Pension Funding and Human Capital

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Abstract

In this paper I analyze the consequences of pension funding in a general equilibrium model of both formal schooling decisions and on-the-job human capital formation à la Heckman, Lochner and Taber (1998). Markets are incomplete in the sense that households can neither insure income nor life span risk and are borrowing constraint throughout the whole life cycle.

I find that, as a result of its implicit tax structure, a perfectly earnings related pension system is regressive with respect to education, meaning that the higher skilled get out more for their contribution than the lower skilled. Consequently, when the pension system is abolished, college enrollment rates will decline. The effects on on-the-job training are however ambiguous. In addition, the positive income effect on future cohorts triggered by a rise in accidental bequests depresses both labor supply and human capital investments. Factor price adjustments can only partially offset these negative effects on human capital formation. In terms of aggregate efficiency, pension funding comes along with neither significant losses nor gains.

JEL Classifications: C68, J24, J26, H55

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1 Introduction

The reform of the pension system has been a major concern in the world wide public discussion for many years. With rising life expectancies and declining birth rates, the sustainability of pay-as-you-go (PAYG) social security regimes seems at risk in the near future. Recent reforms in OECD countries therefore aimed at reducing the upcoming burden that arises from the combination of generous PAYG pension schemes and the recent demographic projections. Typical measures to do so were increasing normal retirement age and indexing the level of pensions to life expectancy. In addition, several reforms paved the way for tax promoted old-age savings, see e.g. OECD (2011) for further information on recent pension reforms. All in all, these reforms have one goal in common: to reduce the size of public pensions and strengthen the role of private savings in retirement income.

In this paper I therefore analyze the consequences of pension funding in a large scale general equilibrium model of overlapping generations. Markets are incomplete in the sense that households can neither insure income nor life span risk and are borrowing constraint throughout the whole life cycle. In contrast to most studies concerned with pension funding, my model explicitly allows for human capital formation both via formal schooling and via on-the-job training. In this setup I study the consequences of pension funding for human capital formation, the macroeconomy, welfare of different cohorts and aggregate efficiency. I thereby clarify the roles of (i) the implicit tax structure of an earnings related pension system, (ii) the absence of annuity markets and (iii) factor price movements on the decision of individuals to form human capital.

In the literature, the consequences of pension funding have been intensively discussed. Various arguments have been put forward in favor and against public pension schemes. Defenders pointed out that they might work as a substitute for missing annuity markets and as a commitment device for myopic agents. Critics, on the contrary, argued that pension contributions mainly distort labor supply and enforce liquidity constraints at younger ages, see Fehr, Habermann and Kindermann (2008) or Fehr and Kindermann (2010) for a discussion of both the literature and macroeconomic, welfare and efficiency effects of pension funding reforms.

However, there is one fact usually neglected in the discussion about the pension system, namely how it interacts with the human capital investment decision of households. Only few studies are concerned with this issue, amongst them Docquier and Paddison (2003) as well as Le Garrec (2012), who analyze the growth and inequality effects of different pension arrangements in stylized OLG models in which schooling is the engine of growth. They find that PAYG pension schemes have a negative effect on human capital formation. As they crowd out capital, the interest rate increases which makes human capital investments less valuable. In addition to this, Le Garrec (2012) finds that Bismarckian pension systems always are to be favored over Beveridgean ones, when benefits are linked to the full earnings history of households. However, there is a pension scheme which consists of a flat part and a part that is only related to the last years of employment, which leads to the same growth rate but less equality than a pure Bismarckian system. Another stream of the literature deals with the interaction between schooling, retirement and the pensions system. Lau and Poutvaara (2006) find that increasing the link between pension benefits and contributions encourages human capital investment. Furthermore, actuarially adjusted arrangements like old-age benefits lead to later retirement compared to a retirement subsidy scheme and therefore prolong the period of yield for human capital investment. In consequence, schooling effort rises further, a result already found by Jensen, Lau and Poutvaara (2004) in a numerical study and confirmed by Montizaan, Cörvers and de Grip (2010) in a quantitative study. Finally, Cascarico and Devillanova (2008) explore the consequences of funding social security in a model of human capital investment and capital skill complementarity in production. They state that the privatization of social security comes along with a higher steady state level of physical and human capital. As the capital stock increases, the wage gap between the skilled and the unskilled widens. Therefore across-group wage and income inequality rises.

In the present study I aim at complementing the above analyses in several ways. I construct a multi-period OLG general equilibrium model in which households make both formal schooling and on-the-job training decisions. I thereby build on the seminal works of Auerbach and Kotlikoff (1987) as well as Heckman et al. (1998), the latter of whom first used their model to study the evolution of wage inequality between unskilled and skilled labor in the US. In order to make the model suitable for analyzing pension reforms, I extend it in various directions. First, I introduce variable labor supply which allows me to account for distortions in the utilization of human capital. As pointed out by Jacobs (2008), taking into account both skill formation and variable labor supply increases labor supply elasticities and might lead to very different conclusions than those derived from a model with inelastic labor supply. Next, I let labor income be uncertain, which has a significant impact on the interest elasticity of savings, see Bernheim (2002), and makes liquidity constraints bind for a larger part of the population. Third, I let life span be risky, a feature that has been neglected in previous studies but seems crucial in the analysis of pension systems. In combination with that and in line with empirical findings I assume that households do not annuitize their wealth upon retirement, see Brown (2009) for a discussion on why this could be the case.[1] Last and most importantly, I do not only compare steady state effects. Instead I compute a transition path from one long-run equilibrium to another. This enables me to look at short-run effects and to do an analysis of both welfare and efficiency effects of the pension system. I calibrate my model to the German economy in 2010, which features a fully earnings related PAYG pension system. I use SOEP data to estimate on-the-job human capital formation technology as well as income shock processes for different schooling types. Having done that, I simulate the complete privatization of the German PAYG pension system.

I find that, as a result of its implicit tax structure, an earnings related pension system like the German one is regressive with respect to education, meaning that the higher skilled get out more for their contribution than the lower skilled. Consequently, when the pension system is abolished, college enrollment rates will decline. The effects on on-the-job training are however ambiguous. Pension funding significantly increases private savings and, under the absence of annuity markets, accidental bequests. In a dynamically efficient economy this induces a positive income effect on future cohorts which causes leisure consumption to rise and therefore depresses both labor supply and human capital investments. Factor price adjustments can only partially offset these negative effects on human capital formation. In terms of aggregate efficiency, I find pension funding to come along with neither significant losses nor gains.

The remainder of the paper is arranged as follows: In the next section I present the numerical general equilibrium OLG model, the calibration of which is discussed in Section 3. Section 4 describes simulation results and the last section offers some concluding remarks.

[1] Note that there is no behavioral reason for not annuitizing wealth in my model. Therefore I assume that annuity markets are absent.

2 The numerical general equilibrium model

I use a model of overlapping generations in the tradition of Heckman et al. (1998) to quantify the impact an earnings related pay-as-you-go pension system has on human capital formation as well as the macroeconomy, welfare of different generations and aggregate efficiency. The model features three sectors: households, firms and the government. In this section, I provide information about the decision rules for these different actors. This model description follows closely the one in Kindermann (2012). Detailed descriptions of a general equilibrium path and computational methods can also be found there.

2.1 Demographics, endowments and intra-cohort heterogeneity

The model economy is populated by J overlapping generations. At each point $t \in \{0, 1, \ldots, \infty\}$ in time a new generation is born, the mass of which is normalized to $N_1 = 1$.[2] From one date to the other a fraction of agents of each cohort dies. Let $\psi_j \leq 1$ be the conditional survival probability to age j of an agent aged $j - 1$. Then

$$N_j = \psi_j N_{j-1}$$

holds with N_j being the size of the age j cohort. At the beginning of their life-cycle, I distinguish households only by their socio-economic background s_p, i.e. the educational level of their parents. Households are assigned to this level according to the probability function $F(s_p)$, which is endogenously determined by the schooling choice of their parents, see below for further details. Individuals start their life with zero assets $a_1 = 0$, an identical amount of human capital $\bar{h}_1$ and the educational level $s_1 = 1$.

At any age during their life, I can distinguish different agents according to their individual state vector

$$z_j = (s_p, s_j, a_j, p_j, h_j, \eta_j).$$

$s_p \in \mathcal{S} = \{1, \ldots, S\}$ denotes agent's socio-economic background and $s_j \in \mathcal{S}$ his education level. $a_j \in \mathcal{A} = [0, \infty)$, $p_j \in \mathcal{P} = [0, \infty)$, $h_j \in \mathcal{H} = [0, \infty)$ and $\eta_j \in \mathcal{E} = [0, \infty)$ describe asset holdings, pension entitlements, household's human capital level and an idiosyncratic shock to labor productivity, respectively. For simplicity reasons I try to omit the time index t whenever possible.

