Analyzing the efficiency of the pension reform: the role for the welfare effects of fiscal closures *

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Running head: Fiscal Closures and Welfare of Pension Reform

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Abstract

Replacing the pay-as-you-go defined benefit (PAYG DB) system with at least partially funded defined contribution (DC) system generates a fiscal costs which need financing. The fiscal closures at hand differ by the channel and the extent of distortions. The main contribution of this paper is a thorough comparison of the welfare effect of the various fiscal closures to the pension system reform. In addition, we decompose the welfare effects to the part attributable to changing the way pensions are financed (PAYG ⇒ pre-funding) and to changing the way pensions are computed (DB ⇒ DC). We show that depending on the fiscal closure the welfare effects differ substantially for the same pension system reform. The financing of the the pension system gap with public debt allows more intergenerational redistribution.

Key words: PAYG, pension system reform, time inconsistency, welfare

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

1 Introduction and motivation

With progressing longevity and lowering fertility rates, maintaining pay-as-you-go defined benefit (PAYG DB) schemes in their current form becomes fiscally (and socially) inviable in many economies. The majority of numerical exercises demonstrate that fiscal balance requires a substantial decrease in retirement benefits or equally substantial increase in contribution rates.[1] The alternative consists of a systemic reform by imposing the so-called (partially) pre-funded defined contribution (DC) schemes that translate longevity to an automatic reduction in the effective replacement rates. This path was followed by some of the Central and Eastern European countries as well as Sweden, among others. Such reform is often referred to as privatization of the pension systems, see Diamond (1993).

A large part of the literature finds that a privatization of the social security is efficient, although the extent of efficiency gain may depend on a number of factors including the extent of time inconsistency (Imrohoroglu et al. 2003, Fehr et al. 2008, Fehr and Kindermann 2010), market imperfections (Nishiyama and Smetters 2007, De la Croix et al. 2012), etc.[2] Such reform implies two main sources of fiscal adjustments. First, a reform changes (future) pension payouts, by changing the effective replacement rates. This directly affects the situation of the (future) retirees, but also indirectly the situation of those who contribute to the pension system in the future, which may not be the same cohorts. Second, a shift of contributions from a pay-as-you go (PAYG) to a (at least partially) funded system leaves a fiscal gap. Pensions of the cohorts whose contributions were sent to PAYG DB, but retire after DC is introduced - generate a public expenditure that requires financing. Direct taxation of labor or consumption in this context may be substituted by allowing the public debt to accumulate, thus yielding future taxation (on labor or consumption). If taxes are distortionary, spreading the costs of reform over many generations may actually induce lower welfare loss than concentrating the distortion among only few working cohorts.[3] On the other hand, any debt needs to be serviced, ushering the financial costs of the reform. Which of the two is a dominant factor remains an open question.

If the choice of the fiscal closure affects the welfare outcome of the reform, the assumption about the fiscal closure may have an important bearing on the judgment if a reform is welfare enhancing. The multiplicity of solutions raises a methodological question about the efficiency of the reform. In fact, it follows that under one fiscal closure pension system reforms may actually be Pareto-improving, whereas under another it would no longer the case. Interestingly enough, the impact of fiscal closures in the literature is usually left out of analysis. On the other hand, the literature is quite inconsistent about the type of fiscal closure used. Nishiyama and Smetters (2007), Okamoto (2005b) use a lump-sum tax, Auerbach and Kotlikoff (1987) adjusts the contribution rates, whereas Fehr et al. (2008), Keuschnigg et al. (2012), Fehr and Kindermann (2010), Ludwig and Vogel (2009) interchangeably employ tax and contribution rate adjustments, just to mention a few. Oddly enough, a solution most widely employed by the governments - raising public debt - has rarely been analyzed.[4] As noted already by Kotlikoff et al. (1999), fiscal closures have welfare effects on their own, i.e. consequences in addition to direct ones driven by changes in pension systems. Yet, despite the paramount policy relevance, the role of the fiscal closures – to the best of our knowledge – has not been analyzed previously in the literature.[5] Thus, we contribute to the literature by quantifying and comparing the macroeconomic and welfare effects of a single pension reform under various fiscal closures. We put these indirect welfare costs in a perspective of total effects of a pension reform.

We rely on an overlapping generations model in the spirit of the seminal contribution by Auerbach and Kotlikoff (1987). The originally fairly constrained model has subsequently been extended in a number of relevant directions.[6] Modern models are equipped with a demographic transition, as deteriorating demographics has been demonstrated to be the driving factor for the changes in the fiscal stance, see De Nardi et al. (1999), Fehr (2000).[7] In addition to demographics, modern models also conceptualize the welfare effects of the reform in addition to the changes in macroeconomic aggregates. The analysis comprises change in utility observed across cohorts along the entire transition path, as pioneered by Breyer (1989) and Feldstein (1995).

We construct an experiment in which welfare effects of a pension system reform are computed for a variety of fiscal closures: (i) lump sum contemporaneous taxation; (ii) labor and consumption (contemporaneous) taxation; and (iii) public debt complemented (if needed) by contemporaneous taxation. To avoid the criticism raised by Holzman and Stiglitz (2001), our results report measures of welfare for living and future cohorts. To compare the overall aggregates for various fiscal closures we utilize a mechanism of the lump sum redistribution authority (LSRA) following Nishiyama and Smetters (2007).[8] Another important advantage of the model is the explicit treatment of the demographic issues: both fertility and mortality rates are dynamic in our model, following the official demographic projection.

In designing and calibrating the model we follow closely the features of a reform as it was implemented by one of the countries which actually undertook the pension system reform from a PAYG DB system to a partially pre-funded DC system – Poland. Thanks to this choice we avoid the risk of the hypothetical design of the reform, as has been customary in the literature. Yet, Poland is a catching up and quickly aging economy, which may limit the general character of our findings. Thus, we complement the scenario which follows the data driven projections with a scenario with a lower technological progress already in the initial steady state and a more favorable demography. This way, although the reform is actual, the economy is more similar to the frequently analyzed cases of advanced economies.[9]

The pension reform in Poland was implemented in 1999. The original system was a DB PAYG scheme. The reform kept the contribution rates constant, but substantially changed the way the pensions were computed. Both of the new compulsory pillars were constructed as defined contribution schemes. After the reform, the first pillar is still a PAYG but the contributions are recorded in the individual accounts in the Social Insurance Fund (SIF) and will serve as a basis for computing an annuity upon retirement – a system referred to as a notionally defined contribution (NDC). The contributions in that pillar are indexed annually according to the payroll growth. The second pillar is a fully funded DC scheme, where Open Pension Funds (OPFs) invest contributions in the name of participants in financial market with returns exempt from the capital income tax. Nor the contributions neither the interest on savings can be claimed prior to the retirement. Both pillars are mandatory.[10] Such a reform creates an inevitable fiscal gap in the first pillar, i.e. SIF. Polish constitution imposes a debt ceiling of 60% debt-to-GDP ratio. If this ceiling is exceeded, the government is obliged to run a balanced budget and reduce debt. At the moment of the reform, the debt share in GDP was equal 45% of GDP, whereas the contemporaneous annual SIF 0.8% of GDP.

Given this design of the reform, our model needs to replicate the PAYG DB initial steady state and the baseline path with this pension system as well as a second path with an unexpected change to a NDC complemented with a funded DC in period 2 of the reform scenario. We replicate the size of the pension system and the split between NDC and funded DC component and obey the debt limit imposed by the constitution in our fiscal adjustment.

Our contribution to the literature is twofold. First, we explicitly differentiate between fiscal closures to compare welfare effects of the pension reform. Indeed, the fiscal closure can matter by as much as 20-30% of the overall welfare effect (expressed in terms of an average over the analyzed fiscal closures). Secondly, we decompose the welfare effects of the pension system reform into a component attributable to the change from DB to DC and a part attributable to the establishment of the pre-funded pillar.

We find that the majority of the welfare effects come from a $DB \rightarrow DC$ change and the subsequent decrease in pensions. Our economy at the moment of the reform still had fairly favorable demographics and relatively high productivity growth. They both deteriorate over time, which makes the baseline scenario of no policy change interesting *per se*. To test how robust our results are, we complement this scenario of productivity and demographics with a one where productivity growth is slower and demographics more favorable to the PAYG DB system. As an additional robustness check, we test if the conclusions are susceptible to the time-inconsistency in the preferences. The results prove robust to these modifications.

