University of Warsaw
Faculty of Economic Sciences

Working Papers
No. 3/2014 (120)

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Does social security reform reduce gains from increasing the retirement age?

Warsaw 2014

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Abstract

The objective of this paper is to analyze the welfare effects of raising the retirement age. With aging populations, in many countries de iure retirement age has been raised. With a standard assumption that individuals prefer leisure to work, such policy necessitates some welfare deterioration. This could be outweighed by lower taxation (defined benefit schemes becoming more balanced) or higher pension benefits (defined contribution schemes yield higher effective replacement rate). Moreover, it is often argued that actuarially fair pension systems provide sufficient incentives for individuals to extend the number of working years, which undermines the need to change de iure retirement age. In this paper we construct an OLG model in which we analyze welfare effects of extending the retirement age under PAYG defined benefit, PAYG defined contribution and partially funded defined contribution pension schemes. We find that such policy is universally welfare improving. However, postponed retirement translates to lower savings, which implies decrease in per capita capital and output.

Keywords:
PAYG, retirement age, pension system reform, time inconsistency, welfare

JEL:
C68, E17, E25, J11, J24, H55, D72

Acknowledgements:
Authors would like to thank Agnieszka Borowska and Marcin Bielecki for wonderful research assistance. Authors are grateful to Jan Hagemejer, Lukasz Drozd, Borys Grochulski, Jaromir Nosal and Jacek Suda for insightful suggestions. The support of National Center for Science (grant UMO-2011/01/D/HS4/04039) is gratefully acknowledged. Usual disclaimer applies.

1 Introduction

Raising the *de iure* retirement age is and will probably continue to be a sensitive political issue. Working for a larger number of years is detrimental to welfare if individuals - as is standard in economic models - like to consume, but not to work. With decreasing fertility, on the other hand, labor force is projected to shrink in vast majority of the advanced economies, which boosts interest in policies amed at raising the overall participation, including higher and longer labor market activity of the elderly. In addition to mitigating the negative consequences due to shrinking working population, this policy can have an additional benefit of reducing the public debt implied by future pensions obligations. But is it welfare enhancing?

Imposing more years of labor market activity (extensive margin) can lead to lowering instantenous labor supply (intensive margin). Indeed, with better health and gradually improving working conditions, the duration of the professional career can be extended, but overall life-time labor supply could remain essentially unaffected by the change in the *de iure* retirement age if already before the change it is aligned with individual preferences, Boersch-Supan (2013). On the other hand, raising the retirement age may also have beneficial effects, while they are different depending on a pension system. Under a defined benefit pay-as-you-go system higher retirement age reduces the fiscal burden allowing lower taxes. In a defined contribution pay-as-you-go scheme, which is by definition actuarially fair, fiscal burden is unaffected by the actual retirement age, but by actuarial fairness pension benefits are increased. Finally, funded defined contribution schemes are similar to DC PAYG schemes in as far as pension benefits are concerned, but are likely to display general equilibrium effects. With higher labor abundance, relative price of capital is likely to increase, thus affecting both life-time earned income and returns to savings. As straightforward as these intuitions are, it remains unclear which of these effects is quantitatively larger or - put otherwise - under which pension scheme is it desirable to raise the retirement age.

In this paper we employ an OLG model to ask which pension system generates (greater) overall welfare gains from raising the retirement age. We compare a DB PAYG to transition from this system to DC financed contemporaneously (NDC) and pre-funded (FDC). In addition to being policy relevant, this question is also empirically intriguing. First, it is not clear if the benefits of higher retirement age are going to be outweighed by the benefits under alternative pension systems. Second, there is no clear theoretical intuition concerning the comparison of the welfare effects across the pension systems. Third, we compare the size of the welfare effects due to changing the retirement age to the welfare effects of reforming the pension system from PAYG DB to pre-funded DC and NDC schemes. This additional insight makes this paper particularly informative for other countries, which still are to choose between the parametric and systemic reforms.

There are two important questions unanswered in the literature: (i) can raising the retirement age be a Pareto improvement? and (ii) does reforming the pension system towards more actuarially fair schemes reduce (eventual) welfare gains from raising the retirement age? In order to answer these questions we construct three experiments. In the first experiment the baseline scenario consists of a flat effective retirement age in a PAYG DB scheme, whereas in the reform scenario we allow the retirement age to increase gradually from 60 to 67 years of age. In the second experiment we repeat the reasoning only for a PAYG DC scheme. Finally, the third experiment covers the funded DC scheme. At the starting point in each of these three experiments economy has the same steady state. In addition, the underlying fundamentals are also identical across the experiments and scenarios. Economy has the same exogenous productivity growth rate, households have the same preferences and production sectors are the same. Thanks to this design, we are able to compare the welfare effects both within and across the experiments. To fully measure the welfare costs associated with the transition periods, we employ a dynamic approach: our measure of efficiency, following Nishiyama and Smetters (2007), is a net worth of a Lump Sum Redistribution Authority (LSRA) who collects gains from all the winners and compensates all eventual loosers.

Our analysis is carefully calibrated to the case of Poland - a country which introduced a change from a DB PAYG to a DC system with partial pre-funding. We find that postponing the retirement is universally welfare improving while the welfare gain is similar across analyzed pension systems. Net consumption equivalent from the implementation of this reform equals around 5%-6% if we assume flat age productivity profile. Welfare gain is much larger if productivity increases with age, amounting to approximately 16%. Importantly, all the cohorts benefit from such pension system reform, although this effect is very small for the oldest cohorts, and much bigger for future generations. Under defined benefit systems agents' felicity is enhanced mainly due to fiscal relief. If the pension system is of defined contribution type, welfare gain is related to higher pensions and slightly lower taxation. Households forced to work for more years, adjusted the average annual labor supply downwards, but aggregated labor supply is much higher in the reform scenario. In the DC pension systems lowered K/L ratio decreases private savings which has a detrimental impact on capital and output (per effective unit of labor). This effect is reinforced by the income effect, which also plays a role under the DB scheme.

The paper is structured as follows. Section 2 discusses briefly the relevant literature. Theoretical model is presented in section 3, while section 4 describes in detail calibration and analyzed scenarios. We present the results and various sensitivity checks in section 5. The paper is completed by the conclusions as well as as a review of political economy mechanisms that may be at play in the context of such reforms.

2 Motivation and insights from the literature

In many countries the *de facto* exit age is substantially lower than the *de iure* retirement age, but in fact both grow gradually over the past two decades, especially for women, Figure 1. Despite the apparent increase, Heijdra and Romp (2009) emphasize that in most countries people tend to retire as early as legally allowed. Summarizing the results of international comparative studies done by Gruber and Wise (2007) and their collaborators, they argue that this stems from the fact, that majority of pension systems fails to assure actuarial fairness[1]. Consequently, growth of pension is less than actuarially fair. If retirement (i.e. leisure) is a normal good these results are not surprising. How to reconcile the patterns of Figure 1 with insights from economic theory?

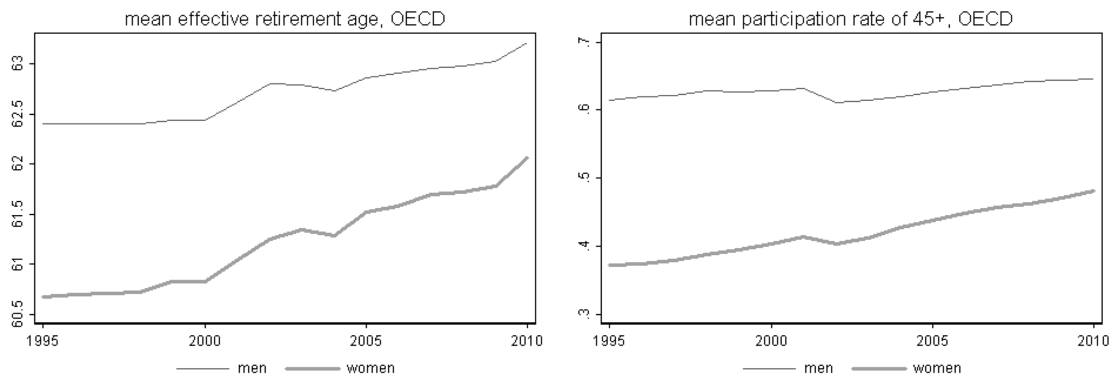


Figure 1: Effective retirement age and labor market participation of the elderly. *Source*: OECD

Building on the seminal work of Auerbach and Kotlikoff (1987), abundant literature analyses the welfare implications of various pension systems empirically, as well as reforms of these pension systems - cfr. Lindbeck and Persson (2003), Fehr (2009). The welfare implications of these reforms are usually conceptualized as a change in utility observed across cohorts, as pioneered by Breyer (1989) and Feldstein (1995). The standard tool here consists of an overlapping generations (OLG) model. In the context of retirement age, the literature thusfar has focused on two questions. First, the literature analyzes optimal retirement age, i.e. age of labor market exit *chosen* by the agents. Here papers include contributions from Cremer and Pestieau (2003), Fehr et al. (2003), Fenge and Pestieau (2005), Galasso (2008), Heijdra and Romp (2009), Fehr et al. (2012). The second strand of research is quantitatively much wider and analyzed the fiscal and welfare effects of various changes in the pension systems, including the increase in the retirement age. Here the the examples date back as early as Auerbach et al. (1989). Typically, raising the retirement age is compared to other reforms or changes in the underlying fundamentals, such as activity rates. Since our paper falls into the second category, in the reminder of this section we will focus on these policy-motivated works.

[1] Boersch-Supan (2000) document this argument for Germany and list actual disincentives for other European countries.

