Preventing Reforming Unequally

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Abstract

Increasing pressures in most developed countries due to population aging have forced policy makers to reform pension systems. While the main focus of these reforms has been on sustainability, inequality looms as "collateral damage". This paper introduces a unified framework to measure the effects of pension reforms on both inequality and sustainability of the pension system. The paper's main innovation is to take feedback effects from labor supply and endogenous retirement decisions into account for a series of pension reforms that have been proposed/implemented worldwide. Results suggest that both sustainability of the pension system and total welfare of individuals tend to increase after the implementation of each pension reform. However, this comes at the cost of increasing intra- and inter-generational inequality, the only exception being the actuarial neutral reform for inter-generational inequality. This stems from a stronger response of high skilled individuals to reforms (intra-generational) and less labor distortions and lower contributions to the pension system by working-age individuals (inter-generational). When taking into account income from assets holding, however, most reforms show a beneficial effect on intra-generational inequality due to stronger reactions in savings by the low skilled households. Because of the rich nature of our unified model framework, we are able to rank reform proposals according to several micro- and macroeconomic criteria.

Keywords:
Population aging, pension reform, inequality, life-cycle behavior, labor supply, retirement age, welfare

JEL classification: C68, D91, E17, H55, J11, J26

1. Introduction

Pension reforms are a subject of controversy in many countries. In Europe, where the number of retirees per worker will continue to increase until about 2050, unsustainability threatens public pay-as-you-go (PAYG) systems. Several arguments have emerged pointing out how to establish a new pension system framework in order to avoid imbalances of the system and how to handle social expectations regarding retirement, income stability, and future well-being. It is feared that decreasing replacement rates or increasing contribution rates will lead to old-age poverty and disincentives in labor supply at younger ages. This demographic transition and the negative effects of early retirement urged countries to take reforms that could no longer wait to be implemented, especially given the risk of unsustainability and the financial crisis that has undermined the budgets of countries in the last decade. Facing this challenge, numerous reforms have been put forward by policy makers to promote more active aging and a longer working life (Graf, et al., 2011; Börsch-Supan, 2007; Huber, et al., 2013; Sonnet, et al., 2014; Börsch-Supan, et al., 2017c; World Bank, 1994; OECD, 2017). Such reforms include increasing the full pensionable age in Germany or Italy (Börsch-Supan, 2007; Boeri, et al., 2016), the introduction of flexible retirement mechanisms in Norway and the UK (Börsch-Supan, et al., 2017a), and even profound changes in the main framework of the pension system as in Sweden and Italy (Palmer, 2000; Moscarola & Fornero, 2009). Despite this immense source of possible pension reforms, most of these studies are mute concerning inequality and redistributive impacts. In the literature on pension reforms, some papers dig into the inequality aspects of social security systems (Hurd & Shoven, 1985; Weizsaecker, 1996; Weizsaecker, 1995), but few studies focus on how reforms of the pension system affect the redistributive effects of the social security system (Etgeton, 2018). The majority investigates policy changes in the structure of the pension system from a typical unfunded PAYG system to a fully funded pension system (Huggett & Ventura, 1999; Hairault & Langot, 2008; Deaton, et al., 2002; Fehr, et al., 2012; Auerbach & Kotlikoff, 1987). The main theoretical findings point to an increase in inequality when a funded pension system is implemented in contrast to a large unfunded PAYG pension system. Van Vliet et al. (2017) find that the higher the weight of the private pensions tier, the higher the levels of income inequality and poverty among the elderly. To our knowledge, no research has been undertaken that analyzes the impact of reforms of the different elements of the pension system, namely changes in the full pensionable[1] ages or in adjustment rates, on inequality. This paper fills this gap in the literature by examining how several reforms proposed in the literature perform under the test for inequality.

[1] Full pensionable age is the pivotal age at which an individual is eligible for full public old-age pension benefits, without reduction for early claiming or premium for later claiming.

This paper combines the lines of research on pension reforms, aging, inequality, and its macroeconomic implications. It sets a base for comparison of different reforms that have been recently proposed by the literature (Börsch-Supan, 2007; Gustman & Steinmeier, 2005) and evaluates the endogenous reactions of households, which may dampen the intended outcomes of each reform and their effects on inequality levels. We build a rich OLG model of the Auerbach and Kotlikoff type (Auerbach & Kotlikoff, 1987) and quantify the effects of pension reforms on the sustainability of pension systems and on intra- and inter-generational inequality, taking into account demographic change and macro- and microeconomic feedback effects.

An important feedback effect arises when reforms aiming at increasing the extensive margin of labor supply lead to smaller reform effectiveness due to negative labor supply adjustments on the intensive margin – the so called backlash effects (Börsch-Supan, et al., 2014). Not taking this into account could therefore bias reform evaluations. Studies have shown that wealth and financial incentives have a great impact on retirement decisions (French, 2005; Chan & Stevens, 2008) as well as on the household composition and income status of individuals (Coile, 2004; van der Klaauw & Wolpin, 2008; Gustman & Steinmeier, 2004; Fuster, et al., 2003). The design of pension systems is of great importance for determining the impact on retirement behavior because individuals' behavior depends on changes in incentives and in the framework of pension systems (Gustman & Steinmeier, 2005; Duggan, et al., 2007; Kotlikoff, et al., 2007; Börsch-Supan & Schnabel, 1998; Gruber & Wise, 1999; Börsch-Supan, et al., 2018). Differences in retirement behavior among individuals results in different income paths which in the aftermath of the reforms may aggravate or reduce income inequality between cohorts or skill groups.

Following the existing literature (Sánchez-Martín, 2010; Catalan, et al., 2010; Fehr, et al., 2012), we start by setting a baseline scenario with a full pensionable age of 65. We study incentives for retirement by focusing on the pension system: the model incorporates a PAYG system that connects individual contributions to social security and to benefits when retired (point system), which is partially or fully implemented in countries like France, Germany, and Norway (Social Security Administration, 2014). We introduce heterogeneity with respect to individual productivity skills, survival rates, consumption preferences and working time costs by defining three equally large groups of individuals which differ in their skills, health and preferences. We define them such that each one of the groups represents a characteristic profile of a worker from a low, intermediate and high percentile of income/wealth group. For example, we assume that a representative of the low percentile income group is an individual who is less productive than the average individual and has a steeper decline in health which leads to increasing time costs of working, a lower survival probability and an increasing preference for leisure to cope with these health problems. These dimensions allow examining endogenous retirement decisions and distributional effects of pension reforms as well as unequal effects of reforms between groups with respect to welfare.

Our model shares some features with the recent papers referred to above. However, it extends the reform settings in a comprehensive way by analyzing a number of new reform scenarios, enabling us to provide comparable outcomes from different reform proposals that have emerged in the literature. Consequently, we contribute a systematic comparison of different reforms and their impacts on inequality to the literature. In addition, our model sets a unified framework to compare different reform proposals and their effects on both sustainability of the pension system and inequality among different population groups. Inequality is evaluated both by studying inter–generational differences in current income, as well as intra-generational effects, via comparison of the current income among heterogeneous groups in the economy. For better understanding of the inter-generational inequality measure, an analysis on income over time is carried out for different age groups. As for welfare changes between reform and baseline scenarios, we calculate consumption equivalent variations. Sustainability will be measured through the burden posed on labor supply (contribution rates) or generosity of the pension system (replacement rates) – only in the case of the hybrid DB/DC system. Accordingly, we interpret higher contribution rates and/or lower replacement rates as defining a less sustainable pension system.

In the baseline scenario, where a typical DB system with full pensionable age of 65 and lower than actuarially neutral adjustment rates is in place, most individuals choose early retirement. We assume that an earnings test is in place, meaning households leave the labor market at the time of claiming pension benefits. This setting represents most pension systems that currently produce incentives for early retirement (Börsch-Supan, 2004; Werding, 2007; Gasche, 2012). Individuals belonging to a low income percentile retire earlier than their wealthier counterparts, motivated by their quickly declining health in old age and financial incentives. As a consequence, they suffer more from the negative financial impacts of population aging in the pension system. Therefore, intra-generational inequality rises over time when one only considers labor and pension income, although asset income may compensate the earnings loss and approximate again all different groups of individuals. In contrast, inter-generational inequality decreases as demographic change effects become less strong over time.

As a first reform, we simulate an increase of the full pensionable age (FPA) from 65 to 67, which has already been or is still being introduced in several countries such as France, Germany, the UK, and others (Social Security Administration, 2014). Our results show that although actual retirement ages might not react fully to the increase in the full pensionable age, this reform leads to an increase in the labor force participation among older workers as observed empirically in Hanel and Riphan

(2012) and Blundell and Emmerson (2007). Moreover, individuals work longer which takes pressure from the pension system's budget constraint and leads to beneficial effects for the PAYG pension system, which allows for lower contributions. However, this is the case because adjustment rates are currently low in most European countries (see Table A.2), otherwise, with actuarial neutral adjustment rates in place, expenditure effects would be neutral when actual retirement ages change. In terms of welfare measures, households are better off in this case than in the baseline scenario in terms of consumption possibilities. One must note that in this paper we measure welfare taking into account consumption equivalent variations and leave aside other measures that also contribute to the welfare of individuals (e.g. decline of health). Positive welfare consequences for increasing full pensionable ages are in line with the literature (Beetsma, et al., 2003; Kotlikoff, et al., 2007; Catalan, et al., 2010). Inter-generational income inequality levels are higher in the aftermath of the reform in comparison to the baseline case. The same holds for intra-generational inequality when measured without income from assets, otherwise there are no differences identifiable.

However, such a reform has only temporary success until the previous imbalances, which were taken care of by the onetime increase of the FPA, emerge again since life expectancy is persistently increasing. That is why an increase in the FPA today to 67 would lead, in about a decade, to the same problems currently being faced by the pension system. A way to prevent a repetition of this political discussion every decade is proposed by Börsch-Supan (2007) and OECD (2017). This proposal suggests that the connection between the full pensionable age and the increase in life expectancy is automatic. We model this reform in a second scenario and find that an automatic update of the FPA generates similar results as in the previous reform scenario (as it should be expected) but it avoids the sometimes conflicting political decisions through time.

Addressing early retirement incentives, we simulate a third scenario with actuarial neutral adjustment rates before and after the FPA. In this case, individuals work longer, removing pressure from the pension system's budget, confirming previous findings in the literature (Börsch-Supan, et al., 2018; Gustman & Steinmeier, 2005) that the sustainability of the pension system improves with such reform. We observe that low income percentile groups react almost as much as high income percentile groups in terms of the change on retirement age. Still, intra-generational inequality increases substantially in comparison to the baseline scenario when neglecting income from assets, otherwise one can see an improvement of equality. Interestingly, inter-generational income inequality is lower due to this reform compared to the baseline scenario since it increases relatively more the income of the old age groups in comparison to the working age groups. In terms of welfare measures, all households are better off when actuarial neutral adjustment rates are added in the previous scenario.

As a final reform, we simulate the introduction of a hybrid DB/DC system. Political supporters of this reform argue that the sustainability of the pension system is jeopardized if such measures are not taken. However, the opponents state that old-age poverty will increase if such reform is introduced and maintained. They advocate that the replacement rate should be held constant at current levels. If, on the one hand, they are right to argue that old-age poverty may increase and create a higher gap between income percentile groups, on the other hand they fail to understand that this reform substantially improves the sustainability of the pension system. Contribution rates decrease by almost 12 p.p. compared to the baseline, while the replacement rates also decrease by around 15 p.p. in the long run. This leads to severe consequences for inter-generational income inequality: young/working age groups profit significantly from this type of reform while older age groups receive lower pension benefits. In the same tone, intra-generational inequality increases for non-asset income measurements compared to the baseline scenario since adjustments in retirement behavior are less costly and more rewarding for high income percentile groups than for their low income counterparts due to differences in health, consumption preferences and productivity. However, taking income from assets into account, a small improvement in intra-generational inequality can be observed.

The paper is structured as follows: Section 2 introduces the model and its components. The numerical solution of the model and calibration procedures are described in Section 3. The baseline scenario is presented and discussed in Section 4. In Section 5, the performance of each reform in comparison to the baseline scenario is analyzed and discussed. Section 6 concludes.

2. The endogenous retirement decision model

We extend the OLG model of the Auerbach and Kotlikoff (1987) type in several dimensions: we add a model of a detailed earnings-related DB-PAYG public pension scheme. In addition, we include monetary incentives for early or late retirement through the adjustment of pension benefits. Consequently, we allow for a discrete endogenous choice on retirement in addition to the continuous leisure/work and consumption/saving trade-offs. Furthermore, we introduce three household types, which differ with respect to four dimensions: consumption preferences, wage profiles, survival rates, and time costs of working. This detailed setting allows for numerous reforms within the same model framework, which will be discussed in Section 5.

2.1 Household problem

There are $k = 3$ different types of perfectly foresighted households at every point in time t with age j (heterogeneous individual setting). Each k-group has a population size equal to $1/k$ of the total population at each time, t. It is assumed that they live up to a maximum age of J years.

Households have preferences over consumption and leisure. Accordingly, household k receives utility from consumption and leisure as given by the following per-period utility function

$$u\left(c_{t,j}^{k}, l_{t,j}^{k}\right) = \frac{1}{1-\theta}\left[(c_{t,j}^{k})^{\phi_j^k}(l_{t,j}^{k})^{1-\phi_j^k}\right]^{1-\theta}. \tag{2.1}$$

u^k is twice continuously differentiable, strictly increasing in consumption and leisure, and strictly concave. ϕ_j^k denotes the utility weight of consumption versus leisure and is household type- and age-dependent. Risk aversion is described by the parameter, θ, and a von Neumann-Morgenstern (VNM) expected utility maximization program over the entire life-cycle.

Leisure is time endowment (normalized to one) less hours worked, $h_{t,j}^k$. Additionally, a time cost $\vartheta\left(h_{t,j}^k\right)$ to take up work (also measured in hours) is introduced:

$$l_{t,j}^{k} = 1 - h_{t,j}^{k} - \vartheta\left(h_{t,j}^{k}\right). \tag{2.2}$$

Time costs $\vartheta(h_{t,j}^k)$ are present when households work and mimic the effect of declining health on the disutility of work (Börsch-Supan & Stahl, 1991). This effect may be non-linear, increasing with the number of hours worked. The cost function is given by

$$\vartheta\left(h_{t,j}^{k}\right) = \chi_j^k\left(1 - \frac{1}{\left(1+h_{t,j}^{k}\right)^{\xi}}\right), \tag{2.3}$$

where χ_j is the household type- and age-dependent time costs of disutility of work and health decline and ξ is a smoothing parameter for these time costs of working[2].

Each household k maximizes utility

$$max \sum_{j=0}^{J} \beta^j \pi_{t,j}^{k} u^k\left(c_{t,j}^{k}, l_{t,j}^{k}\right), \tag{2.4}$$

where β^j is the discount factor and $\pi_{t,j}^k = \prod_{u=0}^{j} \varphi_{t,j}^k$ is the type-dependent (unconditional) survival probability. $\varphi_{t,j}^k$ is the corresponding conditional survival probability. Thus, households have uncertainty about the time of death and, therefore, have their life expectancy determined by the introduction of survival rates, which allows them to account for the probability of dying before

[2] Note that under a sufficient ξ>0, the cost function quickly approaches zero when hours worked are small. We use this shape of the cost function to avoid discrete jumps in time costs at $h_{t,j}^k = 0$. The function smooths the costs function for values of hours worked close to zero. These assumptions on time costs lead to a more realistic hours profile.

reaching age J. We do not include intended bequests in our model and assume that accidental bequests resulting from premature death are taxed away by the government at a confiscatory rate and used for otherwise neutral government consumption.

Wages depend on age and household type,

$$w_{t,j}^{k} = w_t \varepsilon_j^k, \tag{2.5}$$

where ε_j^k generates age and type specific wage profiles.