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 and various sensitivity checks in section 4. The final sections conclude emphasizing the policy recommendations emerging from this study.

2 Theoretical model

We use a general equilibrium overlapping generations model in the spirit of Huang et al. (1997), cast in a framework of exogenous but time varying growth. Bouzahzah et al. (2002) as well as Zhang and Zhang (2009) discuss the sensitivity of OLG models to the assumptions concerning growth in the light of policy reforms and show that when analyzing pension systems, there is little or no effect of endogenizing productivity growth.

Population dynamics. Agents live for $j = 1, 2..., J$ periods and are heterogeneous with respect to age j, but homogeneous within each cohort. 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 $J = 80$ 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.[11] In each period t agents at the age of $j = \bar{J}_t$ are forced to retire.[12]

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.

Preferences and endowments. At each point in time t an individual of age j born at time $t-j$ consumes a non-negative quantity of a composite good $c_{j,t}$ and allocates $l_{j,t}$ time to work (total time endowment is normalized to one). Consumers can accumulate voluntary savings $s_{j,t}$ that earn the interest rate r_t. Consumers lifetime utility is as follows:

$$U_j(c_{j,t}, l_{j,t}) = u_j(c_{j,t}, 1 - l_{j,t}) + \beta \sum_{s=1}^{J-j} \delta^s \frac{\pi_{j+s,t+s}}{\pi_{j,t}} u_j\left(c_{j+s,t+s}, 1 - l_{j+s,t+s}\right) \tag{1}$$

where β denotes time inconsistency in the form of quasi-hyperbolic discounting[13], whereas discounting takes into account time preference δ and probability of survival. There is no risk in the model.[14]. The instantaneous utility function is given by $u_j\left(c_{j,t}, l_{j,t}\right) = c_{j,t}^{\phi}\left(1 - l_{j,t}\right)^{1-\phi}$ and we assume $l_{j,t} = 0$ for $j \geq \bar{J}_t$. In this specification ϕ determines steady state labor supply. Agent of age j in period t maximizes her utility function $u_j(c_{j,t}, l_{j,t})$ subject to the sequence of budget constraints (see Appendix A).

Agents in the transition period are endowed with the so-called initial capital, see section 3.

Production. Individuals supply labor (time) to the firms, and their productivity varies with age. The amount of effective labor of age j used at time t by a production firm is $L_t = \sum_{j=0}^{\bar{J}_t} \omega_j l_{j,t}$, where ω_j is the age-specific productivity.[15] Using capital and labor the producers provide a composite consumption good with the Cobb-Douglas production function $Y_t = K_t^{\alpha}(z_t L_t)^{1-\alpha}$ that features labor augmenting exogenous technological progress denoted as $\gamma_t = z_{t+1}/z_t$. Standard maximization problem of the firm yields the return on capital $r_t^k = \alpha K_t^{\alpha-1}(z_t L_t)^{1-\alpha} - d$ and real wage $w_t = (1-\alpha)K_t^{\alpha} z_t^{1-\alpha} L_t^{-\alpha}$, where d denotes the depreciation rate on capital.

Interest rate. The interest rate r our economy is a net rate of return from investing in a composite asset, which consists of government bonds and a capital asset. The return on the capital asset is given by FOC. We assume that the interest rate on government bonds is lower than on capital assets, $r^G = \xi r^k$ with $\xi < 1$, otherwise the government would be forced to finance debt at a prohibitively high cost. Households purchase a portfolio consisting of capital assets and government bonds, where the share of the latter is determined by the volume of government debt, $r = \mu r^k + (1-\mu) r^G$, where the μ is implied by the share of public debt in the savings portfolio. In the world with no risk and no risk preference – as is the case in our setting – households would invest in asset offering a higher return, thus setting μ

at unity. In order to avoid it we assume that households choose the volume of savings at the composite rate r rather than the composition of portfolio. The share of government expenditure in savings is determined exogenously by the supply of government bonds.

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 with $b_{\bar{J},t} = \rho \cdot w_t \cdot \omega_{\bar{J}} \cdot l_{\bar{J}}$ holding $\forall t$.[16] The benefits are indexed annually with 25% of the payroll growth rate denoted by r^I, $b_{j,t} = (1 + .25r_t^I)b_{j-1,t-1}$. The system collects contributions from the working and pays benefits to the retired:

$$\sum_{j=\bar{J}_t}^{J} \pi_{j,t} N_{t-j} b_{1,j,t} = \tau_{1,t} \sum_{j=1}^{\bar{J}_t - 1} w_{j,t} \pi_{j,t} N_{t-j} l_{j,t} + subsidy_t \tag{2}$$

where $subsidy_t$ is a subsidy/transfer from the government to balance the pension system and $w_{j,t} = \omega_j w_t$.

The post-reform pension system is a DC with two pillars: PAYG NDC and a funded DC. The DC funded pillar of the pension system collects contributions as individual stock of (mandatory) pension savings and at retirement converts them to annuity. The NDC pillar of the system collects the contributions and uses them to cover for contemporaneous benefits, but pays out an pensions computed on the basis of accumulated contributions, as given by eq. (3). For simplicity 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 $b = b_1 + b_2$. Under defined contribution pension system benefits in both pillars at the retirement age are computed according to the following formulas:

$$\begin{aligned} b_{1,\bar{J}_t,t} &= \frac{\sum_{s=1}^{\bar{J}_t-1} \left[\Pi_{\iota=1}^{s} (1 + r_{t-j+\iota-1}^I) \right] \tau_{t-j+s-1} w_{s,t-j+s-1} l_{s,t-j+s-1}}{\prod_{s=\bar{J}}^{J} \pi_{s,t}} \\ b_{2,\bar{J}_t,t} &= \frac{\sum_{s=1}^{\bar{J}_t-1} \left[\Pi_{\iota=1}^{s} (1 + r_{t-j+\iota-1}^{II}) \right] \tau_{2,t-j+s-1} w_{s,t-j+s-1} l_{s,t-j+s-1}}{\prod_{s=\bar{J}}^{J} \pi_{s,t}} \end{aligned} \tag{3}$$

where $r_t^{II} = r_t$. Afterwards pensions are indexed with 25% of the payroll growth in the first pillar, $b_{1,j,t} = (1 + .25r_t^I)b_{1,j-1,t-1}$, and with the interest rate in the second pillar, $b_{2,j,t} = (1 + r_t)b_{2,j-1,t-1}$. Agents see no direct link between contributions and pensions - in the utility function the derivative of pension benefits wrt. to labor supply is zero in both pension systems.

The government. Labor income tax $\tau_{l,t}$ and social security contributions $\tau_{\iota,t}$ are deducted from gross income $\omega_j w_t l_{j,t}$ to yield disposable labor income. Interest earned on savings r_t are 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. The government collects taxes and spends a fixed share of GDP on unproductive yet necessary consumption $G_t = \gamma * Y_t$. Government balances the pension system. Given that the government is indebted, it naturally also services the outstanding debt.

$$T_t \quad = \quad \tau_{l,t}\big(w_t L_t + \sum_{j=\bar{J}_t}^{J} b_{j,t}\pi_{j,t}N_{t-j}\big) + \big(\tau_{c,t}c_t + \tau_{k,t}r_t s_{j,t-1}\big)\sum_{j=1}^{J}\pi_{j,t}N_{t-j} \tag{4}$$

$$G_t \quad + \quad subsidy_t + r_t^G D_{t-1} = T_t + (D_t - D_{t-1}) + \Upsilon_t \sum_{j=1}^{J}\pi_{j,t}N_{t-j}. \tag{5}$$

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. The overall debt to GDP ratio is not allowed to exceed 60% in the model, which is the constitutional limit in Poland. Once this threshold is hit, labor or consumption tax immediately adjust (depending on the selected closure, see below for details).

Measuring welfare gains. Utility of $j-$aged agent in period t is defined as in eq. (10) in the Appendix A. 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

$$U_{1,t}(\tilde{c}_t^B, \tilde{l}_t^B) = U_{1,t}((1+\mu_t)\tilde{c}_t^R, \tilde{l}_t^R) \tag{6}$$

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 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 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

$$U_{j,1}(\tilde{c}_{j,1}^B, \tilde{l}_{j,1}^B) = U_{j,1}((1+\mu_{1,j})\tilde{c}_{j,1}^R, \tilde{l}_{j,1}^R) \tag{7}$$

where $\tilde{c}_{j,1} = (c_{j,1}, c_{j+1,2}, ..., c_{J,J-j+1})$ and $\tilde{l}_t = (l_{1,t}, l_{2,t+1}, ..., l_{J,t+J-1})$.