There are a few stylized facts that the literature tries to capture. First, with longevity, certain increase in the retirement age could be seen as a way to accommodate longer duration of life, but keeping the split between working periods and leisure periods unaffected. With most standard preferences, this sort of "reform" should have little or no welfare effects if consumption levels are unaffected. Thus, if baseline scenario included no demographic or retirement age changes, and reform scenarios would encompass longevity and a proportionally increasing retirement age - welfare would typically stay unaffected, Fenge and Pestieau (2005). However, most of the literature - as most of citizens and policy-makers - assume longevity to constitute a baseline and only retirement age changes to be policy changes. Then, welfare depends on opportunities related to aging, i.e. gain valuable life years. These gains can only be exploited if labor market participation increases, Boersch-Supan (2013).

The link between retirement age and labor market participation is not immediate. Namely, if the life-time amount of work is optimal, extending the retirement age will force households to stay in the labor market *longer*, but they will adjust to welfare deteriorating changes by reducing the amount of labor supplied in each working year, Boersch-Supan et al. (2007), Boersch-Supan and Ludwig (2010). Thus, literature suggests that raising the retirement age is only welfare enhancing if the *de iure* retirement age is too low and pension system provides disincentives to prolonging labor market activity beyond the official legal limit.

Many papers compare the effects of raising the retirement age to other pension system reforms. Auerbach et al. (1989) model the effects on taxes of three types of reforms: postponing retirement by two additional years, 20% cut in pensions and reducing the non-pension expenditure for a number of countries. Similar excercise is done by Hviding and Marette (1998), who additionally include phased abolition of PAYG schemes. Both these studies find, that relatively "painless" adjustment in the retirement age yields gains comparable to these other "painful" reforms. Also Fehr (2000) finds that increasing the retirement age for Germany can yield considerable improvement in fiscal stance. Díaz-Giménez and Díaz-Saavedra (2009) find that delaying the retirement age in Spain by 3 years is able to put the pension system back to balance despite aging, with welfare improvements as early as a few years after the policy change. In a similar spirit, Boersch-Supan and Ludwig (2010) analyze possible reforms that could offset the effects of aging in Germany, France and Italy, showing that reduced distortions (e.g. lower labor taxes and contributions due to lower deficit in the pension system) could result in higher labor supply. The direct and indirect effects of raising the retirement age are positive from the fiscal perspective.

In addition to the fiscal side (and output), also welfare analyses can be found in the literature. Intuitively, if pension system is not actuarially fair, the generations who experience an increase of retirement age very close to reaching it bear negative welfare consequences: their pension grows moderately or not at all, whereas their ability to adapt labor supply during the lifetime to the changed retirement age are scarce. The younger the cohort, the bigger the positive contribution from lower taxes and/or debt and higher ability to chose optimal lifetime labor supply. Thus, future cohorts record mostly welfare gain from this sort of reform, Auerbach et al. (1989). Fehr (2000) shows that with increased retirement age households reduce hours in the middle of working period, but actual welfare gains depend on a strength of the link between contributions and benefits.

Indeed, if pension system is actuarially fair, even older cohorts experience gain (in the form of higher pension). For example, Boersch-Supan et al. (2007) provide simulations of old-age labor supply responses to some policy changes, showing that, for example, actuarially fair adjustments would increase the average endogenous exit age in Germany by more than 3 years. However, if the actuarially fair system is exposed to other systemic risks, as is often the case with pre-funded schemes, increase necessitated by risk-sharing cannot be offset by the increase in the retirement age, Beetsma and Bucciol (2011).

Recently, there are additionally three issues that blended into the debate on raising the retirement age. The first issue is the international context: it is often assumed that increased labor supply (due to an increased retirement age) will necessitate K/L adjustment within that economy. However, with a differentiated pace of aging and schedule of increases in the retirement age, in open economies capital could adjust by flowing between the countries, rather than changing the K/L ratio in response to shrinking labor supply in each respective economy, Boersch-Supan et al. (2006). The second issue is the link between the pension system and the human capital. For example, if human capital formation is endogenous, longer activity implies higher returns to initial investment in skills, which raises the overall human capital in the economy, Annabi et al. (2011).

This additional channel is important also for the forecasts of age-productivity patterns. Finally, the third issue is linked to the assumption about the productivity growth in OLG models. Typically, labor augmenting productivity is exogenous, but for example Bouzahzah et al. (2002) endogenize economic growth and conclude that this assumption has no bearing on the evaluation of such policy changes as raising the retirement age. Similar excercise was done earlier by Futagami and Nakajima (2001), who argue that under PAYG DB system raising the retirement age can reduce savings, thus lowering the capital intensity of the economy, which slows down the growth. This last paper lacks welfare analysis, though.

Summarizing, the literature provides intuition on what effects we should expect from raising the retirement age. Typically extending the working period is welfare improving, but older cohorts typically loose in the process of the reform. Welfare gains in actuarially fair systems are more equally spread across cohorts, which requires less redistribution to make these gains universal. However, majority of studies focused on one particular system, typically PAYG DB schemes. Considerably less attention was devoted to DC schemes - whether pre-funded or pay-as-you-go. Little is known of differences about the efficiency gains from increasing the retirement age under different pension system, *ceteris paribus*.

Our paper fills this gap by investigating the welfare and macroeconomic effects of raising the retirement age under PAYG DB as well as (transition to) PAYG DC and partially funded DC scheme. The model we use replicates the systemic features of Polish economy and Polish pension system prior to the reform from a PAYG DB to a partially funded DC scheme. It is often argued that actuarially fair schemes - such as DC schemes - no longer necessitate policies aimed at raising the retirement age, *via* the virtue of the aligned incentives argument. However, this argument is of more fiscal nature - from a welfare perspective, gains could exist even under DC schemes. We address these issues in our model.

3 The model

Our economy is populated by overlapping generations who in each period face mortality risk. The production sector is fairly standard, with competitive firms, which all dispose of constant returns to scale technology with labor augmenting technological progress. Interest rate is endogenously determined in the model. Households are homogeneous within cohort and have perfect foresight concerning fully deterministic evolution of wages, capital, interest rates, etc. Additionally, our model features pension system and government[2].

3.1 Consumers

Agents arrive in our model at the age of 20 and have a maximum lifespan of $J = 80$ periods. Agents are homogeneous within cohorts, where $j = 1, 2, ..., J$ denotes age. This allows us to abstract from the problem of the timing of the labor market entry (which depends on educational choices). Each agent born in period t has unconditional time varying probability of survival until age of j, $\pi_{j,t}$. We also assume that all consumers who survive until the age of $j = 80$ die with certitude. We denote the size of cohort born in period t as N_t. Lowering fertility is operationalized in our model by adjusting the size of the 20-year old cohort appearing in the economy each year. Longevity is operationalized *via* the adjusting downwards the mortality rates. Our agents discount future exponentially, with discount factor δ. Consumers optimize lifetime log-linear utility derived from leisure $(1 - l_{j,t})$ and consumption $c_{j,t}$:

$$U_0 = \sum_{j=1}^{J} \delta^{j-1} \pi_{j,t-1+j} \ln \left[c_{j,t-1+j}^{\phi} (1 - l_{j,t-1+j})^{1-\phi} \right]. \quad (1)$$

Consumers have elastic labor supply up to the retirement age $\bar{J}_t$, when they have to retire: $l_{j,t} = 0$ for $j \geq \bar{J}_t$. If the incentives concerning the age of exiting the labor market, are aligned with social preferences, no legal limit is necessary to assure that people choose retirement age optimally. Under these circumstances actual retirement age could be modeled as an endogenous decision, where households choose between more years of leisure or higher consumption due to

[2]This model shares many features with Hagemejer et al. (2013), where it is discussed in detail

higher contributions and thus pensions. However, in addition to potential (dis)incentives coming from the retirement system alone, the minimal retirement age in many countries affects also access to many labor market institution (e.g. unemployment benefits are unavailable, training is no longer subsidized by the governments, etc.). These institutions make people even more prone to retire at the earliest, i.e. the legal age. We follow this stylized fact in our model specification, i.e. agents can no longer work after $\bar{J}_t$.

Labor productivity of consumers ω_j is age specific and time invariant. Real wage of agent of age j is equal to $w_{j,t} = w_t \cdot \omega_j$ per unit of labor $l_{j,t}$, where w_t is equal to the marginal product of labor. Additionally, agents pay labor income tax τ_l and social security contributions τ^ι. When agents retire, they receive benefits from the pension system.

We consider three pension schemes: defined benefit (DB), notionally defined contribution (NDC) as well as partially funded defined contribution (FDC). Thus for each agent of age j there can be three streams of pensions $p_{\iota,j,t}$ where $\iota \in \{DB, NDC, FDC\}$. Fehr (2000) argues that benefits of extending the working age depend on the strength of the link between contributions and benefits. In our model agents have perfect foresight, which means they aware of the $p_{\iota,j,t}$. However, they do not see a direct link between the contributions to the system and the pensions received. In this sense, our setting is conservative *vis-a-vis* the main research question of this paper.

Since each cohort faces mortality risk there are unintended bequests. For simplicity, we assume that they are redistributed within the same cohort, $b_{j,t}$. Since there is no risk in our model, this assumption is not problematic in the agents' optimization problem. Since the model is fully deterministic, agents have no preferences towards risk.

Savings of agent j in period t ($s_{j,t}$) are composed of capital assets and government bonds. Savings earn an interest rate r_t and are taxed with the capital income tax τ_k. The budget constraint of agent j in period t is given by:

$$\begin{aligned} (1+\tau_{c,t})c_{j,t} + s_{j,t} + \tau_j + \Upsilon_t &= (1-\tau^\iota_{j,t} - \tau_{l,t})w_{j,t}l_{j,t} \leftarrow \text{ labor income} \\ &+ (1 + r_t(1-\tau_{k,t}))s_{j,t-1} \leftarrow \text{ capital income} \\ &+ (1-\tau_{l,t})p_{\iota,j,t} + b_{j,t} \leftarrow \text{ pensions and bequests} \end{aligned} \tag{2}$$

where Υ_t denotes lump sum tax/transfer equal for all generations. All living agents pay a consumption tax τ_c.

