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The shadow of longevity - does social security reform reduce gains from increasing the retirement age?

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Abstract With increasing longevity 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. However, it could be outweighed by lower taxation (defined benefit schemes becoming more balanced) or higher pension benefits (defined contribution schemes yield higher effective replacement rate). We construct an OLG model in which we analyze welfare effects of raising the minimum eligibility retirement age in the context of longevity in three scenarios: under pay-as-you-go defined benefit, in an economy in transition from pay-as-you-go defined benefit to pay-as-you-go defined contribution and in an economy in transition from pay-as-you-go defined benefit to pre-funded defined contribution. Thus, we provide instrument to compare the effects of a parametric and a systemic reform. We find that raising minimum eligibility retirement age is universally welfare improving, although the channels differ depending on the pension system. However, postponed retirement translates to lower savings, which implies decrease in *per capita* capital and output.

Keywords longevity · aging · PAYG · retirement age · pension system reform · welfare

1 Introduction

Majority if not all demographic projections forecast an increase in life expectancy in most advanced economies, e.g. Wilmoth and Lundstrm (1996). Longevity poses a number of challenges on the fiscal side, including the stability of the pension systems. In defined benefit (DB) systems an increase in life expectancy raises public expenditure, whereas in defined contribution (DC) systems – the pension benefits are substantially reduced. Thus, demographic changes imply considerable consequences to the welfare policies across the globe, as noted already by Keyfitz (1985), Schmahl (1988), Van Imhoff and Henkens (1998).

In response to longevity in many countries the minimum eligibility retirement age (MERA)[1] has been raised in order to keep the work-to-leisure ratio roughly stable. While in many countries the *de facto* exit age is substantially lower than the *de iure* retirement age, but both grow gradually over the past two decades, especially for women, see Figure 1. Heijdra and Romp (2009) emphasize that in

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[1] Often referred to as statutory retirement age, SRA.

most countries people tend to retire as early as legally allowed.[2] Even maintaining the stable ratio still necessitates a decrease in pensions (in DC systems) or a increase in fiscal burden (in DB systems), because the *number of years during retirement* is higher. Moreover, rasing MERA remains politically sensitive. Indeed, working for a larger number of years is detrimental to welfare if individuals – as is standard in economic models – like to consume, but do not like to work. Can such policy be welfare enhancing, then?

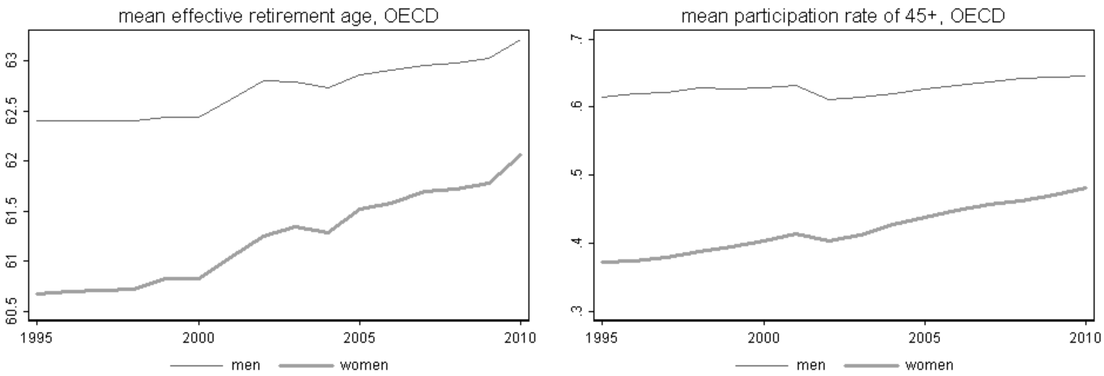


Fig. 1: Effective retirement age and labor market participation of the elderly. *Source*: OECD

One of the arguments often raised in discussions over MERA relies on incentives: if a pension system does not provide incentives to prolong the period of labor market activity despite growing life expectancy, an inefficiency occurs (agents do not fully internalize the general equilibrium benefits from longer employment). In this respect, a pure defined benefit (DB) systems seem to provide least incentives, whereas the opposite is true for defined contribution (DC) systems. In a DB system higher MERA reduces the fiscal burden allowing for reduced taxation. In a DC system, fiscal burden is unaffected by the actual retirement age, but pension benefits are increased for two reasons: contributions are higher whereas life expectancy post-retirement is lower. From this explanation, it follows that a parametric reform of raising MERA under DB and a systemic reform from a DB to a DC system are partial substitutes.[3] As straightforward as these intuitions are, it remains unclear which of these effects is quantitatively larger or - put otherwise - is it still desirable to raise MERA after the systemic reform of the pension system?

In this paper we build on a fairly abundant literature of pension systems and their reforms, cfr. Auerbach and Kotlikoff (1987), 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 overlapping generations (OLG) model is a workhorse in the field, see Lee and Mason (2010), Zamac et al. (2010). If baseline scenario included no demographic or retirement age changes, and reform scenarios would encompass shifts in longevity and a proportionally increasing retirement age - welfare would typically stay unaffected, see Fenge and Pestieau (2005). However, most of the literature – as well as most of the citizens and policy-makers – assume increasing longevity to constitute a fact and only retirement age changes to be policy choices. Then, welfare depends on opportunities related to aging, i.e. gain in valuable life years, see Boersch-Supan (2013).

The literature in the field has thus far has focused on two questions. First, the literature analyzes optimal retirement age, i.e. the age of labor market exit *chosen* optimally 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) among others. 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

[2] Based on international comparative studies, Gruber and Wise (2007) argue that this stems from the fact that the majority of pension systems fail to assure actuarial fairness. Boersch-Supan (2000) documents this argument for Germany and lists actual disincentives for other European countries.

[3] The link between pension system incentives, the statutory 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, see Boersch-Supan et al. (2007), Boersch-Supan and Ludwig (2010).

as early as Holzmann (1988), Auerbach et al. (1989), Gonnot et al. (1995). 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. Hviding and Marette (1998) additionally include a phased abolition of PAYG schemes. Both these studies find, that a relatively "painless" adjustment in the retirement age yields gains comparable to these other "painful" reforms.[4] 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 positive fiscal direct and indirect effects of raising the retirement age.

Summarizing, the literature provides intuition as to what effects we should expect from raising the retirement age *under one pension system regime*. Typically, extending the working period is welfare improving, but older cohorts usually lose 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 more universal. However, the majority of studies focused on one particular system, typically a PAYG DB schemes. Considerably less attention was devoted to DC schemes, whether pre-funded or PAYG. Little is known about the differences in efficiency gains from increasing the retirement age under various pension systems, *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 pre-funded DC scheme.

We construct three experiments employing an OLG model to ask which which pension systems generate welfare gains from raising the retirement age and for which cohorts. 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 *transition* from a PAYG DB to a PAYG DC scheme (we refer to this case as NDC). Finally, the third experiment covers the *transition* from a PAYG DB to a partially pre-funded DC scheme. We refer to this system as FDC. The underlying fundamentals are also identical across the experiments and scenarios. The 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, similar to Nishiyama and Smetters (2007).

