A note on pension system reform and welfare *

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Abstract

Most reforms of the pension systems imply substantial adjustments in between cohort and within cohort redistribution. Fiscal policy, which accompanies these changes may counteract or reinforce the redistribution trends. In an OLG model with uncertainty we show that fiscal closure is crucial for welfare effects of the reform as well as political support for introducing it. We analyze two set of fiscal adjustments. Firstly, pension system was fiscally neutral (contribution rate, replacement rate or retirement age conform). In the second set pension deficit was covered completely by consumption (labour) tax or mix of public debt and taxes.

Key words: pension system reform, fiscal policy, welfare effects

JEL Codes: C68, D72, E62, H55, J26

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1 Introduction and motivation

Large body of literature analyzes the pension reforms in the overlapping generations framework, because with the longevity and deteriorating dependency ratios it is a crucial policy area in the coming decades (see the reviews by ??). While the profession has developed relatively coherent standards as to how this type of models should be built, there is much less consistency in the other aspects of the literature. To be specific, it seems a standard that pension systems are modeled with the use of overlapping generations general equilibrium models with *ex post* heterogeneity due to idiosyncratic income shocks. What is largely heterogeneous in the literature is the pension systems, their reforms as well as the accompanying fiscal closures. Our objective in this paper is to provide a systematic overview of the extent to which alternative assumption about the fiscal closure can determine the conclusions concerning the pension system and its reform.

Namely, the literature is frequently arguing that partially pre-funded defined contribution systems offer a welfare improvement relative to pay-as-you-go defined benefits systems in the context of longevity and decreasing fertility, although the extent of efficiency gain may depend on a number of factors including the extent of time inconsistency (???), market imperfections (??), etc. Changing from PAYG DB to partially funded DC typically changes the incentives for the labor supply and alters the proportions between the implicit and the explicit public debt (e.g. ?). However, the literature is far less consistent in whether the pension system is fiscally neutral and if not – what type fiscal adjustment they provision. For example, ? adjusts the contribution rates, whereas ???? interchangeably employ tax and contribution rate adjustments, just to mention a few. By contrast, ?? use a lump-sum tax. An adjustment most widely employed by the governments - raising public debt - has rarely been analyzed.

The size of necessary fiscal adjustment may indeed be large. Some papers argue a necessary increase in taxation of roughly 40% (?) to provide for pension system imbalance or a 40% reduction in replacement rates (?) to maintain fiscal neutrality of the pension system. Substantial increase in taxes has immediate welfare effects, in addition to the pension system reform (e.g. ??).

The paper is structured as follows. Theoretical model is presented in section 2, while section 3 describes calibration and simulation scenarios in detail. We present the results in section 4. The final sections conclude emphasizing the policy recommendations emerging from this study.

2 Theoretical model

We build a general equilibrium overlapping generations model with idiosyncratic income shocks and thus *ex post* within cohort heterogeneity. The economy is subjected to aging processes. In the baseline scenario an economy follows a pay-as-you-go (PAYG) defined benefit (DB) system. As population ages the pension system in the original steady state becomes unsustainable, necessitating a policy reform: either parameters of the pension system have to change or fiscal adjustment is needed. We compare the results from a number of possible scenarios. The first set of scenarios is fiscally neutral: we adjust replacement rate, contribution rate or retirement age for the pension system to remain balanced. The second set of scenarios leaves pension system intact, adjusting taxes and/or public debt in order to finance the net position of the pension system.

In the reform scenario, we gradually replace PAYG DB with a PAYG defined contribution (DC) pension system. The key feature of the DC pension system is that by construction aging implies no adjustments to the net position of the pension system, nor fiscally. In order to compare the effects of the pension system reform, we run for each possible fiscal closure a baseline scenario of no change in the pension system and a reform scenario. We compare the welfare of the baseline and the reform for all agents in the steady states and on the transition path.

