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Means-Testing Retirement Benefits in the UK

Is it Efficient?

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Means-testing retirement benefits in the UK: Is it efficient?

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Abstract

We construct a dynamic stochastic general equilibrium model with overlapping generations in order to analyze the optimality of means-testing pension benefits in the UK. While previous studies only consider the long-run welfare effects of alternative policy reforms, we compute the full transition paths and separate aggregate efficiency effects by means of compensating transfers.

We first demonstrate that it is qualitatively important to consider transitional cohorts and aggregate efficiency instead of long-run welfare, since the latter approach understates the dramatic savings distortions arising from means-testing. Our findings indicate that the introduction of the pension credit (PC) was efficiency deteriorating. In order to reduce distortions induced by the UK pension system, benefits should be strictly means-tested against second pillar pension income only and not against private wealth.

JEL Classifications: C68, H55, E21

Keywords: stochastic OLG model, pension reform, means-tested pensions

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1 Introduction

Means-testing pension benefits allows governments to accurately target poor pensioners while at the same time keeping the system small and pension outlays under control. With low contribution rates labor supply distortions are fairly modest in a means-tested system. With respect to savings distortions, the effects are not so clear-cut. Those who are eligible for means-tested benefits have a lower incentive to save since the effective return on private retirement savings is reduced relative to those who are not eligible. The strength of the distortion depends on the taper rate which defines the amount of benefit reduction for every additional £ saved. However, while lower taper rates reduce savings distortions of those who are already eligible they also increase distortions for those who are newly covered by the system. When more households receive benefits, contribution rates and labor supply distortions also rise again. Consequently, the optimal taper rate has to trade off distortions of labor supply and savings against distributional and social insurance objectives. A further question arises with respect to the differential treatment of different types of private resources. Especially in countries that operate a multi-tier pension system the optimal system design may include different taper rates for private and second tier pension wealth. Consequently, although means-tested benefits are typically included in pay-as-you-go financed social security systems, the organization differs substantially across OECD countries with respect to benefit generosity, household coverage and the targeting of resources.

The present paper attempts to shed more light on the economic mechanics and costs of means-testing by taking a recent reform of the UK pension system as a starting point. In 2003 the so-called Minimum Income Guarantee (MIG) was substituted by the so-called Pension Credit (PC). With this reform the government effectively lowered the taper rate on private resources from 100 to 40 percent in order to trade off high distortions for a small number of pensioners against smaller distortions for a larger number of agents. This reform had significant impacts on retirees as over one third of British households were already eligible for means-tested benefits before the reform came into force, see Brewer and Emmerson (2003). We develop a dynamic stochastic general equilibrium model with overlapping generations in order to quantify the macroeconomic, welfare and efficiency consequences of this specific reform as well as alternative pension regimes. Households in our model are liquidity constrained and face both longevity and productivity risk during their life cycle. Starting out from the pre-reform benchmark equilibrium of the UK economy, we change the taper regime and/or other parameters of the pension system and compute the transition path, the new long run equilibrium as well as the welfare consequences for different cohorts. Finally we incorporate lump-sum compensations in order to quantify the aggregate efficiency effect of a specific reform scenario.

Our simulations highlight several major results. First, we show that long-run welfare effects of reforms in means-testing regimes employed by most previous studies give misleading policy recommendations. In particular, abstracting from the earnings-related second pension pillar, it is optimal to strictly means-test retirement benefits from a long-run welfare perspective which is in line with previous studies. However, taking transitional cohorts into account through compensating transfers, we show that aggregate efficiency rises with lower taper rates on private wealth as increased insurance provision as well as lower savings distortions increasingly dominate losses from higher labor supply distortions. In contrast to all previous studies, aggregate efficiency peaks in a system that does away with testing for private wealth altogether.

Second, starting from the benchmark model that includes the earnings-related second pillar in the analysis, we show that aggregate efficiency is reduced with the PC system as well as with a universal pension (UP) system where everybody receives the same benefit. While losses are lower under the UP compared to the PC system, aggregate efficiency is enhanced when testing retirement benefits only against second tier pension income and not against private wealth.

Third, we show that it is not efficient to eliminate the first tier if income uncertainty is sufficiently high.

This paper is related to Sefton, van de Ven and Weale (2008) as well as Sefton and van de Ven (2009) who analyze the long-run behavioral responses of agents to the introduction of alternative pension designs in the UK using a large scale partial equilibrium life-cycle model with income and lifespan uncertainty. Their results indicate a positive role for means-testing of benefits as long as the withdrawal rate is around 50 percent. However, their results are based on long-run welfare effects, they completely neglect transitional cohorts and therefore aggregate efficiency. In addition, they model a discrete choice of labor supply which does not adequately capture labor supply responses. Both studies also abstract from second tier pensions, so that they cannot distinguish taper rates for specific types of resources. Kumru and Piggott (2014) extend this approach using a large scale general equilibrium stochastic overlapping generations model calibrated to UK data that includes variable labor supply and second tier pensions in the analysis. They largely confirm the behavioral findings of Sefton et al. (2008) to the PC-reform but find that a 100% taper rate for means-testing is optimal from a long run welfare perspective. Kudrna and Woodland (2011) analyze the abolition of the 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. Our approach heavily builds on Fehr and Uhde (2013) where we also analyze optimal pension design in an overlapping generations model. Based on aggregate efficiency, we find a positive role of means-testing basic pension benefits against second pillar pension income. However, the previous paper applied a very stylized model set-up and only focussed on the economic effects of pension testing, while the present model is calibrated to closely reflect the UK economy and pension system.

The remainder of the paper is organized as follows: the next section describes the general equilibrium model we use in our quantitative analysis. Sections 3 discusses 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. Agents are characterized by the state vector $z_j = (s, a_j, \hat{w}_j, \eta_j)$, with $j \in \mathcal{J} = \{1, \ldots, J\}$ denoting the age of the individual, $s \in \mathcal{S} = \{1, \ldots, S\}$ defining the skill level, $\mathrm{a}_j \in \mathcal{A} = [0, \infty)$ representing liquid assets held by the agent at the beginning of age j and $\hat{w}_j \in \mathcal{W} = [0, w^{max}]$ marking the agent's current average earnings for earnings-related public pension claims. Furthermore, $\eta_j \in \mathcal{E}$ is an idiosyncratic shock to individual labor productivity.

At the beginning of life, individuals are assigned a skill level s with an (exogenous) probability $N_{1,s}$. Since individuals face lifespan uncertainty, cohort sizes decrease over time, i.e. $N_{j,s} = \psi_j N_{j-1,s}$, with $\psi_j < 1$ denoting the time-invariant conditional survival probability of an individual at the age of $j-1$ and $\psi_{J+1} = 0$. 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,

$$\int_{\mathcal{A}\times\mathcal{W}\times\mathcal{E}} \mathrm{d}X_t(z_j) = N_{j,s} \quad \text{and} \quad \sum_{j\in\mathcal{J}}\sum_{s\in\mathcal{S}} N_{j,s} = \sum_{j\in\mathcal{J}}\int_{\mathcal{Z}} \mathrm{d}X_t(z_j) \quad \text{with} \quad \mathcal{Z} = \mathcal{S}\times\mathcal{A}\times\mathcal{W}\times\mathcal{E}$$

Our model abstracts from annuity markets. Individuals that die before the maximum age of J may leave accidental bequests that will be collected by the government. All agents retire at age J_R and start to receive pension benefits. In the following, we will, for the sake of simplicity, omit the time index t, the skill level s and the state index z_j whenever possible. Agents are then only distinguished according to their age j.

2.2 The household decision problem

All agents value streams of consumption c_j and leisure ℓ_j according to the standard expected utility function

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

where β is a time discount factor. Expectations are taken with respect to the stochastic processes governing idiosyncratic labor productivity and mortality. Due to additive separability, we can formulate the decision problem recursively:

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

Since lifespan is uncertain, expected future utility is weighted with the survival probability ψ_{j+1}. Future utility is computed over the distribution of future states of productivity η_{j+1}. Agents maximize (1) subject to the budget constraint

$$a_{j+1} = a_j(1+r) + w_j(1-\tau^m-\tau^e) - T(\cdot) + b_j^m + b_j^e - (1+\tau^c)c_j + \nu_j. \tag{2}$$

where we additionally assume that an individual does not hold any assets at birth and does not leave any intentional bequests, i.e. $a_1 = a_{J+1} = 0$. Furthermore, agents face credit market constraints, i.e. $a_j \geq 0 \quad \forall \ j$. Households receive interest payments from liquid assets held in period j as well as gross labor income $w_j = \omega(1-\ell_j)\epsilon_j\eta_j$, where ϵ_j defines the skill-dependent deterministic age-productivity profile. The wage rate for effective labor and the gross interest rate are denoted by ω and r, respectively. Households pay progressive income taxes $T(\cdot)$ from taxable income, where $T(\cdot)$ defines the progressive tax function computing the individual income tax burden of an agent.

Consumption expenditures are given by c_j, the price of which include consumption taxes levied at the rate τ^c.

After retiring from the labor force at the mandatory retirement age of J_R, agents may claim means-tested retirement benefits b_j^m financed by contributions levied on gross labor income with the rate τ^m. In addition, they receive earnings-related State Second Pension (S2P) benefits b_j^e, financed by the contribution rate τ^e. Earnings-related pension claims depend on average labor income during working phase which evolves according to

$$\hat{w}_{j+1} = \hat{w}_j + (J_R - 1)^{-1} w_j, \tag{3}$$

where $\hat{w}_1 = 0$.