The interest rate earned by the households comes from two types of assets: government bonds and capital assets. Thus, the model has two interest rates: one paid by the government on any debt it issues and one paid by the firms on any investment by the households. Naturally, the former is lower. In the world with no risk and no risk preference, households would only invest in productive capital, thus forcing the government to finance itself at a prohibitively high cost. To solve this problem we introduce $r^G = \xi r$. Households buy as much government debt as is issued at r_G and allocate whatever savings are left to capital accumulation. Please note, that in the long run the government is constrained to converge to the initial steady state debt-to-GDP ratio of 45%, which puts a natural ceiling on long term debt. In addition, in Poland the constitution imposes a limit on debt-to-GDP ratio of 60%, which implies that the government does not issue much debt. Accordingly, the actual interest rate on saving is given by a weighted average of r^G and r, where the weights are implied by government demand (debt) and the size of savings. Data implies that over the 1995-2005 period the government paid approximately 45% of the commercial market interest rate, while this proportion is decreasing at a decreasing rate. Given this, ξ was set conservatively to 33%.

We are modeling a policy change which involves implicit transfers between the generations. To account for that we design a Lump Sum Redistribution Authority, which computes the pre-reform and post-reform utility levels for all cohorts, thus determining if the reform involves a welfare loss or a welfare gain for each generation (Nishiyama and Smetters 2007). Post-reform agents may receive cohort specific compensation (or pay a tax) issued by the Lump Sum Redistribution Authority (LSRA). The LSRA allocates the tax/transfer to each cohort comparing the utility cohort j would have had in the baseline scenario and the one cohort j has in the analyzed policy change scenario. The tax/transfer is computed as consumption equivalence based on the difference in the utilities. The net worth of the LSRA informs about the efficiency of the analyzed policy change.

3.2 Production

Competitive producers have access to the constant returns to scale technology with labor augmenting technological progress. They use capital and labor to produce consumption goods with the following Cobb-Douglas production function $Y_t = K_t^{\alpha}(z_t L_t)^{1-\alpha}$. Firms solve the following problem:

$$\max_{(Y_t,K_t,L_t)} Y_t - w_t L_t - (r_t^k + d)K_t \quad \text{s.t. } Y_t = K_t^{\alpha}(z_t L_t)^{1-\alpha} \tag{3}$$

where L_t represents aggregate labor employment. z_t grows at the exogenous time varying rate γ_t. Note that if the rate of return on capital is r_t^k therefore the rental rate must be $r_t^k + d$, where d denotes capital depreciation. Firm optimization naturally implies $w_t = (1-\alpha)K_t^{\alpha} z_t^{1-\alpha} L_t{}^{-\alpha}$ and $r_t^k + d = \alpha K_t^{\alpha-1}(z_t L_t)^{1-\alpha}$.

3.3 Pension systems

Pension systems we model are closely benchmarked to the legal conditions in Poland. As already mentioned, we consider three types of pension system $\iota \in \{DB, NDC, FDC\}$, where DB, NDC and FDC denote, respectively, defined benefit PAYG , defined contribution PAYG and defined contribution partially funded pension systems. Following the actual design of the pension system and the pension system reform, we keep contributions equal across cohorts, constant across time and the same in all systems: $\tau = \tau_{j,t}^{DB} = \tau_{j,t}^{NDC} = \tau_{j,t}^{FDC}$.

Defined benefit (DB) system. In the DB pay-as-you-go pension system agents pay a contribution rate τ^{DB} and when they retire they receive pension based on an exogenous replacement rate ρ. Later on pensions are indexed in real terms with the 25% of the growth rate of payroll $\kappa_t^{PAYG} = 1 + 0.25 \cdot r_t^I$, where r_t^I denotes the growth rate of labor income is defined as:

$$r_t^I = \frac{\sum_{j=1}^{J}(\pi_{j,t-1}N_{t-j}w_{j,t}l_{j,t} - \pi_{j,t-1}N_{t-1-j}w_{j,t-1}l_{j,t-1})}{\sum_{j=1}^{J}\pi_{j,t-1}N_{t-1-j}w_{j,t-1}l_{j,t-1}}. \tag{4}$$

Consequently, pensions are given by:

$$p_{j,t}^{DBP} = \begin{cases} \rho w_{j-1,t-1}, & \text{for } j = \bar{J}_t \\ \kappa_t^{PAYG} \cdot p_{j-1,t-1}^{DB}, & \text{for } j > \bar{J}_t. \end{cases} \tag{5}$$

Pensions expenditure are financed with contributions of the working as well as subsidy from the government (denoted as $subsidy_t$):

$$\sum_{j=\bar{J}_t}^{J} \pi_{j,t}N_{t-j}p_{j,t}^{DB} = \tau \sum_{j=1}^{\bar{J}_t-1} w_{j,t}\pi_{j,t}N_{t-j}l_{j,t} + subsidy_t^{DB} \tag{6}$$

Funded defined contribution (FDC) system. The partially funded defined contribution consists of two pillars. The first pillar is DC PAYG system and the second is DC fully funded system. The contribution rate is split between two pillars $\tau = \tau_I + \tau_{II}$. Old age pension is the sum of pensions from the first and second pillars: $p_{j,t}^{FDC} = p_{I,j,t}^{FDC} + p_{II,j,t}^{FDC}$. The contributions of agent of age j to the first pillar are used to finance benefits which are calculated at the retirement age according to actuarial fairness. Afterwards, pensions are indexed the same way as in DB PAYG, i.e. $\kappa_t^{PAYG} = 1 + 0.25 \cdot r_t^I$.

$$p_{I,j,t}^{FDC} = \begin{cases} \dfrac{\sum_{i=1}^{\bar{J}_t-1}\left[\Pi_{s=1}^{i}(1+r_{t-i+s-1}^I)\right]\tau_{I,\bar{J}_t-i,t-i}^{FDC}w_{\bar{J}_t-i,t-i}l_{\bar{J}_t-i,t-i}}{\Pi_{s=\bar{J}_t}^{J}\pi_{s,t}}, & \text{for } j = \bar{J}_t \\ \kappa_{I,t}^{PAYG} \cdot p_{I,j-1,t-1}, & \text{for } j > \bar{J}_t \end{cases} \tag{7}$$

Since under defined contribution benefits are actuarially fair, the system is balanced by construction. This principle holds for both pillars. However, in cash terms, contemporaneous payments (to the current retirees) do not need to be equal to the contemporaneous benefits (current contributions from the working population). We thus specify, that the government must fill out the gap with subsidy (or collects the surplus). The old age pensions are financed by the contributions of working agents and subsidy from the government:

$$\sum_{j=\bar{J}_t}^{J} \pi_{j,t} N_{t-j} p_{I,j,t}^{FDC} = \tau_I \sum_{j=1}^{\bar{J}_t - 1} w_{j,t} \pi_{j,t} N_{t-j} l_{j,t} + subsidy_{I,t}^{FDC}. \tag{8}$$

In the second pillar savings of agents are invested with the return equal to the interest rate r_t, but there is no capital income tax on the returns. When agents retire their pensions are calculated according to the actuarial fairness. Given that whatever is not spend on pensions can still be invested we get that the second pillar pensions can be indexed with the interest rate[3]. Therefore:

$$p_{II,j,t}^{FDC} = \begin{cases} \frac{\sum_{i=1}^{\bar{J}_t - 1} \left[\Pi_{s=1}^{i} (1 + r_{t-i+s-1}) \right] \tau_{II} \cdot w_{\bar{J}_t - i, t-i} l_{\bar{J}_t - i, t-i}}{\Pi_{s=\bar{J}_t}^{J} \pi_{s,t}}, & \text{for } j = \bar{J}_t \\ (1 + r_t) p_{II,j-1,t-1}^{FDC} & \text{for } j > \bar{J}_t \end{cases} \tag{9}$$

Notionally defined contribution (NDC) system. For the remaining case of DC pay-as-you-go social security system (NDC) it is constructed exactly like the first pillar of the partially funded DC system (FDC). The only difference is that there is no second pillar, therefore $\tau^{NDC} = \tau_I + \tau_{II} = \tau$. Pensions are payed according to the similar formula as in case of the first pillar of NDC

$$p_{j,t}^{NDC} = \begin{cases} \frac{\sum_{i=1}^{\bar{J}_t - 1} \left[\Pi_{s=1}^{i} (1 + r_{t-i+s-1}^{I}) \right] \tau \cdot w_{\bar{J}_t - i, t-i} l_{\bar{J}_t - i, t-i}}{\Pi_{s=\bar{J}_t}^{J} \pi_{s,t}}, & \text{for } j = \bar{J}_t \\ \kappa_t^{PAYG} p_{j-1,t-1}^{NDC}, & \text{for } j > \bar{J}_t \end{cases} \tag{10}$$

where $\kappa_t^{PAYG} = 1 + 0.25 \cdot r_t^I$. Also subsidy is calculated similarly as the first pillar of FDC

$$\sum_{j=\bar{J}_t}^{J} \pi_{j,t} N_{t-j} p_{j,t}^{NDC} = \tau \sum_{j=1}^{\bar{J}_t - 1} w_{j,t} \pi_{j,t} N_{t-j} l_{j,t} + subsidy_t^{NDC}. \tag{11}$$

3.4 Government

Government, apart from balancing the social security, also collects taxes on income, interest and consumption and spends a fixed share of GDP on government consumption G_t. We compute the path of G_t as a constant share of GDP in the baseline scenario and then impose the same *value* of government expenditure in the reform scenarios.