2.2 The decision problem of individuals

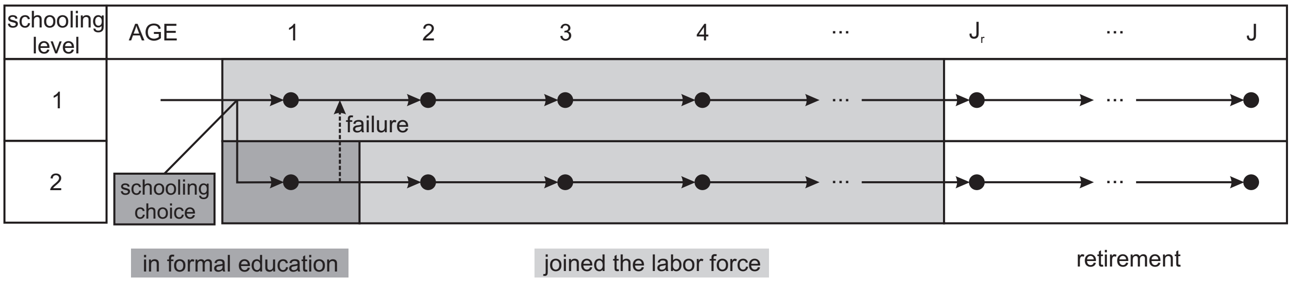
I divide households' life-cycle into three distinct stages. Agents start making economically relevant decisions by the age of $j = 1$ at which they have to decide whether to enroll in college/university[3] or directly join the labor force. There consequently are two different education levels: secondary education ($s = 1$) and tertiary eduction, i.e. a college/university degree ($s = 2$). When agents decide to drop-out of the schooling sector and join the labor force, this decision is irreversible. College education, on the other hand, is a risky investment. When an agent decides to go to college, it is not

[2] I abstract from population growth as well as technological progress.

[3] I will use the terms college and university synonymously.

clear from an ex ante perspective whether or not he succeeds in achieving a degree. If he failed, he would fall back into the group of non-college workers. Having joined the labor force, individuals may still increase their human capital h_j by means of on-the-job training. In addition, they supply labor to the market and enjoy leisure consumption. Finally, every individual has to retire at the mandatory retirement age J_r. Figure 1 sketches the life-cycle of households.

Figure 1: The life-cycle of households



Agents value consumption streams according to the expected utility function

$$E\left[\sum_{j=1}^{J}\beta^{j-1}u(c_j,\ell_j)\right]$$

where c_j and ℓ_j denote monetary and leisure consumption and β is a time discount factor. The instantaneous utility function u satisfies the usual conditions $\frac{\partial u}{\partial c_j}, \frac{\partial u}{\partial \ell_j} > 0$ and $\frac{\partial^2 u}{\partial c_j^2}, \frac{\partial^2 u}{\partial \ell_j^2} \leq 0$. Due to the additive separability of utility with respect to age, I can formulate the individual maximization problem in recursive form.

2.2.1 The retirement phase

Households in the retirement phase use their assets a_j and pension claims p_j to finance consumption c_j. Furthermore, they consume their maximum time endowment of 1 as leisure. Their maximization problem is

$$V_j(z_j) = \max_{c_j,a_{j+1}} u(c_j,1) + \beta\psi_{j+1}V_{j+1}(z_{j+1})$$

with V_j denoting household's value function at age j. The only risk agents face during retirement is survival to the next period $j+1$.[4]

Individuals maximize their utility subject to the budget constraint

$$a_{j+1} + (1+\tau_c)c_j = [1 + r(1-\tau_r)]\,a_j + p_j + b_j,$$

where a_j denotes asset holdings at the beginning of the period. In addition to after tax interest income from savings $(1-\tau_r)ra_j$, households receive pension benefits p_j and accidental bequests b_j. Note that neither income from pensions nor from bequests is due to taxation. The price of the consumption good already contains the consumption tax rate τ_c. By assumption, households are liquidity constrained throughout their whole life, i.e. $a_j \geq 0$ must hold at each j.

[4] Utility is assumed to be 0 in the case of death.

Pension claims are indexed to wages. As such, they evolve according to

$$p_{j+1} = p_j \cdot \frac{\bar{y}_{t+1}}{\bar{y}_t},$$

where $\bar{y}_t$ indicates average labor income of working households at time t.

2.2.2 Working agents

Once joining the labor force, households must decide on how to divide their time endowment between labor supply l_j, leisure consumption ℓ_j and on-the-job training e_j. With the latter of these they can influence their future human capital h_{j+1}. They consequently have to solve the maximization problem

$$V_j(z_j) = \max_{c_j, \ell_j, e_j, a_{j+1}, h_{j+1}} u(c_j, \ell_j) + \beta\psi_{j+1} E\left[V_{j+1}(z_{j+1})\right]$$

subject to the budget constraint

$$a_{j+1} + (1+\tau_c)c_j + \kappa_j + \vartheta_j = [1 + r(1-\tau_r)]\, a_j + (1 - \tau_w - \tau_p)y_j + b_j.$$

Individuals receive income from working in the market

$$y_j = w_{s_j} \cdot h_j \cdot l_j \cdot \eta_j,$$

which is the product of the education specific wage rate w_{s_j}, labor productivity h_j, labor supply $l_j = 1 - \ell_j - e_j$ and an idiosyncratic shock to labor income η_j. In addition to paying taxes on labor and interest income, they have to contribute at the flat rate τ_p to the pension system. Beyond financing consumption and savings, agents use their net income to give intergenerational transfers κ_j to their children and repay their debt out of a governmental student loan scheme ϑ_j. The size of intergenerational transfers is exogenously determined.

In reward for their contribution to the pension system, households accumulate pension claims in proportion to their labor income. Pension claims evolve according to

$$p_{j+1} = \left[p_j + \varrho y_j\right] \cdot \frac{\bar{y}_{t+1}}{\bar{y}_t},$$

where ϱ denotes the accrual rate. Pensions are again wage indexed and $p_1 = 0$.

Should an agent drop out of the schooling system his schooling level persists over the rest of his life, i.e. $s_{j+1} = s_j$. However, he can still influence his human capital by investing on-the-job. I assume that time e_j is the only cost of on-the-job training and let human capital develop according to

$$h_{j+1} = A_s e_j^{\alpha_s} + h_j.$$

The human capital production function therefore is a special case of the function proposed in Heckman (1976). Note that the ability parameter A_s and the elasticity of additional human capital with respect to time input α_s only depend on the agent's schooling level.[5]

[5] An additional division of agents into "ability classes" like in Heckman et al. (1998) is not possible due to the lack of adequate data.

Finally, the idiosyncratic income shock follows a first order Markov process. Let $\pi_s(\eta_{j+1} \mid \eta_j)$ be the probability density function of the future income shock conditional on the current shock and education level. I then can compute future expected utility from

$$E\left[V_{j+1}(z_{j+1})\right] = \int_0^\infty V_{j+1}(z_{j+1}) \cdot \pi_{s_j}(\eta_{j+1} \mid \eta_j)\, d\eta_{j+1}.$$

2.3 Formal education

The formal schooling technology differs from on-the-job training: when in college, individuals have to devote a certain fraction ϖ_{s_p} of their time endowment to studying. In reward for this time, they receive an (exogenous) level of human capital $\bar{h}_2$ after having graduated successfully. With this human capital they enter the labor force in the next period of life. Yet, there is a certain chance that a household does not successfully complete his tertiary degree. In line with García-Peñalosa and Wälde (2000), I assume that at the end of their university phase, students have to take a final exam, which they only pass with a certain probability. This makes college education a risky investment. I let $\pi^e_{s_p}$ denote the probability of an agent to successfully complete college. I follow the evidence in Eckstein and Wolpin (1999), Cingano and Cipollone (2007) as well as Carneiro and Heckman (2002) and assume that the ability to form human capital via formal schooling depends strongly on the agent's socio-economic background s_p, i.e. the schooling level of his parents. Therefore, both effort and probability of success are conditional on s_p.

Households make their college enrollment decision via a comparison of utilities at the beginning of period 1. As they all start out with zero assets and pension claims as well as an identical level of human capital $\bar{h}_1$, their value functions reduce to

$$W_1(s_p) = E\left[V_1(s_p, 1, 0, 0, \bar{h}_1, \eta_1)\right] \quad \text{and} \quad W_2(s_p) = E\left[V_1(s_p, 2, 0, 0, \bar{h}_1, \eta_1)\right]$$

in the cases they directly join the labor force and attend university, respectively. An individual of socio-economic background s_p will then choose to enroll in college, if

$$W_2(s_p) + \varepsilon \geq W_1(s_p).$$

Similar to Willis and Rosen (1979) and Heckman et al. (1998), I capture unobservable characteristics by means of "non-pecuniary costs of schooling" ε, where ε is normally distributed with mean 0 and variance σ^2_ε.[6] I assume that there is a large amount of individuals in each socio-economic group and let the random variables ε for different states be stochastically independent. Then

$$P\left\{W_2(s_p) + \varepsilon \geq W_1(s_p)\right\} = 1 - N_{0,\sigma^2_\varepsilon}\left[W_1(s_p) - W_2(s_p)\right] = d(s_p)$$

is the fraction of individuals of socio-economic background s_p who decide to attend university.

Looking upon his future life, for an agent being in college, i.e. with state $z_1 = (s_p, 2, 0, 0, \bar{h}_1, \eta_j)$, his future possible states are

$$z_2 = \begin{cases} z_2^s = (s_p, 2, a_{j+1}, p_{j+1}, \bar{h}_2, \eta_{j+1}) & \text{with probability } \pi^e_{s_p} \\ z_2^f = (s_p, 1, a_{j+1}, p_{j+1}, \bar{h}_1, \eta_{j+1}) & \text{with probability } 1 - \pi^e_{s_p}. \end{cases}$$

[6] Choosing an expected value of zero ensures utility to remain homogeneous.

