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Efficiency of the pension reform: the welfare effects of various fiscal closures

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Abstract

Pension system reforms involve fiscal consequences. In practice, a variety of fiscal closures may be implemented, while not all of them involve the same extent of distortions. This paper develops an overlapping generations model to analyze the case of a shift from pay-as-you-go defined benefit system to a partly funded defined contribution system. We calibrate the system to mimic the economy of Poland, which actually implemented such reform in 1999. We analyze the efficiency of the reform with two main closure types: public debt and taxes. Regardless of the fiscal closure scenario this particular reform seems to be efficient in terms of welfare and enhances economic performance. Comparing the welfare of various closures we find that while labor taxation yields relatively higher welfare gain, public debt closure involves least need for the redistribution if capital pillar is to be implemented.

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

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

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1 Introduction

Building on the seminal Auerbach and Kotlikoff (1987), abundant literature analyses the welfare implications of various pension systems empirically, as well as reforms of these pension systems - cfr. Lindbeck and Persson (2003), Fehr (2009). The welfare implications of these reforms are usually conceptualized as a change in utility observed across cohorts, as pioneered by Breyer (1989) and Feldstein (1995). However, in addition to the direct general equilibrium welfare effects, any such reform has also fiscal effects. As objectively as they are measured in computable frameworks, the practical implementation of these fiscal consequences may itself affect welfare, Kotlikoff et al. (1999).

For example, consider a standard case in the literature: a country moves from a defined benefit (DB) pay-as-you-go scheme to a defined contribution (DC), usually a fully funded one. Such a reform is frequently referred to as “privatization of the social security”. The pensions of the cohorts whose contributions were sent to PAYG DB, but retire after DC is introduced - generate debt that requires financing. This debt may be financed in two basic ways: by taxes levied immediately or by raising public debt and thus taxes paid by future generations. Undeniably, taxes are to be raised, either on the earned income of working population, or on consumption, capital, etc. Each of these fiscal closures subsequent to the pension system reform significantly affect the actual welfare implications of the reforms. The multiplicity of solutions raises a methodological question about the efficiency of the reform. In fact, it follows that with one version of the fiscal closure pension system reforms may be actually Pareto-improving, whereas under another it could not be the case.

The literature has already addressed a number of technical weaknesses troubling earlier studies, cfr. Holzman and Stiglitz (2001). Namely, efficiency is currently judged based on comparing the welfare across the paths of the reform scenarios[1]. Change in capital is a behavioral outcome of the reform rather than criterion for scenarios evaluation. Notwithstading, the general finding that reform from a DB to a DC pension system leads to higher output stems from higher capital accumulation and thus higher per capita income under DC. Increase in output (relative to benchmark) is under majority of calibrations a necessary precondition for a welfare gain to materialize. Another important advantage of the contemporanous models is explicit tackling of the demographic issues. With deteriorating demographics across most developed economies, long-term forecasts need to take into account this factor.

Majority of the literature finds that privatization of the pension systems is efficient (Nishiyama and Smetters 2007), although the extent of efficiency gain may depend on a number of factors including the extent of time inconsistency (Fehr et al. 2008, Fehr and Kindermann 2010), market imperfections (De la Croix et al. 2012), etc. On the other hand, ”efficiency gain” for the transition generations is typically lower than the reduction in welfare of these generations - it is thus unable to compensate in terms of welfare for the lowering of the effective replacement rate and/or transitory increase in taxation. To address this problem the literature establishes an artificial concept of a ”Lump Sum Redistribution Authority” (LSRA), which collects the welfare surplus due to the efficiency gain from the future generations to compensate the generations that loose on the reform. Models equipped in realistic demography typically find decreasing replacement rates or growing social security contributions - i.e. over a longer horizon welfare loss is inevitable. Thanks to the redistribution, though, in comparison to the benchmark scenario of no system change, efficiency gain remains feasible.

The main contribution of this paper is threefold. First, we explicitly differentiate between fiscal closures to quantitatively capture their welfare effects in the context of the reform. In light of developments by Imrohoroglu et al. (2003), we encompass time inconsistency in the model. Secondly, our model is developed for an economy that actually underwent the DB-to-DC pension system reform. We are able to comment upon the misalignment between the theoretical adjustment path and the actual data from the first decade in the transition from a DB to a DC system first decade. We thus provide some recommendations for the political economy models of pension reform. Finally, we model an emerging economy, which at the moment of reform had still fairly favorable demographics and relatively high productivity growth due to catching up. Since both these characteristics change considerably, the scenario of no policy change is interesting in itself.

The paper is structured as follows. Section 2 describes the motivation, while section 3 discusses the relevant literature. Theoretical model is presented in section 4, while section 5 describes in detail calibration and analyzed fiscal closure scenarios. We present the results and various sensitivity checks in section 6. The paper is completed by the conclusions as well as as a review of political economy mechanisms that may be at play in the context of such reforms.

[1]Studies from 1990s often compared steady states and focused on capital/wealth changes.

