate substantial differences in intragenerational welfare changes and the aggregate efficiency effects of the reform. In order to isolate and quantify these effects, the present study applies a general equilibrium model with overlapping generations in the Auerbach-Kotlikoff (1987) tradition which takes into account the demographic transition in Germany as well as endogenous retirement choices. The latter is the central innovation of the present study. Among others, Fehr (2000), Beetsma, Bettendorf and Broer (2003), Kotlikoff, Smetters and Walliser (2007) as well as Catalan, Guajardo and Hoffmaister (2010) also quantify the macroeconomic and welfare consequences of an increase in the eligibility age for social security. However, the retirement choice in these models is very artificial. Given an exogenous age when they start receiving pension benefits, agents can only decide at what age they quit working. In order to achieve the withdraw from the labor force exactly when agents receive social security benefits, either a significant drop in productivity or a dramatic increase in marginal labor income taxes (due to an earnings test) is assumed. This approach has mainly two disadvantages. First, the drop in individual productivity around retirement is at odds with empirical evidence which shows only a modest decline in productivity between ages 60 and 70, see French (2005). Second, and even more important, since agents have no choice when to draw their pension claims, social security rules which affect the retirement choice can't be captured satisfactory by these models.

[5] A similar phased-in increase in the NRA from 65 to 67 is currently also implemented in the U.S. However, due to the different pension formula, the final benefit reduction amounts to 10 per cent (Mastrobuoni, 2009).

Consequently, recent studies have introduced models where individuals optimize the retirement age when they quite working and start to receive their pensions. Fehr, Sterkeby and Thøgersen (2003) analyze early retirement incentives of the Norwegian pension system in a model with variable labor supply that distinguishes five income classes within a generation. The initial pension system consists of a flat tier and an earnings-based supplementary benefit and includes a very generous early retirement scheme so that retirement ages increase with rising income level from age 62 to age 68. The study then computes the long-run impact of various pension reforms on retirement behavior and welfare of the five income classes. As it turns out, reforms which increase retirement age also have a positive long-run welfare impact. While Fehr et al. (2003) concentrate on long-run effects of labor supply at the intensive and the extensive margin, Sánchez-Martín (2008) includes a demographic transition but only allows for an endogenous retirement choice. The study compares various reforms of the Spanish pension system aimed to improve sustainability. Eisensee (2005) combines endogenous labor supply at the intensive and the extensive margin, includes population ageing along the transition path and considers differential mortality among three income classes in a closed economy model. Comparing a tax increase, a reduction of the replacement rate and an increase in the NRA necessary to retain financial sustainability of the U.S. pension system, the study distinguishes between the direct effect and the general equilibrium effect on retirement behavior. While the former quantifies the impact of the policy in a partial equilibrium framework, the latter also captures the impact of induced changes in wages and interest rates. It turns out that in the first two options considered the indirect effect increases retirement substantially stronger than the direct effect. This finding indicates that partial equilibrium studies of retirement behavior could be quite misleading. However – and in contrast to Fehr et al. (2003) – Eisensee (2005) does not compare the welfare consequences of alternative policy options with endogenous retirement.

This is where the present study steps in. Building on Kallweit (2009), we quantify macroeconomic but also welfare and efficiency consequences of the phased-in NRA increase in Germany. Our results indicate that the previously implemented pension reforms which reduced benefits quite considerably are not able to stabilize long-run contribution rates. In addition, the declining pension level will increase future old-age poverty rates. The considered reform of 2007 will increase the retirement age by 10.8 months on average. Although the reform redistributes towards future cohorts, it will further increase old-age poverty. Reform packages which aim to reduce the latter come at significant efficiency cost and may even harm future cohorts.

The next section presents the general equilibrium model which is applied for the quantitative analysis. Then we discuss the calibration of the baseline path. Section four reports the results from the simulation exercises and section five concludes.

2 The model economy

2.1 Demographics and intracohort heterogeneity

We consider an economy populated by overlapping generations of individuals with the (exogenous) skill level $s \in \mathcal{S} = \{1, \ldots, S\}$. The skill level s determines the individual productivity e_j and affects individual mortality which will also depend on the date of birth (i.e. labor market entry). Consequently, individuals age $j \in (1, \ldots, J)$ may live up to a maximum possible lifespan of J periods, where individual lifespan uncertainty is measured by $\psi^s_{t,j} \leq 1$ the period-dependent conditional survival probability from age $j-1$ to age j of skill type s and $\psi^s_{t,J+1} = 0$. At the beginning of each period t, a new generation is born where we assume a population growth rate n_t.

Our model is solved recursively. Consequently, an age-j agent faces the individual state vector

$$z_j = (s, \mathrm{a}_j, ep_j, rz_j) \tag{1}$$

where $\mathrm{a}_j \in \mathcal{A} = [0, \infty]$ denotes assets held at the beginning of age j, $ep_j \in \mathcal{P} = [0, ep^{max}]$ defines agent's accumulated earning points for public pension claims and $rz_j \in \mathcal{R} = \{0, 1\}$ reveals whether the household is already retired (i.e. receives pension benefits with $rz_j = 1$) or is still working ($rz_j = 0$) at age j. The skill level s determines a specific productivity level at each age j which is exogenously specified and described below. Consequently, in each period t, the age-j cohort is fragmented into subgroups $\xi_t(z_j)$, according to the initial distribution at age $j = 1$ as well as mortality, population growth and optimal household decisions. Let $X_t(z_j)$ be the corresponding cumulated measure to $\xi_t(z_j)$. Hence,

$$\int_{\mathcal{S}} \mathrm{d}X_t(z_1) = 1 \quad \text{with } z_1 = (s, 0, 0, 0) \tag{2}$$

must hold since we have normalized the cohort size of initial newborns to be unity. Let $\mathbf{1}_{h=x}$ be an indicator function that returns 1 if $h = x$ and 0 if $h \neq x$. Let $Z_t = (\xi_t(z_j), \Psi_t)$ denote the state of the economy at the beginning of period t, where Ψ_t defines the known policy schedule of the government at t. Then, the law of motion of the measure of households is,

$$\xi_{t+1}(z_{j+1}) = (1 + n_{t+1})^{-1} \int_{\mathcal{C}} \psi^s_{t+1,j+1} \times \mathbf{1}_{s=s(z_j,Z_t)} \times \mathbf{1}_{a_{j+1}=a_{j+1}(z_j,Z_t)} \times \mathbf{1}_{ep_{j+1}=ep_{j+1}(z_j,Z_t)} \times \mathbf{1}_{rz_{j+1}=rz_{j+1}(z_j,Z_t)} \times \mathrm{d}X_t(z_j). \tag{3}$$

where we have set $\mathcal{C} = \mathcal{S} \times \mathcal{A} \times \mathcal{P} \times \mathcal{R}$ for the sake of simplification. In the following, we will omit the time index t and the state indices z_j and Z_t for every variable whenever possible. Agents are then only distinguished according to their age j.

2.2 Budget constraints and bequests

The budget constraint is defined as follows:

$$\mathrm{a}_{j+1} = \mathrm{a}_j(1+r) + w_j + p_j + b_j + v_j - \tau \min[w_j, 2\bar{w}] - T(y_j^l, y_j^r) - (1+\tau_c)c_j \tag{4}$$

with $\mathrm{a}_1 = \mathrm{a}_{J+1} = 0$ and $\mathrm{a}_j \geq 0$ since we assume borrowing constraints. In addition to interest income from savings $r\mathrm{a}_j$, households receive gross labor income $w_j = w(1-\ell_j)e_j$ during their working period as well as public pensions p_j during retirement. As time endowment is normalized to one, ℓ_j defines leisure consumption and w the wage rate for effective labor. At specific ages households additionally receive accidental bequests b_j and in specific simulations they receive lump-sum transfers v_j which are explained below. Households have to pay social security contributions and income taxes. Due to a contribution ceiling which amounts to the double of average income $\bar{w}$, the contribution rate τ is not applied to income above the ceiling. Income taxes depend on taxable labor income y_j^l, taxable capital income y_j^r, and the tax schedule $T(\cdot)$. Finally, the price of consumption good c_j includes consumption taxes τ_c. Of course, leisure can only be consumed up to the time endowment, i.e. $\ell_j \leq 1$.

Our model abstracts from annuity markets. Consequently, private assets of all agents who died are aggregated and then distributed equally among all working age cohorts younger than the earliest age of retirement and skill groups. Consequently,

$$b_j(z_j, Z_{t+1}) = \frac{\Gamma}{(1+n_{t+1})(1+\lambda)} \sum_{i=1}^{J} \int_{\mathcal{C}} (1-\psi_{i+1}^s)(1+r_{t+1})\mathrm{a}_{i+1}(z_i, Z_t)\mathrm{d}X_t(z_i), \tag{5}$$

where Γ is the inverse of the sum of the working population below the earliest age of retirement and λ measures technological progress.