In order to find the overall effect of the reform we introduce the Lump Sump Redistribution Authority. An agent born in period $t > 1$ pays (if she loses due to reform she pays negative tax) in each period lump-sum tax equal to $\tau_{t,j} = \mu_{t-j+1}c_{j,t}$ and for agents alive in the reform date $\tau_{t,j} = \mu_{1,t-j+1}c_{j,t}$, for

$j \geq t$. Next 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 government 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.

Market clearing. The goods market clearing condition is defined as $\sum_{j=1}^{J} \pi_{j,t} N_{t-j} c_{j,t} + G_t + K_{t+1} = Y_t + (1-d)K_t$, 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: $L_t = \sum_{j=1}^{\bar{J}-1} \pi_{j,t} N_{t-j} \omega_{j,t} l_{j,t}$ and $K_{t+1} = (1-d)K_t + \sum_{j=1}^{J} \pi_{j,t} N_{t-j} \hat{s}_{j,t}$ 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.

Definition 2.1 (Equilibrium) *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* $\{w_t, r_t, r_t^k, r_t^G\}_{t=0}^{\infty}$ *such that:*

- *for all* $t \geq 0$*, for all* $j \in [1, J]$ $((c_{j,t}, ..., c_{J,t+J-j}), (s_{j,t}, ..., s_{J,t+J-j}), (l_{1,t}, ..., l_{J,t+J-j})$ *solves the problem of an agent* j *in period* t*, given prices;*
- *prices are given by;*

$$r_t^k = \alpha K_t^{\alpha-1} (z_t L_t)^{1-\alpha} - d; \qquad w_t = (1-\alpha) K_t^{\alpha} z_t^{1-\alpha} L_t{}^{-\alpha} \tag{8}$$

$$r_t = \mu_t r_t^k + (1-\mu_t) r_t^G; \qquad r_t^G = \xi r_t^k \tag{9}$$

- *government sector is balanced, i.e.* (2), (4) - (5) *are satisfied;*
- *markets clear.*

Model solving. 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 $b_{2,j}$. Following the assumption about consumers perfect foresight, choice variables c_j, s_j and l_j are computed. Finally, k is updated in order to satisfy market clearing. This procedure is repeated until the difference between k from subsequent iterations is negligible[17]. 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, while doing that we use utility at $j = 1$. Since in our model some cohorts in the first period are older than for those cohorts we use their utility at their age at the reforms date for consumption equivalent computations. Furthermore, in our model consumption equivalent is expressed as a permanent percentage change in lifetime consumption. The net balance of the this welfare measure informs about the overall efficiency of the reform, as discussed above.

Fiscal closure scenarios. The benchmark scenario - no policy change - involves maintaining the notional DB pay-as-you-go pension system, subjected to demographic change and exogenous productivity growth slowdown. This simulation yields reference paths for capital, income, labor supply and consumption as well as the vector of utilities across cohorts.

We consider two main scenarios: tax closures and debt closure. For the purpose of comparison with Nishiyama and Smetters (2007) and Okamoto (2005a) we also allow a scenario where the lump-sum tax (Υ) adjusts. In the tax closures, lump-sum, labor or consumption taxes adjust fully, whereas debt is held constant. In the debt closures financing of the gap in the pension system is levied on future generations, i.e. deficit is financed with the government debt. We allow the debt to grow for the first 60 years after the reform or until an upper bound of 60% ratio to GDP[18] is hit (whichever happens sooner). After 60 years the debt is gradually repaid to bring the debt share in GDP to the value from the first steady state (i.e. 45%). We keep the debt at the threshold and repay it using labor tax or consumption tax.[19] Given that retirees pay labor income tax (stylized to Polish legislation), the difference between labor and consumption type of closure in our model is not that much of *who* pays it, but rather *how* *much* of it is paid by each cohort.

3 Calibration and baseline

Calibration was pursued in two stages. First, 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 this parametrization, we calibrated the discount factor δ so that the combined interest rate in the economy in the initial steady state was close to 7.4% and d so that the aggregate investment rate matched the one observed in the data, i.e. app. 21%[20]. In practice, the effective annual interest rates recorded on the savings in the funded pillar II of the pension system amount to annual average of 7.4% in real terms. Nishiyama and Smetters (2007) 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.

Demographics. We use the demographic projection for Poland by EUROSTAT. In the model we use as input data for the number of 20-year-olds born at each period in time and mortality rates as implied by the projection. Thus, the number of agents in each age cohort j at each point in time t is actually a number of 20-year-olds who survived till this age. Demographics is assumed constant after 130 periods (50 periods of the projection + 80 periods for 20-year-olds in the last year of the projection). In addition to the scenario matched to the projection, we also consider a case with non-decreasing fertility, keeping the mortality rates as projected. This more favorable demographics is characterized by lower old-age dependency ratio and positive contributions of population to output, see Figure 1.

[Figure 1 about here]

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, see Figure 1. The overall assumption behind these forecasts is 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.* In addition to the scenario matched to the projection, we consider also an alternative path with a starting values similar to the ones observed for advanced economies, i.e. app. 2% *per annum*.

Age specific productivity (ω_j). We allow for two paths: flat age-productivity profile and one derived from Deaton (1997).[21] *De iure* retirement age is 60 for women and 65 for men, but effective exit age was lower.[22] The *de iure* retirement age is supposed to reach 67 for men in 2018 and for women in 2040. These legislative and cohort effects are reflected in a path of retirement age in our model, which is the same along the path in the baseline and in the reform scenario.

Preference for leisure (ϕ). Agents' preference for leisure/consumption is directly responsible for the labor supply decisions, so we pick it to replicate labor market participation rate of 56.8% (pre-reform value). The final value amounts to 0.53, which seems reasonable: average hours worked in Polish economy amount to app. 2050[23], i.e. 51.5% of the total workable time.

Impatience (discount factor, δ). The value δ was chosen to match the interest rate of 7.4% on the asset portfolio, as described above. We also set the return on government bonds at $\xi = 1/3$ of return on capital assets to match the corresponding ratio observed in the data in the developed countries. In Poland over the 1995-2005 period the return on government bonds was equal to 45% of the commercial market interest rate, while the proportion is decreasing. There is an additional discounting parameter β, whose values are set in line with the literature. Namely, we simulate the model for two values of $\beta = \{1, 0.9\}$, where $\beta = 1$ implies no time inconsistency. Depreciation rate d is calibrated to match the investment rate in the economy, given δ.

Replacement rate (ρ). We set it to match the 5% ratio of pensions to GDP in 1999. Depending on the selected ω scenario, the actual value for the replacement rate differs. The effective rate of contribution 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%. While *de iure* contribution rate amounts to 19.52% of payroll, the actual effective contribution rate consistent with our model amounts to app. 6.1%.

Taxes. Labor income tax (τ_l), which *de iure* amounts to 18% and 32% was set at effective 11%, which matches the rate of labor income tax revenues in the aggregate employment fund. For the social security contributions it is much harder to find a matching relationship. Consumption tax τ_c was set at 11%, which matches the rate of revenues from this tax in aggregate consumption in 1999. There are no tax redemptions on capital income tax, so $\tau_k = 19\%$. Obligatory savings in the fully funded pillar are exempt from capital income tax to follow the actual legal design.

[Table 1 about here]

Savings and wealth. The pension reform implied that the SIF needed to compute the so-called initial capital for all cohorts participating in DC system. Intuitively, the initial capital reflects the counter-factual scenario on what would be the stock of assets in the NDC individual account had the NDC system been instated in the past. We use 1% sample of the adult population made available by the SIF to infer the age specific distributions of wealth. To assure comparability with the model, initial capital is expressed in terms of average wage (w).

3.1 Baseline scenario

Naturally, demography and productivity changes are reflected in the baseline scenario. Since this is the reference for comparison to the policy scenarios, we allow for parallel changes in the baseline. For example, in the scenario with the labor tax closure, labor tax grows to satisfy the budget constraint both in the baseline DB PAYG system and in the transition to the new, partially funded DC system. This is important for our findings. If contributions to the pension system are not changed in the DB baseline scenario – due to increasing longevity and lowering overall labor supply, the accumulated debt in the pension system grows substantially, as shown in Figure 2.

