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On Welfare Effects of Increasing Retirement Age

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Abstract
We develop an OLG model with realistic assumptions about longevity to analyze the welfare effects of raising the retirement age. We look at a scenario where an economy has a pay-as-you-go defined benefit scheme and compare it to a scenario with defined contribution schemes (funded or notional). We show that initially in both types of pension system schemes majority of the welfare effects come from adjustment in taxes and/or prices. After the transition period, welfare effects are predominantly generated by the preference for smoothing inherent in many widely used models. We also show that although incentives differ between defined benefit and defined contribution systems, the welfare effects are of comparable magnitude under both schemes. We provide an explanation for this counter-intuitive result

Keywords:
longevity, PAYG, retirement age, pension system reform, welfare

JEL Classification
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1 Introduction

A rational agent will work for as long as it is individually optimal, coordinating the choice of savings, hours and years of work to maximize lifetime utility. For such a rational agent a minimum eligibility retirement age (MERA) is irrelevant unless it is binding, i.e. she would prefer a different duration of career if it were allowed. Imposing more years of labor market activity (extensive margin) can lead to a decrease in instantaneous labor supply (intensive margin). Overall life-time labor supply could remain essentially unaffected by the change in the *de iure* MERA if it is aligned with individual preferences (see Boersch-Supan 2013). Despite these insights from the theory, data demonstrate that with few exceptions, the *de facto* labor market exit age is substantially lower than MERA in all advanced economies (Heijdra and Romp 2009, Sauré and Zoabi 2012). This puzzle underlies the relevance of the debate over MERA (Gruber and Wise 2007).

Raising *de iure* MERA is and most likely will continue to be a politically sensitive issue (see Feldstein 2016). Intuitively, working longer is detrimental to welfare when individuals have disutility from labor, a standard assumption in most economic models. Yet, with increasing longevity, the old-age dependency ratio is expected to deteriorate, which is further amplified by decreasing fertility. These observed demographic trends boost interest in policies aimed at raising the overall participation, including labor market activity of the elderly (see Fehr 2000, Boersch-Supan and Ludwig 2010). In addition to mitigating the negative consequences of a shrinking working population, unlike other considered policy options, these policies can mitigate the detrimental effects of longevity on the stability of pension systems (Fehr et al. 2008).

One of the main arguments raised in discussions over MERA relies on incentives: if a pension system provides incentives to prolong the period of labor market activity in the light of longer life expectancy with increasing exit age agents may fully internalize the general equilibrium benefits from longer employment duration. It is irrelevant from the welfare perspective (in a representative agent setting) if exit age is endogenous or exogenous: exogenous non-binding constraints will not affect choice, excessive exogenous constraint will only limit access to pension benefits but will not prolong labor market activity. Clearly, defined contribution (DC) system seems to provide stronger incentives, because agents see the link between work and pension benefit and internalize it. The opposite holds for a defined benefit (DB) system, where private incentives are weak. In fact, in a DB system, most of the welfare consequences come from general equilibrium effects (in a DB system higher MERA reduces the fiscal burden allowing for reduced taxation, *ceteris paribus*). Moreover, there are partial equilibrium effects which stem from the fact that in most standard economic setups agents prefer smoother life-cycle paths, hence the preference for longer working periods.

In this paper we develop a series of overlapping generations models to determine the welfare effects of increasing the retirement age. We employ demographic projections to obtain a realistic scenario of longevity and impose a commensurate increase in minimum eligibility age to start collecting pensions (see Fehr 2016). We analyze two cases. In the first, an economy has a defined benefit pay-as-you-go system (DB PAYG). In the second case, a reform is implemented from a PAYG DB to a DC system financed at a pay-as-you-go basis (often referred to as notionally defined contribution, NDC). In both cases, the baseline scenario is characterized by unchanged MERA, despite demographic changes. In the reform scenario MERA is increased in line with longevity, i.e. by as much as 15%. We analyze the welfare and the macroeconomic effects of such policy change.

In addition to being policy relevant, this question is also empirically intriguing. First, it is not clear if the benefits of a higher MERA are going to be outweighed by the disutility of working longer under alternative pension systems. Second, there is no clear theoretical underpinnings on the comparison of the size of the welfare effects across the pension systems. Third, we compare the size of the welfare effects due to changing the retirement age (i.e. one of the examples of the parametric reforms) to the welfare effects of reforming the pension system from DB to DC scheme (i.e. systemic reforms). In comparing these welfare effects, our findings are particularly useful for countries yet to implement any reforms.

We find that the welfare effects of increasing MERA the retirement are similar across both analyzed pension systems, even if stem from different sources. The net consumption equivalent from the implementation of this reform equals around 4% of lifetime consumption. We decompose this overall welfare gain into partial and general equilibrium effects. The former allows us to quantify the value of labor supply smoothing over life-cycle. The latter informs about the welfare effects of improved fiscal balance and prices. We show that initially general equilibrium effects dominate. As the economy transits to the new steady state and prices adjust, the role of partial equilibrium effects strengthens to eventually dominate.

The paper is structured as follows. Section 2 discusses briefly the relevant literature. A 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. We conclude by discussing the results in light of the political economy mechanisms that may be at play in the context of such reforms.