The budget constraint is given by

$$a_{t+1,j+1}^{k} = a_{t,j}^{k}(1 + r_t) + h_{t,j}^{k} w_{t,j}^{k}(1 - \tau_t) + p_{t,j}^{k} - c_{t,j}^{k} \tag{2.6}$$

with

$$0 \leq h_{t,j}^{k} \leq 1 - \vartheta(h_{t,j}^{k}) \text{ and } c_{t,j}^{k} > 0. \tag{2.7}$$

$p_{t,j}^{k}$ are individual pension benefits (see below) and $a_{t,j}^{k}$ denotes assets. τ_t is the contribution rate of the public pension system.

Households' labor and pension income, $h_{t,j}^{k} w_{t,j}^{k}(1 - \tau_t) + p_{t,j}^{k}$, will be the key measure for inequality jointly with income from asset holdings ($a_{t,j}^{k} r_t$). For inter-generational inequality, the Gini coefficient is calculated using current income for all cohorts alive at time *t*. The development of this measure through time reveals some information about how (un)equal income is distributed between cohorts and how this evolves over time. An increase in the measure would therefore mean that younger generations face more inequality in income than older generations. While evaluating reforms, this measure informs about the distribution of the burden/gain between generations. In a second step, we conduct a group analysis of inter-cohort inequality to identify the age groups that profit or lose from the respective pension reforms. This is carried out by calculating each age group's average income and comparing it to the mean of all age groups delivering a measure for the relative income position of each age group. Intra-generational inequality is measured by calculating the Gini coefficient using current income. Accordingly, it measures how income is distributed between household types within a specific cohort. An increase of this measure would mean that households in the high income percentile profit more from a reform than other households, for instance.

Finally, to complement the previous measures we determine changes in welfare by utility comparisons through calculating consumption equivalent variations. It represents the percentage of lifetime consumption that a household would be given in a baseline scenario in order to be as well off as in an alternative scenario.

2.3 The public pension system

The benchmark PAYG pension system is a defined benefit (DB) pension system. It includes relevant characteristics of different pension systems in Europe allowing for a generalization of our results. This DB-PAYG system combines the French and German point systems when it comes to the question of how individual earnings are related to pension benefits. The point system links individual benefits to the number of years contributed to the system and the relative earnings position compared to the economy's average. As a result, households understand the link between contributions and later pension benefits.

A pension system of the defined benefit type means that a cohort of retirees is promised a pension benefit, $p_{t,j}^{k}$, which is typically defined by a replacement rate that is independent from the demographic and macroeconomic environment. The contribution rate to the system must then be adjusted to keep the PAYG system balanced. This set-up puts the highest burden on the young/working generation since the contribution rate has to adjust in order to balance the pension budget equation (see 2.8).

In the pension reform simulation in Subsection 5.4, pension payments are made dependent on demographic developments and economic growth through a factor which adjusts the replacement rate is a similar idea as in notional defined contribution (NDC) pension systems, which were introduced in Sweden and Italy in the 1990s, for instance. This combination of the Italian and German DC and DB systems boils down on a hybrid DB/DC-PAYG system which works as a balancing mechanism that moderates the negative impacts of population aging between different generations. The aforementioned mechanism balances the burden of demographic change between different generations. Accordingly, the contribution rate to the pension system has to adjust less in times of population aging since the adjustment rate automatically scales down individual pension payments.

The yearly pension budget equation is assumed to be balanced and given by

$$\tau_t w_t \sum_{k=1}^{K} \sum_{j=1}^{R_t^k} \varepsilon_j^k h_{t,j}^k N_{t,j}^k = \sum_{k=1}^{K} \sum_{R_t^k+1}^{J} p_{t,j}^k N_{t,j}^k, \tag{2.8}$$

with individual pension benefits, $p_{t,j}^{k}$,given by

$$p_{t,j}^k = \gamma_{t,j}^k b_t w_t (1-\tau_{t,i}) \overline{h}_t \frac{s_{t,j}^k}{\overline{R}_t}. \tag{2.9}$$

$\overline{R}_t$ is the full pensionable age and R_t^k is the actual retirement age of household type k and the cohort retiring in t. $N_{t,j}^k$ represents the number of people aged j, at time t and in household-type k. Further definitions are given by

$$s_{t,j}^k = \sum_{m=0}^{j} \frac{\varepsilon_m^k h_{t-j+m,j}^k}{\overline{h}_{t-j+m,j}^k}, \tag{2.10}$$

where

$$\overline{h}_t = \frac{\sum_{k=1}^{K} \sum_{j=1}^{R_t^k} \varepsilon_j^k h_{t,j}^k N_{t,j}^k}{\sum_{k=1}^{K} \sum_{j=1}^{R_t^k} N_{t,j}^k}. \tag{2.11}$$

$s_{t,j,i}^k$ evolves according to

$$s_{t+1,j+1}^k = s_{t,j}^k + \frac{\varepsilon_j^k h_{t,j}^k}{\overline{h}_t}. \tag{2.12}$$

The term $s_{t,j}^k$ links individual labor (and therefore contributions to the pension system) to the aggregate economy ($\overline{h}_t$) and resembles the accumulation of pension points over the life-cycle. Accordingly, when working the average hours of the economy in a given year t, the household receives one pension point. Upon retirement, the quantity of accumulated pension points decides the level of pension benefits.

Departing from the DB baseline system, in Subsection 5.4, we introduce a mechanism to replicate the hybrid DB/DC-PAYG system, b_t, that scales the pension benefits in equation (2.9) up or down according to developments in wages and demographics. The replacement rate will evolve according to

$$b_t = b_{t-1} * \frac{w_{t-1}(1-\tau_{t-1})}{w_{t-2}(1-\tau_{t-2})} * \left(\frac{RQ_{t-2}}{RQ_{t-1}}\right)^{\mu}. \tag{2.13}$$

RQ_t is the ratio of the number of retirees to the number of contributors to the pension system at time t. Accordingly, pension benefits are scaled down (up) when net wages decrease (increase) and when the quotient RQ_t increases (decreases) over time, which is the case in times of population aging. As Börsch-Supan et al. (2017c) argue, the parameter μ can be set as a political compromise between current voters' preferences and the financial sustainability of the pension system. The parameter captures the intergenerational distribution of the demographic risk generated by population aging.

Setting $\mu=0$ stabilizes the replacement rate of pension benefits to the older generation, while $\mu=1$ stabilizes the contribution rate of the younger generation. The actual value will range within these to extremes constituting a political compromise.

2.4 Endogenous retirement decision

A specific feature of the model is that households decide on the age of retirement. An endogenous retirement decision is modeled and households take into account the optimization of their consumption/savings and hours worked/leisure to define their own optimal age for retirement. Most modern pension systems have a window of retirement defined by an earliest and a latest eligibility age, $R_E \leq R \leq R_L$, which bracket what is colloquially termed the "normal retirement age", R. Accordingly, households have a choice to retire within a given window. Retirement age is defined as the age when the household simultaneously leaves the labor market and claims pension benefits. Accordingly, a full earnings test is in place (see e.g., Börsch-Supan, et al. (2018)).

To penalize earlier retirement and to promote a later retirement age, the pension system incorporates actuarial adjustments before and after the full pensionable age to pension payments if households retire before or after the full pensionable age, $R_E \leq \overline{R}_t \leq R_L$. These actuarial adjustment factors behave as already described in equation (2.14).

$\gamma_{t,j}^k$ is the individual specific adjustment factor of the retirement formula (2.9). The factor equals 1 if the household retires at the full pensionable age. If the household decides to retire earlier, there is a deduction of ω_t percent (adjustment rate) of pension benefits for every year. For each year of delayed retirement, there is a premium of ω_t percent. However, there will always be an earliest retirement age, R_E, that households cannot undercut[3]. $\gamma_{t,j}^k$ is given by:

$$\gamma_{t,j}^k = 1 + \left(R - \overline{R}_t\right)\omega_t. \qquad \text{for} \qquad R \geq R_E \qquad (2.14)$$

As previously mentioned, the adjustment rate, ω_t, creates strong incentives for when to retire (Desmet & Jousten, 2003; Gruber & Wise, 2005; Fisher & Keuschnigg, 2010; Börsch-Supan, et al., 2018). Occasionally, it is referred to as "actuarial adjustment rate," although the term "actuarial" only applies when ω_t is introduced in the pension system such that the present discounted value PDV_t of participating in the pension system for all households is independent of their retirement age, R. Pension systems with benefits independent of the individual retirement age (i.e. $\omega_t = 0$) are not actuarially neutral since they redistribute income from late retirees to early retirees who receive the same benefits over a longer period of time. Therefore, $\omega_t = 0$ creates a strong incentive for

[3] Note that we abstract from disability insurance in our model setting.

workers to retire early. The same argument applies when adjustment rates are lower than the actuarially neutral value. This is the case in many countries; see Table A.1 in the appendix.

2.5 Production

The production sector consists of a representative firm. Production is given by a Cobb-Douglas production function using capital stock, K_t, and aggregate effective labor, L_t, as inputs.

$$Y_t = K_t^{\alpha}(A_t L_t)^{1-\alpha}, \tag{2.16}$$

A_t is technology (growing at rate g_t). α is the capital share in the economy. Since factors earn their marginal product, the wage and interest rate are given by

$$w_t = A_t(1-\alpha)k_t^{\alpha}, \tag{2.17}$$

$$r_t = \alpha k_t^{\alpha-1} - \delta\ , \tag{2.18}$$

where k_t denotes the capital stock per efficient unit of labor ($K_t/(A_t L_t)$) and δ is the depreciation rate of capital. We also introduce a wedge between the interest rate perceived by households and the market interest rate/marginal product of capital.

3. Model solution and calibration

3.1 Computational algorithm

This computable general equilibrium (CGE) model has to be solved numerically. The algorithm searches for equilibrium paths of consumption, hours worked, capital to output ratios and, in case there are social security systems, pension contribution rates. We determine the equilibrium path of the OLG model by using the modified Gauss-Seidel iteration as described in Ludwig (2007). The solution of the life-cycle optimization is solved recursively by taking initial guesses for consumption at last age. Then, the model is solved backwards using recursive methods by applying first order conditions and appropriately handling the constraints. This procedure delivers first guesses for the vectors of consumption and hours worked. Labor time costs are taken into account when calculating hours worked. Costs tend to increase in age and reflect the additional burden of older workers remaining in the labor market. We then calculate savings and assets, using the budget constraint (2.6). The consumption profile, including consumption at last age, is then updated. This procedure is repeated until consumption and the hours profile converge. We do not allow the household to re-enter the labor market. The endogenous decision of retirement is a second step of the algorithm and a by-product of the main optimization method. To solve it and calculate the retirement age, we use an outer loop that searches for the retirement age which maximizes the household's utility. Hereby, we carefully take into account the adjustment rate that gives incentives for early or late retirement. After the convergence of these inner loops, all cohorts' asset holdings and hours worked at a given year, t, are aggregated to receive the capital stock, K_t, and labor supply, L_t. By using equations (2.17) and (2.18), the wage and interest rate can be updated. Our timeline has four periods: a phase-in period, a calibration period, a projection period, and a phase-out period. First, we start calculations with the assumption of an "artificial" initial steady state in 1850. The time period around 2015 is then used as the calibration period to determine the structural parameters of the model. Our projections run from 2015 until 2075. For technical reasons, the model then runs further during a transition to a steady-state population in 2150 and an additional 100-year period until the model reaches its final steady state in 2250.

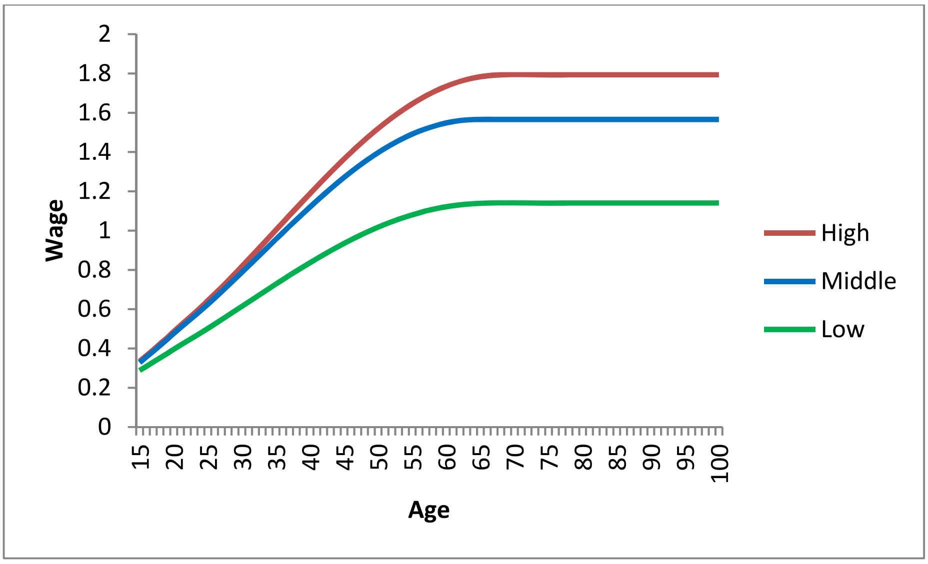
3.2 Calibration

3.2.1 Household types

We introduce three household types and model them by including different life-cycle profiles for wage profiles, survival rates, consumption preferences and time costs. As referred before, we define them such that each one of the groups represents a characteristic profile of an individual from a low, intermediate and high percentile of income/wealth. Therefore, there is a representative household that is less productive than the average individual and has a steeper decline in health. Another type of household is at the other extreme, such that it has a very slow and flat decline in health, and a high level of productivity. An intermediate type is also considered which has characteristics that are in-between the two opposite types.

In the majority of the literature, wage profiles are used to model endogenous retirement decisions (see Altig et al. (2001); French (2005); Huggett et al. (2011)). Often, these wage profiles are hump-shaped, i.e. individual productivity first increases when young and reaches a peak in middle age. Afterwards, productivity decreases again as a consequence of the aging process, like deteriorating health or declining cognitive skills. Lower wages in old age induce retirement at some point because the disutility of work outweighs the utility from receiving income. As Casanova (2013) argues, these hump-shaped wage-age profiles in econometric studies usually stem from "pooling observations of full- and part-time workers." According to her study, however, when only full-time workers are considered, wage-age profiles are flat in later ages. This point is also discussed in detail by French (2005). When estimating hourly wage profiles, he also finds a hump-shaped pattern over age. However, as soon as he controls for part-time work and considers exclusively full-time workers in his regressions, he finds flat wage-age profiles for later ages. The latter finding is consistent with studies that show that there is no decreasing labor productivity at later ages of workers (Börsch-Supan & Weiss, 2016). Accordingly, we introduce wage profiles that do not decline in old age, but rather stay constant after reaching their maximum (see Figure 3.1).

Figure 3.1 – Wage profiles



Source: own calculations.