Finally, agents may receive (or have to finance) specific compensation payments ν_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

$$Y = \Phi K^{\varepsilon} L^{1-\varepsilon}$$

with Y, K and L denoting aggregate output, capital and labor, respectively. The parameter ϵ marks the share of capital in production while Φ 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 market interest rate r plus the depreciation rate of capital δ and the marginal product of labor equals the wage rate for effective labor ω, i.e.

$$r = \varepsilon \Phi \left(\frac{L}{K}\right)^{1-\varepsilon} - \delta \tag{4}$$

$$\omega = (1-\varepsilon)\Phi \left(\frac{K}{L}\right)^{\varepsilon} \tag{5}$$

holds.

2.4 The government sector

The government sector in our model comprises the tax system and the social security system. In each period t, the government issues debt $B_{G,t+1} - B_{G,t}$ and collects accidental bequest B_t and taxes on income and consumption from households in order to finance general government expenditure G which is fixed per capita as well as interest payments on existing debt,[1] i.e.

$$B_{G,t+1} - B_{G,t} + B_t + T_t + \tau_c C_t = G + r B_{G,t}, \tag{6}$$

[1] Since we assume a population growth rate of zero, the government can't issue new debt in a long-run equilibrium.

where T_t and C_t define aggregate income taxes and consumption, respectively. Aggregate income tax revenue T_t is calculated from

$$T_t = \sum_{j=1}^{J} \int_{\mathcal{Z}} T\left(y_j(z_j)\right) \mathrm{d}X_t(z_j),$$

where y_j defines taxable income of workers and pensioners. The income tax code is replicating the UK income tax system where income from labor and capital is taxed progressively. Contributions to public pensions are exempt from income taxation. Earnings-related pension b_j^e are fully taxed during retirement, means-tested benefits b_j^m on the other hand are exempt from taxation. Consequently, taxable income during the working phase is computed from gross labor income and returns on assets net of pension contributions and personal allowances a^w while taxable retirement income sums earnings-related benefits and asset returns net of personal allowances of pensioners a^p:

$$y_j = w_j(1 - \tau^m - \tau^e) + b_j^e + ra_j - a^w - a^p.$$

Finally, the consumption tax rate τ^c is adjusted in every period in order to balance the government budget.

All agents are required to participate in the mandatory social security program that features key elements of the UK social security system. The first tier provides benefits b_j^m which consist of basic state pensions (BSP) $\underline{b}$ and the means-tested benefit. The amount of the latter is determined by the guaranteed income level $\overline{b}$, the BSP $\underline{b}$ and the taper rates φ_a, φ_p which define the means-test against liquid asset income and second pillar old-age pensions, i.e.

$$b_j^m = \max\left\{\overline{b} - \varphi_a\theta \max(a_j - \kappa\,; 0) - \varphi_p b_j^e\,; \underline{b}\right\}. \tag{7}$$

As in the UK, liquid asset income for the means-test is derived by subtracting a fixed allowance κ from assets and applying the imputed return $\theta \in [0, 1]$ on non-exempt assets. Consequently, the level of the basic state pension $\overline{b} \geq \underline{b} \geq 0$ determines the generosity of the first pillar benefit. If $\overline{b} = \underline{b}$, the system provides a universal pension for all retirees, while with $\underline{b} = 0$ all first pillar benefits are means-tested. With a means-test in place, the amount of b_j^m depends on individual characteristics of the retiree. The taper rates $\varphi_a, \varphi_p \in [0, 1]$ determine the precision of the asset- and pension income-test: If $\varphi_a = \varphi_p = 1.0$, all assessable income is taken into account and the first tier benefit b_j^m is reduced by one £ for every additional £ of asset and pension income received by the agent. If one taper rate or both rates are reduced (i.e. $\varphi_a, \varphi_p < 1$), first pillar benefits b_j^m are reduced by φ £ for every additional £ of asset and/or pension income. Of course, if $\varphi_a = \varphi_p = 0$ we again end up at a universal pension for all retired agents.

Second tier S2P-pensions in the UK depend on the individual earnings record at the end of the working career $\hat{w}_{J_R}$. Benefits b_j^e are derived applying the benefit function $\Gamma(\hat{w}_{J_R})$ which is explained in detail below.

Aggregating over all retirees the budgets of first- and second-pillar pensions in period t are

$$\sum_{j=J_R}^{J} \int_{\mathcal{Z}} b_j^m(z_j)\mathrm{d}X_t(z_j) = \tau^m \omega L_t \qquad \text{and} \qquad \sum_{j=J_R}^{J} \int_{\mathcal{Z}} b_j^e(z_j)\mathrm{d}X_t(z_j) = \tau^e \omega L_t, \tag{8}$$

where τ^m and τ^e are adjusted annually to balance the respective budgets.

2.5 Equilibrium conditions

An equilibrium path for a given policy schedule $(\tau^m, \tau^e, \overline{b}, \underline{b}, \theta, \kappa, \varphi_a, \varphi_p, \dots)$ represents a set of value functions $\{V(z_j)\}_{j=1}^J$, household decisions $\{c_j(z_j), \ell_j(z_j)\}_{j=1}^J$, measures of households $\{\xi_t(z_j)\}_{j=1}^J$ and relative prices of capital and labor $\{r, \omega\}$ that satisfy the following conditions $\forall t$:

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

2. Factor prices $\{r, w\}$ are competitive, i.e. (4) and (5) hold.

3. Aggregation holds so that

$$L_t = \sum_{j=1}^{J} \int_{\mathcal{Z}} [1 - \ell_j(z_j)] \epsilon_j \eta_j \mathrm{d}X_t(z_j) \tag{9}$$

$$C_t = \sum_{j=1}^{J} \int_{\mathcal{Z}} c_j(z_j) \mathrm{d}X_t(z_j) \tag{10}$$

and K_t is derived from (4).

4. Defining $\mathbf{1}_{h=x}$ 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:

$$\xi_{t+1}(z_{j+1}) = \psi_j \int_{\mathcal{A}\times\mathcal{W}\times\mathcal{E}} \mathbf{1}_{a_{j+1}=a_{j+1}(z_j)} \times \mathbf{1}_{\hat{w}_{j+1}=\hat{w}_{j+1}(z_j)} \pi(\eta_{j+1}) \mathrm{d}X_t(z_j) \tag{11}$$

5. Unintended bequests satisfy

$$B_t = \sum_{j=1}^{J} \int_{\mathcal{Z}} (1 - \psi_{j+1})(1 + r) a_{j+1}(z_j) \mathrm{d}X_t(z_j) \tag{12}$$

6. The budgets of the government (6) and the pension system (8) are intertemporally balanced.

7. The goods market clears, i.e.

$$Y_t = C_t + G + K_{t+1} - (1 - \delta)K_t + \mathcal{X}_t \tag{13}$$

holds for the small open economy, where $\mathcal{X}_t$ mark the net exports in period t.

3 Calibration and initial equilibrium

We calibrate our model to closely reflect the UK economy before the pension reform of 2003. The following subsection explains the chosen preference, technology and fiscal parameters, then we discuss the resulting initial equilibrium.

3.1 Parametrization

Table 1 reports the central parameters of the model. In order to reduce computational time, each model period covers five years. Agents reach adulthood at age 20 ($j = 1$), retire mandatorily at age 65 ($J_R = 10$) and face a maximum possible life span of 100 years ($J = 16$). Conditional survival probabilities ψ_j for the UK are calculated over the years 2001-2011 from the life tables of both sexes reported in the Human Mortality Database. The resulting life expectancy is then 77.5 years. We distinguish low-, regular- and high-skilled individuals (i.e. $S = 3$). The initial distribution of skill-classes is extracted from the OECD educational attainment estimates for the UK population of age between 25 and 64 reported in Barro and Lee (2001, 35). According to this data base 24 percent are below upper-secondary (i.e. low-skilled), 54 percent are upper secondary (i.e. regular-skilled) and 21 percent are tertiary educated (i.e. high-skilled).

Table 1: Parameter selection

Demographic parameters		*Preference parameters*	
(Adult) Life span (J)	16	Intertemporal elasticity of substitution (γ)	0.20
Retirement period (J_R)	10	Intratemporal elasticity of substitution between	
Skill levels (S)	3	... consumption and leisure (ρ)	0.58
		Coefficient of leisure preference (α)	1.63
		Discount factor (β)	0.86
Technology/Income process		*Government parameters*	
Factor productivity (Φ)	1.49	Debt-to-output (B_G/Y)	0.40
Capital share (ε)	0.30	Government consumption (G/Y)	0.20
Depreciation rate (δ)	0.26	Income guarantee ($\overline{b}$)	$0.3\bar{w}$
World interest rate (r)	0.24	Basic state pension ($\underline{b}$)	0.00
Shock variance (σ^2)	0.065	Exemption asset test (κ)	$0.45\bar{w}$
		Imputed interest (θ)	0.10
		Taper rates (φ_a, φ_p)	1.00

With respect to preferences we use the very same calibration as Sefton et al. (2008). Consequently, the period utility function is defined as

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

where γ denotes the intertemporal elasticity of substitution between consumption at different ages, ρ defines the intratemporal elasticity of substitution between consumption and leisure at each age j and α is an age-independent leisure preference parameter. Following Sefton et al. (2008) we set the intertemporal elasticity of substitution γ to 0.2 and the intratemporal elasticity of substitution ρ to 0.58. The leisure preference parameter α to 1.63 and the annual discount factor is 0.97 which yields a periodic discount factor $\beta = 0.86$. This is within the range of commonly used values, see Auerbach and Kotlikoff (1987).