[Figure 2 about here]

The non-monotonous behavior of benefits in Figure 2 (i.e. wiggles) follows from the changes in the retirement age. Since age is discrete, if the retirement age increases in the particular year then there are no cohorts retiring, and two cohorts will retire in a subsequent year. The opposite effect works if the retirement age is reduced. This non-monotonicity is translated to nearly all simulations in our model.

4 Results

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

4.1 Welfare effects

The initial steady state is the same across all specifications with the calibration details described in section 3 above. On the baseline transition path we consider the following fiscal closures: lump-sum tax, labor tax, consumption tax, debt with adjustment in labor tax and debt with adjustment in consumption tax. Taxation adjustment is only triggered if the debt passes the threshold of ratio to GDP set at 60%. The same five scenarios are possible in the reform scenario, which implies a total of 25 combinations between the baseline and reform paths as far as fiscal closures are concerned.

Overall efficiency and fiscal closures. The gap implied by the privatization of the social security system may be financed by taxing the currently working generations and/or taxing future generations *via* raising public debt. While proportional taxation is distortionary, it may indeed be the case that relatively small distortion across all possible cohorts (because of initial increase in the public debt) are superior in terms of welfare to a larger distortion condensed in a smaller fraction of cohorts. Thus, comparing the welfare effects of various fiscal closures is an empirical question.[24] The contribution of this paper is the comparison of welfare effects depending on the fiscal closure scenarios.

Comparing within rows various closures in reform for the same baseline fiscal adjustment, we can observe the role played by fiscal closures themselves, Table 2. In fact, the differences between the fiscal closures in the reform scenario are relatively large, amounting to even roughly 20-30% of the overall welfare effect. Comparing between the rows serves as a robustness check of our simulations, showing that these large differences do not stem from particularities of one selected baseline. Neither is the conclusion driven by the calibration or the assumptions concerning the trajectories for the demographics and technological progress. Indeed, more favorable demographics and slower technological progress yield somewhat smaller gains, but still the discrepancy within rows is substantial, ranging between 15-30% of the maximum overall welfare gain. Across the board, the proposed reform is welfare enhancing, i.e. after compensating all the generations that loose out as a result of the reform, LSRA has positive net wealth to redistribute irrespectively of the fiscal closure.

[Table 2 about here]

Regardless of the specification, it is the debt combined with a labor tax that yield the highest efficiency gain. Thus, although labor tax rate needs to grow when the debt exceeds the constitutional threshold, in *per capita* terms this increase is lower than the increase in the scenario of no policy change.

This suggests that a politically viable solution is actually welfare enhancing, when compared to the fiscal closures in which the majority of the costs of the reform is born by transition cohorts.

These results have important policy implications. Although efficiency gain in the case of this particular design of the reform seem to be universal, there is a wide discrepancy between the size of the overall welfare gain depending on the fiscal closure. In fact, if we compare the "best" (debt with labor tax) to the "worst" (consumption tax), the differences are as large as 1.28% of permanent consumption, i.e. more than half of the overall pension reform effect in the case of the "worst" fiscal closure and nearly a third in the case of the "best" fiscal closure.

Decomposing the sources of welfare effects. The second contribution of our paper is decomposing which part of the welfare effects can be attributable to forming a pre-funded pillar and which follows from changing a defined benefit mechanism to a defined contribution one. The latter involves lowering of the replacement rates, whereas the first generates a fiscal gap to be financed with (contemporaneous) taxes or public debt.

The analysis of the effects across cohorts and between the components of the reform reveals that redistribution is indeed needed to alleviate the costs for the majority of the living cohorts. Figure 3 demonstrates the decomposition results with reform scenario corresponding to the fiscal closures on the diagonal of Table 2. Clearly, lump-sum taxation involves high welfare loss for relatively poor old cohorts, which reveals a particular characteristic of this type of fiscal closure in the OLG context of heterogeneous agents (wrt. age). Proportional taxation on labor or consumption shows that all the welfare costs of financing the gap are in fact born by the cohorts alive in $t = 0$, whereas the future cohorts experience nothing but welfare gains due to $PAYG$ to fully funded reform. In comparison, fiscal closure via public debt permits to spread the costs of financing the pension system gap (more) equally across generations. In fact, the overall effects of forming the pre-funded pillar are positive, but this value is small, compared to the effects from a $DB \Rightarrow DC$ change.

While it seems that welfare is somewhat smaller in the case of financing the reform with debt (app. 0.1-0.15 pp of permanent consumption), this type of fiscal closure works similarly to LSRA mechanism. In fact, debt automatically redistributes between cohorts, whereas political feasibility of LSRA remains doubtful. On the other hand, debt closures involve some modest efficiency disadvantage in terms of welfare, which implies that substantially raising debt could essentially eliminate the welfare cost of forming the pre-funded pillar but at the expense of overall welfare gains from the reform.[25]

[Figure 3 about here]

The extent of fiscal adjustment in each of the closures is indeed considerable and justifies relatively large welfare effects, Figure 4. Consumption, labor and lump sum tax grow in the initial phase of the pension system change by roughly 2-3pp, whereas this increase is app 1-1.5pp smaller in the baseline. However, this result owes to the fact that actual deterioration in the dependency ratio occurs only about 30 years after the reform. Tax rates are subsequently considerably lower in the reform scenario than in the original DB equilibrium, which follows form the fact that the SIF deficit does not need to be financed with general taxes. Eventually, the amount of excessive taxation reaches as much as 50% of the tax rates.

[Figure 4 about here]

Susceptibility of results to the calibration. The results we obtain could be susceptible to the specification of time inconsistency or age-productivity patterns. Table 3 displays the robustness check. The more myopic the agents are, the lower the welfare gain from the reform across all scenarios. Indeed, although the reform is generally efficient the gains decrease with the extent of time inconsistency, as suggested by Imrohoroglu et al. (2003). This result implies that a disciplining device in the form of forced pension savings with a (partially funded) DC scheme are in fact welfare deteriorating for the generations living during the transition period between the original and the new pension system. While the living generations benefit from the debt closure, future generations will experience welfare gain from lower implied taxation. However, agents with time inconsistent preferences would rather have lower (welfare) costs today than gains in the future.

[Table 3 about here]

4.2 Changes in the economy

The gain in GDP over the baseline scenario amounts to app. 1% in a decade and as much as over 2% over 50 years, Table 4.[26] This output gain follows almost entirely from faster capital accumulation, as changes in the labor supply are minuscule. In fact, capital grows under any of the reform scenarios by app. 7% to 9% more than under *status quo* of no policy change, depending on age-productivity patterns.[27] Most of the changes are driven by the emergence of the funded pillar: in the initial phase of the reform the financing of the reform *via* debt crowds out the private savings, thus hampering the speed of capital accumulation relative to tax scenarios. Once the debt stops crowding private savings out, the rate of capital accumulation speeds up in the reform scenarios relative to the *status quo* of no policy change.

The effects are modest when compared to the literature. For example, Nishiyama and Smetters (2007) find as much as 10% differential in output. However, it is important to recognize that we analyze a reform that involves no change of the contribution rate and only a third of the contributions is directed to the funded pillar with initially only partial participation. A stronger effect would have to originate from either private, voluntary savings or from the labor market. Savings increase by as much as 6% in one generation, which is considerable by all standards. Since labor market is frictionless and perfectly elastic in our model, one should observe little aggregate changes. Naturally, there are also some incentive effects for the labor supply, but as long as households cannot influence their retirement age the effects of system change are bound to be relatively small.

Susceptibility of results to the calibration. Neither the extent of time inconsistency, nor the age-productivity pattern is not neutral to the change in the pension system (Figure 5a-5b). With Deaton (1997) pattern, labor supply grows with age, reflecting higher returns to labor. With aging populations, pensions grow under DB reducing the need for privates savings, whereas under DC private savings grow more to smoothen lifetime consumption. These effects, however, are minor and matter more for the timing of the increase/decrease in the rate of capital accumulation rather than for its actual level.

The results suggest that (large degree of) time inconsistency, the contribution rates to the capital pillar become more binding. Note that the interest rate earned on private savings is subject to capital taxation whereas compulsory savings in the funded pillar are not, thus offering a relatively higher rate of return. Hence, it is not the choice of *how* to save but rather *if* to save at all that is binding for the myopic agents. This finding is consistent with Blake (2000) and others, who emphasize the sustainability of the funded schemes rather than higher rates of return.