College students can split the remainder of their time that is not devoted to studying between consuming leisure and supplying labor to the market. In addition, they receive transfers κ_j from their parents and payments ϑ_j out of a governmental student loan scheme. They again use their net income to finance consumption expenditure and to possibly build up some assets.

2.4 Intergenerational transfers and external effects

In order to link generations, I let parents be of age J_p when children enter their economically relevant phase of life. Unlike Gallipoli et al. (2008) I do not assume parents to be altruistic towards their children. This ensures that I do not run into the problem of Ricardian equivalence. Instead I let transfers between generations κ_j be exogenous and conditional on parents' education level. Specifically, I set

$$\kappa_1(z_1) = \kappa_{s_p} \quad \text{if} \quad z_1 = (s_p, 2, 1, 0, 0, \bar{h}_1, \eta_1),$$

i.e. children only receive transfers from their parents during formal education. Of course, the sum of lump-sum transfers to children must be financed by the parent generation.

The distribution of individuals across different socio-economic backgrounds $F(s_p)$ is determined by the schooling choice of their parents. If e.g. 40 percent of households of the parent generation were holding a university degree $s = 2$, 40 percent of their children would be of socio-economic background 2, i.e. $F(s_p = 2) = 0.4$. As time effort and probability of success in formal schooling depend on households' socio-economic background, parents influence children's educational abilities via their own schooling choice. Since they are not altruistic towards their descendants, they do not take into account the impact of their own behavior on their children. Therefore education triggers positive external effects.

2.5 Firms behavior

A continuum of firms produce under perfect competition with the Cobb-Douglas technology

$$Y = \Lambda \cdot K^{\chi_1} \cdot L^{1-\chi_1}.$$

In line with Katz and Murphy (1992), I compute aggregate labor input in production from

$$L = \left\{ \lambda_1 L_1^{1-\frac{1}{\chi_2}} + \lambda_2 L_2^{1-\frac{1}{\chi_2}} \right\}^{\frac{1}{1-\frac{1}{\chi_2}}}$$

For $\chi_2 < \infty$, labor of different schooling types is therefore not perfectly substitutable. Firms maximize output net of labor and capital costs. Capital costs include a constant depreciation rate of δ_k. Due to the assumption of perfect competition, factor prices equal net marginal products, i.e.

$$r = \frac{\partial Y}{\partial K} - \delta_k \quad \text{and} \quad w_s = \frac{\partial Y}{\partial L_s}.$$

2.6 The government

The government runs two systems with separate budgets: a tax and a pension system.

The tax system The tax system collects taxes on consumption C, labor income $w_1L_1 + w_2L_2$ and capital income rA in order to finance expenditure on public consumption G and on education G_s as well as interest payments on existing debt rB. The costs associated with education level s consist of two components: a fixed cost per student g_s (provision costs) and possible burdens arising from the student loan system ϑ_j.[7] Income taxes are levied at proportional rates τ_w and τ_r. In the initial equilibrium,[8] the level of government debt is constant at B_0 and the consumption tax rate balances the governments budget on a period by period basis. The tax system's budget then reads

$$\tau_c C + \tau_w \left[w_1 L_1 + w_2 L_2\right] + \tau_r r A = G + G_1 + G_2 + rB_0.$$

After a reform has been introduced in period $t = 1$ of the transition,[9] the consumption tax rate however only ensures that the government's budget is balanced intertemporally, i.e.

$$\sum_{t=1}^{\infty} R_t \Big\{ \tau_c C_t + \tau_w \left[w_{1,t} L_{1,t} + w_{2,t} L_{2,t}\right] + \tau_r r_t A_t \Big\} = (1 + r_1) B_1 + \sum_{t=1}^{\infty} R_t \Big\{ G_t + G_{1,t} + G_{2,t} \Big\}$$

with $R_t = \prod_{s=2}^{t} (1 + r_s)^{-1}$ holds. Government debt B_t then balances the budget periodically, i.e.

$$B_{t+1} = G_t + G_{1,t} + G_{2,t} + (1 + r_t) B_t - \tau_c C_t - \tau_w \left[w_{1,t} L_{1,t} + w_{2,t} L_{2,t}\right] - \tau_r r_t A_t.$$

The pension system The pension system runs on a pay-as-you go basis. In every year in the initial equilibrium, it collects contributions at the flat rate τ_p in order to finance pension payments to existing retirees, i.e. its budget constraint reads

$$\tau_p \Big[w_1 L_1 + w_2 L_2 \Big] = P,$$

where P denotes aggregate pension benefits. The pension contribution rate balances the budget periodically. Yet, just as in the tax system, when a reform is introduced in period $t = 1$, the contribution rate only balances the intertemporal budget of the pension system, i.e.

$$\tau_p \sum_{t=1}^{\infty} R_t \left[w_{1,t} L_{1,t} + w_{2,t} L_{2,t}\right] = \sum_{t=1}^{\infty} R_t P_t,$$

and so-called pension debt B_t^p balances the budget on a period-by-period basis, i.e.

$$B_{t+1}^p = P_t + (1 + r_t) B_t^p - \tau_p \left[w_{1,t} L_{1,t} + w_{2,t} L_{2,t}\right].$$

I set $B_0^p = 0$ in the initial equilibrium.

2.7 General equilibrium

Given a specific fiscal policy, a competitive equilibrium path of the economy is a set of competitive factor prices, budget clearing tax rates and stocks of debt as well as household decision rules that satisfy the following conditions:

7 This implies that a reduction in the number of college students relaxes the government's budget.

8 The initial equilibrium will henceforth be denote by $t = 0$.

9 For more details on reform scenarios see Chapter 4.

1. The capital market clears, i.e.

$$A_t = K_t + B_t + B_t^P.$$

2. Labor demand of the firms for the two educational levels equals labor supply.

3. The goods market clears, i.e.

$$Y_t = C_t + G_t + G_{1,t} + G_{2,t} + K_{t+1} - (1 - \delta_k)K_t.$$

A long-run equilibrium is an equilibrium path on which aggregate variables are constant over time.

3 Calibration strategy

I use a combined estimation and calibration strategy with German data that is very much in line with Kindermann (2012) to parameterize my model. Specifically, I

1. specify demographic and schooling parameters;
2. estimate labor income shocks from SOEP panel data;
3. use age fixed effects of this estimation process to determine the parameters of on-the-job training via a method of moments estimator;
4. set the parameters that determine schooling choices;
5. calibrate the remaining model parameters.

3.1 Demographics, educational levels, and the distribution of bequests

I let one model period cover 5 years for computational reasons. Agents start making economically relevant decisions by the age of 20 ($j = 1$), are 44 when their children turn 20 ($J_p = 6$), retire at age 60 ($J_R = 9$) and live up to a maximum of 100 years ($J = 16$). The college enrollment decision therefore has to be taken at age 20, which is line with the German educational system. Individual survival probabilities are taken from Bomsdorf (2002). I classify education levels according to the ISCED 1997 Standard issued by UNESCO (2006). I merge levels 0 to 4 (secondary education) and 5 and 6 (tertiary education) to obtain the two schooling levels.

As for the distribution of unintended bequests, I assume children to inherit the assets of their parents. Therefore, children with a strong socio-economic background will receive a larger amount of bequest and households at ages $j > J - J_p$ do not receive any, since their parents are already dead with certainty.

3.2 Idiosyncratic wage risk

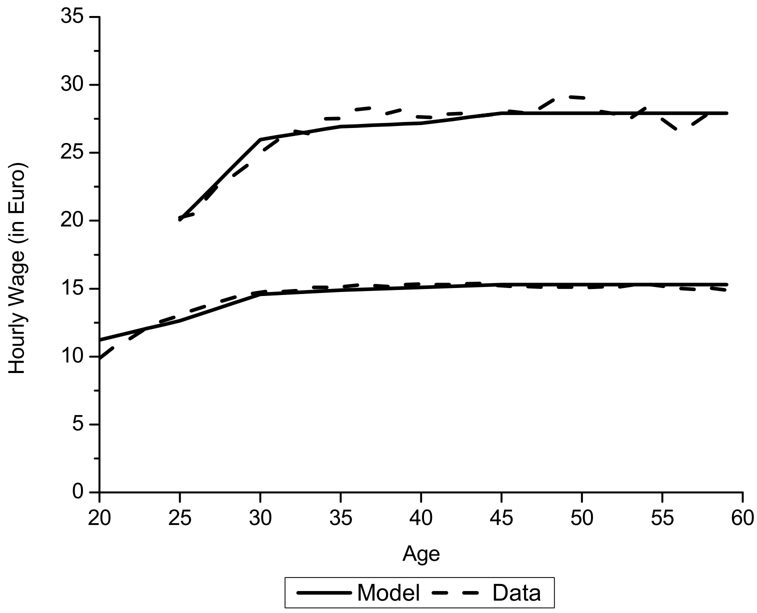
I use data of the German Socio-economic panel (SOEP) to quantify wage risk. Specifically, I calculate deflated hourly wages $h_{i,j,t,s}$ of individuals i at age j and time t and classify them according to the two education levels s mentioned above. Self-employed, interns and civil servants are excluded from my data set, since they tend to have quite different wage dynamics. In addition, I exclude the upper and the lower percentile of the hourly wage distribution in order to rule out errors in the data.