The technology parameter Φ is set to a value of 1.49 in order to normalize the wage rate of effective labor to unity. Furthermore, we follow Sefton et al. (2008) and set the capital share in production to a value of $\varepsilon = 0.3$ as well as assuming a world interest rate of 4% p.a. for the UK as a small open economy. The resulting periodic interest rate is then 24 percent. Following Kumru and Piggott (2014) we assume an annual depreciation rate of 4.8 % which implies a periodic depreciation of 26 percent.

The calibration of the income process follows mostly Kumru and Piggott (2014). Consequently, the deterministic age-dependent mean efficiency profiles for skill class s $\epsilon_{j,s}$ are taken from Robinson (2003), who estimates average earnings profiles over the life cycle for different educational backgrounds for the UK using General Household Survey Data. As Kumru and Piggott (2014), we use their predicted weekly earnings-profiles for men with lower, medium and higher educational backgrounds from the reported quadratic specification. The profiles are normalized around the weekly earnings of a medium-skilled male with one year of experience. We interpolate missing values of the normalized profiles by fitting a cubic spline and use the resulting profiles as mean productivity profiles over the life cycle for three skill classes.

The idiosyncratic productivity shock η_j is assumed to be log-normally distributed with

$$\log(\eta_j) \sim \mathcal{N}(\mu, \sigma^2).$$

The distribution of the shock η_j is approximated by five evenly spaced discrete values in logs on the interval $\left[\frac{-\sigma^2}{2} - 3\sigma\,;\, \frac{-\sigma^2}{2} + 3\sigma\right]$. The value for the variance of the idiosyncratic shock of $\sigma^2 = 0.065$ reported in Table 1 is taken from Kumru and Piggott (2014) as well as the probabilities $\pi(\cdot)$ for the discretized shock $\log(\eta_j)$:

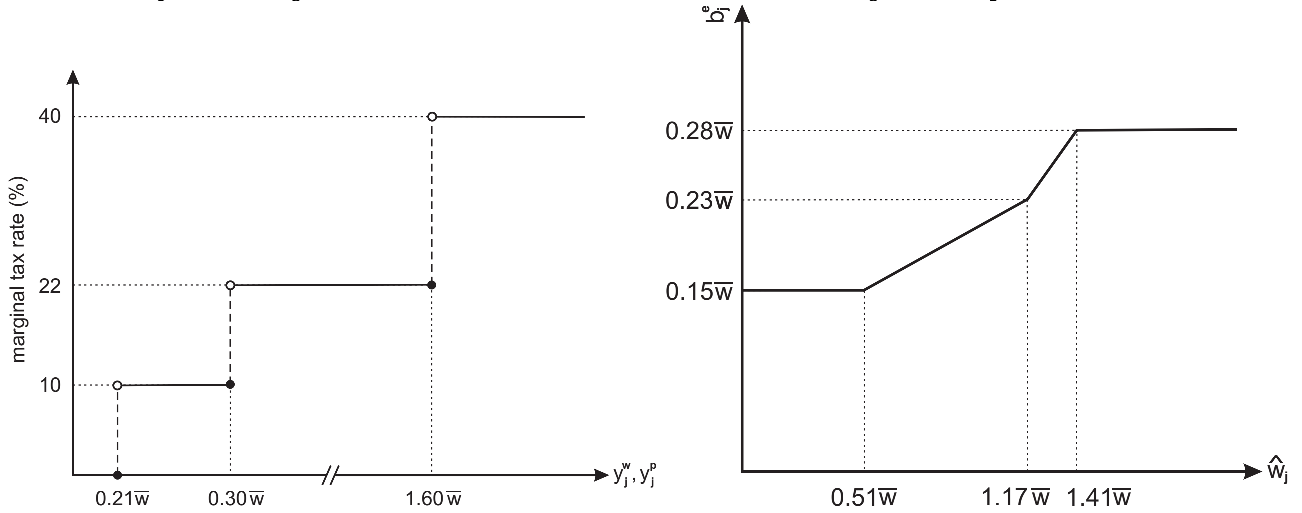
$$\pi(\cdot) = [0.0122; 0.2144; 0.5468; 0.2144; 0.0122].$$

With respect to the public sector we set the GDP shares of government consumption G/Y and government debt B_G/Y to the respective values of 20% and 40% as reported by Eurostat for the year 2003. Taxable income of agents comprises labor income, returns on assets as well as pension benefits and is taxed progressively. Our model closely replicates the UK income tax code of 2003, see Adam and Shaw (2003) for an extensive survey. Given taxable income of workers and pensioners, four taxable bands and rates are applied (see the tax schedule in the left part of Figure 1): the first £ 4,600 of taxable income are not taxed at all. After this basic allowance the next £ 2,000 are taxed at a rate of 10%, income between £ 6,600 and £ 35,000 is taxed at the rate of 22%, while all taxable income above £ 35,000 is taxed at a tax rate of 40%. Given this tax schedule, the personal allowances a^w, a^p are derived endogenously in order to match income tax revenues and net income data. Hereby we take into account that the personal allowance for pensioners exceeds the respective one for workers by £ 2,000.[2]

As in Kumru and Piggott (2014), we include second tier pensions and concentrate on the guaranteed income $\overline{b}$ as the means-tested program of interest, i.e. BSP-benefits $\underline{b}$ are zero for all retirees. In 2003 the first tier grants a maximum benefit equal to the pension guarantee of £ 102 per week for a single pensioner, which is roughly equivalent to 25% of average equivalent labor income calculated from FES-Data. In order to generate realistic benefit outlays we increase this level slightly. Therefore, we compute average labor income $\bar{w}$ and set $\overline{b} = 0.3\bar{w}$. This maximum benefit is reduced by a taper rate of $\varphi_a = 1.0$ for every £ in private assessable savings and investment income. Currently the first £ 10,000 of savings are ignored for means-testing. This is roughly 45% of household average income,

[2] The additional personal allowance of £ 1,100 for pensioners older than 75 years is disregarded.

Figure 1: Marginal tax schedule and benefit function for earnings-related pensions (in £)



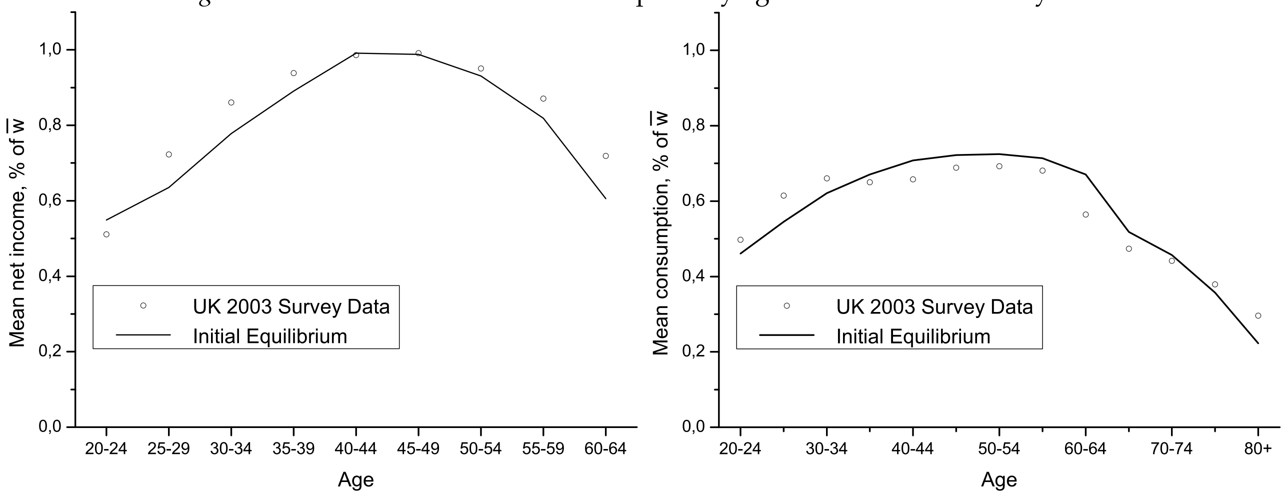
i.e. $\kappa = 0.45\bar{w}$. Finally, for every £ 500 assets above this exemption level £ 1 is added to the weekly income figure. This implies an annual imputed return of $\theta = 0.1$.

With respect to second tier pension benefits, we apply the function $\Gamma(\hat{w}_{J_R})$ shown in the right part of Figure 1. If average income during working years was below £ 11,200, S2P benefits are flat at £ 3,310. In case average income is above this threshold but below £ 25,600, benefits rise linearly up to £ 4,966. For average incomes beyond that bracket benefits rise further until they reach a maximum amount of £ 6,212 at an average income above £ 30,900. Under the Minimum Income Guarantee (MIG) program, first tier benefits were also fully tested against S2P benefits, i.e. $\varphi_p = 1.0$.

