Means-Testing and Economic Efficiency in Pension Design

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Abstract

The present paper studies the efficiency properties of means-tested pay-as-you-go financed social security systems. Starting from a benchmark economy without social security, we introduce pension systems of various institutional designs and compare the costs arising from liquidity constraints as well as distortions of labor supply and the accumulation of savings versus the benefits from insurance provision against income uncertainty and mortality risk. We find a positive role of means-testing pension benefits against private assets from a long run welfare perspective. However, when taking transitional cohorts into account, our findings highlight strong aggregate efficiency losses.

JEL Classifications: C68, H55

Keywords: stochastic OLG model, pension design, means-testing

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1 Introduction

Social security systems of developed countries show a large variety of institutional designs reflecting the specific redistribution and insurance objectives of the respective societies. Countries such as Germany, Austria or France operate universal pension systems of a classic Bismarck design where retirement benefits are linked to the individual earnings history of a retiree. Due to the universality of these systems their respective budgets are very large - public pension outlays in Germany for instance amounted to 10.7% of GDP in 2008, see OECD (2011). On the other end of the spectrum countries like the United Kingdom, Australia, Ireland or New Zealand operate progressive flat-rate schemes of a Beveridge design with the prevention of old-age poverty as their main goal. Pension benefits within these systems are not linked to individual contribution-histories and are typically less generous. In addition, benefits are mostly targeted in order to reduce the size of the program. Consequently, their respective budgets are significantly smaller in comparison - public pension outlays in the UK for instance amounted to only 5.4% of GDP in 2008, see OECD (2011).

Means-testing pension benefits against individual income or assets allows governments to target benefits to poor retirees. Governments can flexibly adjust the margins of the targeted group by setting parameters such as the replacement rate and withdrawal rates of the means-tests, allowing for a higher flexibility to control spending on pension outlays. As a consequence, means-tested schemes require less funds than their universal counterparts, resulting in lower dist ortive contribution rates. On the other hand, means-testing benefits has been shown to be highly distortive to the accumulation of savings of poor elderly who rationally disaccumulate savings in order to maximize individual pension claims. Contrary to the policy intention of the means-test, this in turn contributes to higher pension outlays.

Given the vast diversity of real world targeted social security systems, it is important to understand the specific factors which determine the optimal institutional design: What is the optimal replacement rate? Should benefits be universal or should they be means-tested? What resources should be considered and what withdrawal rate should be applied in a means-test? Should means-tests exempt a minimum level of pensions from withdrawal? In order to answer these questions, the present paper attempts to compare the main merits and costs of means-testing in different pension designs using a general equilibrium overlapping generations model where households decide about savings and labor supply under idiosyncratic uncertainty. In our set-up the social security system increases welfare due to the insurance provision against labor income and longevity risk which is not provided by the market. At the same time contributions to the means-tested pension system distort labor supply and savings decisions and increase liquidity constraints. Consequently, the optimal pension design has to balance these benefits and costs.

Issues related to means-testing in the design of unfunded pension systems have already been discussed extensively by previous studies. Miles and Sefton (2003) as well as Sefton and van de Ven (2009) analyze the quantitative implications of various policy reforms for the UK’s means-tested retirement benefit program using a partial equilibrium life-cycle model. Their results indicate a positive role of means-testing as long as the withdrawal rate is around 50%. Kumru and Piggott (2009) extend this approach using a large scale general equilibrium stochastic overlapping generations model calibrated to UK data. They find that even a 100% taper rate for means-testing is optimal. Tran and Woodland (2012) analyze the interdependence of pension generosity and the income taper rate in a stochastic OLG-model calibrated to the Australian economy. Their findings suggest that the optimal
taper rate falls the more generous pension benefits within the social security system are. Kudrna and Woodland (2011) simulate the abolition of the asset means-test within the Australian pension system. In contrast to all previous studies their approach does not focus on long-run welfare consequences only. Instead they also consider transitional cohorts and compute compensating transfers which neutralize intergenerational income redistribution effects. However, they abstract from income uncertainty so that they do not take the insurance provision properties of the Australian pension scheme adequately into account. The latter is included by Fehr and Uhde (2013) who analyze the optimal design of pay-as-you-go financed social security systems in a model with uncertain income while considering both long-run and transitional cohorts. They find a negative correlation between progressivity and generosity when aggregate efficiency is used to identify the optimal design as well as a positive role for means-testing pensions within multi-pillar systems.

The present study builds on this previous work, but evaluates means-tested pension designs with respect to their optimal generosity and the precision of the means-test. Opposed to previous literature, we do not calibrate our model to match a real world economy, i.e. we start from an initial long-run equilibrium of an artificial economy without social security. In order to quantify the macroeconomic, welfare and efficiency consequences of different pension formulas, we then introduce alternative pension systems of different institutional designs and compute the resulting transition paths, the new long-run equilibria as well as welfare consequences for different cohorts. In order to isolate the effect of the specific reform scenario on aggregate efficiency, we neutralize all resulting intergenerational redistribution in a final step by incorporating lump-sum compensations. We use the resulting pure aggregate efficiency effect as the criterion to compare pension systems with differing institutional parameters in order to identify the optimal design.

In line with previous literature, our simulation results show that long-run welfare is higher in a means-tested system compared to a universal system. However, isolating the pure efficiency properties we show that means-testing induces losses in aggregate efficiency for all considered institutional designs. For systems granting very generous replacement rates, our results indicate that moderately positive taper rates dominate universal and fully means-tested systems. In our model, a universal social security system with a replacement rate of around 40% yields the highest efficiency gains.

The remainder of the paper is organized as follows: Section 2 describes the general equilibrium model we use in our quantitative analysis. Section 3 discusses the parametrization of the model and the calibration of the initial equilibrium. Our simulation results are presented in Section 4, Section 5 concludes.

2 The model economy

2.1 Demographics and intracohort heterogeneity

Our model economy is populated by overlapping generations of individuals which may live up to a maximum possible lifespan of $J$ periods. At each date $t$ a new generation is born with its size normalized to unity, i.e. we assume zero population growth. At the beginning of life, individuals are assigned a skill level $s \in S$ with an (exogenous) probability $N_{1,s}$. Since individuals face lifespan

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1 Hence, tangible policy recommendations for real world social security systems undertaken by previous literature cannot directly be deducted from our results as this would require calibration to match these macro-economies.
uncertainty, cohort sizes decrease over time, i.e. \( N_{j,s} = \psi_{j,s} N_{j-1,s} \), with \( \psi_{j,s} < 1 \) denoting the time-invariant conditional survival probability of an individual of skill level \( s \) at the age of \( j-1 \) and \( \psi_{j+1,s} = 0 \).

Our model is solved recursively. At any given point in time \( t \), agents are characterized by the state vector \( z_j = (s,a_j,\eta_j) \), with \( j \in \mathcal{J} = \{1, \ldots, J\} \) marking the age of the individual, \( a_j \in \mathcal{A} = [0,\infty) \) representing liquid assets held by the agent at the beginning of age \( j \) and \( \eta_j \in \mathcal{E} \) denoting an idiosyncratic shock to individual labor productivity.