Given that the government is indebted, it naturally also services the outstanding debt.

$$G_t + subsidy_t^{\iota} + r_t^G D_{t-1} = T_t + (D_t - D_{t-1}) + \Upsilon_t \sum_{j=1}^{J} \pi_{j,t} N_{t-j}. \tag{12}$$

where

$$T_t = \tau_{l,t} \Big(w_t L_t + \sum_{j=\bar{J}_t}^{J} p_{j,t}^{\iota} \pi_{j,t} N_{t-j} \Big) + \Big(\tau_{c,t} c_t + \tau_{k,t} r_t s_{j,t-1} \Big) \sum_{j=1}^{J} \pi_{j,t} N_{t-j}. \tag{13}$$

We calibrate the level of debt D_t in the initial steady state to match the data and in the final steady state at around 45% of GDP, which was the actual value of debt-to-GDP ratio in 1999. The government deficit is calibrated in the first steady state to 3% in GDP, as is the historical average for Poland as well as the European Union threshold not to be exceeded by the Member States. We calibrate lump sum taxes Υ_t to match the deficit in the initial steady state with these data. Similarly to government expenditure, keeping this as a a constant share of GDP, we compute in the

[3]Here too unintended bequests may occur. For simplicity we assume that II pillar funds of agents who die before the age of J are used to finance pensions of living. The probability of survival until J is thus included in the pension formula in both pillars, according to equations (7)-(9).

baseline the actual path of Υ_t then imposing as a *value* in the reform scenarios. The final steady state has the same debt share in GDP as the initial steady state. Depending on the system, on the transition paths the actual government debt may differ but cannot exceed the upper limit of 60% of GDP.

3.5 Market clearing conditions, equilibrium and model solving

Clearing of the goods market requires

$$\sum_{j=1}^{J} \pi_{j,t} N_{t-j} c_{j,t} + G_t + K_{t+1} = Y_t + (1-d)K_t, \tag{14}$$

We also need market clearing conditions for the labor market and the assets market:

$$L_t = \sum_{j=1}^{\bar{J}_t - 1} \pi_{j,t} N_{t-j} \omega_{j,t} l_{j,t} \qquad \text{and} \qquad K_{t+1} = \sum_{j=1}^{J} \pi_{j,t} N_{t-j} \hat{s}_{j,t} - D_t, \tag{15}$$

where $\hat{s}_{j,t}$ denotes private savings $s_{j,t}$ as well as accrued obligatory contributions in fully funded pillar of the pension system.

An equilibrium is an allocation $\{(c_{1,t},...,c_{J,t}),(s_{1,t},...,s_{J,t}),(l_{1,t},...,l_{J,t}),K_t,Y_t,L_t\}_{t=0}^{\infty}$ and prices $\{w_t,r_t\}_{t=0}^{\infty}$ such that: (i) for all $t \geq 0$, for all $j = 1,2,...,J$ $(c_{j,t},...,c_{J,t+J-j})$, $(s_{j,t},...,s_{J,t+J-j})$ and $(l_{1,t},...,l_{J,t+J-j})$ solve the problem of an agent j, given prices; (ii) for all $t \geq 0$, (K_t,Y_t,L_t) solves the firm's problem (3), given prices; (iii) PAYG part of the social security system is balanced, i.e. (6) or (11) or (8) (depending on the type of pension system) are satisfied; (iv) the government budget is balanced, i.e. (12) is satisfied; and (v) markets clear, i.e. (14)-(15) are satisfied.

If the pension system deficit causes the debt to grow, debt is allowed to increase on a transition path until it reaches a share in GDP of 60%. This level is both the constitutional limit on debt share in Poland and a threshhold for the European Union Member States to be obeyed. If debt surpasses this level, consumption taxes are adjusted to account for the additional expenditure. In the final steady state the debt is forced to return to a share of 45% of the GDP. This adjustment too happens *via* increased consumption taxes. We assume that the adjustment is gradual and starts no sooner than when the youngest of the cohorts living in the first steady state dies. Thus, cohorts living in the begining of the transition path experiece increase in taxation only if the debt implied by the pension system causes the overall public debt to exceed 60% share in GDP. Cohorts born later may see increased consumption tax to have the debt share in GDP decrease to the final steady state.

In order to solve the model we first find the initial and the final steady states and then the transition path. We pick the length of the path so that the new steady state is reached, i.e. the last generation on the transition path spends their whole life in the new steady state. Eventually, we selected the length of the path to be 250 periods (which is more than enough). The initial steady state is calibrated to match the data. The major difference between the early periods and the late periods in the model is the demography (different populations of 20-year-olds and different mortality rates) and productivity growth (in catching up economies usually growth slows down as they converge to the levels of output per capita observed in developed economies), as described in detail in Section 4.

In order to compute our results we solve the model twice. First, we find the benchmark scenario of no policy change (retirement age does not change) but with changes in demographics and productivity. Second, we solve the model with extended retirement age. In both these scenarios the lifetime utilities for all generations are computed. These values of utility constitute basis for the Lump Sum Redistribution Authority (LSRA), similar to Nishiyama and Smetters (2007). Tax/transfer for a given cohort is determined as a consumption equivalent of the baseline scenario against the reform scenario. The net balance of these taxes/transfers informs about the overall efficiency of the reform.

We use the the Gauss-Seidel method that became standard in solving the OLG models (both in the steady state and on the transition path). First, we guess the aggregate capital per effective worker (or its value in the steady state). Subsequently y is computed and used to calculate variables related to pension system and government sector, such as G, T, S, D, Υ as well as the individual benefits p_j^ι, where $\iota = DB, NDC, FDC$. Then using this information as well as w and r we solve the problem of individual consumers and find their choice variables c_j, s_j and l_j. Finally, k is updated using the formula in (15). This procedure is repeated until the difference between k from subsequent iterations is negligible.

4 Calibration

Our model was calibrated to the Polish economy where the social security system was changed from PAYG DB to partially funded DC system. In order to calibrate the initial steady state we use the microevidence on life-cycle characteristics, taxes, growth rates, etc. Given these we next calibrate the depreciation rate d in order to match the investment rate in the data i.e. app. 21% and we calibrate the discount factor δ so that the interest rate in the economy r was equal 7.5%, which is the effective annual interest rates in the funded pillar in real terms. To put this number into a perspective, Nishiyama and Smetters (2007) calibrate the interest rate to 6.25% for the US economy. Given that the Polish economy is scarce in capital and catching up, it is reasonable to consider a somewhat higher value.

4.1 Calibration of the structural parameters

In this section we describe how all structural parameters are calibrated, we focus on demographics, productivity, preferences, government sector and the depreciation rate for capital. The values of the key parameters are presented in Table 1.

Preferences and technology. We pick ϕ, the agents' preference for leisure/consumption, so that the labor market participation rate amounts to 56.8%, as observed in 1999. We set, as it is standard in literature $\alpha = 0.31$. We calibrate the discount factor δ to match the interest rate of 7.5%, and the depreciation rate d to match the investment share in GDP equal to 21%, see Table 1.

Demographics. Demographics in our model is exogenous. We take the number of 20-years olds (which in our model have age $j = 1$) and mortality rates form the demographic projection for Poland[4]. Figure 2 presents the number of 20-year-olds and mortality rates in time as implied by the projection. As in our model we do not distinguish between genders we compute the average population weighted mortality rates. We also assume that demographics stabilizes and remains constant after 130 periods (which corresponds to 50 periods taken from the projection + 80 periods of constant number of 20-year-olds), to assure steady state.

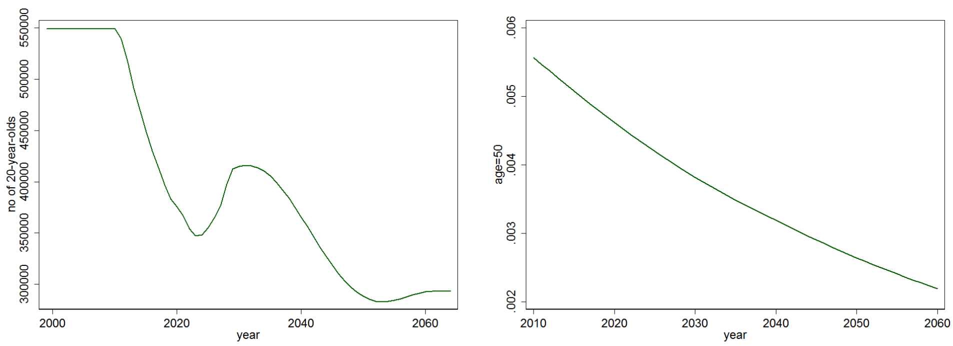


Figure 2: No of 20-year-olds arriving in the model in each period (left) and mortality rates across time for a selected cohort. *Source*: EUROSTAT demographic forecast untill 2060

[4]We use the projection for the years up to 2060 of the European Commission.

Productivity growth (γ_t). The model features labor augmenting exogenous productivity growth $\gamma_{t+1} = z_{t+1}/z_t$. The projected values for the next 50 years are taken from the forecast by the Ageing Work Group of the European Commission, which comprises such time series for all EU Member States, Figure 3. This projection was constructed on general assumption that countries with lower *per capita* output would be catching up until around 2030 and since then exogenous productivity growth for all countries would be converging slowly towards the steady state value of 1.7% *per annum*.