3.2 Initial Equilibrium

The exogenous parameters as well as tax and benefit functions are selected in order to generate an initial equilibrium which represents the UK economy in year 2003 before the MIG was replaced by the Pension credit. Figure 2 compares simulated mean net income profiles over the life cycle as well as

Figure 2: Mean net income and consumption by age - simulated vs. survey data



simulated mean consumption profiles from the benchmark equilibrium with actual UK survey data. Mean net income profiles for different age groups are taken from HM Revenue and Customs (2003), mean equivalent consumption profiles over the life cycle were calculated from 2002/2003 data of the UK Expenditure and Food Survey using the modified OECD equivalence scale, see Haagenars et al. (1994). Numbers are reported as proportions of average annual gross income of £ 21,900 reported in HM Revenue and Customs (2003). As already discussed above, the allowance levels a^w, a^p are adjusted to generate a good match between simulated and survey data on average income dynamics over the life cycle as shown in the left part of Figure 2.

Table 2 compares key features of the simulated income and wealth distribution with UK data. The percentage share of net income and assets is the share that accrues to subgroups of the model population ranked by their net income and liquid asset holdings, respectively. Our model replicates the income- and wealth distribution relatively well but understates the share of income and assets of the richest 10 percent of the population. This simply reflects the fact that our model does not capture the extreme ends of the income and wealth distribution present in reality.

Table 2: Income and wealth distribution

		Percentage share of income/assets		
		Lowest 10%	Highest 10%	Gini Index
Model	Net income	3.5	19.7	0.271
	Assets	0.0	29.6	0.546
UK	Net income[a]	2.8	27.0	0.335[b]
	Assets[c]	0.1	44.1	0.610

[a]DWP (2010, p.25) and [b]OECD (2013): UK 2003 values, [c]ONS (2009, p.10): UK 2006-2008 values

Table 3 reports some key figures of the resulting initial equilibrium.[3] Given the gross capital income share of 30 percent and the depreciation rate as well as the world interest rate, the annual capital-output ratio is (0.3/0.088 $\approx$) 3.4 and the investment share in output is (0.048 $\times$ 3.4) 16.3 percent. Since the private consumption share is roughly 61 percent, net exports are 2.7 percent of GDP. Interest rate payments on per-period debt are (0.04 $\times$ 0.4) 1.6 percent of output while aggregate bequests account for 5.6 percent of GDP. Since the endogenous consumption tax rate is 12 percent, government outlays are financed by consumption and income tax revenues which are (0.12 $\times$ 0.61) 7.3 and (21.6-5.6-7.3=) 8.7 percent of GDP, respectively.

Table 3: The initial equilibrium (in %)

K/Y	$\delta K/Y$	C/Y	B/Y	τ^c	τ^m	τ^e
3.4[a]	16.3	61.0	5.6	12.0	1.2	6.1

[a]p.a.

The pension parameters are calibrated in order to generate two key figures of the UK pension system. First, 34 percent of retirees are entitled to receiving means-tested retirement benefits which is closely

3 See Fehr et al. (2013) for a discussion of the numerical solution algorithm which is applied in this study.

in line with the estimate by Brewer and Emmerson (2003). Second, the contribution rates reported in Table 3 imply that roughly 5 % of GDP is spent for public pension outlays which is closely in line with estimates of the OECD (2011). Finally, since in all skill classes agents of the youngest cohort with negative productivity shocks would like to borrow, roughly 70 percent of younger cohorts are liquidity constrained (i.e. they do not save). For older cohorts, this fraction decreases sharply and we hardly observe any liquidity constrained households older than 40 years.

4 Simulation results

The remainder of this paper will focus on the macroeconomic, welfare and efficiency consequences of various reforms of the UK public pension system. In the first subsection we explain how welfare and efficiency effects are computed. Then we follow Sefton et al. (2008) and simulate alternative taper rates φ in a single-tier pension system. The resulting macroeconomic effects are explained in detail and the difference between long-run welfare and aggregate efficiency is highlighted. The third subsection considers the benchmark model with a two-tier pension system. We first rerun the reforms of the previous subsection and then quantify the impact of the benefit level $\overline{b}$ and the basic pension $\underline{b}$. Finally, we present some sensitivity analysis with respect to key parameter values. The considered reforms are all financed by endogenous payroll and consumption tax rates computed from the respective periodic budgets of the pension system and the government.

4.1 Computation of welfare and efficiency effects

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. Consequently, 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 same factor. With these considerations in mind let's again turn to our simulation model. Assume an individual at state z_j had utility $V^b(z_j)$ in the initial long-run equilibrium path and $V^r(z_j)$ after the policy reform. The compensating variation between the baseline and the reform scenario for the individual characterized by z_j is then given as

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

ϕ then indicates the percentage change in both consumption and leisure individual z_j would require in the initial equilibrium in order to be as well of as after the policy reform. We may also say that an individual is ϕ better (or worse) off in terms of resources after the reform. If $\phi > 0$, the reform is therefore welfare improving for this individual and vice versa.

A special rule applies to individuals not having entered their economically relevant phase of life in the year before we conduct our pension reforms (the so-called future generations). We evaluate their utility behind the Rawlsian veil of ignorance, i.e. from an ex-ante perspective where neither their skill level 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) in a separate simulation.[4] The LSRA thereby proceeds as follows: to all generations already being economically active before the reform it pays lump-sum transfers or levies lump-sum taxes ν_j in order to make them as well off after the reform as in the initial equilibrium. Consequently their compensating variation amounts to zero. Having done that, the LSRA may 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 concept in hand, we can now proceed to our simulation results.

4.2 Long-run welfare vs. aggregate efficiency in the single-tier system

Our first simulation exercise has mainly two purposes: First it serves as an exercise to gain some economic intuition and to justify our welfare measure. Second, we want to be as close as possible to the situation considered in Sefton et al. (2008, 2009) as well as Kumru and Piggott (2014). Consequently, we initially abstract from modeling the State Second Pension (S2P), i.e. we concentrate on the means-tested single tier. In order to do this, we keep all parameter choices discussed in the previous section but set all earnings-related benefits b_j^e to zero, so that the means-test applied to retirement benefits b_j^m boils down to a test of assessable returns on assets only. Hence, the reported reforms in the taper regimes isolate the economic effects of asset-testing. Since we consider the UK as a small open economy the initial equilibrium of the single-tier system is very similar to the calibrated benchmark equilibrium reported in Table 3. Of course, without S2P-benefits the first tier becomes more generous so that the initial contribution rate τ^m increases from 1.2 percent to 4.9 percent.[5] When we now reduce the taper rate to 40 percent (i.e. the PC system) and to zero (i.e. the UP system), the resulting long-run macroeconomic and welfare effects are qualitatively quite similar as in the previous papers.

However, we want to highlight the difference between long-run welfare effects and aggregate efficiency effects of a specific policy reform. For this reason we simulate the whole transition path after the reform and isolate aggregate efficiency by means of compensating transfer payments. When the taper rate is reduced, aggregate efficiency effects are due to changes in insurance provision and behavioral distortions:[6]

- Insurance provision against longevity and income risk rises when more retirees receive flat benefits (efficiency enhancing).
- When the system becomes more generous, contribution rates have to increase, so that labor

[4] The LSRA was introduced by Auerbach and Kotlikoff (1987, 62f.) and has recently been applied by Nishiyama and Smetters (2007) as well as Fehr et al. (2013) in similar stochastic frameworks.

[5] Of course, private assets substitute second tier benefits, so that means-tested benefits hardly change for cohorts entering retirement. However, since private assets are not annuitized they are run down fast afterwards in order to receive higher means-tested benefits.

[6] Of course, economic efficiency is also affected by liquidity effects, but since they go in the same direction as labor supply distortions we neglect them in the following discussion.

supply distortions rise (efficiency deteriorating).

- As already explained above, the impact on savings distortions is not fully clear. Lower taper rates reduce the savings distortions of those who are already receiving (means-tested) pension benefits, but they increase the savings distortions of those who become new members of the system. Savings distortions are completely eliminated in the universal pension system.

In order to explain these channels in detail we report the short- and long-run macroeconomic implications first and then move on to the welfare and efficiency effects.

Macroeconomic implications Before we report the aggregate effects of the considered pension reforms, it is useful to discuss the individual responses to the introduction of the pension credit and the universal pension system. Table 4 shows the skill-specific changes in labor supply and savings for different cohorts. As one can see there is a remarkable difference between low-skilled and high-skilled cohorts. While the former due to their low savings typically already receive means-tested benefits before the reform, the latter only become eligible in old age when the taper rate is sufficiently reduced. Consequently, lower taper rates improve labor supply and savings incentives for low-skilled individuals of all ages while the opposite applies to high-skilled households. Middle-skilled households work more when young and less before retiring. They also reduce their savings either to receive means-tested benefits (with the PC system) or as a response to higher benefits (with the UP system).[7] Note that some very old medium and high-skilled households even increase their savings after the reforms. Of course, this reflects the dramatic distortions of savings induced by means-testing which have now been mitigated with lower taper rates. Consequently, our results largely confirm behavioral responses to reforms in the taper rates reported by earlier studies, in particular the opposing reactions of poor and rich households.

