Pension design, labor supply distortions and human capital investment

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Abstract

This paper studies the optimal design of a PAYG pension system in the presence of endogenous human capital formation. We therefore construct a large scale OLG model in the spirit of Heckman, Lochner and Taber (1998) and Gallipoli, Meghir and Violante (2008) in which individuals can decide about both their schooling level and about how much to invest into human capital formation on the job. Labor supply is endogenous and labor income is due to idiosyncratic shocks.

In this model we try to find the optimal pension system with respect to progressivity and the number of years that should be used to calculate pension benefits. Our simulations indicate that a progressive pension system only comes at efficiency costs, since the distortive effect of pension progressivity on both labor supply and human capital investment outweighs the gains from income insurance. In addition, we find that efficiency is reduced if pension benefits are only calculated from the last year of income rather than from a full income history.

JEL Classifications: C68, H55, J24, J26

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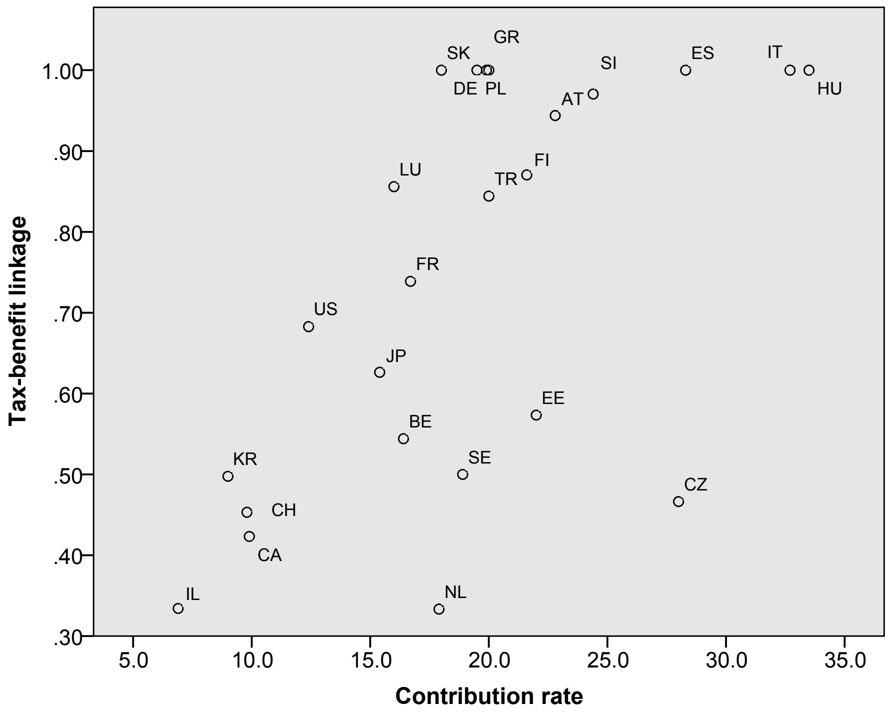
1 Introduction

Within OECD countries, we find a variety of different pension systems. When it comes to the public pillar of these, we basically distinguish between two different models. On the one hand, countries like Germany, Austria, Italy and Spain operate large systems with a very tight tax-benefit linkage, the Bismarckian model. These larger systems directly substitute for private old-age savings. On the other hand, The Netherlands or Canada have much smaller system which only provide a flat pension, the Beveridgean model. These countries rely on additional private old-age savings (e.g. via pension funds) and only guarantee a minimum standard of living. We call systems of the latter type flat or progressive. The link between size of the system and tax-benefit linkage can be seen in Figure

Figure 1: Contribution rates and tax-benefit linkage in public pension systems



Source: OECD (2011).

1, which shows a scatter plot of the contribution rate to the public pension system and a measure of tax-benefit linkage. This measure is defined as the gross replacement rate of a worker earning 1.5 times the average wage of the economy over that of a worker earning 0.5 times the average wage. Hence, if replacement rates are rather similar across different income groups, the tax-benefit linkage is strong and our measure will have a value close to 1.

The literature on the optimal degree of pension progressivity usually trades-off labor supply distortions induced by a weak tax-benefit against an increased insurance provision against labor income risk and old-age poverty. Quantitative studies thereby usually apply overlapping generations (OLG) models in the tradition of Auerbach and Kotlikoff (1987). Huggett and Ventura (1999) or Nishiyama and Smetters (2008) quantify the long-run macroeconomic and welfare effects of different pension designs. Fehr and Habermann (2008) extend this analysis by explicitly accounting for transitional dynamics. Their results tend to be in favor a non negligible progressivity in the pension system.

However, the above studies neglect the fact that a weak tax-benefit linkage not only increases implicit taxes in the pension system and therefore distorts labor supply. A progressive pension systems might also have a significant impact on the willingness of individuals to form human capital both via formal schooling and on-the-job training. Therefore, Docquier and Paddison (2003) and Le Garrec (2005) analyze different pension arrangements in theoretical OLG models in which schooling is the engine of growth. The latter thereby 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 the pure Bismarckian system.

Another stream of the literature deals with the interaction between schooling, retirement and the pensions system. Lau and Poutvaara (2006) therefore construct an analytically solvable model in which agents choose their amount of education and the timing of retirement. They 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 numerical simulations and confirmed by Montizaan, Cörvers and Grip (2010) in a quantitative analysis. In addition, Jensen et al. (2004) surprisingly find that even low ability households might favor Bismarckian over Beveridgean systems, as the positive efficiency effects of higher education might outweigh the adverse redistributional consequences.

One common disadvantage of the above models is that they all neglect labor income uncertainty. Therefore, redistribution induced by flat pensions only takes place between individuals of different schooling levels or abilities. Nevertheless, uninsurable idiosyncratic labor market shocks, which are usually found to be the major source of risk over the life-cycle, can make the insurance component of flat pension arrangements much more valuable to individuals and therefore give rise to higher pension progressivity. Furthermore, in the literature summarized above, human capital is only accumulated by means of either a formal schooling period or on-the-job training. Yet, a reform of the pension system might have an impact on both of these technologies. Studying the interaction between the two might therefore reveal some interesting insights. Finally, up to now, only the long-run effects of different pension designs have been analyzed in models with endogenous human capital formation. However, as shown e.g. in Conesa and Krueger (1999), the short- and long-run effects of pension reforms might severely diverge, so that a reform that produces significant long-run welfare gains might find no support by current generations.

This is where the present paper wants to step in. To quantify the impact of pension reforms that target at changing the progressivity of the system, we form a large-scale OLG model of both formal schooling and on-the-job training. Having completed their formal education, individuals will participate in the labor market and face idiosyncratic productivity shocks. In order to capture distortions on labor supply, households will choose their hours of market work as well as the time invested in human capital formation on the job endogenously. Since formal schooling choices are basically a trade off between after tax present values of income for different degrees of schooling, a detailed modeling of income taxation complements our analysis.

The initial equilibrium of our model is calibrated to the French economy, which runs a public defined benefit (DB) pension scheme that targets at replacing 50 percent of the average of the best 25 years of earnings. Consequently, the tax-benefit linkage in this system tends to be quite high and labor supply distortions are low in the initial situation. This makes the French case particularly interesting. We then run counterfactual experiments in which we change the progressivity of the system and compute a whole transition path up to a new long-run equilibrium. Beneath comparing macroeconomic and welfare effects, we also employ a Lump-sum Redistribution Authority in the spirit of Auerbach and Kotlikoff (1987), which allows us to quantify aggregate efficiency effects of our reforms and determine the optimal degree of progressivity in the pension system.

Our simulations indicate that a progressive pension system only comes at efficiency costs, since the distortive effect of pension progressivity on both labor supply and human capital investment outweighs the gains from income insurance. In addition, we find that efficiency is reduced if pension benefits are only calculated from the last year of income rather than from a full income history.

The remainder of the paper is arranged as follows: in the next section we present our simulation model, the calibration of which is discussed in Section 3. Section 4 discusses our simulation results while the last section offers some concluding remarks.

2 A stochastic OLG model of formal schooling and on-the-job training

As already discussed above, we want to form a model of both formal schooling periods and on-the job training. The model we construct here stands very much in the tradition of the college choice model of Heckman et al. (1998). However, we extend there framework in various directions as can be seen below. A formal, equation-based description of our model as well as a equilibrium definition can be found in the appendix.

2.1 Demographics

Our model is populated by J overlapping generations. At any discrete point t in time, a new generation is born, the mass of which grows with rate n compared to the previous one. During their life-cycle, they only survive from period to period with the age dependent survival probabilities ψ_j, where $\psi_{J+1} = 0$. Since our model abstracts from annuity markets, individuals that die before the maximum age of J may leave accidental bequests that will be distributed in a lump-sum fashion across all working individuals. In the following, we will, for the sake of simplicity, omit the time index t wherever possible.