2 Motivation and insights from the literature

Building on the seminal work of Auerbach and Kotlikoff (1987), an abundant literature analyses the welfare implications of parametric reforms in the pension systems (cfr. Lindbeck and Persson 2003, Fehr 2009). The welfare implications of these reforms are usually conceptualized as a change in utility between a baseline and reform scenario, observed for all cohorts (as pioneered by Breyer 1989, Feldstein 1995). The overlapping generations

(OLG) model is the workhorse in the field (Fehr 2016).

With respect to the retirement age, the literature thus far has focused on two questions. First, the literature analyzes optimal retirement age, i.e. 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 has focused on 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 this second category, in the remainder we summarize the insights from these earlier, policy-motivated works.

There are several stylized facts that the literature tries to capture. First, with increasing longevity, certain increase in the retirement age could be seen as a way to accommodate for longer expected life duration, keeping the relative proportion of the split between working periods and leisure periods unaffected. With most standard preferences, this sort of "reform" should have little or no welfare effects relative to the initial steady state if consumption levels are 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, Wise 2016) as well as changes in labor productivity due to human capital investment (see Annabi et al. 2011)

The link between retirement age and labor supply 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). Thus, the literature suggests that raising the exit age is only welfare enhancing if the *de iure* retirement age is too low and pension system provides disincentives to staying in the labor market beyond the official legal limit. 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. For example, Boersch-Supan et al. (2007) provide simulations of old-age labor supply responses to some policy changes, showing that, 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 rise in the retirement age, Beetsma and Bucciol (2011).

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 exercise 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.

Summarizing, the literature provides intuition as to what effects we should expect from raising the retirement age. 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. No previous study, to the best of our knowledge, analyzed the sources of the welfare effects, particularly the partial equilibrium effects. Moreover, the majority of studies focused on one particular system, typically a PAYG DB scheme, with no analyses of parametric reform between pension systems and/or in the context of systemic reforms.

Our paper fills these gaps by investigating the welfare and macroeconomic effects of raising the retirement age with a specific focus on two policy-relevant issues. First, we compare the effects of increasing MERA in an economy with a PAYG DB to identical increase of MERA in an economy in transition from PAYG DB to a DC system. Thus, we may answer if a systemic reform of pensions influences the welfare effects of changing the retirement age. Second, we separate partial equilibrium effects stemming from more flexibility in choosing an optimal consumption-leisure-savings path from general equilibrium effects which originate from adjustments in prices and taxes.

3 The model

The baseline scenario always consists of a flat effective retirement age in a PAYG DB scheme. We construct two experiments. In the first experiment the reform scenario preserves the PAYG DB system, gradually increasing the retirement age from 60 to 67 years of age. This experiment is similar to most of the parametric pension system reforms analyzed in earlier literature. In the second experiment the reform scenario consists of a *transition* from a PAYG DB to a PAYG DC scheme (we refer to this case as NDC) accompanied by an increase in the retirement age. This experiment is closest to the actual policy events in many North European as well as Central and Eastern European countries. Although the experiment consists of two policy changes at one time, when combined with the first experiment, it allows to provide intuition on the relative size of the welfare effects from retirement age increase both in the presence and in the absence of systemic pension system reform.

In each of the experiments, the economy has the same exogenous productivity growth rate, households have the same preferences and production sectors are the same. This design choice enables us to compare the welfare effects both within and across the experiments. To fully measure the welfare costs associated with the transition periods, we follow Nishiyama and Smetters (2007).

The 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 of the deterministic evolution of wages, capital, interest rates, etc. Additionally, our model features a pension system and a government.

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 $j = 1, 2, ..., J$ indexes 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 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 certainty.[1] 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 the mortality rates downwards.[2] 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.[3]

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 $c_{j,t}$:

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

Consumers have elastic labor supply up to the retirement age $\bar{J}_t$, when they have to retire:

[1] Demographic structures and projections lump together all individuals aged 99 or above.

[2] We discuss the demographic scenario in section 4.

[3] 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.

$l_{j,t} = 0$ 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 ensure 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. However, as evidenced by the literature discussed in section 2, in most countries effective age of labor market exit falls short of *de iure* MERA. 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 $\bar{J}_t$.

On the other hand, these data are historical. Improving health, better working conditions as well as increasing life expectancy may alter the current "preferred" exit age endogenously. Then, current MERA may become binding, creating an inefficiency. It is not warranted, however, that the change in employment opportunities among the elderly are adequately synchronized with the changes in MERA (see a recent volume edited by Wise 2016). Conservatively, we consider a scenario of retirement age increase proportional to the projected longevity.

Labor productivity is assumed flat over the life cycle.[4] Real wage of agent of age j is equal to $w_{j,t}$ 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 two pension schemes: defined benefit (DB) and notionally defined contribution (NDC). Thus for each agent of age j there can be two streams of pensions $p_{\iota,j,t}$ where $\iota \in \{DB, NDC\}$. 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 $p_{\iota,j,t}$ while fully internalizing the link between the contributions to the pension system and the pension benefits received.