2 Motivation

With progressing longevity and lowering fertility rates, maintaining defined benefit schemes may actually become fiscally (and socially) unviable. Majority of numerical excercises demonstrate that without a substantial decrease in retirement benefits or equally substantial increase in effective retirement age - fiscal sustanability is hazarded. On the other hand, pro-fertility policies, even if effective, would not be sufficient to stop the demographic transition in many of the OECD countries. Thus, it seems that the todays notion of retirement welfare - as sufficient, *a priori* defined benefit coming from the state - cannot be maintained in the future.

Policy makers and experts alike propose two somewhat detached solutions. One approach focuses on the fiscal side and proposes inevitably painful reforms to the pension system - raising contributions, contribution base and/or lowering benefits to cut future expenditure. The alternative approach emphasizes the demographic component and favors fertility fostering policies and/or stimulating economic activity, thus in fact raising current expenditure.

A variety of pension policy responses may be observed in Europe. Some countries (e.g. France) 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[2]. Other countries (e.g. Sweden and some of the Central and Eastern European countries) aim at relieving the future generations by imposing so-called (partially) pre-funded DC schemes that involve a considerable reduction in the effective replacement rates.

Such reform - partial "privatization of the social security" - was implemented in Poland in 1999, with the introduction of the three pillar system. The first pillar is a notional defined contribution pay-as-you-go Social Insurance Fund (SIF), where current contributions are used to pay out current benefits, but the contributions are recorded in individual accounts and will serve as a basis for computing an annuity upon retirement. The contributions in that pillar are indexed annually according to payroll growth[3]. The second pillar is a fully funded defined contribution one, where Open Pension Funds (OPFs) invest contributions in the name of participants, earning interest free of capital income tax. These contributions and interest cannot be deemed prior to the retirement. Both these pillars are mandatory. 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. Due to insufficient incentives, the third pillar is not popular, with about 1.3% of the working population contributing any voluntary pension savings schemes.

Poland is an interesting example to analyze in the context of welfare consequences of fiscal closure, since the pension reform has been implemented in 1999, when the demographics were still viable, although already deteriorating. The reform creates an inevitable fiscal gap in the first pillar, i.e. SIF. Originally, this gap in SIF was supposed to be topped by the revenues from privatization. In fact, despite sudden slowdown in the privatization rate as of 2005, for as much as eight years after the reform the cumulated privatization proceeds exceeded the actual transfer to the OPFs. However, due to a typical time inconsistency as well as political instability, this feature of the system was abandoned early despite being fairly feasible, Figure 1.

Conceptually, there are three possible fiscal adjustments to accommodate the gap. The first one consists of adjusting downward the replacement rate as soon as possible to prohibit the gap from growing. Thus, the welfare costs of the reform would burden mostly the old generation. In the second one, taxes could be temporarily raised, shifting the fiscal burden to the currently working population[4]. Finally, one could allow the gap to accumulate into public debt and spread the costs of repaying and servicing this debt across all generations, including the future ones. The first of the fiscal closures may be politically impossible to implement and raises questions about justice, as old generations can do nothing to accommodate such systemic change. Thus, only the second and the third one seem viable. 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. On the other hand, any debt needs to be serviced, which raises the financial as well as welfare costs of the reform. Which of the two is a dominant factor remains an open question. This is the contention this paper seeks to verify in an OLG framework.

While this question is interesting in itself, low level of voluntary pension savings seems to suggest that time inconsistency may play particularly important role. Financial literacy is relatively low in

[2]See for example: EC (2012).

[3]Actually, untill 2004 this was 75% of the payroll growth, but the legislation was changed.

[4]Please note, that under DC raising contributions to the pension system is not a solution, since actuarial fairness would imply higher benefits in the future

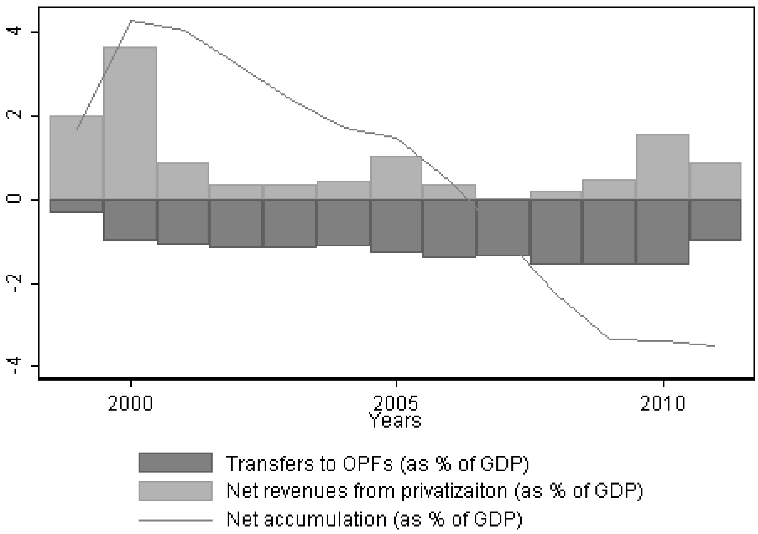


Figure 1: The revenues from privatization were comparable in size to the transfers from SIF to OPFs. *Source*: own computation based on SIF and Treasury anual reports.