Table 4: Long-run behavioral responses to pension credit vs. universal benefits[a]

	Age	Pension credit ($\varphi_a = 0.4$) Skill level			Universal pension ($\varphi_a = 0.0$) Skill level		
		low	median	high	low	median	high
Change in employment (%)	30-34	0.9	0.2	-0.3	1.4	0.7	-0.3
	40-44	1.2	0.7	-1.0	1.9	2.2	-1.3
	50-54	1.3	0.8	-1.1	2.3	2.1	-1.9
	60-64	2.6	-1.7	-1.3	4.2	-1.7	-0.7
Change in wealth (%)	30-34	0.0	-5.6	-8.6	0.0	-7.4	-14.3
	40-44	2.8	-6.2	-10.9	2.4	-8.2	-16.5
	50-54	3.2	-5.7	-11.5	3.6	-6.4	-18.0
	60-64	4.7	-8.0	-13.2	6.7	-8.9	-21.3
	70-74	19.0	-7.9	-19.3	40.5	6.2	-18.1
	80-84	26.1	11.5	-14.2	70.9	62.4	18.1

Given these behavioral responses we can now turn to the aggregate effects in Table 5. The left part reports the macroeconomic effects of the introduction of the pension credit. When the taper rate is

[7] Sefton et al. (2008) report quite similar disaggregated effects. Comparing our life-cycle profiles with the ones reported by Kumru and Piggott (2014), there are striking similarities. Of course, this data is available upon request.

reduced from 100 to 40 percent, the rising eligibility for flat benefits increases the contribution rate immediately by 1.2 percent to 6.1 percent. Higher benefits increase initial consumption slightly and aggregate employment falls initially by 1 percent. Aggregate household assets fall immediately after the reform since negative savings effects dominate the positive ones. With respect to the government budget, lower income tax revenues have to be balanced by a rising consumption tax rate. During the transition aggregate savings decrease further so that means-tested benefits and the respective contribution rate steadily increase. Lower savings reduce the revenues from unintended bequest so that the government has to increase consumption taxes throughout the transition. Since fiscal burdens rise for future cohorts, they work more again and consume less than younger cohorts. In the long run, the contribution rate and the consumption tax rate have increased by 1.8 and 1.4 percentage points respectively.

Table 5: Macroeconomic effects of pension credit and universal pensions (single-tier)[a]

	PC reform ($\varphi_a = 0.4$)				UP reform ($\varphi_a = 0.0$)			
Period	1	3	5	∞	1	3	5	∞
Employment	-1.0	-0.4	-0.2	0.0	-1.1	0.2	0.6	0.6
Consumption	0.1	0.1	-0.5	-1.5	-0.9	0.8	0.7	-0.1
Private wealth	0.0	-2.6	-4.6	-7.4	0.0	-0.8	-2.2	-3.8
Consumption tax rate[b]	0.5	0.4	0.7	1.4	1.6	0.2	-0.2	0.4
Contribution rate[b]	1.2	1.4	1.6	1.8	4.9	4.9	4.9	4.9

[a]Changes in percent over value in initial equilibrium. [b]Changes in percentage points.

The right part of Table 5 reports the aggregate macroeconomic consequences when the taper rate is fully removed. With a UP system, all households automatically receive benefits independent of their private assets. Consequently, the dynamic adjustment process changes and the contribution rate immediately increases by 4.9 percentage points to its long-run level of 9.8 percent. Since people do not have to run down their assets in order to receive pension benefits, aggregate consumption even decreases initially due to higher contribution rates. In order to balance the budget, the consumption tax rate has to increase immediately by 1.6 percentage points. Since savings distortions of the means-test are now completely removed, aggregate assets decrease now by only 3.8 percent in the long run (in contrast to 7.4 percent with the pension credit before). The reduction is mainly due to the fact that now all retirees receive pensions benefits during retirement so that old-age savings decrease.[8] Note that despite higher contribution rates, agents work more than before during the transition. This is mostly due to the intra- and intergenerational income redistribution from future low-skilled towards current high-skilled households.[9]

Welfare and efficiency With the above discussion in mind, we can now turn to the welfare effects of the two considered reforms reported in Table 6. For cohorts already taking economic decisions in the reform year, we report average welfare changes grouped by skill level. For future generations, we

8 Economically, the elimination of means-testing is quite similar to the introduction of a paygo pension for a specific fraction of households!

9 Table 4 clearly shows that especially low-skilled work more in the long run, while future high-skilled work significantly less.

apply the concept of ex-ante welfare and therefore only report aggregate numbers for each cohort. The first column indicates the age of the respective cohort in the reform year.

When the pension credit is introduced, the oldest cohorts experience welfare losses. They already receive maximum benefits so that they are mainly hurt by higher consumption taxes. For low-skilled retirees of the cohort aged 85-89 years in the reform period this welfare loss is equivalent to a fall in remaining lifetime resources of 0.6 percent. Younger (and especially medium- and high-skilled) households experience welfare gains due to higher pension benefits. Welfare gains decrease quickly for younger cohorts since their benefit phase lies in the future while they are hurt by rising contributions and consumption taxes throughout the transition. Very young and future cohorts even experience welfare losses. Cohorts living in the new long-run equilibrium lose roughly 0.9 percent of remaining lifetime resources with the pension credit.

Table 6: Welfare effects of pension credit and universal pension (single tier)[a]

Age in	PC reform ($\varphi_a = 0.4$)				UP reform ($\varphi_a = 0.0$)			
reform		Skill level		with		Skill level		with
year	low	median	high	LSRA	low	median	high	LSRA
85-89	-0.6	-0.6	-0.3	0.0	-1.0	-0.9	-0.5	0.0
65-69	1.9	3.3	2.4	0.0	4.8	10.4	12.5	0.0
45-49	0.3	0.7	0.4	0.0	0.3	1.7	2.3	0.0
25-29	-0.5	-0.2	-0.3	0.0	-1.3	-0.7	-0.3	0.0
15-19		-0.5		0.4		-1.2		2.4
5-9		-0.6		0.4		-1.0		2.4
∞		-0.9		0.4		-1.2		2.4

[a]Changes are reported in percentage of initial resources.

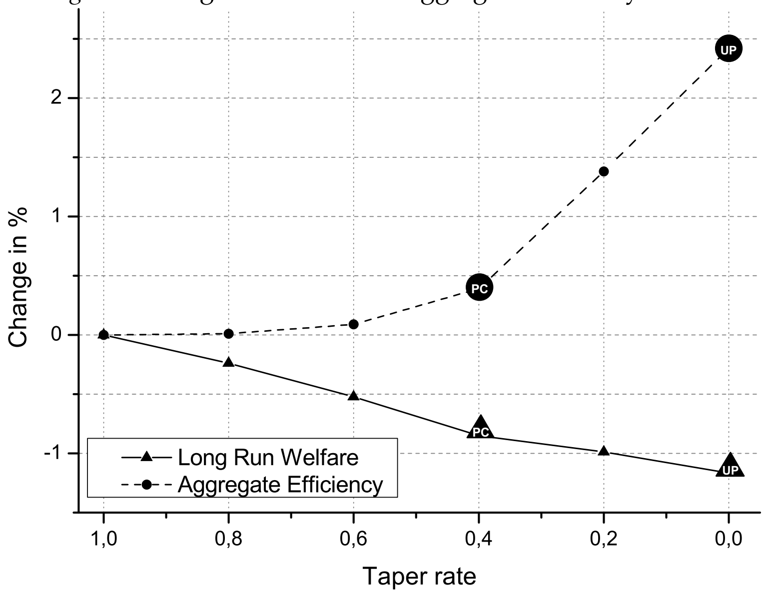
The right part of Table 6 reports the welfare changes when the taper rate is completely eliminated in the UP system. In this case welfare gains of young retirees are significantly higher than before while welfare losses of future cohorts have also increased. These long-run welfare changes are qualitatively in line with the results from Kumru and Piggott (2014). However, since we adjust the consumption tax rate the intergenerational redistribution is less pronounced than in the previous study. But in principle we confirm that future cohorts would lose if we reduce the taper rate of means-tested benefits so that from this perspective the existing MIG system is optimal.

However, long run welfare changes reflect changes in economic incentives but also the induced income redistribution across generations. Since the considered policy reforms clearly redistribute from future towards current cohorts, long-run welfare losses indicate the intergenerational redistribution pattern but not the efficiency effects of the reforms. In order to isolate induced efficiency consequences, one has to compensate households using LSRA transfers as discussed above. The LSRA makes all existing cohorts as well off as in the initial equilibrium and redistributes resources across future generations to make them all face the same welfare changes.

As already discussed above, the reduction of the taper rate has three major efficiency consequences: While higher insurance provision increases aggregate efficiency, higher labor supply distortions decrease efficiency. Changes in savings incentives are a priori unclear as high distortions for few pensioners are traded against less severe distortions for more pensioners. Most likely savings distortions rise with the pension credit and fall with the universal pension. The column marked "with LSRA" of Table 6 reveals the aggregate efficiency effects of both considered policy reforms. In contrast to the reported respective long-run welfare, aggregate efficiency is increasing monotonously with the falling taper rate. While both reforms improve economic efficiency, the UP reform performs better in terms of economic efficiency than the PC reform. The former induces an aggregate efficiency gain of 2.4 percent percent of initial resources while the efficiency gain of the latter reform amounts to only 0.4 percent. This result is mainly due to the fact that benefits from insurance provision and reduction of savings distortions overcompensate losses from rising labor supply distortions.