At a given point in time \( t \), the cohort of \( j \)-old agents is fragmented into subgroups \( \xi_t(z_j) \) determined by the initial distribution at birth, the income process, mortality and the respective optimal decisions of its individuals over their life cycle. We define \( X_t(z_j) \) as the corresponding cumulated measure of \( \xi_t(z_j) \). As \( \xi_t(z_j) \) only gives densities within cohorts and is not affected by cohort sizes,

\[
\int_{\mathcal{A} \times \mathcal{E}} dX_t(z_j) = N_{j,s} \quad \text{and} \quad \sum_{j \in \mathcal{J}} \sum_{s \in \mathcal{S}} N_{j,s} = \sum_{j \in \mathcal{J}} \int_{\mathcal{Z}} dX_t(z_j)
\]

with \( \mathcal{Z} = \mathcal{S} \times \mathcal{A} \times \mathcal{E} \) holding \( \forall \ t \in \{0, \ldots, \infty\} \). Furthermore, we define \( Z_t = (\xi_t(z_j), B_{RAt}, \Psi_t) \) as the state of the economy at the beginning of period \( t \), with \( B_{RAt} \) representing debt of the redistribution authority. \( \Psi_t \) marks the policy schedule at a point in time \( t \). In the following, we will omit the time index \( t \), the skill level \( s \) and the state indices \( z_j \) and \( Z_t \) whenever possible. Agents are then only distinguished according to their age \( j \).

### 2.2 The household side

We assume an identical preference structure for all agents represented by a time-separable, nested CES utility function. By following the approach of Epstein and Zin (1991) we isolate the agent’s relative risk aversion from the intertemporal elasticity of substitution. Abstracting from a specific bequest motive, a \( j \)-old individual decides about its optimal leisure \( \ell_j \), consumption \( c_j \) and asset holdings \( a_j \), while the agent’s time endowment is normalized to unity. The optimization problem of a representative \( j \)-old agent with the state \( z_j \) is formulated recursively as

\[
V(z_j) = \max_{c_j,\ell_j} \left\{ u(c_j, \ell_j)^{1-\gamma} + \beta \left[ \psi_{j+1,s} E \left[ V(z_{j+1}) \right] \right]^{\frac{1}{1-\gamma}} + \left( 1 - \psi_{j+1,s} \right) B(a_{j+1}) \right\}^{\frac{1}{1-\gamma}},
\]

where the parameter \( \beta \) denotes the household’s discount factor and \( \gamma \) marks the intertemporal elasticity of substitution between present and future consumption. The parameter \( \mu \) defines the degree of the agent’s relative risk aversion.\(^2\) Since agents face an uncertain lifespan, expected utility \( E[V(z_{j+1})] \) of the next period is weighted by the survival probability \( \psi_{j+1,s} \) while utility from leaving bequests \( B(a_{j+1}) \) is weighted with the probability to die.\(^3\) The probability of a \( j \)-old agent to have a productivity shock \( \eta_{j+1} \) in the subsequent period conditional on the current productivity shock being \( \eta_j \) is represented by the distribution function \( \pi_j(\eta_{j+1} | \eta_j) \). Expected utility is then given by

\[
E \left[ V(z_{j+1}) \right] = \int_{\mathcal{E}} \pi_j(\eta_{j+1} | \eta_j) \cdot V(z_{j+1})^{1-\mu} \, d\eta_{j+1}.
\]

\(^2\) Note that for the special case \( \mu = \frac{1}{\gamma} \) equation (1) simplifies to the traditional expected utility specification; see Epstein and Zin (1991), p.266.

\(^3\) This type of bequest motive has been called warm glow (De Nardi 2004).
In the event of death agents might derive utility from leaving bequests. This bequest motive is represented by the function

\[ B(a_{j+1}) = \lambda_1 \left( \lambda_2 + \frac{(1 + r)a_{j+1}}{\lambda_3} \right)^{1-\lambda_1} \lambda_1 \geq 0 \]

with \( \lambda_1 \) reflecting the strength of the bequest motive, i.e. the agent’s concern about leaving bequests to others and \( \lambda_2, \lambda_3 \) measuring the extent to which bequests are conceived as a luxury good, see De Nardi (2004). In our benchmark economy we set \( \lambda_1 = 0 \) so that the agent does not derive utility from leaving bequests. In this case, individuals leave bequests which are purely accidental.

The period utility function \( u(c_j, \ell_j) \) in equation (1) is defined as

\[ u(c_j, \ell_j) = \left[ c_j^{1-\rho} + a\ell_j^{1-\rho} \right]^{1-\rho} \]

with \( \rho \) denoting the intratemporal elasticity of substitution between consumption and leisure and \( a \) marking the age-independent leisure preference parameter.

The representative household maximizes (1) subject to the intertemporal budget constraint

\[ a_{j+1} = a_j(1 + r) + y_j(1 - \tau) + p_j + b_j - c_j + \nu_j. \]  

We assume that an individual does not hold any assets at birth, i.e. \( a_1 = 0 \) and \( a_{j+1} = 0 \) holds. Furthermore, agents face credit market constraints, i.e. \( a_j \geq 0, \forall j \). Households receive interest payments from liquid assets held in period \( j \) as well as gross labor income \( y_j = w(1 - \ell_j) \), where \( e_j \) defines the agent’s individual productivity and \( w \) as well as \( r \) denote the wage rate for effective labor and the gross interest rate, respectively. Individual productivity \( e_j \) is determined by the deterministic age-productivity profile and the productivity shock \( \eta_j \) which are both skill-dependent. Consumption expenditures are given by \( c_j \).

The pension system pays out a means-tested Beveridgean basic pension \( p_j \) which is financed by contributions levied on labor income with the rate \( \tau \). Benefits from the public pension system are received after passing the mandatory retirement age of \( j_R \).

As we abstract from modeling annuity markets, agents who do not survive leave their positive assets as accidental and/or intentional bequests, depending on the strength of their bequest motive. These bequests are aggregated for each skill class and distributed as individual bequests \( b_j \) to employees in the last year before retirement within the respective income class.

Finally, agents may receive (or have to finance) specific compensation payments \( \nu_j \) which are described in more detail below.

### 2.3 The production side

A large number of identical firms, the sum of which is normalized to unity, use the factors capital and labor to produce a single good with the Cobb-Douglas production technology

\[ Y = \Phi K^\epsilon L^{1-\epsilon} \]

with \( Y, K \) and \( L \) denoting aggregate output, capital and labor, respectively. The parameter \( \epsilon \) marks the share of capital in production while \( \Phi \) represents a technology parameter which is adjusted in order
to normalize the wage rate of effective labor to unity. Firms maximize their profits renting capital from aggregate private savings and hiring labor from households so that the marginal product of capital equals the world market interest rate $r$ plus the depreciation rate of capital $\delta$ and the wage rate for effective labor $w$ is fixed by the marginal product of labor.