5 Conclusions

This paper addressed the welfare effects of various fiscal closures when switching from a defined benefit pay-as-you-go system to a partially funded defined contribution system. While the efficiency of such types of reform has already been addressed in the literature, there is a considerable variation in the fiscal closures adopted in previous studies. This paper aims at comparing the welfare effects of the reform *depending* on the fiscal closure. In addition, we provide a decomposition of the welfare changes due to the pension (DB to DC) and changes due to the financing mechanism (PAYG to partial pre-funding). While the reform itself has welfare effects, so does the fiscal adjustment necessary to implement the reform.

Our findings reveal that the fiscal closure itself can contribute/deduct up to app. 15-30% of the overall welfare effect of the pension system "privatization". Financing the reform with public debt allows to spread the costs of establishing the pre-funded pillar fairly across all generations, introducing an automatic redistribution between cohorts. We also demonstrate that in the simulations matched to the demographic productivity projections, this fiscal closure yields superior welfare gains when compared to taxation of the generations living at the moment of the reform. The results are robust to a number of parametric choices (time inconsistency and life cycle productivity patterns) as well as the assumptions concerning the demographic projection and the technological progress rate.

The policy implications of this study are quite optimistic. First, the politically viable fiscal closure – rarely employed in the earlier literature – actually yields the highest welfare gains. This suggests that a number of reforms which were not as efficiency enhancing in previous works could be more beneficial if coupled with a debt closure in reality. An important feature of our model is the debt threshold, which necessitates some tax adjustment, thus making debt fiscal closure actually fairly prudent. Second, we show that debt closure is an automatic and credible "redistribution authority", which helps to enforce transfers between the cohorts, unlike tax closures which would require the government to act as a lump-sum redistribution authority (LSRA). Third, we show that although majority of the fiscal gap comes from establishing the pre-funded pillar, majority of the welfare effects come from the downward adjustment in pensions – not from the fiscal cost of establishing the pillar. This finding is universal across the fiscal closures and suggests that the weight of the policy debate should be shifted to the fiscal policy accompanying the reform rather than the reform design.

Tables

Table 1: Calibrated parameters

Demographics scenario and the rate of technological progress		matched to data/projections				alternative
		$\beta = 1$		$\beta = 0.9$		$\beta = 1$
		$\omega = 1$	ω - D97	$\omega = 1$	ω - D97	ω - D97
α	capital share	0.31	0.31	0.31	0.31	0.31
τ_l	labor tax	0.11	0.11	0.11	0.11	0.11
ϕ	preference for leisure	0.527	0.560	0.532	0.565	0.552
δ	discounting rate	0.984	1.008	0.989	1.01	1.006
d	depreciation rate	0.06	0.04	0.06	0.06	0.06
τ	total soc. security contr.	0.061	0.061	0.061	0.061	0.061
ρ	replacement rate	0.251	0.152	0.252	0.153	0.129
		resulting				
$\Delta k_t/y_t$	investment rate	21.5	21.3	21.4	21.4	21.2
r	interest rate	7.1	6.9	7.2	7.1	5.0

Note: D97 denotes calibration according to Deaton (1997) decomposition. Alternative demographics and the rate of technological progress stand for growing population and lower initial technological progress rate, as displayed in Figure 1.

Table 2: Welfare effects - a comparison of the fiscal closures for the pension system reform

Fiscal closure in baseline	Fiscal closure in reform Υ	τ_c	$debt + \tau_c$	τ_l	$debt + \tau_l$	max − min (in % of a max)
	Demographics and productivity paths matched to the projections					
Υ	3.19	2.79	3.44	3.39	4.07	31.4%
τ_c	3.03	2.68	3.4	3.28	3.96	32.3%
$debt + \tau_c$	3.06	2.7	2.79	3.3	3.36	19.6%
τ_l	2.96	2.66	3.26	3.19	3.89	31.6%
$debt + \tau_l$	2.99	2.66	2.74	3.21	3.26	18.4%
	Alternative demographics and productivity paths					
Υ	2.53	2.36	2.84	2.76	3.25	27.3%
τ_c	2.44	2.30	2.80	2.69	3.17	27.4%
$debt + \tau_c$	2.46	2.32	2.40	2.71	2.78	16.6%
τ_l	2.41	2.27	2.74	2.64	3.14	27.7%
$debt + \tau_l$	2.43	2.29	2.37	2.67	2.74	16.3%

Note: Numbers signify a consumption equivalent (in % terms of permanent consumption) under the parametrization of $\beta = 1$ and productivity following Deaton (1997). As described earlier, welfare for each cohort is discounted its age of 20 and stationarized (to adjust for the economic growth). It is expressed as utility (consumption equivalent) net of transfers necessary to compensate the losses induced by the lack of the reform. Table for alternative parametrizations available upon request.

Table 3: Welfare effects for all analyzed fiscal closures depending on parametrization

Fiscal closure	$\beta = 1$		$\beta = 0.9$	
in reform scenario	$\omega = 1$	ω - D97	$\omega = 1$	ω - D97
$debt + \tau_c$	3.74	3.44	0.99	2.54
$debt + \tau_l$	4.10	4.07	2.42	2.95
τ_c	3.29	2.79	1.43	2.05
τ_l	3.63	3.39	1.83	2.43
Υ	3.10	3.19	1.22	2.21

Note: Numbers signify a consumption equivalent (in % terms). In the baseline scenario fiscal closure given by lump sum taxation (Υ). Results for other baseline fiscal closures available upon request.

Figures

Figure 1: LEFT: Population (relative to 1999) according to the demographic projection and an alternative scenario. *Source*: EUROSTAT demographic forecast until 2060. RIGHT: Labor augmenting productivity growth rate according to the projection and an alternative scenario. *Source: European Commission.*

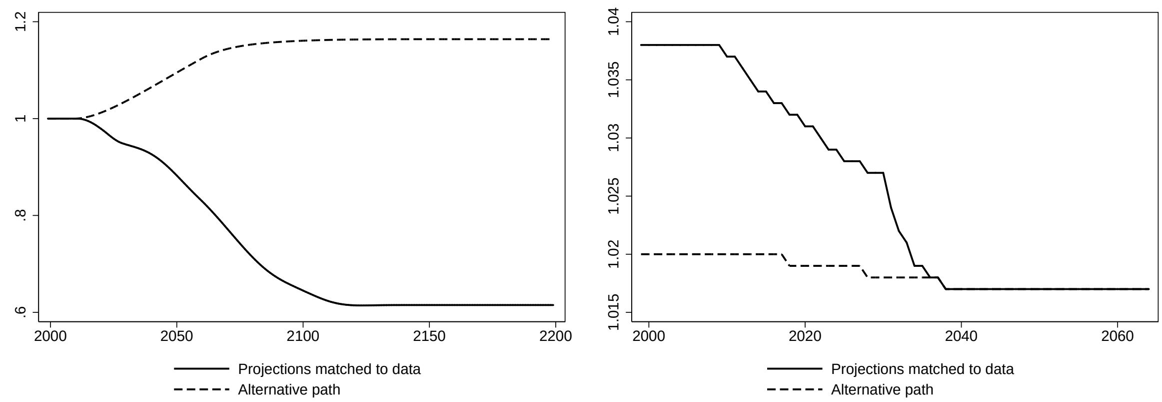


Figure 2: Cumulated changes in SIF balance and pension share in GDP in the baseline scenario of no policy change (with no time inconsistency).