Poland while it has become customary to think about pensions in terms of replacement rate. The "privatization of the social security" might not have been fully accommodated by the citizens, making them unable to judge adequately the necessary level of private savings. This outcome would be empirically indiscernible from time inconsistency and thus it is useful to test the susceptibility of the conclusions to this phenomenon.

3 Literature review

EconLit search on "pension system" and "overlapping generations" returns 434 publications. The literature in the field is not only vast, but also expands at a very high rate. Ever since the original question of Martin Feldstein *would privatizing social security raise economic welfare* (Feldstein 1995), a large number of studies inquired into the generality of three conditions suggested by Feldstein. The original conditions comprised:

1. the marginal product of capital exceeds the rate of economic growth;
2. the capital intensity of the economy is below the welfare maximizing level (i.e., the marginal product of capital exceeds the appropriate consumption discount rate); and
3. the rate of economic growth is positive.

The originally fairly constrained model by Auerbach and Kotlikoff (1987) has subsequently been extended in a number of relevant directions. First, these models were equipped with a realistic demographic transition, which goes beyond changes in a standard mortality rate, Fehr (2000). In fact, deteriorating demography has been demonstrated to be quantitatively the driving factor for fiscal stance change as well as the potential effects of the reform, De Nardi et al. (1999). In the case of Europe, due to more rapid aging, the fiscal effects are particularly large, Boersch-Supan and Ludwig (2010). In addition, demography has one more consequence for the outcomes also 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 speed of longevity may play an important role as well, Sanchez-Marcos and Sanchez-Martin (2006).

Secondly, the models have been enriched from the labor market perspective. 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) .

Third, theoretical extensions include uncertainty and risk. 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 uninsurable shocks to individual productivity, the original conclusions of Feldstein highly stylized model do not necessarily hold. Similar conclusions originates 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)[5]. 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)[6]. 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.

Interestingly enough, the extent of distortion or inefficiency introduced by such systems is usually left outside the scopes of these papers. One of the reason, 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). In addition, building these models is usually time consuming, while running variable policy scenarios requires also considerable computing power, which has become available only fairly recently. Finally, since 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).

Finally, the reform of the pension system typically alters the proportions between the implicit and the explicit public debt. Genakoplos et al. (2000) shows that often the individual benefits from diversification (e.g. by allocating part of the savings in stocks rather than government bonds) are confused with the social benefit of making the implicit public debt explicit (which originates not from diversification *per se*, but from the fact that the property rights to the pension claims are set *ex ante*, not after the retirement). Pre-funding raises rates of return for later generations in this setting, but at the cost of lower returns for today's workers. On the other hand, Kuhle (2010) finds that with uncertainty due to the factor prices, if a government can issue safe bonds and new claims to wage-indexed social security to service a given initial obligation, there exists a set of Pareto-efficient ways to do so. This set is characterized by the conflicting interests of the current young and the yet unborn generations regarding the allocation of factor-price risks.

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 the case of China (e.g. Li and Mérette (2005)), 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)) as well as 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[7]. 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 to the best of our knowledge.

Summarizing, thanks to the development of the theoretical models as well as the growth of computing capacity, current OLG models of the pension systems are currently able to replicate such important features of the reality as (i) risk and uncertainty, (ii) time inconsistency and myopia, as well as (iii) complex working/saving trajectories. The question of reform efficiency, however, has been addressed to a much lesser extent than the simulations of changes originating from encompassing these three types of features. The aim of this paper is not to extend the current and rich variety of model specifications. Rather, we aim to build on the available developments in order to focus on the reform itself, analyzing the welfare effects of various fiscal closures to the model.

[5] Alternative approach has been proposed by Gul and Pesendorfer (2004) with recursive and separable dynamic self-control preferences. Caliendo (2011) generalizes Imrohoroglu et al. (2003) for a continuous time case.

[6] Sometimes time-inconsistency involves the duration of economic activity rather than savings, cfr. Findley and Caliendo (2012)

[7] Also 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.

4 Theoretical model

We implement quasi-hyperbolic discounting in an OLG framework. We use the notation of j for agent's age and t for time. The government taxes consumption and income from capital and labor, issues and services debt, purchases goods (fixed exogenous share of GDP), and pays (part of) retirement benefits. There is a constant returns to scale Cobb-Douglas aggregate production function, constant labor-augmenting technical progress, and no aggregate uncertainty. Equilibrium factor prices are time-varying but deterministic. The model includes demography (agents face the mortality risk and there are new generations arriving in the economy at each period of time). The model consists of consumers' choice, production sector, the pension system and an exogenous government - described in detail in the next subsections.