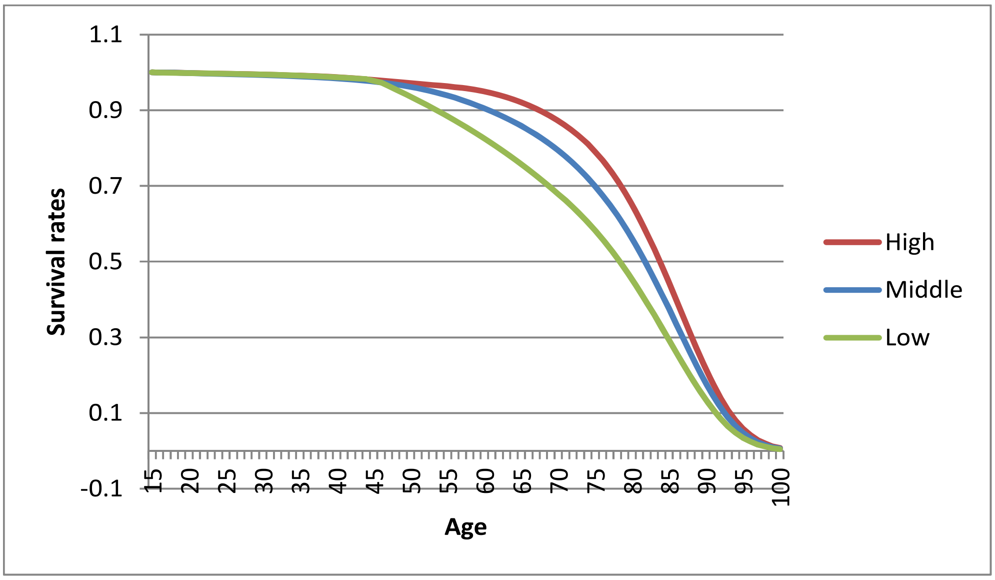
The life-cycle wage profiles ε_j^k depicted in Figure 3.1 are estimated following the procedure of Altig et al. (2001) and Fullerton and Rogers (1993). For empirical estimation, we use waves from 1984 until 2013 of the German Socio-Economic-Panel (GSOEP). The wage profiles are calculated according to the following formula:

$$\varepsilon_j^k = e^{\zeta_0^k + (g+\zeta_1^k)j + \zeta_2^k j^2 + \zeta_3^k j^3}, \tag{3.1}$$

where j stands for age, k for the household-type and g is the constant rate of technological progress. The ζ coefficients are received according to the following procedure (see p. 581 in Altig et al. (2001)). Firstly, hourly wages are regressed on fixed-effect dummies, age-squared, and interactions between age and other demographic variables. Secondly, the coefficients obtained from the previous regression are used to generate predicted life-cycle wage profiles. As a next step, the data is sorted according to the present value of lifetime income and three household types are generated by quintiles. Lastly, the coefficients of equation (3.1) are estimated from the simulated data profiles of each of the three household types. These estimated profiles ε_j^k are used in equation (2.5) to determine individual life-cycle wage profiles for the three household-type groups, taking the prevailing aggregate wage rate w_t in the economy as given.

As a second dimension of heterogeneity, we include mortality risk, which increases with age. Type-dependent survival rates, $\pi_{t,j}^{k}$, for the three household types are computed in several steps. Danish register data (Kallestrup-Lamb & Rosenskjold, 2017) suggests that there is a gap in life expectancy of two years between the intermediate and highest income/wealth groups, while there is a larger gap of 4-4.5 years between the low and intermediate groups. As a second step, average survival rates for the EU28 countries (Eurostat, 2010) are adjusted such that they reproduce the aforementioned gaps in life expectancy. These estimates of the unconditional survival rates, $\pi_{t,j}^{k}$, for the three household types are shown in Figure 3.2. They are used in equation (2.4) to discount future utility in addition to pure time discounting, β^{j}.

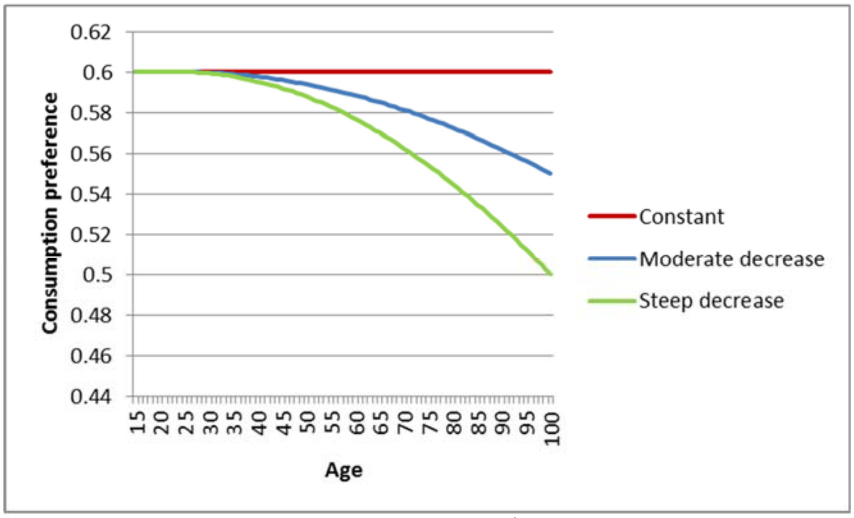
Figure 3.2 – Unconditional survival rates



Source: own calculations.

Representing a parameter that changes through the life-cycle, Figure 3.3 shows the life-cycle profile of the consumption weight parameter for each one of the household types. Declining preferences of consumption implicitly assume a higher preference for leisure when approaching old age. These preferences mimic the aging process of individuals which due to degenerating health or cognitive decline increase their preferences for leisure and reduce their labor supply through time, inducing retirement. We then model the consumption weight parameter as age-dependent. Low percentile group individuals face a decline of 0.10 (steep decrease), while intermediate individuals face a decline of 0.05 (moderate decrease). As for individuals in the high percentile group, there is no decline. In the case of initial consumption preferences of 0.6, they will reach values between 0.6-0.5 at the end of life for individuals from the low to the high percentile groups, respectively.

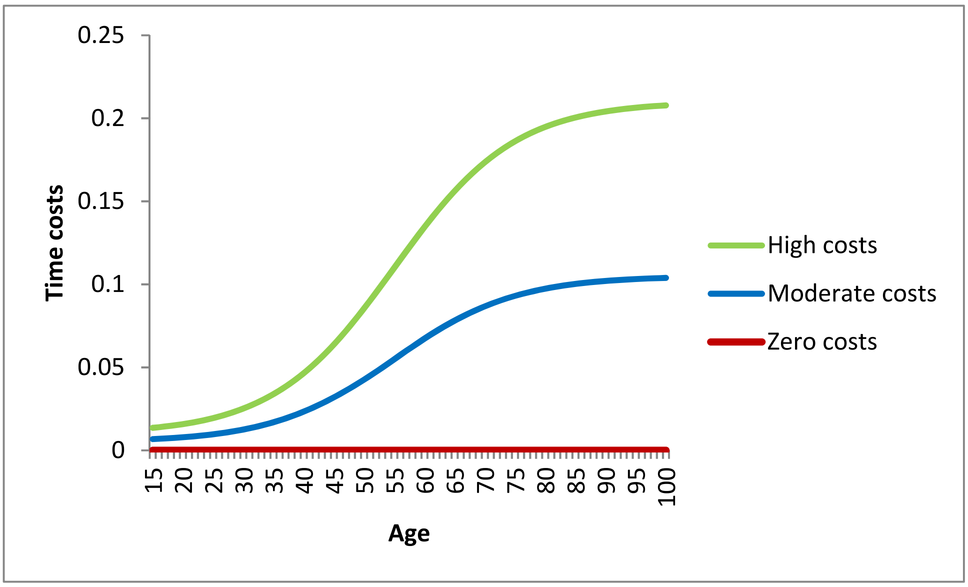
Figure 3.3 – Decreasing weight on consumption



Source: own computations.

Following French (2005), Rogerson and Wallenius (2013) and Cogan (1981), we model time costs $\vartheta(h_{t,j}^{k})$ as time costs that are deducted from leisure and emerge when hours worked are positive. If the household decides not to work, there are no time costs. These costs are modeled considering two components. As it is shown in equation (2.3), there is χ_j^k, which is age-dependent, and the ratio $\frac{\chi_j^k}{(1+h_{t,j})^{\xi}}$. Intuitively, these time costs reflect costs associated with declining health, opportunity costs, like commuting time to work, but also subjective value given to work by individuals. As it is known, different types of individuals suffer from different levels of health decline during their lives. Individuals in the lowest percentile groups suffer from a faster health degeneration and have their costs of working increase faster than high educated workers. Therefore, we assume that time costs increase with age at different rates for different household types. Households from a low percentile income group have a cost profile (χ_j) which increases over time to a maximum value of around 21% of total time available at age 100. For the intermediate percentile group the time cost profile increases to a maximum value of around 10% of total time available when reaching age 100. As an extreme case, households from the highest income percentile group do not face any time costs of working.

Figure 3.4 – Time costs of working



Source: own computations. Note that this figure displays fixed costs functions over age for $h_{t,j}^{k}$ = 1.

We calibrate the time costs profiles jointly with the other aging mechanisms described above such that the claiming age for the benchmark case agrees with empirically observed claiming ages. Since time costs also depend on hours (see equation (2.3)), the actual time costs never reach these high values. Due to the ratio in the cost function, the calibrated value of $\xi = 12$ and the decisions of households regarding leisure and consumption, the cost function will never attain the maximum cost value at any age but will asymptotically approach it for higher working hours[4].

3.2.2 Structural parameters and population data

The life span of the household is assumed to be 100 years. The household enters the labor market at age 15. The structural parameters of the household model are chosen to achieve several calibration targets with reference to other studies. Table (3.1) gives an overview:

[4] Note that with a value of ξ=12, the cost function quickly approaches zero when hours worked are small. As explained before, we use this shape of the cost function to smooth time costs for values of hours worked close to zero.

Table 3.1 – Parameter calibration

Parameter	Values
Discount rate (ρ)	0.02
Risk preference (θ)	2
Earliest retirement age	60
Latest retirement age	72
Initial steady state replacement rate	0.6
Adjustment rate	0.036
Capital share in production (α)	0.33
Growth rate of labor productivity (g)	0.015
Depreciation rate of capital (δ)	0.05
Demographic risk sharing (μ)	0.25
Wedge (capital income tax)	0.264

We choose parameter values such that the simulated moments of our model match their empirical counterparts in the data. Our calibration year is 2017. We target a capital-output ratio of 2.8 (based on estimates of the stock of fixed assets to output). In addition, parameter values are chosen such that people retire around the age of 62 to 64 in the year 2017, which is close to the actual retirement ages in several European countries in previous years (Börsch-Supan, et al., 2017a; OECD, 2015). To achieve these targets, the discount rate, ρ, is set to 0.02 (see overview by Frederick et al. (2002)). The risk preference parameter, θ, is assumed to be 2, which makes the household slightly risk averse and lies in the middle of estimates in the literature (see overview by Bansal and Yaron (2004) and Browning et al. (1999)). The capital share, α, in the economy is assumed to be 0.33 and annual productivity growth is 1.5%. The depreciation rate of capital is 5% per year.

We choose a retirement window from $R_E = 60$ until $R_L = 72$. Age 60 was the former earliest legal retirement age for women in several European countries, for instance in France (age 61), Italy (age 62) or Germany (age 63) (Social Security Administration, 2014; Deutsche Rentenversicherung Bund, 2015a; OECD, 2015) and it is therefore taken as the first possible retirement age. Theoretically, there is no upper bound for late retirement in existence. However, to keep some plausibility in the decisions, we assume 72 as the highest possible retirement age, in accordance with US Social Security regulations. We assume the lower bound value of current adjustment rates across OECD countries (see Table A.1), therefore $\omega = 3.6\%$ (see equation (2.14)).

Demography is described by the size of each cohort, the survival of that cohort and additions through net migration. We treat all three demographic forces as exogenous. The size of the population aged *j* in period *t* is given recursively by

$$N_{t+1,j+1} = N_{t,j}\varphi_{t,j}, \tag{3.2}$$

where $\varphi_{t,j}$ denotes the age-specific conditional survival rate. The original cohort size for cohort c depends on the fertility of women aged k at time $c=t-j$:

$$N_{c,0} = \sum_{k=0}^{\infty} f_{c,k} N_{c,k}. \tag{3.3}$$

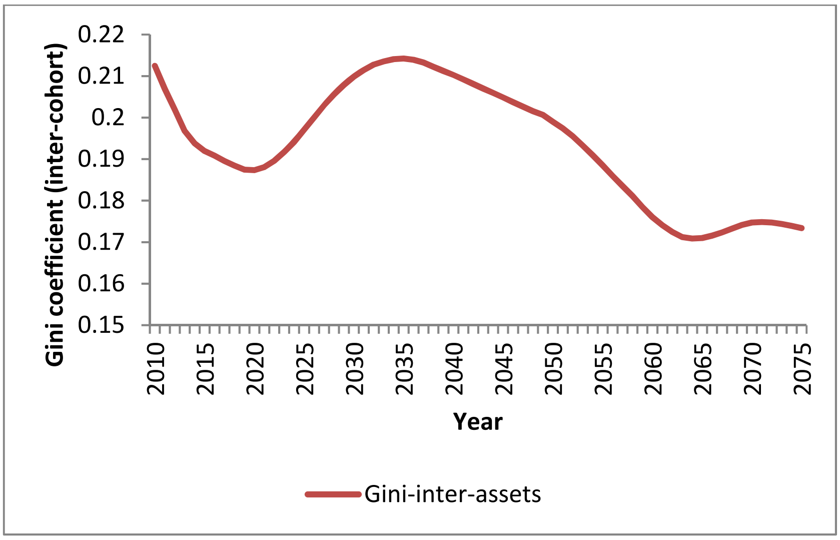
Population aging has three demographic components: past and future increases in longevity, expressed by $\varphi_{t,j}$; the historical transition from baby-boom to baby-bust expressed by past changes of $f_{c,k}$; and fertility below replacement in many countries expressed by current and future low levels of $f_{c,k}$. We consider a prototypical country which is a synthetic aggregation of the population data from the three largest continental European countries (France, Germany, and Italy). Population data, age distributions, and assumptions on projections for fertility, mortality, and migration rates are taken from the Human Mortality Database (2016). Life expectancies are also computed from life tables provided by this source.

4. The baseline scenario

We start by examining the baseline scenario where the impact of reforms on the pension system's sustainability will be discussed and put into perspective together with inequality outcomes. A variety of inequality indicators to measure and predict how inequality evolves over time, given demographic change and the initial DB-PAYG system, will then be employed. Inequality will be evaluated with respect to income inequality between and within cohorts as well as welfare changes of households.

Given the DB-PAYG system and the well-known demographic change process, the sustainability of the pension system is threatened. As we can observe from Figure A.2, contribution rates increase from roughly 23% in 2017 to more than 40% in a time period of 30 years. This shows how the system must adapt to demographic change in order to stay balanced, and shows how unsustainable the system would become if the adjustment on contribution rates would not be possible. As a consequence of the increasing unsustainability of the pension system, the welfare of cohorts will decrease and this has consequences for inequality between cohorts.

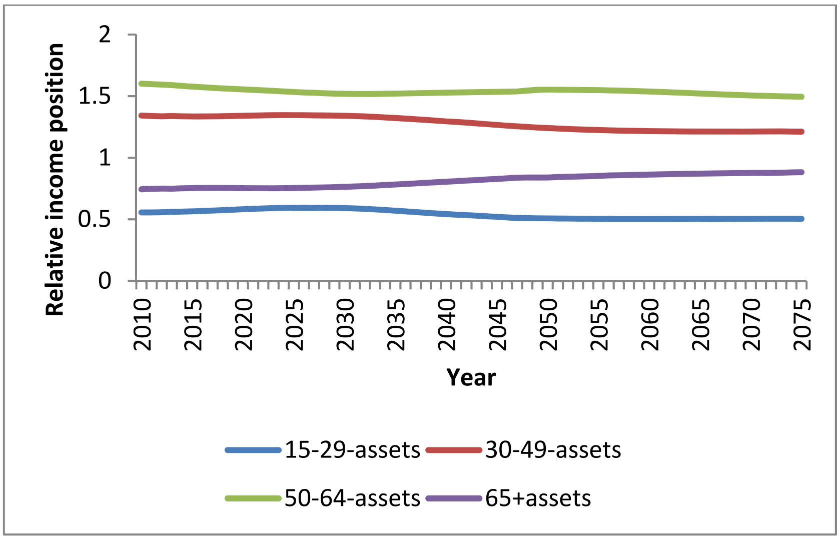
Figure 4.1 - Inter-cohort Gini coefficients



Source: Own Calculations. Note that the Gini coefficient uses current income of the respective year.