2.4 The pension system

The public pension system represents a Beveridge-design system where claims may be means-tested against private assets. It pays out a flat old-age pension $p_j$, the maximum amount of which is determined by a replacement rate $\kappa$ of average labor earnings $\bar{y}$ in the economy and the taper rate $\varphi_a$ which defines the means test against liquid assets, i.e.

$$p_j = \max\left[ \kappa \bar{y} - \varphi_a a_j ; p \right]. \quad (4)$$

Without a means-test in place (i.e. $\varphi_a = 0$), individual pension payments $p_j$ are uniform for all retired agents. If pensions are means-tested (i.e. $\varphi_a > 0$), pension claims are calculated as the difference between the flat general pension level $\kappa \bar{y}$ and the assessable liquid assets $\varphi_a a_j$. Of course, with a means-test in place the amount of $p_j$ depends on individual characteristics of the retiree. The taper rate $\varphi_a \in [0, 1]$ determines the precision of the asset-test: If $\varphi_a$ takes a value of one, all liquid assets are taken into account and the maximum benefit $\kappa \bar{y}$ is reduced by one Euro for every additional Euro of private assets held by the agent. The reduction of flat benefits is restricted to a minimum pension level $p$ which could be zero or any positive figure.

Aggregating over all retirees yields aggregate expenditures on pensions $P_t$ in period $t$ as

$$P_t = \sum_{j=j_R}^{J} \int_Z p_j(z_j, Z_t) dX_t(z_j). \quad (5)$$

In order to finance aggregate expenditures for flat pensions $P_t$ given by (5) in every period $t$, the pension system collects payroll contributions from labor income. In order to omit redistribution and efficiency effects due to periodically changing contribution rates, we assume a time-invariant contribution rate which balances the intertemporal pension budget. Consequently, we allow for a net position $B_{P,t}$ of the system which is adjusted in every transitional period such that

$$B_{P,t+1} = (1 + r) B_{P,t} + P_t - \tau w L_t \quad (6)$$

holds. The time-invariant contribution rate $\tau$ is then computed such that the present value of aggregate pension outlays equals the present value of aggregate payroll contributions, i.e.

$$\tau = \frac{\sum_{t=1}^{\infty} P_t (1 + r)^{1-t}}{\sum_{t=1}^{\infty} w L_t (1 + r)^{1-t}} \quad (6)$$

holds.\footnote{In principle the net position $B_{P,t}$ can also turn negative, i.e. the system can build up a capital fund. We would not interpret such a situation as a move towards a funded system since we completely abstract from modeling individual accounts.}
2.5 Welfare and efficiency calculation

In order to assess the welfare effects of a policy reform on different cohorts we use the ex-ante expected utility of an unborn agent before the productivity level is revealed. Consequently, expected utility of a newborn in period \( t \) is computed from

\[
E \left[ V(z_1, Z_t) \right] = \int_Z V(z_1, Z_t)^{1-\mu} dX_t(z_1) \frac{1}{1-\mu}
\]

where assets are all zero. In order to compare welfare for a respective individual living in the reform year \( t = 1 \) before and after the introduction of the pension system, we compute the proportional increase (or decrease) in consumption and leisure \( \phi \) which would make an agent in the baseline economy as well off as after the reform. Due to the homogeneity of the utility function the necessary increase (or decrease) in percent of resources is

\[
\phi(z_j, Z_1) = \left[ \frac{E \left[ V(z_{j+1}, Z_1) \right]}{E \left[ V(z_{j+1}, Z_0) \right]} - 1 \right] \times 100
\]

Consequently, a value of \( \phi(z_j, Z_1) = 1.0 \) implies that this agent would need one percent more resources in the initial equilibrium to attain the expected utility level he receives after the introduction of the pension system. Aggregation of the percentage changes \( \phi(z_j, Z_1) \) for each skill level \( s \) at age \( j \) across all asset levels and productivity shocks yields average welfare changes at age \( j \) for alternative skill levels \( s \):

\[
\bar{\phi}(s, j) = \frac{1}{N_{j,s}} \int_{A \times E} \phi(z_j, Z_1) dX_0(z_j),
\]

For all newborn cohorts entering the labor market during the transition we only report the ex-ante welfare change for the respective cohort.

In order to assess aggregate efficiency consequences, we introduce a Lump-Sum Redistribution Authority (LSRA) in the spirit of Auerbach and Kotlikoff (1987), Fehr, Habermann and Kindermann (2008) or Kudrna and Woodland (2011) in a separate simulation. The LSRA treats those cohorts already existing in the initial equilibrium and newborn cohorts differently. To cohorts already existing it pays a lump-sum transfer (or levies a lump-sum tax) \( \nu_j(z_j, Z_1) \) to bring their expected utility level after the reform back to the level of the initial equilibrium \( E \left[ V(z_j, Z_0) \right] \).

Since utility depends on age and state, these transfers (or taxes) have to be computed for every agent in the first year of the transition. Consequently, after compensation, their relative welfare change is \( \phi^c(z_j, Z_1) = 0.0 \). Furthermore, those who enter the labor market in period \( t \geq 1 \) of the transition receive a transfer \( v_1(z_1, Z_t, V^*) \) which guarantees them an expected utility level of \( V^* \) through a (compensated) relative consumption change \( \phi^c(z_1, Z_t) \) which is identical for all newborn future cohorts. Note that the transfers \( v_1(z_1, Z_t, V^*) \) may differ among future cohorts but the expected utility level \( V^* \) is identical for all. This expected utility \( V^* \) is chosen so the present value of all LSRA transfers is zero\(^5\):

\[
\sum_{j=2}^J \int_Z v_j(z_j, Z_1) dX_j(z_j) + \sum_{t=1}^\infty v_1(z_1, Z_t, V^*)(1 + r)^{1-t} = 0.
\]

\(^5\) Note that in order to avoid LSRA transfers causing major liquidity effects at any age, transfers are given as an annuity to agents before or after they retire.
In the first period of the transition the LSRA builds up debt (or assets) from

\[ B_{RA,2} = \sum_{j=1}^{J} \int_{Z} v_j(z_j, Z_1) dX_1(z_j) \]  \hspace{1cm} (10)

which has to be adjusted in each future period according to

\[ B_{RA,t+1} = (1 + r) B_{RA,t} - v_1(z_t, Z_t). \]  \hspace{1cm} (11)

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

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

### 2.6 Equilibrium conditions

An equilibrium path for a given policy schedule represents a set of value functions \({V(z_j, Z_t)}\) \(_{j=1}^J\), household decisions \({c_j(z_j, Z_t), \ell_j(z_j, Z_t)}\) \(_{j=1}^J\), distributions of unintended bequests \({b_j(z_j, Z_t)}\) \(_{j=1}^J\) and measures of households \({\xi_t(z_j)}\) \(_{j=1}^J\) that satisfy the following conditions \(\forall t:\)

1. The household decisions \({c_j(z_j, Z_t), \ell_j(z_j, Z_t)}\) \(_{j=1}^J\) solve the household decision problem (1) subject to the respective constraint (2).

2. Aggregation holds so that

\[ L_t = \sum_{j=1}^{J} \int_{Z} [1 - \ell_j(z_j, Z_t)] c_j dX_1(z_j) \]  \hspace{1cm} (12)

\[ C_t = \sum_{j=1}^{J} \int_{Z} c_j(z_j, Z_t) dX_1(z_j) \]  \hspace{1cm} (13)

and the capital stock \(K_t\) is adjusted so that

\[ K_t = \left( \frac{r + \delta}{\Phi \epsilon} \right) \downarrow L_t \]  \hspace{1cm} (14)

holds.