Population dynamics. Agents live for $j = 1, 2..., J$ periods and are heterogeneous with respect to age j, one period corresponds to 4 years. Consumers are born at the age of 20, which we denote $j = 1$ to simplify the problem of labor market entry timing as well as educational choices. Consumers face age and time specific survival rates $\pi_{j,t}$, which is period t unconditional survival probability up to age j. At all points in time, consumers who survive until the age of $J = 20$ die with certitude. The share of population surviving until older age is increasing, to reflect changes in longevity. Decreasing fertility is operationalized by falling number of births. The data for mortality and births come from a demographic projection until 2060 and is subsequently treated as stationary until the final steady state.[1] In each period t agents at the age of $j = \bar{J}$ retire.

Agents have no bequest motive, but since survival rates $\pi_{j,t}$ are lower than one, in each period t certain fraction of cohort j leaves unintentional bequests, which are distributed within the cohort.

Endowments and intracohort heterogenity An agent starts life with assets $a_{1,t} = 0$. Total time endowment is normalized to one. Individuals differ with respect to labor productivity $\omega_{j,t}$, which depends on idiosyncratic shocks $\eta_{j,t}$. The idiosyncratic component is iid across individuals. It is specified as a first-order autoregressive process. We approximate this continuous process with a three-state, first-order discrete Markov process (**?**). Conditional distribution is given by $\Pi(\eta_{j,t}|\eta_{j-1,t-1})$. Individuals' labor productivity multiplier is then given by $\omega_{j,t} = e^{\eta_{j,t}}$

In the DC scheme during working period, agents accumulate pension funds in both pillars $f_{j,t} = (f^1_{j,t}, f^2_{j,t})$ which determine their pension benefits after retirement Therefore, agents' state is characterized by

$$\psi_{j,t} = (a_{j,t}, \eta_{j,t}, f_{j,t}) \in \Psi \tag{1}$$

Laws of motion for individual's state The budget constraint that agents face follows

$$a_{j+1,t+1} + (1 + \tau_{c,t})c_{j,t} + \tau_j + \Upsilon_t = (1 - \tau_{l,t})(1 - \tau_t)\omega_{j,t}w_{j,t}l_{j,t} + (1 + r_t(1 - \tau_{k,t}))\, a_{j,t} + \Gamma_{j,t} \tag{2}$$

when working, whereas for the retired population ($j \geq \bar{J}$) it takes the form of:

$$a_{j+1,t+1} + (1 + \tau_{c,t})c_{j,t} + \tau_j + \Upsilon_t = (1 + r_t(1 - \tau_{k,t}))a_{j,t} + b_{j,t} + \Gamma_{j,t}. \tag{3}$$

[1] Note, that this is a conservative assumption in a sense that PAYG DB systems are more fiscally viable if population stabilizes.

where $b_{\iota,j,t}$ is the pension benefit for person at age j in time t from system ι. Pension systems are indexed by ι, which corresponds to either Defined Contribution or Defined Benefit ($\iota \in \{DB, DC\}$). $\Gamma_{j,t}$ denotes bequests of agents the cohort j receives at time t from agents of the same cohort that died at the end of $t-1$.

Pension funds accumulation is given by

$$f^1_{j,t} = (1+r^I_t)f^1_{j-1,t-1} + \tau^1_{j,t}\omega_{j,t}w_{j,t}l_{j,t} \tag{4}$$
$$f^2_{j,t} = (1+r_t)f^2_{j-1,t-1} + \tau^2_{j,t}\omega_{j,t}w_{j,t}l_{j,t} \tag{5}$$

where r^I_t is the indexation rate in the PAYG DC pillar, equal to the payroll growth in the economy. Contributions to the funded pillar are invested with return of r_t.