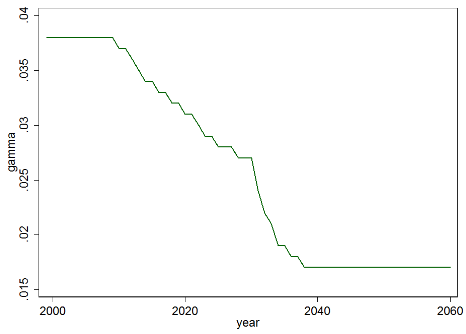


Figure 3: Labor augmenting productivity growth rate projection. *Source*: European Comission

Age specific productivity (ω_j). Despite numerous studies, the shape of age-productivity pattern remains a discretionary area. Most of the studies assume an inverted U-shaped pattern[5]. On the other hand, when adequately controlling for self-selection and cohort effects, age-productivity profile becomes fairly flat and - if anything - slightly increasing until the age of 65, see Boersch-Supan and Weiss (2011). In our case we follow Deaton (1997) in decomposing the differences in individual productivities into age effects, cohort effects and time effects. The profile that we obtained is presented in Figure 4 (left panel). We also use a flat age-productivity pattern as a robustness check.

Retirement age and replacement rate. In Poland legal retirement age is 60 for women and 65 for men. However, due to numerous exceptions effective retirement age was substantially lower. In 2009 most of these exceptions were removed as of 2009 and the legal retirement age is to increase to reach 67 for men in 2018 and for women in 2040. Additionally, generations working mostly

[5]See Skirbekk (2004) as well as a special issue of Labor Economics (volume 22, 2013).

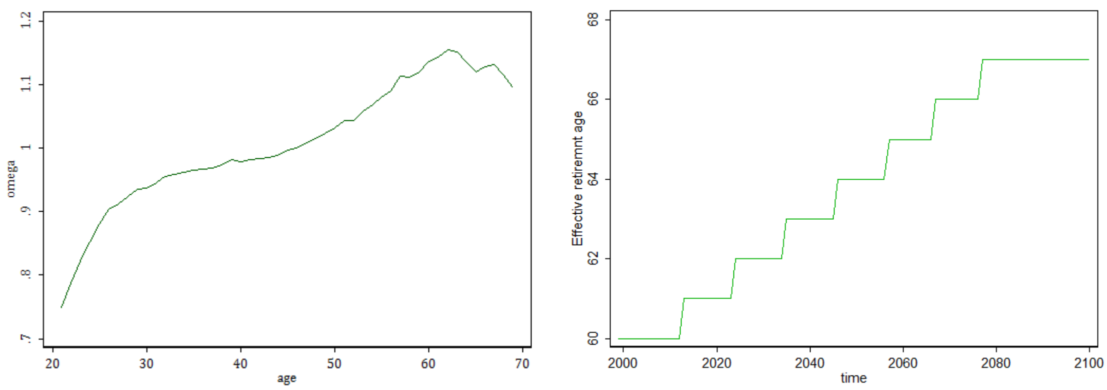


Figure 4: Age specific productivity multiplier (left) and actual retirement age in economy, past values and forecasts. *Source*: ω computed according to Deaton (1997) decomposition using 16 years of LFS data for Poland. Effective retirement age based on SIF annual reports untill 2012, afterwards it is a reform scenario.

pre-transition had stronger preference for relatively early exit while cohorts working mostly post-transition with skills better matching the demand in the labor market have preferences for staying longer in the labor market. These features are reflected in a path of retirement age in our model, see Figure 4 (right panel). In Poland *de iure* replacement is flat after passing a threshold of 20 years or active labor market participation. Thus in our model replacement rate is constant. We calibrate the replacement rate, ρ, to match the 5% pensions to GDP ratio in 1999. Depending on the selected productivity profile, the values for the replacement rate are different, see Table 1.

Taxes. We set the tax rate on income (labor and pensions) at 11% to match the rate of income tax revenues in the aggregate employment fund. We set social security contributions match the ratio of total contributions to GDP equal to 4.2%. Consumption tax τ_c is fixed at 11%, which matches the rate of revenues from this tax in aggregate consumption in 1999. There are no tax redemptions on capital tax, so our effective measure is the *de iure* capital income tax $\tau_k = 19\%$.

Table 1: Calibrated parameters

		Age-productivity profile	
		ω - D97	$\omega = 1$
α	capital share	0.31	0.31
τ_l	labor tax	0.11	0.11
ϕ	preference for leisure	0.576	0.538
δ	discounting rate	0.998	0.981
d	depreciation rate	0.055	0.042
τ	total soc. security contr.	0.060	0.063
ρ	replacement rate	0.150	0.270
		resulting	
Δk_t	investment rate	20.7	21
r	interest rate	7.5	7.6

Note: D97 denotes calibration with productivity profile according to Deaton (1997) decomposition, $\omega = 1$ denotes flat age productivity profile.

4.2 Scenarios

It is often emphasized that reforming the pension system from a defined benefit to a defined contribution scheme no longer requires adjustment in the retirement age. Defined contribution systems are by construction actuarially fair, which implies that increasing total individual contributions increases pensions as well. Overall, tampering with the retirement age does not change what people get from the pension system, thus having no important effect on fiscal balance. Consequently, welfare effects could only come from two channels: (a) different choice between leisure and consumption and (b) general equilibrium effects. Importantly, agents can affect the former even without the change in the statutory retirement age, simply raising labor supply prior to retirement age. After extending retirement age agents could work exactly the same number of total life hours, only over larger number of years. This contraction of hours worked in response to longer working period has been emphasized by the literature. In other words, under DC little or no welfare gain should exist from raising the retirement age.

In the DB pay-as-you-go system, extending the retirement age lowers taxes therefore providing additional incentive to work longer hours. And since it reduces the distortions from taxation, intuition on the origins of welfare gains is straightforward. However, there could be important general equilibrium effects (happening *via* relative scarcity of capital as well as on the fiscal side) as well as important redistribution effects between the cohorts. Thus, our objective here is to test the prediction that raising retirement age is important in DB systems, but much less so in DC systems. We do that by comparing the welfare effects of extending the retirement age under defined benefit and defined contribution schemes. We include the pay-as-you-go and the partially funded DC in the comparison to observe the link between labor supply and capital accumulation if part of the savings happens *via* a compulsory pension system.

In order to provide a more rigorous verification to these thought experiments, we model the change in the retirement age in three pension systems. In the baseline there are changes in the demographics and in the aggregate exogenous labor augmenting productivity. In practice we have three baseline scenarios: one for each of the pension systems. Then, in the reform scenario we increase the retirement age, as showed in Figure 4 (right panel). Consequently, each pension system has a baseline of no-policy change and a reform scenario of increasing retirement age. Summarizing:

- in DB pay-as-you-go scenario the baseline consists of a DB pay-as-you-go with a flat effective retirement age and reform scenario consists of a DB pay-as-you-go with a gradually increasing retirement age;
- in NDC scenario the baseline consists of a transition from DB pay-as-you-go with a flat effective retirement age to a NDC with flat retirement age and reform scenario consists of a similar transition with a gradually increasing retirement age;
- in FDC scenario the baseline consists of a transition from DB pay-as-you-go with a flat effective retirement age to a partially funded DC with a flat effective retirement age and reform scenario consists of a similar transition with a gradually increasing retirement age.

In each case the change in the effective retirement age is the same. The details of the transition reflect the legal regulations in Poland and are described in detail in Hagemejer et al. (2013), but none of these features is relevant for the analysis in question. Please, note that transition between the original DB pay-as-you-go system and any of its alternative is present also in the baseline scenario, thus our simulations isolate the pure effect of extending the retirement age.

5 Results

The conventional wisdom would suggest large welfare gains under pay-as-you-go BD system *via* lower taxes needed to subsidize the pension system and little or no direct welfare effects under actuarially fair DC systems. The overall results seem to suggest the opposite. Under all systems raising the retirement age is welfare enhancing, Table 2. It is large compared to the effects of the pension system reform reported for the same calibration and economy in Hagemejer et al. (2013) - roughly 3-4%. The size of the welfare gain is comparable within calibrations, but are much larger with Deaton (1997) age-productivity pattern, where as much as 16% of lifetime consumption equivalent is obtained. This outcome is partially a consequence of the way age-specific productivity (ω_j) is computed. Namely, given the shape derived from the microeconometric evidence, it was calibrated to an average of 1 on the population structure in the first steady state. However, subsequently population ages, which changes its composition from more younger (i.e. less productive) workers towards more older (i.e. more productive) workers. In other words, there are some level effects with Deaton (1997) parametrization, which give an extra boost to the exogenous labor augmenting productivity growth γ_t. The calibration with a flat productivity profile, however, does not have that feature and yields qualitatively the same results.

Table 2: Net consumption equivalent from extending the retirement age

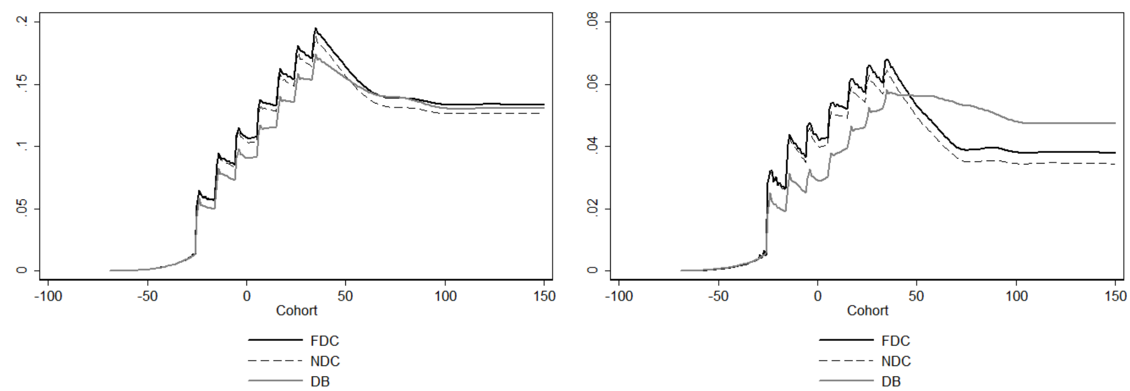
Age-productivity profile	DB	NDC	FDC
Deaton (1997)	13.36%	12.87%	13.35%
flat	4.79%	3.43%	3.64%

While it seems that clear welfare gains stem from raising the retirement age, regardless of the pension system, the distributional effects as well as chanels of adjustment could differ depending on the system. In the next subsection we discuss in detail the welfare effects for respective cohorts, subsequently moving to the adjustments happening in the economy. The final part of this section discusses the role the microfoundations on age-productivity profile play in determining macroeconomic aggregates in the effect of raising the retirement age.