I then apply the method described in Kindermann (2012) to determine both income uncertainty and human capital production functions for individuals of different educational levels. I first estimate an age- and year fixed effect regression with an AR(1) process for income uncertainty. I then use the age fixed effects to determine human capital production functions via a partial equilibrium method of moments estimation. The results of this process are shown in Table 1 and Figure 2. They are very much in line with the ones reported in Kindermann (2012).

Table 1: Estimation results for income uncertainty and human capital production on-the-job

	$s = 1$	$s = 2$
Autoregressive parameter ρ_s	0.8510	0.9019
	(0.00414)	(0.00246)
Variance of innovaton $\sigma^2_{\epsilon,s}$	0.0547	0.04660
	(0.00246)	(0.00568)
Variance of process $\sigma^2_{\eta,s}$	0.1740	0.24029
	(0.00240)	(0.00559)
Productivity A_s	13.47444	32.48548
Elasticity wrt time α_s	0.99787	0.99895
Initial human capital $\bar{h}_s$	13.46004	24.75562

Figure 2: Hourly wage profiles for different schooling levels



3.3 Schooling choice

Table 2 shows the parameters determining household's college enrollment decision. The annual transfers in Euro from the government and from parents to their children during college attendance are taken from Autorengruppe Bildungsberichterstattung (AB) (2008). Note that households have to repay half of the transfers they received from the government without interest starting 5 years after they left university. This is in line with the German practice.

Table 2: Determinants of formal schooling decisions

	$s_p = 1$	$s_p = 2$	Average
Transfers from government ϑ_j	4 650	3 948	4 387
Transfers from parents κ_{s_p}	4 284	6 600	5 153
Probability of success $\pi^e_{s_p}$	0.75	0.85	0.79
Time costs ϖ_{s_p}	0.60	0.54	0.58

Having set monetary transfers, I calibrate time costs of studying and probabilities of success in order to replicate participation rates reported in Heineck and Riphahn (2009) as well as failure rates taken from AB (2008). Note that time costs of studying do not necessarily reflect pure time efforts. They might also incorporate "mental studying costs", since I assumed unobservable characteristics ε_s to have zero mean. Finally, I set the variance $\sigma^2_\varepsilon = 0.00514$ which is in line with the estimates of Heckman et al. (1998). Table 3 reports participation rates computed from Heineck and Riphahn (2009) as well as my model generated data.

Table 3: Participation rates by socio-economic background

	Data			Model	
	$s = 1$	$s = 2$		$s = 1$	$s = 2$
$s_p = 1$	74.30	25.70	$s_p = 1$	74.34	25.66
$s_p = 2$	42.66	57.34	$s_p = 2$	42.75	57.25

3.4 Household preferences, production technology, and the government

Household preferences I let instantaneous utility be represented by the CRRA utility function

$$u(c, \ell) = \frac{1}{1-\gamma} \left[c^{1-\nu} + \mu \ell^{1-\nu} \right]^{\frac{1-\gamma}{1-\nu}} .$$

γ denotes risk aversion and ν the inverse of the elasticity of substitution between consumption and leisure. μ is a measure for leisure preference. I choose a fairly standard risk aversion of 2 which implies an intertemporal elasticity of substitution of 0.5. ν is set to 1.7 leading to a Marshallian compensated elasticity of labor supply of 0.44. Fenge et al. (2006) report values between 0.215 for German men and 0.565 for women. Since I only consider unisex households, an elasticity of 0.44 seems to be reasonable. I calibrate μ to 0.8. This causes the average of working hours to amount to

29.4 percent, which is in line with the data reported in Institute der Deutschen Wirtschaft (IW) (2011). Finally, I set the time discount factor at $\beta = 0.85$. This choice corresponds to a 3.2 percent annual time discount rate and leads to a capital to output ratio of 3.3. IW (2011) reports a value of 3.5 for 2010.

Production technology In the production sector I let $\chi_1 = 0.35$, which guarantees a labor income share of 0.65. I then take the elasticity of substitution between labor of different types from Heckman et al. (1998) ($\chi_2 = 1.41$) and calibrate the labor shares λ_s so as to receive the same wage rate for effective labor for both skill classes. A technology level of $\Lambda = 0.12$ ensures wage rates to be normalized to unity. Finally, I assume an annual depreciation rate of capital of 5.3 percent which leads to an investment level of 19.5 percent of GDP.

The government I calibrate consumption and income tax rates so as to match tax revenues from these sources reported in IW (2011). This leads to $\tau_c = 0.20$ and a uniform income tax of $\tau_w = \tau_r = 0.10$. I let government debt be 60 percent of GDP in the initial equilibrium, which is the long term target of the European Stability Pact, and set public expenditure on different educational levels G_s to the values reported in OECD (2009). In the pension system, I set the accrual rate ϱ to an amount that generates a contribution rate of 20 percent, which is close to the current contribution rate of the German pension system.

Table 4 summarizes calibrated parameter values and their targets.

Table 4: Calibrated model parameters and their targets

Parameter	Value		Target
Household preferences:			
Risk aversion γ	2.00		Literature
Leisure preference μ	0.80		Average hours worked
Inv. of intratemp. elast. of substitution ν	1.67		Labor supply elasticity
Time discount factor β	0.85		Capital to GDP ratio
Production technology:			
Capital share χ_1	0.35		Labor income share
Elast. of substitution labor types χ_2	1.41		Heckman et al. (1998)
Labor shares λ_s	0.52	0.48	$w_1 = w_2$
Technology Λ	0.12		$w_s = 1$
Government:			
Income tax rates τ_w, τ_r	0.10		Tax revenues to GDP
Consumption tax rate τ_c	0.20		Tax revenues to GDP
Debt B to GDP	0.60		Euro Stability Pact
Education expenditure G_s to GDP (in %)	3.10	1.10	OECD (2009)
Contribution rate τ_p (in %)	0.20		German pension system

4 Simulation results

In this chapter, I present evidence on how my model performs in replicating German macroeconomic and distributional data. I then describe how I implement policy reforms. The remainder of the chapter is dedicated to policy analyses.

4.1 The initial equilibrium

All my simulations start from an initial long-run equilibrium that replicates selected macroeconomic and distributional facts of the German economy. Table 5 compares model generated macro data with their real equivalents in Germany in 2010. Since I assume a closed economy setting and Germany is a net exporter, private consumption is higher than in reality. Public consumption, on the other hand, is a little too low. This is because the government can not issue new debt in the initial equilibrium. Overall I find that my model reasonably replicates German macroeconomic indicators.

Table 5: Macro data in initial equilibrium (in % of GDP)

	Model	Germany
Expenditure:		
Private Consumption	62.9	58.8[a]
Public Consumption	17.7	19.7[a]
Investment	19.5	17.0[a]
Net exports	0.0	4.6[a]
Capital market:		
Capital stock	330.3	350.0[a]
Government debt	60.0	67.7[a]
Accidental bequests	4.5	4.7-7.1[b]
Interest rate (in % p.a.)	4.3	–
Tax revenues:		
Consumption tax	12.6	13.1[a]
Income tax	8.3	8.4[a]
Pension system:		
Contribution rate (in %)	20.0	19.9[a]
Pension benefits	12.2	11.6[a]

Source: [a]IW (2011), [b]Braun et al. (2002).

Table 6 reports some distributional measures. As I used German income data to parameterize my model, it is not surprising that it replicates the distribution of income quite accurately. The Gini coefficient of net income is a little higher than in reality, which is because my model neglects the distributional effects of progressive income taxes and transfers to low income households.[10] As for the wealth distribution, the Gini index in my model is considerably lower than in the data. This

[10] It would be no problem to include progressive taxes into household decisions. However, this would induce additional distortions on human capital formation and complicate the interpretation of simulation results. Simulations with a progressive tax system are available upon request.

might be due to the fact that I only consider employed workers and ruled out self employment as well as unemployment from my model. Finally, my model predicts a significantly lower fraction of the population to have no wealth at all. This could indicate that it understates the problem of liquidity constraints. Another explanation would be that there are no means tested social security systems in the model.

Table 6: Distributional measures in initial equilibrium

	Model	Germany
Income distribution:		
Gini index of net income	0.316	0.290[a]
Share of lowest decile	3.7	3.6[a]
Share of highest decile	25.5	24.0[a]
Wealth distribution:		
Gini index of wealth	0.580	0.799[a]
Fraction of pop. with no wealth	19.6	37.0[a]

Source: [a]Sachverständigenrat (2009)

4.2 The reform experiment

In this paper, I want to analyze the consequences of pension funding on the accumulation of human capital, the macroeconomy, welfare and efficiency. I therefore simulate my counterfactual, i.e. the full privatization of the PAYG pension system, in the following way: I start from the initial equilibrium ($t = 0$) described above. In the reform period ($t = 1$), I shut down the accumulation of new pension claims, i.e. I set the accrual rate $\varrho_t = 0, t \geq 1$. Consequently, households will not accumulate any more pensions, but existing claims will be kept and payed out by the system along the transition.[11] The remainder of pension claims will be financed by a mixture of payroll taxes and public debt as described in Section 2.6. Obviously, since pension payments have to be made at the beginning of the transition, but the payroll tax rate will be adjusted once in the reform period and then stay constant forever, the pension system will have to run into debt in the initial periods of the transition. Interest payments on this debt will then be financed by the taxes raised from all future generations. We can therefore say that my reform experiment makes implicit debt inherent in the current German pension system explicit, see Werding (2007).