2.2 Endowments and intra-cohort heterogeneity

Individuals start their economically relevant life with zero assets $a_1 = 0$ just after having finished compulsory schooling. Note that we restrict assets to be greater or equal to zero throughout the whole life cycle, i.e. agents might be liquidity constrained. In addition, they are endowed with a certain amount of human capital $\bar{h}_1$. At the moment agents enter our model, they are only distinguished by there socio-economics background $s_p \in \mathcal{S}$, i.e. the schooling level of their parents. Their own schooling level at this time is $s_j = 1$. They now have to decide whether to stay in school – indicated by $\varsigma_j = 1$ – or irreversibly drop out of the schooling system and fully join the labor force $\varsigma_j = 0$. When they decide to stay in school for another period, their schooling level increases to $s_j = 2$

and their human capital endowment to $\bar{h}_2$. In the next period, they have to make another drop out decision. This process continues until they have reached the maximum schooling level S and therefore the maximum human capital endowment h_S. If an agent decides to drop out of the schooling system and fully join the labor force, she can devote her overall time endowment of 1 to working, on-the-job training or consuming leisure. Both the schooling decision and the on-the-job human capital accumulation technology will be described in more detail below. When working in the market, individuals accumulate pension claims $ep_j \in \mathcal{P}$. Finally, labor income depends on the individual level of human capital $h_j \in \mathcal{H}$ and idiosyncratic labor productivity shocks $\eta_j \in \mathcal{E}$. Consequently, individuals' state is completely characterized by

$$z_j = (s_p, s_j, \varsigma_j, a_j, ep_j, h_j, \eta_j) \in \mathcal{Z} = \mathcal{S}^2 \times \{0,1\} \times \mathcal{A} \times \mathcal{P} \times \mathcal{H} \times \mathcal{E}.$$

2.3 The laws of motion for individual states

The budget constraint is

$$a_{j+1} = (1+r)a_j + y_j + p_j - \tau \min[y_j, 1.4\bar{y}] - T(y_j, p_j, ra_j) + \kappa_j + g_j + b_j - (1+\tau_c)c_j,$$

where future assets a_{j+1} are derived from current assets (including interest), gross income from labor y_j, pension payments p_j, pension contributions at rate τ up to the contribution ceiling, taxes on income from labor, pensions, and savings, intergenerational transfers κ_j, direct transfers from the government g_j, accidental bequests b_j and consumption expenditures c_j (including consumption taxes). Labor income $y_j = w_s h_j \eta_j l_j$ is due to the wage rate for effective labor of schooling type s, individual level of human capital h_j, the idiosyncratic shock η_j and hours worked l_j.

Accumulated pension claims consist of both a flat and a perfectly earnings related part. Specifically we let

$$ep_{j+1} = ep_j + \min\left\{[(1-\lambda)y_j + \lambda\bar{y}], 1.4\bar{y}\right\}, \tag{1}$$

where $\bar{y}$ indicates the average labor income of the economy. When $\lambda = 0$, agents face a perfectly earnings related system, whereas $\lambda = 1$ means that the pension system is completely flat. Note that the contribution ceiling of $1.4\bar{y}$ also applies to the accumulation of pension claims and that $ep_{j+1} = ep_j$ holds after retirement.

When they have successfully completed schooling level s, individuals are endowed with a certain amount of human capital $\bar{h}_s$. On the job, human capital is accumulated using a Ben-Porath (1967) style technology without depreciation with the single input factor time e_j, i.e.

$$h_{j+1} = A_s e_j^{\nu_s} + h_j. \tag{2}$$

Note that the accumulation technology depends on the highest degree of schooling an individual has achieved. The assumption of no depreciation on human capital is supported by both US and French data, see Heckman et al. (1998) and confer our calibration section.

We assume productivity shocks to be independent across individuals and to be identically distributed across individuals of a specific educational degree s. They follow a time and age independent Markov process, the conditional distribution of which is given by $\pi(\eta_{j+1}|\eta_j)$.

2.4 Linking generations

By assumption, parents are of age j_p when their children enter the economically relevant age. Accordingly, the initial distribution of households across socio-economic backgrounds s_p depends on the number of agents of different schooling types s_{j_p} at age j_p. For example, assume that there are only two types of education, i.e. $S = 2$, and at age j_p 60 percent of agents hold a low education degree and 40 percent a high degree. Hence, in the newborn cohort, there will be 60 percent of agent with socio-economic background $s_p = 1$ and 40 percent with $s_p = 2$.

During their periods of formal education, individuals receive lump-sum transfers κ_j by their parents generation. Note that this is not a dynasty model. Hence, we do not assume individuals of different generations to form a decision unit nor do we assume the parental generation to be altruistic towards their children. Therefore, κ_j will be exogenously specified and will not vary with changes in the economic environment, e.g. a change in the pension system. Yet, we need these transfers to assure a certain standard of living for students. In addition to these inter vivos transfers, the children generation will inherit accidental bequests of the parental generation. Consequently, since the more educated tend to be the richer, individuals with a higher socio-economic background, i.e. better education parents, will inherit higher amounts than those of a lower socio-economic background.

2.5 Individual preferences

Preferences over consumption c_j and and leisure ℓ_j are assumed to be representable by a time-separable utility function of the form

$$E \sum_{j=1}^{J} \Psi_j \beta^{j-1} u(c_j, \ell_j),$$

with Ψ_j being the unconditional probability to survive until age j. Due to this separability, we can define the individual optimization problem recursively by

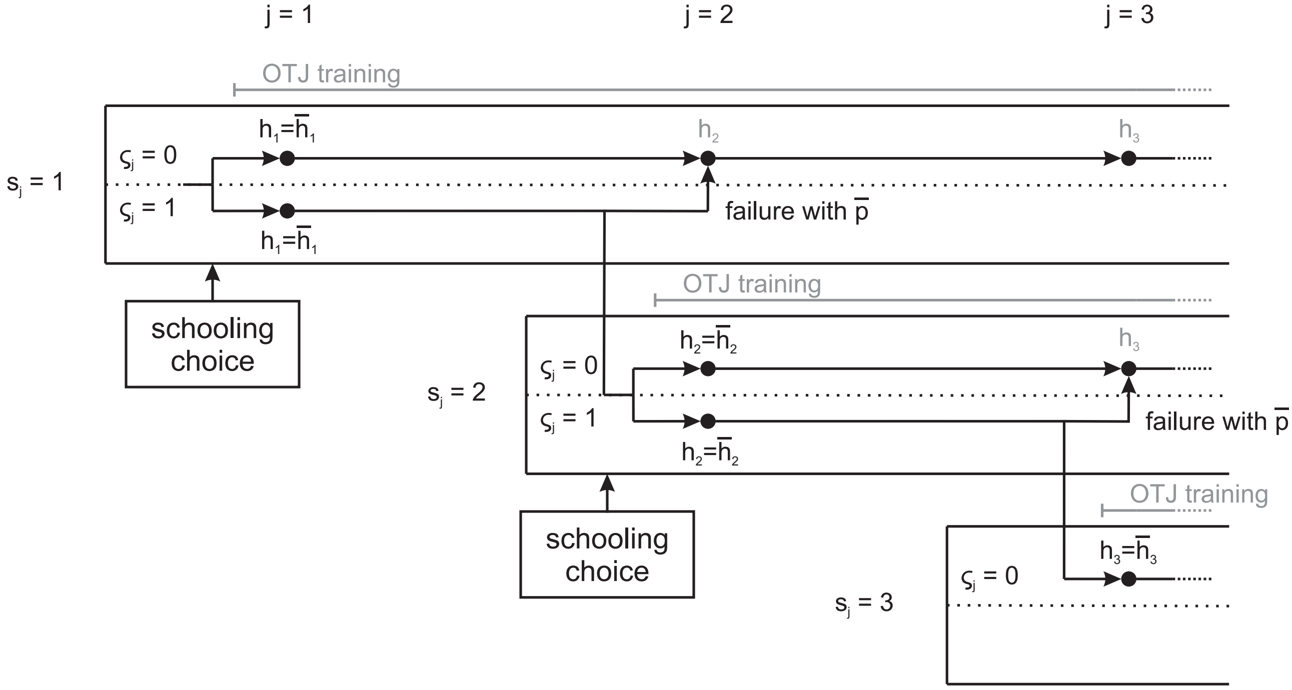
$$V(z_j) = \max_{c_j, \ell_j, e_j} \left\{ u(c_j, \ell_j) + \psi_{j+1} \beta E_j \left[V(z_{j+1}) \right] \right\}.$$

2.6 Schooling choices

Extending the choice set of Heckman et al. (1998), we assume individuals to make several schooling choices similar to Gallipoli et al. (2008). To complete a schooling level by assumption takes one model period. Having dropped out of the schooling system, individuals can still decide to form human capital via on-the-job training. When in formal schooling, agents have to devote an exogenously specified fraction of their time $\varpi_{s_p,s}$ to the schooling measure. Furthermore, we consider schooling to be of risky type, i.e. there is a certain chance $\bar{p}_{s_p,s}$ of dropping out. Both time investment and failure rates may depend on the educational level as well as parental education background. Having successfully completed schooling level s, human capital increases to $\bar{h}_s$. Figure 2 summarizes the life-cycle of human capital formation for three schooling levels.