5.1 Detailed cohort effects of extending the retirement age

All cohorts universally benefit from increased retirement age, see Figure 5. This finding differs from Auerbach et al. (1989), but in fact this study considers an alternative set of policies. Auerbach et al. (1989) employ contribution rate as a fiscal closure, which implies that cohorts just prior to retirement have to work longer and see only a small gain in lowered τ. In Auerbach et al. (1989) welfare effects of postponing retirement age vary between cohorts. Younger and future generations benefit from positive effect on net wages. Retirees benefit only little from lower contribution rates and face disutility from reduced leisure, which implies a net negative welfare effect for older cohorts. In our setting, it is the consumption tax that is lowered, which gives a welfare gain to all consumers. Clearly, in our economy gain from lower taxes is higher - in terms of welfare - than loss due to forced longer labor market activity.

More specifically, in comparison to baseline scenario first increase in effective retirement age by one year occurs in 14th year from the starting point. Consequently, it is the cohort born in 1953 that works longer. Already this cohort enjoys fiscal relief due to lower tax rates, since deficit in the pension system is lower. The net effect for the oldest cohorts is very small but positive. Among generations which in the moment of the first rise in retirement age were middle-aged, and those who were young but already in the labor force, the positive welfare effect is stronger and amounts up to around 3% for the youngest workers under flat productivity profile, and around 9% under productivity profile according to Deaton (1997). This gain is present in both DB and actuarially fair systems because the cohorts in question are in transition from PAYG DB to either of the DC schemes. Although the last change of retirement age occurs in year 2077, and directly affects the cohort born in year 2010, generations born up to 2050 experience changes in fical adjustments caused by that increase. Since in our model population stabilizes after 160 years, so do the welfare gains from the reform at a level, which stems directly from the dependency ratio. Thus, for later-born cohorts the welfare gain slightly decreases stabilizing at the level of around 5.7% for the flat productivity profile, and 16.5% for the Deaton (1997) productivity under partially funded DC system.



(a) Deaton (1997) productivity

(b) flat productivity

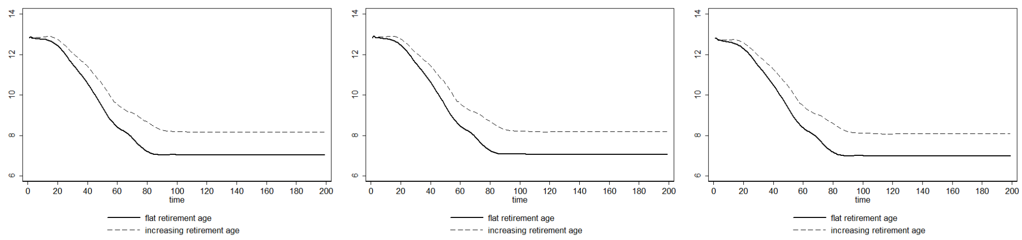
Figure 5: Consumption equivalent

The welfare gains are slightly different under NDC and DB system. For cohorts born before 2050 welfare gains are highest under DB system. Under NDC the consumption equivalent is almost the same as under DB. Such ranking of welfare gains applies both to simulation with flat productivity profile, and with Deaton (1997) productivity. Nevertheless, the difference between welfare gains under partially funded system and under pay-as-you-go system are bigger in the model with flat productivity. Increased retirement age allows to lower the costs of transition from DB to a pre-funded DC scheme.

The adjustments in labor supply, output and taxes are discussed in detail in the subsequent section. In section 5.2 we discuss the results for the preferred specification with Deaton (1997) productivity pattern. In section 5.3 we inquire to what extent the results may be driven by the assumption about the age-productivity pattern.

5.2 Changes in the economy

Clearly, an increase in the retirement age postpones the period in which households have access to pension benefits. In fact, in our setting labor supply may be low or even zero even prior to the retirement age, but after reaching $\bar{J}$ nobody is allowed to work at all. Consequently, if retirement age is increased beyond individually optimal levels, pre-retirement activity will be low. However, if the retirement age is too low *vis-a-vis* individually optimal, labor supply may be increased for working years to allow *more* work. In such a setting, raising the retirement age has two types of effects. First, extra cohorts stay in the labor market, which raises labor supply sharply. However, cohorts having sufficient number of working periods prior to retirement age are able to adjust labor supply to optimal levels by changing the hours worked. Figure 6 shows the overall effect on the labor supply in three analyzed pension schemes. Consistent with the literature, actuarially fair systems yield larger labor market effects in the transition period. However, in the long run the effects for the DB and DC systems are similar.



(a) DB (b) NDC (c) FDC

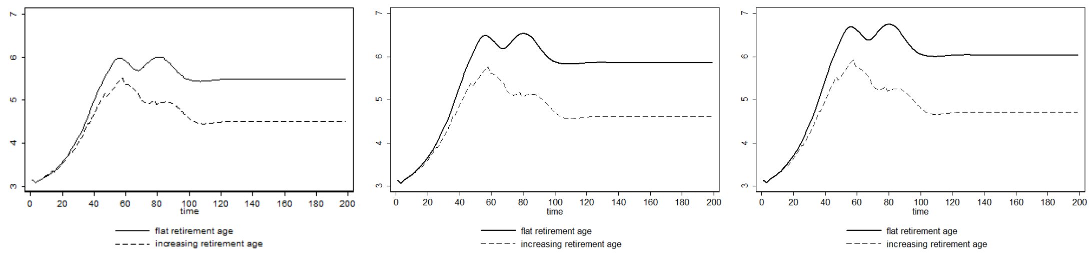
Figure 6: Labor supply (in mio of individuals)

We also decompose the change in labor supply to intensive and extensive margin. The latter is the component related to additional years on the labor market, whereas the former is the adjustment of hours worked before the retirement age. Agents forced to stay longer on the labor market, may increase the hours of leisure in every period in order to achieve a higher overall utility (Boersch-Supan and Ludwig 2010). Positive income effect, related to lower consumption taxes in defined benefit systems or to higher benefits in defined contribution ones, may reinforce this adjustment further. The increase in the retirement age by 7 years corresponds to 17.5% more time for work. In our setting, in the original steady state participation rate amounts to 58.6%. Demographic transition alone increases this indicator to 62-63%, depending on the pension system, Table 3. In fact, the overall increase in the labor supply is by approximately 16%, which is close to the extent of the reform. In the final steady state, the average labor supply over the working life is approximately 3% lower in the reform scenario with increased retirement age, whereas the supply by the elderly is larger than the average during the lifetime prior to the reform. The extent of this adjustment is comparable across the pension systems.

Table 3: Labor supply effects of the reform

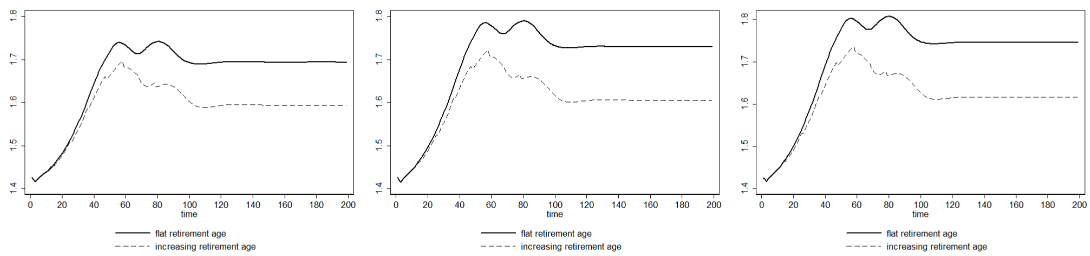
	Baseline	Reform scenario			
	overall	$j < 60$		$j \geq 60$	Total
	LFP	LFP	baseline=100	LFP	baseline=100
DB	62%	61%	97.0%	70%	116.2%
NDC	63%	61%	96.5%	71%	115.8%
FDC	62%	60%	96.2%	71%	115.8%

Actuarially fair systems yield more private savings, because effective replacement rate is much lower than the nominal replacement rate under DB pay-as-you-go, Figure 7. Higher private savings imply more capital accumulation, yielding higher capital per effective unit of labor. However, an increase in the retirement age raises labor supply, lowering the K/L ratio permanently. In addition, there can also be income effects, which further reduce private savings. In fact, the results of the retirement age are quantitatively larger than those due to introducing a pension scheme incentivizing more private savings. These detrimental effects on capital are the strongest when retirement is postponed in the economy with partially funded DC system. In the steady state, the capital is lower by about 22%. The loss in K/L ratio is the lowest under DB pay-as-you-go system, where only income effect is at play. In our model output follows directly from capital, which implies that the time patterns are alike, Figure 8. Reduction in K/L ratio translates directly to a reduction in GDP *per capita* by approximately a third of the effect observed on capital.