Figure 3 highlights the difference between long-run welfare and aggregate efficiency effects for alternative reforms of the asset taper regime. The already discussed results for the PC and the UP reform are highlighted in the figure.

Figure 3: Long-run welfare vs. aggregate efficiency effects



Based on these efficiency figures, the conclusion for public policy changes dramatically. While Sefton et al. (2008) recommend to keep means-testing of private wealth at least with a taper rate of 40 percent in order to slightly increase long-run welfare and Kumru and Piggott (2014) even promote a taper rate of 100%, we argue that the asset test should be completely removed in order to improve economic efficiency. The next section clarifies whether our conclusion remains robust in the two-tier benchmark system.

4.3 Means-testing pensions in the benchmark two-tier system

In this subsection we introduce the fully calibrated version of the model by including the S2P in the initial equilibrium. The means-test in the first tier then comprises both a test against assets as well as S2P benefits. Similar as in Kumru and Piggott (2014) the earnings-related benefit remains unchanged when we introduce the PC and the UP reform. As in the previous subsection, we first discuss the macroeconomic consequences and then move on to welfare and efficiency results.

Macroeconomic implications The left part of Table 7 reports the macroeconomic effects of the introduction of the pension credit in the benchmark model. Qualitatively, the effects are very similar as in Table 5 but the amplitude is much higher. When the taper rate is reduced to 40 percent, the contribution rate rises immediately from 1.2 percent to 3.6 percent. The stronger redistribution towards the elderly increases initial consumption by 4.4 percent and reduces initial labor supply by 4 percent. The significantly lower income tax revenues are balanced by the higher consumption tax base, so that the consumption tax rate rises almost as before by only 0.6 percentage points. Aggregate household assets now decline much stronger during the transition so that the long-run asset level decreases by almost 35 percent. Consequently, means-tested benefits and the respective contribution rate now increase by 4.7 percentage points while the government has to increase consumption taxes by 7 percentage points in the long run.[10]

Table 7: Macroeconomic effects of pension credit and universal pensions (benchmark model)[a]

	PC reform ($\varphi_a = \varphi_p = 0.4$)				UP reform ($\varphi_a = \varphi_p = 0.0$)			
Period	1	3	5	∞	1	3	5	∞
Employment	-4.0	-1.8	-0.8	0.3	-5.7	-1.5	-0.1	0.9
Consumption	4.4	-0.4	-3.7	-6.9	4.8	0.5	-3.6	-8.0
Private wealth	0.0	-16.5	-25.6	-34.9	0.0	-20.8	-32.6	-43.0
Consumption tax rate[b]	0.6	5.0	5.8	7.0	2.2	4.1	6.4	8.2
Contribution rate[b]	2.4	4.1	4.4	4.7	8.6	8.6	8.6	8.6

[a]Changes in percent over value in initial equilibrium. [b]Changes in percentage points.

The right part of Table 7 reports the complete elimination of means-testing. Again, the adjustment is qualitatively similar as with the pension credit but changes in economic variables are much stronger now. The contribution rate for flat benefits immediately rises to 9.8 percent inducing a fall in employment by 5.7 percent and a rise in consumption by 4.8 percent. Since all households now receive very generous first-tier benefits, aggregate savings decline much further during the transition. In the long run, consumption tax rate and first tier contribution rate rise by more than eight percentage points each.[11] Finally, note that in both reforms the second tier contribution rate is hardly affected.

Welfare and efficiency Table 8 summarizes welfare consequences for different cohorts in the benchmark model. Compared to Table 6 above, now even the oldest cohorts gain strongly with the PC reform, since they receive higher first tier benefits which compensate for higher consumption taxes. Of course, the rise in benefits depends on second tier pension benefits and accumulated assets, therefore low-skilled pensioners experience higher welfare gains than high-skilled. Welfare gains of the cohort aged 85-89 years in the reform period range from 13.4 percent of remaining lifetime resources (for low-skilled) to 10.2 percent of lifetime resources (for high-skilled). In contrast, cohorts living in the long-run equilibrium experience a welfare decrease of almost 4 percent of remaining lifetime resources. This intergenerational welfare redistribution is further amplified when the taper rate is completely eliminated in the right part of Table 8. The welfare changes amount to 21 and 16.3 per-

[10] Kumru and Piggott (2014) only adjust the first pillar contribution rate and compute a long run increase of roughly 9 percentage points.

[11] Kumru and Piggott (2014) compute an increase of about 18.5 percentage points for the first pillar contribution rate.

Table 8: Welfare effects of pension credit and universal pensions[a]

Age in	PC reform ($\varphi_a = \varphi_p = 0.4$)				UP reform ($\varphi_a = \varphi_p = 0.0$)			
reform		Skill level		with		Skill level		with
year	low	median	high	LSRA	low	median	high	LSRA
85-89	13.4	11.7	10.2	0.0	21.0	18.4	16.3	0.0
65-69	9.5	6.4	3.4	0.0	18.2	16.6	14.0	0.0
45-49	1.5	0.9	-0.2	0.0	1.7	1.5	0.9	0.0
25-29	-1.4	-1.5	-1.8	0.0	-3.1	-3.0	-2.9	0.0
15-19		-2.3		-1.4		-4.1		-0.4
5-9		-3.1		-1.4		-4.6		-0.4
∞		-3.9		-1.4		-5.5		-0.4

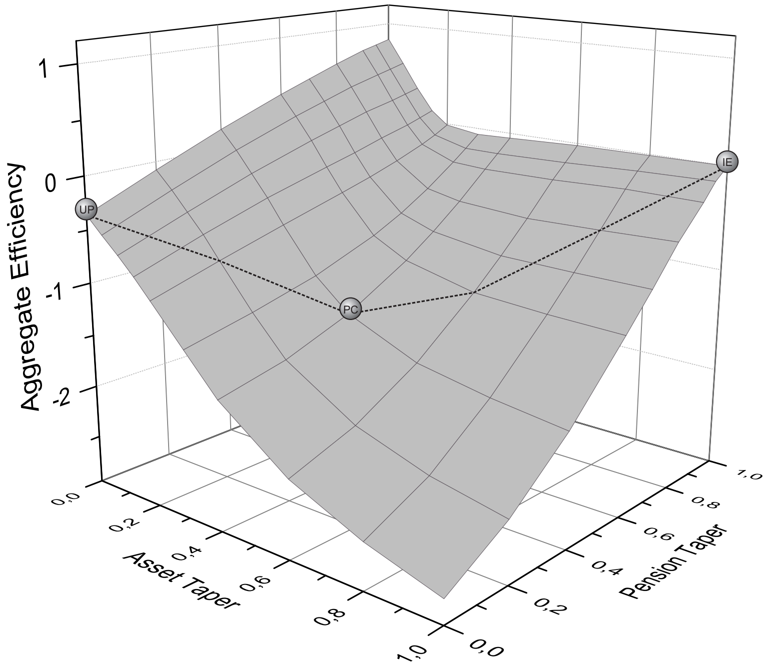
[a]Changes are reported in percentage of initial resources.

cent for the oldest low- and high-skilled in the reform year, respectively. Welfare gains decrease quickly for younger cohorts and cohorts living in the new long-run equilibrium lose 5.5 percent of remaining lifetime resources.

The column marked "with LSRA" of Table 8 reveals the aggregate efficiency effects of both considered policy reforms. In contrast to the previous subsection, aggregate efficiency is now decreasing with the falling taper rate. While now both reforms reduce economic efficiency, the pension credit reform performs worse in terms of economic efficiency than the universal pension reform. The former induces an aggregate efficiency loss of 1.4 percent while the latter reduces aggregate efficiency by roughly 0.4 percent of initial resources. With a (progressive) second-tier pension system in place, insurance benefits against longevity and income risk mostly disappear. Consequently, aggregate efficiency losses of the pension credit are mainly due to higher labor supply and savings distortions. When the taper rate is further reduced to zero, labor supply distortions rise further, but now savings distortions are completely eliminated. Since the latter dominates the former, efficiency losses are dampened compared to the pension credit reform.

Figure 4 reports aggregate efficiency effects for alternative taper rate combinations. Starting from the initial equilibrium (IE) the line of the benchmark reform shows that aggregate efficiency decreases initially with the taper rate (i.e. higher labor supply distortions dominate lower savings distortions) and then increases again (i.e. higher labor supply distortions are dominated by lower savings distortions). Again, the respective figures for the pension credit (where $\varphi_a = \varphi_p = 0.4$) and universal pensions (where $\varphi_a = \varphi_p = 0.0$) can be found in Table 8. Figure 4 also reveals the differing effects of tests against either pension income or private wealth. When only the taper rate on pension income is reduced while the taper rate on private wealth remains at the pre-reform level of 100% aggregate efficiency clearly deteriorates. Means-testing against pension income does not distort savings. Consequently, lowering just the taper rate on pension income does not produce gains from lower savings distortions, only labor supply distortions rise. When first-tier pensions are only tested against asset income (i.e. $\varphi_a = 1.0$, $\varphi_p = 0.0$), aggregate efficiency would be reduced by about 3.7 percent of resources. The opposite happens when we simulate the sole reduction of the taper rate for asset income while keeping the taper rate on pension income constant. In this case the aggregate efficiency line in Figure 4 remains constant for a while and then increases significantly. Since means-testing against asset income strongly distorts savings, higher labor supply distortions are balanced by lower

Figure 4: Benchmark reform vs. pension taper reform



savings distortions initially. When the taper rate on assets is fully removed, the reduction of savings distortions dominates the increase in labor supply distortions so that aggregate efficiency rises by 0.8 percent compared to the initial equilibrium.