We find that postponing the retirement is universally welfare enhancing while the welfare gain is actually similar across all analyzed pension systems. In other words, although systemic and parametric reforms can indeed be considered partial substitutes from a fiscal perspective, they are not so from a welfare perspective. Net consumption equivalent from the implementation of this reform equals around 3.7%-4.7% of lifetime consumption. Importantly, all the cohorts benefit from such pension system reform, although this effect is the smallest for the oldest cohorts.

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

2 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. Our model features a pension system and a government.

[4] Also Fehr (2000) finds that increasing the retirement age for Germany can yield considerable improvement in fiscal stance, but actual welfare gains depend on a strength of the link between contributions and benefits. 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, but Beetsma and Bucciol (2011) argue that this result is conditional on lack of financial instruments risk in the model. Díaz-Giménez and Díaz-Saavedra (2009) argue 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.

2.1 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. Each agent born in period t has an unconditional time varying probability of survival until the age of j, $\pi_{j,t}$. We also assume that all consumers who survive until the age of $J = 80$ die with certitude. Since each cohort faces mortality risk there are unintended bequests. We assume that they are redistributed among all the survivors, which is equivalent to a perfect annuity market.[5] 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* adjusting downwards the mortality rates.[6]

Our agents discount future exponentially, with discount factor δ. Consumers maximize their lifetime log-linear utility derived from leisure $(1 - l_{j,t})$ and consumption $c_{j,t}$:

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

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 higher contributions and thus pensions.

As discussed earlier, in most countries effective age of labor market exit falls short of *de iure* MERA. Thus, in addition to potential (dis)incentives coming from the retirement system alone in a static setting, reducing this inefficiency by increasing MERA may be welfare enhancing. Furthermore, improving health, less devastating working conditions as well as increasing life expectancy may alter the current "preferred" exit age. Moreover, in many countries there is a limited access to many labor market institutions (e.g. unemployment benefits are unavailable, training is no longer subsidized by the governments, etc.). These shortcomings make people even more prone to retire at the earliest, i.e. the *de iure* MERA. 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.[7]

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

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

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

[5] Please note that mortality probability is not actually risk – agents have perfect information about these probabilities and they are identical within cohort, which implies that this formulation is equivalent to a certain fraction of a cohort surviving until the next period. Since the model is fully deterministic, agents have no preferences towards risk.

[6] We discuss the demographic scenarios in section **??**.

[7] 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.

Maximizing (1) subject to (2), we obtain the final solution for consumption and labor supply (and thus instantaneous savings) for the working cohorts:

$$c_{j,t} = \frac{(1+r_t(1-\tau_{k,t}))s_{j-1,t-1} - \Upsilon_t + (1-\tau_{\iota,t})(1-\tau_{l,t})w_t l_{j,t} + \Omega_{j,t} + \Gamma_{j,t}}{\frac{1}{\phi} + \frac{1}{\phi}\beta\sum_{s=1}^{\bar{J}-j-1}\delta^s\frac{\pi_{j+s,t+s}}{\pi_{j,t}} + \beta\sum_{s=\bar{J}-j}^{J-j}\delta^s\frac{\pi_{j+s,t+s}}{\pi_{j,t}}} \tag{3}$$

$$l_{j,t} = 1 - \frac{1-\phi}{\phi}\frac{(1+\tau_{c,t})c_{j,t}}{(1-\tau_{\iota,t})(1-\tau_{l,t})\omega_j w_{j,t}} \tag{4}$$

with

$$\Omega_{j,t} = \sum_{s=1}^{\bar{J}-j-1}\frac{(1-\tau_{\iota,t+s})(1-\tau_{l,t+s})w_{j+s,t+s} + b_{j+s,t+s} - \Upsilon_{t+s}}{\prod_{i=1}^{s}(1+r_{t+i}(1-\tau_{k,t+i}))}$$

$$\Gamma_{j,t} = \sum_{s=\bar{J}-j}^{J-j}\frac{(1-\tau_{l,t+s})p_{\iota,j+s,t+s} + b_{j+s,t+s} - \Upsilon_{t+s}}{\prod_{i=1}^{s}(1+r_{t+i}(1-\tau_{k,t+i}))}.$$

Numerator of eq. (3) represents the current discounted value of the future lifetime income.

2.2 Production

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

$$\max_{(Y_t,K_t,L_t)} Y_t - w_t L_t - (r_t^k + d)K_t \tag{5}$$
$$\text{s.t. } Y_t = K_t^{\alpha}(z_t L_t)^{1-\alpha}$$

where 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 $r_t^k + d = \alpha K_t^{\alpha-1}(z_t L_t)^{1-\alpha}$.

2.3 Pension systems

The 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 pre-funded pension systems. Following the actual design of the pension system and the pension system reform, we keep contributions rates equal across cohorts, constant across time and the same in all systems: $\tau = \tau^{DB} = \tau^{NDC} = \tau^{FDC}$.

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.[8] 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:

$$r_t^I = \frac{\sum_{j=1}^{J}(\pi_{j,t-1}N_{t-j}w_{j,t}l_{j,t} - \pi_{j,t-1}N_{t-1-j}w_{j,t-1}l_{j,t-1})}{\sum_{j=1}^{J}\pi_{j,t-1}N_{t-1-j}w_{j,t-1}l_{j,t-1}}. \tag{6}$$

Consequently, pensions are given by:

$$p_{j,t}^{DB} = \begin{cases} \rho w_{j-1,t-1}, & \text{for } j = \bar{J}_t \\ \kappa_t^{PAYG} \cdot p_{j-1,t-1}^{DB}, & \text{for } j > \bar{J}_t. \end{cases} \tag{7}$$

8 See Lapkoff (1991) on a discussion on equity issues associated with the design of the pay-as-you-go system.

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

$$\sum_{j=\bar{J}_t}^{J} \pi_{j,t} N_{t-j} p_{j,t}^{DB} = \tau^{DB} \sum_{j=1}^{\bar{J}_t-1} w_{j,t}\pi_{j,t} N_{t-j} l_{j,t} + subsidy_t^{DB} \tag{8}$$

Subsidy from the government is needed in the modeling due to the fact that in our NDC and FDC scenarios economy is *in transition* from the PAYG DB to a funded system. Thus, it carries over pension system deficit from the initial steady state and has an additional – albeit transitory – deficit which stems from establishing the pre-funded pillar.

Funded defined contribution (FDC) system. The partially pre-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 $\tau^{FDC} = \tau_I^{FDC} + \tau_{II}^{FDC}$. 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. $\kappa_t^{PAYG} = 1 + 0.25 \cdot r_t^I$.