Preferences At each point in time t an individual of age j consumes a non-negative quantity of a composite good $c_{j,t}$ and allocates $l_{j,t}$ time to work. Consumers can accumulate voluntary savings $s_{j,t} = a_{j+1,t+1}$ that earn the interest rate r_t. The consumer at age j and state ψ_j maximize expected value of lifetime utility. We can define individuals' optimization problem in recursive form as

$$V(\psi_{j,t}) = max\big[u(c_{j,t}, 1-l_{j,t}) + \delta\frac{\pi_{j+1,t+1}}{\pi_{j,t}}E\big(V(\psi_{j+1,t+1})\big)\big] \tag{6}$$

subject to (2) and (3). The instantaneous utility function is given by

$$u\left(c_{j,t}, l_{j,t}\right) = [c^{\phi}_{j,t}\left(1-l_{j,t}\right)^{1-\phi}] \tag{7}$$

Production. Individuals supply labor (time) to the firms. Using capital and labor the economy produces a composite consumption good a standard Cobb-Douglas production function with labor augmenting exogenous technological progress $Y_t = K^{\alpha}_t(z_tL_t)^{1-\alpha}$ where $z_{t+1}/z_t = \gamma_t$. Standard maximization problem of the firm yields the return on capital and real wage

$$r_t = \alpha K^{\alpha-1}_t(z_tL_t)^{1-\alpha} - d \quad \text{and} \quad w_t = (1-\alpha)K^{\alpha}_t z^{1-\alpha}_t L^{-\alpha}_t, \tag{8}$$

where d denotes the depreciation rate on capital.

Pension system The pre-reform (baseline) pension system is a PAYG DB system, with an exogenous contribution rate τ and an exogenous replacement rate ρ in terms of average wage in economy. Therefore pension system gives perfect insurance from idiosyncratic shock during working period. The system collects contributions from the working and pays benefits to the retired:

$$b_{\bar{J},t} = \rho \cdot w_{avg,t} \quad \text{and} \quad b_{j,t} = (1+r^I_t)b_{j-1,t-1} \tag{9}$$
$$\sum_{j=\bar{J}_t}^{J} N_{j,t}b_{j,t} = \tau_t w_t L_t + subsidy_t \tag{10}$$

where r_t^I is payroll growth rate and $subsidy_t$ is the net position of the pension system.

In reform scenario we denote by τ_1 the obligatory contribution that goes into the DC PAYG system and by τ_2 the mandatory contribution that goes into the funded system with $\tau = \tau_1 + \tau_2$, whereas b_1 and b_2 denote benefits from these two components of the pension system with $b = b_1 + b_2$. During working period agents accumulate pension funds. At retirement age, collected assets are divided by life expectancy. Hence, benefits age are computed according to the following formulas:

$$b_{1,\bar{J}_t,t} = \frac{f^1_{\bar{J}_t,t}}{\sum_{s=1}^{J-\bar{J}} \frac{\pi_{j+s,t+j}}{\pi_{j,t}}} \qquad \text{and} \qquad b_{2,\bar{J}_t,t} = \frac{f^2_{\bar{J}_t,t}}{\sum_{s=1}^{J-\bar{J}} \frac{\pi_{j+s,t+j}}{\pi_{j,t}}} \tag{11}$$

Afterwards pensions are indexed with the payroll growth in the first pillar, $b_{1,j,t} = (1+r_t^I)b_{1,j-1,t-1}$, and with the interest rate in the second pillar, $b_{2,j,t} = (1+r_t)b_{2,j-1,t-1}$.

The government First, social security contributions τ_t and subsequently labor income tax $\tau_{l,t}$ are deducted from gross income $\omega_{j,t} w_t l_{j,t}$ to yield disposable labor income. Interest earned on savings is taxed with $\tau_{k,t}$. In addition, there is a consumption tax $\tau_{c,t}$ as well as a lump sum tax/transfer Υ_t equal for all generations, which we use to set the budget deficit in concordance with the data. In addition to collecting taxes, the government spends on unproductive yet necessary consumption $G_t = \gamma \sum_{j=1}^J N_{j,t}$. Government expenditure is thus constant in per capita terms. Government balances the pension system. Given that the government is indebted, it naturally also services the outstanding debt.

$$T_t = \tau_{l,t}(1-\tau_t)w_t L_t + \tau_{c,t}C_t + \tau_{k,t}r_t S_{t-1} \tag{12}$$

$$G_t + subsidy_t + r_t D_{t-1} = T_t + (D_t - D_{t-1}) + \Upsilon_t \sum_{j=1}^{J} N_{j,t}. \tag{13}$$

We set initial steady state debt D_t at the initial data level, and final steady state at around 45% of GDP, which was the actual value of debt to GDP ratio in 1999. We calibrate Υ_t in the steady state to match the deficits and debt to maintain long run debt/GDP ratio fixed and keep it unchanged throughout the whole path.