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

[4]Despite numerous studies, the shape of the age-productivity pattern remains a discretionary area. Most of the studies assume an inverted U-shaped pattern, e.g. special issue of Labor Economics (volume 22, 2013). 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.

period t is given by:

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

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

3.2 Production

Competitive producers have access to the constant returns to scale technology with labor augmenting exogenous 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:

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

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

3.3 Pension systems

The pension systems we model are closely benchmarked to the legal conditions in Poland. As already mentioned, we consider two types of pension systems $\iota \in \{DB, NDC\}$, denoting defined benefit PAYG and defined contribution PAYG, respectively. 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: $\tau = \tau^{DB} = \tau^{NDC}$.

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 a 25% of the growth rate of payroll $\kappa_t^{DB} = 1 + 0.25 \cdot r_t^I$, where r_t^I denotes the growth rate of labor income which is defined as:

$$r_t^I = \frac{w_t L_t - w_{t-1}L_{t-1}}{w_{t-1}L_{t-1}}. \tag{4}$$

Consequently, pensions are given by:

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

Pensions expenditure are financed with contributions of the working and a subsidy from the government (denoted by S_t):

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

The government subsidy is needed in order to balance the pension system.

Notionally defined contribution (NDC) system. The contributions of an agent of age j are used to finance actuarially fair benefits calculated at the retirement age. Afterwards, pensions are indexed the same way as in DB PAYG, i.e. $\kappa_t^{PAYG} = 1 + 0.25 \cdot r_t^I$. Pensions are payed according to the formula:

$$p_{j,t}^{NDC} = \begin{cases} \frac{\sum_{i=1}^{\bar{J}_t-1} \left[\Pi_{s=1}^{i}(1+r_{t-i+s-1}^I)\right] \tau^{NDC} \cdot w_{\bar{J}_t-i,t-i} l_{\bar{J}_t-i,t-i}}{\prod_{s=\bar{J}_t}^{J} \pi_{s,t}}, & \text{for } j = \bar{J}_t \\ \kappa_t^{DB} p_{j-1,t-1}^{NDC}, & \text{for } j > \bar{J}_t \end{cases} \tag{7}$$

where $\kappa_t^{DB} = 1 + 0.25 \cdot r_t^I$ and the subsidy is such that:

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

3.4 Government

The 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.

$$G_t + subsidy_t^{\iota} + r_t D_{t-1} = T_t + (D_t - D_{t-1}) + \Upsilon_t \sum_{j=1}^{J} \pi_{j,t} N_{t-j}. \tag{9}$$

where

$$T_t = \tau_{l,t}\Big((1-\tau^{\iota}) w_t L_t + \sum_{j=\bar{J}_t}^{J} p_{j,t}^{\iota} \pi_{j,t} N_{t-j}\Big) + \Big(\tau_{c,t} c_t + \tau_{k,t} r_t s_{j,t-1}\Big) \sum_{j=1}^{J} \pi_{j,t} N_{t-j}. \tag{10}$$

We calibrate the level of debt D_t in the initial steady state to match the data at around 45% of GDP and we assume that it remains at that level in all our simulations. We close the fiscal deficit using lump sum taxes Υ_t.

3.5 Market clearing conditions, equilibrium and model solving

Clearing of the goods market requires

$$\sum_{j=1}^{J} \pi_{j,t} N_{t-j} c_{j,t} + G_t + K_{t+1} = Y_t + (1-d)K_t, \tag{11}$$

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

$$L_t = \sum_{j=1}^{\bar{J}_t - 1} \pi_{j,t} N_{t-j} \omega_{j,t} l_{j,t} \qquad \text{and} \qquad K_{t+1} = \sum_{j=1}^{J} \pi_{j,t} N_{t-j} \hat{s}_{j,t} - D_t, \tag{12}$$

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

3.6 Solution method

In order to solve the model we first find the initial and the final steady states. Subsequently we find 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. 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.

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 of 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 the basis for calculation of consumption equivalents, denoted as μ_t, similar to Nishiyama and Smetters (2007).

$$U_{1,t}((1-\mu_t)\tilde{c}^R_{j,t}, \tilde{l}^R_{j,t}) = U_{1,t}(\tilde{c}^B_{j,t}, \tilde{l}^B_{j,t}) \tag{13}$$

A positive value of μ_t informs us that the reform is welfare improving for a 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. We then 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 (for both the steady states and the transition path).

3.7 Scenarios

It is often emphasized that reforming the pension system from a defined benefit to a defined contribution scheme would no longer require 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. In the DB system, extending the retirement age increases the extensive margin of labor supply (partial equilibrium). However, there could be important general equilibrium effects happening mostly through lower taxes, but also *via* relative scarcity of capital as well as on the fiscal side) as well as important redistribution effects between the cohorts.

In order to provide a rigorous quantification of these effects we provide the following experiments. Each pension system has a baseline of no-policy change and a reform scenario of increasing retirement age. In DB PAYG scenario the baseline consists of a DB 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 each case the change in the effective MERA is the same.

4 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.

