An Earned Income Pension Credit as a means to reduce old-age poverty risk

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Abstract

In this paper, we study the optimal design of pension systems that aim at reducing old-age poverty risk. We argue that a pension scheme that grants subsidies to the earnings poor based on their annual earnings is superior to a redistribution scheme that is based on the life-time earnings history of individuals, like e.g. US social security. In particular, we find that pension subsidies for individuals with low earnings that are designed in a similar way as the Earned Income Tax Credit provide both insurance against old-age poverty and incentives for labor force participation. As such, the Earned Income Pension Credit (EIPC) generates substantial long-run welfare gains, especially for single women. To arrive at this conclusion, we evaluate the individual and macroeconomic consequences of redistributive pension reforms in a quantitative overlapping generations model that accounts for a rich set of demographics (gender, marital status, and family size), permanent labor market characteristics, idiosyncratic labor productivity shocks, individual savings choices and labor supply decisions at the extensive and the intensive margin.

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1 Introduction

How to provide adequate old-age income to every retiree in times when pension systems are under severe demographic pressure? This fundamental question is at the core of the political debate in many Western societies. It becomes even more pressing as the baby boomer generation starts to retire and the ratio of working to retired cohorts changes fundamentally. Reducing pension replacement rates and increasing retirement ages to avoid excessive social security contributions, however, is not a one-size-fits-all solution to the problem. Having a full career becomes more uncertain at least for some parts of the population and life expectancy between education and income groups diverges. Furthermore, old-age poverty risk is most pronounced for older women, and especially so for single mothers, see OECD (2017). A sustainable pension system, hence, has to balance the needs of various population groups and account for differences in the individual ability to privately provide for retirement.

In this paper, we study the optimal design of pension systems that explicitly aim at providing sufficient old-age income to those in need. To this end, we evaluate the individual and macroeconomic consequences of different pension systems that feature a redistributive component. We do so in a quantitative overlapping generations model that accounts for a rich set of demographics, permanent labor market characteristics and idiosyncratic labor productivity shocks. In our model, individuals of different gender, marital status and family size make labor supply choices at the extensive and the intensive margin and save for retirement in a risk-free asset. One important lesson we draw from our analysis is that the design of redistributive pensions matters a lot. In fact, we find that a pension system that grants pension subsidies for individuals with low earnings in a similar way as the Earned Income Tax Credit in the US provides both insurance against old-age poverty and incentives for labor force participation. As such, the Earned Income Pension Credit (EIPC) generates substantial long-run welfare gains, especially for single women.

The starting point of our analysis is the observation that redistribution within the pension system can be based on two distinct characteristics: an individual's life-time average earnings or an individuals instantaneous earnings. Prominent pension systems that grant subsidies to the income poor population, like for example social security in the US, link redistribution to life-time earnings. The US system, for example, calculates an index of average life-time earnings for each retiree and then applies different replacement rates to different income levels. An overproportionally high replacement rate at the bottom of the income distribution therefore generates substantial pension progressivity. Alternatively, redistribution could be based on instantaneous earnings. This means that an individual would be granted a pension subsidy in every year she or he faces a low earnings episode and consequently accumulate fewer pension entitlements when income rich.

Theoretically, the effects of these two systems are ambiguous. Redistribution on the basis of lifetime earnings might be preferred over annual redistribution, as it completes the set of available tax and transfer instruments of the government. Age-dependent or life-time income taxation is usually infeasible in reality, whereas theory would predict that such a scheme can lead to substantial welfare gains, see for example Kapica (2020). Yet, as we will show below, redistribution based on life-time earnings creates substantial labor supply distortions. On the other hand, a redistribution scheme that is based on annual earnings with a subsidy region, like an Earned Income Pension Credit, has the potential to encourage labor supply especially at the extensive margin, see for example Saez (2002). The activation of the entire workforce potential can ease the pressure on social security and therefore lead to welfare gains.

We quantify the individual and macroeconomic consequences of different pension reforms that aim at reducing old-age poverty using a simulated overlapping generations model. When entering the economy, individuals draw a specific gender and education level at random. They are then potentially matched to a partner of the opposite gender to form a marriage. Martial status is invariant over the entire life, meaning that marriages don't get divorced and individuals who don't get matched stay single for their entire life. We allow for assortative mating with respect to education by assuming that the likelihood to get matched with a partner of a certain education level depends on the individual's own education. Throughout their life, individuals make labor supply decisions at the extensive and the intensive margin. In particular, they can decide whether to work full time, part time, marginally or not at all. At age 30, a fraction of women are having two children. Children arrive according to a stochastic process that differs across singles and married. The presence of children induces both a time cost on women as well as monetary costs to the family. As a result, mothers have to cut back on labor hours which, in case they are single, puts them at a substantial risk of poverty. This risk may spill over to retirement, both in terms of low pension benefits and low private retirement savings. When entering retirement, all individuals draw a shock to their life expectancy which correlates with their prior labor productivity as well as their gender. Men live shorter than women, on average, and their gradient between income and life expectancy is larger.

We calibrate our model to the German economy, which currently features only little redistribution within the pension system. Starting from this benchmark, we introduce different types of redistributive pension systems into the economy and quantify their long-run effects on individual labor supply decisions, old-age poverty, the macroeconomy and welfare. A US-style social security system that redistributes pension payments on the basis of life-time earnings substantially compresses the distribution of old-age income, but at the cost of high labor supply distortions. Employment and intensive labor hours fall for most demographic groups and labor productivity levels, leading to a weaker long-run macroeconomic performance. Overall, such a system reduces long-run welfare for all population groups, women and men, singles and married alike.

An Earned Income Pension Credit with a subsidy region for low earnings provides substantial insurance against old-age poverty as well. However, the fact that the redistributive component is based on annual and not life-time earnings sets positive employment incentives at the extensive margin, and especially so for married women and single mothers. As a result, the system allows for a better targeting towards the needy. By stimulating employment, the long-run consequences for the macroeconomy are also less severe. This leads long-run welfare to rise despite a 2 percentage decline in GDP. The main beneficiaries of such a system are single mothers, i.e. those with the highest risk of old-age poverty in the first place. We conclude from this that design plays an important role when conducting pension reforms that aim at targeting those in need. While redistribution based on life-time earnings may seem attractive from an optimal tax perspective, redistribution based on annual income allows the policy maker to set the right labor supply incentives.

Relation to the literature Redistribution through the pension system is not undisputed in the economics literature. As with any progressive fiscal tax or transfer scheme, an optimal system balances the gains from redistribution and insurance against the losses from labor supply distortions. Several studies have addressed this issue in quantitative OLG models with single earner or unisex households, including Huggett and Ventura (1999), Nishiyama and Smetters (2008), Fehr and Habermann (2008) or Fehr et al. (2013). However, these studies typically consider intensive margin labor supply decisions. O'Dea (2018) uses an estimated life-cycle model with extensive margin labor supply decisions to show that substantial welfare benefits can be generated by strengthening a country's means-tested old-age income floor at the cost of reducing pension payments related to the individual earnings history. In recent work, Kindermann and Pueschel (2021) have pointed to the fact that progressive pensions might also encourage extensive margin labor supply, if designed in the right way. French et al. (2021) use a pension policy experiment in Poland to measure the employment elasticity with respect to the return to work for cohorts aged 51-54. Their results suggest that already at this point in the life cycle, where individuals are still quite fare away from retirement, they respond with their labor choice to incentives set by the pension system.

Our paper more generally connects to the literature on extensive margin labor supply responses and the role for the fiscal tax and redistribution system. Saez (2002) was among the first to show that, when labor supply responses are concentrated along the intensive margin, an optimal labor tax policy explicitly subsidizes employment. As direct employment subsidies are generally not feasible,[1] a second best policy looks quite similar as the Earned Income Tax Credit in the US. Such a policy encourages extensive margin labor supply and at the same time redistributes resources to the earnings poor. A series of studies has quantified the

[1]Households might only have a fictitious working contract or work minimal hours.

EITC's impact on labor supply, savings, insurance and welfare, including Chan (2013), Athreya et al. (2010), and Ortigueira and Siassi (2019).

Finally, our paper relates to a recent literature that uses large scale quantitative simulation models with very detailed heterogeneity on the household level to study the impact of public policies on individuals of different gender or family type. Examples include Guner et al. (2021) or Kurnaz (2021).

The remainder of our paper is structured as follows: In Section 2, we describe the mechanisms of the three pension systems in detail. In Section 3, we present our full quantitative simulation model, and discuss its calibration in Section 4. In Section 5, we present simulation results for life-cycle choices, macroeconomic performance and long-run welfare. The last section concludes.

2 The Structure of Pay-as-you-go Pension Systems

The mechanics of a pay-as-you-go (PAYG) pension system are quite simple. The system collects *contributions* from current workers. In reward for their contributions, workers *accumulate* pension entitlements.[2] Finally, the sum of all contributions is redistributed as *pensions* to all retirees in relation to their pension entitlement.

In a *proportional* pension system, contributions, entitlements, and pensions are all proportional to a worker's earnings or earnings history. Let us denote by y a worker's labor earnings. Then a proportional pension system is characterized by

- the contribution formula

$$T_p(y) = \tau_p \times y, \tag{1}$$

- the accumulation formula for pension entitlements

$$e^+ = e + y, \tag{2}$$

- and the pension formula

$$p = \kappa \times e. \tag{3}$$

In each working year, a worker pays contributions at rate τ_p to the system. In reward, she accumulates pension entitlements e in direct proportion to her earnings. Upon entering retirement, the pension formula converts accumulated entitlements into pension payments by multiplying the earnings index e with a replacement rate κ.[3]

[2] Pension entitlements are usually some index of the worker's earnings or contribution history.