2.3 Individual preferences and the decision to retire

Our model assumes a preference structure that is represented by a time-separable, nested CES utility function. Individual period utility depends on consumption of goods c_j and leisure ℓ_j and is defined by

$$u(c_j, \ell_j) = \frac{1}{1-\frac{1}{\gamma}} \left[c_j^{1-\frac{1}{\rho}} + \alpha \ell_j^{1-\frac{1}{\rho}} \right]^{\frac{1-\frac{1}{\gamma}}{1-\frac{1}{\rho}}}, \tag{6}$$

where ρ denotes the intratemporal elasticity of substitution between consumption and leisure at each age j and γ defines the intertemporal elasticity of substitution between consumption and leisure in different years, while α is the age-independent leisure preference para-meter.

Households maximize intertemporal utility by taking into account the budget constraint (4). Technically, this decision problem is solved recursively. Consumption, leisure and assets are chosen in order to maximize the utility function

$$V(z_j) = \max_{c_j, \ell_j} \quad \left\{ u\left(c_j, \ell_j\right) + \psi^s_{j+1} \beta V(z_{j+1}) \right\}, \tag{7}$$

where β defines the time discount factor and $\ell_j = 1$, if the household is already retired.

At the beginning of each period of the retirement window $[\underline{j}; \bar{j}]$, households have to decide whether to retire or not, i.e. change their status from $rz_j = 0$ to $rz_j = 1$. We assume retirement to be a one-time, irreversible decision.[6] The retirement decision is made similarly to the college choice in Heckman, Lochner and Taber (1998) via a comparison of utilities. Let $V(z^0_j)$ and $V(z^1_j)$ denote utilities from being in the labor force and being retired at age j. Consequently we let

$$\left[\frac{V(z^1_j)}{V(z^0_j)}\right]^{\frac{1}{1-\frac{1}{\gamma}}} - 1 - \epsilon_z$$

the consumption equivalent variation of retiring, where $\epsilon_z \sim N(\mu, \sigma^2)$ captures additional non-pecuniary (i.e. psychological) gains or cost from retirement which are not observed by the model. We assume that those costs are normally distributed within each skill class with mean μ and variance σ^2. Due to the law of large numbers, we can now compute the fraction of households that decide to retire from

$$P\left(\left\{\left[\frac{V(z^1_j)}{V(z^0_j)}\right]^{\frac{1}{1-\frac{1}{\gamma}}} - 1 - \epsilon_z\right\}\right) = \Phi_{\mu,\sigma^2}\left(\left[\frac{V(z^1_j)}{V(z^0_j)}\right]^{\frac{1}{1-\frac{1}{\gamma}}} - 1\right).$$

The optimal retirement age j_R of an individual is then defined as the youngest age j where rz_j is equal to one.

2.4 The production side

Firms in this economy use capital and labor to produce a single good according to a Cobb-Douglas production technology $Y_t = \varrho K_t^{\epsilon} L_t^{1-\epsilon}$ where Y_t, K_t and L_t are aggregate output, capital and labor in period t, respectively, ϵ is capital's share in production, and ϱ defines a technology parameter. Capital depreciates at a constant rate δ_k and firms have to pay corporate taxes $T_{k,t} = \tau_k \left[Y_t - w_t L_t - \delta_k K_t\right]$ where the time-invariant corporate tax rate τ_k is applied to the output net of labor costs and depreciation. Firms maximize profits renting capital and hiring labor from households so that net marginal products equal r_t the interest rate for capital and w_t the wage rate for effective labor.

[6] A similar simplification is assumed by Eisensee (2005) and Sanchez-Martin (2008).

2.5 The government sector

The tax system

Our model distinguishes between the tax system and the pension system. In each period t the government issues new debt $(1+n_{t+1})(1+\lambda)B_{G,t+1} - B_{G,t}$ and collects taxes from households and firms in order to finance general government expenditure G, which is fixed per capita, as well as interest payments on its debt,[7] i.e.

$$(1+n_{t+1})(1+\lambda)B_{G,t+1} - B_{G,t} + T_{y,t} + T_{k,t} + \tau_{c,t}C_t = G + r_t B_{G,t}, \tag{8}$$

where revenues of income taxation are computed from

$$T_{y,t} = \sum_{j=1}^{J} \int_{\mathcal{C}} T(y_j^l(z_j, Z_t), y_j^r(z_j, Z_t)) \mathrm{d}X_t(z_j)$$

and C_t defines aggregate consumption (see (21)). The intertemporal budget is balanced by consumption taxation.

Our model takes into account the transition towards deferred taxation of pension benefits in Germany introduced in 2005. Consequently, taxable labor income y_j is computed from gross labor income net of (a fraction κ_1 of) pension contributions and a work related allowance $d(w_j)$ and – after retirement – (a fraction κ_2 of) public pensions.

$$y_j^l = \max[w_j - \kappa_1 \tau \min[w_j, 2\bar{w}] - d(w_j); 0] + \kappa_2 p_j. \tag{9}$$

Furthermore, we apply a fixed saving allowance d_s, so that taxable interest income is given by

$$y_j^r = \max[ra_j - d_s, 0]. \tag{10}$$

Given taxable income, we apply the German progressive tax code of 2005 to labor income and assume that all households are married couples (i.e. full income splitting). Interest income, however, is taxed at a constant rate τ^r which reflects the flat capital income tax recently introduced in Germany. A solidarity surcharge of 5.5 percent is applied to the final tax burden. Consequently,

$$T(y_j^l, y_j^r) = 1.055 \times (2 \times T05(y_j^l/2) + \tau_r y_j^r).$$

[7]We assume a debt to output ratio of 60 percent in 2008. Afterwards, we keep government debt constant per capita.

The pension system

In each period t, the pension system pays old-age benefits and collects payroll contributions from labor income below the contribution ceiling $2\bar{w}_t$. Individual pension benefits p_j of a retiree of age $j \geq j_R$ in a specific year are computed from the product of the adjustment factor $\nu(j_R)$ which depends on the individual retirement age j_R, earning points ep_{j_R} he has accumulated until retirement age and the actual pension amount (APA) per earning point:

$$p_j = \nu(j_R) \times ep_{j_R} \times APA. \tag{11}$$

Accumulated earning points of the pension system depend on the relative income position $w_j/\bar{w}$ of a worker. Since the contribution ceiling is fixed at the double of average income $\bar{w}$, maximum earning points collected per year are 2. Therefore, earning points accumulate according to

$$ep_{j+1} = ep_j + \min[w_j/\bar{w}; 2], \tag{12}$$

where $ep_1 = 0$.

Finally, the actual pension amount APA_t is adjusted according to

$$APA_t = APA_{t-1} \times \frac{w_{t-1}L_{t-1}(1-\tau^p_{t-1}-\tau_{t-1})}{w_{t-2}L_{t-2}(1-\tau^p_{t-2}-\tau_{t-2})} \times \left\{1 + 0.25 \times \left(1 - \frac{PR_{t-1}}{PR_{t-2}}\right)\right\}. \tag{13}$$

Equation (13) reflects the central elements of the adjustment formula which was introduced by the pension reforms 2001 and 2004. Since then, changes in the actual pension amount are related to lagged changes of an artificial income concept which is computed from gross labor earnings net of fictive contributions τ^p (which amount to 3 percent before and 4 percent after 2008) to the private pension scheme and actual contributions to the public pensions. The last part of (13) reflects the sustainability factor where $PR_t = P_t/\tilde{L}_t$ defines the pensioners ratio which measures the ratio of retired to working households of a specific year.[8] Since this pensioners ratio will increase in the future, the adjustment factor will decrease future benefits. However, the impact of the rising dependency ratio is dampened by the weight 0.25. It is important to note here that any delay in retirement induced by the reform of 2007 will dampen the sustainability factor.