Market clearing The goods market clearing condition is defined as $C_t + G_t + K_{t+1} = Y_t + (1-d)K_t$, where we denote the size of the generation born in period t as N_t. This equation is equivalent to stating that at each point in time the price for capital and labor would be set such that the demand for the goods from the consumers, the government and the producers would be met. This necessitates clearing in the labor and in the capital markets. Thus labor is supplied and capital accumulates according to: $L_t = \sum_{j=1}^J N_j \int_\Psi \omega_{j,t} l_{j,t} dX(\psi_{j,t})$ and $K_{t+1} = (1-d)K_t + \sum_{j=1}^J N_j \int_\Psi \hat{(s)}(\psi_{j,t}) dX(\psi_{j,t}) - D_t$ where $\hat{(s)}_{j,t}$ denotes private savings $s_{j,t}$ as well as accrued obligatory contributions in the fully funded pillar of the pension system

Measuring welfare gains Utility of $j-$aged agent in period t is defined as in equation (6). We denote allocation and welfare in the baseline scenario (no reform) with superscript B and in the reform scenario with superscript R. Then the consumption equivalent of the reform is computed according to the following formula

$$U_{1,t}(\tilde{c}_t^B, \tilde{l}_t^B) = U_{1,t}((1+\mu_t)\tilde{c}_t^R, \tilde{l}_t^R) \tag{14}$$

where $\tilde{c}_t = (c_{1,t}, c_{2,t+1}, ..., c_{J,t+J-1})$ and $\tilde{l}_t = (l_{j,1}, l_{j+1,2}, ..., l_{J,J-j+1})$. Negative value of μ_t informs 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 have to be compensated for the lack of the reform (in percent of permanent post reform consumption). For the agent $j-$aged alive in reform date $t = 1$ we compute it analogously

$$U_{j,1}(\tilde{c}_{j,1}^B, \tilde{l}_{j,1}^B) = U_{j,1}((1+\mu_{1,j})\tilde{c}_{j,1}^R, \tilde{l}_{j,1}^R) \tag{15}$$

where $\tilde{c}_{j,1} = E(c_{j,1}, c_{j+1,2}, ..., c_{J,J-j+1})$ and $\tilde{l}_t = E(l_{1,t}, l_{2,t+1}, ..., l_{J,t+J-1})$. On the average an agent would be willing to pay a lump-sum tax $\tau_{t,j} = \mu_{t-j+1}c_{j,t}$ to make sure that the reform is implemented (pays a negative tax, i.e. receives a compensation in case of welfare loss). We sum those taxes from all cohorts and all periods (positive for agents that gain and negative for those who lose) and discount it to period 1 with the interest rate. If the tax collection by the government is positive it means that overall welfare effect of the reform is positive. Next, in order to express this overall welfare gain in percent of consumption of each agent we redistribute back this tax revenue to all agents in equal proportion to their consumption.

Fiscal closure - fiscally neutral scenarios The first set of fiscal closures is fiscally neutral. We change the pension system parameter to remain it balanced. It is equivalent to keep $subsidy_t = 0$ for each t. Initially the benefits level is adjusted by introducing pension multiplier m_t such that

$$\sum_{j=\bar{J}_t}^{J} N_{j,t} m_t b_{j,t} = \tau_t w_t L_t \tag{16}$$

Alternatively contribution rate is changed in a manner that

$$\tau_t = \frac{\sum_{j=\bar{J}_t}^{J} N_{j,t} b_{j,t}}{w_t L_t} \tag{17}$$

Furthermore, retirement age may by set to minimalize $subsidy_t \geq 0$. Then τ_t is used as residual.