3. Defining \(1_{h=x}\) as an indicator function to return 1 if \( h = x \) and 0 otherwise, the following law of motion for the measure of households \({\xi_t(z_j)}\) \(_{j=1}^J\) holds:

\[ \xi_t(z_{j+1}) = \psi_{js} \int_{A \times E} 1_{a_{j+1} = a_{j+1}(z_{j+1}, Z_t)} \times \pi(y_{j+1} | \eta_j) dX_1(z_j) \]  \hspace{1cm} (15)

4. Unintended bequests satisfy

\[ \int_{Z} b_j(z_{j+1}, Z_{t+1}) dX_{t+1}(z_{j+1}) = \sum_{j=1}^{J} \int_{Z} (1 - \psi_{j+1, s})(1 + r) a_{j+1}(z_j, Z_t) dX_1(z_j) \]  \hspace{1cm} (16)
5. The budgets of the pension system (6) and the lump-sum redistribution authority (11) are intertemporally balanced.

6. The goods market clears, i.e.

$$Y_t = C_t + K_{t+1} - (1 - \delta)K_t + X_t$$

holds for the small open economy, where $X_t$ marks the net exports in period $t$.

The computation of an equilibrium follows the Gauss-Seidel method introduced by Auerbach and Kotlikoff (1987). A more detailed description of our computation algorithm is provided in Fehr and Uhde (2013).

### 3 Calibration of the initial equilibrium

Regarding the calibration of the initial equilibrium, we follow Fehr and Uhde (2013) closely. In order to reduce computational time, each model period covers five years. We distinguish three skill classes ($S = 3$) where low-, medium- and high-skilled individuals initially represent 20, 55 and 25 percent of the population. Agents start their life at the age of 20 ($j = 1$), are forced to retire at age 60 ($j_R = 9$) and face a maximum possible life span of 100 years ($J = 16$). The conditional survival probabilities $\psi_{j,s}$ are computed from the year 2050 Life Tables reported in Bomsdorf (2003). Skill-specific differences in life expectancy are initially disregarded and considered in the sensitivity analysis. With respect to the preference parameters we set the intertemporal elasticity of substitution $\gamma$ to 0.5, the intratemporal elasticity of substitution $\rho$ to 0.6, the coefficient of relative risk aversion $\mu$ to 2.0 and the leisure preference parameter $\alpha$ to 1.6. This is within the range of commonly used values (see Auerbach and Kotlikoff, 1987, and Cecchetti et al., 2000) and yields a compensated (uncompensated) wage elasticity of labor supply of 0.55 (-0.02) in our benchmark. In our baseline economy we abstract from a bequest motive ($\lambda_1 = 0$), hence all bequests left by the agents are purely accidental. Finally, we set the time discount factor $\beta$ to 0.87 (which implies an annual discount rate of about 3 percent), in order to calibrate a realistic capital-output ratio.

With respect to technology parameters we choose the general factor productivity $\Phi = 1.38$ in order to normalize labor income and set the capital share in production $\epsilon$ at 0.35. The annual depreciation rate for capital $\delta$ and the world interest rate $r$ are set at 6 and 2.4 percent per anno, respectively. The resulting values for the model period as well as all other exogenous parameters are summarized in Table 1.

Log-productivity for an individual of skill class $s$ evolves over the life-cycle according to

$$\log e_j = \xi_0 + \xi_1 \cdot j + \xi_2 \cdot j^2 / 100 + \eta_j$$

where $\eta_j$ follows an AR(1) process of the form

$$\eta_j = \varphi \eta_{j-1} + \varepsilon_j \quad \text{with} \quad \varepsilon_j \sim N(0, \sigma^2_{\varepsilon,s}).$$

The parameters for the skill-specific productivity profiles are derived from German household data, the estimation procedure is described in Fehr, Kallweit and Kindermann (2013). With rising skill level the AR(1) correlation coefficient $\varphi$ increases from 0.3304 to 0.6284, while the transitory variance rises from 0.1012 to 0.1467.
### Table 1: Parameter selection

<table>
<thead>
<tr>
<th>Demographic parameters</th>
<th>Preference parameters</th>
<th>Productivity parameters</th>
<th>Technology parameters</th>
<th>Pension parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>$N_{1,1} = 0.20$</td>
<td>$\gamma = 0.5$</td>
<td>$\epsilon_1 = 0.3304$</td>
<td>$\Phi = 1.38$</td>
<td>$\kappa = 0.0$</td>
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<tr>
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<td>$\epsilon = 0.35$</td>
<td>$\varphi_a = 0.0$</td>
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<td>$\epsilon_3 = 0.6284$</td>
<td>$\delta = 0.266$</td>
<td>$\nu = 0.0$</td>
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<tr>
<td>$J = 16$</td>
<td>$\alpha = 1.6$</td>
<td>$\sigma^2_{\epsilon,1} = 0.1012$</td>
<td>$r = 0.13$</td>
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<tr>
<td>$j_R = 9$</td>
<td>$\beta = 0.87$</td>
<td>$\sigma^2_{\epsilon,2} = 0.1120$</td>
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<tr>
<td>$\psi_{j,s}$: Bomsdorf (2003)</td>
<td>$\lambda = 0.0$</td>
<td>$\sigma^2_{\epsilon,3} = 0.1467$</td>
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</tbody>
</table>

Table 2 reports some key numbers of the resulting benchmark equilibrium. Note that we abstract from skill-specific mortality rates initially. The model’s income and wealth distribution is fairly equal, which simply reflects the fact that our model does not capture the extreme ends of the income distribution. Note that in all skill classes agents of the youngest cohort with negative productivity shocks would like to borrow because they expect a higher productivity (and therefore income) in the future. For older cohorts, the fraction of liquidity constraint agents decreases sharply and we hardly observe liquidity constrained households older than 40 years. Aggregate bequests of 9.7 percent of GDP are purely accidental since annuity markets are missing and we abstract from a bequest motive initially, i.e. $\lambda_1 = 0.0$ holds.

### Table 2: The initial equilibrium

<table>
<thead>
<tr>
<th>Life expectancy</th>
<th>Trade Balance</th>
<th>Gini index income</th>
<th>Liquidity constraints (20-29)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.4&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.40</td>
<td>65%</td>
</tr>
<tr>
<td>Dependency ratio</td>
<td>Capital-output ratio</td>
<td>Gini index wealth</td>
<td>Liquidity constraints (30-39)</td>
</tr>
<tr>
<td>52.6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.5</td>
<td>0.56</td>
<td>23%</td>
</tr>
</tbody>
</table>

<sup>a</sup> i.e. 80.5 years. <sup>b</sup> ages 60+/20-59. <sup>c</sup> in % of GDP.

### 4 Simulation results

Starting out from the initial equilibrium without a social security system in period $t = 0$, we introduce pension systems of various designs in period $t = 1$ and compute the macroeconomic and welfare changes for different cohorts along the transition path towards a new long run equilibrium, both without and with neutralizing compensation payments of the Redistribution Authority. First, we highlight macroeconomic and welfare consequences of introducing a representative flat universal system. Then we analyze the optimal structure of means-tested flat benefits both from a long-run steady-state comparison perspective as well as from an aggregate efficiency point of view in the third subsection. The fourth subsection presents some sensitivity analysis.
4.1 Economic effects of means-testing

Before we discuss the results of our initial simulations it is useful to abstract from labor supply distortions and liquidity constraints in a thought experiment in order to highlight the insurance properties of the pension system. If employees were allowed to borrow against their future pension benefits, the optimal contribution rate of a universal flat pension system would be 100 percent. In this case everybody receives the same income during years of retirement and all income and longevity uncertainty is completely eliminated.