The budget of the pension system must be balanced in ever period by adjusting the contribution rate. Consequently, the budget of the pension system is given by

$$PB_t = \tau_t PC_t \tag{14}$$

[8] Strictly speaking, the pensioners ratio is computed in practice from the standardized numbers of "equivalence pensioners" and "equivalence contributers" derived from (fictive) standard pensions and average earnings.

where

$$\begin{aligned}
PB_t &= \sum_{j=\underline{j}}^{J} \int_{\mathcal{S}\times\mathcal{A}\times\mathcal{P}\times\{1\}} p_j(z_j, Z_t)\mathrm{d}X_t(z_j) \qquad \text{and} \\
PC_t &= \sum_{j=1}^{\bar{j}-1} \int_{\mathcal{S}\times\mathcal{A}\times\mathcal{P}\times\{0\}} \min[w_j(z_j, Z_t); 2\bar{w}(Z_t)]\mathrm{d}X_t(z_j)
\end{aligned}$$

define aggregate pensions benefits and contributions in period t while

$$P_t = \sum_{j=\underline{j}}^{J} \int_{\mathcal{S}\times\mathcal{A}\times\mathcal{P}\times\{1\}} \mathrm{d}X_t(z_j) \quad \text{and} \quad \tilde{L}_t = \sum_{j=1}^{\bar{j}-1} \int_{\mathcal{S}\times\mathcal{A}\times\mathcal{P}\times\{0\}} \mathrm{d}X_t(z_j) \tag{15}$$

define the numbers of pensioners and workers in a specific year, respectively.

2.6 Welfare and efficiency calculation

In order to compare welfare for a specific individual before and after the reform, we follow Auerbach and Kotlikoff (1987, 87) and compute the proportional increase (or decrease) in consumption and leisure ϕ which would make an agent in the baseline path as well off as after the reform. We can compare all cohorts living in the reform year $t = 1$ and all newborn cohorts along the transition path before and after the reform since they have identical individual state variables. Due to the homogeneity of the utility function (6) and (7) the necessary increase (or decrease) in percent of resources is

$$\phi(z_j, Z_t) = \left\{ \left[\frac{V(z_j, Z_t^1)}{V(z_j, Z_t^0)} \right]^{\frac{1}{1-\frac{1}{\gamma}}} - 1 \right\} \times 100 \tag{16}$$

where Z_t^0 and Z_t^1 indicate that utility of the specific person is measured before and after the reform, respectively. Consequently, a value of $\phi(z_j, Z_t) = 1.0$ implies that this agent would need one percent more resources in the initial baseline path to attain the utility level he receives after the policy reform.

In order to asses aggregate efficiency consequences, we introduce a Lump-Sum Redistribution Authority (LSRA) in the spirit of Auerbach and Kotlikoff (1987, 62f.) as well as Nishiyama and Smetters (2007) or Fehr and Habermann (2008) in a separate simulation. The LSRA treats those cohorts already existing in the initial equilibrium and newborn cohorts differently. To already existing cohorts it pays a lump-sum transfer (or levies a lump-sum tax) $v_j(z_j, Z_1), j > 1$ to bring their expected utility level after the reform back to the level of the initial equilibrium $V(z_j, Z_1^0)$. Since utility depends on age and state, these transfers (or taxes) have to be computed for every agent in the first year of the transition. Consequently, after compensation, their relative welfare change is $\phi^c(z_j, Z_1) = 0.0$. Furthermore, those who enter the labor market in period $t \geq 1$ of the transition receive a transfer $v_1(z_1, Z_t, \phi^c(z_1, Z_t))$ which guaranties them a (compensated) relative consumption change $\phi^c(z_1, Z_t)$ which is identical for all newborn future cohorts. Note that the transfers $v_1(z_1, Z_t, \phi^c(z_1, Z_t))$ may differ among future cohorts but the relative utility change $\phi^c(z_1, Z_t)$ is identical for all. This utility change is chosen by requiring that the present value of all LSRA transfers is zero:[9]

$$\sum_{j=2}^{J} \int_{\mathcal{C}} v_j(z_j, Z_1) \mathrm{d}X_1(z_j) + \sum_{t=1}^{\infty} v_1(z_1, Z_t, \phi^c(z_1, Z_t)) \Pi_{s=2}^{t} (1+n_s)(1+\lambda)(1+r_s)^{-1} = 0.$$

In the first period of the transition the LSRA builds up debt (or assets) from

$$(1+n_2)(1+\lambda)B_{RA,2} = \sum_{j=1}^{J} \int_{\mathcal{C}} v_j(z_j, Z_1) \mathrm{d}X_1(z_j)$$

which has to be adjusted in each future period according to

$$(1+n_{t+1})(1+\lambda)B_{RA,t+1} = (1+r_t)B_{RA,t} - v_1(z_1, Z_t). \tag{17}$$

Of course, LSRA assets are also included in the asset market equilibrium condition (22).

If $\phi^c(z_1) > 0$ ($\phi^c(z_1) < 0$), all households in period one who lived in the previous period would be as well off as before the reform and all current and future newborn households would be strictly better (worse) off. Hence, the new policy is Pareto improving (inferior) after lump-sum redistributions.

2.7 Equilibrium conditions

Given the fiscal policy $\Psi_t = \{G, \tau_k, T(y), B_{G,t}, B_{RA,t}, \tau_{c,t}, \tau_t\} \quad \forall\ t$, a recursive equilibrium path is a set of value functions $\{V(z_j, Z_t)\}_{j=1}^{J}$, household decision rules $\{c_j(z_j, Z_t), \ell_j(z_j, Z_t), rz_j(z_j, Z_t)\}_{j=1}^{J}$, distribution of unintended bequest $\{b_j(z_j, Z_t)\}_{j=1}^{J}$, measures of households $\{\xi_t(z_j)\}_{j=1}^{J}$, and relative prices of labor and capital $\{w_t, r_t\}$ such that the following conditions are satisfied $\forall\ t$:

1. households' decision rules solve the household decision problem (7) subject to the given constraints;

[9] In order to avoid that transfers have liquidity effects at young ages, they are actually given (with interest) to cohorts when they retire or later. Further information on the computation of ϕ^* is available upon request.

2. factor prices are competitive, i.e.

$$w_t = (1-\epsilon)\varrho \left(\frac{K_t}{L_t}\right)^{\epsilon} \tag{18}$$

$$r_t = (1-\tau_k)\left[\epsilon\varrho\left(\frac{L_t}{K_t}\right)^{1-\epsilon} - \delta_k\right] \tag{19}$$

3. in the closed economy aggregation holds,

$$L_t = \sum_{j=1}^{J}\int_{\mathcal{C}}(1-\ell(z_j,Z_t))e_j\,\mathrm{d}X_t(z_j) \tag{20}$$

$$C_t = \sum_{j=1}^{J}\int_{\mathcal{C}} c_j(z_j,Z_t)\mathrm{d}X_t(z_j) \tag{21}$$

$$K_t = \sum_{j=1}^{J}\int_{\mathcal{C}} \mathrm{a}_j\mathrm{d}X_t(z_j) - B_{G,t} - B_{RA,t} \tag{22}$$

   while in the small open economy aggregate capital is derived from (19);

4. the laws of motion (2) and (3) for the measure of households hold;

5. unintended bequests satisfy

$$(1+n_{t+1})(1+\lambda)\sum_{j=1}^{j-1}\int_{\mathcal{C}} b_j(z_j,Z_{t+1})\mathrm{d}X_{t+1}(z_j) =$$
$$\sum_{i=1}^{J}\int_{\mathcal{C}}(1+r_{t+1})\mathrm{a}_{i+1}(z_i,Z_t)(1-\psi^s_{i+1})\mathrm{d}X_t(z_i); \tag{23}$$

6. the budgets of the government, the pension system and the redistribution authority (8), (14) and (17) are balanced in the long-run;

7. the goods market clears, i.e.

$$Y_t = C_t + (1+n_{t+1})(1+\lambda)K_{t+1} - (1-\delta_k)K_t + G \quad \text{(closed economy)}$$
$$Y_t = C_t + (1+n_{t+1})(1+\lambda)K_{t+1} - (1-\delta_k)K_t + G + NX_t \quad \text{(open economy)}$$

   with NX_t as net exports in period t.

3 Calibration of the initial equilibrium

Since we assume a realistic demographic transition, the initial year of the simulation model is not a long-run equilibrium and the reference simulation for the policy reforms is a baseline path of the economy under the existing fiscal system. In order to compute the initial equilibrium and the subsequent baseline path, households of the first year are endowed with a profile of assets and pension claims. In the short run the baseline path mainly depends on the exogenous dynamics of the population structure. In the medium run, the model returns to a stable population structure so that in the long run the economy can converge to a steady state. We provide the economy with 300 years to return to the long run equilibrium. The following subsections discuss the assumed demographic, productivity, preference, technology and fiscal parameters required to solve the model numerically.