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

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:

$$\sum_{j=\bar{J}_t}^{J} \pi_{j,t} N_{t-j} p_{I,j,t}^{FDC} = \tau_I^{FDC} \sum_{j=1}^{\bar{J}_t-1} w_{j,t}\pi_{j,t} N_{t-j} l_{j,t} + subsidy_{I,t}^{FDC}. \tag{10}$$

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[9]. Therefore:

$$p_{II,j,t}^{FDC} = \begin{cases} \frac{\sum_{i=1}^{\bar{J}_t-1}\left[\Pi_{s=1}^{i}(1+r_{t-i+s-1})\right]\tau_{II}^{FDC} \cdot w_{\bar{J}_t-i,t-i} l_{\bar{J}_t-i,t-i}}{\prod_{s=\bar{J}_t}^{J}\pi_{s,t}}, & \text{for } j = \bar{J}_t \\ (1+r_t) p_{II,j-1,t-1}^{FDC} & \text{for } j > \bar{J}_t \end{cases} \tag{11}$$

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 $\tau^{NDC} = \tau$. Pensions are payed according to the similar formula as in case of the first pillar of NDC

$$p_{j,t}^{NDC} = \begin{cases} \frac{\sum_{i=1}^{\bar{J}_t-1}\left[\Pi_{s=1}^{i}(1+r_{t-i+s-1}^I)\right]\tau \cdot w_{\bar{J}_t-i,t-i} l_{\bar{J}_t-i,t-i}}{\prod_{s=\bar{J}_t}^{J}\pi_{s,t}}, & \text{for } j = \bar{J}_t \\ \kappa_t^{PAYG} p_{j-1,t-1}^{NDC}, & \text{for } j > \bar{J}_t \end{cases} \tag{12}$$

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

$$\sum_{j=\bar{J}_t}^{J} \pi_{j,t} N_{t-j} p_{j,t}^{NDC} = \tau \sum_{j=1}^{\bar{J}_t-1} w_{j,t}\pi_{j,t} N_{t-j} l_{j,t} + subsidy_t^{NDC}. \tag{13}$$

[9] 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 (9)-(11).

2.4 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 level of government expenditure in the reform scenarios.

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

$$G_t + subsidy_t^{\iota} + r_t D_{t-1} = T_t + (D_t - D_{t-1}) + \Upsilon_t \sum_{j=1}^{J} \pi_{j,t} N_{t-j}. \tag{14}$$

where

$$T_t = \tau_{l,t}\Big((1-\tau^{\iota})w_t L_t + \sum_{j=\bar{J}_t}^{J} p_{j,t}^{\iota}\pi_{j,t}N_{t-j}\Big) + \Big(\tau_{c,t}c_t + \tau_{k,t}r_t s_{j,t-1}\Big)\sum_{j=1}^{J}\pi_{j,t}N_{t-j}. \tag{15}$$

We calibrate the level of debt D_t in the initial steady state to match the data at around 45% of GDP. We close the fiscal deficit using lump sum taxes Υ_t.

2.5 Market clearing conditions, equilibrium and model solving

Clearing of the goods market requires

$$\sum_{j=1}^{J} \pi_{j,t} N_{t-j} c_{j,t} + G_t + K_{t+1} = Y_t + (1-d)K_t, \tag{16}$$

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

$$L_t = \sum_{j=1}^{\bar{J}_t - 1} \pi_{j,t} N_{t-j} \omega_{j,t} l_{j,t} \qquad \text{and} \qquad K_{t+1} = \sum_{j=1}^{J} \pi_{j,t} N_{t-j} \hat{s}_{j,t} - D_t, \tag{17}$$

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 (5), given prices; (*iii*) the social security system is balanced, i.e. (8) or (13) or (10) (depending on the type of pension system) are satisfied; (*iv*) the government budget is balanced, i.e. (14) is satisfied; and (*v*) markets clear, i.e. (16)-(17) are satisfied. If the pension system deficit causes the debt to grow, Υ grows to fill this gap.

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 entire life in the new steady state. Eventually, we selected the length of the path to be 350 periods. 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 3.

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 the extended MERA. In both these scenarios the lifetime utilities for all generations are computed. We denote utility in the baseline scenario (no reform) with superscript B and in the reform scenario with superscript R. These values of utility constitute basis for calculation of consumption equivalents, denoted as μ_t, similar to the Nishiyama and Smetters (2007).

$$U_{1,t}((1-\mu_t)\tilde{c}_{j,t}^{R}, \tilde{l}_{j,t}^{R}) = U_{1,t}(\tilde{c}_{j,t}^{B}, \tilde{l}_{j,t}^{B}) \tag{18}$$

Positive value of μ_t informs us that the reform is welfare improving for cohort born in period t. Consumption equivalent is expressed as a measure of compensating variation, i.e. how much the consumer would be willing to pay for the reform not to be reverted (in percent of permanent consumption).

Next, in order to assess the aggregate welfare gain, we collect the consumption equivalents as the extra lump sum taxes in all periods (positive for agents that gain from the reform and negative for those who lose) and we discount it to period 1. Next we compute by how much we can increase consumption of each agent with the collected taxes, assuming that everyone gets the same proportional change in consumption.

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 (17). This procedure is repeated until the difference between k from subsequent iterations is negligible.

2.6 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. In the defined contribution systems increasing total individual contributions increases pensions as well. Overall, with DC 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 MERA, simply raising labor supply prior to retirement age. After extending retirement age agents could work exactly the same number of total lifetime hours, only over larger number of years. This contraction of hours worked in response to longer working period has been emphasized by Boersch-Supan (2013). In other words, under DC little or no welfare gain should exist from raising the retirement age except for reducing potential inefficiency.

In the DB PAYG 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 DC and the partially pre-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 3 (right panel). Consequently, each pension system has a baseline of no-policy change and a reform scenario of increasing retirement age. Summarizing:

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

In each case the change in the effective MERA is the same. Please, note that the transition between the original DB pay-as-you-go system and any of its alternatives is present also in the baseline scenario, thus our simulations isolate the pure effect of extending the retirement age.

3 Calibration

Our model was calibrated to the Polish economy where the social security system was changed from a PAYG DB to a 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 7.4%, 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.

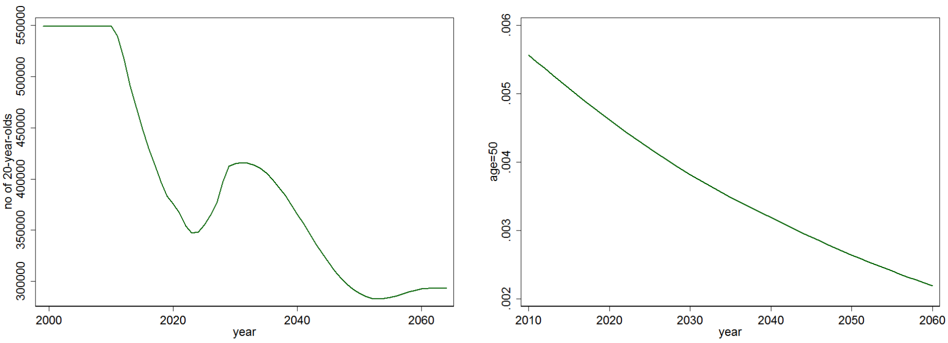
3.1 Calibration of the structural parameters

In this section we describe how all structural parameters are calibrated, we focus on demographics, productivity, preferences, government sector and the depreciation rate of capital. The values of the key parameters are summarized 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 $\alpha = 0.3$, following the standard in the literature. We calibrate the discount factor δ to match the interest rate of 7.4%, 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[10]. Figure 2 presents the number of 20-year-olds and mortality rates in time as implied by the projection. We assume births number to be constant beyond 2060. As in our model we do not distinguish between genders we compute the average population weighted mortality rates. We assume mortality rates constant beyond 2060. We also assume that demographics stabilizes and remains constant after 210 periods (which corresponds to 50 periods taken from the projection + 80 periods of constant number of 20-year-olds + 80 years of survival), to assure stationary population and steady state of the economy.

Fig. 2: No of 20-year-olds arriving in the model in each period (left) and mortality rates across time for a selected cohort.