As soon as liquidity constraints and variable labor supply are taken into account, the optimal replacement rate (which determines the contribution rate) drops significantly. Fehr and Uhde (2013) show that the introduction of PAYG-financed pension systems is associated with efficiency gains as long as benefits from the provision of insurance against income and longevity risk dominate the costs from tightened liquidity constraints and increased labor market distortions.

Testing pension benefits against private assets results in trading off two additional sources of distortions compared to the model setup in Fehr and Uhde (2013). Means-testing reduces distortional contribution rates significantly as a precise targeting of a smaller group of pensioners results in lower pension outlays financed by payroll contributions. On the other hand, means-testing induces severe direct distortions of savings accumulation as well as labor supply over the life cycle. Whether a social security system should entail means-tested benefits crucially depends on which of the two counteracting effects dominates.

The left part of Table 3 reports the resulting consequences of introducing a universal flat rate pension with a replacement rate of 40 percent of average income (i.e. $\kappa = 0.4$) on aggregate labor supply, consumption and savings. In the left part of the Table we disregard means-testing while in the right part a full means-test (i.e. $\varphi = 1.0$) is applied.

<table>
<thead>
<tr>
<th>Period</th>
<th>Universal ($\varphi = 0.0$)</th>
<th>Fully means-tested ($\varphi = 1.0$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Labor supply</td>
<td>Consumption</td>
</tr>
<tr>
<td>1</td>
<td>-15.2</td>
<td>19.5</td>
</tr>
<tr>
<td>3</td>
<td>-4.3</td>
<td>5.2</td>
</tr>
<tr>
<td>5</td>
<td>-1.2</td>
<td>-4.3</td>
</tr>
<tr>
<td>$\infty$</td>
<td>0.1</td>
<td>-11.9</td>
</tr>
</tbody>
</table>

Changes are reported in percentage over initial equilibrium, $\kappa = 0.4$, $p = 0$. \(^b\) In percent of GDP

If universal annual benefits amount to 40 percent of average income, the contribution rate $\tau$ rises to 21.1 percent. As a consequence, labor supply and employment (as well as the capital stock and GDP) decreases sharply initially by more than 15 percent while consumption rises and private savings fall. In the transitional years younger individuals receive less bequests so that private consumption also falls by more than 10 percent in the long run compared to the initial level. The reduction of future resources also reduces leisure demand and increases employment again. Changes in employment directly affect average income so that pension benefits adjust accordingly. Since the asset reduction does not affect pension outlays, aggregate benefits in each period can be financed with a constant
contribution rate so that the pension system does not need to build up resources for the future.

In the right part of table 3 macroeconomic consequences of introducing a system which tests pension payments against private asset holdings are reported. Since now many medium- and high-skilled households receive zero or reduced pensions benefits, the contribution rate \( \tau \) only rises to 9.7 percent although the replacement rate remains unchanged at \( \kappa = 0.4 \).\(^6\) Due to the lower contribution rate, labor supply and employment is reduced by a lesser amount initially, but now employment also falls significantly in the long run. This is surprising on first glance since both lower bequests and lower contribution rates should tend to increase labor supply. However, with means-tested pension benefits especially low- and middle-skilled households reduce labor supply sharply before retirement and consume their assets in order to increase their individual pension benefits. Figure 1 compares the average savings profiles of low- and high-skilled households for universal and asset-tested pension schemes in the two respective long-run equilibria. While poor households decrease their (already low) asset holdings due to the asset test, rich households save more since they do not receive pension benefits, see the right part of Figure 1.

\[\text{Figure 1: Long-run asset accumulation with universal vs. means-tested pensions}\]

Consequently, our model generates the well documented result from the empirical and theoretical literature that means-tested social insurance programs may be a part of the explanation why rich households save more than poor households and why poor households often do not hold any assets for retirement, see Dynan, Skinner and Zeldes (2004) and Hubbard, Skinner and Zeldes (1995). In addition, our results are broadly in line with the results from Sefton, van de Ven and Weale (2008), who document that households react quite differently to changes in the asset test regime of retirement benefits depending on their position in the income distribution. Rising taper rates encourage poor households to save less while prompting richer agents to save a higher amount compared to a situation with universal benefits.

In the present parametrization the reaction of rich households dominates so that aggregate savings decrease less than in the previous simulation without means-testing. The savings reduction of poor

\[^6\] We also simulated this reform with a periodically balanced budget. In this case the contribution rate rises slowly from 0.2 percent in period 1 to 15.5 percent in the long-run equilibrium. The macroeconomic and welfare effects of this simulation are available upon request.
households also explains why the pension system now has to accumulate assets during the transition. Initially, private assets are given so that aggregate pension benefits are significantly lower. During the transition, low income households get rid of their assets before retirement so that aggregate pension benefits increase steadily. With constant contribution rates the latter have to be financed from the returns on pension assets.

Next we turn to welfare consequences for different cohorts in the reform year and the long run without and with compensation payments from the LSRA. As already explained above, we first compute the welfare changes of agents before their productivity is revealed and then derive an average welfare change for the different skill types in each cohort that already lives in the initial equilibrium. Therefore, Table 4 distinguishes between “poor”, “median”, and “rich” households in each cohort. “Poor” agents are the 20 percent of the cohort with the lowest skill level, “median” are those 55 percent who have a medium skill level and “rich” are those 25 percent of the cohort with the highest skills. For newborn cohorts along the transition path we are not able to disaggregate ex-ante welfare effects. Consequently, we report in the middle column the ex-ante welfare change of the whole cohort. The left part of Table 4 reports the results for the simulated introduction of a universal system, while the right part reports the results of the introduction of a fully means-tested system.

<table>
<thead>
<tr>
<th>Age in reform year</th>
<th>Universal ($\varphi_a = 0.0$)</th>
<th>Fully means-tested ($\varphi_a = 1.0$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Consumers compesated</td>
<td>Consumers compesated</td>
</tr>
<tr>
<td>Poor</td>
<td>45.9</td>
<td>25.3</td>
</tr>
<tr>
<td>Median</td>
<td>39.2</td>
<td>20.8</td>
</tr>
<tr>
<td>Rich</td>
<td>29.1</td>
<td>13.8</td>
</tr>
<tr>
<td></td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Poor</td>
<td>35.1</td>
<td>16.6</td>
</tr>
<tr>
<td>Median</td>
<td>29.9</td>
<td>13.1</td>
</tr>
<tr>
<td>Rich</td>
<td>22.0</td>
<td>8.1</td>
</tr>
<tr>
<td></td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Poor</td>
<td>8.9</td>
<td>3.3</td>
</tr>
<tr>
<td>Median</td>
<td>6.6</td>
<td>1.1</td>
</tr>
<tr>
<td>Rich</td>
<td>3.5</td>
<td>-1.0</td>
</tr>
<tr>
<td></td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Poor</td>
<td>-4.2</td>
<td>-1.9</td>
</tr>
<tr>
<td>Median</td>
<td>-4.8</td>
<td>-3.0</td>
</tr>
<tr>
<td>Rich</td>
<td>-5.6</td>
<td>-3.7</td>
</tr>
<tr>
<td></td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Poor</td>
<td>-6.1</td>
<td>-6.2</td>
</tr>
<tr>
<td>Median</td>
<td>0.8</td>
<td>-3.3</td>
</tr>
<tr>
<td>Rich</td>
<td>0.8</td>
<td>-1.5</td>
</tr>
<tr>
<td></td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

*Changes are reported in percentage of initial resources, $\kappa = 0.4$, $\rho = 0$.