3.1 Demographic projections

Since the model's period is one year, agents start economic life at age 20 ($j = 1$) and face a maximum possible life span of 99 years ($J = 80$). In order to derive different skill classes, we have classified individuals between ages 20 and 60 of the years 1984 to 2006 from German Socio-Economic Panel (SOEP) data[10] into three different educational groups ($S = 3$) according to the International Standard Classification of Education (ISCED). For low-skilled we have merge levels 0 to 2 (primary and lower secondary education), levels 3 and 4 (higher secondary and post-secondary education) are merged to middle-skilled and levels 5 and 6 (tertiary education) to high-skilled individuals. In our data set, low-, medium- and high-skilled individuals represent 26, 55 and 19 per cent of the population. These relative shares were also applied in the model. The projection starts in the initial year 2008 with the population vector taken from StaBu (2009b). For the middle-skilled types we apply conditional survival probabilities ψ_j which are computed from the year 2000 Life Tables for Germany reported in Bomsdorf (2003). They yield a (cross-sectional) life expectancy of 79.6 years which fits quite well to the official figure of 79.8 years computed from the 2006/2008 Life Tables (StaBu, 2009b). Since our model takes into account the positive relationship between life expectancy and lifetime income, we adjust the conditional survival probabilities of low- and high-skilled so that their initial life expectancy is 77.1 and 82.1 years, respectively. The assumed 5 year difference in life expectancy between low- and high-skilled is well in line with the results from Reil-Held (2000) and von Gaudecker and Scholz (2007) for Germany. We assume that this mortality difference within skill classes will be retained in the future.

[10] The SOEP data base is described in Wagner, Frick and Schupp (2007).

Table 1: Assumptions for population projections

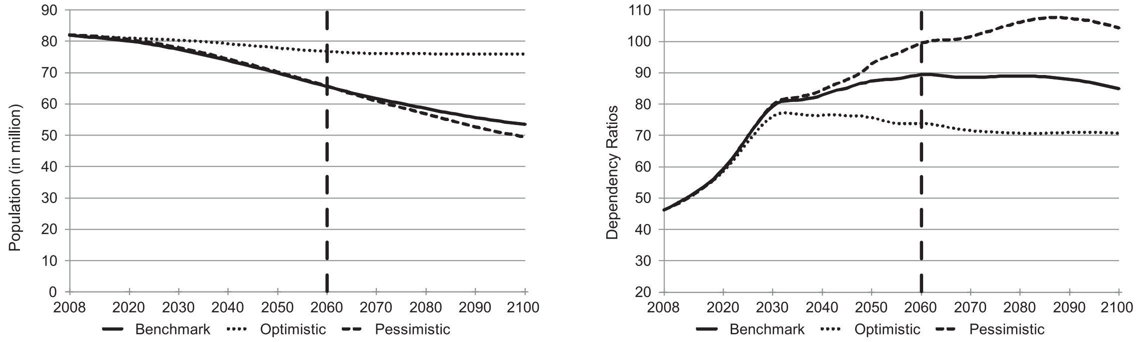
	Scenarios		
	Benchmark	Optimistic	Pessimistic
Birth rate	1.4	1.6	1.2
Life expectancy in 2060 (in years)	86.9 (+7.3)		89.3 (+9.7)
Migration after 2014 (in 1000)	100	200	100

The models population projections are based on the latest population forecast of the German Statistical Office (StaBu, 2009b). This forecast compares fifteen alternative combinations of assumptions with respect to fertility, life expectancy and migration which all end in year 2060. We take one of their "benchmark scenarios" and compare it with two alternative scenarios which we call "optimistic" and "pessimistic". Table 1 reports the differences in the assumptions. Following the official projections, our benchmark scenario assumes that the birth rate remains at 1.4 children per woman until 2060. Afterwards the birth rate adjusts endogenously in order to build up a stable populations structure with zero population growth. Life expectancy increases linearly until year 2060 by 7.3 years to an age of 86.9 years for the middle-skilled households. After year 2060 we assume constant mortality rates. Finally, following StaBu (2009b) we assume that the negative net migration of 50.000 in year 2008 changes gradually again and increases to 100.000 net migrants until year 2014 and beyond.[11] In the optimistic scenario we keep life expectancy constant and assume a higher birth and net migration rate. In the pessimistic scenario we keep net migration constant, but assume – as in StaBu (2009b) – lower fertility combined with a stronger increase in life expectancy. Figure 1 reports the resulting population dynamics in this century.

In 2008, Germany has a population of 82 million people. In the benchmark scenario of the model simulation, this number decreases until 2060 to 65.6 million people. In the optimistic and pessimistic scenarios the German population declines to 76.7 and 65.7 million people, respectively. The corresponding numbers from the StaBu (2009b) projection for 2060 are 64.7, 74.5 and 64.0 million. The right part of Figure 1 shows the development of the dependency ratio, measured by 60 year-old and older to 20-59 year-old. Starting from a ratio of 46.1 in year 2008, this number increases until 2060 to 89.4 (92.3) in the models' (official) benchmark simulation. The respective figures for the optimistic and pessimistic scenario are 73.8 (81.7) and 99.4 (104.8), respectively. Of course, the models' dependency ratio reflects the fact that our immigrants are younger than those of the official projections.

[11] Due to the model structure, we have to assume that all net migrants enter at age 20 (i.e. $j = 1$).

Figure 1: Alternative population projections



3.2 Productivity assumptions

The productivity profile e_j of the three skill classes is of special importance for our quantitative results, since productivity in old age is a decisive determinant of retirement behavior. If productivity of older people declines sharply, retirement behavior will not be affected by the increase in the normal retirement age. However, estimating the productivity of elderly households is complicated by the fact that those with low productivity retire, so that those who remain in the labor force after age 60 represent a biased productivity of the respective cohort. In order to deal with this problem, our productivity estimates are split in two parts, i.e.

$$e_j = \begin{cases} e^{\left(\varsigma_1 + \varsigma_2 \times j + \varsigma_3 \times j^2\right)} (1+\lambda)^{j-1}, & j \leq 60 \\ [\varsigma_4 + \varsigma_5 \times (j-60) + \varsigma_6 \times (j-60)^2](1+\lambda)^{j-1} & j > 60. \end{cases}$$

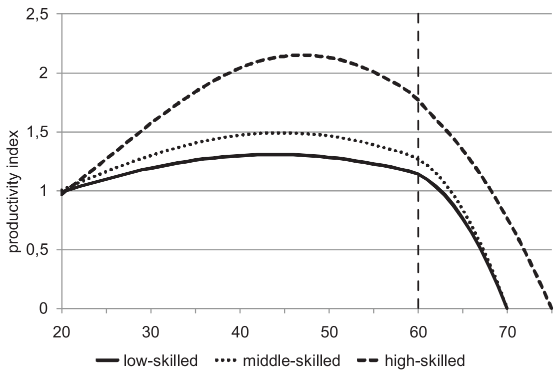
where we also include technological progress which is assumed to cause the time endowment to grow, see Kotlikoff et al. (2007). For individuals up to age 60 we estimate productivity profiles from inflated income data of primary household earners from the German SOEP. Our unbalanced panel data covers full-time workers with a total of 83893 observations which are already divided into the three skill groups explained above. Following the conventional procedure, we correct income for working time and assume that log wages depend on an agent's age and age squared. The resulting parameters are reported in Table 2.

For productivity at and above age 60 we simply assume that it declines in a quadratic fashion until it reaches zero at age 70 and 75 for the low-/middle-skilled and high-skilled, respectively. This procedure yields an average annual productivity decline of 7, 15 and 15 per cent for the low-, middle- and high skilled class after age 60. Consequently, our assumptions are somewhere between the figures in Eisensee (2005) where the respective figures are 8, 19 and

Table 2: Productivity parameters

	ς_1	ς_2	ς_3	ς_4	ς_5	ς_6
Low-skilled	9.6207	0.0437	-0.0500	1.16486	-0.01891	-0.00791
Medium-skilled	9.4190	0.0575	-0.0649	1.30297	-0.02599	-0.00841
High-skilled	8.6649	0.1025	-0.1090	1.83888	-0.05204	-0.00393

Figure 2: Productivity profiles for skill-classes



17 per cent and French (2005) who estimated a productivity decline of 4 per cent in old age from U.S. data. Figure 2 shows the productivity profiles for the different skill classes.

3.3 Preference, technology and fiscal parameters

With respect to the preference parameters, we set the intertemporal elasticity of substitution γ to 0.5, the risk aversion to 2.0, the intratemporal elasticity of substitution ρ to 0.6 and the leisure preference parameter α to 1.5. This is within the range of commonly used values (see Auerbach and Kotlikoff, 1987, Meyer and Meyer, 2005). In order to calibrate a realistic capital to output ratio, the discount factor is set at 0.995 which implies an annual discount rate of about 0.5 percent. Finally, in order to calibrate a realistic retirement behavior, we assume an identical variance σ^2 for all skill classes and adjust the skill-specific expectation value μ as reported in Table 3 below.