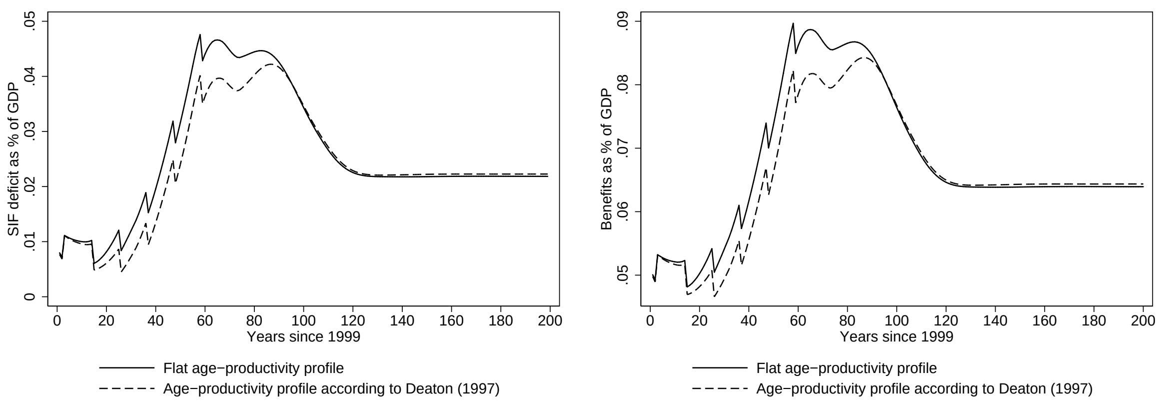
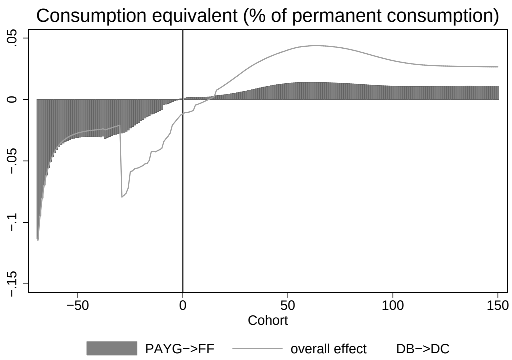
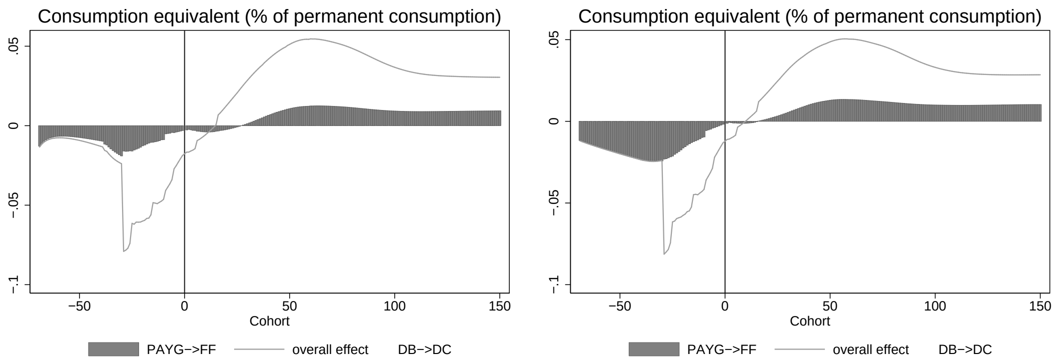


Figure 3: The decomposition of welfare effects.

(a) lump sum tax



(b) labor tax (left) and consumption tax (right)



(c) debt closure with labor tax (left) and consumption tax (right)

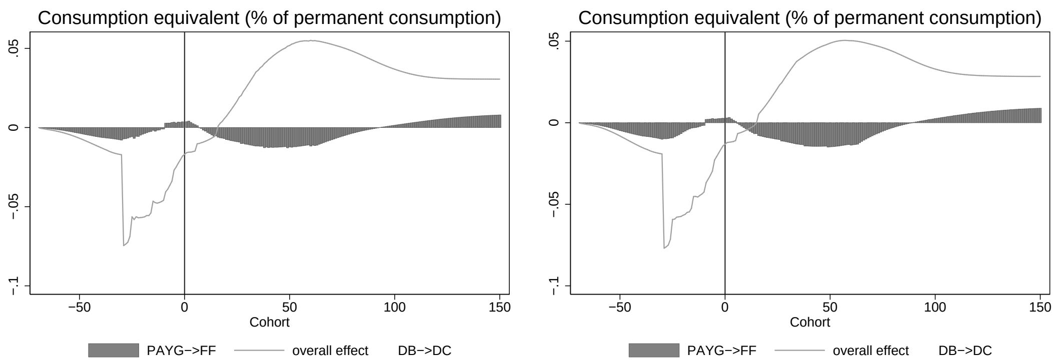
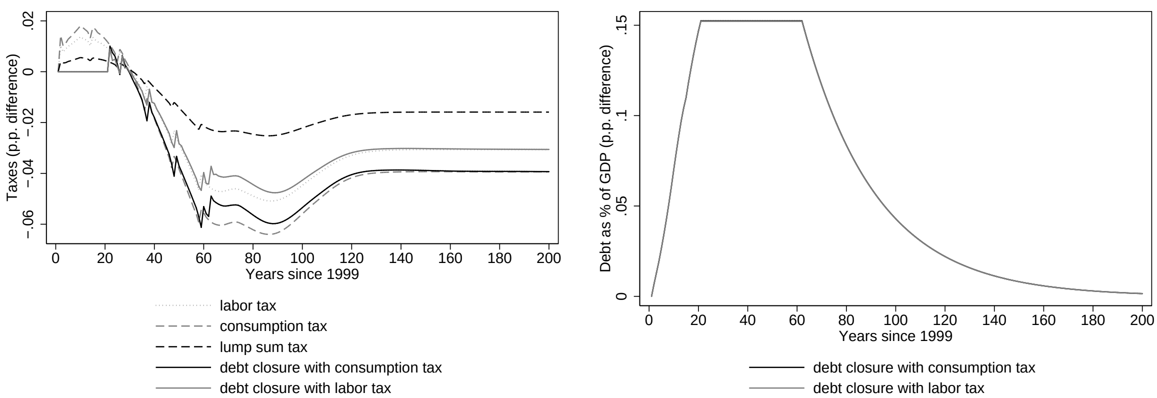


Figure 4: Changes to taxes and debt share (lump sum tax in baseline scenario)



A Solution of the consumer problem

Denote a stream of consumtion for agent $j-$aged in period t as $\tilde{c}_{j,t} = (c_{j,t}, c_{j+1,t+1}, ..., c_{J,t+J-j})$ and a stream of labor $\tilde{l}_{j,t} = (l_{j,t}, l_{j+1,t+1}, ..., l_{J,t+J-j})$. Consumer at age j in period t optimizes her lifetime utility

$$U_j(\tilde{c}_{j,t}, \tilde{l}_{j,t}) = u_j(c_{j,t}, 1 - l_{j,t}) + \beta \sum_{s=1}^{J-j} \delta^s \frac{\pi_{j+s,t+s}}{\pi_{j,t}} u_j\left(c_{j+s,t+s}, 1 - l_{j+s,t+s}\right) \tag{10}$$

subject to the budget constraint

$$(1 + \tau_{c,t})c_{j,t} + s_{j,t} + \tau_j + \Upsilon_t = (1 - \tau_{\iota,t} - \tau_{l,t})\omega_j w_{j,t} l_{j,t} + \left(1 + r_t\left(1 - \tau_{k,t}\right)\right) s_{j-1,t-1} + \Gamma_{j,t} \tag{11}$$

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

$$(1 + \tau_{c,t})c_{j,t} + s_{j,t} + \tau_j + \Upsilon_t = (1 + r_t(1 - \tau_{k,t}))s_{j-1,t-1} + (1 - \tau_{l,t})(b_{\iota,j,t}) + \Gamma_{j,t}. \tag{12}$$

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 $t-1$.

Solving, we obtain the final solution for consumption and labor supply (and thus instantaneous savings) for the working cohorts:

$$\begin{aligned} c_{j,t} &= \frac{(1 + r_t(1 - \tau_{k,t}))s_{j-1,t-1} - \tau_{j,t} - \Upsilon_t + (1 - \tau_{s,t} - \tau_{l,t})w_{j,t} + \Omega_{j,t} + \Gamma_{j,t}}{\frac{1}{\phi} + \frac{1}{\phi}\beta \sum_{s=1}^{\bar{J}-j-1} \delta^s \frac{\pi_{j+s,t+s}}{\pi_{j,t}} + \beta \sum_{s=\bar{J}-j}^{J-j} \delta^s \frac{\pi_{j+s,t+s}}{\pi_{j,t}}} \\ l_{j,t} &= 1 - \frac{1-\phi}{\phi} \frac{(1 + \tau_{c,t})c_{j,t}}{w_{j,t}} \end{aligned} \tag{13}$$

with

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

Numerator of eq. (13) represents the current discounted value of the future lifetime income.