Not surprisingly, existing retirees benefit dramatically in both simulations, while future cohorts lose significantly. In addition, due to the progressive system, the gain of poor households is much higher than the one for rich households. Since the generosity of the system is reduced, means-testing mainly reduces the implied intergenerational redistribution. Older cohorts benefit significantly less since they receive lower pensions due to the asset test. At the same time, younger and future cohorts lose less since they benefit from lower contributions.

In order to quantify the aggregate efficiency consequences of the introduction of the considered system designs, one has to compare the transitional welfare gains and long run welfare losses. Consequently, we simulate both reforms with lump-sum compensation payments of the LSRA.⁷ The compensated welfare changes for all generations alive in the initial equilibrium are then zero and newborn generations experience identical welfare changes measured in remaining lifetime resources. As shown in the forth column, the introduction of the universal pension system increases aggregate efficiency by 0.8 percent of remaining resources. The positive efficiency effect is due to the fact that

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⁷ We do not report the macroeconomic effects of simulations with compensation payments, but they are available on request.
the benefits from income and longevity insurance dominate the efficiency costs from higher liquidity constraints and labor supply distortions. However, as reported in the right column, aggregate efficiency decreases by 1.5 percent when benefits are fully tested against private assets. Even though the means test reduces the total size of the system considerably which in turn yields lower labor supply and liquidity distortions through a lower contribution rate, strong additional distortions are introduced due to the asset test, completely offsetting the positive effects. This results in a decline in aggregate efficiency by 2.3 percentage points reported above.

In the next step we explore the introduction of a means-tested pension system with a taper rate of only 40 percent. Comparing the macroeconomic effects in the right part of Table 3 and the left part of Table 5 we find exactly the same aggregate pattern. Employment falls slightly less with the reduced taper rate while assets are reduced even further in the long-run. Since benefits are now more generous, the contribution rate rises from 9.7 to 10.8 percent and the system has to build up less pension wealth. As one would expect, higher pension benefits increase the intergenerational redistribution from the currently young and future cohorts towards the currently elderly. The left part of Table 6 shows that welfare of existing pensioners rises significantly while long-run welfare decreases further (compared to the right part of Table 4). However, if we take the welfare consequences for transitional cohorts into account, then the reduction of the taper rate is clearly efficiency enhancing. As shown in Table 6, the aggregate efficiency loss decreases from 1.5 percent of aggregate resources (with taper rate $\phi_a = 1.0$) to 1.3 percent (with taper rate $\phi_a = 0.4$).

<table>
<thead>
<tr>
<th>Period</th>
<th>Without basic pension ($p = 0$)</th>
<th>With basic pension ($p = 0.75 \kappa y$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Labor supply</td>
<td>Consumption</td>
</tr>
<tr>
<td>1</td>
<td>-11.5</td>
<td>16.1</td>
</tr>
<tr>
<td>3</td>
<td>-4.6</td>
<td>2.7</td>
</tr>
<tr>
<td>5</td>
<td>-2.7</td>
<td>-6.6</td>
</tr>
<tr>
<td>$\infty$</td>
<td>-2.2</td>
<td>-10.4</td>
</tr>
</tbody>
</table>

$^a$Changes are reported in percentage over initial equilibrium, $\kappa = \phi_a = 0.4$. $^b$ In percent of GDP

Next, we keep the reduced taper rate and introduce a basic pension which limits the maximum benefit reduction to 25 percent. Since pension benefits are now much higher, the contribution rate increases from 10.8 to 17.1 percent. The right part of Table 5 shows that despite this significant rise in the contribution rate labor supply is reduced much less in the long run. Of course, this is due to the fact that the incentives to reduce income and savings right before retirement are now much lower. Consequently, private assets fall less than before and the required accumulation of pension wealth is much smaller.

The right part of Table 6 shows that the basic pension increases intergenerational redistribution towards the existing elderly. As the last column in Table 6 shows, due to lower labor supply and savings distortions, aggregate efficiency increases significantly after the introduction of the basic pension. While we still find that means-testing decreases economic efficiency, the combination with a basic pension at least generates an improvement of the resource allocation compared to the situation without a pension system in place.
Table 6: Welfare effects of means-tested benefits without and with basic pension

<table>
<thead>
<tr>
<th>Age in reform year</th>
<th>Without basic pension ($p = 0$)</th>
<th>With basic pension ($p = 0.75\kappa\bar{y}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Consumers poor</td>
<td>Consumers median</td>
</tr>
<tr>
<td>75-79</td>
<td>30.0</td>
<td>24.3</td>
</tr>
<tr>
<td>65-69</td>
<td>18.7</td>
<td>14.8</td>
</tr>
<tr>
<td>45-49</td>
<td>3.9</td>
<td>1.6</td>
</tr>
<tr>
<td>25-29</td>
<td>-2.0</td>
<td>-3.1</td>
</tr>
<tr>
<td>20-24</td>
<td>-3.5</td>
<td>-1.3</td>
</tr>
<tr>
<td>$\infty$</td>
<td>-3.5</td>
<td>-1.3</td>
</tr>
</tbody>
</table>

Changes are reported in percentage of initial resources, $\kappa = \varphi_a = 0.4$.

4.2 Optimal design of flat pensions - the long run perspective

In order to identify the optimal structure of flat pensions with respect to pension generosity and the taper rate, we first follow traditional studies which focus on a long-run perspective. To assess the welfare properties of alternative pension designs, studies such as Tran and Woodland (2012) or Kumru and Piggott (2009) neglect transitional issues. Instead they compare long-run equilibria with alternative pension systems for the UK and use the expected ex-ante utility of an unborn agent as the welfare criterion.

Table 7: Long-run welfare effects of different pension designs

<table>
<thead>
<tr>
<th>$\kappa$</th>
<th>0.0</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>-1.60</td>
<td>-0.34</td>
<td>-0.31</td>
<td>-0.28</td>
<td>-0.27</td>
</tr>
<tr>
<td>0.2</td>
<td>-3.13</td>
<td>-1.05</td>
<td>-0.97</td>
<td>-0.92</td>
<td>-0.84</td>
</tr>
<tr>
<td>0.3</td>
<td>-4.64</td>
<td>-2.23</td>
<td>-2.09</td>
<td>-2.01</td>
<td>-1.96</td>
</tr>
<tr>
<td>0.4</td>
<td>-6.18</td>
<td>-3.59</td>
<td>-3.48</td>
<td>-3.44</td>
<td>-3.26</td>
</tr>
<tr>
<td>0.5</td>
<td>-7.81</td>
<td>-5.09</td>
<td>-4.98</td>
<td>-4.95</td>
<td>-4.83</td>
</tr>
<tr>
<td>0.6</td>
<td>-9.62</td>
<td>-6.77</td>
<td>-6.60</td>
<td>-6.52</td>
<td>-6.42</td>
</tr>
<tr>
<td>0.7</td>
<td>-11.68</td>
<td>-8.70</td>
<td>-8.47</td>
<td>-8.37</td>
<td>-8.19</td>
</tr>
<tr>
<td>0.8</td>
<td>-14.08</td>
<td>-10.90</td>
<td>-10.64</td>
<td>-10.48</td>
<td>-10.14</td>
</tr>
<tr>
<td>0.9</td>
<td>-16.87</td>
<td>-13.44</td>
<td>-13.11</td>
<td>-12.93</td>
<td>-12.14</td>
</tr>
<tr>
<td>1.1</td>
<td>-23.75</td>
<td>-19.77</td>
<td>-19.28</td>
<td>-18.96</td>
<td>-18.59</td>
</tr>
<tr>
<td>1.2</td>
<td>-27.97</td>
<td>-23.67</td>
<td>-23.00</td>
<td>-22.65</td>
<td>-22.63</td>
</tr>
</tbody>
</table>

Changes in % of initial resources, $p = 0$.