As Figure 4.1 shows, there is inter-generational inequality in total income. Inequality between cohorts stems mostly from differences in earnings between prime age and old age retirees and very young workers. This inequality tends to, in the long-run, decrease over time due to the forces of demographic change and its macroeconomic effects, fundamentally on the pension system. The reason for this pattern becomes clearer when taking into account the group analysis, see Figure 4.2. While the relative income position of all working age groups decreases in the long-run, income of pensioners relatively increases over time. This is a result of increasing contribution rates to be paid by workers in order to guarantee the sustainability of the DB-PAYG system (see Figure A.2 in the appendix). Contribution rates have to increase to finance the pensions of more pensioners while the number of workers is decreasing. These high contribution rates constitute a negative incentive to work which is why households decrease their working hours. Therefore, work income, being the product of decreasing net wage and declining working hours, decreases substantially more than pension income. As a result, in relative terms, pensioners lose less than working age people whose income relatively decreases due to very high contribution rates and negative work incentives. In addition, a large fraction of young pensioner's income is asset income from their retirement savings. While the other age groups suffer from increasing contributions from their work income, asset income is not harmed by increased contributions to the pension system. This makes the pensioners relatively better off and decreases inter-generational inequality in the long-run.

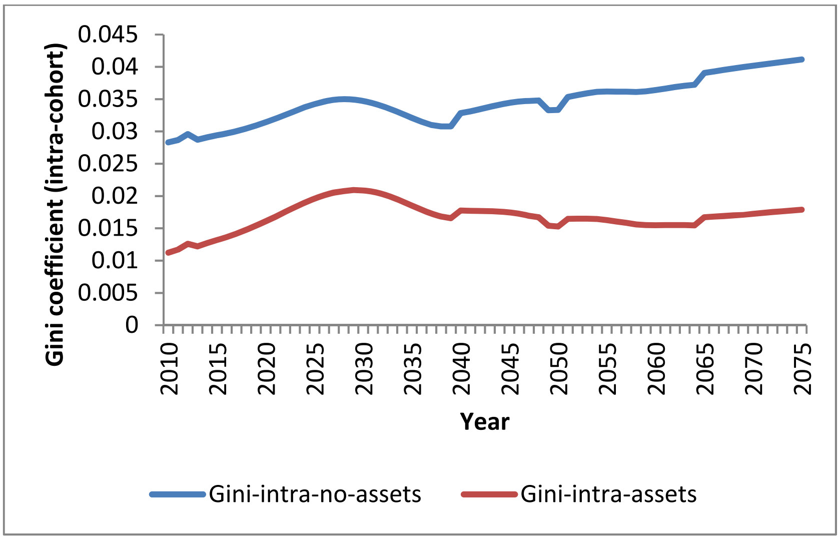
Figure 4.2 – Relative income position



Source: Own Calculations. Note that the relative income position is calculated using current income of the respective year of each age group.

In contrast to the inter-generational Gini coefficient, the intra-cohort Gini coefficient, given the level of heterogeneity between income groups, is low. Next to the income measure incorporating income from assets, the figure also includes an income measure without income from assets but only from labor and pension income. Nevertheless, the measure without income from assets shows an increase through time reflecting the impact of population aging and the higher impact that changes in the pension system imply for the low income groups. These, due to their specific characteristics (e.g. health/time costs), cannot react so much to these changes, see Figure 4.3. In case of the measure incorporating income from assets, the measure stabilizes after the initial increase and even decreases slightly. This is due to the consumption of savings by the vanishing baby boomers generation that leads to a transitional small increase of interest rates that has a more than proportional reaction by low income individuals. They increase their savings more than the high income individuals and therefore benefit from more asset income. This makes their total earnings closer to the ones from high income individuals which closes some part of the income gap and reduces inequality.

Figure 4.3 - Intra-cohort Gini coefficients



Source: Own Calculations. Note that the Gini coefficient is calculated using current income.

The explanation for this increase in intra-generational inequality can be found in the development of retirement ages due to demographic change (see Figure A.1 in the appendix). Older cohorts retire relatively early while new younger cohorts of all income groups gradually retire later. Because of continuous population aging, interest rates decrease over time, labor becomes scarcer, and the capital stock rises because of higher savings. This increases the relative wages vis-à-vis the decreasing interest rate, which induces incentives to work longer and makes early retirement more harmful.

Still, households of the low income group retire earlier than those from the high skill group. This stems from three main reasons. First, higher consumption preferences of high skill groups lead to later retirement, as individuals prefer not to be penalized in present and future consumption by the deductions imposed by the adjustment rates. Second, high skilled groups exhibit better health during old age (see section on calibration) which allows them to work longer. Third, high skilled groups are more productive during high ages (see section on calibration), which increases the incentives to make use of this and extend working life even further. Overall, during this time frame, high income groups, who already retire later, increase their retirement ages by 3 years, while low income groups, in contrast, only increase their retirement ages by 1 year. This increases the gap in working time and consequently income between skill groups, which fosters the rise in intra-cohort inequality displayed in Figure 4.3.

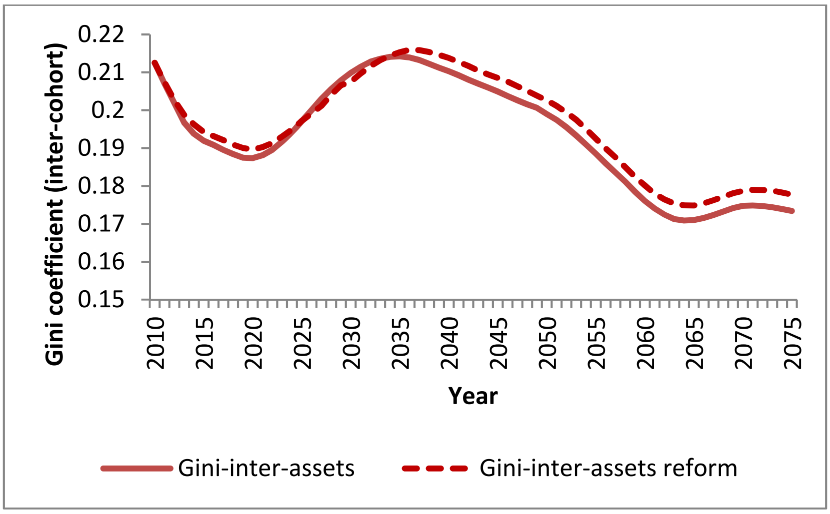
5. Pension reforms, sustainability and inequality

5.1 Increasing the full pensionable age to 67

One of the most widespread policy measures to keep public pension systems sustainable is the increase of the full pensionable age at which people can retire without any deductions. In France, the full pensionable age is gradually rising from age 65 to 67 from 2016 to 2022 and in Italy it will reach 67 in 2028, and in Germany in 2029. The same is happening in many other European countries. As an example, we make a compromise between different European countries' pathways when increasing the full pensionable age in this section while keeping the DB pension system from the baseline scenario. In detail, the full pensionable age increases one month every year until 2023 and two months every year from 2024 onwards until it reaches the full age of 67.

Concerning the sustainability of the pension system, the reform meets its goal. As Figures A.3 and A.4 in the appendix reveal, households retire later due to incentives created by the higher full pensionable age. Shorter periods of pension payments and lower pension levels for those who do not postpone retirement relax the pension system's budget equation. As a result, contribution rates are by about 4 p.p. lower compared to the baseline scenario (see Figure A.5 in the appendix). In response, households work more due to higher net wages, which increases their income substantially. Since workers profit substantially from lower contributions, inter-generational inequality (see Figure 5.1) is higher in the aftermath of this reform than in the baseline scenario. This becomes especially clear for later years when the reform unfolds its full effects, although not as strong as needed since the FPA only increases by two years and stays constant afterwards. This argument is further strengthened in the group analysis in Figure 5.2.

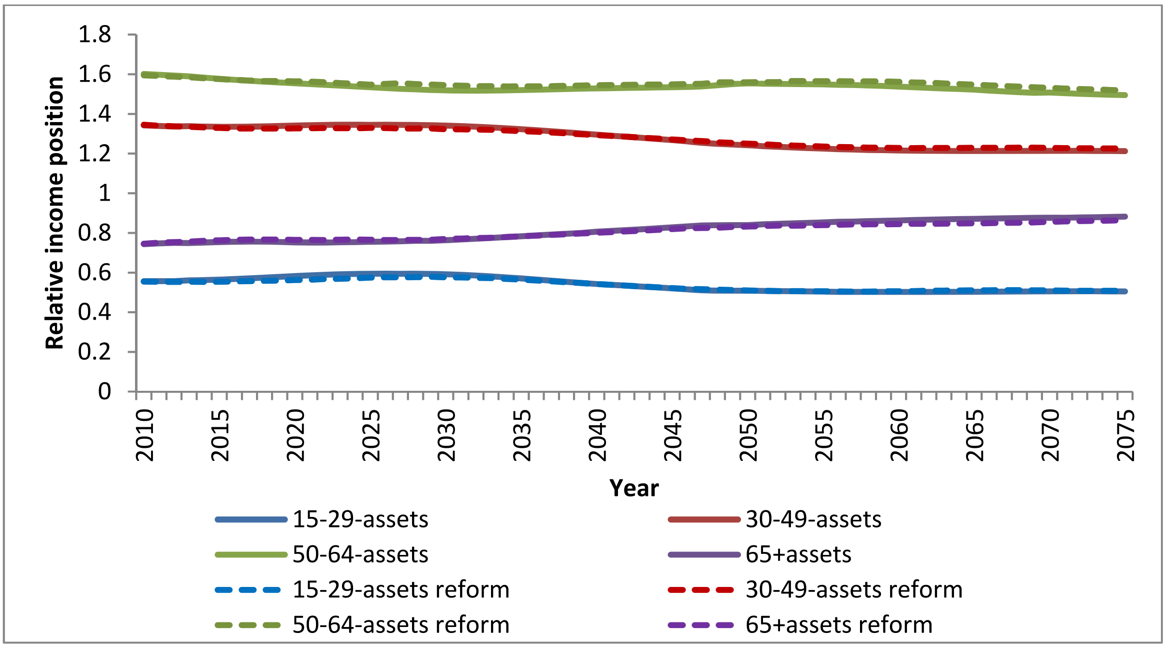
Figure 5.1 - Inter-cohort Gini coefficients



Source: Own Calculations. Note that the Gini coefficient uses current income of the respective year.

Looking at the relative income position of the four groups it becomes clear that the inter-generational inequality has to increase: while groups with already higher than average income receive even more (age groups 50-64 and 30-49), groups below the average (age group 65+) slightly lose or do not change (age group 15-29). Accordingly, this divergence in the relative income position widens the gap between age groups increasing inter-generational income inequality. This development can be explained by the effect of the reform on average wages prevailing in the economy. Due to the higher full pensionable age and corresponding higher actual retirement ages (see Figures A.3 and A.4 in the appendix), contribution rates to the DB pension system are lower in the reform case than in the baseline scenario. This increases average net wages in the economy. This is essential to understand the developments in the relative income position. Due to higher net wages, all groups profit from the reform in absolute terms. Even the pensioners whose pension benefits is a function of net wages (see equation 2.9) profit in absolute terms. However, since the average wage is increasing so strongly, in relative terms, pensioners lose in their income position which increases inter-generational inequality.

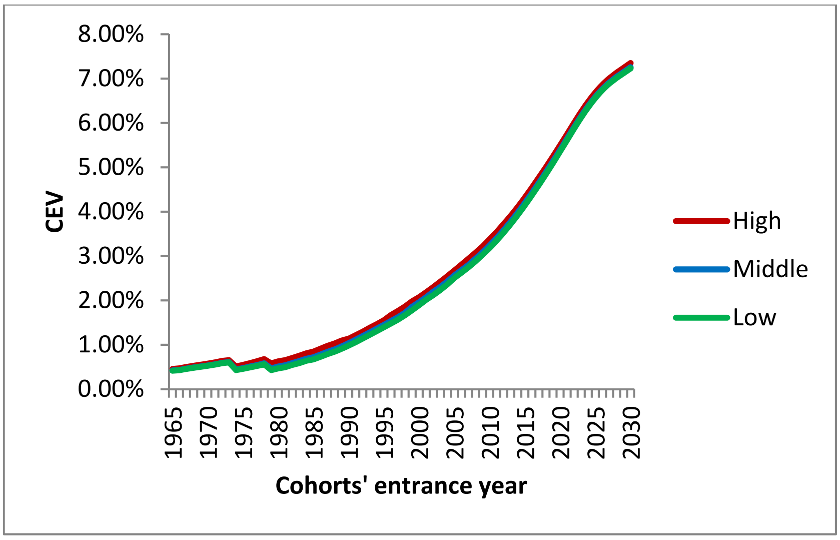
Figure 5.2 – Relative income position



Source: Own Calculations. Note that the relative income position is calculated using current income of the respective year of each age group.

In addition to the inter-generational inequality effects generated by income differences, Figure 5.3 depicts the consumption equivalent variation for cohorts entering the labor market at the time indexed on the horizontal axis. The vertical axis shows the percentage of lifetime consumption that a household would be given in the baseline scenario in order to be as well off as in the reform scenario. Positive values, therefore, denote that cohorts in the reform case are better off than in the baseline scenario. Households entering the labor market in the second half of the 20th century are only slightly better off since they only profit late in working life from lower contribution rates. For cohorts that enter after the reform is implemented, they see their welfare increasing substantially: CEVs increase around 7% and stay at this level afterwards. In sum, small short-term welfare improvements are followed by large long-term welfare gains. We can also observe that this reform does not grant sufficient additional gains in work income for the low skilled households, which could lead to a more than proportional increase in consumption and welfare in comparison to the high skilled. For every cohort studied, the high skilled group has a slightly higher increase in CEV in comparison with low and middle skilled groups, since they react stronger and delay more their retirement age. This is mostly due to low and middle skilled individuals, whose health deteriorates faster and who have large preferences for leisure, and therefore prefer not to postpone so much their retirement ages.

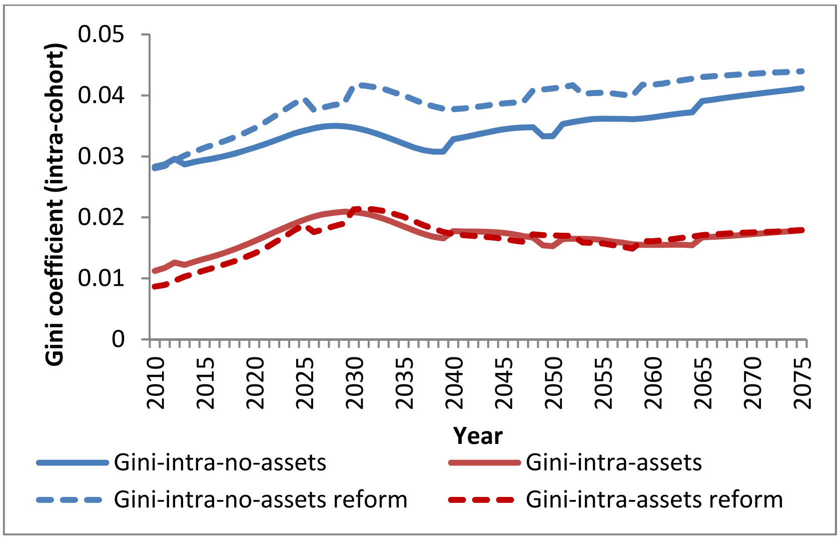
Figure 5.3 – Consumption equivalent variation



Source: own calculations.

The latter finding is also mirrored by the patterns of the intra-cohort Gini-coefficient (see Figure 5.4, non-asset income measure) - an increase of the full pensionable age leads to an increase in inequality within cohorts. As changes in retirement ages due to the reform indicate (see Figures A.3 and A.4 in the appendix), low skilled groups react less intensively to the reform which turns the gap of retirement ages between low and high skilled larger, contributing to an increase of intra-generational inequality. The foregone benefits that low skilled workers lose drag their income down in comparison to high skilled workers that work longer and guarantee an extra premium in their pension benefits. The reason for the dampened reaction of low skilled households can be found in their characteristics: when growing old, time costs of working increase strongly while they do not so for high skilled workers. As discussed in the calibration section, this reflects a more quickly deteriorating health of low skilled households. Also lower preferences for consumption and higher preferences for leisure of low skilled households lead to the aforementioned result. Last, also higher productivity at old ages for high skilled household induce a larger reaction of this group compared to their less productive counterparts.

Figure 5.4 - Intra-cohort Gini coefficients



Source: Own Calculations. Note that the Gini coefficient is calculated using current income.