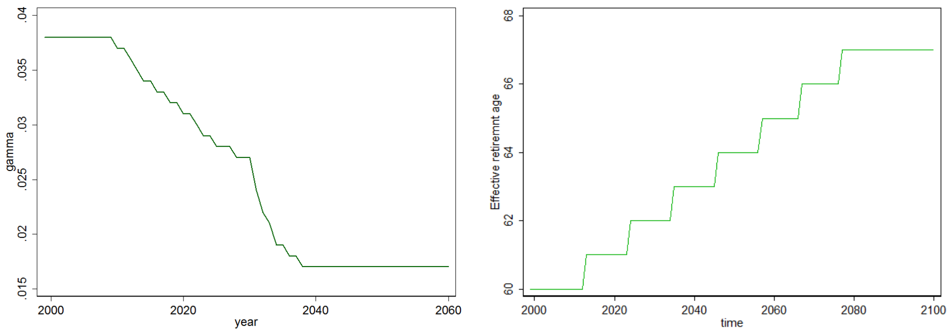


Source: EUROSTAT demographic forecast untill 2060

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 Aging Work Group of the European Commission, which comprises such time series for all EU Member States, see 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*.

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

Fig. 3: Labor augmenting productivity growth rate projection (left) and actual retirement age in economy, past values and forecasts.



Source: technological progress rate following European Commission & effective retirement age based on SIF annual reports until 2012, afterwards it is a reform scenario.

Age specific productivity (ω_j). Despite numerous studies, the shape of the age-productivity pattern remains a discretionary area. Most of the studies assume an inverted U-shaped pattern[11]. 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 Deaton (1997), Boersch-Supan and Weiss (2011). For the sake of conservative assumptions, we set flat age-productivity profile. If we assumed a positively sloped profile, increasing activity of the elderly would change the overall labor productivity because of the composition effects, thus providing an additional boost to the economy. The opposite holds for the inverted u-shaped or negatively sloped pattern. To identify solely the effects of extending MERA without additional assumptions concerning productivity at older ages, we thus keep ω constant across all j's.

Retirement age and replacement rate. In Poland the *de iure* MERA is at 60 for women and at 65 for men. However, due to the numerous exceptions, the effective retirement age was substantially lower. Despite ϕ matched to the aggregate labor supply observed in the economy, average exit ages were 52.6 and 61.6 respectively. One can expect that with calibrated ϕ, agents in our model would "prefer" to work longer than up to 60 years old even with the PAYG DB in place. Yet, in the data exits occur earlier than "optimal" in the model, which emphasizes the role of $\bar{J}$.

As of 2009 most of the early retirement schemes were removed and MERA is to increase to reach 67 for men in 2018 and for women in 2040. Additionally, generations working mostly 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 3 (right panel) – but the rate of MERA growth is much slower. In short, we assume that there will be increase of one additional year in $\bar{J}$ once every decade, reaching effectively 65 years of age. In Poland the *de iure* replacement rate is flat after 20 years of active labor market participation. Thus, in our model replacement rate ρ is constant and we calibrate the replacement rate, ρ, to match the 5% pensions to GDP ratio in 1999. Depending on the selected productivity profile, the calibrated 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 $\tau_k = 19\%$.

Figure 14 summarizes the life-cycle patterns of consumption , labor supply, savings and pensions in the initial steady state following this calibration with a productivity pattern implied by Deaton (1997). With growing productivity, agents gradually increase labor supply over lifetime, which allows both consumption and savings to increase. In fact, young agents need to borrow because contemporaneous earnings fall short of optimal consumption. Pensions, being indexed with 25% of the payroll growth (which mimics the legislation), decrease quite sharply in life, necessitating a decrease in consumption.

[11] See a special issue of Labor Economics (volume 22, 2013).

Table 1: Calibrated parameters

α	capital share	0.31
τ_l	labor tax	0.11
ϕ	preference for leisure	0.526
δ	discounting rate	0.979
d	depreciation rate	0.045
τ	total soc. security contr.	0.060
ρ	replacement rate	0.227
		resulting
Δk_t	investment rate	21
r	interest rate	7.4

In the next section we discuss how these patterns and the macroeconomic aggregates change when MERA is increased, depending on the pension system implemented in an economy.

4 Results

Raising MERA is welfare enhancing, see Table 2. The welfare gain amounts to roughly 4-5%. The extent of the welfare gains is comparable for different scenarios, and is approximately twice the effects of the systemic reform, as reported for the same calibration and economy in Makarski et al. (2015). Gains in DB system originate from lower taxation, whereas in the DC economies they mostly stem from higher pensions, so the channels differ substantially, which we discuss in detail in Section 4.2.

Table 2: Net consumption equivalent from extending the retirement age

Pension system	consumption equivalent
DB system	3.70%
transition to NDC	4.41%
transition to FDC	4.70%

While it seems clear that welfare gains stem from raising the retirement age, regardless of the pension system, the distributional effects as well as channels of adjustment 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 adjustments in labor supply, output and taxes are discussed in detail in the subsequent section.

4.1 Cohort welfare effects of raising MERA

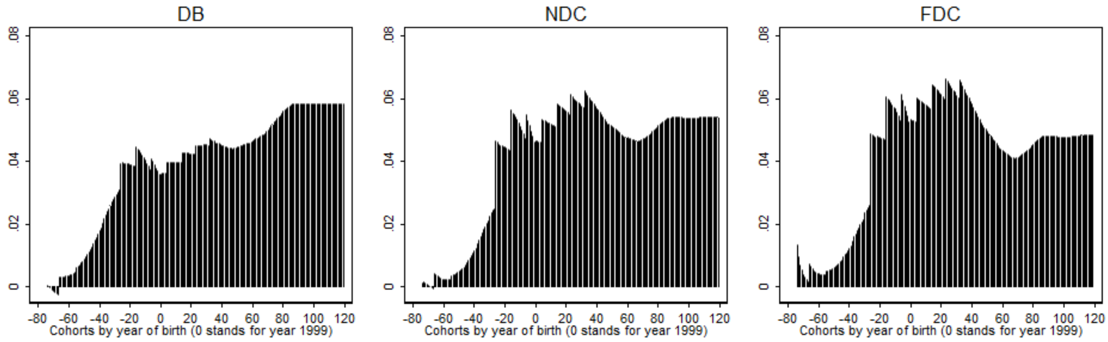
All cohorts universally benefit from increased retirement age, see Figure 4. This finding differs from Auerbach et al. (1989), but in fact this study considers an alternative set of policies and employ contribution rate as a fiscal closure.[12] In our setting, it is the lump-sum tax that is lowered, which redistributes welfare gains across all cohorts. Clearly, in our economy the gain from lower taxes is higher - in terms of welfare - than the loss due to forced longer labor market activity.

In comparison to the baseline scenario, the first increase in the effective retirement age by one year occurs in the 14th year from the starting point. Consequently, it is the cohort born in 1953 that works longer. The net effect for the oldest cohorts is very small but positive. Among the generations which at the moment of the first rise in the retirement age were middle-aged, and those who were young but already in the labor force, the positive welfare effect is stronger.

The welfare gains are slightly different under the NDC and DB system. For the cohorts born before 2050, welfare gains are highest under the DB system. Under the NDC the consumption equivalent is almost the same as under the DB. Increased retirement age allows to lower the costs of transition from a DB to a pre-funded DC scheme.