Table 7 summarizes the changes in long-run ex-ante expected welfare as a percentage of initial resources for different institutional designs with regards to pension generosity and taper-rates of the asset means-test. As already shown before, future cohorts typically lose after the introduction of a pension system but they lose less when the system is means-tested against private assets. Our simulation exercises show that this pattern holds true for all considered system sizes: For any system of a Beveridgean design with a given replacement rate, raising the taper rate on private assets results in a rise in the long run welfare change. Therefore, the taper rate that maximizes long run welfare

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8 The parameter combinations discussed above are highlighted in bold letters. Note that differences in long run welfare changes compared to numbers presented above are due to rounding.
for a system of given generosity is always 100%. This result is in line with Kumru and Piggott (2009) who find means-testing to be long-run welfare enhancing and conclude that the UK pension system should be fully means-tested. If long-run expected utility as a measure for welfare is used to compare the different systems, we conclude that flat pension benefits should always be fully means-tested. However, transitional cohorts are neglected and intergenerational redistribution effects drive most of the results. Hence, we argue that long-run welfare effects themselves are not an adequate criterion of optimality.

4.3 Optimal design of flat pensions - aggregate efficiency

With the LSRA neutralizing all intergenerational redistribution effects by compensation payments given to cohorts along the transition path, we isolate the aggregate efficiency properties of social security systems of different institutional designs. As was already shown in subsection 1 for a universal and a fully means-tested system of the same generosity, aggregate efficiency rises with the introduction of a universal system when benefits from additional insurance provision outweigh additional costs from liquidity constraints and distortions. In contrast, aggregate efficiency declines due to the introduction of a fully means-tested system: additional distortions of labor supply and the accumulation of savings due to the asset means-test overcompensate lower distortions as a result of a smaller contribution rate.

Of course, the question is how efficiency effects change when we alter the size of the pension system for different taper rates. Figure 2 shows the aggregate efficiency effects for alternative replacement rates and asset taper rates. Note that we abstract from including a basic minimum pension in this simulation exercise, i.e. $p = 0$. Consider first the straight line which shows efficiency effects of introducing universal Beveridgean systems with different replacement rates. With low replacement rates the benefits from insurance dominate the losses due to reduced liquidity and higher labor supply
distortions so that higher replacement rates imply a rise in economic efficiency. The highest efficiency gains are realized in a system with a replacement rate of $\kappa = 0.4$ which was discussed above. If the size of the system increases further efficiency gains decrease since now the cost from reduced liquidity and increased labor market distortions dominate the positive insurance effects. For replacement rates above $\kappa = 0.65$, distortions completely dominate any insurance gains so that aggregate efficiency decreases in comparison to the benchmark equilibrium without a social security system. These losses increase further with rising replacement rates.

With a full means-test in place ($\varphi_a = 1.0$), aggregate efficiency effects of introducing the means-tested systems immediately turn negative for all replacement rates considered, see the dashed line in figure 2. Efficiency losses increase initially but then remain constant at roughly 2 percent of aggregate resources when the replacement rate is varied between 50 percent and 70 percent. This reflects a balancing of the additional direct savings distortions by reduced labor supply distortions due to reduced contribution rates. For replacement rates above 70 percent, aggregate efficiency drops sharply if the systems are fully means-tested. Figure 2 reveals that aggregate efficiency is always higher in universal systems than in fully means-tested systems, i.e. the straight line is always above the dashed line.

A reduction in the taper rate from $\varphi_a = 1.0$ to $\varphi_a = 0.4$ is shown to be efficiency enhancing for all replacement rates considered. For replacement rates up until 95%, the universal system dominates all means-tested systems in terms of aggregate efficiency. Only for very high replacement rates greater than 95%, we find a system with a low degree of asset-testing to be more efficient than a universal system. In this case, the positive effect of a reduced contribution rate due to the asset-test overcompensates moderate distortions of the savings behavior of a relatively large number of agents. In contrast, the equally large universal system features significantly higher contribution rates while it is less distortive to the savings accumulation of agents.

As was shown above, a fully means-tested system is less efficient than the respective universal and partially means-tested counterparts. In figure 3 we keep the taper rate of $\varphi_a = 1.0$ constant and explore the exemption of different levels of asset holdings from the asset test by including minimum pension floors $p$ for different replacement rates of up to 70%. The straight line again shows the aggregate efficiency curve of the benchmark universal system while the finely dotted line represents its fully means-tested counterpart without a minimum pension, i.e. $p = 0$. Figure 3 reveals that even low pension floors of 25% of the pension level increase economic efficiency compared to a system without a floor. This gain rises with higher exemptions, but the highest efficiency gains are still achieved in a universal social security system. Of course, if the level of the minimum pension approaches the pension level $\bar{y}$, the system effectively becomes universal as most asset holdings are exempt from the means-test.

Summing up the results of this section we show that from a long-run welfare perspective, means-testing pension benefits against private assets is always beneficial. This is in line with previous literature such as Sefton and van de Ven (2009) or Kumru and Piggott (2009). However, these previous studies do not take the welfare consequences of means-testing pension benefits for transitional cohorts into account. We show by neutralizing intergenerational redistribution effects that means-testing induces dramatic distortions of the accumulation of savings and labor supply, resulting in losses in aggregate efficiency. Even though reducing the taper rate or exempting assets from the means-test through a minimum pension is shown to be efficiency enhancing, we find that a universal system dominates any means-tested system for replacement rates of up to 95%.
4.4 Sensitivity analysis

Of course, the numerical results reported above strongly depend on the specific parametrization and assumptions of our simulation model. With respect to the aggregate efficiency consequences mainly liquidity effects and distortions of labor supply and (with asset-testing) savings are negative while the provision of insurance against income and longevity risk has positive impacts. Consequently, aggregate efficiency curves are shifted upwards if we increase income uncertainty, relax borrowing constraints and dampen the elasticity of labor supply. At the same time, lower risk aversion, the existence of private annuity products or a progressive tax system would shift all efficiency curves downwards.