[3] Note that in practice many pension systems feature a contribution and/or accumulation ceiling. For now, we want to keep the discussion as simple as possible. We will, however, include such a ceiling in our quantitative model.

If the government wants to include redistributive elements into the pension system, there are two obvious starting points to do so. Redistribution can be achieved through either an adjustment of the accumulation formula for pension entitlements or changes in the pension formula that converts entitlements into real pension claims.[4] As we will argue in the remainder of the paper, this choice makes a difference. There is one close questions related to this: Should redistribution be based on life-time earnings or on instantaneous earnings? If the former were the case, then progressivity should enter the pension system through the pension formula. For the latter, redistributive elements should enter the accumulation formula. Before we elaborate on the economic effects of introducing different systems of pension progressivity into an economy, let us first introduce two examples.

2.1 The US Social-Security System

US Social Security is a prime example of a redistributive pension system, in which redistribution is based on life-time earnings. While the accumulation equation is the same as in 2, the US pension system converts life-time earnings into pension payments according to the formula

$$p = \begin{cases} \kappa_1 e & \text{if } e < b_1 \\ \kappa_1 b_1 + \kappa_2 (e - b_1) & \text{if } e < b_2 \\ \kappa_1 b_1 + \kappa_2 (b_2 - b_1) + \kappa_3 (e - b_2) & \text{else,} \end{cases} \tag{4}$$

where $\kappa_1 > \kappa_2 > \kappa_3$ are the replacement rates and b_1 and b_2 are so-called bend points.[5]

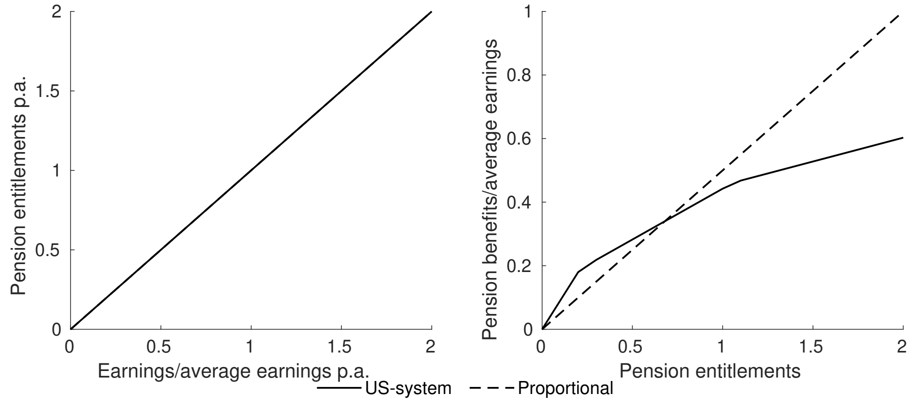
Figure 1 graphically illustrates the workings of US pension progressivity as compared to a proportional pension system. The left panel of the figure shows the relationship between individual earnings and accumulated pension claims (where earnings were normalized by the average earnings of the employed population). An increase in instantaneous earnings y directly increases pension entitlements on a one-to-one basis.[6] The right panel illustrates the relationship between accumulated pension entitlements and the final pension payment. Pension entitlements were normalized by the average pension entitlement of the population. Pension

[4] Strictly speaking, the government could also introduce progressivity into the contribution formula. There are, however, several reasons why this hardly makes sense. First, there is a one-to-one mapping between progressive pension contributions and a progressive entitlement formula, as the only thing that matters for the individual is the relationship between contributions and entitlements. Second, when the aim of the government is to free up resources or redistribute during working years it should resort to the income tax and not the pension system.

[5] Note again, that the US system has a contribution ceiling, which we will consider in our quantitative analyis.

[6] In fact, the US social security system calculates an average earnings index based on the entire individual earnings history, but the five lowest earnings realizations will be dropped from the calculation.

Figure 1: The US-system



benefits are again measured in terms of average earnings. Assuming a gross replacement rate of 50 percent, a worker with average pension entitlement receives a pension worth 50 percent of the average earnings under a proportional system. The US progressive pension formula weakens the link between entitlements and earnings. As a result, workers with a low earnings history receive overproportionally large pensions as compared to the earnings rich.

2.2 The Earned Income Pension Credit

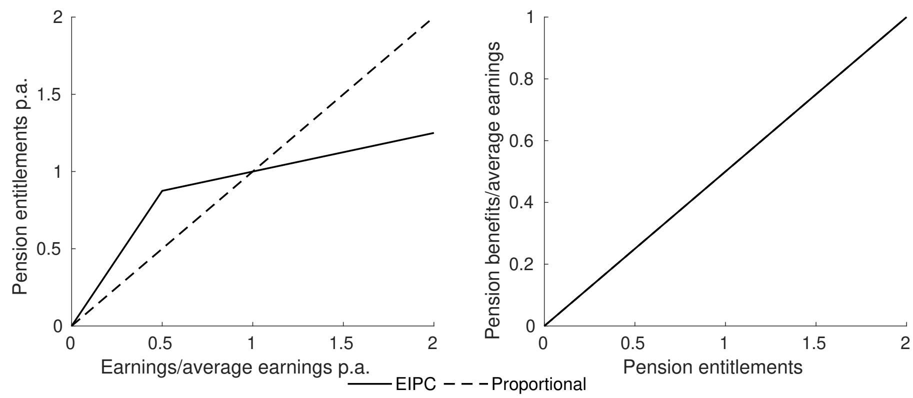
An alternative to the US Social Security System would be an Earned Income Pension Credit (EIPC). Similar to the Earned Income Tax Credit, such a system pays implicit transfers to low-earnings working households. As such, it provides additional resources to the earnings poor. What is more, if earnings subsidies are credited on an annual basis, such a system can encourage labor supply responses, especially at the intensive margin, see e.g. Saez (2002).

In the EIPC system, the pension formula is the same as under a proportional system, see again (3). Yet the accumulation formula changes to

$$e^{+} = \begin{cases} e + (1+\lambda)y & \text{if } y < 0.5\bar{y} \\ e + \lambda\bar{y} + (1-\lambda)y & \text{else} \end{cases} \tag{5}$$

This formula has two regions. First, a subsidy region for low earners, where individuals are credited overproportionally high entitlements relative to their contributions. We assume that the subsidy region covers earnings from 0 to 0.5 times the average earnings of the employed. We define λ to be the surcharge that is paid on top of a proportional system. In the second region, the phase-out region, workers only accumulate underproportional pension entitlements. The system is set up in a way that the average earner is exactly indifferent between accumulating pensions on a proportional or an EIPC basis. Hence, when looking at the left panel of Figure 2, the two accumulation formulas intersect exactly at relative earnings of one.[7]

Figure 2: The EIPC-system



The economic effects of the two systems are theoretically ambiguous. On the one hand, redistribution on the basis of lifetime earnings might be preferred over annual redistribution, as it completes the set of available tax and transfer instruments of the government. An age-dependent or life-time income taxation is usually not feasible in real life, whereas theory would predict that such a taxation scheme can lead to welfare gains, see for example Kapica (2020). On the other hand, as we will show below, redistribution based in life time earnings creates substantial labor supply distortions. An annual redistribution through an EIPC, however, has the potential to encourage labor supply, especially at the extensive margin. To elaborate on the size of labor supply effects and the benefits of redistribution, we now investigate the effects of such pension systems in a quantitative model.

3 The Quantitative Simulation Model

We employ a general equilibrium overlapping generations model with population growth and survival risk with single and couple households. This model is an extension with families to the model used in Kindermann and Pueschel (2021). Each individual draws a persistent shock to sex, marital status and labor productivity at the beginning of life. Marriages are stable, couples retire and die jointly. Households decide about labor supply at the intensive and extensive margin as well as about consumption and savings. Couples make joint decisions. Over time, individuals are subject to transitory income shocks as well as a one-time fertility

[7] Note that we assume that the underaccumulation of pension claims even continues for individual with earnings above average earnings. This makes the system more comparable to US social security. A pure EIPC which mimics the EITC would assume a proportional accumulation for individuals with relative earnings above 1.

shock and a one-time health shock that determines life expectancy. In the benchmark model, the government operates a proportional pay-as-you-go pension system financed by payroll taxes. Further, the government collects resources through the progressive taxation of labor earnings and a proportional consumption tax to cover general government expenditure. We consider an open economy framework, so that the prices for capital and labor are fixed, but government parameters adjust in order to keep the fiscal tax and transfer systems balanced. Since we only consider long-run equilibria, we omit the time index t in the following wherever possible.

3.1 Demographics

The economy is populated by overlapping generations of heterogeneous individuals. At each point in time t, a new generation of size N_t is born. Individuals are either male ($g = m$) or female ($g = f$) and live in a single ($o = 0$) or a couple ($o = 1$) household. The probability of $g = m$ is ϕ_g and $o = 1$ is ϕ_o. A couple consists of a wife and a husband. We assume that the population grows at a constant rate n. Households start their economic life at age $j = 20$ and live up to a maximum of J years, after which they die with certainty. Individuals can supply labor to the market until they reach the mandatory retirement age j_R. Throughout their entire life, individuals are subject to idiosyncratic survival risk. Specifically, we denote by $\psi_{j,g,h}$ the conditional probability of an individual to survive from period $j-1$ to period j, with $\psi_{20,h} = 1$ and $\psi_{J+1,h} = 0$. Survival probabilities, and hence life expectancy, depend on sex g, marital status o and health h, discussed in more detail below.

As population grows with a constant rate n, a long-run equilibrium in this economy is characterized by all aggregate variables growing at this very same rate. To make aggregates stationary again, we express all variables in per capita terms of the youngest generation at a certain date t. We denote by m_j the time-invariant relative size of a cohort aged j at any point in time.