4.1 Consumers' choice

Consumers are assumed to discount in a quasi-hyperbolic fashion and live for $j = 1, 2..., J$ periods. They optimize lifetime utility derived from leisure and consumption:

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

The intra-temporal choice, as standard in this literature, concerns leisure $(1 - l_{j,t})$ and consumption $(c_{j,t})$, whereas consumers are free to accumulate savings $s_{j,t}$ throughout the life-time (inter-temporal choice). The coefficient of β denotes time inconsistency in the form of quasi-hyperbolic discounting[8]. 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. The notation of π in equation (1) conveys the non-zero probability of dying between the age of j and $j + 1$. Discounting takes into account time preference δ and probability of survival π. Short lived agents will necessarily have higher preference for today. Consumers know the exact age and time specific mortality rates. At all points in time, consumers who survive until the age of $j = 79$ die with certitude when reaching the age of $J = 80$. Longevity and lowering fertility is operationalized in our model by decreasing across time the size of the 20-year old cohort as well as decreasing the mortality rates.

Consumers are perfectly free to chose labor supply during the working period (elastic labor supply), but once they reach the age of $\bar{J}$ they are "forced" to retire and are unable to supply any labor. In exchange for supplying age-specific amount of labor l_j consumers receive earned income of w, i.e. market clearing marginal productivity of labor. Since individuals are characterized by age-specific productivity path ω_j, individual at age j receives gross total labor earnings of $l_j \cdot w \cdot \omega_j$, labor income tax τ_l and social security contributions τ_s are deducted from earned income to yield disposable labor income. All agents are characterized by the same age-specific productivity pattern ω_j.

Interest earned on savings r_t are taxed with τ_k. In addition, there is a consumption tax τ_c as well as a lump sum tax/transfer Υ_t equal for all generations. In order to be able to compensate across generations once the reform is introduced, we additionally design τ_j which is a cohort-specific lump sum tax/transfer allocated by the Lump Sum Redistribution Authority (LSRA). Thus, for working age population $(j < \bar{J})$ the budget constraint at time t is given by:

$$(1 + \tau_{c,t})c_{j,t} + s_{j,t} + \tau_j + \Upsilon_t = (1 - \tau_{\iota,t} - \tau_{l,t})w_{j,t}l_{j,t} + \left(1 + r_t\left(1 - \tau_{k,t}\right)\right) s_{j,t-1} \tag{2}$$

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

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

where $b_{\iota,j,t}$ denotes pension benefit for person at age j in time t. Pension systems are indexed by ι, which corresponds to either Defined Contribution or Defined Benefit $(\iota \in \{DB, DC\})$. The Lump Sum Redistribution Authority (LSRA) allocates the tax/transfer to each cohort comparing the utility cohort j would have had in the no-change scenario and the one cohort j has in the analyzed policy change scenario. The tax/transfer is computed as consumption equivalence based on the difference in the utilities.

The utility function, as standard in the literature, is taking the CRRA form. The instantaneous utility function is given by

$$u_j\left(c_{j,t}, l_{j,t}\right) \quad = \quad c_{j,t}^{\phi}\left(1 - l_{j,t}\right)^{1-\phi} \tag{4}$$

[8]We follow Imrohoroglu et al. (2003), who discuss various alternatives to such formulation of time-inconsistency, as well as its microfoundations.

and we assume $l_{j,t} = 0$ for $j > \bar{J}$. In this specification ϕ is the intra-temporal substitution elasticity between consumption and leisure. Thus agent of age j in period t maximizes

$$u_j(c_{j,t}, l_{j,t}) + \beta \sum_{s=1}^{J-j} \delta^s \frac{\pi_{j+s,t+s}}{\pi_{j,t}} u_j\left(c_{j+s,t+s}, l_{j+s,t+s}\right) \tag{5}$$

subject to the budget constraints (2)-(3).

4.2 Production

Using capital and labour the producers provide a composite consumption good with the Cobb-Douglas production function $Y_t = K_t^{\alpha}(z_t L_t)^{1-\alpha}$. Firms solve the following problem:

$$\begin{aligned} \max_{(Y_t, K_t, L_t)} \quad & Y_t - w_t L_t - (r_t + d) K_t \\ s.to \quad & Y_t = K_t^{\alpha} (z_t L_t)^{1-\alpha} \end{aligned} \tag{6}$$

where L_t represents aggregate labuor employment. We allow for labor augmenting exogenous economic growth $\gamma_t = z_{t+1}/z_t$. Bouzahzah et al. (2002) 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. Thus, for clarity, we model this economy as governed by exogenous productivity growth.

Note that if the return on capital rate is r_t then the rental rate must be $r_t + d$, where d denotes capital depreciation. Firm optimization naturally implies $w_t = (1-\alpha)K_t^{\alpha} z_t^{1-\alpha} L_t{}^{-\alpha}$ and $r_t + d = \alpha K_t^{\alpha-1}(z_t L_t)^{1-\alpha}$.