In line with Taber (2002), agents decide about their drop-out via a comparison of utilities. An agent having successfully completed schooling level s at age j will stay in school for another period and

Figure 2: Formal schooling and on-the-job training



achieve schooling level $s + 1$, if

$$V_j\left(z_{j_s}^1\right) + \varepsilon \geq V_{j_s}\left(z_{j_s}^0\right).$$

Hereby $V_j\left(z_j^1\right)$ and $V_j\left(z_j^0\right)$ are the utilities agent receives from staying in school or dropping out, i.e. $z_j^1 = (s_p, s, 1, \cdot, \cdot, \cdot, \cdot)$ and $z_j^0 = (s_p, s, 0, \cdot, \cdot, \cdot, \cdot)$, respectively. ε is a measures of psychological or non-pecuniary costs of schooling and is assumed to be normally distributed with mean 0 and variance σ^2 across individuals of a socio-economic background s_p. The assumption of differences in tastes for schooling brings some heterogeneity into the model. Therefore not all individuals of one background level s_p will choose the same educational path, but a certain fraction will drop out in every period. Assuming a large amount of people in every cohort, due to the law of large numbers,

$$P\left(\left\{V_j\left(z_j^1\right) + \varepsilon < V_j\left(z_j^0\right)\right\}\right) = \Phi_{0,\sigma^2}\left[V_j\left(z_j^0\right) - V_j\left(z_j^1\right)\right]$$

is the fraction of agents that decide to drop out of the schooling system at age j, where Φ_{0,σ^2} is the cumulative normal distribution function with mean 0 and variance σ^2.

2.7 The production side

Firms in this economy use capital and labor of different types s to produce under perfect competion a single good according to a Cobb-Douglas production technology

$$Y = \varrho \cdot \tilde{h}^{\chi} \cdot K^{\epsilon} L^{1-\epsilon},$$

where Y, K and L are aggregate output, capital and labor, respectively, and ϵ is capital's share in production. ϱ defines a basic technology level, $\tilde{h}$ is the average stock of human capital per worker and $\tilde{h}^{\chi}$ is an externality à la Lucas (1988). This externality make the technology in the economy endogenous and accounts for the fact that a higher skilled labor force may produce on a higher technology level. Labor of different schooling levels is aggregated by a CES-technology

$$L = \left(\sum_{s=1}^{S} \lambda_s L_s^{1-\frac{1}{\mu}} \right)^{\frac{1}{1-\frac{1}{\mu}}}, \quad \text{with} \sum_{s=1}^{S} \lambda_s = 1.$$

Therefore, any type of labor has an own price w_s. Capital depreciates at a constant rate δ_k and firms have to pay corporate taxes

$$T_k = \tau_k \left[Y - \sum_{s=1}^{S} w_s L_s - \delta_k K \right],$$

where a corporate tax rate τ_k is applied to output net of labor costs and depreciation. Note that corporate taxes in this model act like an additional tax on capital income, since firms will not make any profits under prefect competition. Firms maximize profits renting capital and hiring labor from households, so that net marginal products equal r the interest rate for capital and w_s the wage rates for effective labor of different types.

2.8 The government sector

The government sector in our model splits into a tax and a pension system. The budgets of both of these systems are closed separately on an annual basis. While the consumption tax rate insures that government expenditure equals tax payments, the pension contribution rate balances the DB pension systems budget.

The tax system The tax system levies proportional taxes on consumption at rate τ_c, corporate turnover net of labor and depreciation costs at rate τ_k and on labor income. In addition, it may issue new debts nB. The income tax is oriented towards the French income tax schedule where labor and pension income is taxed progressively and capital at a constant rate. Tax revenue and new debt is used to finance general government expenditure G, educational expenditure G_s which is fixed per student, aggregate transfers to individuals $\bar{g}$, subsidies to the pension sytem P and interest payments on existing debt, so that

$$T_y + T_k + T_c + nB = G + \sum_{s=1}^{S} G_s + \bar{g} + P + rB$$

holds for every period with aggregate income and consumption tax revenues T_y and T_c.

The pension system The pension system is very much in line with the public DB pension system in France. During their working periods, individuals pay payroll taxes at a rate τ up to a contribution ceiling of 1.4 times the average labor income $\bar{y}$ of the economy. In reward for their contributions, households accumulate pension claims. The system targets at replacing a fixed fraction ω of the average of labor income over the life cycle up to a maximum of the contribution ceiling after a full career of 40 years, i.e. the pension payment at retirement is calculated from

$$p_j = \omega \cdot \frac{ep_{j_r}}{j_r} = \omega \cdot \frac{1}{j_r} \sum_{j=1}^{j_r} \min \left\{ [(1-\lambda)y_j + \lambda \bar{y}], 1.4\bar{y} \right\}, \tag{3}$$

where j_r is the retirement age and λ the pension progressivity index. Note that the French tax system actually replaces the average of the 25 highest incomes throughout working life. Due to computational constraints, however, we have to approximate this practice by taking the average of the full labor income history.

2.9 Equilibrium conditions

Given a specific fiscal policy, an equilibrium path of the economy has to solve the household decision problem, reflect competitive factor prices, and balance aggregate inheritances with unintended bequests. Furthermore aggregation must hold, and consumption tax and pension contribution rate have to balance the tax and pension system's budgets. Since we assume a closed economy setting, output has to be completely utilized for private consumption C, public consumption $G + \sum_{s=1}^{S} G_s$ and investment purposes, i.e.

$$Y = C + G + \sum_{s=1}^{S} G_s + (n + \delta_k)K.$$

3 Calibration of the initial equilibrium

We calibrate our model to the French economy. We thereby use a three step calibration procedure. In the first step, we use a stylized model to estimate the parameters of the human capital production function as well as the income risk process. In a second step we set schooling parameters in order to obtain a realistic picture of the French schooling system. Finally, we calibrate the remaining model parameters to match some major macroeconomic calibration targets.

3.1 The basic environment

For computational reasons, we assume one model period to cover 5 years. However, as can be seen below, this will not be a major restriction. Agents enter the model at the age of 15 ($j = 1$) and live up to a maximum of age 100, i.e. $J = 17$. Children are born between 25-29, i.e. $j_p = 3$.

The International Standard Classification of Education (ISCED-97) issued by the UNESCO in 1997 distinguishes between 7 different schooling levels, summarized in Table 1. Our model will have three levels. Since ISCED levels 0 to 2 denote compulsory schooling in France (lower secondary education), we summarize them to education level $s = 1$. ISCED levels 3 and 4 consist of pre-vocational and vocational training (excluding tertiary education) that usually qualifies a student for the entry into the tertiary education sector. Therefore, we summarize these two levels as education level $s = 2$ in our model. Finally, levels 5 and 6 denote college and university education and constitute our third education level. According to OECD (2009a), the typical graduate from ISCED levels 3 and 4 is between 18 and 21 years old and the tertiary education ages range between 20 and 29. Therefore, assuming that in our model agents start to make there first decisions at age 15 after having completed compulsory schooling and letting every additional educational degree take 5 additional years of formal schooling is quite in line with the French schooling system.

Table 1: Educational levels

Model	ISCED-97	Description
1	0	Pre-primary education
	1	Primary education
	2	Lower secondary education
2	3	Higher secondary education
	4	Post-secondary education
3	5	First stage of tertiary education
	6	Second stage of tertiary education

3.2 On-the-job human capital formation and idiosyncratic income risk

In order to estimate the parameters for on-the-job human capital formation and idiosyncratic income uncertainty, we use inflated individual labor earnings data y_{its} of full-time working individuals from the French Labor Survey "Enquête Emploi" provided by the French National Institute of Statistics and Economic Studies INSEE. "Enqûete Emploi" has a panel structure and contains information about occupational status, income, educational level etc. of individuals that is collected on an annual basis. Our unbalanced panel data covers full-time workers up to age 60 of the years 1995 to 2002. Following Guvenen (2009), we only include individuals that worked more than 1500 hours in a given year, had an average hourly earnings between a preset minimum (the social existence level in France) and a maximum wage rate (the top percentile of incomes in the sample) to exclude extreme observations. Our sample was divided into the three different educational groups mentioned above. This approach leads us to a total of 165 588 observations, where we have 53 472, 77 436 and 34 680 observations in groups 1 to 3, respectively.