3.2 Technology

A continuum of identical firms produce a single good Y under perfect competition. They hire both capital K at price r and labor L at price w on competitive spot markets. Firms operate a constant returns to scale technology

$$Y = \Omega K^{\alpha} L^{1-\alpha}. \tag{6}$$

Ω denotes the aggregate level of productivity, whereas α is the elasticity of output with respect to capital. In the process of production, a fraction δ of the capital stock depreciates. Given the assumptions about competition and technology, we can safely assume the existence of a representative firm that takes prices as given and operates the aggregate technology in (6). In addition to employing factor inputs, the firm has to invest I_t into its capital stock. The law of motion for the capital stock reads

$$(1+n)K_{t+1} = (1-\delta)K_t + I_t.$$

3.3 Preferences and Endowments

Preferences Individuals have preferences over stochastic streams of consumption $c_j \geq 0$ and labor supply $\ell_j \geq 0$.

Single households maximize the discounted expected utility

$$U_0 = E_0\left[\sum_{j=1}^{J} \beta^{j-1} u(c_j, \ell_j)\right],$$

couple households maximize the discounted expected utility

$$U_0 = E_0\left[\sum_{j=1}^{J} \beta^{j-1} \Big(\lambda_m u(c_{j,m}, \ell_{j,m}) + (1-\lambda_m) u(c_{j,f}, \ell_{j,f})\Big)\right],$$

where expectations are formed with respect to survival risk, idiosyncratic wage risk and fertility risk. Individuals discount the future with the constant time discount factor β. λ_m denotes the husband's intra-household bargaining power.

Labor productivity risk Individuals are ex ante homogeneous, but differ ex post in their labor productivity $z(j, s, \eta)$. At the beginning of life, they draw one of two education levels: high-school education ($s = 0$) or college education ($s = 1$); the probability to draw $s = 1$ is ϕ_s. All individuals of education s share a common deterministic age-specific labor productivity profile $\theta_{j,s}$.

Throughout their working life, households' labor productivity is due to idiosyncratic shocks η and follows a standard AR(1) process in logs

$$\eta^+ = \rho\eta + \varepsilon^+ \quad \text{with} \quad \varepsilon^+ \sim N(0, \sigma_\varepsilon^2), \tag{7}$$

where innovations ε^+ are iid across households. The wage rate w per efficiency unit of labor depends on the intensive margin decision ℓ. Further, the wage of a female worker depends on her age j (gender wage gap) and if she has children $k \in \{0, 1\}$ or not. Finally, the wage an individual faces equals the product of the wage rate per efficiency unit of labor and her individual labor productivity $w(j, g, k, \ell) \times z(j, s, \eta)$.

Families Households start economic life without having children ($k = 0$). This changes at age j_k, according to the probability distribution $\pi_k(k^+|k, j, g, o)$. Both single and married women can give birth, males cannot. The kids (who are always twins) live for 18 years in the household[8], are not productive and are hungry. Families benefit from economies of scale in consumption. Consumption expenditure c for families is given by:

$$c = (c_m + c_f) \times \upsilon_{j,k,m}. \tag{8}$$

$\upsilon(j, k, m)$ is a scale factor that depends on the households age and the composition of family members.

Budget constraint Markets are incomplete and households can only self-insure against fluctuations in individual labor productivity by saving in a risk-free asset a with return r. Savings are subject to a tight borrowing constraint, so that household wealth needs to satisfy $a \geq 0$. Households' resources are composed of their current wealth (including returns), their income from working $y_m + y_f$, where $y_g = w(j, g, k, \ell) \times z(j, s, \eta)\ell_g$, intergenerational transfers $b_m + b_f$,[9] as well as pension payments $p_m + p_f$. They use these resources to finance consumption expenditure $(1 + \tau_c) \times c$, savings into the next period a^+, contributions to social security $T_p(y_m + y_f)$ as well as progressive income taxes $2T\Big[0.5\Big(y_m + y_f - T_p(y_m + y_f) + p_m + p_f\Big)\Big]$. Households can deduct social security contributions from gross income for the purpose of taxation. In turn, all pension benefits are liable for taxation. A couple has a joint budget constraint and hence, marriage can provide additional insurance against individual income fluctuations.

Individual life expectancy A household's savings behavior is shaped by the interest rate, the discount factor, productivity risk and life expectancy. As for the latter, we assume that individual survival probabilities are defined by some health state h.

Singles: Each health level is associated with a set of age and gender specific survival probabilities $\psi_{j,g,h}$ that lead to a certain life expectancy. An agent's health status can change over the life cycle according to the probability distribution $\pi_h(h^+|h, j, g, s, \eta)$. Future health h^+ hence is conditional on current health, age, gender, education and individual labor productivity.

Couples: We assume that a wife and a husband are of the same age and that they die together. Survival probabilities of couples $\psi_{j,h}$ are the average of male and female survival probabilities.

Dynamic optimization problem - Singles: The current state of a single household is described by a vector $\mathbf{x_s} = (j, g, s, \eta, h, k, a, e)$ that summarizes the

[8] We refer to a household with more than one member (singles) to families. Families can take the form of single-mothers, couples and couples with children.

[9] Intergenerational transfers consist only of accidental bequests that households might leave if they die before the terminal age J. We assume that the total of those accidental bequests is distributed lump-sum to all working age households.

household's age j, education s, her current labor productivity shock η, health h, number of kids k, her wealth position a as well as the amount of already accumulated pension claims e. The dynamic optimization problem of an individual then reads

$$v(\mathbf{x_s}) = \max_{c,\ell,a^+,e^+} \; u(c,\ell) + \beta\psi_{j+1,h} E\Big[v(\mathbf{x_s}^+) \;\Big|\; j,g,s,\eta,h,k\Big] \tag{9}$$

with $\mathbf{x_s}^+ = (j+1, g, s, \eta^+, h^+, k^+, a^+, e^+)$. Households maximize (9) subject to the borrowing constraint $a^+ \geq 0$ and the budget constraint

$$(1+\tau_c)c + a^+ + T_p(y) + T\Big(y - T_p(y) + p\Big) = (1+r)a + y + y_{mini} + p + b$$
$$\text{with } \; y = w(j,g,k,\ell) \times z(j,s,\eta)\ell.$$

Dynamic optimization problem - Couples: The current state of a couple household is described by a vector $\mathbf{x_c} = (j, s_m, s_f, \eta_m, \eta_f, h_m, h_f, k, a, e_m, e_f)$ that summarizes the household specific states age j, number of kids k and wealth position a, as well as the partner specific states education s_g, current labor productivity shock η_g, health h_g, and accumulated pension claims e_g. The dynamic optimization problem of a household then reads

$$\begin{aligned} v(\mathbf{x_c}) = \max_{\substack{c_m,c_f,\ell_m,\ell_f,\\ a^+,e_m^+,e_f^+}} \; & \Big[\lambda_m u(c_m,\ell_m) + (1-\lambda_m)u(c_f,\ell_f)\Big] \\ & + \beta\psi_{j+1,h} E\Big[v(\mathbf{x_c}^+) \;\Big|\; j, s_m, s_f, \eta_m, \eta_f, h_m, h_f, k\Big] \end{aligned} \tag{10}$$

with $\mathbf{x_c}^+ = (j+1, s_m, s_f, \eta_m^+, \eta_f^+, h_m^+, h_f^+, a^+, e^+, e^+)$. Households maximize (10) subject to the borrowing constraint $a^+ \geq 0$ and the budget constraint

$$\begin{aligned} (1+\tau_c)c + a^+ + T_p(y_m) + T_p(y_f) + 2T\Big[0.5\Big(y - T_p(y_m) - T_p(y_f) + p\Big)\Big] \\ = (1+r)a + y + y_{mini} + p + b \\ \text{with } \; y = y_m + y_f, \;\; y_{mini} = y_{mini,m} + y_{mini,f}, \;\; p = p_m + p_f, \;\; b = b_m + b_f, \\ \text{where } \;\; y_g = w(j,g,k,\ell) \times z(j,s,\eta)\ell_g \text{ and } \;\; c = (c_m + c_f) \times \upsilon(j,k,m). \end{aligned}$$

y_{mini} are earnings from a mini job. The accumulation equation for pension claims ep^+ is discussed in Section 3.5 and the law of motion for health π_h in 4.1. The result of this dynamic program are policy functions c_g, ℓ_g, e_g, a^+, and e_g^+ that all depend on the household's current state $\mathbf{x}$.

3.4 Labor Supply

The time endowment per period is 1 and can be used for labor and leisure. Individuals can work full-time, part-time or in a mini-job with $\ell \in \{0.4, 0.2, 0.1\}$, respectively. Earnings from part-time and full-time work $y = w(j,g,k,\ell) \times z(j,s,\eta)\ell$ are subject to labor tax and social security contribution. Mini-jobs pay a fixed salary y_{mini} which is tax and contribution free. Couples decide about each partners optimal labor supply jointly to maximize household utility.

3.5 The Pension System

In the benchmark economy, we consider a purely proportional pension system. Both pension benefits and contributions are based on individual earnings, rather than family earnings. The pension system collects payroll taxes at rate τ_p on earnings below two times average labor earnings of the employed $2\bar{y}$. The pension contribution $T_p(y)$ of an individual with labor earnings y hence reads

$$T_p(y) = \tau_p \times \min\left[w(j,g,k,\ell)z(j,s,\eta)\ell,\ 2\bar{y}\right].$$

In reward for contributing to the system, households earn pension claims e according to

$$e^+ = e + \min\left[w(j,g,k,\ell)z(j,s,\eta)\ell,\ 2\bar{y}\right]. \tag{11}$$

In the proportional system, earned pension claims are solely determined by contributed earnings. Hence, they are capped at twice the average earnings and earnings from mini jobs do not increase pensions claims. Finally, individual pension benefits $p(e)$ are calculated from earned pension claims as

$$p(e_{j_R}) = \bar{y} \times \kappa \times \frac{e_{j_R}}{j_R - 19}.$$

The second factor in this equation reflects the average pensionable earnings of an individual and κ is the replacement rate.