As for technology parameters we specify the general factor productivity $\theta = 0.92$ in order to normalize labor income and set the capital share in production ϵ at 0.3 which is quite realistic for Germany. The annual depreciation rate for capital δ_k is set at 4.75 percent which yields – given one per cent productivity growth – a realistic investment ratio. Finally, the rate of technological progress λ is set to one per cent which is slightly below the average trend of

1.3 per cent for the period 1995-2006 reported in Erber and Fritsche (2009) but accounts for the declining trend in productivity growth.

With respect to the fiscal parameters we assume a debt-to-output ratio of 60 percent in 2008 and a corporate tax rate of 15 per cent along the transition path. The annual APA value is chosen in order to derive a realistic contribution rate of 19.9 per cent in the initial equilibrium. As already explained, early retirement is possible starting at age 60, while retirement can be delayed until age 70. In the benchmark path (before the reform) the normal retirement age j_R^n is fixed at age 65. Pensions are reduced by 3.6 per cent for each year of early retirement before age j_R^n and increased by 6 per cent for each year of delayed retirement. However, as will be discussed below, the model abstracts from increases in pensions due to delayed retirement so that

$$\nu(j_R) \quad = \quad \begin{cases} (1 - (j_R^n - j_R) \times 0.036)\,, & j_R < j_R^n \\ 1, & j_R \geq j_R^n. \end{cases} \tag{24}$$

Finally, the taxation of gross income (from labor, pensions and capital) is close to the current German income tax code and the marginal tax rate schedule $T05$ which was introduced in 2005. For capital income we consider an annual allowance of 1.600 € and a tax rate of $\tau_r = 0.25$. With respect to labor income, we assume that 4 percent of gross income could be deducted from the tax base in addition to an annual allowance of 1.200 €. The two parameters κ_1, κ_2 are adjusted in every year and for every cohort in order to reflect the phased-in deferred taxation of public pensions in Germany. Starting in 2005, 60 percent of contributions could be deducted from the tax base. This fraction increases every year by 2 percentage points until in 2025 all contributions to pensions could be deducted from the tax base. Similarly, in 2005 only 50 percent of pensions of existing and new pensioners had to be taxed. Since then, the taxable fraction κ_2 of pensions increases for every new cohort of pensioners by initially one and later two percentage points, so that cohorts retiring in year 2040 or later have to tax their full pension.[12] As for the tax schedule, the marginal tax rate rises linearly after the basic allowance of 7.800 € from 15 percent to a maximum of 42 percent when y_j^l passes 52.000 €.

Given revenues from income and corporate taxation, we fix the consumption tax rate at 17 percent and compute government consumption G endogenously to balance the budget. Table 3 reports our parameter values and Table 4 presents some calibrated figures of the initial equilibrium.

Our calibration aims to reproduce a realistic government sector and the current German

[12]Note that the phased-in taxation of pension benefits might induce earlier retirement in our model, but these effects can be neglected.

Table 3: Preference, technology and fiscal parameters

Preferences	Technology	Government
$\gamma = 0.5$	$\theta = 0.92$	$\tau_c = 0.17$
$\rho = 0.6$	$\epsilon = 0.3$	$\tau_k = 0.15$
$\alpha = 1.5$	$\delta_k = 0.0475$	$B_G/Y = 0.6$
$\delta = 0.995$	$\lambda = 0.01$	$d_s = 1600$
$\sigma = 10^{-8}$		$T(y)$ see text
$\mu_1 = 2 \cdot 10^{-4}$		APA see text
$\mu_2 = -7 \cdot 10^{-5}$		$[\underline{j}; \bar{j}] = [60, 70]$
$\mu_3 = -2 \cdot 10^{-4}$		$\bar{j}_R^n = 65$

Table 4: The benchmark equilibrium

	Model benchmark	Germany 2008[a]
Expenditures on GDP (% of GDP)		
Private consumption	62.9	56.3
Government consumption	18.3	18.1
Gross fixed investment	18.8	19.3
Export - Import	0.0	6.3
General government indicators		
Aggregate pension benefits (% of GDP)	13.9	11.3
Tax revenues (% of GDP)	20.3	23.8
Social security contributions (in %)	19.9	19.9
Poverty rate among elderly (60/40)	16.2/2.7	13.0/2.4[b]
Interest rate (in %)	4.4	—
Capital-output ratio	3.0	3.1

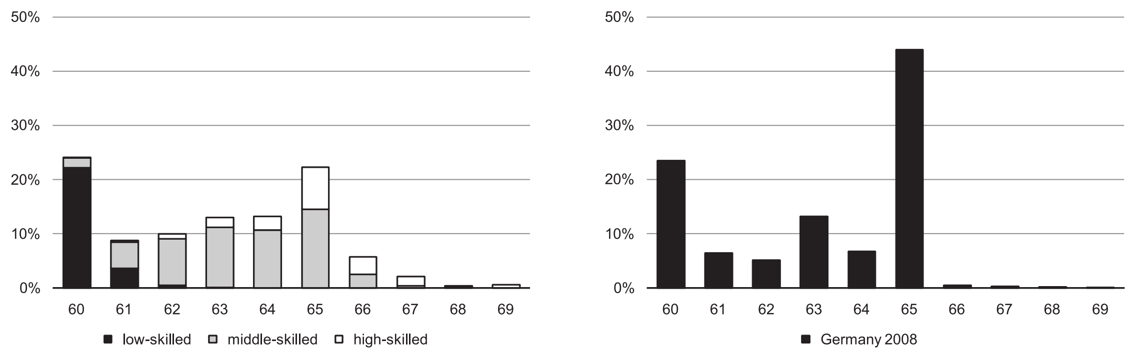
[a] IdW (2009), [b]EU-SILC survey of 2008, SVR (2008/2009)

capital-output ratio. The central differences between model and reality are due to the assumption of a closed economy which on the one side implies an endogenous interest rate but also requires a zero trade balance which does not reflect Germany's situation as world's (former) export champion. Table 4 also reports the shares of elderly (i.e. those age 65 and older) who receive either 60 or 40 per cent of median net income in the economy. The first poverty rate in our model is close to the recent figure of 13 per cent computed by the European Union Statistics on Income and Living Conditions (Deckl, 2008), the second poverty rate indicates the number of elderly who are below the social assistance level. Currently, about 2.4 per cent of people older than 64 years receive the (means-tested) basic benefit in Germany, see SVR (2008/2009, p. 379).

3.4 Retirement behavior and baseline path

Of course, we are mostly interested how well the model could replicate the observed retirement behavior. As can be seen in the right part of Figure 3, actual retirement ages in Germany are described by three peaks at ages 60, 63 and 65.[13] Age 60 is the earliest age where woman, unemployed or disabled people who are eligible could receive an old age pension, while age 63 is the earliest age where long-term insured can receive an old age pension. In both cases, however, early retirees have to accept the actuarial adjustments of their pension benefits. Those who retire at the normal retirement age of 65 can receive a full pension without reductions. Surprisingly, there is currently almost no retirement after the NRA. Partly this may be due to the fact that firms pay seniority wages and therefore want to get rid of their elderly employees. In addition, since there are no legal restrictions for working after age 65, people can receive pensions and receive income from labor at the same time. Our model is not able to capture these two aspects. Consequently, as can be seen in the left part of Figure 3, a significant share of individuals is still working after age 65. If we would include actuarial adjustments of benefits after age 65, this fraction would be even higher.

Figure 3: Retirement behavior in the initial equilibrium



The model is able to replicate the two peaks at ages 60 and 65. As one can see, low-skilled individuals retire earlier than middle- and high-skilled individuals. The mean retirement age of low-skilled in the initial year is age 60.2 and rises to ages 63.5 and 65.1 for middle- and high-skilled. While it is not possible to isolate retirement behavior of different skill-types with the data from Deutsche Rentenversicherung (2009), Himmelreicher et al. (2009) indicate that there exists a delayed retirement of high-skilled in Germany, but the difference seems to be smaller than in the model simulation. According to their study, high-skilled

[13] This distribution is calculated from data of Deutsche Rentenversicherung (2009).

individuals retired in year 2006 between 8 and 18 months later than low-skilled individuals. In our model this difference is exaggerated by the fact that there is a perfect correlation between skill-type and life expectancy. Consequently, not only low-skilled retire early, but also those with lower life expectancy. At least in the U.S., this seems to be supported by the data where Waldron (2001) finds a clear negative correlation between retirement age and mortality.