Fiscal closure - contemporaneous tax scenarios First we use pure $\tau_{c,t}$ or $\tau_{l,t}$ closure. Taxes adjust immediately in each period to close government budget constrain and cover pension system imbalance. It implies

$$\tau_{c,t} = \frac{G_t + subsidy_t + (1+r_t)D_{t-1} - D_t - \Upsilon_t \sum_{j=1}^{J} N_{j,t} - \tau_{l,t}(1-\tau_t)w_t L_t - \tau_{k,t} r_t S_{t-1}}{C_t} \tag{18}$$

$$\tau_{l,t} = \frac{G_t + subsidy_t + (1+r_t)D_{t-1} - D_t - \Upsilon_t \sum_{j=1}^{J} N_{j,t} - \tau_{c,t} C_t - \tau_{k,t} r_t S_{t-1}}{(1-\tau_t) w_t L_t} \tag{19}$$

Fiscal closure - public debt scenarios Contemporaneous taxation focuses the burden of the reform in few cohorts. We hence develop scenarios which spread the cost of the reform on a larger number of cohorts, reducing the burden to each cohort *via* public debt. We assume following fiscal rule:

$$\tau_{c,t} = (1-\varrho)\tau_c^{final} + \varrho\tau_{c,t-1} + \varrho_D(D/Y)_t - (D/Y)^{final}) \tag{20}$$

$$\tau_{l,t} = (1-\varrho)\tau_l^{final} + \varrho\tau_{l,t-1} + \varrho_D(D/Y)_t - (D/Y)^{final}) \tag{21}$$

where ϱ measures the autoregression of the tax rate, and ϱ_D the strength of reaction to deviation of government debt from its steady state values. The values of τ_c^{final}, τ_l^{final} and $(D/Y)^{final}$ denote in the new steady state values of consumption tax, labor tax and debt share in GDP, respectively.

2.1 Consumer problem and model solving

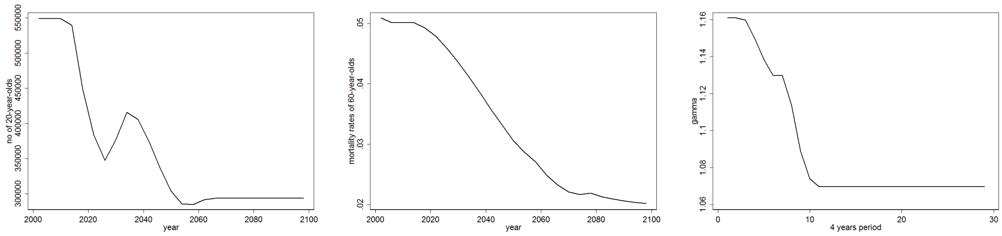
To solve the consumer problem, we discretized the continuous state space Ψ. Wherefore we choose $\hat{A} = \{a^1, ..., a^{n_A}\}$, $\hat{F} = \{f^1, ..., a^{n_F}\}$ and $\hat{H} = \{\eta^1, ..., \eta^{n_H}\}$. Next for all discrete $\psi_{j,t}$ we find the agent optimal consumption and labor supply according to the following rules.

- For $j = J$ agents consume all available resources and are not allowed to work. Probability of survival to next period is equal zero. We calculate $V(\psi_{J,t})$ according to equation (6).
- For other j we find solution recursively using Powell's algorithm. It exacts continuous function, hence we interpolate $V(\psi_{j+1,t+1})$.

We solve the model by finding the transition path between the initial and the final steady states. First, we establish the initial and final steady states. We set the length of the path in order to assure that the new steady state is reached, i.e. last generation analyzed lives the whole life in the new demographic steady state. We use Gauss-Seidel algorithm. First, we guess the path (or the single value of capital per worker in the steady states). Then we compute w and r. 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 $b_{1,j}$ and $b_{2,j}$. Using algorithm the consumer problem is solved. Finally, k is updated in order to satisfy market clearing. This procedure is repeated until the difference between k from subsequent iterations is negligible. In each iteration, error is computed as the l_1-norm of the difference between capital vector in subsequent iterations. Once the the equilibrium is reached, utilities are computed and discounted to reflect utility of the first generation in our model, i.e. 20-year olds.