(a) DB (b) NDC (c) FDC

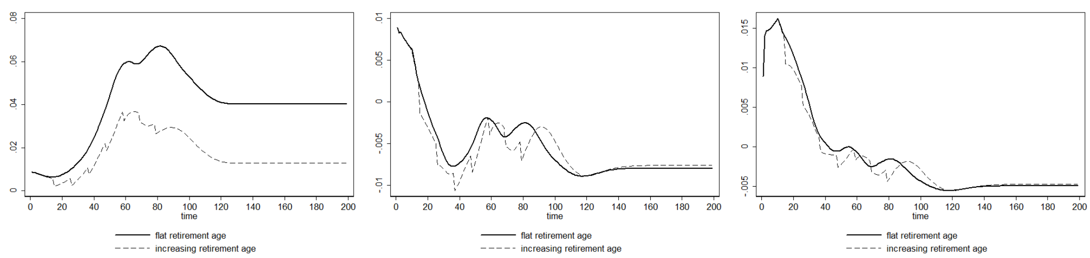
Figure 7: Capital (per effective unit of labor)



(a) DB (b) NDC (c) FDC

Figure 8: Output (per effective unit of labor)

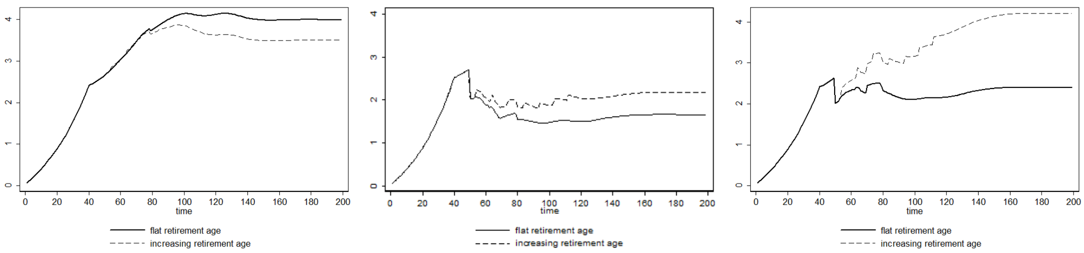
Raising the retirement age is of crucial importance for determining the balance of pension system under the DB scheme. Higher contribution base and lower payments imply lower deficit, which is clearly visible in Figure 9. In actuarially fair DC systems effects of raising the retirement age are of only transitory nature and follow from changes in contemporaneous balance between contributions and payments. In general, these systems are individually balanced by definition, whereas deficit or surplus follows from the dependency ratio.



(a) DB (b) NDC (c) FDC

Figure 9: Pension system deficit (as % of GDP)

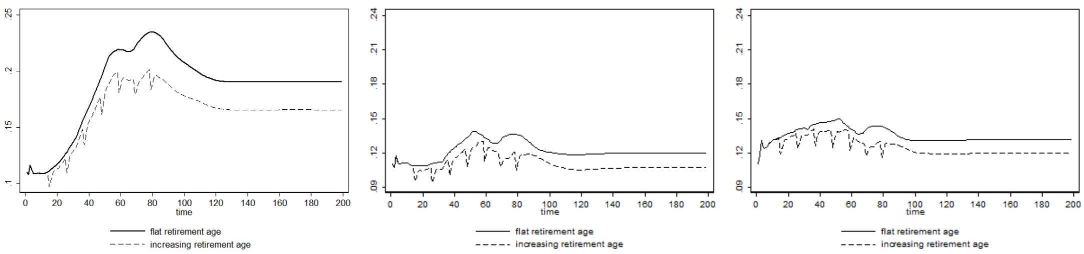
The opposite is true for benefits under the three analyzed pension schemes, Figure 10. Namely, DB systems should see little changes from the raised retirement age and indeed it is the case. The source of the differences between the baseline and the reform scenario in DB pay-as-you-go scheme stems from lower output and thus wages. On the other hand, in actuarially fair systems, raising the retirement age yields a sort of a double gain to the retirees. Namely, longer savings period and shorter retirement period allow pensions to be higher. In DC systems lower capital and thus output also has detrimental effect on pensions, but that effect has an opposite impact. Indeed, in partially funded DC pensions are higher in the final steady state than under DB pay-as-you-go. In NDC scheme, indexation is lower due to slower output growth, which yields overall lower pensions paid to the retirees compared to FDC scheme.



(a) DB (b) NDC (c) FDC

Figure 10: Pension per retiree (stationarized)

In DB pay-as-you-go the largest part of the welfare gain does not come from higher pensions, but from substantially reduced taxation. Regardless of the system, higher retirement age allows to reduce the tax rate. In DB it is possible because the overall pension system deficit is lower, thus necessitating lower tax increase (an increase at all is inevitable due to the demographic changes). Since DC systems are balanced by construction, tax increase is only needed to finance the bulk of debt built prior to the pension system change. In addition, FDC needs to raise taxes in order to finance the gap created by pre-funding. This explains why partially consumption tax in FDC is slightly higher than NDC.



(a) DB (b) NDC (c) FDC

Figure 11: Tax rate (extent of fiscal adjustment for long term stable debt/GDP ratio)

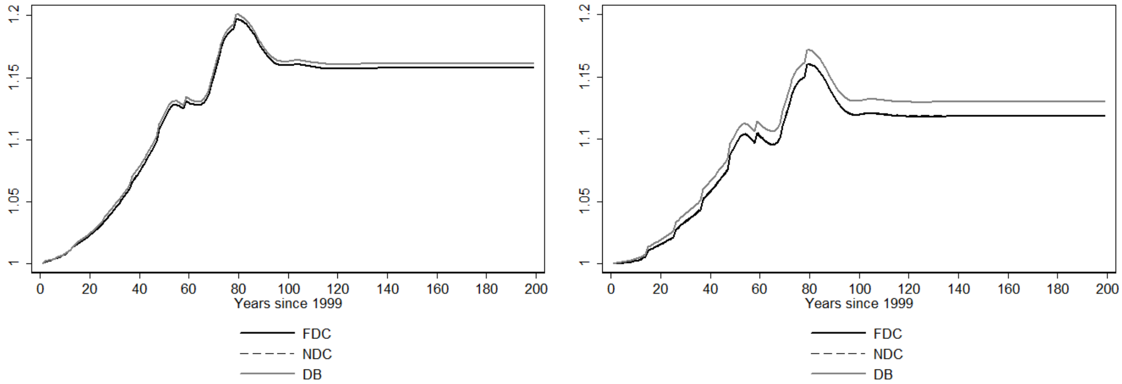
Large effects from delaying the retirement age are especially apparent when comparing the tax rates between the pension schemes. In fact, the implied tax rate in DB pay-as-you-go is only slightly higher than NDC and similar to partially funded DC *without* the adjustment in retirement age. This explains why the welfare gains from delaying retirement may in fact be so large and universal across cohorts.

As discussed earlier, with the changing age structure of the population, age-productivity patterns based on Deaton (1997) may in fact increase aggregate productivity growth *via* the changes in the labor force composition. With a higher productivity growth, it is easier to finance public debt, while this assumption is also friendly towards pay-as-you-go schemes rather than pre-funded schemes. In the reminder of this section we show that our results are not a consequence of these composition effects, i.e. the results hold in general also for the calibration with a flat age-productivity profile.

5.3 Robustness check - the role of age-productivity profile

With age-specific productivity, labor adjustment is much stronger than with flat productivity. Larger increase in labor supply follows from the fact that productivity at older ages is relatively larger than in the reminder of the working period. Thus, providing more labor at older ages gives larger returns than at younger ages. Consequently, the overall increase in labor is larger, Figure 12. Relative to the baseline of flat retirement age labor supply grows by roughly 15% under Deaton (1997) and approximately 13% with uniform age-productivity pattern. This translates to a larger reduction in capital, Figure 13. While there are differences depending on the age productivity pattern, the time evolution is similar. The ordering is consistent between the pension schemes. As suggested earlier, actuarially fair schemes which foster private savings have more extensive capital adjustment, which implies that despite eventually similar effect on labor supply, they differ in the effect on capital and thus output. Since age-specific productivity a la Deaton (1997) additionally reinforces this mechanism, adjustment is deeper with non-flat ω's. The difference is approximately 7 percentage points on capital, which translates to approximately 2.5 percentage points on output.

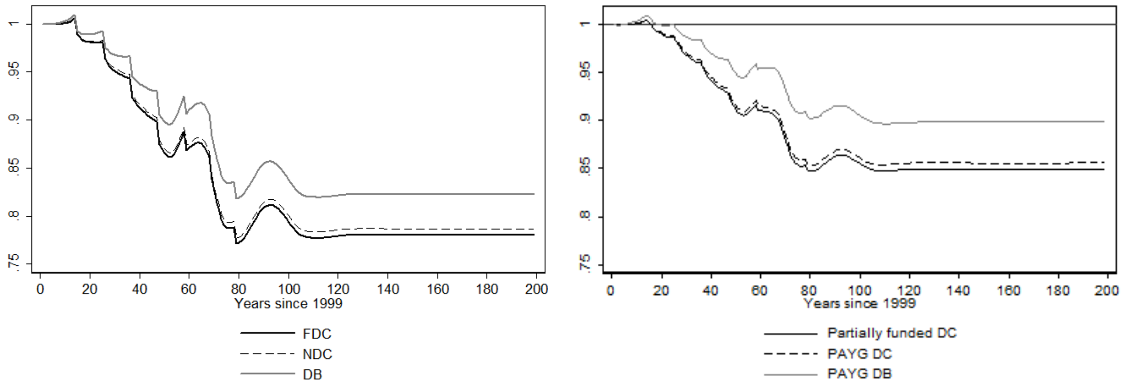
The shape of the age-productivity pattern has only a minor bearing on the extent of fiscal adjustment. Relative to baseline, the changes in pension system balance, pensions and taxes are of comparable size and similar evolution across time. This conforms with the intuition, that only general equilibrium effects could be relevant here and they are not large. Naturally, level differences between the pension schemes are important and nicely display the differences in response the economy has to raising the retirement age, depending on the pension scheme.