The pension system operates on a pay-as-you-go basis. In equilibrium, total pension contributions hence need to be equal to the total amount of pension payments. Letting Φ denote the cross-sectional measure of households over the state space,[10] we require

$$\kappa \times \underbrace{\int e \times \mathbb{1}_{j \geq j_R}\, d\Phi}_{\text{total pension claims}} = \tau_p \times \underbrace{\int \min\Big(w(j,g,k,\ell)z(j,s,\eta)\ell,\ 2\bar{y}\Big)\, d\Phi}_{\text{contribution base}}. \tag{12}$$

3.6 The Tax System and Government Expenditure

The government collects proportional taxes on consumption expenditure and progressive taxes on taxable labor earnings net of social security contributions as well as pension payments. Tax revenue is used to finance (wasteful) government

[10] Φ is a measure and indicates the mass of households on each subset of the state space. We require that for each age j, Φ sums up to the total mass of households in a cohort m_j.

spending. As we abstract from any government debt, the tax system is balanced whenever

$$\tau_c \times C + \int T\Big(y - T_p(y) + p\Big)\ d\Phi = G \ \text{ with } \ y = w(j,g,k,\ell)z(j,s,\eta)e\ell. \quad (13)$$

C denotes aggregate consumption and T the progressive income tax schedule discussed in section 4.4. We assume that government consumption is fixed per capita. Consequently, we adjust the income tax system to keep the fiscal system in balance.

3.7 Capital Markets, Trade and Equilibrium

We model a small open economy that freely trades capital and goods on competitive international markets. All private savings that are not employed by the domestic production sector are invested abroad at the international interest rate $\bar{r}$. The capital market equilibrium reads

$$K + Q = A,$$

where A are aggregate private savings and Q is the country's net foreign asset position. As the economy grows at rate n, the net foreign asset position increases over time such that the capital account is $-nQ_{t+1}$. Net income from abroad, on the other hand, amounts to $\bar{r}Q_t$. According to the balance of payments identity, we therefore have a trade balance of

$$TB = (n - \bar{r})Q. \quad (14)$$

We assume that the government collects all accidental bequests and redistributes them in a lump-sum way among the surviving working-age population. Consequently,

$$b_j = \frac{\int \frac{1-\psi_{j,h}}{\psi_{j,h}} \times (1+r)a\ d\Phi}{\int \mathbb{1}_{j<j_R}\ d\Phi} \quad \text{if } j < j_R. \quad (15)$$

Given an international interest rate and the exogenous fiscal policy parameters, a *recursive competitive equilibrium* of this model is a set of household policy functions, a measure of households, optimal production inputs, factor prices, accidental bequests, a net foreign asset position and a trade balance that are consistent with individual optimization and market clearance.

4 Calibration

This section discusses our choices of functional forms and parameters in detail. We pay particular attention to the labor supply decision of households along the extensive and the intensive margin and to the relationship between life-time income and life expectancy. We calibrate our model to the German economy, which currently features a proportional pension system in line with the one described in the previous section. Germany therefore serves as a good benchmark for reforms that aim at introducing progressivity into the pension formula.

4.1 Demographics

We assume a population growth rate of $n = 0.0$, which is a compromise between the average growth rate of 0.4% reported in the period 2012 to 2017 for the German population at large, and the fact that most of German population growth came from refugee migration, see German Statistical Office (2020).[11] We let households start their economic life at the age of 20 and allow for a maximum life span of 99 years. Mandatory retirement is at the age of 64, which equals the current average retirement age of the German regular retirement population, see Deutsche Rentenversicherung Bund (2019).

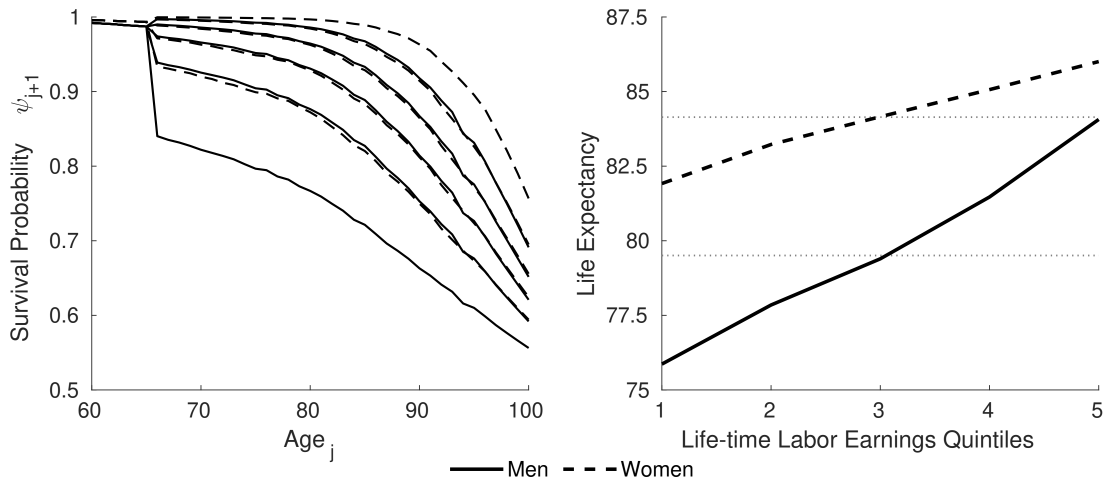
Life expectancy With regards to life expectancy, we extract the 2017 annual life tables for men and women from the Human Mortality Database (2020) to calculate average survival probabilities $\bar{\psi}_{j,g}$ of the overall population. We assume that all households share these common survival probabilities throughout their working life. Upon entering retirement, each individual draws one out of six different health shocks $h \in \{0, \ldots, 5\}$. A health shock is associated with a set of survival probabilities $\psi_{j,g,h}$ that we choose such that (i) life expectancy at the lowest health shock $h = 0$ is ten years below average, (ii) life expectancy at the highest health shock $h = 5$ is ten years above average and (iii) life expectancy evolves linearly with health shocks h.[12] The left panel of Figure 3 shows the respective survival probability profiles.

The probabilities $P(h|g, s, \eta)$ to draw a certain health shock upon entering retirement depend on the individual's gender g, education s and on the labor productivity shock η at the date directly prior to retirement. This modeling choice is grounded on two pieces of empirical evidence: First, Luy et al. (2015) find that in Germany men (women) with college education live on average 2.5 (1.7) years longer than those with lower education levels. Second, Haan et al. (2020) report a life expectancy gap of around 7 years between men in the top and the bottom life-time labor earnings decile (4 years for women). In accordance with these findings, we assume $P(h|g, s, \eta)$ to be the probability mass function of a binomial distribution with success probabilities $p_{g,s,\eta}$ depending on education and

[11] In fact, the growth rate of the native population was -0.2% in the same time period.

[12] See Appendix for more details on how we derive these profiles from the average survival probabilities.

Figure 3: Survival probabilities and life expectancy



labor productivity. In particular, we let

$$p_{g,s,\eta} = \Phi\left(\iota_{0,g} + \iota_{1,g} \times \mathbb{1}_{s=\text{college}} + \iota_{2,g} \times \eta\right), \tag{16}$$

where Φ is the probability distribution function of the standard normal distribution and $\mathbb{1}_{s=\text{college}}$ is an indicator function that takes a value of one for households with college education. We set the parameters $\iota_1(m, f) = (0.76, -0.24)$ and $\iota_2(m, f) = (0.82, 0.70)$ to target the reported life expectancy gaps by education level and life-time labor earnings. Finally, we choose $\iota_0(m, f) = (-0.13, 0.04)$ such that the average life expectancy for single men and single women amounts to 79.5 and 84.1 years, respectively. We target this value according to the Human Mortality Database (2020) life tables. The right panel of Figure 3 shows the relation between life-time labor earnings and life expectancy. While men (women) in the bottom quintile expect their life to be about three (two) years shorter than that of the population average, the average life of a top quintile earner is three (two) years longer.

Incorporating these probabilities into model notation, we have

$$\pi_h(h^+|h, j, g, s, \eta) = \begin{cases} P(h|g, s, \eta) & \text{if } j = j_r - 1 \text{ and} \\ \mathbf{I} & \text{otherwise,} \end{cases}$$

with $\mathbf{I}$ being the identity matrix. Consequently, our model features one single health shock that individuals are exposed to right before entering retirement. After the individual health status is revealed, households retain their health level for the rest of their life. While agents share a common set of gender specific survival probabilities during their entire working life, they still form expectations with respect to their potential health shocks at retirement. Hence, the need for old-age savings differs across individuals of different education levels, gender and labor productivities.

Since we assume that couples die jointly, things are slightly different for them. Before entering retirement, each partner draws one individual health shock h_g. The joint health shock h, is given by rounding the weighted average $\phi_h h_m + (1 - \phi_h)h_f$ to the nearest integer value. Joint survival probabilities $\psi_{j,h}$ depend only on the joint health shock h and are computed according to

$$\psi_{j,h} = 0.5\psi_{j,m,h} + 0.5\psi_{j,f,h}. \tag{17}$$

Children Households start economic life without having children. At age j_k, each women are subject to a fertility shock $k \in \{0, 1\}$. Women who draw $k = 1$ give birth to twins in the same period and raise these kids for 18 years. The probability $P(k|o)$ to give birth depends on a women's marriage status o. According to estimates from the German statistical office German Statistical Office (2020), the probability to become a mother is $\phi_{k,m=0} = 0.45$ for single women and $\phi_{k,m=1} = 0.80$ for married women. Incorporating these probabilities into model notation, we have

$$\pi_k(k^+|k, j, g, o) = \begin{cases} P(k|o) & \text{if } j = j_k \text{ and } g = f \\ \mathbf{I} & \text{otherwise,} \end{cases}$$

with $\mathbf{I}$ being the identity matrix. Consequently, our model features one single kids shock that individuals are exposed to at age $j_k = 30$. Kids need care and women suffer disutility from raising children in their free time. The disutility is governed by parameter ζ as discussed in section 4.3.1. Kids are exogenous to our model and never enter the mass of economic active individuals.