B Results for the main macroeconomic indicators

Table 4: Macroeconomic effects of the reform, Υ fiscal closure in baseline scenario, demographics and technological progress paths matched to data/projections

Fiscal closure in the reform scenario		GDP				Labor supply				Capital			
		$\beta = 1$		$\beta = 0.9$		$\beta = 1$		$\beta = 0.9$		$\beta = 1$		$\beta = 0.9$	
	Period	D97	flat	D97	flat	D97	flat	D97	flat	D97	flat	D97	flat
Labor tax	10	1.00	1.01	1.00	1.01	0.99	0.99	0.99	0.99	1.01	1.02	1.01	1.02
	30	1.01	1.02	1.01	1.02	0.99	1.00	0.99	1.00	1.05	1.05	1.05	1.05
	50	1.02	1.02	1.02	1.02	0.99	1.01	0.99	1.01	1.07	1.08	1.07	1.08
	∞	1.02	1.02	1.02	1.02	0.99	1.01	0.99	1.01	1.06	1.06	1.06	1.07
Debt with labor tax	10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	1.00	0.99	1.00
	30	1.01	1.01	1.01	1.01	0.99	1.00	0.99	1.00	1.02	1.02	1.02	1.02
	50	1.01	1.01	1.01	1.01	1.00	1.01	1.00	1.01	1.05	1.05	1.05	1.05
	∞	1.02	1.02	1.02	1.02	0.99	1.01	0.99	1.01	1.06	1.06	1.06	1.07
Consumption tax	10	1.00	1.01	1.00	1.01	0.99	1.00	0.99	1.00	1.01	1.02	1.01	1.02
	30	1.02	1.02	1.02	1.02	0.99	1.00	0.99	1.00	1.05	1.06	1.05	1.06
	50	1.02	1.02	1.02	1.02	0.99	1.01	0.99	1.01	1.08	1.08	1.07	1.08
	∞	1.02	1.02	1.02	1.02	0.99	1.01	0.99	1.01	1.07	1.07	1.07	1.07
Debt with consumption tax	10	1.00	1.00	1.00	1.00	0.99	1.00	0.99	1.00	0.99	0.99	0.99	0.99
	30	1.00	1.01	1.00	1.01	0.99	1.00	0.99	1.00	1.02	1.02	1.01	1.02
	50	1.01	1.02	1.01	1.02	0.99	1.01	0.99	1.01	1.05	1.05	1.05	1.05
	∞	1.02	1.02	1.02	1.02	0.99	1.01	0.99	1.01	1.07	1.07	1.07	1.07
Lump sum tax	10	1.00	1.01	1.00	1.01	1.00	1.00	1.00	1.00	1.01	1.02	1.01	1.02
	30	1.02	1.02	1.02	1.02	0.99	1.01	0.99	1.01	1.05	1.06	1.05	1.06
	50	1.02	1.03	1.02	1.03	1.00	1.02	1.00	1.02	1.08	1.09	1.08	1.09
	∞	1.02	1.02	1.02	1.02	0.99	1.01	0.99	1.01	1.06	1.07	1.06	1.07

Note: Numbers signify ratio to baseline scenario of no policy change. Long run denotes the new steady state after 250 periods. D97 denotes calibration according to Deaton (1997) decomposition.

Table 5: Macroeconomic effects of the reform, Υ fiscal closure in baseline scenario, alternative demographics and technological progress paths

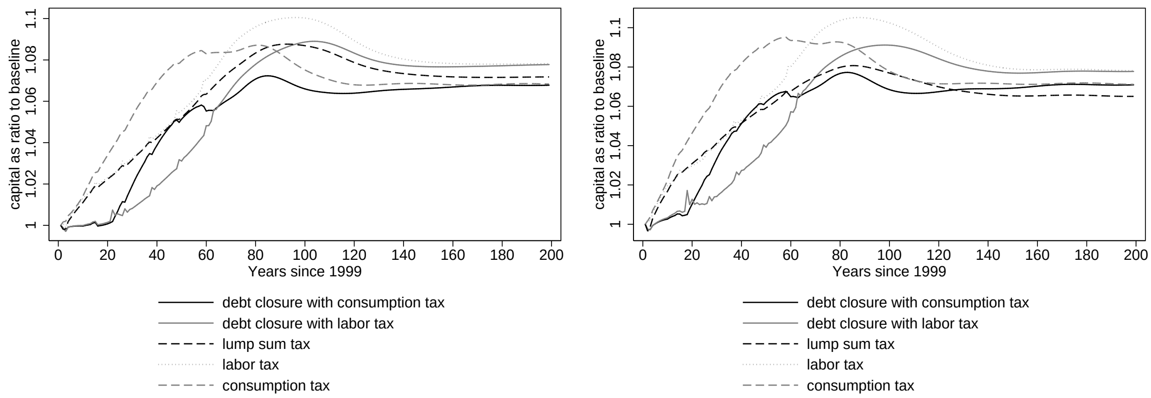
Fiscal closure in the reform scenario	Period	GDP $\beta = 1$ D97	Labor supply $\beta = 1$ D97	Capital $\beta = 1$ D97
Labor tax	10	1.00	0.99	1.01
	30	1.01	0.98	1.03
	50	1.01	0.99	1.04
	∞	1.02	0.99	1.07
Debt with labor tax	10	1.00	1.00	1.00
	30	1.00	0.98	1.01
	50	1.01	0.99	1.02
	∞	1.02	0.99	1.07
Consumption tax	10	1.00	0.99	1.01
	30	1.01	0.99	1.05
	50	1.02	0.99	1.06
	∞	1.02	0.99	1.06
Debt with consumption tax	10	1.00	0.99	1.00
	30	1.01	0.99	1.02
	50	1.01	0.99	1.03
	∞	1.02	0.99	1.06
Lump sum tax	10	1.00	1.00	1.01
	30	1.01	0.99	1.03
	50	1.01	0.98	1.05
	∞	1.02	0.98	1.06

Note: Numbers signify ratio to baseline scenario of no policy change. Long run denotes the new steady state after 250 periods. D97 denotes calibration according to Deaton (1997) decomposition.

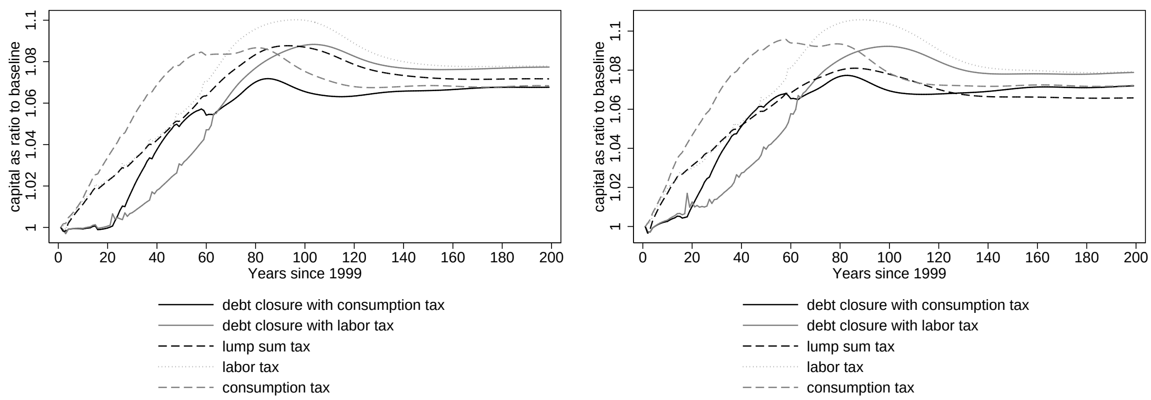
C Adjustments in capital, depending on model parametrization

Figure 5: Changes to capital in reference to no-policy-change scenario (ratio)

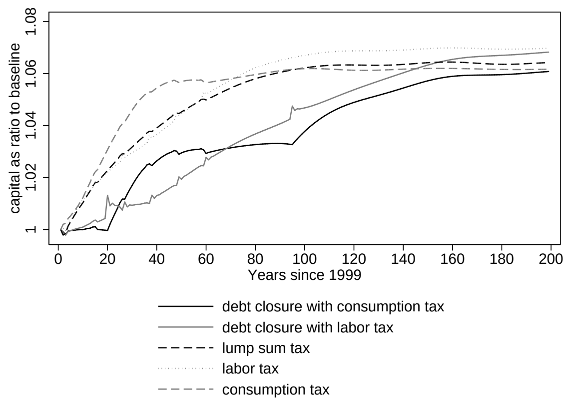
(a) Deaton (1997) productivity (left) and flat age productivity profile (right), **no** time inconsistency.