On-the-job human capital production Having extracted this data, we use a variant of the estimation technique proposed by Heckman et al. (1998). Specifically, we take the above household model and assume that there are no shocks to labor income, agents are not liquidity constraint and there is no leisure consumption. In order to make the model comparable to the above specification with leisure choice, we assume for the estimation process a maximum time endowment of 0.4, which amounts to a 40 hours workweek length, see Auerbach and Kotlikoff (1987). Following Taber (2002), we then approximate the French tax schedule employed in our simulation model using a third order polynomial T_a.

In this simplified model setup, we can separate consumption choice from human capital investment decisions. Hence, an agent's utility maximizing amount of on-the-job-training can be calculated from

$$PVE(h_j, ep_j) = \max_{e_j} \Big\{ (0.4 - e_j)h_j(1-\tau) + p_j - T_a\left[(0.4 - e_j)h_j w^s (1-\tau) + p_j\right] + \frac{PVE(h_{j+1}, ep_{j+1})}{1 + r(1-\tau^r)} \Big\}, \quad (4)$$

where h_j and ep_j evolve according to (2) and (1), respectively.[1] As we use a partial equilibrium model for the estimation procedure, we normalize the interest rate $r = 0.045$ and set the wages per efficiency unit of all three types of labor to 1. Next, we fix the pension contribution rate at $\tau = 0.15$ and choose a replacement rate in the pension system in line with our general equilibrium model simulations. Our model extends the estimation model of Taber (2002) by explicitly accounting for a PAYG pension system. Unfortunately, since we do not have data on it, we can't estimate ability parameters that depend on agent's educational background.

With the above model, we now estimate the parameters A_s, ν_s and $\bar{h}_s$, i.e. initial human capital endowment, in the following way via non-linear least squares. We start with some initial guesses of the parameters and compute the age gross income profiles $\hat{y}_{ts} = (0.4 - e_j)h_j$ for every educational background resulting from the above model (4). We then form log-residual sum of squares between simulated labor income and actual observations

$$RSS = \sum_i \sum_t \sum_s (\log(y_{its}) - \log(\hat{y}_{ts}))^2. \tag{5}$$

Our algorithm updates the parameter guesses in order to minimize RSS.

Table 2: Parameter estimates for human capital production functions

	Group 1	*Group 2*	*Group 3*
ability A_s	0.2460	0.2640	0.5820
	(0.0088)	(0.0074)	(0.0059)
elasticity educational time ν_s	0.6262	0.4921	0.6818
	(0.0175)	(0.0161)	(0.0082)
initial human capital $\bar{h}_s$	3.5891	4.0206	6.3014
	(0.0114)	(0.0189)	(0.0157)

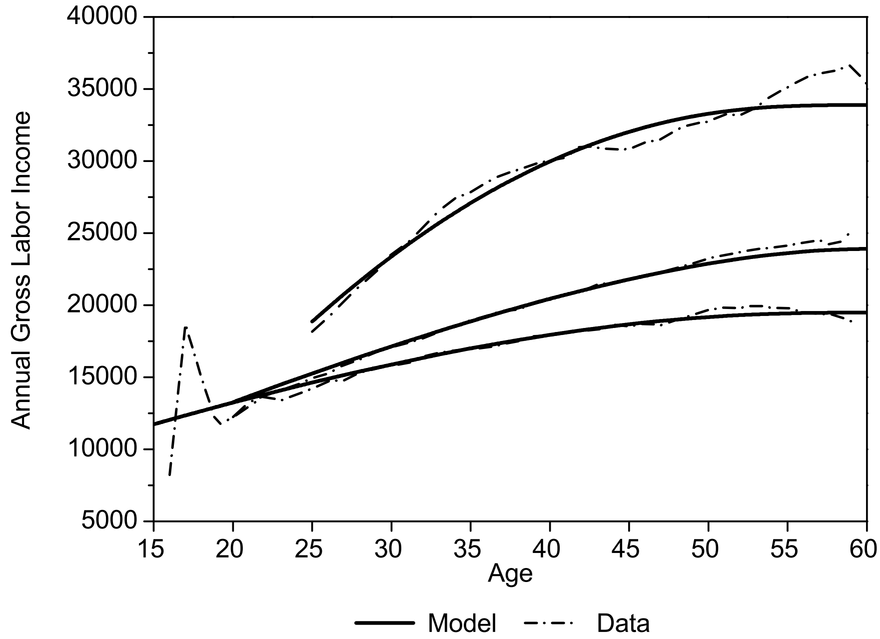
The resulting parameters and the corresponding Huber-White type standard errors (in parentheses) are reported in Table 2. We find all our parameters to be significantly positive. Estimated gross income profiles and the respective means computed from the data are shown in Figure 3. As we estimate these parameters on a one year basis, we adapt the productivity parameter A_s in order to yield the same amount of human capital produced on-the-job in our 17 period complete simulation model. We therefore set $A_1 = 1.3601$, $A_2 = 1.4660$ and $A_3 = 3.4266$.

Idiosyncratic income uncertainty Taking log residuals $\log(y_{its}) - \log(\hat{y}_{ts})$ of our above parameter estimation, we can now estimate labor income risk processes η_j. As mentioned above we assume labor income shocks to follow a first order Markov process. Specifically we parameterize the process structure using an AR(1) process as

$$\log \eta_j = \rho \log \eta_{j-1} + \varepsilon_j \quad , \quad \varepsilon_j \sim N(0, \sigma_\varepsilon^2) \quad \text{and} \quad \eta_0 = 0.$$

[1] Note that we also tried a specification of the human capital production à la Heckman et al. (1998), where the own human capital stock is also an input to production. This however lead us to large standard errors for A and the elasticity of additional human capital with respect to existing human capital which indicates mis-specification and a possible colinearity between these two parameters.

Figure 3: Estimated and mean income profiles



We estimate processes separately for any of the three educational groups s by means of Restricted Maximum Likelihood estimation. This approach leads us to the parameter estimates shown in Table 3 (standard errors are again reported in parenthesis). We are very much aware of the fact that there are more sophisticated models of labor income risk taking into account individual random effects and stochastic income growth rates. However, to make our computations feasible we have to restrict ourselves to the above model structure.

Table 3: Parameter estimates for individual productivity

	Group 1	*Group 2*	*Group 3*
AR(1) correlation ϱ	0.8692	0.8666	0.8662
	(0.0015)	(0.0013)	(0.0019)
transitory variance σ_ϵ^2	0.0214	0.0211	0.0255
	(0.0008)	(0.0007)	(0.0012)
overall variance σ_η^2	0.0875	0.0849	0.1019
	(0.0008)	(0.0007)	(0.0012)

There are some things to notice. First, we find a weaker AR(1) correlation than usually found for US data, see e.g. Guvenen (2009). This might be due to different labor market dynamics. Second, our transitory variance is somewhat lower than the estimates in Guvenen (2009), however they correspond pretty good to what is found in Hubbard et al. (1994). Since the latter also categorize there data by three educational levels and estimate cubic income profiles, their approach comes closer to what we do here. !!! Net versus gross income !!!

We finally have to aggregate the process in order to obtain an AR(1) process that covers five years. This can easily be done via computing variance and correlations of the process

$$\pi_j^n = \sum_{j=1}^{n} \pi_{j+i-1}.$$

with $n = 5$. The respective aggregated process then has a correlation and variance of

$$\varrho_n = \varrho^n \quad \text{and} \quad \sigma_{\epsilon,n}^2 = \Gamma_n \cdot \sigma_\epsilon^2 \cdot \frac{1-\varrho^{2n}}{1-\varrho^2} \quad \text{with} \quad \Gamma_n = \frac{1}{n^2} \sum_{i=0}^{n-1} \sum_{j=0}^{n-1} \varrho^{|j-i|}.$$

For computational reasons, we finally approximate the shock π^n by a first order discrete Markov process with three nodes using a discretization algorithm as described in Tauchen and Hussey (1991). Given the low autocorrelation in the 5 year process (about 0.5), this amount of nodes paired with this approximation procedure should be sufficient, see Kindermann (2010).

3.3 The schooling system

Some of the institutional details of the schooling system have already been discussed above. What remains is to calibrate inter-vivos transfers from parents to their children at school as well as the time input and failure rates that apply to individuals in different schooling degrees. The main calibration goal of these parameters is to match participation rates of agents of different socio-economic background in different schooling levels. Therefore, we extracted data on the highest degree achieved of both individuals that have left the schooling system aged 28 or younger and their parents from the 2003 wave of the Professional Formation and Qualification survey "Enquête sur la formation et qualification professionelle" again provided by INSEE. We use this data to generate the schooling participation matrix shown in Table 4. This participation matrix shows in the different columns the

Table 4: Decision matrix

	Data			*Model*		
$s_p \setminus s$	*1*	*2*	*3*	*1*	*2*	*3*
1	33.11	48.91	17.98	32.57	49.60	17.82
2	24.77	50.67	24.56	23.93	50.79	25.27
3	17.80	39.73	42.47	16.92	39.71	43.37

fraction of individuals that achieve a certain educational degree classified by the education level of their parents.