4.3 The direct effects of earnings related pensions on human capital formation

Before we turn to the simulation results, we should derive some intuition about how an earnings related pension system might influence the decision of individuals to form human capital. These influences may be of two types: indirect effects that arise through changes in factor prices and direct effects. The first part of simulation results will be dedicated to these direct effects.

[11] Note that the last pensions will be payed in period 15 of the transition, when the cohort aged 1 in the initial equilibrium reaches age $J = 16$.

A major characteristic of a PAYG pension system is that contributions to it do usually not pay off the market interest rate. The internal rate of return of a PAYG pension system depends on the population structure as well as on whether the system is indexed to wages or prices, but it will usually range somewhere below capital market returns. Consequently, individuals perceive part of the contribution to a pension system as a pure tax. We can then divide the contribution of an agent into an implicit savings part, namely that share of the contribution that would have to be saved in the capital market in order to generate the same amount of pension as the PAYG system does, and an implicit tax part, i.e. that part of the contribution that is not implicit savings. In addition to demographics and growth rates, the size of the implicit tax share crucially depends on the pension benefit formula. Suppose for example that the system would be fully flat, i.e. everyone gets paid out the same pension, regardless of his contribution. Then obviously an increase in the size of the contribution (e.g. by working longer hours) has no effect on benefits and therefore the full contribution would be perceived as tax. If on the other hand the system is perfectly earnings related, then increasing the contribution also increases the benefit and the implicit tax share is strictly lower than one.

In the present model it is fairly straightforward to calculate implicit savings and tax shares of pension contributions. Suppose a household aged j would increase his labor supply l_j by one marginal unit. As a consequence, he would have to contribute at rate $\tau_p \cdot w_{s_j} \cdot h_j \cdot \eta_j$ to the pension system. In reward for that his pension benefits would increase by $\varrho \cdot w_{s_j} \cdot h_j \cdot \eta_j$ in every year of retirement. The question now is what the agent would have to save in the capital market in order to generate an additional income stream of $\varrho \cdot w_{s_j} \cdot h_j \cdot \eta_j$ in every successive age of his retirement phase. The answer is

$$\left[\varrho \cdot w_{s_j} \cdot h_j \cdot \eta_j\right] \cdot \sum_{i=J_r}^{J} [1 + r(1 - \tau_r)]^{j-i}$$

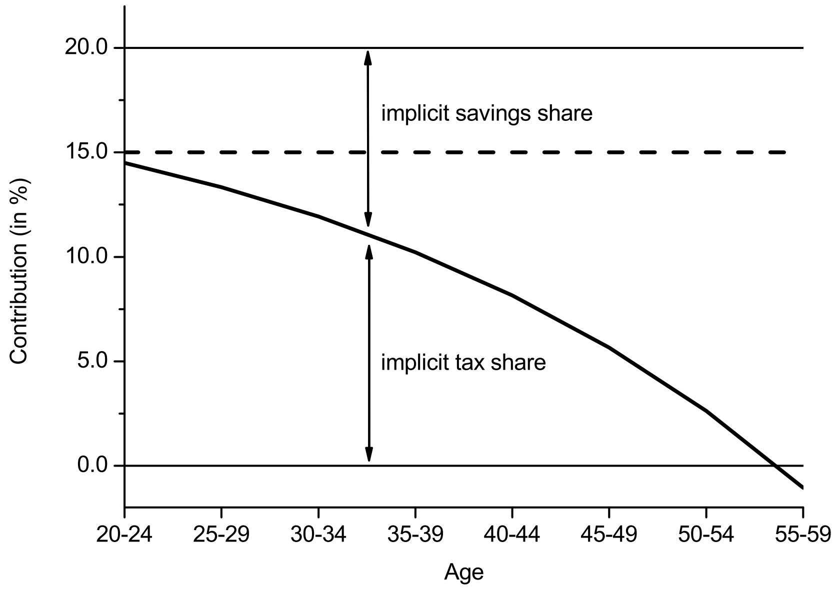
Relating this to the contribution the household has actually made to the pension system gives us the implicit savings share

$$s_j^{\text{impl}} = \frac{\varrho}{\tau_p} \cdot \sum_{i=J_r}^{J} [1 + r(1 - \tau_r)]^{j-i}.$$

The implicit tax share then just is $1 - s_j^{\text{impl}}$. Note that implicit tax and savings share as calculated above do depend on the agent's actual age j. The solid line in Figure 3 therefore shows how these shares evolve over the working life of a household. We can see a significant increase in the savings share over the life cycle. This can be explained by the fact that the pension income stream generated by a marginal increase in the contribution is the same regardless of the household's age. As interest payments accumulate, the amount that needs to be saved at the beginning of the life cycle to generate this very income stream is much smaller than shortly before retirement. This feature of pension systems has already been discovered by Fenge et al. (2006) and analyzed in more detail by Fehr and Kindermann (2010).

But what is the impact of this implicit tax/savings structure on the individual decision to acquire human capital? Lets start with the schooling decision. An alternative interpretation of Figure 3 is that wage income that was earned later in life is relatively more important to the households budget. As the implicit tax rate becomes even negative towards the end of the working career, labor incomes at older ages become factually subsidized, while at young ages it gets taxed. Taking a look back at Figure 2 we see that the difference in human capital and therefore in earnings capacities between the lower and the higher skilled significantly increases with age. Another way to put this is that

Figure 3: Implicit savings and tax components of pension contributions



the higher skilled tend to earn their income much later in life than the lower skilled, since they use the early periods for investing in education. Paired with the implicit tax structure discussed above, we therefore suspect the pension system to actually be regressive in terms of education, i.e. to redistribute from the less towards the more skilled. In order to substantiate this proposition, Table 7 shows the ratio of the present value of pension benefits over the present value of pension contributions for the average earner of each educational group. As expected, high skilled individuals get about 4 percent more pensions for their contributions compared to low skilled earners. In this sense we can call the earnings related pension system in this model regressive with respect to education. This result is, to the best of my knowledge, new to the literature. Consequently, when we abolish this system and therefore the subvention of higher education that comes with it, we would expect the schooling effort of individuals do decrease.

Table 7: Ratio of pension payments and contributions

s	1	2
Ratio	25.2	29.1

The implicit tax structure of the pension system also has an influence on on-the-job training effort of the household. Again in early working life, i.e. during the time of investment in human capital, tax rates on labor income are relatively high, while towards retirement, i.e. in the time the investment brings yields, tax rates are low. Therefore, we suspect the pension system to also enhance on-the-job training efforts. Yet, in this case, there is a counteracting effect which arises from the presence of borrowing constraints. When I privatize the pension system, the contribution rate will decrease (see the dashed line in Figure 3). It does not decrease to zero, since existing pension claims throughout the transition need to be financed, yet, it decreases from 20 to roughly 15 percent, see below for further discussions. This causes positive income effects on households in every year of working life. In the initial periods of the life cycle, this income effect will certainly relax borrowing constraints. As agents do have more cash at hand, they may reduce working effort for a higher investment in human capital via on-the-job training.[12] The direct effect of the pension system on on-the-job training is therefore ambiguous.

Summing up, we can expect the following direct effects from pension funding:

1. Since the PAYG pension system in this model is regressive with respect to education, we expect college enrollment rates to decrease as soon as we shut down the pension system.
2. The implicit tax structure encourages human capital investment via on-the-job training, but the negative income effect of pension contributions strengthens liquidity constraints and therefore discouraged training efforts. The overall direct effect of pension funding on on-the-job training is therefore ambiguous.

4.4 Simulation results: Direct effects

With my simulation model, we can both get a sense for the size of the above effects as well as for which of the two effects on on-the-job training is the dominant one. In order to keep things as simple as possible for now, I start out with a model version that features a perfect insurance against longevity risk, i.e. people can buy fair annual annuities. The households' budget constraint then turns into

$$a_{j+1} + (1+\tau_c)c_j = \frac{[1+r(1-\tau_r)]}{\psi_j} a_j + p_j + b_j$$

for retirees and likewise for workers and individuals in school. Note that there will be no bequests at all in this case. The assumption of perfect annuities therefore avoids feedback effects that would arise from changes in accidental bequests, see below. By adjusting the time preference rate to $\delta = 0.84$, the capital to GDP ratio remains at 3.3 and the interest rate at 4.3 percent annually. I furthermore had to adjust $\varpi_1 = 0.60$ and $\varpi_2 = 0.56$ to guarantee that households make the same schooling choice. Last but not least, I assume for these simulations a small open economy setting and let labor of different educational levels be perfectly substitutable ($\chi_2 = \infty$). Therefore, factor prices will remain unchanged along the transition path and in the new long-run equilibrium.

In this bequest free version of the model, I conduct the pension funding experiment described above. Table 8 reports in the left panel the long-run results from a simulation scenario in which schooling choices are fixed at initial equilibrium values, i.e. the only way for agents to affect their human capital is via on-the-job training.[13] Not surprisingly, when I shut down the accumulation of pension claims, agents will start saving privately for their retirement. This causes private assets to increase by roughly 50 percent over their initial equilibrium value. A natural consequence of this is that the government raises more revenue from capital income taxation. Therefore, the consumption tax rate (which balances the budget of the tax system) can be decreased by 0.5 percentage points in any period of the transition as well as in the long-run equilibrium. As capital income tax revenues successively rise throughout the transition, the government has to run into debt in order to guarantee a constant

[12] This reasoning does not apply to college education, since college students tend to not work at all or only very little in my model.