(b) Deaton (1997) productivity (left) and flat age productivity profile (right), **with** time inconsistency.



(c) Deaton (1997) productivity, **no** time inconsistency, and alternative demographic and productivity projection.



Notes

[1]Some countries (e.g. France, Italy, Germany) partially reduce the generosity of the social security system and attempt to raise contributions base by increasing the participation and compliance. Macroeconomic simulations show, however, that such measures are far from satisfactory and at best delay the fiscal consequences, e.g. EC (2012)

[2]Recently McGrattan and Prescott (2013) advocate in favor of abolishing a PAYG DB pension system in the US *without* replacing it with a mandatory (partially) funded one. They show universal welfare gains from no pension system at all.

[3]In addition, the reforms of the pension system typically alter the proportions between the implicit and the explicit public debt, see Genakoplos et al. (2000), Kuhle (2010).

[4]One of the reasons, as may be understood from Fehr (2009), is the fact that these models still focus on relatively fundamental questions (efficiency of the potential reform and the role of the demographics), leaving aside "technicalities" such as fiscal policy. Pension systems are largely a political – not only policy – matter, there is a number of attempts to extend these models to comprise a political economy component and test the political stability of the reform with the changing demographics, cfr. Galasso (1999), Kumru and Piggott (2010), Wright et al. (2012).

[5]Huggett and Ventura (1999) discusses the distributional effects of the social security system reform, but compares only the steady states, without explicitly analyzing the transition in between the old and the new system.

[6]See Lindbeck and Persson (2003) as well as Fehr (2009) for an overview of the abundant literature.

[7]In the case of Europe, as demonstrated by Boersch-Supan and Ludwig (2010) the fiscal effects are particularly large due to more rapid aging. In addition, demography has one more consequence for the outcomes from a modeling perspective. More specifically, mortality rates discount future consumption, income and utility. Consequently, lower mortality implies more patience in discounting future, while uncertainty about the pace of mortality reduction may play an important role as well, e.g. Sanchez-Marcos and Sanchez-Martin (2006).

[8]Conceptually, LSRA is much more than the way to compute welfare – it is a redistribution mechanism, which alleviates the potential inequality in distribution of welfare changes due to the reform. Technically, LSRA finances the transfers to compensate welfare losses through lump-sum taxes on generations that experience welfare gains. The intermediate budget of LSRA – i.e. once all losses are compensated for and prior to distributing the reminder - shows the overall efficiency gains due to the reforms.

[9]In terms of geography, originally the majority of analyses focused on the US economy and subsequently also UK, e.g. Kotlikoff et al. (1999), Cipriani and Makris (2001). Subsequently, however, there has been a number of attempts to simulate various reforms and features of the system in Germany (e.g. Coppola and Wilke (2010), Bucher-Koenen and Lusardi (2011), Spain (e.g. Díaz-Giménez and Díaz-Saavedra (2009)), few selected EU countries Ludwig and Vogel (2009)), Europe as a whole, e.g. Feldstein and Siebert (2002), Aglietta et al. (2007), Keuschnigg et al. (2012). An abundance of papers on aging and pension reform in Japan includes also Okamoto (2005a,b) who compares the welfare effects of various pension reforms with financing coming from labor taxation or consumption taxation. To the best of our knowledge, for the Central and Eastern Europe countries, with the exception of Slovenia, cfr. Verbič et al. (2006) and Verbič (2007), there are no fully fledged OLG models. Li and Mérette (2005) offers an analysis for China.

[10]The system is completed by a third pillar, where savings are also exempt from the capital income tax, but the contributions are voluntary and subject to a cap.The third pillar is not popular, with only about 1.3% of the working

population contributing to voluntary pension savings schemes. Thus, we ignore this feature in subsequent analysis and private savings are in general subject to capital income tax.

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

[12]We assume that the retirement age is time-varying and exogenous (calibrated to the Polish data, see section 3).

[13]We follow Imrohoroglu et al. (2003), who discuss various alternatives to such formulation of time-inconsistency, as well as its microfoundations. Caliendo (2011) generalizes Imrohoroglu et al. (2003) for a continuous time case. Sometimes time-inconsistency involves the duration of economic activity rather than savings, cfr. Findley and Caliendo (2012).

[14]As noted by Nishiyama and Smetters (2007), while privatizing social security can improve labor supply incentives, it can also reduce risk sharing. With randomized and non-insurable shocks to individual productivity, the original conclusions of Feldstein highly stylized model do not necessarily hold. Similar conclusions originate from models incorporating time inconsistency into the consumer choice, Imrohoroglu et al. (2003), Bassi (2008), Fehr et al. (2008), van de Ven and Weale (2010), Fehr and Kindermann (2010), Kumru and Thanopoulos (2011). Alternative approach has been proposed by Gul and Pesendorfer (2004) with recursive and separable dynamic self-control preferences. Specifically, the pension system is viewed as a disciplining device or technology (in terms of savings), whereas PAYG component of the pension systems usually replaces the otherwise absent insurance mechanism (at the tax/expense of inefficiency). In the world where savings for future expenditure are too low, incentives to raise them to an optimal level may actually help improve social welfare, despite reducing leisure and consumption in the working periods. The reasons for which savings may be too low, as analyzed in the literature, include unexpected longevity and/or negative income shock in the working period, as well as myopia, time-inconsistent preferences and insufficient financial literacy.

[15]Our treatment of the labor market, for the purpose of brevity, comprises of no frictions. Building on earlier development Keuschnigg et al. (2012) develop a framework with social assistance, unemployment as well as a fully fledged search & matching. In addition, a number of attempts have been made to endogenize the retirement age decision, e.g. Vogel et al. (2012) .

[16]In fact the legislation necessitates averaging over 10 best out of last 20 years of professional activity. We replicate this feature of the pension system in computations.

[17]In each iteration, error is computed as the l_1-norm of the difference between capital vector in subsequent iterations.

[18]We experimented with a number of higher and lower values and the results were qualitatively unaffected by the choice of this parameter.

[19]The duration of 80 years was chosen because this is as much the youngest transition cohort will live. The second condition for setting the bound on debt growth is dictated by the fact that even if economically stable over the long run, some levels of reform induced debt may be politically infeasible, Andolfatto and Gervais (2008), Cabo and Garcia-Gonzalez (2014).

[20]Depending on the period over which the average is taken, it ranges from 20.8% for five years ahead and five years post reform, 23.1% for 2 years before-after span and 24.1% for a 1 year before-after span. The average for the period between 1995 (first reliable post-transition data) and 2010 amounts to 20.7%.

[21]There is a considerable body of literature analyzing the changes in productivity across the life cycle. The major difficulty from an empirical perspective consists typically of separating the cohort effects (consistent with downward

sloping pattern) from the actual changes in individual productivity. Majority of the microeconometric analyses confirm an inverted U-shaped pattern, cfr. Skirbekk (2004) as well as a forthcoming special issue of Labor Economics (volume 22, 2013).. On the other hand, some analyses show that, when adequately controlling for cohort effects and self-selection, in fact age-productivity relation is fairly flat and - if anything - slightly increasing until the age of 65, Boersch-Supan and Weiss (2011).

[22]SIF annual reports

[23]Conference Board, averaged for 1999-2012 (*ahwpol* from The Conference Board Total Economy Database).

[24]Please note that the actual number of future cohorts is irrelevant for the computation of the overall efficiency measure, see section 2.

[25]Debt hits the upper bound (60% of GDP) already after 15-20 periods in the reform scenario and after 30-40 periods in the baseline scenario. Thus, most of the periods it is the actually the tax closures that operate, which explains negligible difference between the two types of fiscal closures. If debt was allowed to go beyond 60% of GDP, more redistribution would be possible. This threshold is rooted in the constitution as well as the Treaty of Maastricht.

[26]We show the macroeconomic effects prior to the redistribution by the LSRA.

[27]As has been visible in our calibrations, the initial replacement rate may indeed be lower in those simulations where productivity grows in age. This explains why flat age profiles yield *ceteris paribus* higher capital accumulation and thus higher output.

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