4.2 Technology

On the technology side we choose a depreciation rate of $\delta = 0.07$, leading us to a realistic investment to output ratio. We set the capital share in production at $\alpha = 0.3$ and normalize the technology level Ω such that the wage rate per efficiency unit of labor w is equal to 1. Finally, we assume an international interest rate of $\bar{r} = 0.03$, which constitutes as mix between the (currently) very low interest rates on deposits and long-run investment opportunities that offer higher returns.

4.3 Preferences and Endowments

4.3.1 Preferences

We let the period utility function be

$$u(c_j, \ell_j),$$

and

$$\lambda_m u(c_{j,m}, \ell_{j,m}) + (1 - \lambda_m) u(c_{j,f}, \ell_{j,f}),$$

for singles and couples respectively. The functional form of period utility $u(c_j, \ell_j)$ is given by

$$u(c_j, \ell_j) = \frac{c_j^{1-\frac{1}{\sigma}}}{1 - \frac{1}{\sigma}} - \nu \frac{(\zeta_j + \ell_j)^{1+\frac{1}{\chi}}}{1 + \frac{1}{\chi}} - \xi \times \mathbb{1}_{\ell_j > 0}.$$

We choose an intertemporal elasticity of substitution σ of 0.67.[13] The choice of σ has important implications for the size of the income effect of wage changes on labor supply. Heathcote et al. (2014) estimate a similar value for this parameter in a life-cycle model using cross-sectional data on earnings and consumption from PSID and CEX. Our preferred value for the Frisch elasticity is $\chi = 0.6$, like in Kindermann and Krueger (2021). This medium range value represents a mix between the very low empirical estimates of the labor supply elasticity of men and the much higher elasticities of women, see for example Keane (2011). We set the time discount factor to $\beta = 0.98$ and chose the level parameter of intensive labor supply $\nu = 43$ so as to target a 33 hour work week for the employed. Finally, we calibrate the parameter ζ_j to target empirical labor supply patterns of mothers when raising kids German Statistical Office (2020).

The micro Frisch elasticity χ only is an intensive margin elasticity and does not incorporate extensive margin choices. The macro labor supply elasticity, which incorporates both intensive and extensive margin choices, is typically larger, see the discussion in Keane and Rogerson (2011) or Peterman (2016). The extensive margin labor supply reaction to a change in wages is to a large degree determined by the probability density of the utility costs of employment ξ. If a large fraction of households is located directly at the threshold between not working and working, an increase in wages causes a greater fraction of households to switch from non-employment to employment.

Our calibration strategy for the distribution of participation costs ξ is the following: We assume that ξ is iid across households, drawn at the household-level and independent of the individual labor productivity $z(j, s, \eta)$. We let ξ follow a log-normal distribution with mean μ_ξ and variance σ_ξ^2. The mean $\mu_\xi = 0.92$ is set so as to target an employment-to-population ratio for the 25 to 54 year old of 78 percent. The variance σ_ξ^2 determines the participation elasticity.

4.3.2 Labor Productivity

We need to parameterize labor productivity. In our quantitative model labor productivity $z(j, s, \eta)$ depends on age j, education level s, and the transitory pro-

[13] In a model with inelastic labor supply, the implied risk aversion would then be equal to 1.5.

ductivity shock η. At the beginning of life, they draw one of two education levels: high-school education ($s = 0$) or college education ($s = 1$); the probability to draw $s = 1$ for a man is $\phi_{s,m} = 0.22$ and for a woman $\phi_{s,m} = 0.21$, according to German Statistical Office (2020). All individuals of education s share a common deterministic age specific labor productivity profile $\theta_{j,s}$. We calibrate labor productivity profiles and risk according to the estimates of Kindermann and Pueschel (2021)[14] as summarized in Table 1.

Table 1: Parameter values of labor productivity profiles and risk

	High School $s=0$	College $s=1$
Intercept $b_{0,s}$	−2.0732	−7.3497
Linear age term $b_{1,s}$	0.5981	4.3161
Quadratic age term $b_{2,s}$	−0.0570	−0.8465
Cubic age term $b_{3,s}$	0.0000	0.0562
Stagnation threshold $j_{M,s}$	∞	50
Autocorrelation ρ_s	0.9869	0.9900
Innovation Variance $\sigma^2_{\varepsilon,s}$	0.0054	0.0047

This functional form is flexible enough to capture both a hump-shaped ($j_{M,s} = \infty$) and a stagnating ($j_{M,s} < j_R$) life-cycle labor productivity profile. Note that in the case of a stagnating profile, labor productivity is constant from age $j_{M,s}$ onward.

4.4 Government Policies

We fix the pension contribution rate at $\tau_p = 0.186$, the current statutory rate of the German pension system. In equilibrium, our choice of τ_p results in a value of $\kappa = 0.46$, the gross replacement rate of the system. This is close to the replacement rate in Germany, which was around 45 percent in our base year 2017.

In our benchmark economy, we fix government consumption at 19 percent of GDP. We set the consumption tax rate at $\tau_c = 0.18$, thereby acknowledging the fact that some goods are taxed at rates smaller than the regular consumption tax rate of 19% in Germany. Modeling the progressive labor tax is important, as progressive income taxation already implies some redistribution and insurance. Following Benabou (2002), we assume a progressive labor income tax function of the form

$$T(y) = y - (1 - \tau_0)y^{1-\tau_1},$$
$$T(y_m, y_f) = 2\Big[\frac{y_m + y_f}{2} - (1 - \tau_0)\frac{y_m + y_f}{2}^{1-\tau_1}\Big],$$

[14]Kindermann and Pueschel (2021) make a distinction between so-called low productive worker and normal workers. The share of low productivity worker is set to zero in this analysis.)

for singles and couples, respectively. In this specification, τ_0 roughly resembles the average tax rate and τ_1 is a measure for progressivity. If $\tau_1 = 0$, the tax function collapses to a purely proportional one. A larger τ_1 means more redistribution across households of different income levels. As in Kindermann et al. (2020), we set $\tau_1 = 0.128$. We then choose $\tau_0 = 0.175$ such that the government collects enough tax revenue to finance its expenditures. Tables 2 summarizes the parameters of our model.

5 Simulation Results

In this section, we present simulation results from our quantitative model. We start by showing the central features of our benchmark economy. We then turn to counterfactual policy simulations, in which we introduce progressive components into the pension system.

5.1 The Benchmark Economy

Table 3 summarizes central macroeconomic aggregates of our benchmark economy with a proportional pension system as outlined in Section 3.5. Private savings are not enough to cover total capital demand. As a result, the economy exhibits a negative net foreign asset position of around 1.16 times GDP. On the goods market, this implies exports amounting to 3.41 percent of GDP to foreign countries. The government consumes 19 percent of GDP and 21 percent are invested into the future capital stock. The remainder is consumed by private households. The average work week of employed individuals between ages 25 and 54 amounts to 36 and 29 hours for men and women, respectively. The employment to population ratio (of the cohorts aged 25-54) is at 84 for men and 72 percent for women.

Table 4 provides an overview on labor supply for different family status. Single men and single women without kids show a similar pattern, with nearly 70 percent working full time. The proportion of single mothers working full-time is only half as high, while their share of part-time workers is with 35 percent relatively large, compared to other groups. On average, about 18 percent of the singles are not employed. Labor force participation rates of couples largely depend on gender. Only 13 percent of married fathers are not employed, while 37 percent of married mothers are not working and 15 percent have a mini-job. This implies that more than 50 percent of married mothers do not earn pensions entitlements. Within couples that don't have kids, men are the main earners. Women have lower participation rates and work less hours.

Table 2: Summary of model parameters

Parameter	Value	Data/Target
Exogenous parameters		
Bargaining weight husband: λ_m	0.500	
Share college educated men$\phi_{s,m}$	0.221	German Statistical Office (2020)
Share college educated women$\phi_{s,f}$	0.201	German Statistical Office (2020)
Assortative mating: $\phi_{s,m} = \phi_{s,f} = 0$	0.906	German Statistical Office (2020)
Assortative mating: $\phi_{s,m} = \phi_{s,f} = 1$	0.614	German Statistical Office (2020)
Gender wage gap		Schrenker and Zucco (2020)
Returns to scale in consumption $\upsilon_{j,k,m}$		OECD equivalence scale
Average survival probabilities $\bar{\psi}_{j,g}$		HMD (2020)
Population growth rate n	0.000	German Statistical Office (2020)
Retirement age j_R	64	DRV (2019)
Age kids shock j_k	30	
Pension contribution rate τ_p	0.186	DRV (2019)
International interest rate $\bar{r}$	0.030	
Capital share in production α	0.300	Labor share of 0.70
Intert. elasticity of substitution γ	0.667	Heathcote et al. (2014)
Frisch elasticity of labor supply σ	0.600	Kindermann and Krueger (2021)
Tax progressivity τ_1	0.128	Kindermann et al. (2020)
Consumption tax rate τ_c	0.180	German Statistical Office (2020)
Government consumption G/Y	0.190	German Statistical Office (2020)
Endogenous parameters		
Depreciation rate δ	0.07	I/Y: 0.21
Technology level Ω	0.92	Wage rate: 1
Disutility of intensive labor ν	43	Working hours per week: 33.0
Mini-job salary y_{mini}	$0.15\bar{y}$	max. mini-job earnings GER
Mean disutility employment μ_ξ	0.92	Participation rate: 0.78
Variance disutility employment σ_ξ^2	2.73	Participation elasticity
Disutility of kids ζ_j		Targets from German Statistical Office (2020)
Health shock probabilities $P(h\|s,\eta)$		see Section 4.1
Kids shock probabilities $P(k\|m=0)$	0.45	German Statistical Office (2020)
Kids shock probabilities $P(k\|m=1)$	0.80	German Statistical Office (2020)
Replacement rate κ	0.46	Budget balancing pension system
Average labor tax rate τ_0	0.17	Budget balancing tax system
Part time penalty	0.00	

5.2 Pension Reforms and Incentive Effects

We now present results from counterfactual policy analyses that emerge from reforming the pension system. In particular, we calculate alternative economies, where each economy features one of the pension systems discussed in Section 2.