[13] I will focus on transitional dynamics in another section. For now, long-run results are enough to explain what happens in the model.

consumption tax rate throughout the transition. As already indicated above, the contribution rate of the pension system decreases by 5.0 percentage points in every period of the transition. Therefore individuals will still have to contribute at a rate of 15 percent to the pension system after the reform has been made. These revenues are needed to finance existing pension claims of the elderly that were accumulated before the change in regimes. Since contributions are paid in any period of the transition and the new long-run equilibrium, but the pension system pays out benefits only in the first 15 periods of the reform path, it has to heavily run into debt. In the long-run, the stock of pension debt amounts to 194.5 percent of GDP, which reflects the implicit debt inherent in the current pension system. In terms of labor supply of the two different educational groups $s = 1$ and $s = 2$, I find a slight increase of 0.8 and 1.1 percent of initial equilibrium values, respectively. This is mainly due to the fact that individuals invest more in human capital after the reform than before. We therefore can conclude that the effect of relaxed borrowing constraints dominates the tax incentive effects inherent in the implicit tax structure of the pension system. The amount of human capital formed by on-the-job training consequently increases by roughly 26 and 18 percent compared to the initial equilibrium for the two educational groups, respectively.

Table 8: Direct effects of pension funding

Simulation	(1)		(2)	
Schooling	fix		variable	
Annuities	yes		yes	
χ_2	∞		∞	
Smopec	yes		yes	
Assets[a]	49.7		48.7	
Bequests[a]	0.0		0.0	
Interest rate[b]	0.0		0.0	
Cons. tax[b]	-0.5		-0.6	
SS tax rate[b]	-5.0		-5.0	
Government debt[c]	70.7		69.0	
Pension debt[c]	194.5		194.4	
	$s=1$	$s=2$	$s=1$	$s=2$
Labor supply[a]	0.8	1.1	3.0	-2.7
Wages[a]	0.0	0.0	0.0	-0.0
On-the-job training[a]	25.8	18.1	23.8	18.3
	$s_p=1$	$s_p=2$	$s_p=1$	$s_p=2$
Schooling Choice[b]	0.0	0.0	-1.4	-1.7

Change in [a]percent over initial equilibrium values,
[b]percentage points, [c] in percent of GDP.

In the right panel of Table 8, I also allow schooling to adjust to the reform made in period $t = 1$ of the transition. There is no major effect on the accumulation of assets and the changes in tax rates or government debt. This is basically due to the assumption of a small open economy and the perfect substitutability of labor supply. Yet, in the lower part of the right panel, we can see that both labor supply and schooling have changed compared to the previous simulation. As expected, the fraction of agents from both socio-economics backgrounds s_p is reduced as the regressive effect of the pension system vanishes. This in turn causes labor supply to shift from high skilled towards low skilled labor.

We can conclude from this section that a privatization of the pension system could give additional incentives for on-the-job training while it will have a moderate negative effect on college enrollment rates. Yet, up to this point, we assumed life span risk to be perfectly insurable. A lot of evidence however points into the direction that households tend to not annuitize their retirement wealth, see Brown (2009) for a discussion of how we could explain this phenomenon. Given this observation, I will assume in the following that there are no annuities available to households.

4.5 Simulation results: the role of accidental bequest

We now move back to the model setup without annuitization and use the parameter values for δ and ϖ_s as reported in the calibration section. Yet, we still hold up the assumption of a small open economy and perfectly substitutable labor. Consequently, the upcoming results isolate the consequences of pension funding under the absence of annuity markets.

Before we turn to the simulation results, lets again first build some intuition on what happens in this case. When shutting down the pension system, agents start saving privately for their retirement which – under the assumptions of non-annuitized savings – causes bequests to rise drastically. In order to understand how rising bequests influence individual behavior, we have to recall that my model economy is dynamically efficient. This causes the pension system – i.e. transfers from young to old cohorts – to pay off less than the market interest rate and therefore to have a negative impact on household's budget. By the very same reasoning, however, accidental bequests – i.e. transfers from the elderly to the younger – will have a budget enhancing effect on future cohorts. This positive income effect will have two major consequences:

1. It will increase leisure consumption in every period of the working phase, therefore reduce both labor supply and the need to form human capital.
2. Most of the additional income from bequests will flow towards the later periods of the working phase, when agents' parents become really old. This strengthens the need for resources at the beginning of the life cycle, therefore giving additional incentives to reduce human capital investment in a world where households are borrowing constraint.

Furthermore, the arguments of the previous subsections still hold. Hence, we expect on-the-job training effort to be significantly less than in the previous simulations, yet, not necessarily to turn negative.

The left panel of Table 9 shows the long-run macroeconomic results of my pension funding exercise under the absence of annuity markets. In such a situation, private assets have to rise even further compared to the situation with perfect annuities, as there now is a precautionary savings motive related to longevity risk. The significant rise in private savings increases the flow of accidental bequests by over 130 percent of their initial equilibrium value. Since additional assets constitute pure life-cycle savings and therefore will all be taken along the retirement phase, the effect on bequests is much larger than that on private savings.[14] On the government side, the positive revenue effect associated to a higher interest income from savings is now overlaid by the reduction of labor supply

[14] Note that a large part of households' savings is precautionary savings due to income risk. These savings tend to vanish towards the end of the working phase and therefore do not end up as inheritances to descendants.

and the consequential decline in labor income tax revenues. The consumption tax rate can therefore only be reduced by 0.3 percentage points. In a situation with perfect annuities the implicit savings share of the pension system is naturally smaller than in a world without annuitization, as generating a constant income stream during retirement is much more costly in the latter case. This is reflected in the fact that the social security tax rate can now be lowered by 5.6 percent compared to the 5 percent in the previous simulations.

Table 9: The role of accidental bequests

Simulation	(3)		(4)	
Schooling	fix		variable	
Annuities	no		no	
χ_2	∞		∞	
Smopec	yes		yes	
Assets[a]	65.9		57.7	
Bequests[a]	133.1		120.7	
Interest rate[b]	0.0		0.0	
Cons. tax[b]	-0.3		-0.4	
SS tax rate[b]	-5.6		-5.5	
Government debt[c]	70.6		58.1	
Pension debt[c]	185.9		189.6	
	$s=1$	$s=2$	$s=1$	$s=2$
Labor supply[a]	-9.8	-4.4	5.5	-29.8
Wages[a]	0.0	0.0	0.0	-0.0
On-the-job training[a]	-41.6	-1.6	-40.4	0.2
	$s_p=1$	$s_p=2$	$s_p=1$	$s_p=2$
Schooling Choice[b]	0.0	0.0	-5.6	-9.1

Change in [a]percent over initial equilibrium values,
[b]percentage points, [c] in percent of GDP.

As argued earlier and can be seen from the lower left part of Table 9, the positive income effect of rising bequests causes labor supply for households of both educational levels to decline. Yet, this effect is much stronger for the lower than for the higher educated. To understand the reasons behind that, we have to take a closer look at the labor income of parents and their children. If parents and children completed the same schooling level, then they both share the same earnings capacity. If schooling levels however differ, then low educated workers have parents that are much richer than themselves, while college graduates will have poorer parents. As the level of bequests parents leave to their descendants is strongly related to their labor income, a certain fraction of low educated households will inherit over-proportionally much from their parents, while exactly the opposite is true for college graduates. Summing up, the income effect of bequests will (on average) be significantly stronger for the lower than for the higher educated. Consequently, labor supply decrease more for the former than for the latter. Exactly the same reasoning applies to on-the-job training efforts. Overall, this causes human capital formed by on-the-job training to decrease from 26 and 18 percent in the previous simulation to about -42 percent for the lower educated and to only -2 percent for college workers.

In the right panel of Table 9, I again allow college choice to adjust to the situation after the reform. In this situation the number of college students and therefore the number of high skilled workers significantly decreases, which has a negative impact on both private savings and accidental bequests. Again labor shifts from the group of high skilled towards the group of low skilled workers. Consequently, high skilled labor declines by 29.8 percent while low skilled labor slightly rises by 5.5 percent. While on-the-job training efforts are nearly the same as before, there is a remarkable reduction in the number of college graduates. To understand the effects of pension funding on educational decisions under the absence of annuity markets, we have to again recall what the effect of rising bequests is on individuals with different socio economic backgrounds. First of all, as argued above, the positive income effect through rising bequests leads to higher consumption of leisure and therefore weakens the incentives to built human capital. In addition, individuals with a stronger socio-economic background, meaning richer parents, receive much more accidental bequests compared to agents with a weaker background. Therefore the incentive to not go to college, is higher for these types and the fraction of college graduates in this group decreases by 9.1 percentage points. For individuals with a weaker background the fraction of college students only declines by 5.6 percent.

Summing up, I find that the long-run effects of pension funding in a world with no market for annuities significantly differ from those in a world with perfectly insurable life span risk. The strong increase in accidental bequests by about 120 percent of their initial equilibrium values triggers a positive income effect. As a result, individuals consume more leisure, which weakens the incentives to work and therefore to form human capital both via on-the-job training. This effect is stronger for the less educated, since they (on average) tend to have relatively richer parents then their highly educated counterparts.