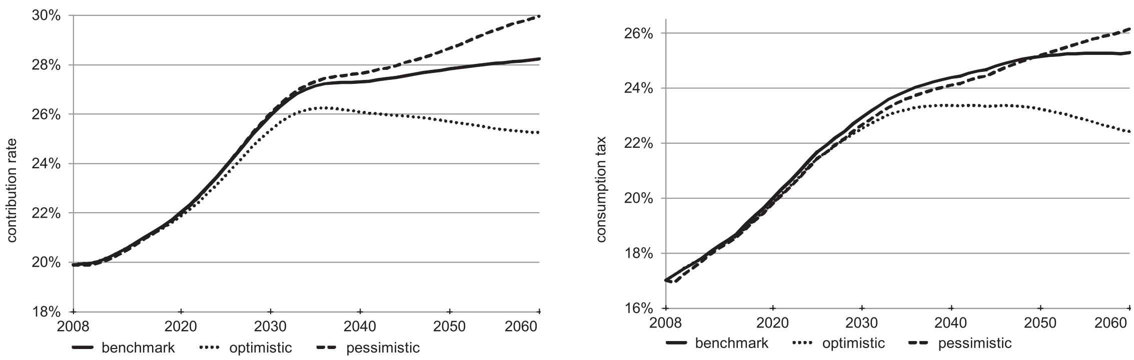
This should suffice to explain our calibration and initial equilibrium. Table 5 reports the baseline path of the economy until 2060 if the NRA is kept at its current level. Due to the positive productivity growth, (effective) labor supply and therefore employment increases despite the fall in the number of workers. However, savings as well as assets and the capital stock grow quite stronger, so that wages increase and the interest rate falls throughout the transition. Due to the change in the age structure, consumption grows stronger than employment and the share of pension expenditures in GDP rises from initially 13.9 to 19.8 per cent in 2060. Note that the retirement age almost remains constant until 2060 despite the increase in life expectancy. During the same time, poverty rates among elderly almost double due to the reduction in pension benefits.

Table 5: Baseline path of the economy

Year	2008	2020	2030	2040	2050	2060
Employment	100.0	105.6	104.1	107.1	110.7	114.2
Capital	100.0	117.8	127.2	129.3	132.2	135.9
Consumption	100.0	107.9	110.1	112.4	115.0	118.3
Wage	100.0	103.4	106.2	105.8	105.0	105.4
Interest Rate	4.4	3.9	3.4	3.4	3.5	3.5
Mean retirement age	63.1	63.1	63.2	63.2	63.2	63.2
Pension benefits	13.9	15.4	18.2	19.1	19.5	19.8
Elderly poverty rate	16.2/2.7	23.9/5.5	30.8/5.3	32.3/5.7	33.0/5.6	31.6/5.3

Figure 4 shows the dynamics of the contribution rate and the consumption tax rate. In all three population scenarios considered, the former rises from currently 19.9 to roughly 24 per cent until 2030. Therefore, current pension policy is not able to stabilize the contribution rate at 22 per cent in the short run, as originally intended. Even worse, in the medium and long run our model predicts that the contribution rate will rise up to 28 per cent even in the benchmark scenario. The optimistic and pessimistic scenarios mainly differ in their long run implications where contribution rates either decline to 25 per cent or increase further to 30 per cent. Note that in the right part of Figure 4 the consumption tax also increases significantly by 5 and almost 8 percentage points in the medium and long run. This is due to the fact that public goods are constant per capita and therefore rise with the total population, while taxes are currently mainly paid by employed persons.[14] Since the tax base declines much stronger than the demand for public goods, the tax rate has to increase during the transition.

Figure 4: Social security contributions and consumption taxes on baseline path



Is it possible to design a pension reform package which dampens the long-run increase in contribution and poverty rates without harming future cohorts? The next section tries to answer this question by considering specific reform scenarios and computing their welfare and efficiency implications.

4 Simulation of policy reforms

This section considers four specific policy reform scenarios. The benchmark reform is the pension reform of 2007 which increases the normal retirement age from currently age 65 to age 67. More specifically, starting in 2012 the NRA for the cohort born in year 1947 increases by one month. For the cohort born in 1948, the NRA increases by two months and so forth. For cohorts born in and after year 1959, the NRA increases by fourteen, sixteen, eighteen months and so on until, finally, cohorts born in and after 1964 all face an increase in the NRA of two years. This benchmark reform is compared with alternative packages where we supplement (starting in year 2009) the pension reform of 2007 with the following measures:

a) Flat pensions: Earning points are computed with a flat fraction, i.e. equation (12) changes to

$$ep_{j+1} = ep_j + 0.7 \min[w_j/\bar{w}; 2] + 0.3. \tag{25}$$

[14]This argument still holds despite the fact that the model takes into account the deferred taxation of pensions in the future.

b) Life expectancy adjustment: Following Breyer and Hupfeld (2010) we introduce a correction factor $\frac{10}{5+5ep_{j_R}/j_R}$ for life expectancy in the pension formula (11). In our model low income households (i.e. where $ep_{j_R}/j_R < 1$) also have a lower life expectancy, so that the correction factor increases their pension benefit. The opposite holds for high income households.

c) Age-dependent contribution rates: Following Cremer and Pestieau (2003), we assume that the contribution rate for workers age 60 and above decreases to 15 per cent. The contribution rate for younger workers increases accordingly.

The next subsection discusses the macroeconomic effects of these four policy packages. We then report the resulting welfare and efficiency effects and perform some sensitivity analysis in the last subsection.

4.1 Macroeconomic effects of pension reforms

Table 6 compares changes of some specific macroeconomic variables along the transition path. The first reform considered is the increase in normal retirement ages as implemented by the "Pension reform 2007". Since the reform reduces future pension benefits, people save more and delay retirement by roughly 10.8 months on average in the long run which in turn increases employment by 0.5 per cent. The increase of the mean retirement age is somewhere around the long-run retirement age increase of 8 months estimated by Berkel and Börsch-Supan (2004). It is also in line with the results from Mastrobuoni (2009), who finds evidence that the mean retirement age of the affected cohorts in the U.S. increases by about half as much as the increase in the NRA.[15] Since savings grow stronger than employment, long-run wages increase. Higher income tax revenues allow to reduce consumption taxes and the longer working phase allows to reduce contribution rates in the long run. Note, however, that both measures of old-age poverty increase significantly in the long run due to the reduction in pension benefits.

Figure 5 disaggregates the change in the contribution rate and the retirement decision. As shown in the left part, if we keep the retirement ages of the baseline path "exogenous", contribution rates would remain constant for quite a while and then fall in the long run by about one percentage point. With "endogenous" retirement ages, the delay of retirement has a much stronger impact on contribution rates in the short and medium run due to the immediate increase of the contribution base. In the long run, however, higher pension ben-

[15] Of course, one should not overemphasize these comparable findings, since the figures are derived in a completely different context. However, they indicate that our results are not completely unrealistic.

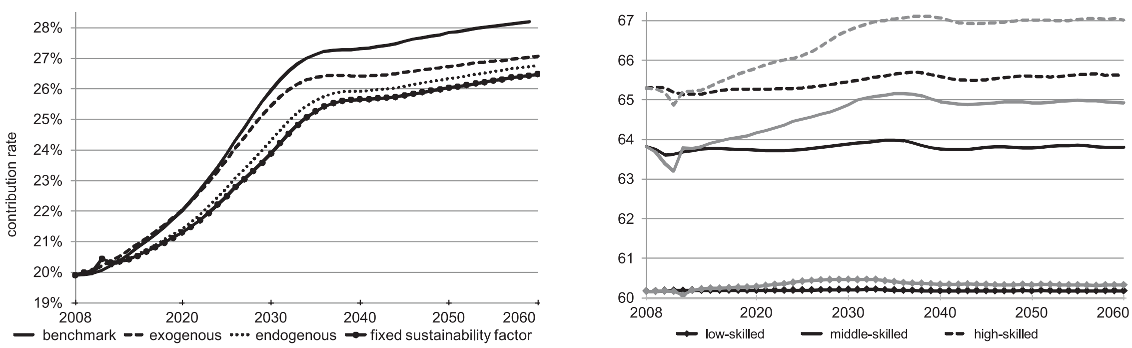
Table 6: Macroeconomic effects of the considered pension reforms*

Variable	Pension reform 2007	Flat pensions	Life expectancy adjustment	Age-depependent contribution rates
Capital stock				
2020	-0.5	-1.9	-4.1	-0.9
2040	1.2	-0.9	-6.3	0.2
2060	2.3	-0.1	-7.1	0.8
Employment				
2020	0.0	-2.0	-3.3	-0.1
2040	0.4	-1.4	-2.4	0.5
2060	0.5	-1.4	-2.2	0.7
Wage rate				
2020	-0.2	0.0	-0.2	-0.3
2040	0.2	0.2	-0.8	-0.1
2060	0.3	0.3	-1.1	0.0
Consumption tax rate				
2020	0.0	0.9	1.7	0.1
2040	-0.4	0.6	1.7	-0.3
2060	-0.6	0.5	1.7	-0.5
Contribution rate				
2020	-0.6	-0.6	0.3	-0.5
2040	-1.4	-1.3	0.3	-1.0
2060	-1.4	-1.5	0.3	-0.9
Mean retirement age (in months)				
2020	4.8	7.2	6.0	6.0
2040	10.8	15.6	18.0	14.4
2060	10.8	14.4	16.8	14.4
Poverty Rates (60/40)				
2020	2.2 / 0.2	1.5 / 0.4	-2.5 / -0.4	1.8 / 0.4
2040	8.7 / 2.6	-2.3 / 2.5	-1.7 / -1.1	6.9 / 2.4
2060	9.4 / 3.4	-0.9 / 2.8	-1.8 / -0.6	7.3 / 3.0