The model is solved two times. First, the benchmark scenario is computed for no policy change, but with changes in demographics and in productivity (see section 3). Second time the model is solved for the analyzed policy change scenario. In both these runs utility for all generations is computed. Finally, we convert the net welfare for each cohort into a consumption equivalent, discounted to $j = 1$.

Figure 1: No of 20-year-olds arriving in the model in each period, (4 years) mortality rates across time for a selected cohort and (4 years) labour augmenting productivity growth rate .



(a) number of 20-year-olds (b) mortality rates (c) γ_t

3 Calibration and baseline

The model is calibrated to match features of Polish economy where the social security system was changed from a PAYG DB to a partially funded DC system. The model period coresponds to four years. Using microeconomic evidence and the general characteristics of the Polish economy we established reference values for preferences, life-cycle productivity patterns, taxes, technology growth rates, etc. Given these, the discount factor δ was set to match initial steady state interest rate close to 7.4%. To give this number the context, **?** calibrate interest rate to 6.25% for the US economy. It is thus reasonable to consider a slightly higher value for a catching up country, scarce in capital. Depreciation rate d so that the aggregate investment rate matched the one observed in the data, i.e. app. 21%

Demographics. Demography is based on the EUROSTAT's projection for the next 50 years. As input data we use the number of 20-year-olds born at each period in time and mortality rates. After periods covered by projection we asuume constant demographic, see Figure 1.

Productivity growth (γ_t). The model specifies labor augmenting growth of technological progress $\gamma_{t+1} = z_{t+1}/z_t$. The values for 50 years ahead projection were taken from the forecast by the Aging Work Group of the European Commission, which comprises of such time series for all EU Member States and recalculated for four years period, see Figure 1. This forecast is besed on assumption that countries with lower *per capita* income will continue to catch up but around 2030 all countries exogenous productivity growth will be converging slowly towards the steady state value of 1.7% *per annum*.

Productivity idiosyncratic shock (η). The idiosyncratic component is specified as a first-order autoregressive process with autoregression $\varrho_\eta = 0.783$ and variance $\sigma_\eta = 0.074$ which are values for middle skilled workers estimated in **?**.

Preferences. Agents' preference for leisure/consumption $\phi = 0.491$ was chosen to replicate the labor market participation rate of 56.8% (pre-reform value). The discount factor $\delta = 931$

value was chosen to match the interest rate of 7.8%.

Pension system parameters We set replacement rate $\rho = 0.229$ to match the 5% ratio of pensions to GDP in 1999. The effective rate of contribution $\tau = 6.0\%$ was set such that the pension system deficit in % of GDP in the original DB steady state matches the one observed in the data, i.e. 0.8%. In 1999 *de iure* retirement age was 60 for women and 65 for men. However, due to numerous exceptions, the effective exit age was much lower. These exclusions from the general rule were mostly removed as of 2009, and at the same time the legal retirement age was gradually increased and is supposed to reach 67 for men in 2018 and for women in 2040. Nonetheless, in 2016 increasing retirement age was reversed. Thus, we keep $\bar{j}_t = const = 10$ responding to age 60.

Taxes. The capital income tax τ_k was set to 19%, which is equal to d*e iure* tax rate. The marginal tax retes on labour and consumption were set to 11%. It matches the rate of labor income tax revenues in the aggregate employment fund and the rate of revenues from consumption tax in aggregate consumption in 1999.

Table 1: Calibrated parameters

Parameters		Calibration
ϕ	preference for leisure	0.491
δ	discounting rate	0.913
ϱ_η	idiosyncratic shock persistence	0.783
σ_η	idiosyncratic shock variance	0.074
ϱ	tax rate persistence	0.550
ϱ_D	strenght of debt tax link	0.300
d	depreciation rate	0.100
τ_l	labor tax	0.110
τ_c	consumption tax	0.110
τ_k	capital tax	0.190
τ	social security contributions.	0.060
ρ	replacement rate	0.229
		coutcome values
$\Delta k_{t+1}/y_t$	investment rate	21.1
r	interest rate	7.8

Savings and wealth. The pension reform implied some transition cohorts - with working period in old pension system and future benefits calculated base on DC formula. For those cohorts we calculated so-called initial capital. It corresponds to a theoretical value base on agents gross labour income and the contribution rate τ_1.

$$InitCap_j = \sum_{\tilde{j}=1}^{j_{dc}-1} \tau_1 w_1 l_{\tilde{j},1} \tag{22}$$

where $j_{DC} = 6$ stand for maximum age of agents assign to DC sheme at reform period.