Table 3: Macroeconomic aggregates

Variable	Value
Private Savings	184.40
Capital Stock	300.00
Net Foreign Assets	−115.60
Private Consumption	56.89
Government Consumption	19.00
Investment	21.00
Trade Balance	3.41
Labor Tax Revnue	9.80
Consumption Tax Revnue	10.19
Average Work Week of Employed 25-54 (in hrs)	32.89
Employment-to-Population Ratio 25-54 (in %)	78.08

Variables in percent of GDP if not indicated otherwise.

Table 4: Labor Supply Choices Age 30 - 54

Type	No empl.	Mini-job	Part-time	Full-time
Singles				
Men no kids	0.1777	0.0009	0.1259	0.6955
Women no kids	0.1783	0.0050	0.1408	0.6759
Women with kids	0.1774	0.0595	0.3550	0.3550
Coulpes				
Men no kids	0.2276	0.0426	0.1917	0.5382
Men with kids	0.1314	0.0293	0.1051	0.7342
Women no kids	0.2869	0.0653	0.2862	0.3616
Women with kids	0.3701	0.1483	0.2341	0.2475

To ensure comparability between simulations, we use the same set of structural parameters, but fix per-capita government consumption as well as the pension contribution rate at the benchmark economy's levels. The average tax rate in the labor tax system and the replacement rate of the pension system serve to balance the government's budgets.

The US-system In the US-system, the accumulation formula remains proportional and evolves according to

$$e^{+} = e + \min\left[w(j,g,k,\ell)z(j,s,\eta)\ell,\ 2\bar{y}\right]. \tag{18}$$

The progressive element enters the pension system trough the pension formula which is given by

$$pen = \begin{cases} r_1 \frac{e_{j_R}}{j_R - 19} \bar{y} & \text{if } \frac{e_{j_R}}{j_R - 19} < b_1 \\ r_1 b_1 \bar{y} + r_2 (\frac{e_{j_R}}{j_R - 19} - b_1) \bar{y} & \text{if } \frac{e_{j_R}}{j_R - 19} < b_2 \\ r_1 b_1 \bar{y} + r_2 (b_2 - b_1) \bar{y} + r_3 (\frac{e_{j_R}}{j_R - 19} - b_2) \bar{y} & \text{else.} \end{cases} \tag{19}$$

See Section 3.5 for a discussion of the incentive mechanism. The bend points are set to $b_1 = 0.2110,\ b_2 = 1.0614,$ and $b_3 = 1.2724$ which is equivalent to the bend points in the US in our base year 2017. The replacement rates r are initially set to the true US values ($r_1 = 0.9,\ r_2 = 0.32,$ and $\ r_3 = 0.15$). We then add $\tilde{\kappa}$ to each rate which is chosen such that the pension budget balances. See Table 6 for the final parameter values.

Note that the original US-pension system also provides benefits to spouses of retired workers. When entering retirement, a married individual can choose between pension payments based on her own pension entitlements or pension payments that worth 50 percent of the partner's pension. We implement this feature into our model as well.

The EIPC-system The *EIPC-system* follows the description in Section 3.5. The pension accumulation formula has two regions and is given by

$$e^+ = \begin{cases} e + (1 + \lambda_2) \frac{\min\left[w(j,g,k,\ell) z(j,s,\eta)\ell,\ 2\bar{y}\right]}{\bar{y}} & \text{if } w(j,g,k,\ell) z(j,s,\eta)\ell < 0.5\bar{y} \\ e + \lambda_2 + (1 - \lambda_2) \frac{\min\left[w(j,g,k,\ell) z(j,s,\eta)\ell,\ 2\bar{y}\right]}{\bar{y}} & \text{else.} \end{cases} \tag{20}$$

We set the progressivity parameter λ_2 to 0.75. The pension formula is proportional and given by

$$p(e_{j_R}) = \bar{y} \times \kappa \times \frac{e_{j_R}}{j_R - 20}. \tag{21}$$

The employment-linked system The employment-linked system is a special case of the EIPC system, where the upper threshold level for the subsidy region converges to zero. As such, the system provides a fixed subsidy to all employed households, regardless of their labor earnings. Kindermann and Pueschel (2021) discuss the effects of such a system in more detail. They conclude that such a system can maximize positive labor supply effects at the extensive margin. Compared to the benchmark model, we modify the pension accumulation formula by adding an *employment component*. Pension entitlements ep^+ then evolve according to

$$e^+ = e + \Big[\lambda_1 \bar{y} + (1 - \lambda_1) \min\left[w(j,g,k,\ell) z(j,s,\eta)\ell,\ 2\bar{y}\right]\Big]. \tag{22}$$

We set $\lambda_1 = 0.5$. Section 3.5 provides a description of the progressive mechanism and the labor supply incentives. The pension formula

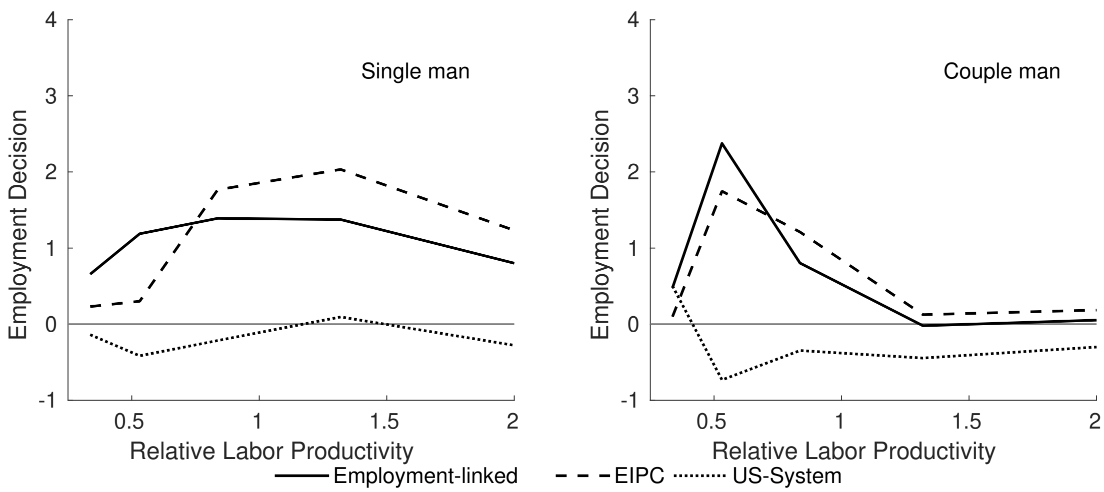
$$p(e_{j_R}) = \bar{y} \times \kappa \times \frac{e_{j_R}}{j_R - 19} \tag{23}$$

is again proportional.

5.3 Labor Supply Effects of Pension Progressivity

This section summarize the effects on labor supply at the extensive- and intensive margin of the simulated reforms. The horizontal axis denotes an agent's labor productivity relative to the average labor productivity of working-age men and women, respectively. On the vertical axis, we plot the change in employment rates/hours between the benchmark system and the reformed systems in percentage points. The effects are evaluated at the average distribution of wealth and pension claims for 40 year old high school educated men and women.

Figure 4: Labor force participation men



Extensive margin labor supply Figure 4 shows the simulation results for male worker. First, we focus on the solid and dashed line, which represent the results of a reform to the employment-linked system and to the EIPC system. For single men, the effect of the employent-linked system is fairly flat across all productivity types. Labor force participation increases by about 1 percentage point on average. In the EIPC system, the participation rate of low productive singles hardly changes, but the response of medium to high productive singles is 0.5 percentage points larger than what we observe for the employment-linked system. The picture looks different for married men. While more productive worker hardly react, the group of less to medium productive worker shows the strongest response. At the peak, the employment rate increases by 2.2 percentage points for the employment-linked system and by 1.8 percentage points for the EIPC system. The dotted line shows the results for the US-system. The effects are smaller in magnitude and slightly negative for most individuals. The participation rate drops by 0.15 and 0.25 percentage points on average for single and married men.