4.1 Calibration of the structural parameters

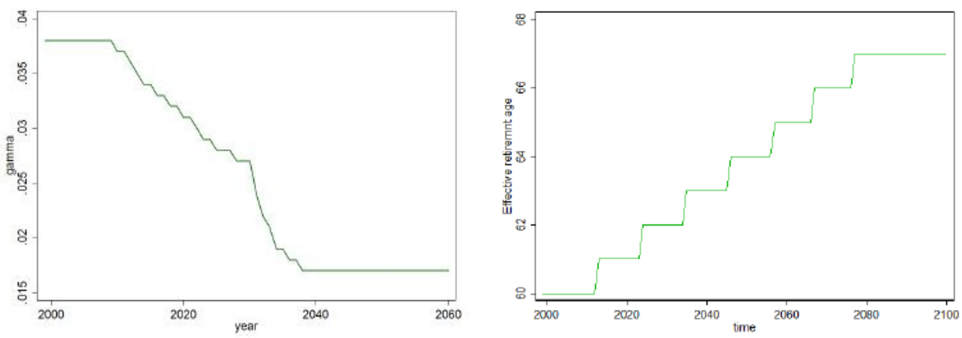
In this section we describe how all structural parameters are calibrated, we focus on demographics, productivity, preferences, government sector and the depreciation rate of capital. The values of the key parameters are summarized in Table 1.

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. Demographic change 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[5]. We assume the number of births 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 stabilize and remain 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 ensure stationary population and steady state of the economy.

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 1. 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 1: Labor augmenting productivity growth rate projection (left, assumption) and retirement age in economy (right, reform scenario)



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

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

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 is "optimal" in the model, which emphasizes the role of $\bar{J}$. 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. Replacement rate ρ is constant and we calibrate it to match the 5% pensions to GDP ratio in 1999.

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

α	capital share	0.30
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

Figure A.1 summarizes the life-cycle patterns of consumption, labor supply, savings and pensions in the initial steady state following this calibration. Internalizing the effects of labor supply prior to retirement, agents gradually increase labor supply over their 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.

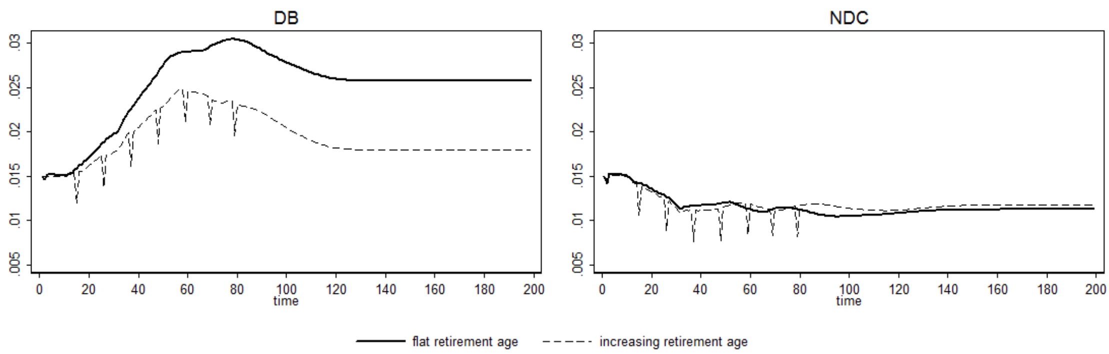
5 Results

Raising MERA has important macroeconomic consequences and considerably affects welfare of agents. Welfare effects are quantitatively similar across different pension systems, but the channels through which they are realized differ. We describe adjustments in labor supply, pensions, output and taxes. In the subsequent subsection we discuss in detail the welfare effects for respective cohorts.

5.1 Fiscal, labor supply and capital adjustments

The implied tax rate in DB declines considerably, hence yielding substantial welfare effects, see Figure 2. Because the overall pension system deficit declines, the necessary tax increase is lower (an increase at all is inevitable due to the demographic changes). In the case of NDC, changes in taxes are negligible over the long-run. This comes from the fact that DC systems over the long run are balanced by construction, so an increase in MERA does not affect fiscal balance. Nevertheless, in the DC systems there are temporary tax declines corresponding to the periods in which retirement age changes which for some cohorts could mean lower lifetime taxes. Large effects of the postponement of the retirement age are especially apparent when comparing the tax rates between the pension schemes. In fact, the implied tax in DB is considerably lower than in the case of NDC *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.

Figure 2: Lump-sum tax



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 prior to the retirement age, but after reaching $\bar{J}$ nobody works. Hence, 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 3 shows the overall effect on the aggregate labor supply in two 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 different pension systems.

Figure 3: Labor supply ($L_t = \sum_{j=20}^{j=\bar{J}} N_{j,t} \cdot l_{j,t}$)

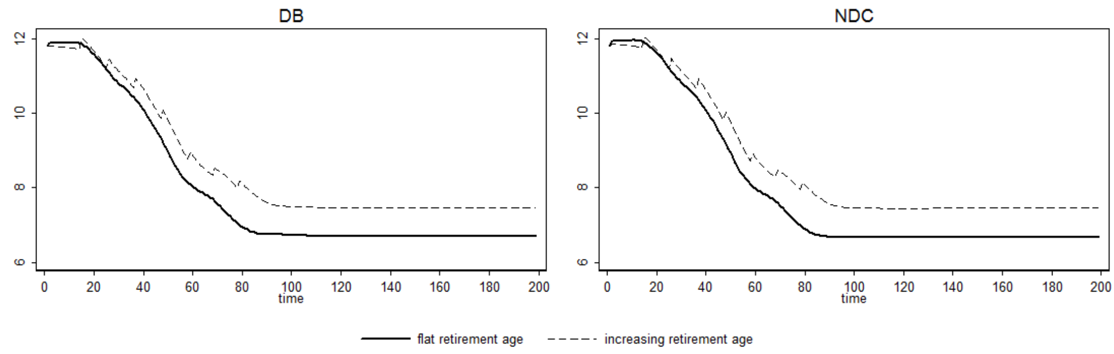


Figure 4: Labor supply over the life cycle in the final steady state ($l_{j,T}$)