This clear increase in intra-generational inequality in the aftermath of the reform is much less pronounced when taking into account income from assets (see Figure 5.4, with asset income measure). In this case, the presence of asset income dampens this increase or even turns around results. In some years, income inequality is even lower due to the reform than in the baseline scenario. The reason for this can be found in the reaction of savings behavior due to the reform. Since contributions are lower, households can build up higher savings and this is especially true for low skilled households who increase their savings substantially in the aftermath of the reform in contrast to their high skilled counterparts who hardly change their savings behavior. As a consequence, income from asset holdings increases more for low skilled households being beneficial for intra-cohort equality.

5.2 The 2:1 reform

Pension reforms as the one described in the previous section, may be successful in deterring temporarily the imbalances of the pension system but due to continuous increases of life expectancy these imbalances will arise again. This is why an increase in the full pensionable age today to 67 would lead, in about a decade, to the same current problems faced by todays' pension system.

A possible solution for this, which was previously presented by Börsch-Supan (2007), offers a systematic and clear rule that could be understood by any citizen and that accommodates changes on demographic dynamics. This rule, called the 2:1 rule, dictates that sufficient increases in life expectancy of individuals should be automatically compensated by increases in the full pensionable age on a proportional basis. As a rule of thumb, since an individual works approximately two thirds of his life, for instance, an increase of 3 years in life expectancy should promote an increase of 2 years in the full pensionable age and 1 year spent in retirement – a 2:1 rule. In order to specify this rule, we define a benchmark life expectancy age of cohorts retiring in 2017. From this year on, any cohort whose life expectancy exceeds 1.5 years from the benchmark will face an increase in the full pensionable age of 1 year. This life expectancy will be the new benchmark and later on, the next cohort with expected 1.5 years more of life expectancy will face another increase in the full pensionable age.

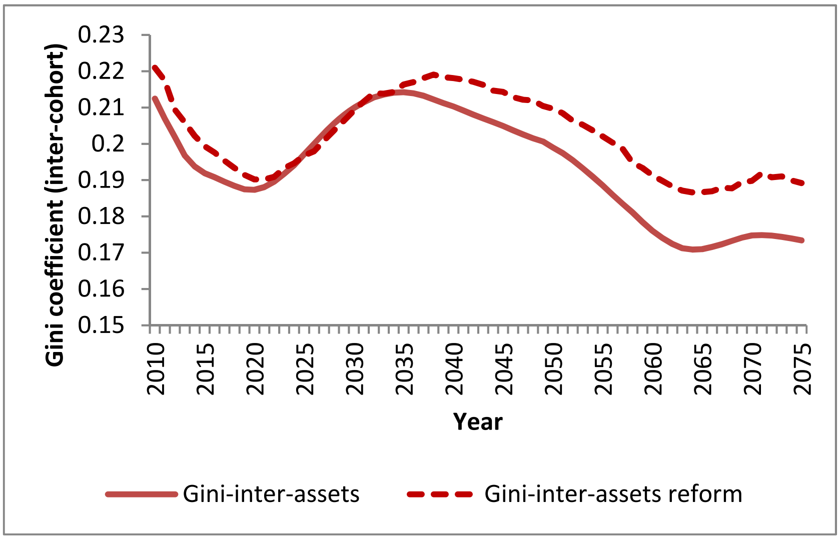
Table 5.1 – Evolution of full pensionable ages

Years	Full pensionable age
2017-2021	65
2022-2028	66
2029-2037	67
2038-2042	68
2043-2051	69
2052 - onwards	70

Source: own calculations using population data forecasts from the Human Mortality Database (2016).

As before, inter-generational inequality is higher in the aftermath of the reform compared to the baseline scenario – Figure 5.5. Since the full pensionable age rises continuously and automatically over time, the effect size is substantially larger. Again, the key to understand this mechanism are again contribution rates (see Figure A.8 in the appendix). As can be seen in Figures A.6 and A.7 in the appendix, households retire substantially later due to incentives created by the higher full pensionable age. Delayed pension payments and lower pension benefits for those who do not adjust their behavior relax the pension system's budget equation such that contribution rates can be lower compared to the baseline scenario. Additionally, higher net wages incentivize households to work more which increases their income substantially.

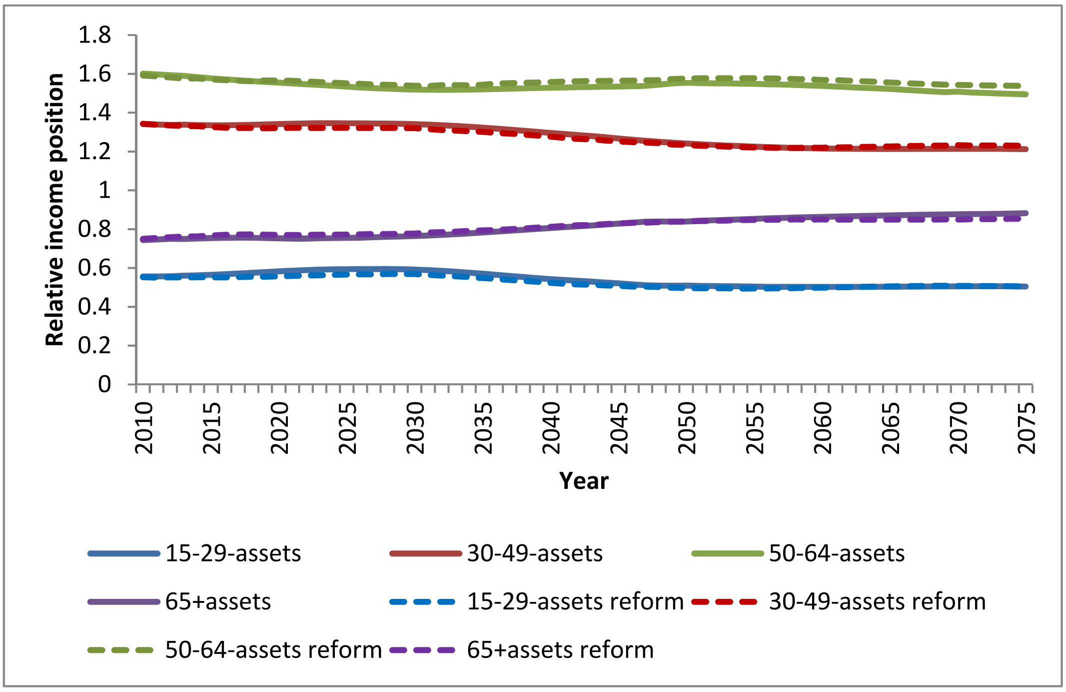
Figure 5.5 - Inter-cohort Gini coefficients



Source: Own Calculations. Note that the Gini coefficient uses current income of the respective year.

Figure 5.6 reveals that groups with already higher than average income gain more (age groups 50-64 and 30-49), while groups below the average (age group 65+) slightly lose or do not change at all (age group 15-29). Following the same line of argumentation as in the previous section, increasing net wages and their incentives to work more is the key to understand this development.

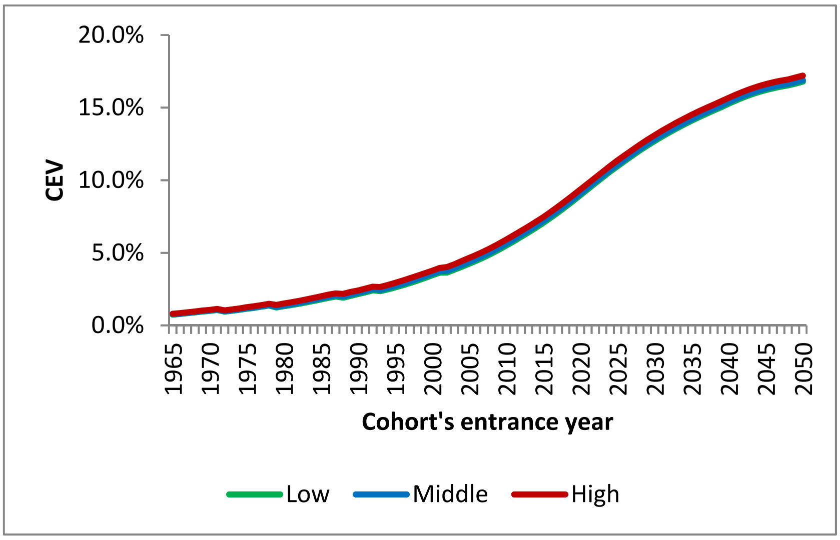
Figure 5.6 – Relative income position



Source: Own Calculations. Note that the relative income position is calculated using current income of the respective year of each age group.

Comparing utility changes in terms of the CEV, Figure 5.7 shows, as expected, that cohorts are substantially better off with this reform. The gains attained are around 17% for cohorts entering in the long-term. These values are higher than in any other scenario studied in this paper and come along with substantially lower contribution rates than in the baseline case (see Figure A.8 in the appendix). The lower contribution rates make cohorts much better off since they earn more and pay less than in the baseline scenario or in any other scenario. Older cohorts do not benefit very much because they only benefit in the last years of their lives based on the new changes in the pension system. The decrease in contribution rates is the main driver behind the finding that high skilled cohorts profit more than their low skilled counterparts. In reaction to lower contribution rates, high skilled households work longer both intensively and extensively and their reaction is stronger than that of low skilled (see Figures A.6 and A.7 in the appendix). Therefore, welfare gains of these cohorts are similar or even larger for high skilled households.

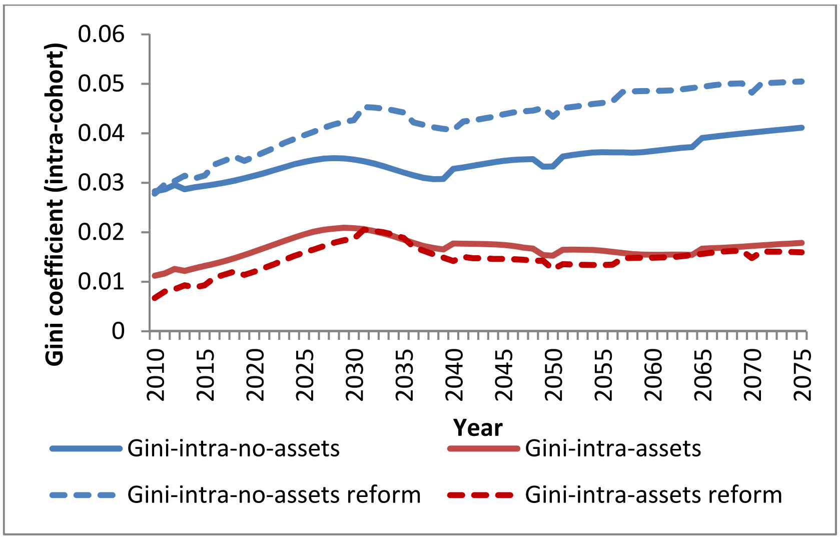
Figure 5.7 – Consumption equivalent variation



Source: own calculations.

This is again reflected in the inequality indicator between skill groups. As Figure 5.8 shows, intra-cohort inequality (non-asset income) is clearly higher than in the baseline scenario in the aftermath of the reform. By revising the full pensionable age according to life expectancies, the reform increases the disincentives to retire early and makes high skilled individuals, which are the ones with higher propensity to retire late, more prone to retire later and benefit from longer work income and also from a premium in their pension benefits, or, at least, much lower deductions. This will increase the gap in income of individuals with different skills since low skilled individuals react less extensively to these successive increases of full pensionable age as they already retire much earlier in the baseline scenario (see Figure A.1 in the appendix).

Figure 5.8 - Intra-cohort Gini coefficients



Source: Own Calculations. Note that the Gini coefficient is calculated using current income.

However, for this reform, taking into account income from assets totally turns around previous findings (see Figure 5.8): intra-generational inequality is now clearly lower than in the baseline scenario. This is again due to the larger effects on savings. Since contributions are much lower, savings are substantially higher for low skilled households. Income from assets increases consequently due to the reform hitting low skilled households disproportionally. This effect is large enough to turn around the increase in intra-generational inequality as measured by only labor and pension income.

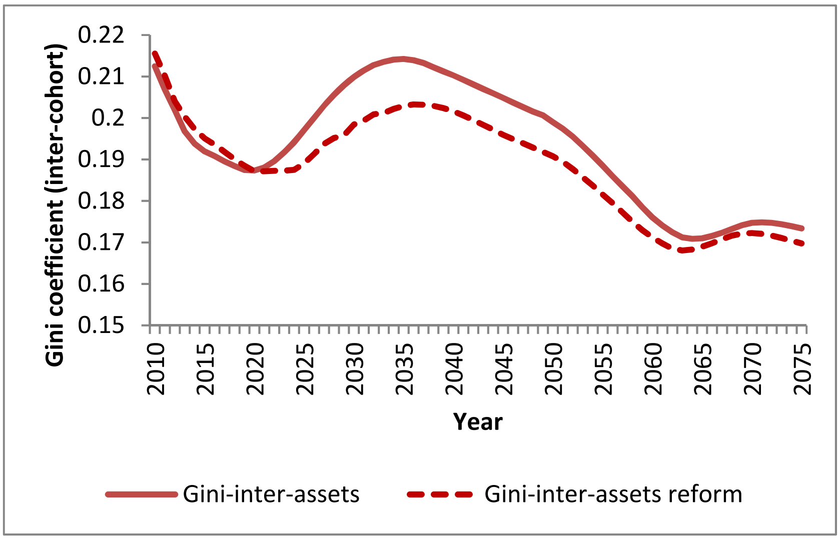
5.3 Actuarial neutral adjustment rates

So far, we have used the lower bound value of current adjustment rates across OECD countries of 3.6%, observed in many pension systems across countries (see Table 2.1). However, these rates are significantly lower than the actuarially neutral adjustment rates ranging from 5 to 8% found by Börsch-Supan (2004), Werding (2007), Gasche (2012) and Queisser and Whitehouse (2006) for the different OECD countries. Since current adjustment rates create early retirement incentives and therefore threaten the sustainability of pension systems, in this section we simulate our model with adjustment rates closer to the actuarial neutral values and use the actuarial neutral adjustment rate of 6.3% for early and late retirement. We further assume that this hypothetical reform is implemented in the year 2017. From then on, adjustment rates rise linearly from their current levels until the year 2032, where they reach their final values of 6.3%.

As observed in Figure A.11, the sustainability of the pension system is again improved by this reform. Since individuals now face higher deductions when retiring earlier than the FPA, actual retirement ages increase substantially. This relieves the pressure from the pension system and reduces contribution rates up to 8 p.p.. This is also an indirect result of postponed retirement (see Figures A.9 and A.10 in the appendix) and therefore augmented labor supply which turns contribution rates more favorable and increases net wages substantially.

After this reform, inter-generational inequality is clearly lower in the reform case compared to the baseline scenario (see Figure 5.9). This might be surprising at first, since lower contribution rates led workers in the previous reforms to profit more from the reforms, which increased inter-generational inequality. Nevertheless, under this reform, the strong increase in the average income is the key to understand the effect.

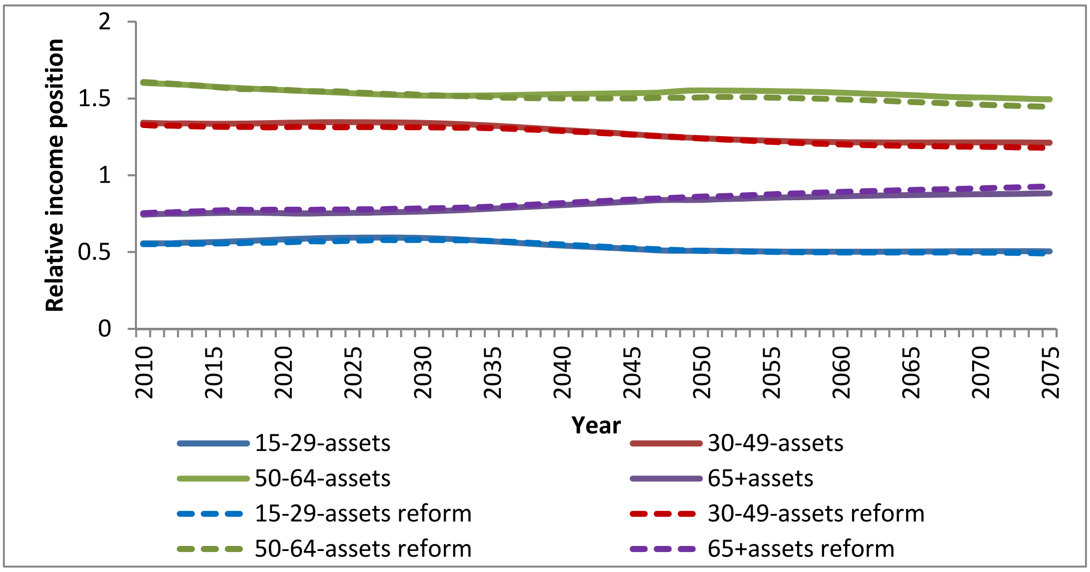
Figure 5.9 - Inter-cohort Gini coefficients



Source: Own Calculations. Note that the Gini coefficient uses current income of the respective year.