In order to achieve a similar educational pattern as the one shown above, we set our educational parameters as shown in Table 5. We thereby assume a standard deviation of psychological costs at $\sigma = 0.00518$, which is in line with the estimates reported in Heckman et al. (1998).[2] First we set the

2 We adjusted the standard deviation in order to account for the fact that we let agents make their schooling choice via a comparison of utilities, not present values of income and have a period length of 5 years.

Table 5: Educational parameters

Time input $\varpi_{s_p,s}$			*Failure rates* $\bar{p}_{s_p,s}$			*Inter vivos Transfers* κ_j			*Government transfers* g_j		
$s_p \setminus s$	2	3	$s_p \setminus s$	2	3	$s_p \setminus s$	2	3	$s_p \setminus s$	2	3
1	0.25	0.46	1	0.00	0.45	1	10 539	1 692	1	0	3 480
2	0.25	0.44	2	0.00	0.40	2	10 627	2 232	2	0	2 856
3	0.25	0.36	3	0.00	0.30	3	7 016	3 780	3	0	2 004
Av.	0.25	0.42	Av.	0.00	0.38	Av.	9 570	2 546	Av.	0	2 761

time input needed to achieve a higher secondary educational degree to 0.25 which corresponds to about 1250 hours a year. According to OECD (2009a), the intended instruction time of a 15 year old is 1060 in France plus some extra time for doing homework. Next we set the failure rate in higher secondary education to 0, which is a typical number for Western European countries, confer OECD (2009a). Last, we calibrate inter vivos transfers from parents to children that are in a higher secondary schooling program, such that we achieve participation rates similar to the ones described above. Note that we assume that children will not work during their time of higher secondary education and not receive any direct governmental transfers. Therefore the inter vivos transfer has to be much larger than the one during tertiary education. In addition, since individuals of higher socio-economic background have the higher probability to finally become a university graduate and earn a lot of money, they require a lower inter vivos transfer than agents with poorer educated parents.

For college and university students, we set the annual transfer to the amounts reported in EUROSTUDENT (2008). In addition, we assume that the government provides a government micro credit that amounts to 3480, 2856 and 2004 Euros a year for college students from the three different socio-economic background, respectively. This credit has to be payed back over a time span of 10 year 5 years after graduation without interest, which is very much in line with the French student assistance scheme, confer EUROSTUDENT (2008). Next, we calibrate college failure rates such that we average failure rate amounts to 0.38. Hence, only about 0.62 of students actually graduates from college/ university, confer OECD (2009a). The difference in drop out rates is based on a recent study by Cingano and Cipollone (2007) who show using Italian data, that a ten year increase in schooling of the father, i.e. going from lower secondary to tertiary education, induces a 14 percent decrease in college drop out probability of the kid. Last, we calibrate the time input needed to participate in the tertiary education system such that we obtain realistic tertiary education participation rates. On average, students time input is 0.42 which roughly amounts to a full work week of 40 hours. Note that individuals with poor socio-economic background will have to spend more time on education, which reflects their lower ability !!! Eckstein and Wolpin !!! The simulated participation rates of our model can be seen in the right part of Table 4.

3.4 Remaining model parameters

The remaining model parameters are calibrated as follows:

Household On the household side, we use conditional survival probabilities extracted from the Human Mortality Database.[3] In addition we assume a population growth rate of $n = 0.035$ which corresponds to the average annual population growth rate of 0.7 percent reported over the last 5 years, see OECD (2010).

We let individual preferences over consumption and leisure be represented by the instantaneous CRRA utility function

$$u(c, \ell) = \frac{1}{1-\frac{1}{\gamma}} \left\{ c^{1-\frac{1}{\rho}} + \alpha \ell^{1-\frac{1}{\rho}} \right\}^{\frac{1-\frac{1}{\gamma}}{1-\frac{1}{\rho}}},$$

where ρ denotes the intra-temporal elasticity between consumption and leisure and α is a taste parameter for leisure consumption. γ represents the inter-temporal elasticity of substitution between consumption in different years. In order to calibrate the parameters of the utility function we first set γ at 0.5, which is in the range of commonly used parameters in these types of models, see Imrohoroglu and Kitao (2010). We then chose $\rho = 0.6$ in order to obtain realistic labor supply elasticities !!! Discussion !!!. To normalize average hours worked in the economy at 0.4, which implies a 40 hours work week length, we let $\alpha = 1.0$. Finally, we chose a value of 0.983 for the time discount factor β to obtain a capital to output ratio of 2.2, which is close to the one observed in France.

Production sector The labor income share in France amounts to roughly 0.67. Hence, we set the capital share in production $\alpha = 0.33$. Furthermore, following Bouzahzah et al. (2002), we assume a Lucas externality parameter of $\chi = 0.1$. The size of this parameter is not undisputed in the literature. Therefore, a sensitivity analysis will clarify its influence on the results. We use the estimate of $\mu = 1.441$ for the elasticity of substitution between different types of labor from Heckman et al. (1998) and calibrate the basic technological level ϱ as well as the factor shares λ_s in a way that insures a wage level of 1 for each of the three types of labor input. Specifically, we set $\varrho = 2.92$, $\lambda_1 = 0.26$, $\lambda_2 = 0.41$ and $\lambda_3 = 0.33$. Finally, we let the depreciation rate on capital $\delta_k = 0.436$ in order to achieve a realistic investment to GDP ratio.

The tax system The tax schedule in our model is close to the French tax system. We set the consumption tax rate at $\tau_c = 0.19$, the tax rate on interest income at $\tau_r = 0.301$ and the corporate tax rate at 0.19.[4]. The income tax burden is calculated in two steps. First, 7.76% of labor income net of social security contributions as well as 6.745% of pension income have to be payed as social charges. Then, labor income plus 90 percent of pension income net of social security contributions and social charges are taxed according to the French progressive tax schedule described in !!! Source !!!. We thereby assume every household to be a married couple with two children and apply the French family splitting method. Finally, we assume a debt to GDP ration of 0.6, which is in line with the Maastricht criteria and close to the one of 0.65 observed in France. The appearance of a government as an additional demander for capital is crucial in our model, since it allows us to calibrate a realistic capital to output ratio without setting the time discount factor at extremely low values. On the expenditure side, we set per student expenditure such that aggregate expenditure equals 3.2, 1.4 and 1.3 percent of GDP for the three different schooling levels in the initial equilibrium.

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[3] *Human Mortality Database*. University of California, Berkeley (USA), and Max Planck Institute for Demographic Research (Germany). Available at www.mortality.org or www.humanmortality.de (data downloaded on 20.03.2011).

[4] The capital tax rate includes social charges.

The pension system We let the pension contribution rate be $\tau = 0.15$ and the contribution ceiling 1.4 times the average wage, which is in line with French pension law. In addition, following Hairault and Langot (2008), we assume a pension progressivity parameter of $\lambda = 0.115$ which best describes the redistributive effects in the French pension system. Finally, we assume that the tax system finances 24 percent of pension payments out of social charges. This leads us to the replacement rate of 50 percent of average income over the life cycle, see OECD (2011).

3.5 The initial equilibrium

Table 6 compares the most important statistics of our initial equilibrium to French data. Since we

Table 6: The initial equilibrium

	Model solution	*France 2008*
Macroeconomy		
Capital-output ratio	2.2	2.0
Consumption (in % of GDP)	60.8	57.1
Investment (in % of GDP)	20.9	21.9
Government consumption (in % of GDP)	18.2	23.2
Trade balance (in % of GDP)	0.0	-2.2
Pension benefits (% of GDP)	12.5	12.4
Pension contribution rate (in %)	15.0	15.0
Tax revenues on income and profits (in % of GDP)	12.4	10.4
Tax revenues on goods and services (in % of GDP)	11.6	10.5
Other benchmark coefficients		
Interest rate p.a. (in %)	4.5	4.5
Bequest (in % of GDP)	5.5	–
Human capital formed on-the-job (in % of $\bar{h}_s$)		
- lower secondary education	29.6	–
- higher secondary education	42.1	–
- tertiary education	27.3	–
Wage premium on tertiary education (in %)	56.7	58.0

Source: OECD (2009b) and OECD (2010)

assume a close economy setup, private consumption has to be higher than in reality. On the other hand, as income, profit and goods taxation are the only sources of government revenue, government consumption is lower than in the French economy.

4 Simulation results

In this section we present results from our counterfactual simulations. We thereby proceed in several steps. The first subsection describes our simulation methodology and how we quantify welfare and efficiency effects of a reform. Subsection two than shortly discusses the implicit tax structure of the

French pension system and its influence on human capital accumulation. We then present results from simulations where we switch from the current French tax system towards a completely flat pension and then try to determine the optimal progressivity of the pension system in our setup. Finally, we discuss a proposal by Le Garrec (2005), who suggests to calculate pension claims only from the last income earned and therefore increase pension progressivity.