*Changes compared to the baseline path.

efits dampen the reduction in contribution rates. The right part of Figure 5 shows that the increase in effective retirement ages is not uniform across skill classes. While middle- and high-skilled delay retirement by more than one year, low-skilled hardly alter their retirement behavior. There also is a small announcement effect which decreases retirement ages in year 2011 right before the implementation of the reform since households who initially planned to retire early in year 2012 may now find it optimal to already retire in 2011. Finally, the left part of Figure 5 also isolates the consequences of the change in the sustainability factor which partly neutralizes the reform impact. As one would expect, simulating the reform while keeping the sustainability factors from the baseline path would further reduce the contribution rate in the long run. However, this effect is fairly small.

Figure 5: Pension reform 2007: Contribution rates and effective retirement ages



Next, we turn back to Table 6 and consider alternative packages which supplement the "Pension reform 2007". If the increase in NRAs is combined with a partial introduction of flat pensions, mean retirement ages increase even stronger by 14.4 months in the long run. Due to the loser link between contributions and pension benefits, labor supply distortions increase, so that employment decreases as well as savings. Lower pension benefits and lower savings induce people to work longer and delay retirement. This, however, does not neutralize the original reductions in employment. As one can see in the bottom part of Table 6, the reduction of the tax-benefit linkage could hardly reduce the increase of the very poor elderly. However, it dampens the increase in retirees below 60 per cent of median income.

The adjustment for life expectancy as proposed by Breyer and Hupfeld (2010) accomplishes to improve both poverty measures. The mean retirement age now increases by even 17 months in the long run. Since productivity in old age is below average productivity at all skill-levels, all households have an incentive to delay retirement in order to decrease average earning points. Since in our model even the middle-skill class receives an increase in benefits after the reform, aggregate employment and savings fall dramatically after the reform. As a consequence, wages decrease and the consumption tax rate increases by 1.7 percentage points. Now contribution rates even increase despite the delay in retirement!

Finally, we assume in the right part of Table 6 that the contribution rate for workers age 60 or older decreases to 15 per cent. Of course, this measure has a positive impact on retirement age which now increases on average by 14.4 months in the long run. At the same time, the contribution rate for younger workers increases by roughly 0.5 percentage points compared to the "Pension reform 2007" scenario. Overall, the reform increases aggregate employment but reduces savings, since people mainly work longer. This has a positive impact on old-age poverty rates which are both smaller than in the "Pension reform 2007" scenario.

4.2 Welfare and efficiency effects

Of course, the fiscal and macroeconomic consequences of different reform scenarios discussed in the preceding subsection can not explain the intra- and intergenerational redistribution effects, nor can they indicate the changes in aggregate efficiency. In order to quantify the former, one has to compute the changes in welfare across and within cohorts due to a specific reform scenario. The latter requires to implement the LSRA redistribution mechanism explained in section 2.6.

As one would expect, Table 7 shows in the right top corner that the pension reform of 2007 improves welfare of already retired due to the consumption tax reduction. Middle-aged cohorts lose, since the reform decreases their future pension benefits, while households living in the long run benefit from reduced contribution rates early in life. The computed long run welfare gains roughly amount to 0.4 per cent of aggregate lifetime resources. Due to lower life expectancy and earlier retirement, the reduction of pension benefits hurts low-skilled households significantly stronger than high-skilled ones. Younger high-skilled even benefit from the reform.[16] Finally, after implementing LSRA-transfers the right column shows that the pension reform of 2007 will increase aggregate efficiency by 0.18 percent of aggregate resources. Of course, these positive efficiency effects are due to reduced labor supply distortions.

The right upper part of Table 7 reports the welfare consequences when the tax benefit linkage is reduced in order to reduce old-age poverty rates. As one can see, such a reform would have very negative welfare effects for all households.[17] Already retired households

[16]Since we apply an ex-ante welfare measure, it is not possible to distinguish skill classes for households who enter the labor market after the reform.

[17]Fehr (2000) explains this result in more detail by referring to the change of the marginal contribution rate over the life cycle.

Table 7: Welfare effects of the considered pension reforms*

Pension reform 2007

Birth	without LSRA			with
year	poor	median	rich	LSRA
1940	0.26	0.32	0.33	0.00
1960	-0.95	-0.38	-0.28	0.00
1980	-0.52	-0.06	0.09	0.00
2000		0.26		0.18
2020		0.43		0.18
∞		0.37		0.18

Flat pension

Birth	without LSRA			with
year	poor	median	rich	LSRA
1940	-0.72	-0.67	-0.58	0.00
1960	-1.26	-0.64	-1.05	0.00
1980	-0.75	-0.34	-0.71	0.00
2000		-0.14		-0.67
2020		-0.01		-0.67
∞		-0.02		-0.67

Life expectancy adjustment

Birth	without LSRA			with
year	poor	median	rich	LSRA
1940	-1.70	-1.73	-1.60	0.00
1960	0.07	0.21	-1.40	0.00
1980	-0.44	-0.26	-1.10	0.00
2000		-0.68		-1.15
2020		-0.79		-1.15
∞		-0.78		-1.15

Age-dependent contribution rates

Birth	without LSRA			with
year	poor	median	rich	LSRA
1940	-0.11	-0.09	-0.06	0.00
1960	-1.10	-0.33	-0.20	0.00
1980	-0.61	-0.07	0.22	0.00
2000		0.23		0.09
2020		0.33		0.09
∞		0.29		0.09

* Changes measured in percent of resources in initial equilibrium.

now lose, since they are hurt by the increase in consumption taxes. Welfare losses are now quite similar for middle-aged low- and high-skilled. However, even middle-aged low-skill households do not benefit from flat pensions compared to the "Pension reform 2007", since labor market distortions increase significantly. In the long run, the higher consumption tax rate reduces welfare of future cohorts. The increased distortions are clearly indicated by the aggregate efficiency measure shown in the right column of Table 7, where overall efficiency now decreases by 0.67 percent of aggregate resources.

A very similar reasoning applies to the numbers reported in the scenario where the pension formula is adjusted for life expectancy. In this case current retirees and future cohorts even lose more, while current poor and median workers benefit compared to the previous scenario. As one would expect, distortions are much higher so that aggregate efficiency now decreases by 1.15 per cent.

Finally, if the pension reform of 2007 is supplemented by age-dependent contribution rates, intergenerational redistribution is dampened while intragenerational redistribution is reinforced. Compared to the benchmark reform, aggregate efficiency decreases. On first sight this result might be surprising since among others Cremer and Pestieau (2003) as well as Lozachmeur (2006) propose such an age-dependent contribution structure on efficiency grounds. However, the theoretical studies only take into account the extensive labor supply margin and neglect the intensive margin. Due to the tax-benefit linkage, marginal contribution rates already decline with age (Fehr, 2000). The considered age-structure for contributions therefore further steepens the age-structure of marginal contribution rates.[18]

4.3 Sensitivity analysis

Simulating the "Pension reform 2007" with the "optimistic" and "pessimistic" demographic scenarios discussed above has only negligible macroeconomic and welfare effects, since changes in demographic parameters mainly alter the path of the economy but not the impact of the policy reform. Similarly, since the interest rate remains almost unaffected by the considered reform, the small open economy results also look very similar.