While those age groups which earn above average (age groups 50-64 and 30-49) relatively lose due to the reform and earn now more closely to the average, low income groups such as pensioners (age group 65+) gain. The age group containing 15-29 year old households does not show a substantial difference. This narrowing gap between income groups depicted in Figure 5.10 leads to a decrease of inter-generational inequality in the aftermath of the reform as seen in Figure 5.9. It must be noted that in absolute measures, all age groups profit from the reform with respect to their income. As a result, the average income rises substantially in the economy. The relative income position of working age groups, however, decreases while the relative income position of pensioners increases. This means that, in relative terms, pensioners gain more than working age groups due to higher pensions, which reduces inter-cohort inequality as shown in Figure 5.9. This comes from the fact that each group's average income is divided by the average income in the economy to obtain the relative income position depicted in Figure 5.10.

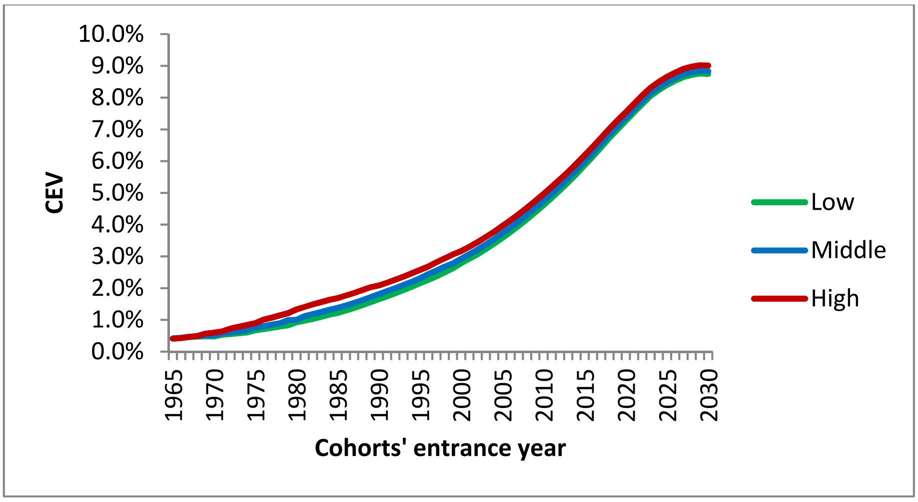
Figure 5.10 – Relative income position



Source: Own Calculations. Note that the relative income position is calculated using current income of the respective year of each age group.

Lifetime utility of households as measured in CEV is higher in the reform case. Looking at welfare implications in detail, Figure 5.11 reveals that households are better off in the reform scenario than in the baseline case by up to 9%. This maximum value holds for cohorts entering the labor market around the year 2028 since they fully profit from lower contributions. Earlier cohorts profit less since they are only influenced by the reform during part of their lives. Furthermore, high skill groups seem to profit more from the higher adjustment rates than their low skill counterparts. This results again from the larger reaction in actual retirement ages in the aftermath of the reform (see appendix, Figures A.9 and A.10) in combination with the higher adjustment rates.

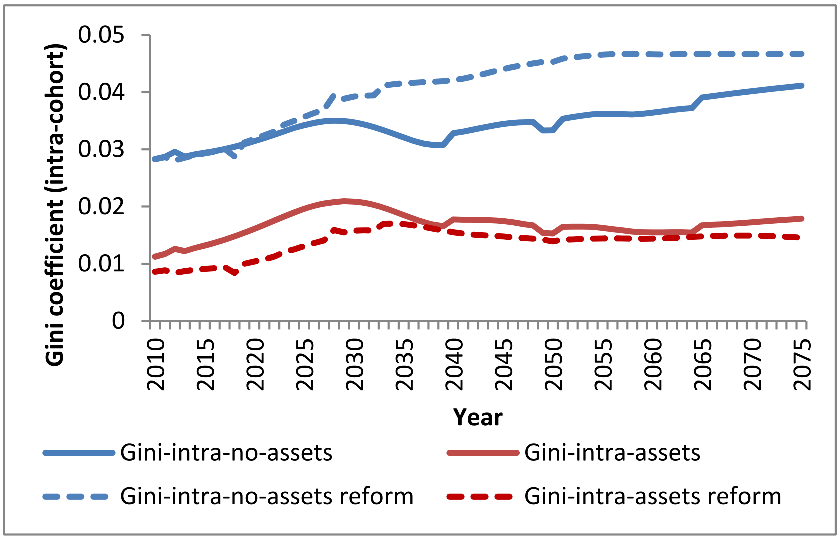
Figure 5.11 – Consumption equivalent variation



Source: own calculations.

Confirming differences in CEVs, it becomes clear from Figure 5.12 that in the reform scenario with actuarial neutral adjustment rates, intra-generational inequality (non-asset income measure) is higher during most years compared to the baseline scenario. The explanation can be found in the resulting changes in retirement behavior (see Figure A.10 in the appendix): households generally retire later due to the reform. Importantly, low skilled households postpone retirement slightly less in early years than high skilled. Due to this smaller postponement in retirement and corresponding higher premium (or lower deductions), low skilled households can increase their income less than their high-skilled counterparts. Later in time, the retirement pattern turns around and low skilled groups postpone retirement more which consequently leads to a narrowing of the inequality gap according to the previous argument. This consequently decreases the gap in income equality in the aftermath of the reform. During the most recent years, finally, the retirement pattern turns around once more such that intra-generational inequality increases again.

Figure 5.12 - Intra-cohort Gini coefficients



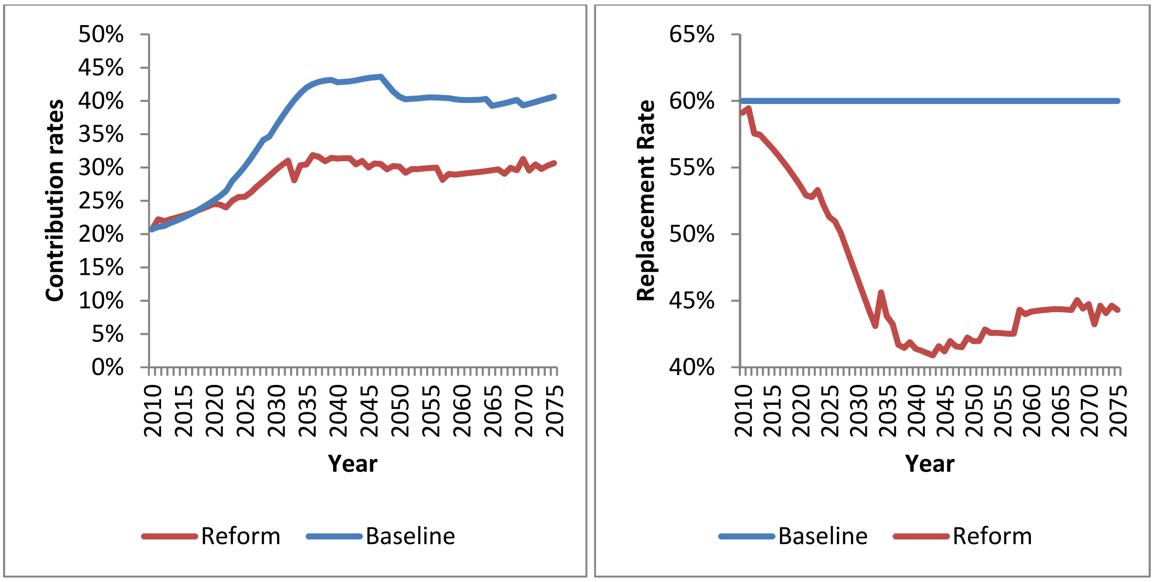
Source: Own Calculations. Note that the Gini coefficient is calculated using current income.

Similar to the previous reform, the macroeconomic feedback effects through savings on the total asset income are high enough to turn the previous message around: when measuring also asset income, intra-generational income inequality is lower in the aftermath of the reform than in the baseline scenario (Figure 5.12, with asset income).

5.4 A hybrid DB/DC PAYG pension system

The baseline scenario and all studied reforms so far have assumed a DB-PAYG pension system, which sets the replacement rate constant. Consequently, the contribution rate adjusts endogenously such that the PAYG pension system's budget is balanced. In the following reform, we deviate from this type of system and introduce a mechanism to replicate a hybrid DB/DC-PAYG system starting in 2010. The presence of such a hybrid DB/DC mechanism leads to an automated adjustment of pension benefits to demographic trends and the evolution in wage growth (see equation 2.13) as described in detail in section 2.3. The aim of such a mechanism is to make the PAYG pension system more sustainable by sharing the burden of an aging population between generations without requiring politics to constantly intervene. As can be seen above in equation (2.13) and Figure 5.13 (right), population aging leads to a fall in the replacement rate. In other words, the young, working generations do not suffer as much from strongly increasing contribution rates but also pensioners will suffer from a decline in their replacement rates. Since on the expenditure side lower pension benefits are paid out due to a lower replacement rate, the contribution rate does not rise as strong as in a DB pension system setting taking pressure from the working population. These two reform effects are depicted in Figure 5.13, which displays the evolution of contribution and replacement rates in the aftermath of such a reform and compares them to the baseline scenario. Thus, contribution rates do not rise to levels of roughly 40% but rather stabilize around 30% in this reform scenario. At the same time the replacement rate is not fixed to 60% anymore but stabilizes around 45% in the long-run.

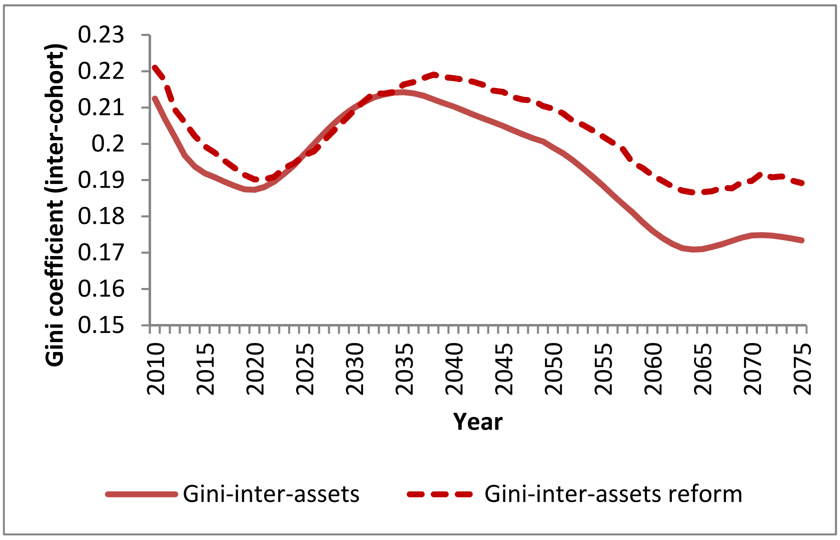
Figure 5.13 – Contribution and replacement rates



Source: own calculations.

Given the demographic effects on the pension system, inter-generational inequality (Figure 5.14) is higher in the aftermath of the reform than in the baseline scenario. The cause is straightforward: when giving up the DB pension system, the replacement rate is decreasing (see 5.13, right) after the reform, which hurts pensioners by decreasing their benefits. All working age groups, in contrast, profit from higher net wages due to lower contribution rates (Figure 5.13, left). Consequently, in relation to the working population, who enjoys higher income, pensioners receive lower pension benefits compared to the baseline scenario. Additionally, the lower burden on their labor income increases incentives to work more which further strengthens the worker's relative position to pensioners.

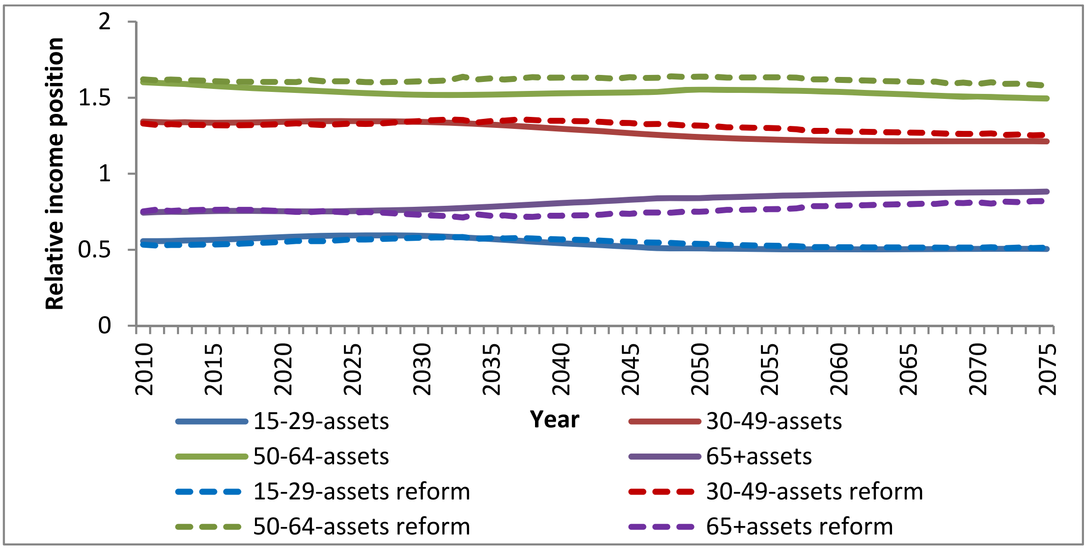
Figure 5.14 - Inter-cohort Gini coefficients



Source: Own Calculations. Note that the Gini coefficient uses current income of the respective year.

This is exactly what we find in the group analysis depicted in Figure 5.15. Lower replacement rates make pensioners lose relative to the average income. Lower contribution rates increase net wages and foster labor supply incentives strengthening the relative income position of all working groups.

Figure 5.15 – Relative income position



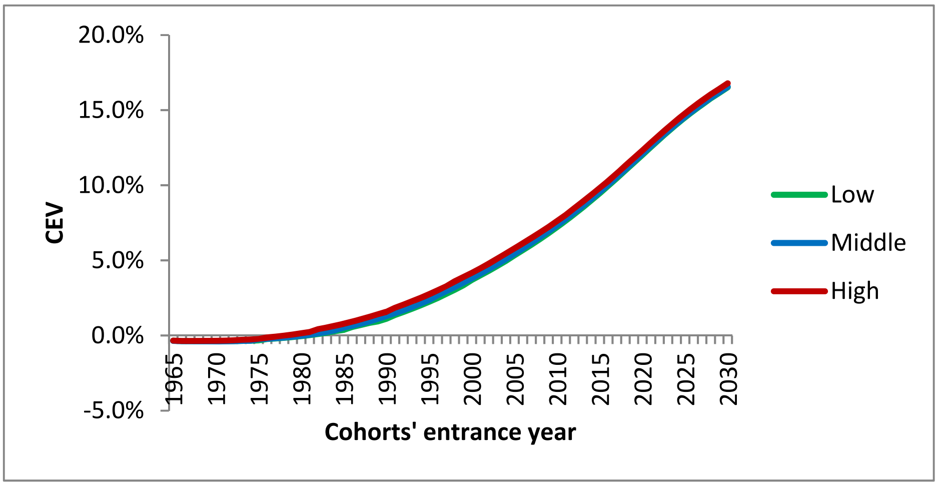
Source: Own Calculations. Note that the relative income position is calculated using current income of the respective year of each age group.