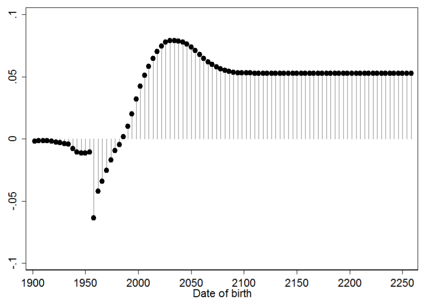
4 Results

Below we present the welfare effects of fiscal closures and then move on to the macroeconomic effects of the pension system reform under various fiscal closures.

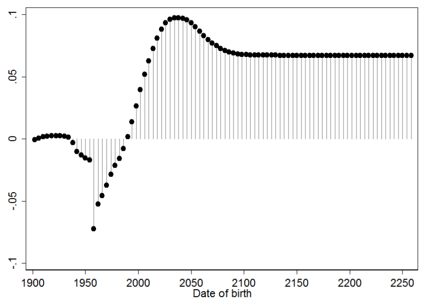
Table 2: Welfare effects and political support for all analyzed fiscal closures

Fiscal closure	τ_c	τ_l	frule τ_c	frule τ_l	τ_ι	m_t	$\bar{j}$
unif	0.12%	-0.15%	0.07%	-0.01%	t.b.c.	t.b.c.	t.b.c.
support	0%	32%	66%	65%	t.b.c.	t.b.c.	t.b.c.

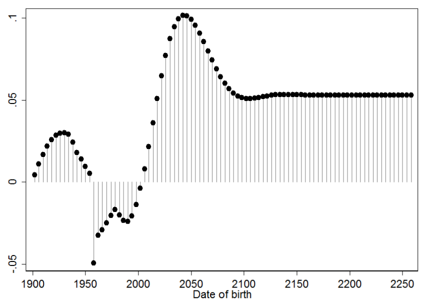
Figure 2: Consumption equivalent for all analyzed fiscal closures



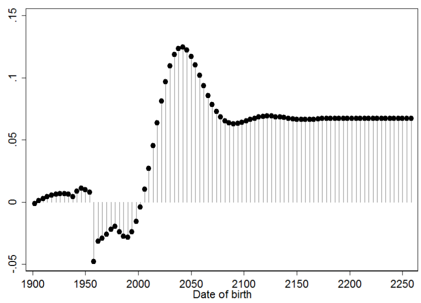
(a) τ_c



(b) τ_l

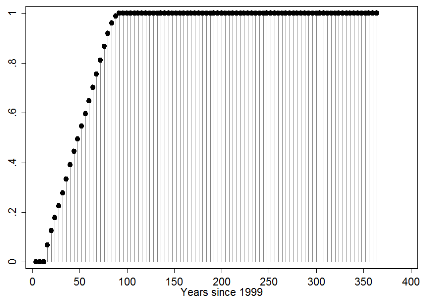


(c) frule τ_c

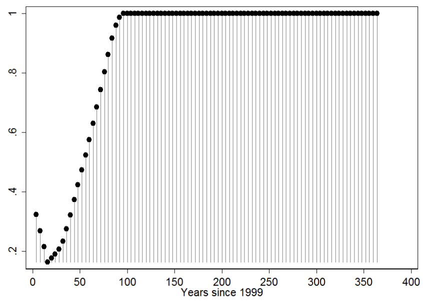


(d) frule τ_c

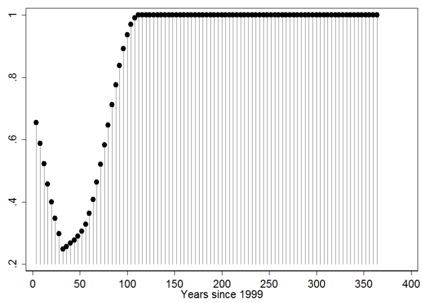
Figure 3: Share of living population gaining from the reform, weighted by cohort size for all fiscal closure