4.6 Simulation results: Factor price effects

Up to this point, the factor price effects of pension funding have been completely neglected. I therefore assume in the left panel of Table 10 that labor of different education levels is not perfectly substitutable anymore, but I still uphold the assumption of a small open economy. Consequently, wages will adjust to the new situation after the reform, but the interest rate will still be constant. Naturally, with a decline in the amount of high skilled labor, wages for college graduates increase by about 3.0 percent while those for low skilled labor decline. This dampens the effect on college enrollment rates compared to the previous simulation without factor price adjustments. As a result, the fractions of college graduates now only decline by 1.3 and 2.9 percent, respectively. With this only modest reduction in college enrollment rates, asset accumulation is again strengthened compared to the previous situation and the shift of labor from high towards low skilled is somewhat mitigated. Yet, as interest rates are still constant, there is nearly no impact on on-the-job training efforts.

This changes when I finally assume a closed economy setting in the right panel of Table 10. The enhancement of private savings boosts supply on the capital market. A large part of additional savings is however absorbed by the government's demand for debt. Therefore productive capital only increases by 7.5 percent and the interest rate adjusts downward by only 0.6 percentage points in annual terms. Consequently, private assets and accidental bequests are only sightly lower compared to the previous situation. As financing public debt becomes cheaper with a declining interest rate, both government and pension debt increase compared to the small open economy case, while at the same time consumption and social security tax rates can be reduced. The falling interest rate makes the alternative investment to physical capital more attractive. This consequently enhances both on-

Table 10: Pension funding in general equilibrium

Simulation	(5)		(6)	
Schooling	variable		variable	
Annuities	no		no	
χ_2	1.41		1.41	
Smopec	yes		no	
Assets[a]	63.5		61.9	
Capital[a]	-8.6		7.5	
Bequests[a]	129.5		118.1	
Interest rate[b]	0.0		-0.6	
Cons. tax[b]	-0.3		-0.7	
SS tax rate[b]	-5.5		-6.4	
Government debt[c]	66.6		70.6	
Pension debt[c]	186.6		206.1	
	$s=1$	$s=2$	$s=1$	$s=2$
Labor supply[a]	-5.1	-12.3	-0.4	-7.6
Wages[a]	-2.5	3.0	1.5	6.9
On-the-job training[a]	-41.5	-1.9	-5.5	8.9
	$s_p=1$	$s_p=2$	$s_p=1$	$s_p=2$
Schooling Choice[b]	-1.3	-2.9	-0.8	-2.4

Change in [a]percent over initial equilibrium values,
[b]percentage points, [c] in percent of GDP.

the-job training effort as well as college enrollment rates and causes labor supply to rise compared to the previous situation. As labor supply yet still decreases in absolute terms and capital increases, wages rise for any educational group in the long-run.

All in all we saw in this section that factor prices adjustments will dampen the negative effects of pension funding on college enrollment rates, on-the-job training effort as well as the shift in labor supply from high skilled towards low skilled labor. In stark contrast to the existing literature on pension funding in general equilibrium, however, I find that factor price effects are not able to really boost human capital investment. This is because a large part of additional old-age savings will be absorbed by the pension system's desire for running into debt.

4.7 Transitional effects

To get a sense for the channels through which my pension funding exercise affects individual human capital formation, it was enough to focus on long-run effects. Yet, in order to understand welfare effects for different generations, we also have to take a look at transitional dynamics. Table 11 therefore shows both the short- and long-run effects of my pension funding reform with factor price reactions. Not surprisingly, as cohorts that were already living in the initial equilibrium had still accumulated some pension claims, private assets (and with them accidental bequests) will only successively adjust to the reform. Since most of the additional savings are absorbed by pension debt initially, it takes a while for the capital stock to grow and for the interest rate to consequently decrease. As already mentioned above, consumption as well as social security tax rate will only be adjusted once in period 1 of the transition and then stay constant afterwards. As overall tax revenues rise throughout the transition due to higher interest income, government debt is mainly needed in the first periods of the transition to finance the gap between tax revenues and public expenditure. The payment of existing pension claims is financed by a mixture of social security taxes and pension debt. As the last pension is payed by period 15 of the transition, pension debt increases quickly.

Table 11: Transitional effects of pension funding in general equilibrium

Simulation			(6)			
Period t	1	3	5	7	9	∞
Assets[a]	0.0	12.9	28.5	43.7	54.8	61.9
Capital[a]	0.0	0.9	2.7	4.9	6.8	7.5
Bequests[a]	0.0	3.7	14.2	35.5	64.5	118.1
Interest rate[b]	0.0	-0.1	-0.2	-0.3	-0.5	-0.6
Cons. tax[b]	-0.7	-0.7	-0.7	-0.7	-0.7	-0.7
SS tax rate[b]	-6.4	-6.4	-6.4	-6.4	-6.4	-6.4
Government debt[c]	60.1	64.6	68.3	70.3	70.9	70.6
Pension debt[c]	0.0	42.6	93.0	142.2	179.0	206.1
Labor supply[a]						
- $s = 1$	-0.2	-0.1	0.2	0.6	0.3	-0.4
- $s = 2$	-0.3	-0.7	-1.4	-3.2	-5.3	-7.6
Wages[a]						
- $s = 1$	0.0	0.2	0.6	0.9	1.3	1.5
- $s = 2$	0.2	0.7	1.7	3.6	5.4	6.9
On-the-job training[b]						
- $s = 1$	25.0	16.1	0.2	-5.3	-5.6	-5.5
- $s = 2$	22.0	18.0	12.6	9.5	9.1	9.0
Schooling Choice[b]						
- $s_p = 1$	-0.3	-0.5	-1.1	-1.3	-1.0	-0.8
- $s_p = 2$	-1.0	-2.0	-3.5	-3.1	-3.6	-2.4

Change in [a]percent over initial equilibrium values,
[b]percentage points, [c] in percent of GDP.

To understand the dynamics of labor supply, we should first look at on-the-job training efforts and the schooling decisions of individuals. Bequests only rise successively throughout the transition. Consequently, the effect on on-the-job training initially is very similar to the long-run numbers in Simulations (1) and (2) with perfect annuities. We learned from this simulations that loosening credit constraints lead to higher human capital investment on the job. As accidental bequests successively increase, so decline on-the-job training efforts. For college enrollment rates I find an only moderate impact in period 1 of the transition. The reason is that on the one hand, by abolishing the regressivity of the pension system with respect to education, college enrollment rates will decline. On the other hand, anticipating that wages will rise much stronger for the higher than for the lower educated, going to college becomes more attractive to individuals of any socio-economic background. Again, rising bequests lead to decreasing college enrollment rates throughout the transition. Note that the lowest enrollment rates can be found in period 5, not in the long-run equilibrium. The reason is that the interest rate declines in later periods of the transition, leading to a slightly higher college attendance. In terms of labor supply, I initially find a drop for both educational classes. It results from individuals investing more on-the-job, i.e. delaying their labor supply to later periods in life. As the human capital stock rises in the medium run, labor supply goes up again, while in the long-run it ranges below its initial equilibrium values, see the previous subsection for an intensive discussion.

We can conclude that from my pension funding reform we might expect an initial increase in the efforts to form human capital. Yet, as accidental bequests successively increase, the incentives to form human capital both via schooling and on-the-job training are seriously weakened along the transition.

4.8 Welfare effects

With the transitional dynamics at hand, we can now proceed to the welfare effects of the reform. I measure welfare effects along the transition and in the new equilibrium by means of income equivalent variation. Due to the homogeneity of my utility function,

$$u\left[(1+\phi)c_j, (1+\phi)\ell_j\right] = (1+\phi)^{1-\gamma} u\left[c_j, \ell_j\right]$$

holds for any c_j, ℓ_j and ϕ. Since utility is additively separable with respect to time, if consumption and leisure were simultaneously increased by the factor $1+\phi$ at any age j, life-time utility would increase by the factor $(1+\phi)^{1-\gamma}$. Suppose two agents have the same characteristics z_j in the initial equilibrium and the reform year. Let $V_0(z_j)$ and $V_1(z_j)$ be their corresponding value functions. The income equivalent variation for an individual characterized by z_j between living in the initial equilibrium and in the reform year is then given by

$$\phi = \left\{ \frac{V^1(z_j)}{V^0(z_j)} \right\}^{\frac{1}{1-\gamma}} - 1.$$

ϕ indicates the percentage change in both consumption and leisure this individual would require in order to be as well off in the initial equilibrium as in the reform year. Alternatively, I may say that he is ϕ better (or worse) off in terms of resources in the reform year than in the initial equilibrium. If $\phi > 0$, the reform therefore is welfare improving for this agent and vice versa. A special rule applies to individuals not having entered their economically relevant phase of life in the initial equilibrium (the so-called future generations). I evaluate their utility behind the Rawlsian veil of ignorance, i.e. from an ex-ante perspective where neither their socio-economic background, nor their skill level or any labor market shock has been revealed. The concept of income equivalent variation thereby applies likewise.

Table 13 shows the welfare effects for households of different cohorts and educational levels. With the consumption tax rate decreasing immediately after the reform was implemented, especially older retirees slightly gain. This gain is depressed for the younger and especially the higher skilled, as the interest rate successively decreases throughout the transition. Workers of older cohorts, however, are the big losers of this reform experiment. Not only do they lose part of their longevity risk insurance, we also have to recall that the implicit tax structure discussed in Figure 3 made contributions at later ages of working life extremely valuable. Therefore it is not surprising that welfare losses are the largest for the cohorts between ages 40 and 60. Note that since assets income is a relatively more important source for richer households in retirement, their welfare losses are smaller than those of their unskilled counterparts. As cohorts get younger and younger, they profit from the successive rise in bequests throughout the transition and the associated income effects. With the lower skilled experiencing higher income effects as the higher skilled of the very same cohort (see discussion above), their welfare effects are generally larger.