The effect on inter-generational inequality is also visible in Figure 5.16 which depicts the consumption equivalent variation: cohorts entering the labor market in early years lose from this reform since they receive lower pension benefits having paid higher contributions during their life.

The main result, however, is a significant increase in the comparative welfare of the young generations that will have to contribute much less to guarantee the sustainability of the system. In fact, cohorts entering in later years are always much better off. Those entering in 2030 are 17% better off than their counterparts in the baseline scenario in terms of lifetime consumption. In short, and not surprisingly, younger cohorts, who profit the longest from the reform, are the biggest winners.

Again by inspecting Figure 5.16, we can observe that high skilled workers (see Figures A.12 and A.13 in the appendix) are again the ones who profit the most from the reform, mostly because of their larger increase in actual retirement ages.

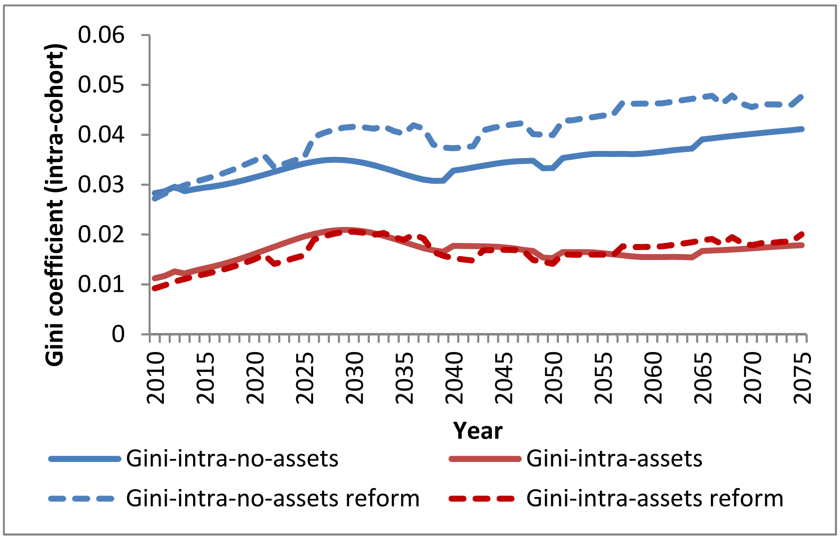
Figure 5.16 – Consumption equivalent variation



Source: own calculations.

The consequence of differing retirement behavior is also reflected in Figure 5.17. It pictures the development of the intra-cohort Gini coefficient showing an increase in intra-cohort inequality compared to the baseline scenario (non-asset income measure). As referred to above, also for this reform, the reason for the increase in income equality is again found in retirement ages (see Figures A.12 and A.13 in the appendix) which increase more for high skilled groups. The reason for the stronger reaction of high skilled groups is the same as in the previous sections: when incentives change, adjusting the retirement behavior is less costly and more rewarding for high skilled groups than for their low skilled counterparts due to differences in health, consumption preferences and productivity. Next to this argument, it is also the core of the reform that causes inequality to rise: holding the replacement rate constant in the baseline scenario is especially beneficial for low skilled households with low pensions. For them, income from private asset holdings is much smaller than for rich, high skilled households. Therefore, lowering pension benefits in the reform scenario increases their income and therefore intra-generational inequality.

Figure 5.17 - Intra-cohort Gini coefficients



Source: Own Calculations. Note that the Gini coefficient is calculated using current income.

The just described increase in the inequality measure is not identifiable when taking into account income from assets (see Figure 5.17). In this case, savings also increase to compensate lower pension payments after retirement. This increase is relatively not so strong for low skilled households as in previous scenarios. Consequently, higher asset income for low skilled households leads to the results that the trend in inequality in this reform scenario does not substantially differ from the baseline scenario.

5.5 Synthesis of reform outcomes

This section provides an overview of the previous reform proposals and ranks them according to the best result regarding inter-generational inequality. Table 5.2 summarizes and compares the effects of each reform with the benchmark scenario. For the inter-generational Gini coefficient and contribution rates, which are displayed on the left of Table 5.2, we compare the 10 year averages for the time range 2040-2050. These years are chosen because they correspond to the years when all reforms are fully in place. The two columns "Gini coefficient (intra cohort)" display the average change of the Gini coefficient of income between the respective reform and baseline scenario for the same time range (2040-2050) as previously explained. While the left column does not consider asset income, the column in the right already includes it in the calculation of the Gini-coefficient. For utility comparisons (CEVs), the value range represents the mean CEV's for the three skill groups. The averages are calculated for a period of 10 years between 1995 and 2005 since, for a matter of consistency, these are the years when the cohorts retiring around 2040-2050 enter the same labor market (see right column of Table 5.2).

Table 5.2 – Summary results

Reform proposal	Gini coefficient (inter-cohort) *	Gini coefficient (intra-cohort, no asset income)*	Gini coefficient (intra-cohort, with asset income)*	Contribution rates (in p.p.)	Utility (CEV in %)
Actuarial neutral	-0.87	1.00	-0.23	-5.5	2.8 to 3.2
Increase of FPA to 67	0.36	0.52	-0.02	-4.6	1.9 to 2.1
2:1 reform	0.66	0.96	-0.27	-8.8	3.4 to 3.8
Hybrid DB/DC system	0.93	0.62	-0.13	-12.1	3.7 to 4.2

Note: ***Time range***: 2040-2050

*** - (rescaled by a factor of 100)**

Time range with respect to cohorts' entry years: 1995-2005.

Source: own calculations.

In terms of inter-generational inequality, the actuarial neutral reform is the only reform which reduces income inequality. As argued above, despite all groups profit from this reform in absolute terms (see CEV analysis in previous sections and far right column in Table 5.2), it is the strong increase in average wages that makes working age groups slightly worse off compared to the mean income closing the gap between workers and retirees. The hybrid DB/DC reform, in contrast, increases inter-generational inequality the most, followed by the 2:1 and the "increasing the FPA to 67" reform. The reason is, as stated above, the increase of labor supply which hampers the rise in the contribution rates during younger cohorts' working life, which would otherwise suffer the most from the effects of an aging population. This makes working age groups better off than in the baseline case, which increases the gap between workers and pensioners.

The main mechanism that drives our welfare results (measured in CEVs) are contribution rates: as soon as a reform leads to declining contribution rates as a direct effect, this diminishes the labor disincentives of working. As a consequence, individuals are less constrained and work more which further drives down the contribution rates. In detail, the hybrid DB/DC reform shows the largest fall in contribution rates (-12.1 p.p.) accompanied by the highest average increase in welfare (3.7 to 4.2 p.p.). It is followed by the 2:1 reform with a decline of 8.8 p.p. in contribution rates and a gain in welfare of 3.4 to 3.8 p.p., while in the actuarial neutral reform contribution rates decrease by 5.5

p.p. and welfare increases by up to 3.2 p.p.. Increasing the FPA to 67 leads to a decline of contribution rates of only 4.7 p.p. and a mild increase of welfare up to 2.1 p.p., thereby confirming the only temporary advantage of such a reform. Therefore, in terms of sustainability and welfare, the hybrid DB/DC reform is the most beneficial reform proposal.

All reforms studied have mostly negative consequences in terms of the intra-generational inequality between skill groups, as it is observed by the increase of the intra-generational Gini coefficient in the aftermath of each reform if the Gini coefficient only takes into account labor and pension income. The reform introducing actuarial neutral adjustment rates is the one harming intra-generational equality the most, while the 2:1 reform follows very closely. The reforms that introduce a hybrid DB/DC system and the one that increases the FPA to age 67 have a much smaller impact on intra-generational inequality. The reason for this increase in intra-generation inequality can be found in different retirement behavior in the aftermath of the reforms. As was already noticed above, high income groups generally react stronger to positive labor supply incentive, therefore widening the gap in income between the income groups.

Nevertheless, when measuring intra-generational inequality by accounting for income from asset holdings, it decreases within cohorts. The reason stems from a higher relative rise in savings of low skilled households than of high skilled households in the aftermath of those reforms that lead to higher income from assets for low skilled households. The reform that imposes the strongest decrease on inequality is the 2:1 reform closely followed by the actuarial neutral adjustment rates reform and by the reform introducing a hybrid DB/DC system. Only the reform that increases the FPA to age 67 almost has no influence on inequality, strengthening our previous claim about its temporary and low effects.

6. Conclusions

How to reform the pension system has been the center of debate in the last decades. In order to keep the finances of the pension system sustainable many policy proposals have been presented that essentially focus on creating incentives for working and introducing measures to reduce the expenses and increase revenues of the pension system. This has led to the introduction of several reforms that focus on changing the paradigm of the pension system but forget the big picture. Sustainability should not be the only goal but instead must be put into perspective together with the well-being of all generations alive and yet to come. Given the gap in the literature regarding these issues, we compare different policy reforms and examine their impact on inequality and individuals' welfare taking into account at the same time the implications for the sustainability of the pension system.

Our model takes into account household behavioral feedback effects and realistic life-cycle components, namely backlash effects on labor supply and endogenous retirement decisions, life-cycle patterns on productivity, health, mortality and consumption preferences. These features and the framework implemented provide the necessary correspondence to reality and make our outcomes also robust with respect to differing growth and interest rate regimes representing current macroeconomic tendencies. All together, we learned that sharing the burden of keeping the pension system sustainable between generations, given by the hybrid DB/DC reform, yields the most positive effects in terms of sustainability and total welfare of households, however at the cost of the largest rise in inter-generational inequality. In terms of intra-generational inequality, this reform does not perform so badly, as it is only third in terms of equality deterioration, when one does not account for asset income. If we account for it, then equality increases but still in at a much lower intensity than other reforms. This reform is followed in terms of sustainability and welfare gains by the continuous rule (2:1) that automatically changes the FPA according to the evolution of the life expectancy. However, again both intra- and inter-generational inequality measures, vis-à-vis the baseline scenario, rise significantly despite the substantial increase in welfare of all individuals. When taking into account income from assets, however, this constitutes the most beneficial reform in terms of intra-generational inequality. In comparison to this reform, a simple increase of the FPA to 67 falls behind in terms of effectiveness, since not only are the effects temporary, but the magnitude is not enough to cope with the forces of population aging on the sustainability of the pension system in the long term. The only reform showing some improvement in inter-generational inequality is the one that raises adjustment rates close to their actuarial neutral values. The fall in inequality is combined with an increase of welfare of all individuals. Nevertheless, this reform falls short in terms of improvements of the sustainability of the pension system and in terms of intra-generational inequality, which constitutes the largest increase among all reforms when not taking into account asset income. Nevertheless, when asset income is included in calculations the effect is completely overturned and this reform is the second best in this respect.

In view of our results, independently of the scenario in question, we conclude that focusing only on the sustainability of pension systems as a reform outcome can be misleading. There is a trade-off that economists and politicians face when introducing new reforms in pension systems, namely whether to favor sustainability and welfare, or inequality between and among generations. By enlarging our spectrum of analysis to other dimensions such as inequality and welfare, we deliver informed policy recommendations on how to reform pension systems *equally*.

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Appendix

Table A.1 – Actuarial adjustment rates at earliest age of retirement benefits

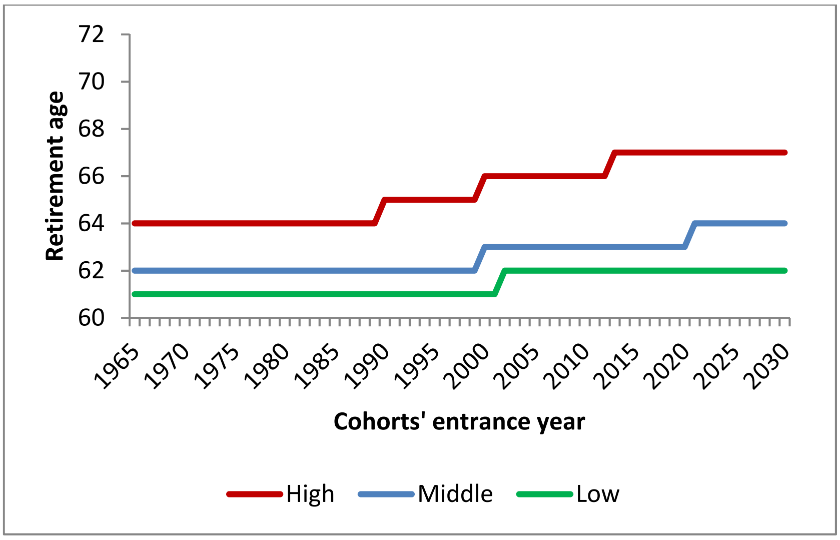
	Current legislation	Actuarially neutral
Austria	4.2	7.5
Canada	7.2	7.3
Finland	4.8	7.7
Germany	3.6	6.3
Italy	1-2	7.6
Japan	8.4	6.6
Spain	6.5-8	7.4
Sweden	4.1 - 4.7	6.9
US	5.0 - 6.67	8.2

The table shows the adjustment rates for statutory early retirement. Many countries have additional pathways not included here. The underlying interest rate is 2%. Source: Blundell et al. (2017)*, OECD* (2015) *and Queisser & Whitehouse* (2006).

Appendix

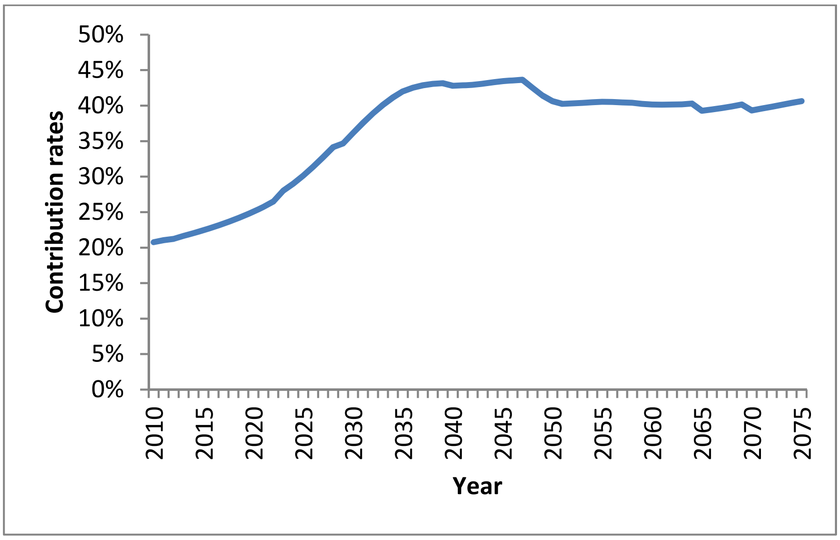
A.1 Baseline retirement ages

Figure A.1 – Retirement ages



Source: own calculations.

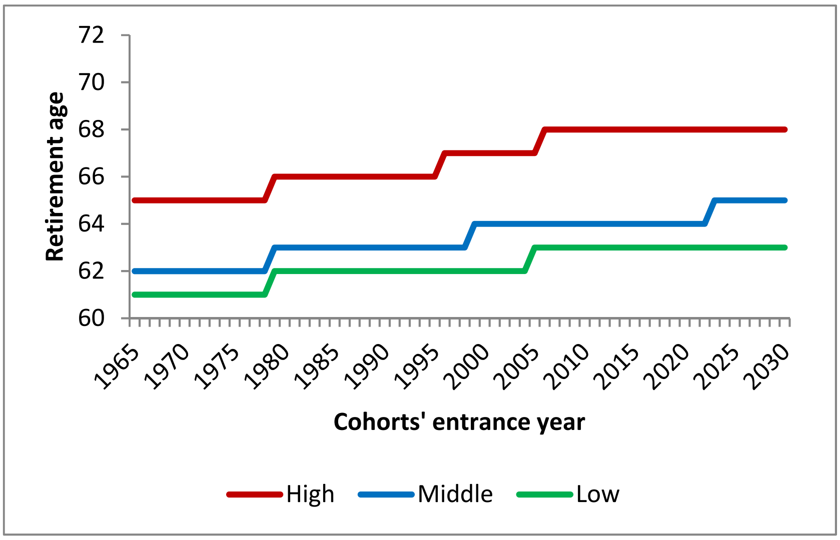
Figure A.2 – Contribution rates



Source: own calculations.