4.1 Simulation methodology and the quantification of welfare and efficiency effects

In order to run our counterfactual simulations, we proceed as follows. Coming from our initial equilibrium, we change some parameters of the pension system – we e.g. alter the pension progressivity parameter λ. Individuals will then react to this policy change and adapt their consumption behavior, labor supply and human capital investment. We compute a complete transition path from the moment the reform is implemented up to a new long-run equilibrium and report macroeconomic, welfare and efficiency effect.

The concept we apply to quantify welfare effects is compensating variation à la Hicks. Due to the homogeneity of our utility function,

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

holds for any c_j, ℓ_j and ϕ. In consequence, since utility is additively separable with respect to time, if consumption and leisure were simultaneously increased by the factor $1+\phi$ at any age, life-time utility would increase by the factor $(1+\phi)^{1-\frac{1}{\gamma}}$. With this considerations lets again turn to our simulation model. Assume an individual at state z_j had utility $V^i(z_j)$ in the initial equilibrium and $V^r(z_j)$ in the reform path. The compensating variation between the initial equilibrium and the reform scenario for the individual characterized by z_j is then given as

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

ϕ thereby indicates the percentage change in both consumption and leisure the individual would require in the initial equilibrium in order to be as well of as in the reform scenario. The other way round we may say that an individual is ϕ better (or worse) off in terms of resources in the reform path than in the initial equilibrium. If $\phi > 0$, the reform is therefore welfare improving for this individual and vice versa.

A special rule applies to individual not having entered their economically relevant phase of life – i.e. they are not yet 15 years old – in the year directly before we conduct our policy reform. We evaluate their utility behind the Rawlsian veil of ignorance, i.e. from an ex-ante perspective where neither their socio-economic background nor any labor market shock has been revealed. The concept of compensating variation thereby applies likewise.

In order to isolate the pure efficiency effects of the reform, we apply the hypothetical concept of a Lump-Sum Redistribution Authority (LSRA) used by Auerbach and Kotlikoff (1987) in a separate simulation. The LSRA thereby proceeds as follows: to all generations already being economically active in the year before the reform it pays lump-sum transfers or levies lump-sum taxes in order to make them as well off in the reform year as in the initial equilibrium. Consequently, their compensating variation amounts to zero. Having done that, the LSRA might have run into debt or build up some assets. It now redistributes this debt or assets across all future generations in a way that they all face the same compensating variation. This variation can be interpreted as a measure of efficiency. Consequently, if the variation is greater than zero, the reform is Pareto improving after compensation and vice versa. With this concepts in hand, we can now proceed to our simulation results and the question of optimal progressivity of the pension system.

4.2 The implicit tax structure of the French pension system

Before we discuss our simulation results, we want to bring into focus the distortive and redistributive effects that are at work in earnings related PAYG pension systems like the French one. In such systems, implicit taxes typically decrease over the working phase of a households, as accumulated pension claims or earnings points don't pay any interest (like e.g. in the French or German pension system) or less interest than the capital market interest rate (like e.g. in the Italian NDC system). It is quite easy to calculate implicit tax and savings rate of the overall pension contribution from (3). Suppose an agent's labor income at age j marginally increases. He then pays a contribution of τ to the pension system. On the other hand, his pension payment at retirement increases by

$$\frac{\partial p_j}{\partial y_j} = \omega \cdot \frac{(1-\lambda)}{j_r},$$

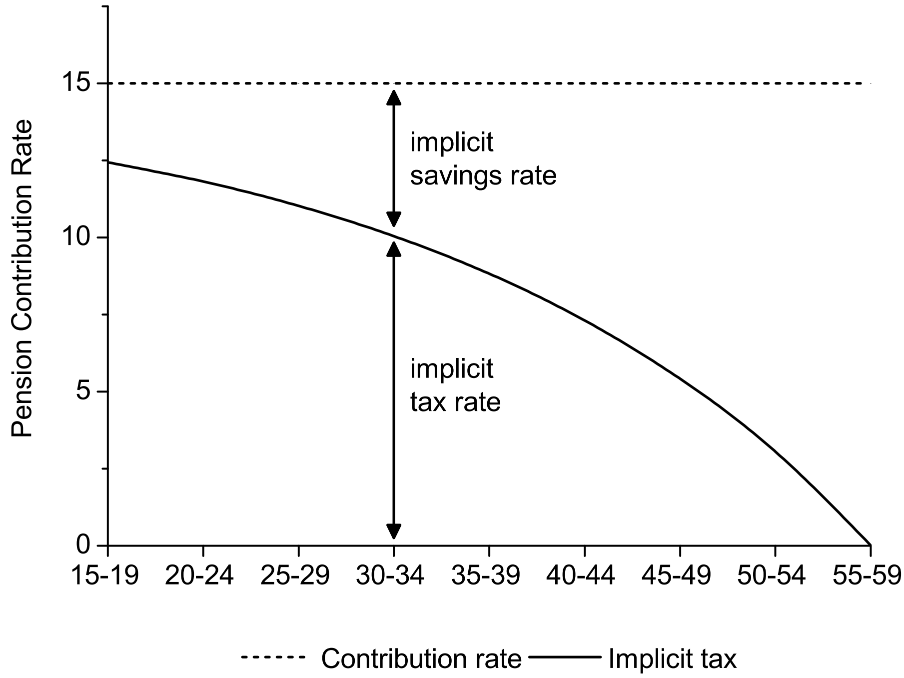
when the agent doesn't earn income above the contribution ceiling. The present value as of age j of the additional pension payment consequently is $\omega \cdot \frac{(1-\lambda)}{j_r} \cdot \sum_{i=j_r}^{J} (1+r)^{j-i}$. Hence, the household had to save exactly this fraction of his marginally increased income in the capital market in order to receive a pension of the same size on a funded basis. This fraction is called the implicit savings rate of the pension system τ_j^{sav}. Consequently, $\tau - \tau_j^{sav}$ constitutes the implicit tax share, i.e. the part of the pension contribution that is perceived as tax by the individual. Implicit savings and tax rates over working life in our model are depicted in Figure 4. Note that the implicit tax component strongly depends on the pension progressivity parameter λ. If $\lambda = 0$, tax shares are minimized. If $\lambda = 1$, the full contribution is perceived as tax. As mentioned above, the implicit tax component decreases with age.

The decreasing tax share in pension contributions basically has two effects. First, implicit taxes are high during the time of on-the-job human capital investment and low during the time of yield. Hence, on-the-job human capital investment should be encouraged by the pension system's tax structure. Second, as can be seen in Figure 3, the difference in average labor income between the lower and higher skilled rises with age. Consequently, we would expect this implicit tax structure to actually redistribute pension payments from the lower towards the higher educated. If the pension progressivity parameter λ was equal to 0, the system therefore should factually be regressive with respect to the individual's educational level. These two effects should be kept in mind when we now turn to our simulation results.

4.3 Pension progressivity

In this subsection, we present result from simulations in which we alter the progressivity of the pension system by changing the progressivity factor λ. We start with a rather extreme reform experiment, namely the change from the current French pension system towards a completely flat pension, i.e. $\lambda = 1$. Note that the pension progressivity parameter only applies to newly earned pension claims

Figure 4: Savings and implicit tax component of pension contributions



along the reform path. Existing pension claims will be left unchanged, confer (1). As a result of the introduction of a flat pension, the full pension contribution will now be perceived as tax and the human capital stimulating effect will vanish. In addition, a flat pension system redistributes from higher income earners towards lower income earners. This will make going to college less attractive, since a flat pension reduces the payoff from higher education.

Macroeconomic effects Tables 7 and 8 show the macroeconomic effects of our pension reform. In order to disentangle the different effects of on-the-job human capital formation and endogenous schooling, we start with a situation in which both on-the-job investment and schooling will be held fix at the initial equilibrium values, i.e. human capital formation can be regarded as completely exogenous. The model in simulation (1) therefore is quite similar to the one in Nishiyama and Smetters (2008) or Fehr and Habermann (2008). Consequently, there are mainly two effects at work. On the one hand, since the full contribution to the pension system is now perceived as tax, labor supply is distorted. On the other hand, the flatness of pension benefits insures individuals against labor market uncertainty. The first part of Table 7 clearly indicates these labor market distortions. We find a decrease in labor supply for all three different types of labor, i.e. labor of the low, middle and highly educated, $s = 1, 2, 3$. The reduction in labor supply is much stronger for the lower than for the higher skilled. This is clear from the fact, that the newly introduced flat pension now redistributes from the higher towards the lower skilled. The resulting income effect then causes low educated individuals to work less and highly educated to work more. Since labor of the three different types is only partly substitutable in production, wages for the three different labor types react exactly in the opposite direction, i.e. the wage of the low educated increases and that of the higher educated falls. This constitutes an additional redistribution mechanism from the richer towards the poorer. With the distortion in labor