4.3 Pension system and the government

The DB PAYG pension system consists of an exogenous contribution rate τ and an exogenous replacement rate ρ. The system collects contributions from the working and pays to the retired:

$$\sum_{j=\bar{J}}^{J} \pi_{j,t} N_{t-j} b_{1,j,t} = \tau_{1,t} \sum_{j=1}^{\bar{J}-1} w_{j,t} \pi_{j,t} N_{t-j} l_{j,t} + subsidy_t \tag{7}$$

where $subsidy_t$ is a subsidy/transfer from the government to balance the pension system.

The DC funded pension system collects contributions as individual stock of (mandatory) pension savings and at retirement converts them to annuity. For simplicity we denote by τ_1 the obligatory contribution that goes into the PAYG system and by τ_2 the mandatory contribution that goes into the funded system, whereas b_1 and b_2 denote benefits from these two components of the pension system. Reform consists of two important components: (i) changing the values for these parameters and (ii) changing the way the benefits are established. Namely, under DB the replacement rate ρ specifies the benefit received upon retirement. Under DC, however, all contributions are converted into an annuity. This allows to capture the fact that majority of the reforms retain a public pension fund with the PAYG character, but individual savings give the basis for computing the benefit[9]. Thus, under DB the benefit is given by:

$$b_{DB,j,t} = \rho_t w_{\bar{J}_t - 1}. \tag{8}$$

Under defined contribution pension system, benefits are given by:

$$\begin{aligned} b_{1,j,t} &= \frac{\sum_{s=1}^{\bar{J}-1} \left[\Pi_{\iota=1}^{s}(1 + r_{t-j+\iota-1}^{I})\right] \tau_{1,t-j+s-1} w_{j,t-j+s-1} l_{j,t-j+s-1}}{\prod_{s=\bar{J}}^{J} \pi_{s,t}} \\ b_{2,j,t} &= \frac{\sum_{s=1}^{\bar{J}-1} \left[\Pi_{\iota=1}^{s}(1 + r_{t-j+\iota-1}^{II})\right] \tau_{2,t-j+s-1} w_{j,t-j+s-1} l_{j,t-j+s-1}}{\prod_{s=\bar{J}}^{J} \pi_{s,t}} \\ b_{DC,j,t} &= b_{1,j,t} + b_{2,j,t}, \end{aligned} \tag{9}$$

where r^I denotes the indexation rate in the obligatory notional defined contribution pillar. This particular rate is defined by legislation and bases on the growth rate of the contribution base:

$$r_t^I = \left(\frac{\sum_{j=1}^{J} \left(N_{t-j} w_{j,t} l_{j,t} - \pi_{j,t-1} N_{t-1-j} w_{j,t-1} l_{j,t-1}\right)}{\sum_{j=1}^{J} \pi_{j,t-1} N_{t-1-j} w_{j,t-1} l_{j,t-1}} \right). \tag{10}$$

[9]This is frequently referred to as Notional Defined Contribution - NDC.

The interest rate r^{II} in pillar II is a net rate of return from investing in a composite asset. For brevity the model has no risk (and thus no risk preferences). However, the model requires two interest rates: one paid by the government on any debt it issues and one paid by the firms on any investment by the households. Naturally, the former is lower. In the world with no risk and no risk preference, households would only invest in firms' productive capital, thus forcing the government to finance itself at a prohibitively high cost. To solve this problem we introduce $r^G = \xi r$. Households buy as much government debt as is issued at r_G and allocate whatever savings are left to capital accumulation. The actual interest rate on private saving - both mandatory (in pillar II) and voluntary - is given by a weighted average of r^G and r, where the weights are implied by government demand (debt) and size of savings. Data implies that over the 1995-2005 period the government paid approximately 45% of the commercial market interest rate, while this proportion is decreasing at a decreasing rate. Thus, ξ was set to 33%.

If the capital pillar II of the pension system is actuarially fair, the benefits paid out to an agent equal the contributions he has made to the system, thus the system is by construction balanced. For the NDC component of the DC pension system (the I pillar) the same holds in principle, but since the collected contributions are contemporaneously paid out in the form of benefits to the retirees, under deteriorating demographics it may occur that at obligations exceed the revenues. We thus specify, that this is the government that collects social security contributions and pays out pensions.

$$subsidy_t = \tau_{1,t} w_t L_t - \sum_{j=\bar{J}}^{J} b_{1,j,t}\pi_{j,t}N_{t-j} \tag{11}$$

Naturally, in addition to balancing the social security, the government collects taxes on earnings, interest and consumption and spends a fixed share of GDP on unproductive (but necessary) consumption. Given that the government is indebted, it naturally also services the outstanding debt.

$$\begin{aligned} T_t &= \tau_{l,t}\Big(w_t L_t + \sum_{j=\bar{J}}^{J} b_{j,t}\pi_{j,t}N_{t-j}\Big) + \Big(\tau_{c,t}c_t + \tau_{k,t}r_t s_{j,t-1}\Big)\sum_{j=1}^{J}\pi_{j,t}N_{t-j} && (12)\\ G_t &+ subsidy_t + r_t^G D_{t-1} = T_t + (D_t - D_{t-1}) + \Upsilon_t \sum_{j=1}^{J}\pi_{j,t}N_{t-j}. && (13)\end{aligned}$$

with $G_t = \gamma_g Y$. 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 to match the deficits and debt to maintain long run debt/GDP ratio fixed.