Figure 5: Labor force participation women

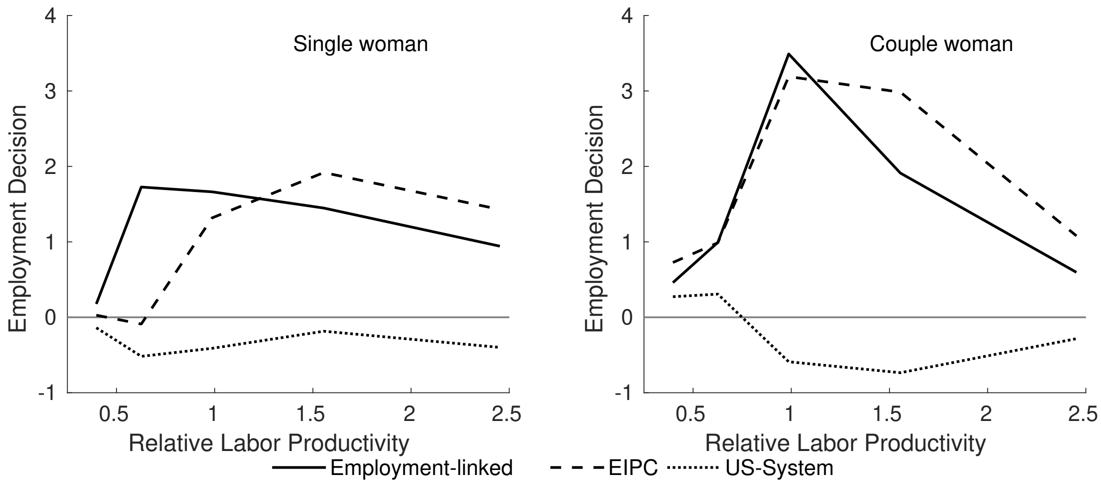
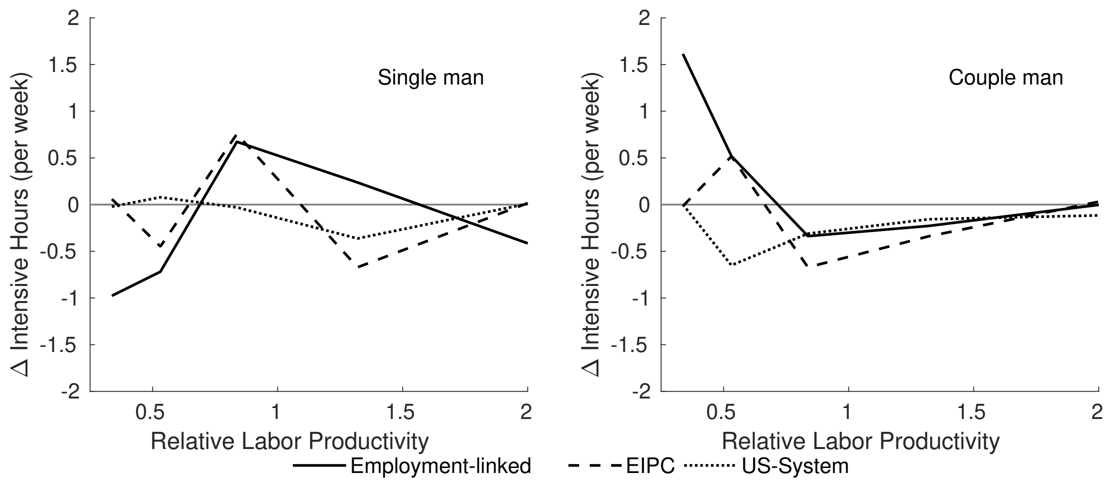


Figure 5 shows the effects for female worker. Single women react pretty much like single men. Compared to their male counterpart, the effects on married women are similar in shape but larger in magnitude. For instance, the participation rate of a medium productive wife increases by 3.5 percentage points when switching to either the employment-linkes system or the EIPC system. The US-system shows small negative effects on employment. Only low productive married women increase participation slightly.

Overall, we find that both the employment-linked system and the EIPC system provide positive labor supply incentives at the extensive margin. The effects are in particular strong for less productive married individuals. This group is often not employed and lives on the earnings of a more productive partner. Hence, they provide quantitatively great potential to enter the labor force. The US-system on the other hand distorts labor supply at the extensive margin. Low productive individuals are distracted, as they expect higher transfers in old age. More productive individuals, who are the net payers of the system, are distracted by a higher implicit tax rate.

Intensive margin labor supply The structure of these figures is the same as the previous one, though on the vertical axis we show the change in intensive margin labor hours of employed individuals. Figure 6 shows the simulation results for male worker to our proposed reforms. The picture is quite heterogeneous

Figure 6: Labor hours men



across reforms, productivity groups and marital status. Overall, married men tend to reduce hours in all reform scenarios, but the effects are small in magnitude (about -0.5 percentage points). Only low and less productive husbands increase hours with a reform to the employment-linked system. The effect peaks at 1.5 percentage points in the group of least productive individuals. The effect for single men fluctuates between -1 and +1 percentage points. Reactions to the US-system are smoother, but vary in the sign as well.

Figure 7: Labor hours women

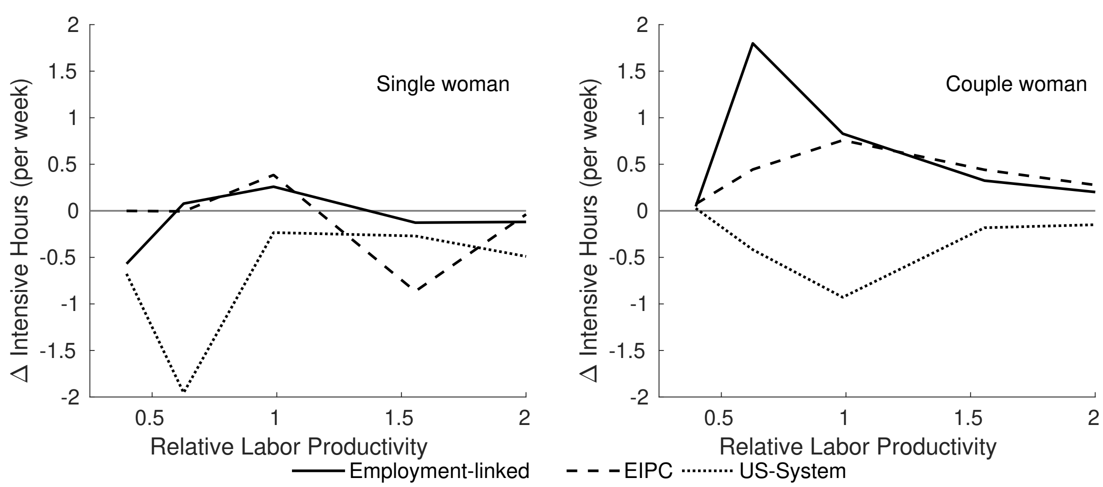


Figure 7 shows the intensive margin effects for women. Reactions to a reform to the emplyoment-linked and EIPC system fluctuate between -1 and +0.5 percentage points for singles, while married women increase hours. A reform to the

US-system disturbs intensive margin labor supply, with a stronger effect for single than for married women.

The effect on hours after a reform to either the employment-linked system or the EIPC-system is not clear. Reactions are fairly heterogeneous. In contrast when switching to the US-system, individuals of all groups tend to reduce hours. However, reactions in hours are overall small in magnitude.

5.4 The Distribution of Pension Claims and Old-age Poverty

5.4.1 Old-age pensions

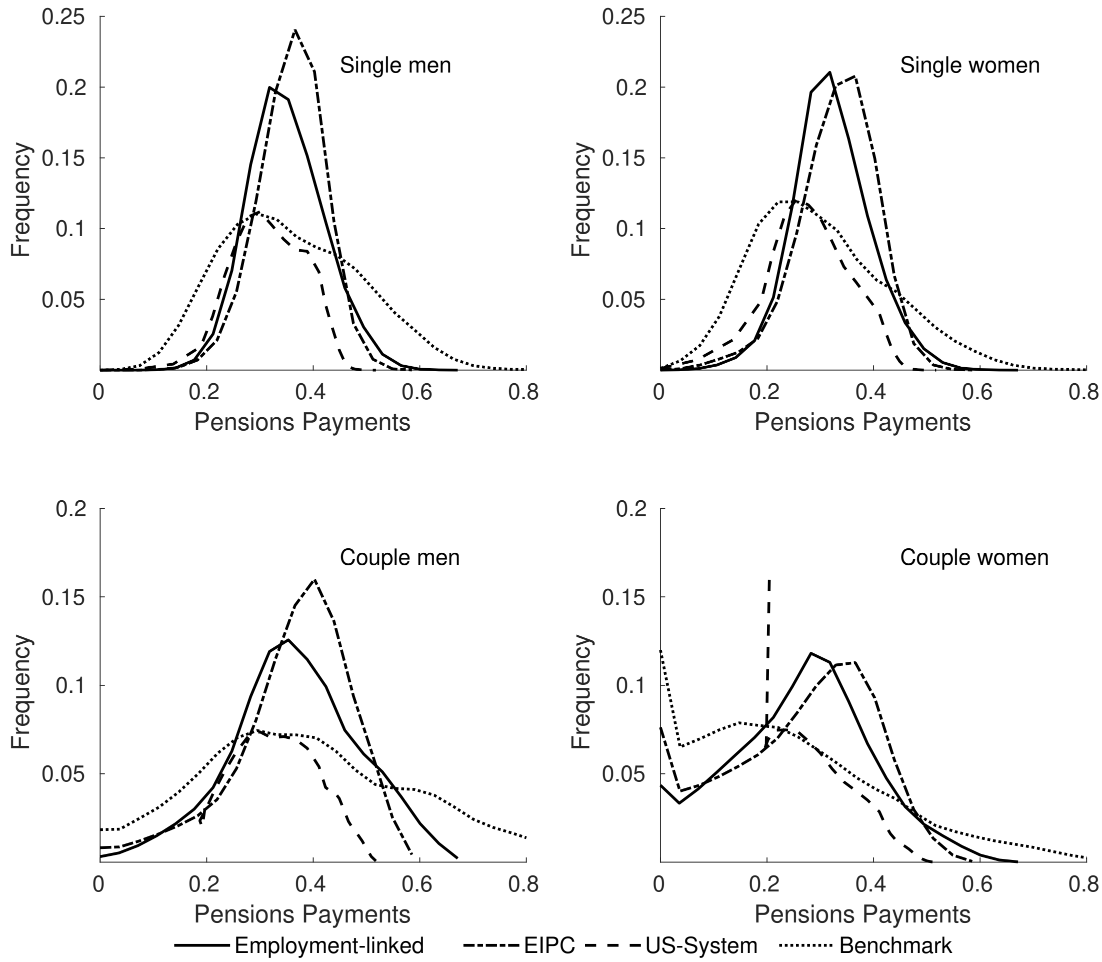
Increased pension progressivity not only comes with labor supply effects, it also alters the distribution of pension claims an individual accumulates over her working life. Figure 8 shows the distribution of pension payments relative to average labor earnings at the retirement age j_R for different pension systems. Recall that the pension contribution rate is $\tau_p = 0.186$ in all three scenarios.