[12] In Auerbach et al. (1989) contribution rates balance the pension system, which implies that cohorts just prior to retirement have to work longer and see only a small gain in lowered τ. Thus, welfare effects of postponing retirement age vary between cohorts. Initially young 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 the older cohorts.

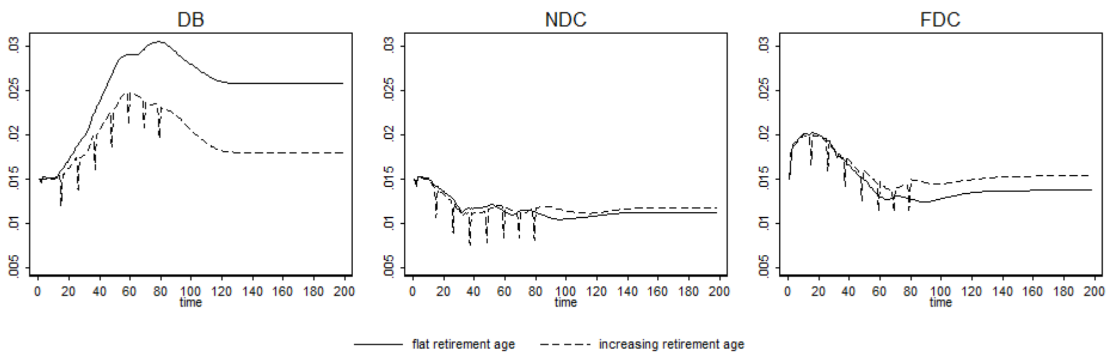
Fig. 4: Consumption equivalent



4.2 Changes in the economy

Large effects from postponing the retirement age are especially apparent when comparing the tax rates between the pension schemes. In fact, the implied tax rate in DB PAYG is considerably lower than NDC and partially funded DC *even without* the adjustment in MERA. This explains why the welfare gains from delaying retirement may in fact be so large and universal across cohorts. In the DB PAYG the largest part of the welfare gain come from substantially reduced taxation. Because the overall pension system deficit is lower, lower tax increase is necessary (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 temporarily raise taxes in order to finance the gap created by pre-funding. This explains why the lump-sum tax in the FDC is slightly higher than in the NDC.

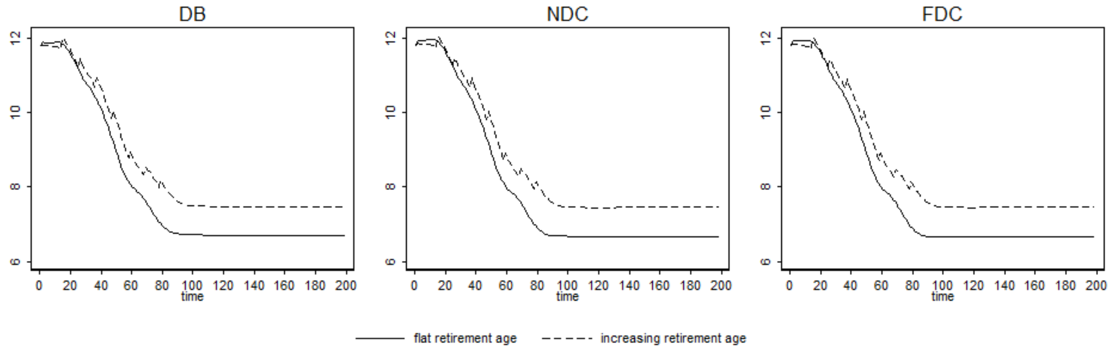
Fig. 5: Lump-sum tax rate (extent of fiscal adjustment for long term stable debt/GDP ratio)



An increase in the MERA postpones the period in which households start to receive 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. In such a setting, raising MERA has two types of effects. First, additional cohorts stay in the labor market, which raises labor supply sharply. However, cohorts having sufficient number of working periods prior to the retirement age are able to adjust labor supply to optimal levels by changing the hours worked. Figure 6 shows the overall effect on the aggregate labor supply in three analyzed pension schemes. With the properties of the Cobb-Douglas preferences, income effect and substitution effect – which work in the opposite directions – are of similar size, which limits the scope of differentiation between the adjustments in the overall labor supply for diffrent pension systems.

We also analyze how the labor supply over the life cycle in the final steady states differs between the baseline and reform scenario. Figure 7 illustrates the final steady states labor supply across cohorts with and without change in MERA for the three pension scenarios. In line with the literature – e.g.

Fig. 6: Labor supply (in mio of individuals)



Boersch-Supan and Ludwig (2010) – agents in our model forced to stay longer on the labor market, increase leisure in every period. This suggests that although perhaps agents would still "prefer" to work longer, they could work less in total. We decompose this effect in our simulation results for the final steady state.

Fig. 7: Labor supply over the life cycle in the final steady state

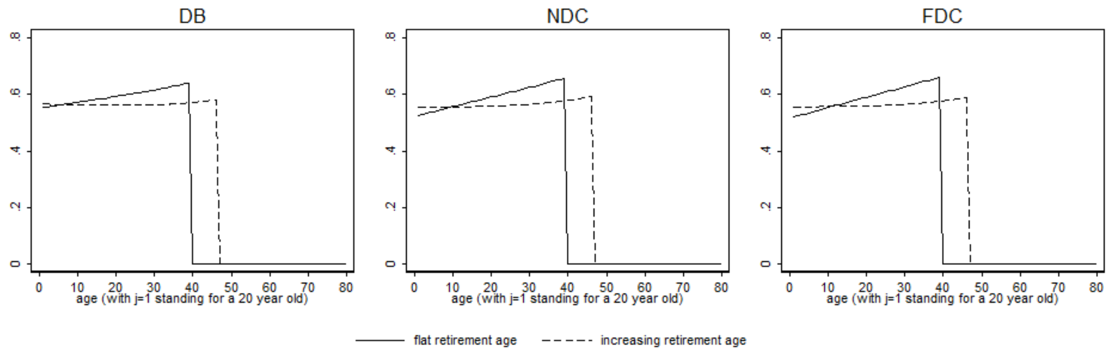
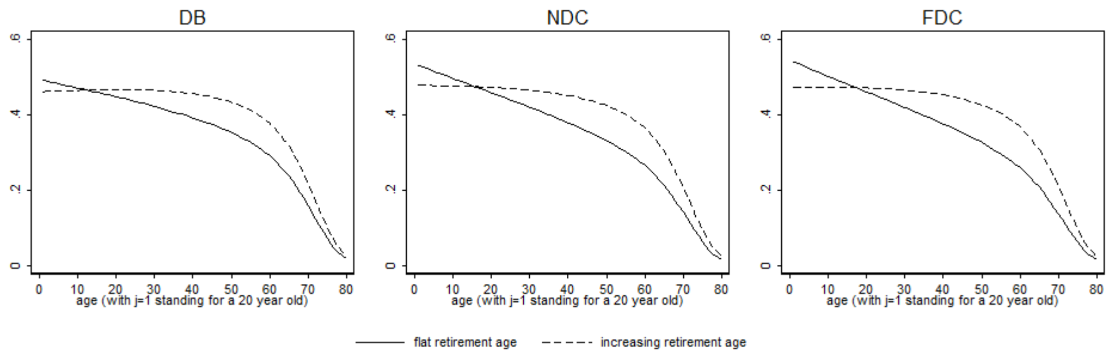


Fig. 8: Consumption over the life cycle in the final steady state



In fact, the downward adjustment in labor supplied before the age of 60 is more than compensated by the additional years of working due to increased MERA. Table 3 quantifies these effects. In our setting, in the original steady state labor supply amounts to 58.6% of their available time. Demographic transition alone increases this indicator to 61.7-63.2% in the final steady state. During additional years in the labor market agents use on average around 72% of their available time to supply labor. Yet, increase in MERA results in average annual labor supply lower by app. 4-6% in every period, relative to baseline scenario (it is still slightly more than in the initial stady state). Overall, the aggregate labor supply in the reform scenarios is 13.7%-15.4% higher. The extent of described adjustments is comparable across the pension systems.