Table 7: Macroeconomic effects of flat pensions

Simulation		*(1)*				*(2)*		
On-the-job training		*no*				*yes*		
Schooling decision		*no*				*no*		
Smopec		*no*				*no*		
Period t	*1*	*3*	*5*	∞	*1*	*3*	*5*	∞
Assets[a]	0.0	-0.8	-1.2	-7.6	0.0	-0.3	-0.5	-6.0
Interest rate[b]	-1.2	-0.9	-0.8	2.0	-1.1	-1.1	-1.2	1.6
Cons. tax[b]	0.9	0.9	1.0	2.4	0.8	1.0	1.1	2.7
SS tax rate[b]	0.2	0.2	0.2	2.8	0.3	0.2	0.2	2.8
Average human capital[a]	0.0	0.0	0.0	0.0	0.0	-0.3	-0.6	-1.2
Labor supply[a]								
- $s = 1$	-4.5	-4.5	-4.5	-4.9	-3.8	-4.5	-5.0	-5.5
- $s = 2$	-3.4	-3.4	-3.7	-3.9	-3.1	-3.5	-4.0	-4.6
- $s = 3$	-1.2	-1.2	-1.4	-1.2	-1.2	-1.0	-1.3	-1.4
Wages[a]								
- $s = 1$	2.1	1.8	1.6	-0.8	1.7	2.0	2.0	-0.2
- $s = 2$	1.3	1.1	1.0	-1.0	1.2	1.2	1.3	-0.9
- $s = 3$	-0.2	-0.6	-0.6	-2.9	-0.2	-0.5	-0.6	-3.1
On-the-job training[b]								
- $s = 1$	0.0	0.0	0.0	0.0	-13.2	-13.9	-14.6	-15.5
- $s = 2$	0.0	0.0	0.0	0.0	-7.5	-7.6	-8.3	-8.3
- $s = 3$	0.0	0.0	0.0	0.0	-4.3	-4.4	-4.7	-4.4
Schooling Choice[b]								
- $s = 1$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
- $s = 2$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
- $s = 3$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Change in [a]percent over initial equilibrium, [b]percentage points.

supply, interest rates initially fall by about 1.2 percentage points.[5] With the fall in labor income due to higher labor market distortions as well as the increased insurance provision against labor income risk, assets will successively decrease throughout the transition. This in turn again increases interest rates and causes wages to fall. Lower labor market and interest income obviously diminish the income tax base and therefore reduce income tax revenues. As a consequence, the consumption tax rate has to increase in order to keep the government's budget balanced. In addition, the social security tax rate has to be adjusted upwards by about 2.8 percentage points in the long run which again is due to the decline in labor supply. Obviously, since we kept on-the-job investment and schooling effort constant at the initial equilibrium level, average human capital does not change throughout the transition.

In Simulation (2) in the right part of Table 7, we now let on-the-job human capital formation respond to the pension policy change, but still hold schooling fix at the initial equilibrium level. As the stimulating effect on on-the-job human capital accumulation induced by the implicit tax structure in

[5] Note that this change is for interest rates on a 5 year basis.

the initial equilibrium vanishes with the reform, we find a strong decline in on-the-job training effort. For individuals with lower secondary education, human capital formed on-the-job decreases by 15.6 percent in the long run. For individuals with a higher schooling degree, the effect is weaker, since a larger fraction of them tends to earn incomes above the contribution ceiling of $1.4\bar{y}$. Since above this ceiling neither pension contributions are payed nor are pension claims earned, there is no stimulating effect on human capital investment. The decrease in on-the-job training finally results in a further reduction of labor supply from period 5 onwards. This is clear from the fact, that labor productivity is lower at older ages than in the initial equilibrium and therefore individuals reduce their hours worked. As the effect on on-the-job training is the largest for the lower educated, the impact on labor supply also is larger for this group. Finally, average human capital per worker decline from the reform which causes a drop in output and factor prices through the Lucas externality.

Simulation (3) now uses our complete model including endogenous schooling choice. The results are reported in Table 8. Beneath the effect on on-the-job investment through the implicit tax structure,

Table 8: Macroeconomic effects of flat pensions (cont.)

Simulation		*(3)*				*(4)*		
On-the-job training		*yes*				*yes*		
Schooling decision		*yes*				*yes*		
Smopec		*no*				*yes*		
Period t	*1*	*3*	*5*	∞	*1*	*3*	*5*	∞
Assets[a]	0.0	-0.2	-0.4	-6.2	0.0	2.3	3.5	-12.5
Interest rate[b]	-1.0	-1.2	-1.3	1.6	0.0	0.0	0.0	0.0
Cons. tax[b]	0.6	0.7	1.0	2.7	0.5	0.5	0.7	3.3
SS tax rate[b]	0.2	0.2	0.2	2.8	0.2	0.2	0.2	2.8
Average human capital[a]	-0.6	-1.0	-1.3	-1.7	-0.5	-1.1	-1.5	-1.5
Labor supply[a]								
- $s = 1$	-3.7	-3.3	-3.1	-3.9	-2.9	-3.1	-3.5	-3.3
- $s = 2$	-3.0	-3.4	-3.9	-4.5	-2.3	-3.3	-4.3	-3.8
- $s = 3$	-0.9	-1.9	-3.4	-3.3	-0.3	-1.8	-3.8	-3.0
Wages[a]								
- $s = 1$	2.0	1.5	1.1	-1.2	1.1	0.4	-0.2	0.0
- $s = 2$	1.1	1.2	1.2	-1.2	0.3	0.2	0.0	0.1
- $s = 3$	-0.5	-0.2	0.6	-2.2	-1.4	-1.2	-0.6	-0.8
On-the-job training[b]								
- $s = 1$	-13.8	-14.1	-14.5	-15.6	-15.9	-15.8	-15.3	-12.9
- $s = 2$	-7.4	-7.9	-8.3	-8.3	-8.6	-8.7	-8.6	-6.9
- $s = 3$	-3.3	-4.2	-4.8	-4.4	-5.0	-5.3	-4.7	-2.0
Schooling Choice[b]								
- $s = 1$	2.2	1.2	0.8	0.7	2.2	1.3	0.8	0.7
- $s = 2$	-0.2	0.1	0.3	0.1	-0.2	0.0	0.3	0.2
- $s = 3$	-1.9	-1.3	-1.0	-0.8	-1.9	-1.3	-1.1	-0.9

Change in [a]percent over initial equilibrium, [b]percentage points.

we now can also observe the impact of the redistribution from the lower towards the higher educated that was going on in the initial equilibrium (see above). This redistribution is completely reversed by the introduction of flat pensions. After the policy reform, the pension system redistributed from the higher towards the lower educated which narrows the payoff from going to university and therefore induced a reduction in the number of college students of about 2 percent in the reform year. The decline in the number of highly educated workers in turn forces firms to adapt their wages. Consequently, wages of college graduates are higher in nearly any period of the transition path up to the long-run equilibrium compared to the previous simulation. In addition, the wage spread between the lower and the higher educated that was observed in the previous simulations is narrowed. In terms of labor supply, we find that the change is much more uniform between different types of labor. This is due to the fact, that the size of the tertiary educated labor force shrinks with the reduction in the number of college students while the size of the lower educated work force grows. Finally, in Simulation (4) we consider the case of a small open rather than a closed economy, which is a typical setup the France. In this case, interest rates remain unchanged at a world capital market level. We assume for comparability reasons, that this rate is the same as the one used in the above simulations. Since interest rates do not react to the change in private asset holdings, savings decline further compared to the previous simulation. With the resulting decrease in capital income tax revenues, the consumption tax rate has to increase by 3.3 percentage points in stead of 2.7 in the long run. The effect on labor supply is quite similar, however, the general wage level is higher than before, which again is due to the missing reaction of the interest rate. Changes in the interest rate always have an impact on on-the-job human capital investment, since on-the-job and capital market investments can be seen as two alternative investment strategies. The household will therefore pick the strategy that promises higher returns. As interest rates were lowered in the short-run and increase in the long-run in the closed economy setting, on-the-job investment reacted accordingly. This effect is absent in the small open economy model. Finally, the schooling decision remains effectively unchanged, since the general wage level is fixed, however, wages for the respective types of labor may still be adapted by the firms.