An interesting extension concerns the adjustment of the early eligibility age $\underline{j}$ of the retirement window. Up to now it was assumed that people could continue to retire at age 60, if the accept dramatic reductions in their pension benefits. In reality, the reform of 2007 also gradually increases the early eligibility age from currently $\underline{j} = 60$ to $\underline{j} = 61$ in year 2018 and $\underline{j} = 62$ in year 2024. In our model we can't replicate the phased-in increase, but we

[18] Of course, this could be optimal if labor supply elasticity increases strongly with old age. In our model, this is not the case even with endogenous retirement.

can consider two discrete jumps from 60 to age 61 and from 61 to age 62 at the respective years. Of course, in this case the mean retirement age increases much stronger since low-skilled are forced to delay their retirement. However, labor supply during younger ages falls, so that overall employment decreases significantly compared to the previous "Pension reform 2007". Consequently, and very surprisingly, compared to the simulation in Table 6 the contribution rate declines slightly less although people retire significantly later.[19]

5 Conclusions and discussion

The results of this paper strongly suggest that the current German pension system faces substantial increases in long run contribution rates despite all previous reform efforts to improve sustainability. If the existing retirement behavior remains unaltered, contribution rates would increase up to 26 per cent in the year 2040 even in the most optimist demographic scenario. In addition, the future reductions in benefits will increase old-age poverty rates in Germany substantially. The recently implemented increase in the normal retirement age will delay retirement by 10.8 month on average which in turn reduces future contribution rates by roughly 1.5 per cent. While the reform is beneficial for future generations, it comes at the cost of increased old-age poverty within cohorts. Reforms which intend to reduce future old-age poverty by means of the pension system are misleading since they imply substantial efficiency losses which hurt future cohorts.

Of course, our quantitative conclusions heavily depend on the assumed model structure and demographic projections. We feel that the results are quite robust with respect to the demographic projections and model parameters. However, specific assumptions of the model structure which seem to be important for our results should be highlighted. First, in order to reduce the models dimensionality, we have assumed a perfect (positive) correlation between life expectancy and skill-level. While this simplification greatly reduces computational time it is not realistic. In order to isolate the impact of life expectancy and income on retirement behavior it would be optimal to distinguish nine household types within a cohort. At the moment our approach seems to exaggerate redistribution within the cohorts. Second, our model abstracts from income uncertainty which might be important especially at old age when people become unemployed. Introducing income uncertainty especially during the years before retirement man not only change the households' retirement behavior, but also turn around efficiency effects of policy reforms. With uncertain income, redistribution serves as an insurance device which is not captured in the present study, see Fehr and Habermann

[19] Note that our result nicely complements Gielen (2008) who finds that woman who are forced to work more due to working hour restrictions will retire earlier in the U.K.

(2008). Third, our model completely abstracts from disability retirement. At least some people always have the choice to retire earlier on disability benefits or to remain in the labor force and retire as ordinary retirees, see Diaz-Gimenez and Diaz-Saavedra (2009) for a recent application of this issue in Spain. If the model allows for a disability retirement option, the consequences of the "Pension reform 2007" may completely change since people may now opt for earlier retirement with disability benefits. In future work we plan to implement these extensions in the model.

References

Auerbach, A.J. and L.J. Kotlikoff (1987): *Dynamic fiscal policy*, Cambridge University Press, Cambridge.

Berkel, B. and A. Börsch-Supan (2004): Pension reform in Germany: The impact on retirement decisions, *FinanzArchiv 60(3)*, 393-421.

Beetsma R., L. Bettendorf and P. Broer (2003): The budgeting and economic consequences of ageing in the Netherlands, *Economic Modelling 20*, 987-1013.

Bomsdorf, E. (2003): Sterbewahrscheinlichkeiten der Periodensterbetafeln für die Jahre 2000 bis 2100, Eul Verlag, Köln.

Börsch-Supan, A., A. Reil-Held and D. Schunk (2008): Saving incentives, old-age provision and displacement effects: evidence from the recent German pension reform, *Journal of Pension Economics and Finance 7(3)*, 295-319.

Breyer, F. and M. Kifmann (2002): Incentives to retire later - a solution to the social security crisis? *Journal of Pension Economics and Finance 1(2)*, 111-130.

Breyer, F. and S. Hupfeld (2010): On the fairness of early-retirement provisions, *German Economic Review,* forthcoming.

Catalan, M., J. Guajardo and A. Hoffmaister (2010): Coping with Spain's aging: retirement rules and incentives, *Journal of Pension Economics and Finance*, forthcoming.

Cremer, H. and P. Pestieau (2003): The double dividend of postponing retirement, *International Tax and Public Finance 10*, 419-434.

Deutsche Rentenversicherung (2009): Rentenzugang 2008, Berlin.

Deckl, S. (2008): Leben in Europa 2005 und 2006, Wirtschaft und Statistik 9, 796-807.

Diaz-Gimenez, J. und J. Diaz-Saavedra (2009): Delaying retirement in Spain, *Review of Economic Dynamics 12*, 147-167.

Eisensee, T. (2005): Essays on public finance: Retirement behavior and desaster relief, Institute for International Economic Studies, Stockholm University, Monograph Series no. 54, Stockholm.

Erber, G. and U. Fritsche (2009): Productivity growth in Germany: No sustainable economic recovery in sight, DIW Berlin, Weekly Report 5(3), 19-25.

Fehr, H. (2000): Pension reform during the demographic transition, *Scandinavian Journal of Economics 102*, 419-443.

Fehr, H. and C. Habermann (2006): Pension reform and demographic uncertainty: The case of Germany, *Journal of Pension Economics and Finance 5*, 69-90.

Fehr, H. and C. Habermann (2008): Risk sharing and efficiency implications of progressive pension arrangements, *Scandinavian Journal of Economics 110(2)*, 419-443.

Fehr, H., W.I. Sterkeby, and Ø. Thøgersen (2003): Social security reform and early retirement, *Journal of Population Economics 16*, 345-361.

French, E. (2005): The effect of health, wealth, and wages on labor supply, *Review of Economic Studies 2*, 395-427.

Gielen, A.C. (2008): Working hours flexibility and older workers' labor supply, *Oxford Economic Papers 61*, 240-274.

Heckman, J., L. Lochner und C. Taber (1998a): Explaining rising wage inequality: Explorations with a dynamic general equilibrium model of labor earnings with heterogeneous agents, *Review of Economic Dynamics 1*, 1-58.

Herbertsson, T.T. and M.J. Orszag (2003): The early retirement burden: Assessing the costs of the continued prevalence of early retirement in OECD countries, IZA Discussion Papers 816, Bonn.

Himmelreicher, R.K., C. Hagen, and W. Clemens (2009): Bildung und Übergang in den Ruhestand, *Kölner Zeitschrift für Soziologie und Sozialpsychologie 61(3)*, 437-452.

Institut der deutschen Wirtschaft (IdW) (2009): Deutschland in Zahlen, Köln.

Kallweit, M. (2009): Rentenreform und Rentenzugangsentscheidung - Eine numerische Gleichgewichtsanalyse, *Jahrbücher für Nationalökonomie und Statistik 229/4*, 426-449.

Kotlikoff, L.J., K.A. Smetters and J. Walliser (2007): Mitigating America's demographic dilemma by pre-funding social security, *Journal of Monetary Economics 54*, 247-266.

Lozachmeur, J.-M. (2006): Optimal age-specific income taxation, *Journal of Public Economic Theory 8(4)*, 697-711.

Mastrobuoni, G. (2009): Labor supply effects of the recent social security benefit cuts: Empirical estimates using cohort discontinuities, *Journal of Public Economics 93*, 1224-1233.

Meyer, D. and J. Meyer (2005): Relative risk aversion: What do we know? *Journal of Risk and Uncertainty 31(3)*, 243-262.

Nishiyama, S. and K. Smetters (2007): Does social security privatization produce efficiency gains? *Quarterly Journal of Economics 122*, 1677-1719.

OECD(2009): Pensions at a Glance, Paris.

Reil-Held, A. (2000): Einkommen und Sterblichkeit in Deutschland: Leben Reiche länger? Beiträge zur angewandten Wirtschaftsforschung 580-00, Universität Mannheim.

Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung (SVR) (2008): Jahresgutachten 2008/2009, Wiesbaden.

Sánchez-Martín, R.A. (2008): Endogenous retirement and public pension system reform in Spain, Working Paper 08.06, Universidad Pablo de Olavide.

Scheubel, B., D. Schunk and J. Winter (2009): Don't raise the retirement age! An experiment on opposition to pension reforms and East-West differences in Germany, CESifo Discussion Paper No. 2752, Munich.

Statistisches Bundesamt (StaBu) (2009a): Statistisches Jahrbuch 2009, Wiesbaden.

Statistisches Bundesamt (StaBu) (2009b): Bevölkerung Deutschlands bis 2060, 12. koordinierte Bevölkerungsvorausberechnung, Wiesbaden.

von Gaudecker, H.M. and R.D. Scholz (2007): Differential mortality by lifetime earnings in Germany, *Demographic Research 17(4)*, 83-108.

Wagner, G.G., J.R. Frick and J. Schupp (2007): The German Socio-Economic Panel Study (SOEP) - Scope, evolution and enhancements, *Journal of Applied Social Science Studies 127(1)*, 139-169.

Waldron, H. (2001): Links between early retirement and mortality, ORES Working Paper Series No. 93, Social Security Administration, Washington.