Please, note this utiity function is already favorable for welfare under DB schemes. Namely, should agents expect the taxes to grow in the future (e.g. because of higher SIF deficit for example), they save *ex ante* to accomodate for this change. The perfect foresight for all macroeconomic variables thus assures that consumers are not surprised by e.g. pensions lower than expected. Whereas this is consistent with a rational agent, it seems fairly unlikely to hold in reality, especially in DB schemes. This feature is partly tackled by time-inconsistency in our model.

4.4 Market clearing conditions

The goods market clearing condition is standardly defined as

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

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:

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

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

4.5 Definition of equilibrium and model solving

An equilibrium is an allocation $\{(c_{1,t},...,c_{J,t}),(s_{1,t},...,s_{J,t}),(l_{1,t},...,l_{J,t}),K_t,Y_t,L_t\}_{t=0}^{\infty}$ and prices $\{w_t,r_t\}_{t=0}^{\infty}$ such that

- 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 for all t, given prices;
- (K_t,Y_t,L_t) solves the firm's problem (6);
- government sector is balanced, i.e. (7) - (13) are satisfied;
- markets clear, i.e. (14)-(15) are satisfied.

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. While eventually the length of the path was set to 250 periods it is actually irrelevant for the results as long as it exceeds 140 periods (60 years of demographic projection plus 80 years of optimization of the first generation born in the new steady state).

It is the initial steady state that is calibrated. Regardless of the scenario, the major difference between the initial and the final steady state consists of demography (different populations of 20-year-olds and different mortality rates) and productivity growth (converging from higher rates to rates observed in developed economies), as described in detail in Section 5. Since the model has a unit root in the labor-augmenting technology process z_t, the analyzed economy evolves along a deterministic growth path. Therefore, non-stationary variables are detrended and all aggregates are expressed in *per capita* terms. Between the initial and the final steady states lies the transition path.

The model is solved three times[10]. First, the benchmark scenario is computed for no policy change, but changes in demographics and in productivity. Second time the model is solved for the analyzed policy change scenario. In both these runs utility for all generations is computed. The utilities constitute basis for the Lump Sum Redistribution Authority (LSRA), similar to Nishiyama and Smetters (2007). Tax/transfer is set as a consumption equivalent for each cohort between the baseline scenario and the analyzed scenario. In the third run, to account for the general equilibrium effects, individuals in the analyzed policy scenario obtain the transfer (positive or negative, depending on a cohort) from the LSRA. The net balance of the LSRA informs about the overall efficiency of the reform. The focus of this paper is not on the reform efficiency, though, but rather on the welfare effects of various fiscal closures once the pension system reform is implemented. Thus, we stick to the welfare comparisons throughout the presentation of the results, but the post-reform results contain the transfer/tax compensating for the policy change. The net balance of the LSRA adds to the public debt in the model.

We use the following algorithm to solve the model (both in the steady states and on the transition paths). First, we guess the path (or the value of capital per worker). Then we compbute 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 using the formula in (15). This procedure is repeated until the difference between k from subsequent iterations is negligible[11]. Along the transition path, in each iteration, the values from the previous period indeed come from the previous period, while in the steady state they are just the values from the previous iteration. 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.

Once the initial and the final points of the transition path are established, algorithm seeks equilibrium for each period between these two points. Initial starting values for capital k on the path need to be set, but the method of filling this vector (e.g. linear, jump-wise, exponential, etc.) affects only how long the equilibrium is computed, but not the equilibrium itself. In a similar manner vector of values for all necessary remaining variables is filled to enable point-wise computations on the transition path (these are individual labor supply, individual consumption, individual savings, individual benefits in the first and the second pillar and individual saving in the second pillar).

[10] As is standard in the literature, we use the Gauss-Seidel method.

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

5 Calibration

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 paths, taxes, growth rates, etc. Given these parametrization, we calibrated the discount factor δ so that the combined interest rate in the economy r was close to 7.4% and d so that the aggregate investment rate matched the one observed in the data, i.e. app. 21%[12]. 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.

5.1 Calibration of the structural parameters

This section describes the calibration of all structural parameters in the model. We discuss below demographics, productivity, preferences and depreciation as well as taxation.

Demographics. The model is a dynamic one, we thus used the demographic projection for Poland[13]. 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, Figure 2. 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. It is well known that female mortality rates are lower than the male mortality rates, but since our model is blind to gender, used mortality rates are population weighted averages of the two values. Demographics is assumed constant after 130 periods (50 periods of the simulation + 80 periods for 20-year-olds in the last year of the simulation), to assure the steady state properties.