It should be clear that the optimal replacement rate increases with relaxed liquidity constraints and with an increasing degree of risk aversion. On the other hand, with reduced risk aversion the optimal replacement rate will be quite lower. For example, with risk neutral preferences (i.e. \( \mu = 0.0 \)) the optimal replacement rate without means-testing amounts to 30 percent and the respective aggregate efficiency gain is reduced to 0.3 percent of aggregate resources. This fall in aggregate efficiency is due to a complete disregard of the income insurance gains. Introducing the universal flat pension still yields positive effects from insurance against longevity.\(^9\)

In the following sensitivity analysis we consider the impact of bequest motives and differential mortality. Both aspects seem to be relevant in practice and have not been covered so far by our model. If households have bequest motives of any kind, the positive effect of a given pension scheme regarding insurance provision against longevity is significantly reduced since households also benefit from

\(^9\) There is reason to believe that the present income process underestimates income risk since it does not include unemployment and disability risk during employment and long-term care risk during retirement.

\(^{10}\) For a more detailed discussion of these issues see Fehr and Uhde (2013).
positive asset balances which remain after death. The slower downsizing of assets at old age also changes the efficiency effects of asset-tested pension benefits.

In the following we explore in two separate simulation exercises the impacts of intentional bequests when bequests are either conceived as a luxury good and only rich agents have a bequest motive (i.e. $\lambda_1 = 13.2$, $\lambda_2 = 1$, $\lambda_3 = 10$) or all agents have a bequest motive (i.e. $\lambda_1 = 0.5$, $\lambda_2 = 0$, $\lambda_3 = 1$). The parameters determining the properties of the respective bequest motive are set to yield the same aggregate bequests in both situations. Of course, due to the bequest motive aggregate savings as well as bequests are higher in the initial equilibrium compared to the initial equilibrium considered before. Nevertheless, as we model a small open economy, higher savings are only affecting the trade balance so that the capital-output ratio in the economy remains the same as in Table 2.

The left part of Figure 4 compares the aggregate efficiency effects of introducing a universal vs. an asset-tested flat pension when intentional bequests modeled as a luxury good, i.e. only rich agents leave intentional bequests while poor agents behave in the same fashion as in the situation without a bequest motive. Obviously, due to the reduced (or even eliminated) longevity insurance provision, the universal pension system now yields much lower (and even negative) aggregate efficiency effects compared to the respective economy without a bequest motive considered in Figure 2. Without a bequest motive, asset-testing in Figure 2 mainly distorts the savings behavior of low- and medium-income households while rich households mainly realize income effects due to lower contribution rates. Consequently, this distortion pattern is not affected by a bequest motive that only applies to rich households so that the loss in aggregate efficiency due to asset-testing in the left part of Figure 4 is quite similar as in Figure 2.

The right part of Figure 4 shows the same simulation exercise with all agents leaving small intentional bequests while aggregate bequests are the same as in the left part. The introduction of asset-testing has now very little efficiency impacts with low replacement rates since poor households have no incentive to change their saving behavior. With rising replacement rates more and more agents choose to run down their asset holdings faster in order to maximize their pension claims despite the present bequest motives. Consequently, the resulting aggregate efficiency loss due to asset-testing is even higher than before.

Therefore, the introduction of a bequest motive does not automatically affect the efficiency losses due
to asset-testing. Only if poor households would like to leave bequests and if the replacement rate of
the pension system is low then efficiency losses induced by asset-testing are dampened significantly.

In a second sensitivity test for our results we analyze the impact of skill-specific life expectancy.
More specifically, we assume that high-skilled individuals can expect to live 2.5 years longer than
the medium-skilled while life expectancy of low-skilled agents is 2.5 years lower than that of the
medium-skilled. At first glance one would expect the high-skilled to benefit significantly more
and the low-skilled to benefit less from the introduction of a pension system due to higher (lower)
longevity insurance gains. However, one also has to take into account that saving rates now also
rise significantly with skill level which dampens the impact of the pension system. Consequently,
macroeconomic and welfare effects of pension systems do hardly change when we consider differen-
tial mortality.11

5 Discussion

This paper aims at analyzing the optimal design of means-tested PAYG-financed public pension sys-
tems of a Beveridgean design. We apply an overlapping generations model that features realistic
labor income and longevity risk, liquidity constraints and endogenous labor supply. Compared to
previous studies that focus on optimal pension design, the present approach computes the whole
transition path between steady states without and with social security. In addition, our study isolates
the aggregate efficiency effects of the considered reforms in a separate simulation with compensating
transfers. The latter are used to derive the following major quantitative and qualitative results. Our
simulation results highlight the economic effects of asset means-testing of flat pensions. We show
that means-testing allows for a precise targeting of poor pensioners in order to keep the social secu-
rrity system and the distortive contribution rate low but comes at the cost of substantial distortions of
the savings profiles over the life cycle. In line with previous studies, we find that distortive effects on
savings profiles are heterogenous over the distribution of agents. From a long run welfare perspec-
tive, we concur with previous studies which find means-testing to be beneficial for long-run welfare
for all system generosities considered. However, by neutralizing intergenerational redistribution we
show dramatic efficiency losses induced by asset means-testing of flat pensions due to substantial
savings distortions.

Of course, although our model is very flexible with respect to alternative pension structures it still
excludes various design issues by assumption. First, we abstract from any information problem gov-
ernments face in reality when they design the pension system. We neglect disability risk and assume
that the government can observe the expected individual life span. Consequently, all households
quit working and receive their benefits at the same age in the model, there are no explicit choices
for the labor market exit and/or the pension benefit take up. In practice the design of the transi-
tion rules into retirement are an important policy problem since the government neither observes the
expected individual life span nor the physical condition of potential retirees. Simonovits (2003) has
analyzed the optimal pension rule for flexible retirement which takes the information constraints of
the government regarding individual lifespan explicitly into account. He finds that benefits should
rise with the age of retirement more slowly than actuarially fair in order to dampen redistribution
from the shorter-lived towards the longer-lived. Cremer, Lozachmeur and Pestieau (2008) analyze

11 Of course, simulation results are again available upon request.
the optimality of an earnings test after retirement when the government cannot observe individual health and productivity. They show that an earnings test after retirement may be part of an optimal tax system in order to restrict the mimicking of agents with low productivity.

Second, our approach also completely abstracts from capital market uncertainty and the choice between funded and unfunded pension pillars. All optimal design issues considered are restricted within the unfunded pension pillar. In practice, stock market returns are uncertain as well as the implicit returns of the PAYG-system. Taking the structure of aggregate risks explicitly into account, Matsen and Thogersen (2004) show that in most countries it is optimal to offer a mix of funded and unfunded social security. Although PAYG-returns are lower they may be used to hedge against high-yielding capital market risk.

Finally, our approach only considers fully rational individuals and abstracts from myopic households who do not save enough for their retirement. The latter would give rise to paternalistic considerations that affect the optimal pension design. Cremer and Pestieau (2011) review recent studies that analyze the optimal pension design in such a context while Fehr, Habermann and Kindermann (2008) compare the efficiency consequences of pension reforms in economies with rational and myopic households in a very similar model. The consideration of myopic households will improve the aggregate efficiency of the considered pension system. However, it will hardly change the qualitative results of the present study discussed above.

Despite the limitations and even though our results are not directly comparable to earlier literature that explicitly simulate policy reform in calibrated models, we feel that our results have important implications for public policy regarding pension reform. Our results suggest that countries operating social security systems of a Beveridgean design might benefit from lowering taper rates on asset-means tests from an efficiency point of view.

References