(a) Deaton (1997) productivity

(b) flat productivity

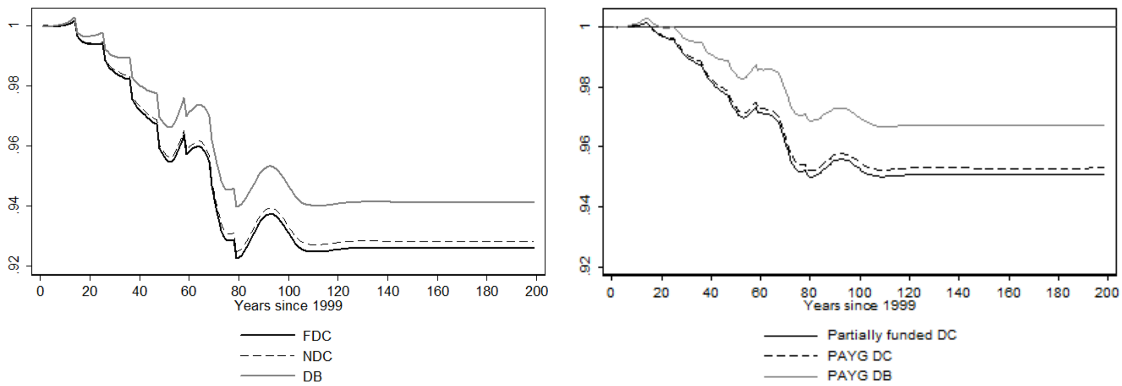
Figure 12: labor supply - reform relative to baseline for all three types of pension schemes



(c) Deaton (1997) productivity

(d) flat productivity

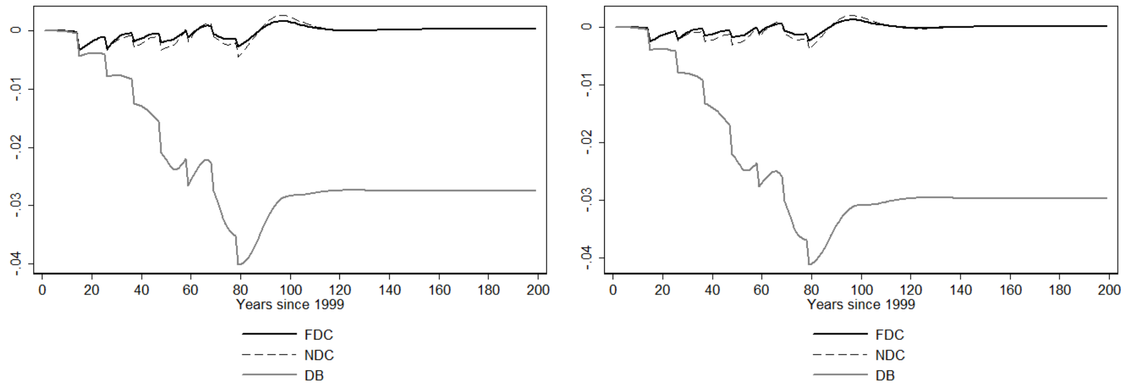
Figure 13: Capital - reform relative to baseline for all three types of pension schemes



(a) Deaton (1997) productivity

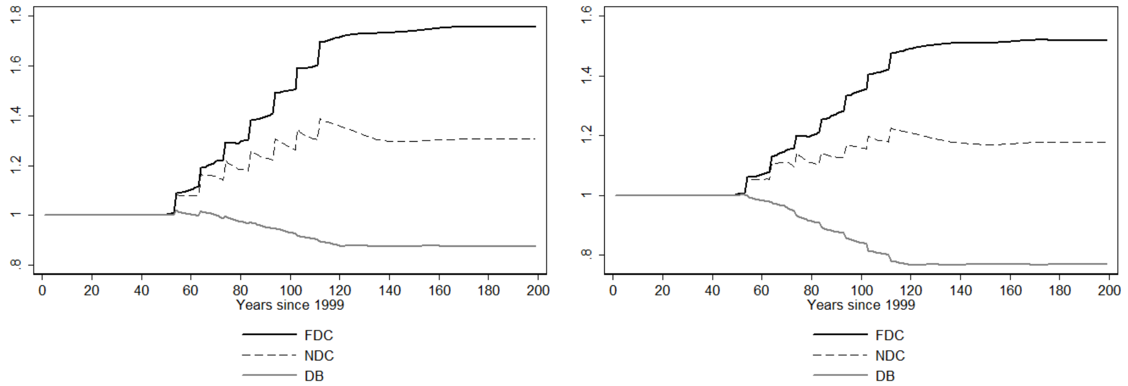
(b) flat productivity

Figure 14: Output (per effective unit of labor) - reform relative to baseline for all three types of pension schemes



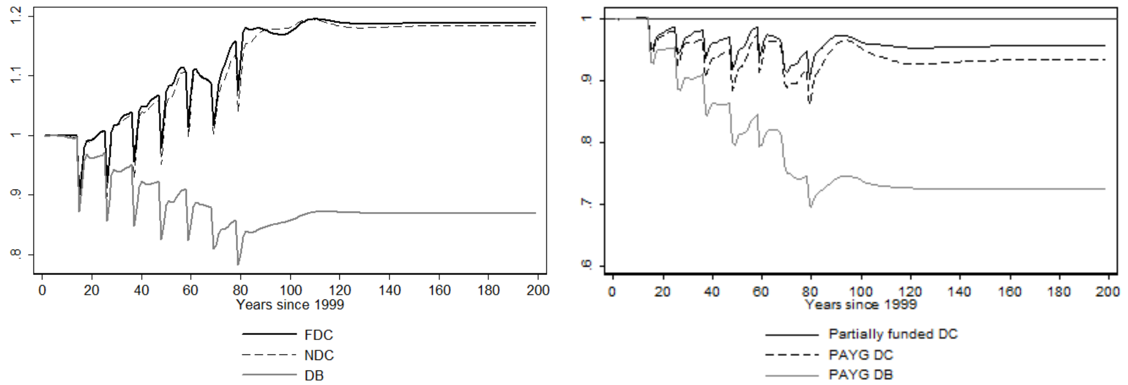
(a) Deaton (1997) productivity (b) flat productivity

Figure 15: Pension system balance - reform relative to baseline for all three types of pension schemes



(c) Deaton (1997) productivity (d) flat productivity

Figure 16: Pensions per retiree - reform relative to baseline for all three types of pension schemes



(a) Deaton (1997) productivity (b) flat productivity

Figure 17: Tax rate - reform relative to baseline for all three types of pension schemes

6 Conclusions

Inevitable longevity in many advanced economies raises policy relevance of the retirement age, especially if improved health of the elderly is associated with lowering fertility and thus aging. This paper analyzes the welfare effects of raising the retirement age in three types of pension systems: defined benefit pay-as-you-go, defined contribution pay-as-you-go and defined contribution fully funded system. These three types encompass majority of pension system schemes existing in developed economies.

Intuitively, increasing the retirement age may immediately imply lowering the labor supply by households. If the utility function reflects preference for consumption and dislike for work, increasing the retirement age will automatically cause adjustment in effective labor supply in each year. Forced to stay active for more periods, households may in fact accommodate the regulatory change by reducing the labor supply in each of these periods. This type of adjustment was emphasized by Boersch-Supan and Ludwig (2010). It is equally paramount that DB pay-as-you-go reduces fiscal imbalances, allowing welfare gains from lower taxes and/or public debt. Under DC schemes there are no direct fiscal effects, but higher pensions and general equilibrium effects are also likely to affect welfare.The objective of this paper was to inquire the size of the welfare effects associated with the extensions of the retirement age. We do that for three of the most popular pension schemes: DB pay-as-you-go, DC pay-as-you-go and partially funded DC. For each of the systems we simulate the economy with a *status quo* of unchanged retirement age and a *reform scenario* of a gradually increasing effective retirement age. We compare welfare across cohorts and compute the measure of the overall welfare gain.

It is often argued that if a DB system is replaced with a DC system - better yet a pre-funded DC - there is no need to raise the retirement age. In a sense, introducing a pension scheme which provides incentives to stay active longer in the labor market is believed to effectively address the problem of fiscal pressure due to longevity. Our study shows, that it is not the case. More specifically, there are considerable and fairly comparable welfare gains from raising the retirement age regardless of the pension system. These gains under defined benefit system stem mainly from lower tax rates, while under defined contribution - both from much higher pensions. It is likely that the DC systems would yield similar results with endogenous retirement age, but with DB systems aligning the social and private incentives would be difficult. Transition to DC systems enhances this effect, as it allows to spread the costs of reform more evenly across cohorts.

Our model permits to isolate the effects of raising the retirement age from other confounding context. We were careful in calibrating the model economy to match the characteristics of the original steady state. However, this paper leaves a number of avenues open for further research. First, it is implicitly assumed that age-productivity patterns do not change in the simulation horizon. While we test the robustness of the findings to the shape of this profile, it is unlikely that the technological change and increasing human capital will leave the age-productivity pattern unaffected. It seems thus desirable to develop alternative scenarios of the changes in the lifetime profile of productivity. Second, we do not analyze gender differences in longevity and activity rates. In fact, in our setting households may choose to retire prior to the official retirement age, but cannot prolong their professional activity beyond that date. With lowering fertility and increased access to care facilities, it is likely that professional activity will gradually increase. Our major result would not be altered if increase in the retirement age happened at a faster pace and reached higher levels. However, the actual size of the welfare effects is likely to depend on these processes, thus generating a potential justification for prior investment, e.g. in fostering access to care facilities.

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