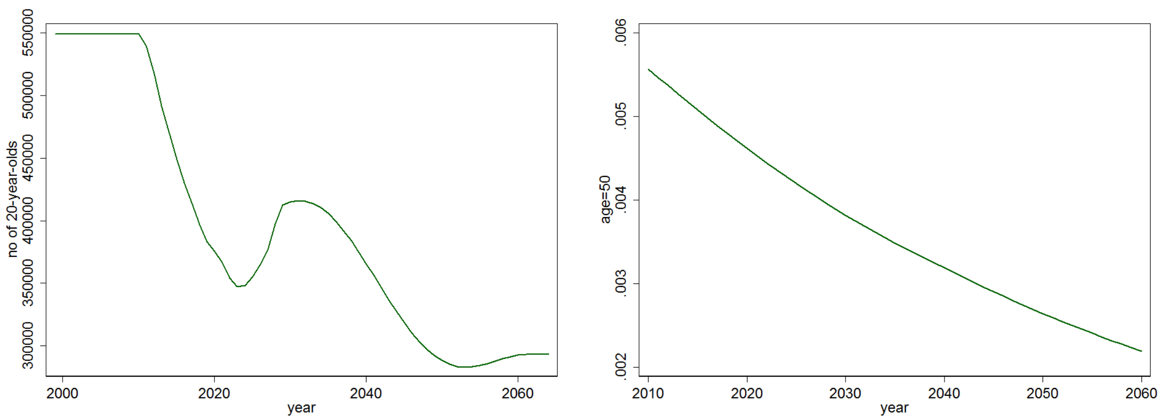


Figure 2: No of 20-year-olds arriving in the model in each period (left) and mortality rates across time for a selected cohort. *Source*: EUROSTAT demographic forecast untill 2060.

Productivity growth (γ_t). The model specifies labour augmenting growth of productivity $\gamma_{t+1} = z_{t+1}/z_t$. The values for 50 years ahead projection were taken from the forecast by the Ageing Work Group of the European Commission, which comprises such time series for all EU Member States, Figure 3. 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*.

Preference for leisure (ϕ). Agents' preference for leisure/consumption, as specified by ϕ in the utility function is directly responsible for the labor supply decisions. Just before the reform labor market participation rate amounted to 56.8% and ϕ was chosen to match this participation rate. The

[12]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. Average for a period between 1995 (first reliable post-transition data) and 2010 amounts to 20.7%.

[13]Polish Central Statistical Office publishes data at lower frequency and for five-year age groups, we thus used the projection of the European Commission.

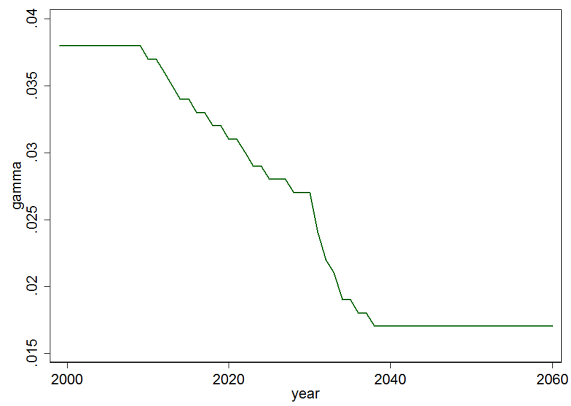


Figure 3: Labor augmenting productivity growth rate projection. *Source*: European Comission

final value amounts to 0.53, which seems reasonable: average hours worked in Polish economy amount to app. 2050[14], i.e. 51.5% of the total workable time.

Impatience (discount factor, δ). All consumers discount future at a rate of δ whose value was chosen to match the actual investment rate with the interest rate of 7.5%, as described above. Depreciation rate is subsequently calibrated to match the investment rate in the economy. However, in the scenarios with time inconsistency, there is an additional discounting parameter β, whose values are set in line with the literature. Namely, we simulate the model for three values of $\beta = \{1, 0.9, 0.8\}$, where $\beta = 1$ implies no time inconsistency.

Age specific productivity (ω_j). 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[15]. 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). For the purpose of this analysis we decomposed the differences in individual productivities into age effects, cohort effects and time effects, using Deaton (1997) decomposition. We used 16 years of consecutive quarterly Labour Force Survey datasets. While the computation does not account for the Heckman type selection effects, we did include education, occupation and industry in the decomposition to account for the significant structural changes underwent by the economy due to the transition from a centrally planned to a market economy. The age effects estimates obtained from the Deaton (1997) decomposition were subsequently standardized to average 1 in a life cycle, Figure 4 (left panel). This set of parameters is stable throughout time. As a robustness check, we also run the model with flat age-productivity pattern.