Table 12: Welfare effects of pension funding

Simulation	*(6)*		
Age	$s = 1$	$s = 2$	ex ante
90-94	0.27	0.23	
80-84	0.22	0.18	
70-74	0.17	0.12	
60-64	0.10	0.06	
50-54	-1.41	-1.14	
40-44	-1.56	-1.22	
30-34	-1.01	-0.73	
20-24	(0.08)	(0.06)	0.07
10-14	(0.69)	(0.63)	0.66
0- 4	(1.49)	(1.31)	1.40
∞	(1.70)	(1.52)	1.61

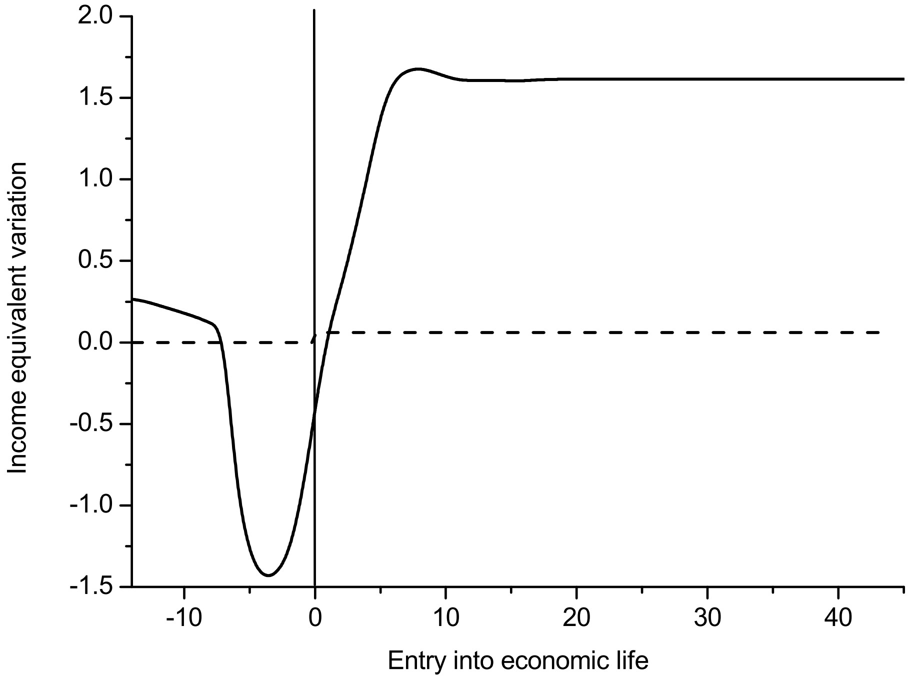
Change in percent of initial resources.

4.9 Efficiency effects

In the previous section we saw that welfare effects are positive for some households and negative for others. We can't say, however, which part of these welfare effects is due to efficiency gains or losses and which part a result of pure intergenerational redistribution. In order to isolate pure efficiency effects, I apply the hypothetical concept of a Lump-Sum Redistribution Authority (LSRA) à la Auerbach and Kotlikoff (1987) in a separate simulation. The LSRA rules out any effect of intergenerational redistribution. It therefore proceeds as follows: to all generations that already were economically active in the initial equilibrium, it pays lump-sum transfers (positive or negative) in the reform year. These transfers are set in such a way that the welfare change of these generations equals zero. Having done that, the LSRA might have run into debt or build up some assets. It now redistributes this debt or assets by means of lump-sum transfers across all future generations so as to make them all equally well off. Hence, they all face the same welfare change compared to the initial equilibrium. This change can be interpreted as a measure of efficiency. If it is greater than zero, the reform is Pareto improving after compensation and vice versa. Figure 4 illustrates this. The solid line shows the above welfare effects of different cohorts before, the dashed line after I applied the compensation scheme.

There are several channels through which pension funding affects aggregate efficiency. Fehr et al. (2008) isolate four different sources of efficiency effects in a very similar setup but without endogenous human capital formation. They mainly attribute the negative aggregate efficiency consequences of pension funding to the loss of longevity insurance. Furthermore, they find loosened liquidity constraints to be the major source of efficiency gains. Overall, closing down the public pension system in their model comes along with an efficiency loss of 0.54 percent of aggregate resources.

Figure 4: Welfare consequences of pension funding in general equilibrium



In order to have a good starting point for my efficiency analysis, I calculated efficiency effects in a model version in which both the schooling decision as well as time effort devoted to forming human capital on-the-job is held fix at initial equilibrium values. This makes the model somewhat comparable to the work of Fehr et al. (2008). If find an efficiency loss of 0.12 percent of aggregate resources. This is considerably lower than the 0.54 percent reported in Fehr et al. (2008). Yet, in their work, the authors assume a population growth rate of 1 percent annually. This causes the internal rate of return of the pension system to be considerably higher than in my model and therefore leads to higher efficiency losses from pension funding.

Table 13: Efficiency effects of pension funding

Human capital	χ_2	SMOPEC	Efficiency
no	∞	yes	-0.12
yes	∞	yes	-0.01
yes	1.41	yes	-0.05
yes	1.41	no	0.05

When I now allow for human capital formation via schooling and on-the-job training to adjust, the efficiency effect basically shrinks down to zero, meaning that privatizing the pension system is efficiency neutral.[15] The reason for this is the following: in the initial equilibrium there were two mechanisms discriminating physical asset accumulation and enforcing human capital formation, a tax on interest income and the implicit tax structure of the pension system. These two mechanisms

[15] Note that this is not a universal result, but it depends on assumptions about both functional forms and the economic environment.

distort household's decisions in the direction of human capital formation. When I shut down the pension system, one of these distortions is removed. However, we can only expect efficiency gains from removing a distortions, if agents can react with their own decisions to it. In the model of endogenous human capital formation this is the case. Therefore we produce some slight efficiency gains compared to the model where human capital investments were held fix.

Up to this point, I held wages of the two schooling classes as well as interest rates fixed at initial equilibrium values. The next two columns present efficiency effects in simulations where these assumptions are successively relaxed. Allowing wages to adjust to the situation after the reform again deteriorates efficiency. In order to understand why, we have to recall that by shutting down the pension system, we also eliminated the regressive effect of pensions with respect to education, i.e. some redistribution from the poorer towards the richer. In a model in which agents are risk averse, this produces efficiency gains. If now, however, wages grow for the higher educated and decline for the lower skilled, parts of this redistributive effect are again offset and therefore aggregate efficiency is lower than before.

In the last simulation, I also let interest rates adjust. Usually one thinks of factor price reactions to be pure measures of intergenerational redistribution and to not have any efficiency effects. However this is different in a model with liquidity constraints. In such a model, a decline in the interest rate usually leads to a flatter consumption path for a households over the life cycle and therefore to a lower propensity to save. This alleviates the burden from liquidity constraints at the beginning of working life and can therefore produce efficiency gains. Nevertheless, the overall efficiency effects of pension funding in this model are fairly small in any simulation. This indicates that the positive effects of pension funding described so far are wiped out by the fact that households lose insurance provision against longevity risk when the pension system vanishes. Consequently, pension funding is a fairly efficiency neutral reform experiment in my model.

5 Conclusion

In this paper I analyze the consequences of pension funding in a general equilibrium model of both formal schooling decisions and on-the-job human capital formation. I find that the implicit tax structure of an earnings related PAYG pension system as the German one plays an important role in determining these consequences, as it leads to the pension system actually being regressive in terms of education. Consequently, when the pension system is abolished, college enrollment rates will decline. The effects on on-the-job training are however ambiguous. On the one hand, the human capital promoting effect of the implicit tax structure vanishes with the pension system's privatization. On the other hand, liquidity constraints are loosened due to higher income in the initial periods of working life which increases on-the-job training efforts. Overall, evidence from my model suggests that the latter effect dominates the former. Furthermore, pension funding significantly increases private savings and, under the absence of annuity markets, accidental bequests. In a dynamically efficient economy this induces a positive income effect on future cohorts which causes leisure consumption to rise and therefore depresses both labor supply and human capital investments. Factor price adjustments can only partially offset these negative effects on human capital formation. In terms of aggregate efficiency, I find pension funding to come along with neither significant losses nor gains, since the positive efficiency effects of pension funding tend to be outweighed by the loss of longevity insurance.

My results give rise to reconsidering the role of the pension system. In addition, they can have a significant impact on its design. When it comes to the question of redistribution in a pension system, the classical discussion of insurance effects versus labor supply distortions should certainly be extended to the area of human capital accumulation. Furthermore, as shown above, a perfectly earnings related pension system pays an implicit skill premium and therefore most likely increases inequality. Therefore it might be interesting to look at whether a complementary Beveridgean pillar could counteract this redistributive issue. Finally, the discussion about whether in Bismarckian systems only the last years of employment should be used to calculate pension benefits should also take into account the fact that such a feature already is inherent in an earnings related pension scheme, even if pension claims are calculated from the whole earnings history. Summing up, my analysis leaves room for more research and discussion.

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