Table 3: Labor supply effects of the reform in the final steady state

	Labor supply without MERA increase	Labor supply with MERA increase			
		$j < 60$		$j \geq 60$	Total
	Average	Average	Aggregate (baseline=100%)	Average	Aggregate (baseline=100%)
DB	63.2%	59.6%	94.4%	71.8%	113.7%
NDC	62.0%	58.8%	94.8%	72.3%	114.7%
FDC	61.7%	59.0%	95.5%	72.2%	115.4%

Higher net income from wages, combined with higher levels of pensions (see Figure 16 in the Appendix) results in increased consumption over the life cycle, see Figure 8. The life cycle pattern of savings in the final steady state shifts to the right, reflecting the increase in MERA, see also Figure 15 in the Appendix. The overall level of savings remains fairly unchanged.

In aggregate terms, DC systems yield more private savings, because the effective replacement rates are much lower than the nominal replacement rate under a DB, see Figure 9. Higher private savings imply more capital accumulation, yielding higher capital per effective unit of labor. However, an increase in the retirement age reduces the need for accumulating assets, lowering the K/L ratio permanently. In addition, there are income effects, which further reduce private savings. We decompose the changes in aggregate capital to those attributable to changed private (voluntary and obligatory) savings and those attributable to changed aggregate labor supply because of increased MERA, see Figure 10.

In fact, the results of the retirement age are quantitatively larger than those due to the introduction of a pension scheme incentivizing more private savings. These detrimental effects on capital are the strongest when retirement is postponed in the economy with a partially funded DC system (FDC). In the steady state, the capital is lower by about 15%. The loss in the K/L ratio is the lowest under DB pay-as-you-go system, where only the income effect is at play. Output in our model follows directly from capital, which implies that the time patterns are alike, see Figure 11. Reduction in the K/L ratio translates directly to a reduction in GDP *per capita* by approximately a third of the effect observed on capital.

Raising the retirement age is of crucial importance for determining the balance of the pension system under the DB scheme. Higher contribution base and lower payments imply lower deficit, which is clearly visible in Figure 12. In the DC systems effects of raising the retirement age are of only transitory nature and follow from changes in the contemporaneous balance between contributions and payments (due to the abrupt changes in the contribution base). In general, these systems are individually balanced, although temporary deficits orsurpluses are possible due to swings in the dependency ratio.

The opposite is true for benefits under the three analyzed pension schemes. Namely, DB systems should see little changes in the level of pensions from the raised MERA. However, shorter retirement period lowers the total discounted pension payments per retiree. Indeed, the former seems to quantitatively dominate. We show that in Figure 13, where we present total discounted and stationarized pension benefits per retiree (starting from a cohort entering the labor market when the first change in MERA is implemented).

On the other hand, in DC systems, raising the retirement age yields a sort of a double gain to the retirees. Namely, longer contributory period makes the amount of savings on individual accounts larger, which results in higher discounted pension payments per retiree. Additional effect comes from shorter retirement period, so higher accumulated pension savings are paid over lower number of years. Thus, the level of pensions raises even more, than the discounted pension payments, Figure 13. In NDC scheme, effective indexation is lower both pre and post-retirement[13], which yields overall lower pensions paid to the retirees compared to FDC scheme.

[13] These features of the model replicate the Polish legal system.

Fig. 9: Capital (per effective unit of labor)

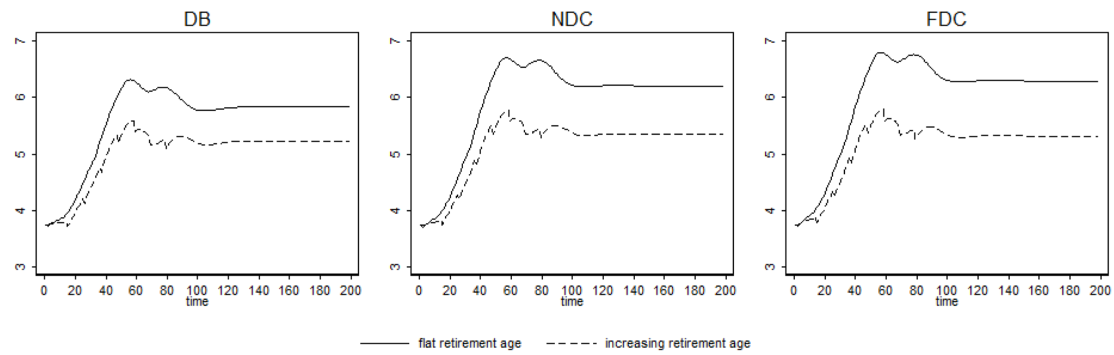


Fig. 10: Change in capital (per effective unit of labor) - decomposition

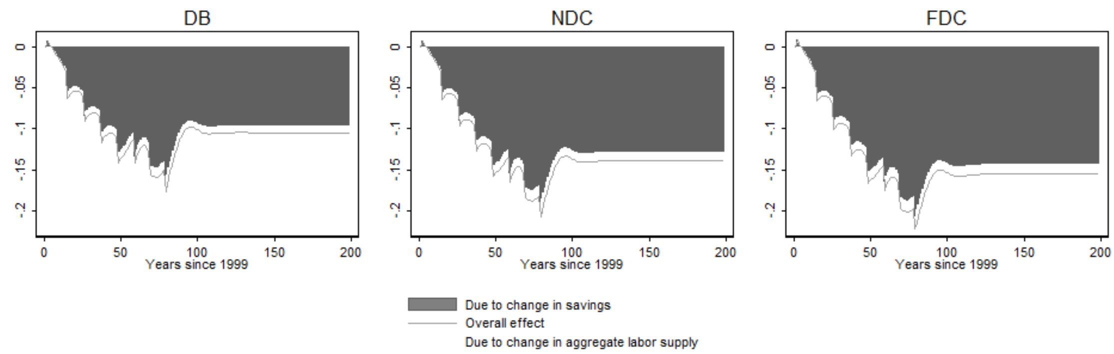
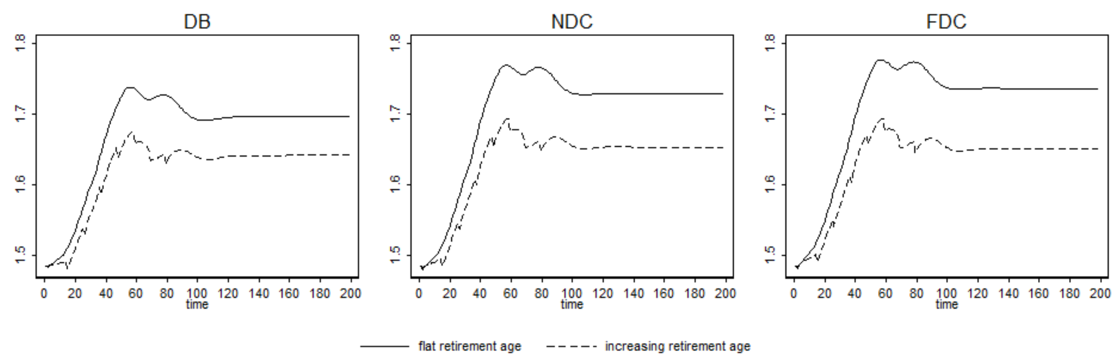


Fig. 11: Output (per effective unit of labor)



5 Conclusions

An inevitable increase in 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 the majority of pension system schemes existing in the developed economies.