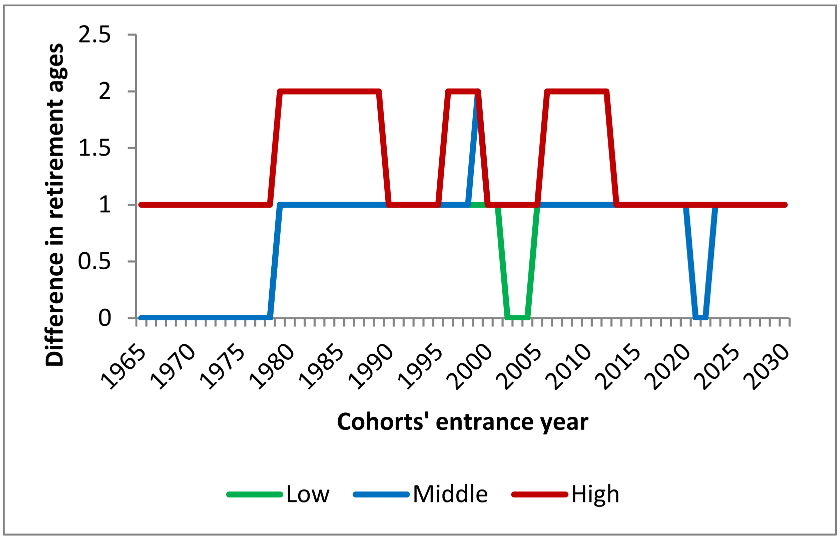
A.2 Increasing retirement age reform

Figure A.3 – Retirement ages



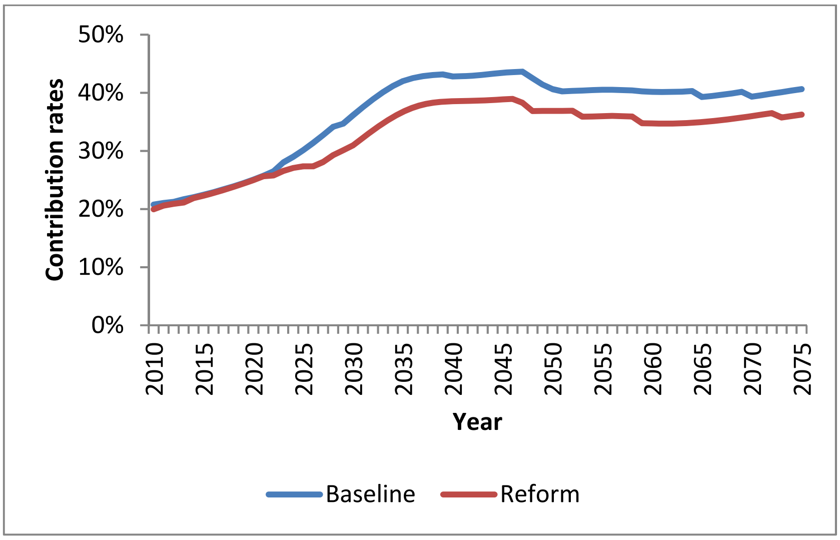
Source: own calculations.

Figure A.4 – Retirement ages (differences)



Source: own calculations.

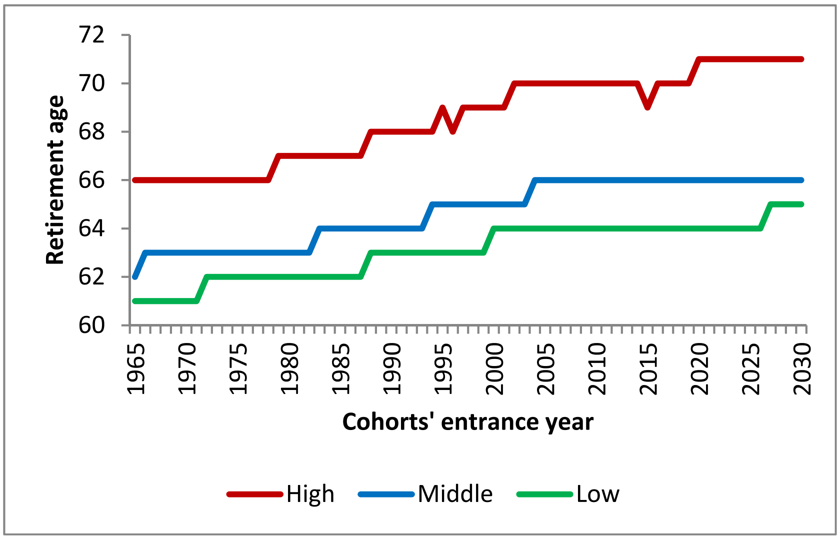
Figure A.5 – Contribution rates



Source: own calculations.

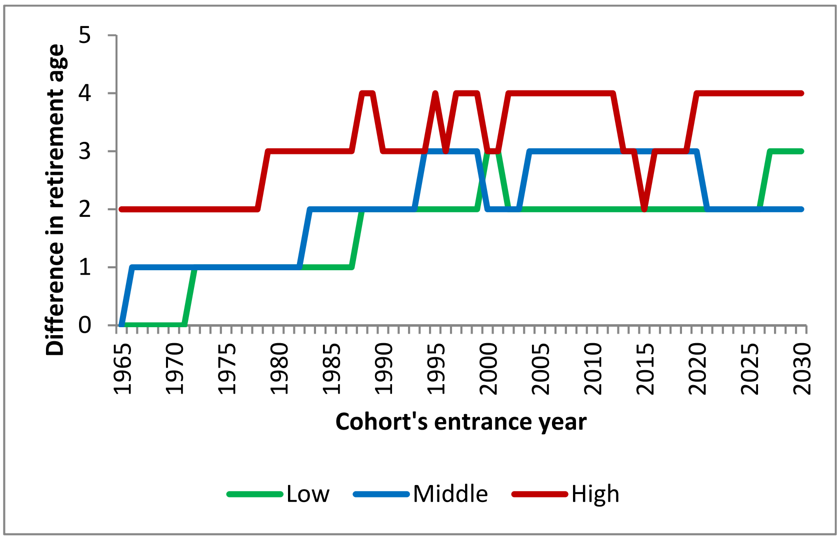
A.3 The 2:1 reform

Figure A.6 – Retirement ages



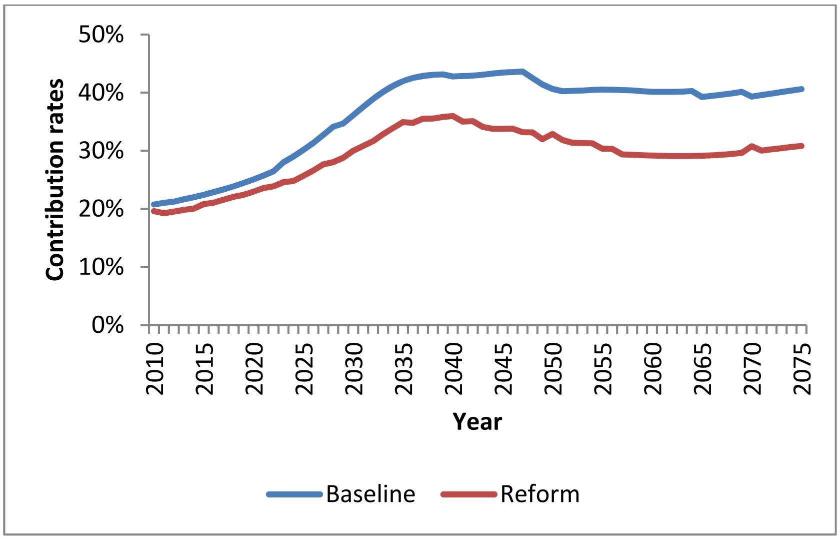
Source: own calculations.

Figure A.7 – Retirement ages (differences)



Source: own calculations.

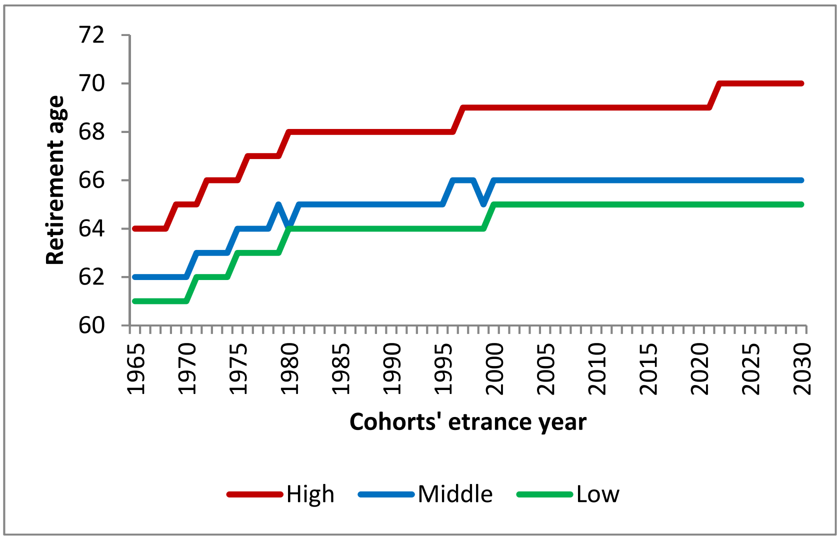
Figure A.8 – Contribution rates



Source: own calculations.

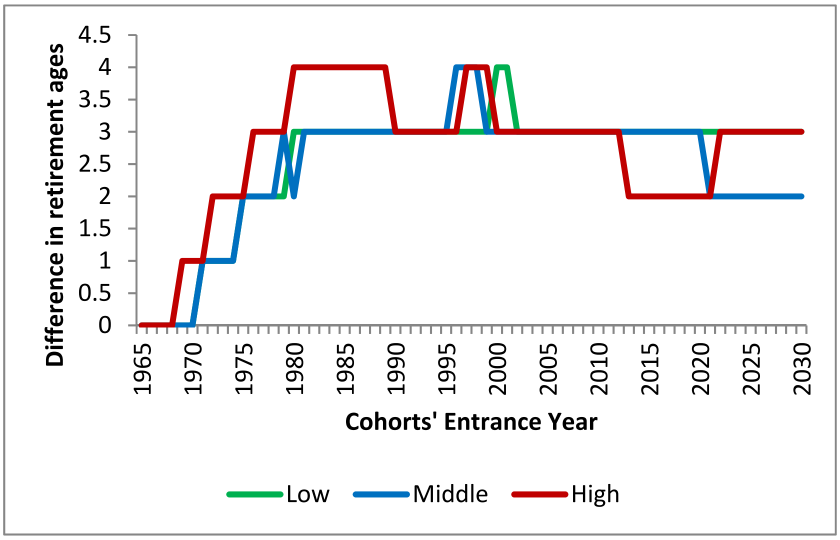
A.4 Actuarial neutral adjustment rates

Figure A.9 – Retirement ages



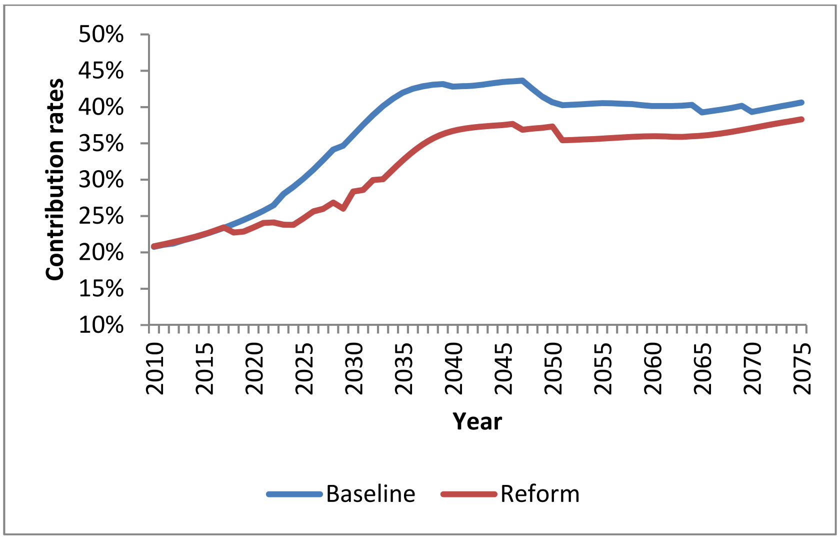
Source: own calculations.

Figure A.10 – Retirement ages (differences)



Source: own calculations.

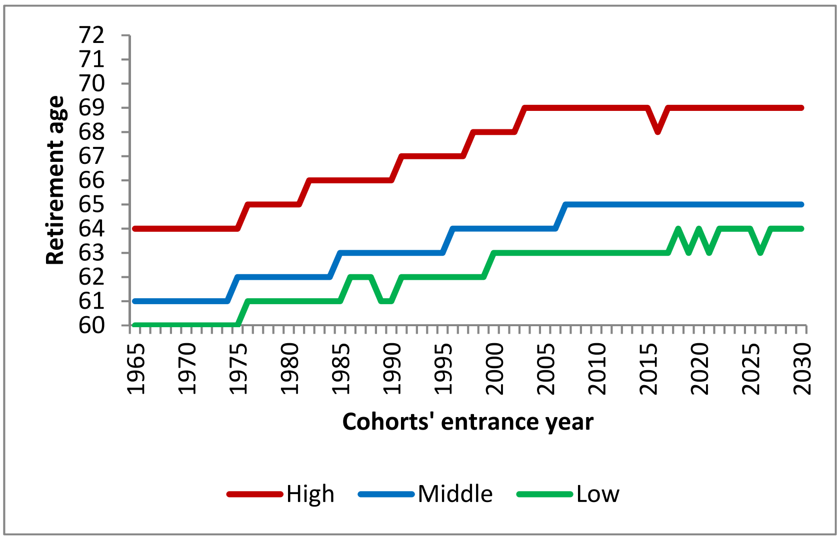
Figure A.11 – Contribution rates



Source: own calculations.

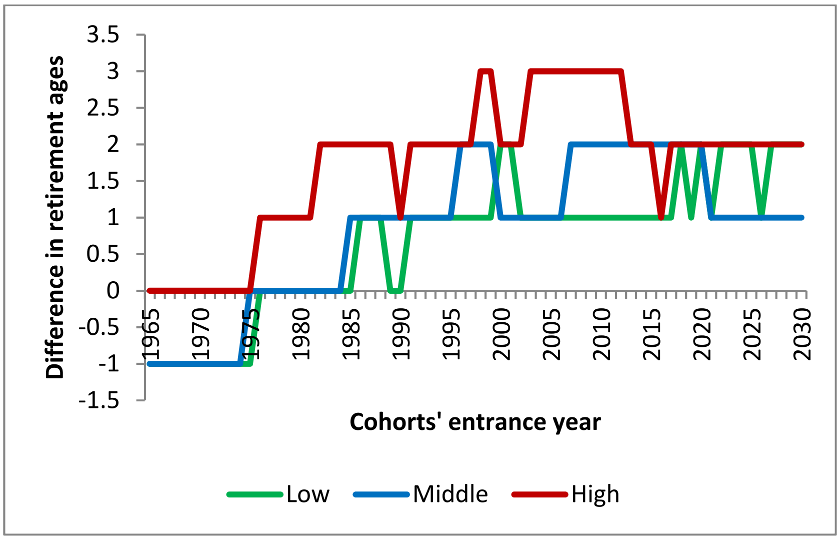
5.5 A hybrid DB/DC PAYG pension system

Figure A.12 – Retirement ages



Source: own calculations.

Figure A.13 – Retirement ages (differences)



Source: own calculations.