Figure 4 reveals an important result of our study. The optimality of means-testing retirement benefits from an aggregate efficiency perspective does strongly depend on the kind of resources pension benefits are tested against. Our results show that testing against private wealth decreases aggregate efficiency while testing against second pillar pension income is beneficial. Consequently, our results advocate a reform that completely does away with testing benefits against private wealth but keeps benefits strictly means-tested against second tier pensions. This reform would result in a gain in aggregate efficiency of 0.8 percent, therefore dominating the pension credit as well as the universal pension.

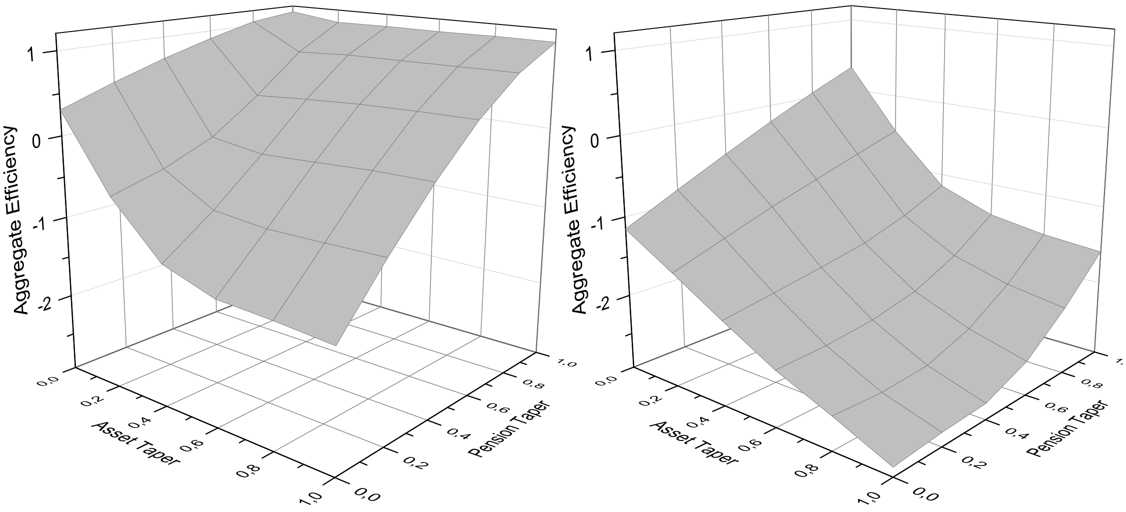
4.4 Optimal design of two-tier system

Of course, the above results are derived for a very specific combination of the guaranteed income and basic state pension levels ($\overline{b} = 0.3\bar{w}$ and $\underline{b} = 0.0\bar{w}$). The question is what happens with aggregate efficiency when we alter these levels. Figure 5 shows the resulting aggregate efficiency effects for alternative combinations of taper rates when the income guarantee is either reduced to $\overline{b} = 0.2\bar{w}$ (left part) and when it is increased to $\overline{b} = 0.4\bar{w}$ (right part) while at the same time the BSP-level is kept at zero.

When means-tested benefits become less generous distortions of labor supply and savings decline as well as the insurance provision. Since the former dominates the latter, aggregate efficiency effects of different combinations of taper rates in the left part of Figure 5 have the same shape as in Figure 4 but they are always higher. For example, if both taper rates are kept at their initial level (i.e. $\varphi_a = \varphi_p = 1.0$) then aggregate efficiency increases to 1 percent of aggregate resources, if only

Figure 5: Aggregate efficiency effects of alternative guaranteed income levels

$\overline{b} = 0.2\overline{w}$ $\overline{b} = 0.4\overline{w}$



means-testing on private assets is eliminated (i.e. $\varphi_a = 0.0$, $\varphi_p = 1.0$) then aggregate efficiency further increases to 1.1 percent of aggregate resources. Eliminating means-testing against private assets hardly changes aggregate efficiency any more since very few households receive those benefits so that savings distortions are low. If we completely eliminated the first tier (i.e. $\overline{b} = \underline{b} = 0.0$) then the surface would become completely flat at 1.15 percent of aggregate resources.

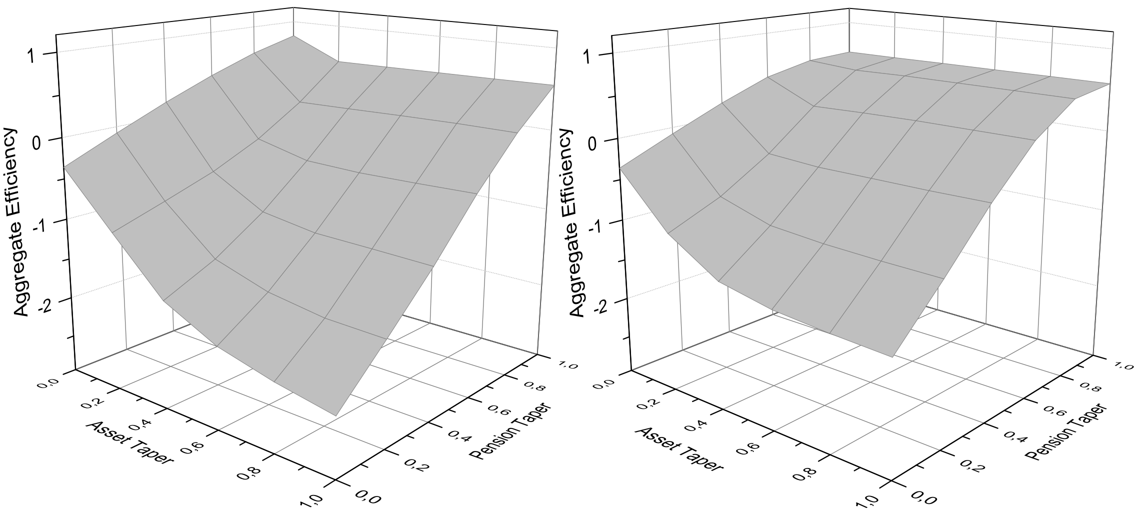
Not surprisingly the opposite happens when we increase the generosity of the first tier in the right part of Figure 5 where the guaranteed income level increases from 30 percent to 40 percent of average wages. Since labor supply and savings distortions rise stronger as the additional insurance provision aggregate efficiency effects are always lower than before. Full means-testing (i.e. $\varphi_a\varphi_p = 1.0$) now reduces aggregate efficiency by 1.6 percent of aggregate resources, while the elimination of means-testing for private assets increases aggregate efficiency by only 0.3 percent. With the UP system ($\varphi_a = \varphi_p = 0.0$) savings distortions completely disappear but the increase in $\overline{b}$ induces higher labor supply distortions which dominate the increased insurance provision.

Next, we perform a similar exercise where we keep the guaranteed income at initial level ($\overline{b} = 0.3\overline{w}$) but increase the BSP-level $\underline{b}$ successively to 7.5 and 15 percent of average wages. Of course, in this case the fraction of the means-tested benefit decreases so that savings distortions decline. Consequently, the left part of Figure 6 has a similar shape as Figure 4 but aggregate efficiency effects are slightly higher. When both taper rates are now kept at their initial level (i.e. $\varphi_a = \varphi_p = 1.0$), aggregate efficiency increases to 0.5 percent of aggregate resources, if only means-testing on second pillar pensions is eliminated (i.e. $\varphi_a = 1.0$, $\varphi_p = 0.0$) then aggregate efficiency decreases by 2.2 percent of aggregate resources.

Note that in the UP system (i.e. where $\varphi_a = \varphi_p = 0.0$) the BSP-level has no impact on aggregate efficiency as long as it is below the guaranteed level, i.e. $\underline{b} \leq \overline{b}$. Consequently, Figures 4 and 6 both report an aggregate efficiency loss of 0.4 percent of resources. The right part of Figure 6 shows that aggregate efficiency flatten out when the BSP-level is increased to $\underline{b} = 0.15\overline{w}$. The elimination of means-testing against private assets now has no effect on aggregate efficiency since only few households receive means-tested benefits. If only means-testing on second pillar pensions is eliminated

Figure 6: Aggregate efficiency effects of alternative BSP levels

$\underline{b} = 0.075\bar{w}$ $\underline{b} = 0.15\bar{w}$



(i.e. $\varphi_a = 1.0$, $\varphi_p = 0.0$) then aggregate efficiency decreases by only 1.6 percent of aggregate resources. It should be clear that the surface plane becomes completely flat at -0.4 percent when we further increase the BSP level to 30 percent of average earnings.