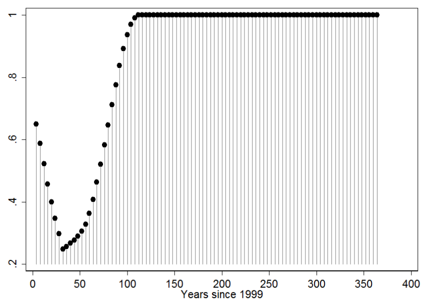
(a) τ_c



(b) τ_l



(c) frule τ_c



(d) frule τ_c

References

Auerbach, Alan and Lawrence J. Kotlikoff, *Dynamic Fiscal Policy*, Cambridge University Press, 1987.

Blake, David, "Does it matter what type of pension scheme you have?," *The Economic Journal*, 2000, *110* (461), 46–81.

Deaton, Angus, *The analysis of household surveys: a microeconometric approach to development policy*, Johns Hopkins University Press, 1997.

Fehr, Hans, "Computable stochastic equilibrium models and their use in pension-and ageing research," *De Economist*, 2009, *157* (4), 359–416.

_ **and Fabian Kindermann**, "Pension funding and individual accounts in economies with life-cyclers and myopes," *CESifo Economic Studies*, 2010, *56* (3), 404–443.

_ **, Christian Habermann, and Fabian Kindermann**, "Social security with rational and hyperbolic consumers," *Review of Economic Dynamics*, 2008, *11* (4), 884–903.

_ **, Manuel Kallweit, and Fabian Kindermann**, "Should pensions be progressive?," *European Economic Review*, 2013, *63*, 94 – 116.

Huggett, Mark and Gustavo Ventura, "On the Distributional Effects of Social Security Reform," *Review of Economic Dynamics*, 1999, *2* (3), 498–531.

Imrohoroglu, Ayse, Selahattin Imrohoroglu, and Douglas H. Joines, "Time-Inconsistent Preferences and Social Security," *The Quarterly Journal of Economics*, 2003, *118* (2), 745–784.

Keuschnigg, Christian, Thomas Davoine, and Philip Schuster, "Aging and pension reform, a general equilibrium approach," Background paper for the ECA Old-Age Insurance report - Final report, European Comission 2012.

Kotlikoff, Laurence J, Kent Smetters, and Jan Walliser, "Privatizing Social Security in the U.S. – Comparing the Options," *Review of Economic Dynamics*, 1999, *2* (3), 532–574.

la Croix, David De, Olivier Pierrard, and Henri R Sneessens, "Aging and pensions in general equilibrium: Labor market imperfections matter," *Journal of Economic Dynamics and Control*, 2012, *37* (1), 104–124.

Lindbeck, Assar and Mats Persson, "The gains from pension reform," *Journal of Economic Literature*, 2003, *41* (1), 74–112.

Ludwig, Alexander and Edgar Vogel, "Mortality, Fertility, Education and Capital Accumulation in a Simple OLG Economy," MEA discussion paper series, Mannheim Research Institute for the Economics of Aging (MEA), University of Mannheim 2009.

Nishiyama, Shinichi and Kent Smetters, "Does Social Security Privatization Produce Efficiency Gains?," *The Quarterly Journal of Economics*, 2007, *122*, 1677–1719.

Okamoto, Akira, "Simulating progressive expenditure taxation in an aging Japan," *Journal of Policy Modeling*, 2005, *27* (3), 309–325.

Tauchen, George, "Finite state markov-chain approximations to univariate and vector autoregressions," *Economics letters*, 1986, *20* (2), 177–181.

Yared, Pierre, "Politicians, taxes and debt," *The Review of Economic Studies*, 2010, *77* (2), 806–840.