Intuitively, increasing the retirement age may immediately imply lowering the labor supply of households. If the utility function reflects preference for consumption and dislike for work, increasing the retirement age will automatically cause an adjustment in the 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 a DB PAYG reduces fiscal imbalances,

Fig. 12: Pension system deficit (as % of GDP)

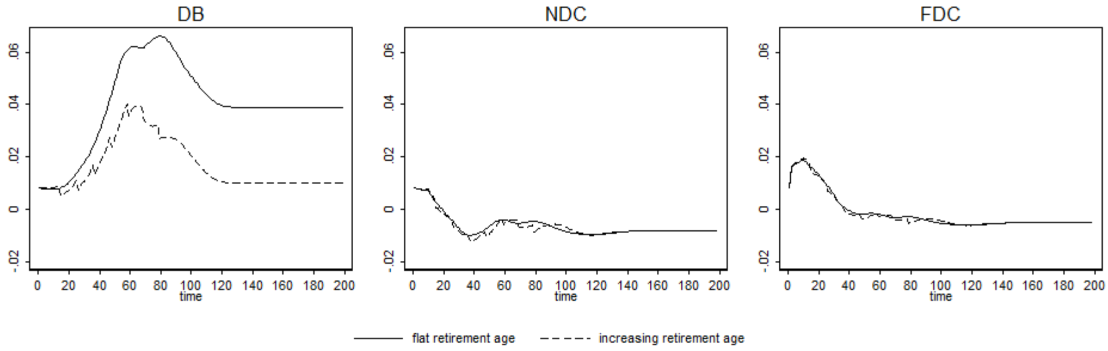
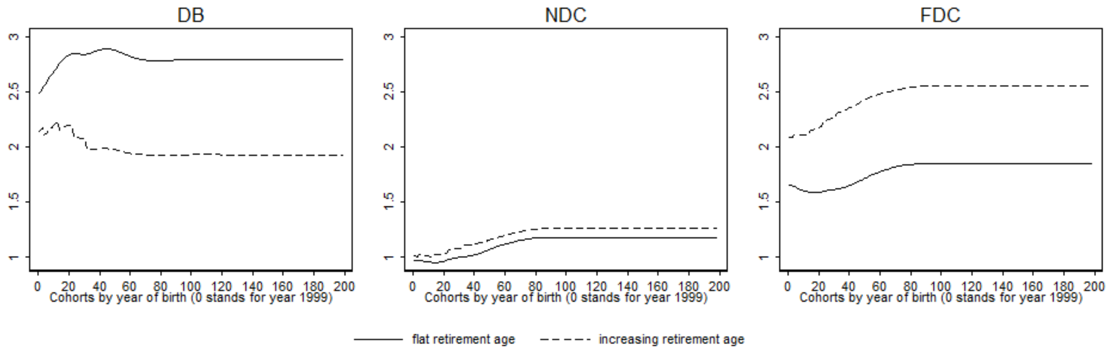


Fig. 13: Discounted total pension payments per retiree (stationarized)



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 postponing the retirement age. We do that for three of the most popular pension schemes: DB PAYG, DC PAYG 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 increasing longevity. Yet, data seem to suggest that even when incentives are aligned, effective exit age falls short of the minimum eligibility retirement age. Our study shows that even with DC systems raising MERA may be beneficial. More specifically, there are considerable and fairly comparable welfare gains from raising the retirement age regardless of the pension system, though the channels differ depending on the features of the pension system. Under defined benefit system gains stem mainly from lower tax rates, while under defined contribution – from much higher pensions. Under defined benefit systems agents' felicity is enhanced mainly due to fiscal relief. If the pension system is of defined contribution type, welfare gain follows from higher pensions. Because in our model the NDC and FDC scenarios are *in transition* from a PAYG DB, there are also small gains due to 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. Our major result would not be altered if the 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 or in human capital.

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. With lowering fertility and increased access to care facilities, it is likely that professional activity will gradually increase, which would be equivalent to changing the preference for leisure on the transition path. Finally, using an exogenous (and possibly binding) retirement age in an OLG model may be viewed as a shortcoming. In our setting households may choose to retire prior to MERA, but cannot prolong their professional activity beyond that date. Indeed, it is possible that the DC systems would yield similar results with endogenous retirement age. However, with the DB systems aligning the social and private incentives would be difficult. Also, modeled endogenous effective exit age higher than observed in the data is poorly indicative of feasible policy options. Our study also shows that a transition to the DC systems enhances the welfare gains from raising MERA. In this sense systemic and parametric reforms can be viewed as complementary rather than substitutes.

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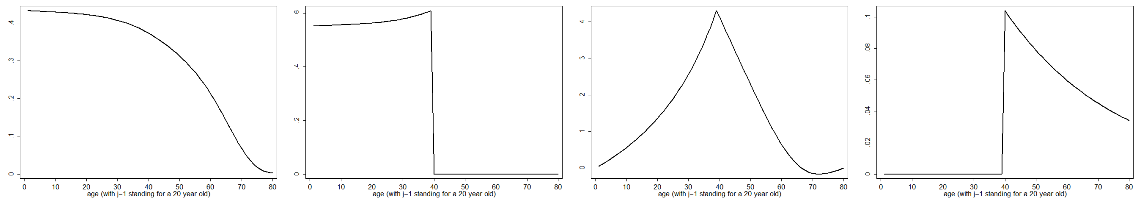
A Initial steady state

Fig. 14: Agents' behaviour over the life cycle (initial steady state)