Summing up the above results we conclude that from an aggregate efficiency point of view it is optimal to either eliminate the first tier in the UK completely. If such a radical reform is not feasible then means-testing should be at least restricted to second tier benefits. Our results therefore suggest a downsizing of means-testing in the UK. The latter is in stark contrast to Sefton and van de Ven (2009) who find a significant role for means testing in the provision of pension benefits. Again, this study only considers long-run welfare effects and so completely disregards transitional cohorts. Our aggregate efficiency measure is more consistent since it also includes transitional cohorts. Savings distortions hurt more for transitional cohorts, since most of them have already accumulated substantial private wealth which is immediately affected. In contrast, cohorts living in the long-run steady state first will have to build up wealth in the far future, so that the induced distortions arise later in the life cycle.

Next we try to evaluate the robustness of our results.

4.5 Sensitivity analysis

Of course, the aggregate efficiency consequences discussed above strongly depend on the parameter specification of our benchmark model. Since insurance benefits are always dominated by higher labor supply and savings distortions it is optimal to eliminate the first tier completely.[12] It should be clear that insurance benefits of pensions increase when labor income becomes more uncertain. In this subsection we therefore present results of model simulations where we specify an autoregressive income process estimated from longitudinal UK income data. As was shown above, an income process featuring i.i.d.-shocks to productivity limits potential gains from insurance provision as income

[12] This result is in line with Kumru and Piggott (2014) who also find a privatization of the means-tested pillar to be welfare enhancing.

uncertainty within the model plays only a minor role. We explore this issue in a sensitivity analysis where we apply a different productivity process featuring autocorrelated shocks and simulate key reforms again.[13] Given this autoregressive income process, the Gini-indices of net income and assets increase to 0.294 and 0.582, respectively. As income uncertainty within the model rises, households build up higher precautionary savings in the initial equilibrium already. However, as we model a small open economy, this only affects the trade balance and the other aggregate variables are very similar to our calibrated benchmark equilibrium. As a result, the aggregate figures from Table 3 only slightly change.

Table 9 summarizes the results from the benchmark model discussed above. The PC-reform is worse than the UP-reform in terms of aggregate efficiency and the highest efficiency gains result from a complete elimination of the means-tested pillar. If we increase the uncertainty of the income process, the insurance provision of public pensions becomes more important. Consequently, it is not efficient to eliminate the first tier anymore. Instead the highest efficiency gains result from lowering the taper rate on private wealth to zero but strictly tapering benefits against second pillar pension income. Such a program provides the needed insurance while reducing savings distortions significantly and keeping the increased labor distortions in check.

Table 9: Sensitivity of the results

	Parameter values				Aggregate efficiency (in %)		
	$\overline{b}$	$\underline{b}$	φ_a	φ_p	Benchmark model	Autoregressive shocks	Fixed labor supply
Initial equilibrium	$0.3\bar{w}$	0.0	1.0	1.0			
PC-reform			0.4	0.4	-1.4	-0.6	0.9
UP-reform			0.0	0.0	-0.4	0.2	2.9
Pension taper only			0.0		0.8	0.8	1.4
Asset taper only				0.0	-2.7	-1.5	0.8
Higher generosity	$0.4\bar{w}$		0.0		0.4	0.7	2.3
BSP-increase		$0.15\bar{w}$	0.0		0.6	0.5	1.7
S2P only	0.0				1.1	0.3	0.2

The last column of Table 9 reports the aggregate efficiency effects of alternative reforms when we assume the income process of the benchmark model but keep labor supply of the initial equilibrium constant after the reforms.[14] Consequently, a higher contribution rate as a result of lower taper rates within the means-test regime does not distort labor supply anymore. Not surprisingly, the UP-reform is now most efficient, since it eliminates all savings distortions while at the same time providing insurance benefits to all households. Eliminating only the taper rate on private wealth is worse since it provides less insurance. Finally, the lowest efficiency gains now result from an elimination of the means-tested program.

Of course, we could also alter parameters of the public tax and transfer system. For example, if the tax system was less progressive, the optimal insurance provision of the pension system would be higher which should have similar consequences as increased uncertainty. In our opinion the central

[13] A more detailed description of the data and the estimation is given in the appendix.

[14] More technical details are available upon request.

qualitative result can be formulated as follows: In order to increase economic efficiency of the UK pension system it is best to eliminate the tapering of private wealth in the means-tested system.

5 Conclusion

Previous studies which have analyzed the long run effects of means-testing retirement benefits in the UK found strong support for high taper rates and argue that means-testing should play a significant role in the UK pension system. A system that provides universal retirement benefits is altogether discarded as welfare deteriorating. In a model featuring both productivity and longevity risk calibrated to the UK economy, we reassess the question whether public retirement provision should be means-tested.

Our results highlight that policy recommendations should not be based on long run welfare considerations as the latter represent a mixture of efficiency and intergenerational redistribution effects. A consistent and comprehensive approach has to compensate the intergenerational income redistribution in order to isolate aggregate efficiency consequences. While we are able to reproduce the results of previous studies arguing that a decrease in the taper rate leads to a decline in long run welfare, we show that aggregate efficiency considerations may lead to opposite policy recommendations. Based on our measure of economic efficiency, our study highlights severe savings distortions induced by means-testing of benefits against private wealth. In this case benefits from decreasing savings distortions and increased insurance provision dominate higher labor supply distortions. Consequently, lower taper rates within the means-test lead to gains in aggregate efficiency.

However, we also show that testing pension benefits against pension income from other pillars is beneficial from an efficiency point of view. As pension testing does not distort the accumulation of savings while helping to keep contribution rates low, a reduction in the pension taper rate only results in rising labor supply distortions that cannot be offset by additional insurance gains from the larger system. Consequently, our results show that the optimal taper rate strongly depends on what resources benefits are tested against. Of course, it also depends on the generosity of the existing progressive social security system as well as the underlying uncertainty structure.

The line of argument we have pursued suggests several avenues for future research. First, one of the central arguments in favor of social security and means-testing is that people are not rational enough to save for their own retirement. Feldstein (1987) examines the conditions when social security should be means-tested with myopic households. A natural extension of the present approach would therefore be to quantify how non-rational agents change the above conclusions. Second, although we have provided some sensitivity analysis with respect to income uncertainty, our analysis still incorporates too much homogeneity of agents. It would be very useful to consider very specific (and very rare) risks such as health or disability shocks which lead to long lasting (or even complete) productivity losses. As a consequence the tails of the distribution of second tier benefits would be broader and more realistic. A final issue concerns the application of the above approach to the institutional settings of other countries. Most countries operate some form of means-tested social security system but the designs vary substantially.

Appendix: Estimation of alternative income process

Following Fehr et al. (2013), we model the process

$$\log w_{i,j,t,s} = \varsigma_{0,s} + \varsigma_{1,j,s} + \varsigma_{2,t,s} + \log \eta_{i,j,t,s} + \xi_{i,j,t,s}$$

with the autoregressive term

$$\log \eta_{i,j,t,s} = \varrho_s \cdot \log \eta_{i,j-1,t-1,s} + \varepsilon_{i,j,t,s}$$

with $\varsigma_{0,s}$ marking an intercept. Age- and time fixed effects are represented by $\varsigma_{1,j,s}$ and $\varsigma_{2,t,s}$ while $\xi_{i,j,t,s} \sim N(0, \sigma^2_{\xi,s})$ are i.i.d. errors. The innovation $\varepsilon_{i,j,t,s}$ is normally distributed with mean 0 and variance $\sigma^2_{\varepsilon,s}$, ϱ_s marks the AR(1) autocorrelation coefficient for a skill class s.

We use panel data of the British Household Panel Survey (BHPS) to estimate this process. In particular, we use deflated hourly wages of individuals i at age j and time t. Individuals are distinguished into three skill classes s according to the ISCED standard of the UNESCO: individuals with primary and lower secondary education (levels 1 and 2) are classified as low-skilled ($s = 1$), the ones with higher secondary education (levels 3 and 4) as medium-skilled ($s = 2$) and individuals of tertiary education (levels 5 and 6) as high-skilled ($s = 3$), respectively. Our data set covers workers between ages 20 and 64 of the years 1991 to 2009. As in Fehr et al. (2013), we exclude the upper and lower percentile of the hourly wage distribution to control for outliers. This leads to a dataset with 51005, 36193 and 17204 observations within the respective skill classes s. The parameters are estimated in two steps: First, the fixed effects $\varsigma_{1,j,s}$ and $\varsigma_{2,t,s}$ are obtained with an OLS-estimation. Using the residuals, we estimate the life cycle risk process via a restricted Maximum-Likelihood method for each skill class s.

We find high autocorrelation coefficients of $\varrho_1 = 0.919649$, $\varrho_2 = 0.930306$ and $\varrho_3 = 0.910821$ for the three respective skill classes in the UK with negligibly small standard errors. These results are comparable to numbers reported in Bayer and Juessen (2012) who estimate a similar process for the UK with BHPS data. Fehr et al. (2013) report similar results for a process estimated with German panel data. In line with them, we find the total variance of the wage risk process $\sigma^2_{\eta,s}$ to be slightly increasing with the skill level (from 0.182 to 0.207) as well as transitory variances $\sigma^2_{\varepsilon,s}$ which rise from 0.0280 to 0.035 with the skill level. Following Fehr et al. (2013), we discretize the AR(1)-process for the three skill classes using a Rouwenhorst method with 5 approximation points. The mean productivity profiles are the same as in the benchmark i.i.d.-shock model.

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