Welfare and efficiency effects As shown above, the introduction of flat pensions strongly influences labor supply as well as human capital investment. In addition, the policy reform reverses the redistributive effect of the pension system and actually comes along with redistribution from the higher towards the lower educated. These effects have a major impact on individual welfare, as can be seen from Tables 9 an 10. In these we report uncompensated welfare changes divided by the three different types of education levels for those generations that already were economically active in the initial equilibrium. For generations born along the transition path, we report ex ante welfare. We find that existing retirees are the big losers of the reform. They face a loss of about 1.3 percent of resources due to the increase in consumption taxes and therefore in the price of the consumption good. The winners of the reform are the lower educated, currently working cohorts. This is clear from the fact, that the newly introduced flat pension now redistributes towards these individuals. The welfare level is generally higher for younger workers than for the older ones. As the implicit tax share in pension contribution was lowest for older workers, making the full pension contribution a tax distorts older workers' labor supply the most and therefore leads to lower welfare levels for these generations. We also find a positive welfare effect for the short-run future generations, which is due to the newly gained insurance provision of flat pensions outweighing the losses from decreased labor supply distortions. In the long-run however, there are significant welfare losses. Since assets decrease in the long-run, accidental bequests decrease. This enforces liquidity constraints at young ages and comes along with a reduction in welfare. The effect is promoted by the increase in the social

Table 9: Welfare and efficiency effects of flat pensions

Simulation	(1)				(2)			
	without LSRA			with	without LSRA			with
Age	$s=1$	$s=2$	$s=3$	LSRA	$s=1$	$s=2$	$s=3$	LSRA
80-84	-1.32	-1.28	-1.15	0.00	-1.39	-1.19	-1.07	0.00
60-64	-1.36	-1.32	-1.19	0.00	-1.37	-1.33	-1.21	0.00
40-44	0.65	-0.38	-1.48	0.00	0.51	-0.48	-1.58	0.00
20-24	0.87	0.11	-0.33	0.00	0.80	0.06	-0.44	0.00
10-14		0.37		-0.82		0.31		-0.96
0- 4		0.22		-0.82		0.15		-0.96
∞		-1.43		-0.82		-1.55		-0.96

Change in percent of initial resources.

security tax rate that additionally lessens households disposable income. In the column "with LSRA" we report welfare changes from a separate simulation in which the LSRA compensates existing cohorts such that their welfare change equals zero and guarantees any future generation the same ex ante welfare level. We find welfare of future generations to be about 0.82 percent lower than in the initial equilibrium. This indicates that the introduction of completely flat pensions reduces aggregate efficiency.

Table 10: Welfare and efficiency effects of flat pensions (cont.)

Simulation	(3)				(4)			
	without LSRA			with	without LSRA			with
Age	$s=1$	$s=2$	$s=3$	LSRA	$s=1$	$s=2$	$s=3$	LSRA
80-84	-1.25	-1.20	-1.08	0.00	-1.24	-1.17	-1.01	0.00
60-64	-1.40	-1.35	-1.23	0.00	-1.22	-1.13	-0.95	0.00
40-44	0.63	-0.30	-1.41	0.00	0.68	-0.24	-1.29	0.00
20-24	0.65	0.05	-0.24	0.00	0.61	-0.03	-0.32	0.00
10-14		0.22		-1.04		0.16		-1.12
0- 4		0.03		-1.04		-0.03		-1.12
∞		-1.70		-1.04		-1.77		-1.12

Change in percent of initial resources.

In the right part of Table 9 as well as in Table 10, we report welfare and efficiency effects of the simulations with endogenous human capital formation. We find the welfare effects to be qualitatively the same, however, especially welfare of younger and future generations is lower due to the negative effects of the reform on human capital formation. The column "with LSRA" indicates that the impact on human capital investments also strengthens efficiency losses. In the complete model setup with on-the-job training and endogenous schooling, efficiency is about 0.2 percent lower than in the model without endogenous human capital formation.

The optimal progressivity Summing up so far, we conclude that the introduction of a fully flat pension system causes efficiency losses of about 1 percent of initial resources. However, it might be that there is an optimal mix between earnings-related and flat pensions that actually improves aggregate efficiency. Therefore Table 11 shows the efficiency effects resulting from the introduction of different degrees of pension progressivity. As can be seen from the first row, a completely earnings related

Table 11: Optimal progressivity

λ	0.00	0.25	0.50	0.75	1.00
Complete	0.11	-0.11	-0.38	-0.69	-1.04

pension system provides the highest level of aggregate efficiency.

Sensitivity analysis [To be added]

4.4 Increasing the starting age of pension accumulation

In his paper, Le Garrec (2005) proposes to increase the first age in which pension claims are accumulated in order to further stimulate the accumulation of human capital. In turn, he argues in favor of a partially flat pension that mitigate the negative redistributive effect of this reform. We want to analyze whether this reform option might lead to efficiency gains in a model with endogenous labor supply and a much more detailed economic environment. We therefore run a counterfactual simulation, in which we assume that the pension payment will be computed just from the last year of labor earnings instead of the full income history for any future generation.

Macroeconomic results are shown in Table 12. The short-run effects of this reform are very modest. This is quite intuitive, since our reform only applies to the pension rights of future generations and therefore needs some time to take effect. However, in the long-run, we see remarkable changes in macroeconomic aggregates. First, since the reform obviously stimulates human capital investment, individuals will save less in the capital market. This causes the interest rate to increase by 8.4 percentage points. As capital income tax revenues decline, the consumption tax has to be adjusted upwards. We keep the replacement rate of the pension system constant at the value of the initial equilibrium. Consequently, since labor earnings in the last working year tend to lie above the average of life-cycle earnings, pension benefits increase dramatically and therefore the pension contribution rate has to be adjusted upwards by 7.3 percentage points. This increase in pension contributions again distorts labor supply especially of the lower educated, as the higher educated tend to earn incomes above the contribution ceiling. Wages then react accordingly. Interestingly, the reform mainly stimulates on-the-job human capital investment of the lower educated. This is due to the relatively low contribution ceiling. Since the last labor income of most college workers is above this ceiling anyway, there is not much reason to increase human capital in this period. Finally, there nearly is no reaction in schooling choices.

Table 13 summarizes welfare and efficiency effects of the reform. For the already existing generations, welfare changes are only modest, since they are only affected by small short-run changes in the consumption tax rate. Short-run future cohorts aged "10-14" and "0-4" in the reform year are the

Table 12: Macroeconomic effects of increased eligibility age

Simulation	*(5)*			
Period t	*1*	*3*	*5*	∞
Assets[a]	0.0	0.2	0.2	-14.3
Interest rate[b]	0.0	-0.3	-0.6	8.4
Cons. tax[b]	0.1	0.1	0.4	4.1
SS tax rate[b]	0.0	0.0	0.1	7.3
Average human capital[a]	0.0	0.0	-0.1	0.5
Labor supply[a]				
- $s = 1$	-1.1	-1.9	-2.8	-3.9
- $s = 2$	0.0	-0.3	-1.1	-1.6
- $s = 3$	0.5	0.3	-0.8	3.3
Wages[a]				
- $s = 1$	0.9	1.5	1.8	-3.8
- $s = 2$	0.0	0.1	0.3	-5.5
- $s = 3$	-0.5	-0.4	-0.1	-8.7
On-the-job training[b]				
- $s = 1$	24.6	22.4	19.0	15.5
- $s = 2$	12.0	11.3	10.1	9.6
- $s = 3$	5.1	4.6	2.5	4.9
Schooling Choice[b]				
- $s = 1$	-0.2	-0.2	0.0	-0.5
- $s = 2$	0.7	0.5	0.4	0.0
- $s = 3$	-0.5	-0.3	-0.4	0.5

Change in [a]percent over initial equilibrium, [b]percentage points.

Table 13: Welfare and efficiency effects of increased eligibility age

Simulation	*(5)*			
	without LSRA			with
Age	$s = 1$	$s = 2$	$s = 3$	LSRA
80-84	-0.04	-0.04	-0.04	0.00
60-64	-0.28	-0.28	-0.28	0.00
40-44	-0.11	-0.40	-0.48	0.00
20-24	0.23	-0.15	-0.16	0.00
10-14		1.10		-0.77
0- 4		0.78		-0.77
∞		-3.87		-0.77

Change in percent of initial resources.

main beneficiaries of the reform, since they experience higher pension payments at retirement, but only face a small increase in contribution rates. In the long-run, however, we find tremendous welfare losses of about 3.8 percent, which are due to the increased distortions in the pension system and the crowding-out of capital more than overcompensating the stimulating effects on on-the-job training. In consequence, we find a significant efficiency loss of about 0.8 percent of aggregate resources. Further analysis should reveal to which extend this welfare loss is coming from the increase in the pension system' size.

Sensitivity analysis [To be added]

5 Concluding remarks

This paper studies the optimal design of a PAYG pension system in the presence of endogenous human capital formation. We therefore construct a large scale OLG model in the spirit of Heckman et al. (1998) and Gallipoli et al. (2008) in which individuals can decide about both their schooling level and about how much to invest into human capital formation on the job. Labor supply is endogenous and labor income is due to idiosyncratic shocks.

In this model we try to find the optimal pension system with respect to progressivity and the number of years that should be used to calculate pension benefits. Our simulations indicate that a progressive pension system only comes at efficiency costs, since the distortive effect of pension progressivity on both labor supply and human capital investment outweighs the gains from income insurance. In addition, we find that efficiency is reduced if pension benefits are only calculated from the last year of income rather than from a full income history.

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