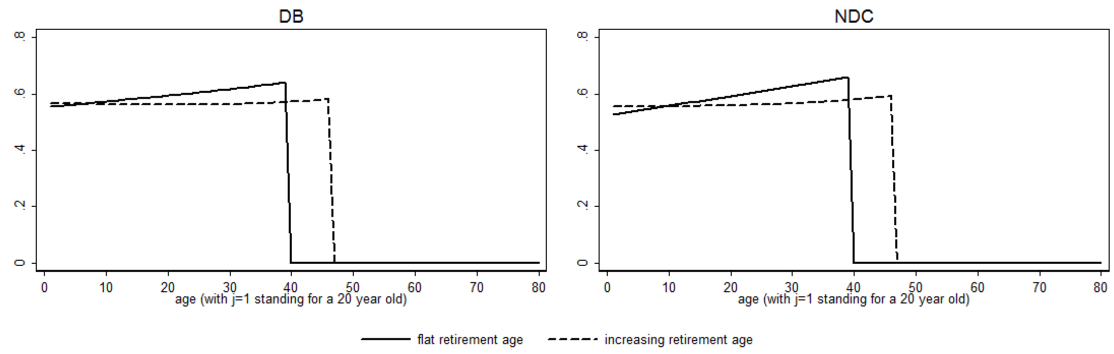


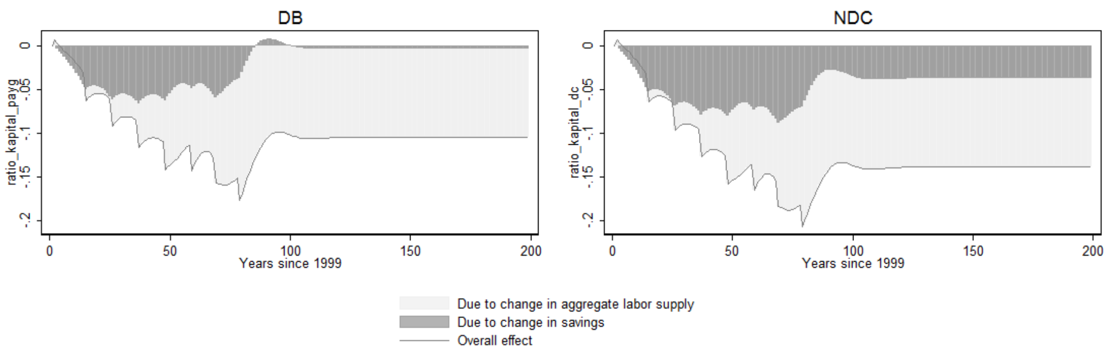
Figure 4 illustrates the final steady states labor supply across cohorts with and without change in MERA for the three pension scenarios. Agents, forced to stay longer in the labor market, increase leisure in almost every period (except for early years of their career). This finding is consistent with the literature (e.g. Boersch-Supan and Ludwig 2010) and suggests that although agents work longer years, they could work less in total. In fact, the downward adjustment in labor supplied before the age of 60 is more than compensated for by the additional years of working due to increased MERA. In the original steady state labor supply amounts to 58.6% of their available time. Demographic transition alone increases this indicator only slightly to 58.9-60.0% in the final steady state. During additional years in the labor market agents use on average around 58% of their available time to supply labor. Yet, an increase in MERA results in average annual labor supply falling by app. 2-3 percentage points in every period, relative to baseline scenario. Overall, the aggregate labor supply in the reform scenarios is 12%-13% higher. The extent of proscribed adjustments is comparable across the pension systems.

Table 2: Labor supply effects of the reform in the final steady state

	Labor supply baseline	Labor supply with MERA increase			
		$j < 60$		$j \geq 60$	Total
	Average	Average	Aggregate (baseline=100%)	Average	Aggregate (baseline=100%)
DB	58.9%	57.0%	96.7%	56.9%	113.1%
NDC	60.0%	57.3%	95.5%	58.3%	112.0%

Naturally, increasing MERA results in lower private savings. This is the first source of downward adjustment in capital per effective unit of labor. The second source is the fact that labor supply increases, affecting relative price of labor and capital. Figure 5 shows the relative contribution of these two effects. In case of both DC and DB, there is a shift to the right of the life-cycle profile of savings in the final steady state, reflecting the increase in MERA, see Figure B.2 in the Appendix. In case of DB system shorter retirement period, lower taxes combined with no change in pension levels (see Figure B.3 in the Appendix) result in only temporary decline in savings. On the one hand people want to save less since they stay for a shorter period in retirement, but on the other hand they become better off (lifetime income goes up) and since their pensions do not increase they want to save more. In the long run these two effects balance each other. In case of DC systems shorter retirement period is combined with higher pension income (see Figure B.3 in the Appendix) so savings decline.