The dotted line in Figure 8 displays the distribution of pension payments in the benchmark equilibrium. As pension claims are perfectly earnings related, this distribution is closely linked to the lifetime earnings distribution of households.

Singles: The shape of the distributions are similar for men and women. However, the women's curves are shifted to the left in all scenarios, which indicates lower pensions on average. Both the employment-linked system and the EIPC system result in a more concentrated distribution, compared to the benachmark with the EIPC system being slightly more progressive. The distribution of pension payments for the US-system is also more compressed relative to the benchmark, but has lower mean pensions than the alternative reforms.

Couples: The distribution of pension claims of married men exhibits fat tails. This is because men are often the main earners in a family and hence accumulate more pension entitlement over working live. Low productive husbands on the other hand end up with very low pension entitlements, living on the women's earnings. Further, we see that there are no husbands with pensions that are less than 0.14 in the US-system, which is exactly the cut-off value for the spouse benefits. A sizable fraction of married women enters retirement with no own pension payments at all. Most likely these women are married to a high productive husband and have hence not worked at all or were employed in a non-contributory mini-job. However, we see that the share of women with no own entitlements is largest in the benchmark case (12 percent), and shrinks to 4 (7) percent with an employment linked (EIPC) pension system. This shows that both systems are good for pulling individuals who are only loosely attached to the labor force into employment. The US-system exhibits a large spike at 0.13 due to spouse benefits.

Figure 8: Distribution of pension claims



5.4.2 Old-age poverty

In this section we measure the share of individuals who live at or below the existential minimum in old age. The German social security system defines the annual existential minimum as roughly $0.26\bar{y}$ for singles and $0.45\bar{y}$ for couples.

We compute the annual available resources $\tilde{y}_{j_R}$ at age j_R as

$$\tilde{y}_{j_R} = p_{j_R} - T(p_{j_R}) + \frac{a_{j_R}}{\bar{j} - j_R},$$

where $\bar{j}$ is expected age at death. Hence available resources per year in retirement are given by net pensions plus a fraction of current savings. Table 5 shows the share of individuals at age j_R who are at or below the poverty line. Almost a quarter of the population retires with resources below the existential minimum. Most worrying is the situation of single women with 41 percent. The EIPC system performs best in terms of poverty reduction. The aggregate number shrinks to 18.75 percent, the share of single women to one third. In the employment-linked system and the US-system the aggregate share of poor individuals also declines, but the situation of singles improves only a little bit. Couple households are the main beneficiaries in these reforms.

Table 5: Old-age poverty: share below poverty line at retirement age

		Reform		
Population group	benchmark	employment-linked	EIPC	US-System
Total population	**23.91**	**20.08**	**18.75**	**21.07**
Single men	25.08	23.45	19.83	24.93
Single women	41.09	39.09	33.67	40.57
Married men	19.88	15.12	15.24	15.88
Married women	19.88	15.12	15.24	15.88

Values are reported in percent of total population at age j_R.

5.5 A Macroeconomic Evaluation

The long-run macroeconomic effects that result from the reform scenarios are summarized in Table 6. Overall, the effects are moderate. Private savings increase slightly in all scenarios, which is a result of reduced pension payments to the income rich and hence more need for old-age savings. Note that there is an opposing effect on private savings, though. By providing insurance against unlucky labor productivity draws, a progressive pension reduces the need for precautionary savings. The two effect almost balance here. The capital stock declines as well to ensure a constant capital to labor ratio. Net foreign assets decline by as much as 5 percent in the US-system, the effects are smaller for the alternative reforms.

On the labor market side, all reforms distorts total intensive labor hours of the employed. The effects are more pronounced for women, who reduce hours by 3 percent in the EIPC system and by 2.5 percent in the US-system. Owing to the extensive margin incentive, total employment increases by 2 percent for women and by more than one percent for men in both the employment-linked and the EIPC system. In the US-system female labor force participation drops by 0.8 percent and male participation by 0.5 percent. The reduction in aggregate labor and capital causes a drop in GDP and private consumption.

Finally, with respect to the pension system, the replacement rate hardly changes in an employment-linked and EIPC system. Earned pension entitlements value as much as in the baseline scenario. As the US pension formula is piecewise-defined, we can not directly compare the replacement rates. The replacement rates are

Table 6: Reform exercise: macroeconomic effects

	Pension System		
Variable	Empl.-linked	EIPC	US
Private Savings	0.35	0.30	0.70
Capital Stock	−1.46	−2.01	−2.36
Net Foreign Assets	−2.94	−3.81	−5.02
Total Intensive Labor Hours (M)	−2.01	−2.40	−1.06
Total Intensive Labor Hours (W)	−1.96	−3.00	−2.45
Employment (M)	1.12	1.25	−0.48
Employment (W)	2.02	2.09	−0.78
GDP	−1.46	−2.01	−2.37
Private Consumption	−1.87	−2.47	−2.87
Average labor tax rate (in %p)	0.01	0.01	0.01
Aggregate pension payments	−1.11	−2.02	−2.93
Pension replacement rate (total)	0.44	0.46	
Pension replacement rate (in %p)	−0.02	0.00	
Replacement rates US (total)			0.86, 0.28, 0.11

Table reports percentage changes over initial equilibrium values if not indicated otherwise.

0.86, 0.28 and 0.11 for the low, medium and high entitlements in equilibrium (see Equation 20 for the corresponding cut-off values).

Most importantly to take away from this section is, that the adverse macroeconomic consequences in terms of output, capital accumulation and consumption are weaker in an employment-linked or EIPC system than for the US system. Positive employment effects due an extensive margin incentive can compensate disturbances at the intensive margin. Of course, we expect these effects to also impact on aggregate welfare, which we illustrate next.

5.6 Welfare Analysis

We now evaluate the welfare effects of progressive pensions. To this end, we calculate ex-ante expected life-time utility EV before any information about the household's education level or labor productivity has been revealed. We then compare two steady state allocations: the benchmark scenario with a proportional pension system and utility level EV_0, and a scenario with a progressive pension system with an associated utility level EV_∞. To give the welfare numbers a meaningful interpretation, we calculate the consumption equivalent variation CEV between the two utility levels. The consumption equivalent variation indicates by how many percent we would have to increase or decrease the consumption level of households at each age and each potential state in the benchmark equilibrium in order to make them as well off as in a reform scenario with progressive pensions. A negative value for CEV indicates that a reform of the pension system deteriorates long-run welfare and that households would be willing to pay a positive amount of resources in order to stay in the benchmark equilibrium.

The first row of the first panel in Table 7 shows the aggregate ex-ante welfare effects of the three proposed pension systems.

Table 7: Labor Supply Effects

	Reform		
Variable	employment-linked	EIPC	US-System
Change in ex-ante long-run welfare	**1.40**	**0.17**	**-0.97**
– for Single Men	−0.20	−0.18	−1.26
– for Single Women	1.36	1.36	−0.21
– for Married Men	1.70	−0.09	−1.27
– for Single Women	1.85	0.01	−0.89

Labor supply responses are reported as percentage changes over initial equilibrium.
Welfare effects are reported as CEV over initial equilibrium in percent.

The employment-linked system provides by far the largest welfare gains. Only single men would lose a little bit in this reform scenario. In the EIPC system, the group of single women benefit most, with welfare gains of 1.36 percent. However, this group represents only 15 percent of the total population. The other groups experience only minor changes in welfare, resulting in overall welfare gains of 0.17 percent. Finally, the US-system generates welfare losses. Every subgroup looses adding up to an aggregate welfare decline of 0.97 percent.

6 Conclusion

When thinking about the incentive effects of a progressive component in the pension system, the timing when the subsidy is credited matters. Our analysis has shown that a well-designed pension reform has the potential to increase both equity and efficiency of the system.

Starting from a purely proportional pension system, we conduct three reform exercises. In reform one (employment-linked system) and two (EIPC), we change the accumulation formula of pension entitlements such that an earnings-depended pension subsidy is rewarded for every period an individual participates in the labor force during working life. In reform scenario three (US-system), the pension subsidy enters the pension system through the pension formula, i.e. the equation that determines pension payments when entering retirement. Hence, the subsidy is based on life-time earnings rather than annual earning. Our analysis shows, that the behavioral responses differ substantially.

Aggregate effects show, that reform one and two distort labor supply along the intensive margin by weakening the link between individual earnings and accumulated pension claims. However, it implicitly subsidizes steady employment. In addition, it compresses the distribution of pension entitlements when individuals enter retirement.

For reform three, the US-system, we find quite distinct effects. While the former system encourages employment the latter discourages it. In addition, the distribution of pensions payments exhibits a lower mean and aggregate pension payments are below the values in the other two reforms.

A welfare analysis reveals that both the employment-linked and the EIPC reform have the potential to increase long-run welfare, while the US-system deteriorates welfare.

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