(a) consumption (b) labor supply (c) savings (d) pensions

B Final steady state

Fig. 15: Savings over the life cycle in the final steady state

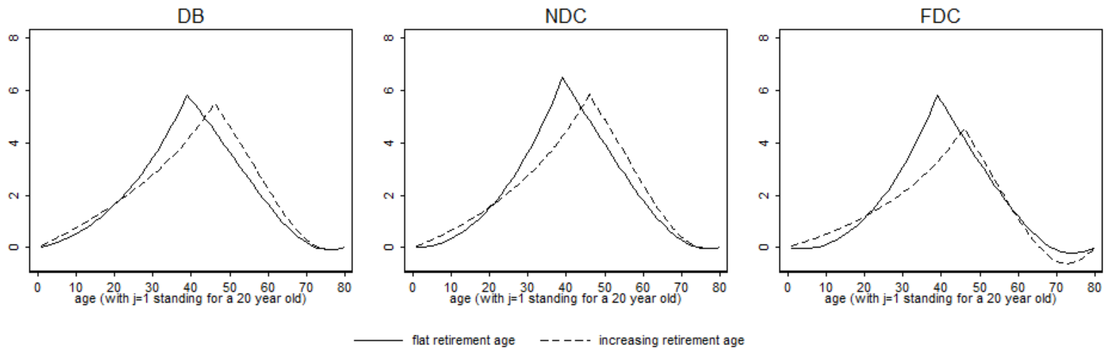


Fig. 16: Pensions over the life cycle in the final steady state

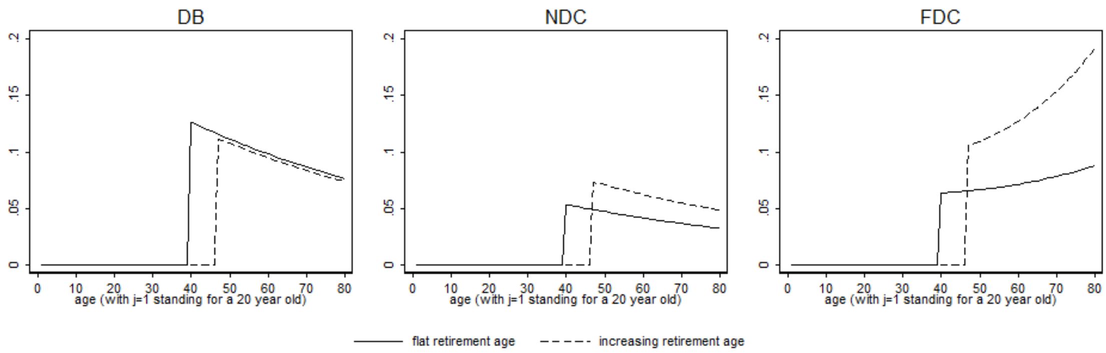


Fig. 17: Labor supply over the life cycle in the final steady state

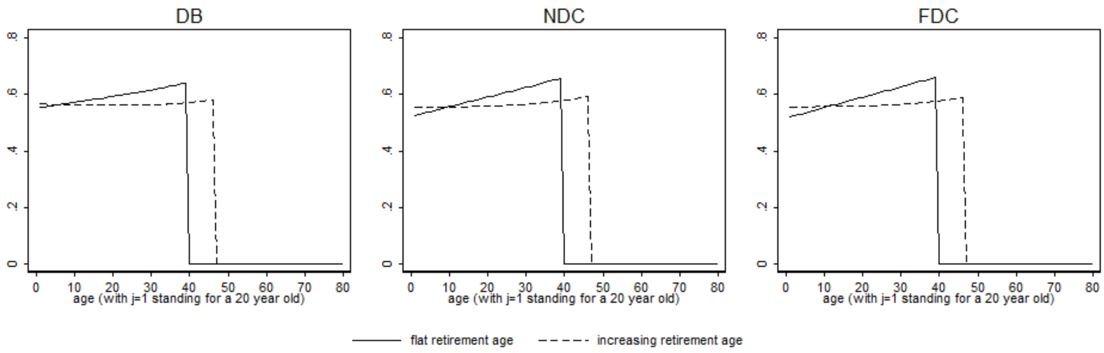


Fig. 18: Pension system balance - reform relative to baseline for all three types of pension schemes

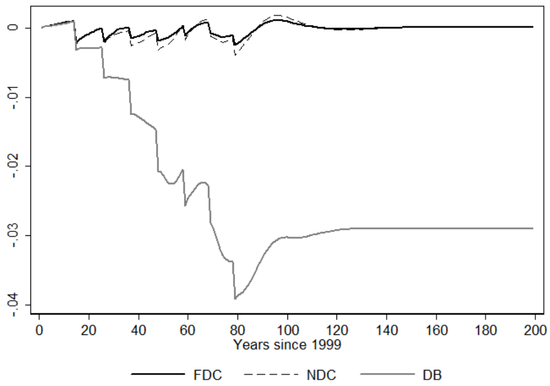


Fig. 19: Labor supply - reform relative to baseline for all three types of pension schemes

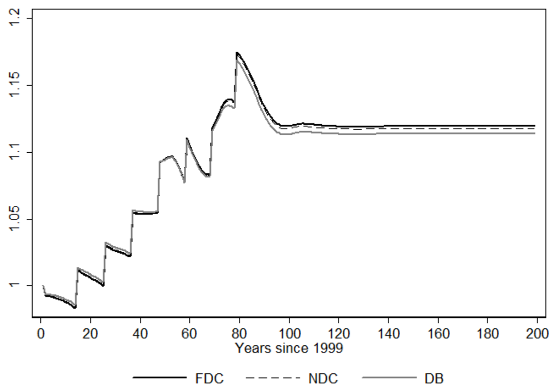


Fig. 20: Capital - reform relative to baseline for all three types of pension schemes

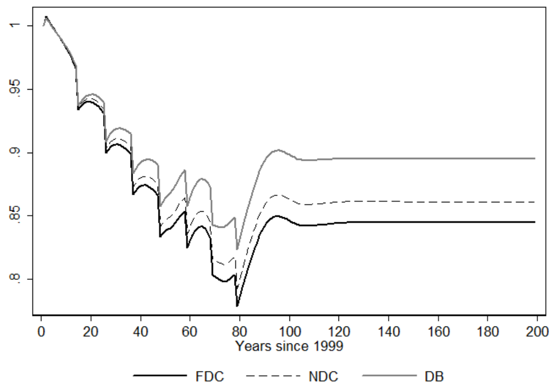


Fig. 21: Output (per effective unit of labor) - reform relative to baseline for all three types of pension schemes

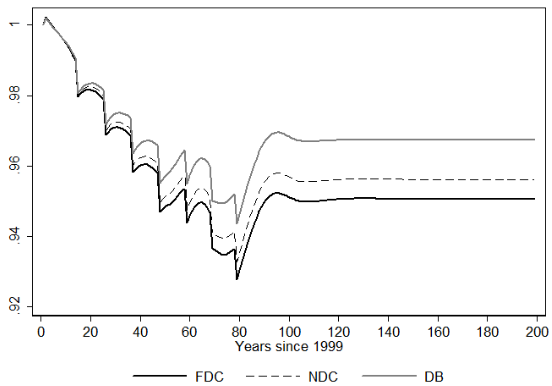


Fig. 22: Discounted pensions payments per retiree - reform relative to baseline for all three types of pension schemes

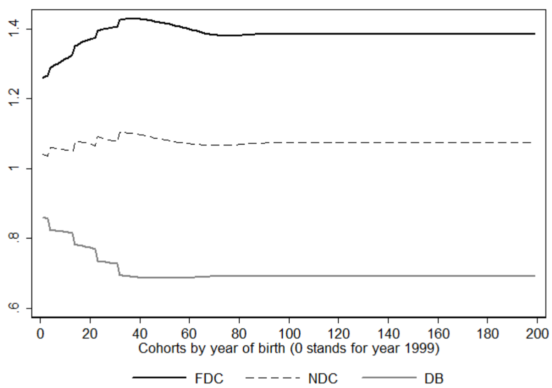


Fig. 23: Lump sum tax rate - reform relative to baseline for all three types of pension schemes