Figure 5: Change in capital per effective unit of labor - decomposition



In fact, the effects from increasing 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 stronger in the economy with a DC system. In the steady state, the capital is lower by about 15% in DC, but much less in DB, where only the income effect is at play. The extent of the welfare gains from postponing retirement at par with longevity is approximately twice the effect of the systemic reform, as reported for the same calibration and economy in Makarski et al. (2016). Adjustment in capital is roughly 50% stronger, and in the opposite direction: introducing DC fosters voluntary savings, whereas postponing retirement yields the opposite.

5.2 Welfare effects of raising MERA

An increase in the minimum eligibility retirement age has substantial welfare effects itself, but the differences between the two analyzed systems are minor. The overall welfare effect of gradual increase ranges from 3.7% of lifetime consumption in the case of DB to 4.4% in the case of DC. These numbers reflect the welfare effects after compensating all the welfare losses and are expressed in consumption equivalents. While the size and the sign of this overall number is a consequence of many intertwining processes, we may analyze the welfare effects per cohort and decompose the sources of welfare changes to those attributable to partial equilibrium effects (more flexibility in consumption-leisure-savings choice) and general equilibrium effects (different prices of work and capital as well as taxes and pensions). This decomposition is depicted in Figure 6. We show the overall effect and partial equilibrium effect. The general equilibrium effect is the difference between the two.[6]

In case of the DB system partial and general equilibrium effects contribute fairly equally to the overall effect for each cohort. However, smoother adjustment in labor supply is only feasible for cohorts still active at the moment of first change in MERA, so the partial equilibrium effects appear later. The general equilibrium effects come predominantly from lower taxes (see Figure 2) and lower capital per effective unit of labor (see Figure 5) which affects the interest rate and wages. A substantial role of the general equilibrium effect is consistent with misalignment of incentives under DB. Notably, this misalignment persists permanently, because with lower retirement age, DB systems have higher taxation.

In case of the DC system the role of the general equilibrium effects is pronounced for as long as economy adjusts to the new equilibrium. Hence, the main source of welfare effects is change in lifetime income due to longer working period, along with the accompanying change in prices of work and capital. In fact, taxation adjusts only temporarily, in the years when a full cohort stays a year longer in the labor market (see Figure 2). Longer working and shorter retirement periods imply less need for savings (in our model they serve to smoothen consumption), which lowers the effective stock of capital, *ceteris paribus*. Hence, especially during the transition periods, there are strong adjustments in prices, for some cohorts general equilibrium effects amount to a half of the overall welfare effect. As soon as the adjustment is completed, smoother labor supply choice becomes the only source of

[6] In the case of partial equilibrium, agents observe prices and taxes from baseline but the actual retirement age as in the reform scenario (in the case of NDC agents observe the new pension benefits, i.e. ones with adjustment in years of work and years after retirement). For the analysis in general equilibrium prices and taxes are fully endogenous.

Figure 6: Consumption equivalent for gradual retirement age increase

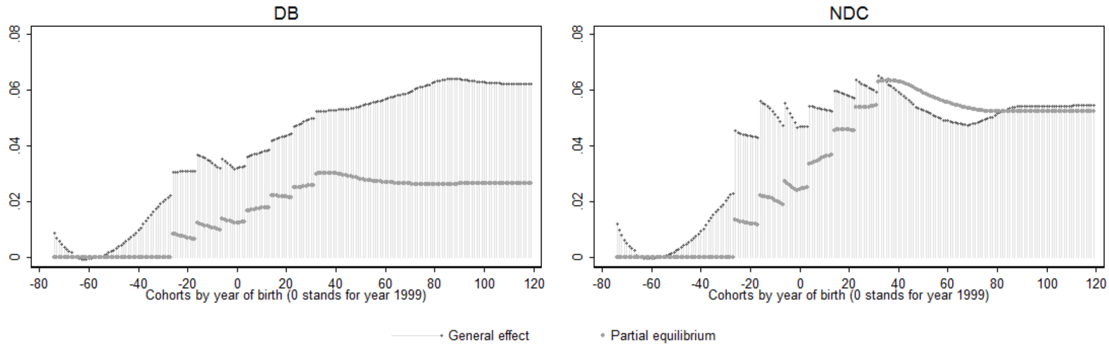
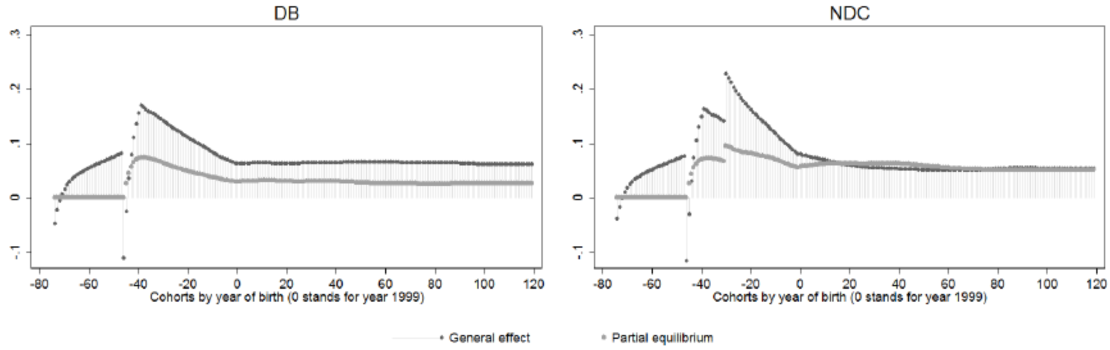


Figure 7: Consumption equivalent for immediate change of retirement age



general equilibrium effects, as one would expect in a DC system.

Hence, the differences in the effects of retirement age increase between DB and DC systems appear only in long-term horizon: under DB there continue to be general equilibrium effects due to taxes, whereas under DC partial equilibrium dominates. We corroborate this conclusion by analyzing a hypothetical scenario of immediate increase of retirement age eligibility by the same amount. Such policy reform is probably never feasible, but helps to analyze the mechanisms behind the adjustments also in the case of gradual increases of MERA, Figure 7. Moreover, relatively higher taxation attenuates the incentives to adjust labor supply, which reduces the scope for the partial equilibrium effects in the DB scenario. When incentives are correctly aligned, as in the DC scenario, partial equilibrium effects are simply larger.

Our result differs from Auerbach et al. (1989) as in our case the welfare gains are generally universal. However, in our setting DB pension system is not automatically balancing, whereas Auerbach et al. (1989) set contribution rates to balance the pension system in every period. This implies that cohorts just prior to retirement have to work longer and see only a small gain in lowered τ. The welfare effects of postponing retirement age therefore vary between cohorts. Initially young and future generations benefit from positive effect on net wages. Near-retirees benefit only modestly from lower contribution rates and face disutility from reduced leisure, which implies a net negative welfare effect for the older cohorts. In our setting, it is the lump-sum tax that is lowered, which redistributes welfare gains across all cohorts.

6 Conclusions

Earlier research suggests that households, forced to work for more years, adjust the average annual labor supply downwards. This type of adjustment was emphasized by Boersch-Supan and Ludwig (2010). This opposition between intensive and extensive margin adjustments implies that evaluating the overall employment effect of increasing the minimum eligibility retirement age is inherently an empirical question. Our objective in this paper has been to provide guidance on what outcomes could be expected given a country starting point. We show how the economy adjusts to changed retirement eligibility rules and what are the welfare implications of these adjustments, as decomposed to general and partial equilibrium effects.

If the economy has a defined benefit pension system, postponing retirement reduces fiscal imbalances. These processes were considered to be the main sources underlying the welfare effects of the postponement, making it a frequent policy recommendation for countries struggling with high pension system deficit. However, from the perspective of agents, postponing retirement eligibility basically reduces lifetime income from pensions and possibly also increases lifetime disutility from work. Welfare effects are then theoretically ambiguous. If the economy has a defined contribution pension system, postponing retirement age has no direct fiscal effect. Neither is pension income affected. Hence, recommendation to increase retirement age is more frequent in the case of countries with DB system. Moreover, welfare effects of such reform should be minor.

Our analysis in this paper reveals that these theoretical expectations are not the full picture. First, in addition to the fiscal/price effects, there are also partial equilibrium effects arising from more flexibility to set hours worked, consumption and savings. These partial equilibrium effects play a substantial role in the overall welfare effects. Second, adjustment in stock of labor triggers adjustment in capital price and stock, making general equilibrium effects relevant also in the case of DC system in spite of negligible fiscal effects. Third, the role of the partial equilibrium effects is paramount. This hints that in models with endogenous decision to retire, the individual adjustments may be insufficient relative to centralized equilibrium outcomes. This finding is new in the literature which typically assumes perfect foresight and full transmission from macro to micro. Given the failure of OLG models to explain prevalent early labor market exit, this direction of advancing the literature seems particularly promising.

An important policy implication from our study concerns the relationship between parametric and systemic pension reforms. Conventional wisdom considers parametric reforms of the pension systems – such as changing the retirement age or replacement/contribution rates – as policy options that are a substitute of a systemic pension reform – such as replacing defined benefits with defined contribution. 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 deteriorating dependency ratios. Our paper shows that a systemic pension reform does not reduce the welfare effects of postponing retirement – on the contrary, the two types of reforms complement each other to the extent to which increasing retirement age eases the transition from DB to DC.

Admittedly, adjustment in labor supply is considerable in our study. Although we increase pensionable age at par with projected longevity, so far little is known about the actual working potential beyond the currently observable empirical regularities. Although in a vast majority of countries individuals tend to retire as early as possible, usually well before *de iure* retirement age, a large body of literature has argued that this pattern stems from misaligned incentives in the labor market and pension system institutional design. In fact, there is little evidence so far that health in general is an important obstacle to remain active for longer number of years. Notwithstanding, once *de iure* retirement age is increased beyond 60+ on average, these empirical regularities may no longer hold. Thus, our results should be interpreted tentatively and not for the parameters they use for operationalization. In fact, our findings concerning welfare are conditional on actual ability to remain active by a representative, average household in an economy.

Our 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. 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 average professional activity will gradually increase due to the increasing labor market participation of women. That would be equivalent to changing the preference for leisure on the transition path. Analyzing the two processes in conjunction is likely to inform policy better. Finally, using an exogenous (and possibly binding) retirement age in an OLG model may be viewed as a shortcut. In our setting households may choose to retire prior to MERA, but not later. Hence, it seems valuable to exploit earlier findings concerning endogenous retirement age and combine this literature with the literature on parametric pension system reforms.

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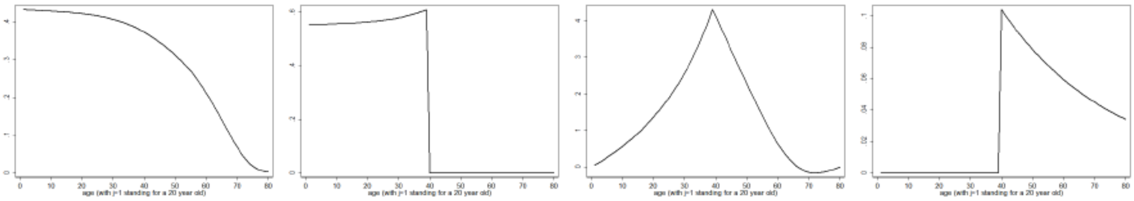
A Initial steady state

Figure A.1: Agents' behaviour over the life cycle (initial steady state, expressed in efficiency units)



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

B Final steady state

Figure B.2: Savings per efficiency units over the life cycle in the final steady state

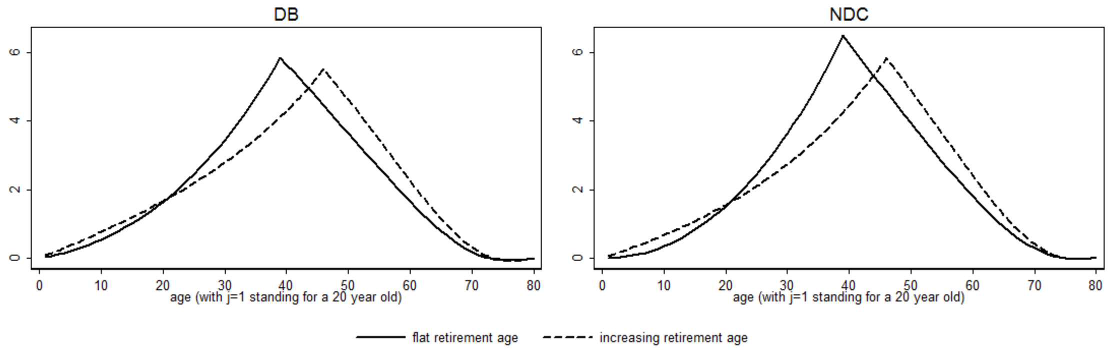
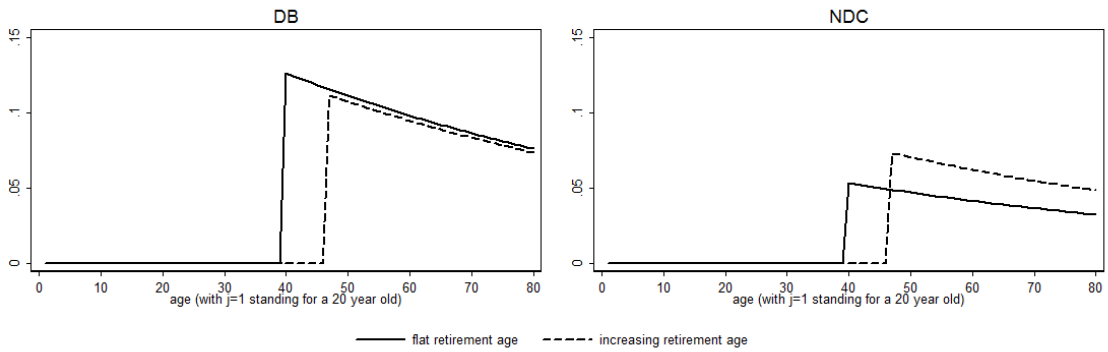


Figure B.3: Pensions per efficiency units over the life cycle in the final steady state



C Transition

Figure C.4: Discounted total pension payments per retiree (per efficiency units)

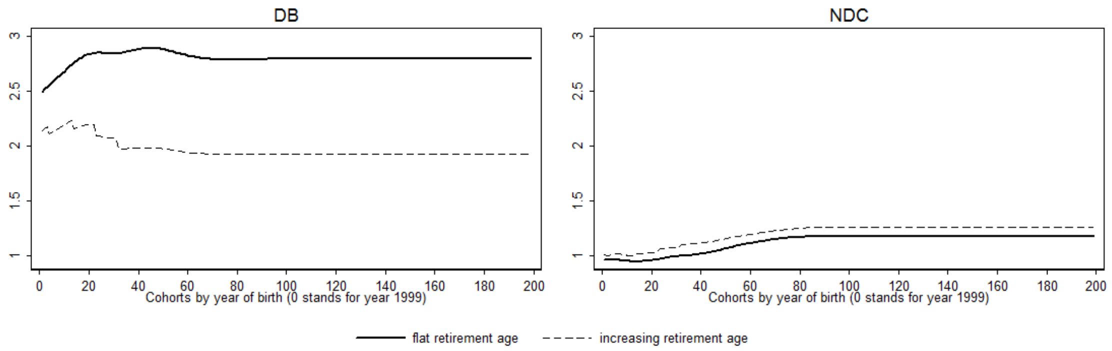


Figure C.5: Pension system deficit (as % of GDP)