Retirement age ($\bar{J}$). *De iure* retirement age is 60 for women and 65 for men. However, the age when exiting labour market to receive some form of retirement benefit is effectively much lower due to a number of exempts from general retirement age across occupations and age cohorts. These exceptions were partly removed as of 2009, while the *de iure* retirement age is supposed to reach 67 for men in 2018 and for women in 2040. In addition, there seem to be important cohort effects with the generations working mostly pre-transition having preference for relatively early exit and better skilled cohorts working mostly post-transition staying longer in the labour market. These legislative and cohort effects are reflected in a path of retirement age in our model, Figure 4 (right panel). Past values for the effective average age of retirement come from SIF annual reports.

Replacement rate (ρ). The *de iure* replacement rate is defined by legislation. In fact pension is only granted if cumulative 25 years of work is documented by the future retiree (20 for women). Individual reported earnings are benchmarked against the average earned income the country in each year, yielding an average multiplier. The actual multiplier is not based on all reported periods bt an average of the best

[14]Conference Board, averaged for 1999-2012 (*ahwpol* from The Conference Board Total Economy Database).
[15]Skirbekk (2004) as well as a forthcoming special issue of Labor Economics (volume 22, 2013).

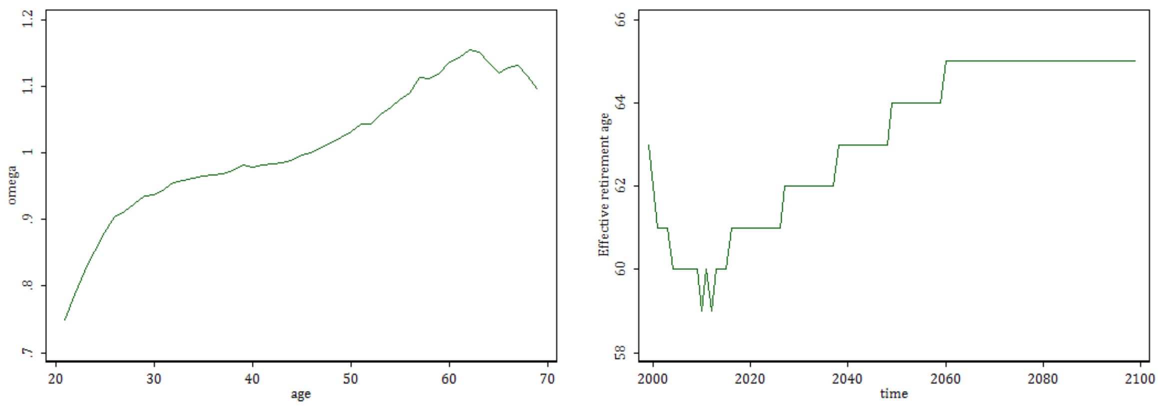


Figure 4: Age specific productivity multiplier (left) and actual retirement age in economy, past values and forecasts. *Source*: ω computed according to Deaton (1997) decomposition using 16 years of LFS data for Poland. Effective retirement age based on SIF annual reports, own projection

10 out of the last 20 working years. This multiplier combined with the base rate announced annually by the government yields the reference pension. The actual pension consists of a minimum pension and reference pension multiplied by the share of time worked in total period over which the contributions were made. On the other hand, in 1999 there was a large number of exceptions concerning not only the retirement age, but also the number of working years to be documented as well as the actual basis for computing the reference pension. Consequently, it is impossible to calibrate this parameter based on the legislation. On the other hand, SIF publishes annually the average pension to the new retirees, whereas Central Statistical Office reports both the participation rates for the working population and the national economy compensation. Using these sources we set $\rho = b_{DB,t}/w_t l_t = 0.51 * 56.8\% = 29\%$. However, this calibration yielded a pension to GDP ratio that was too low. We thus raised ρ to match the 5% pensions to GDP ratio in 1999. Depending on the selected ω scenario, the actual value for the replacement rate differs.

Taxes on labor income (τ, τ_l). Due to the incomplete coverage for the labor taxes and social security contributions, we set these rates in order to match the macroeconomic aggregates. The incomplete coverage results from the fact that various forms of labor contracts are characterized by different effective taxation rates. In addition, tax system comprises a large number of exceptions, redemptions and caps, which result in lowering the actual share of taxes in incomes. Thus, labor income tax, 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. Thus, 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. 6.5% (depending on the ω scenario).

Other taxes (τ_k, τ_c). 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.

5.2 Savings and wealth

Wealth data is not available in any micro-level dataset that could be used to calibrate the distribution across generations. We are also unable to match private savings to age cohorts, as sources such as Household Budget Survey only provide data on savings made at the moment of survey, i.e. flows instead of stocks. Nonetheless, the pension reform implied that the SIF needs to compute for all cohorts participating in DC system the so-called initial capital. Intuitively, initial capital reflects the counterfactual scenario on what would be the value of the records in the NDC individual account had the NDC system been instated already in the past.

SIF gave access to 1% of all contributors, including the data on initial capital. Based on the SIF

Table 1: Calibrated parameters

		$\beta = 1$		$\beta = 0.9$		$\beta = 0.8$	
		$\omega = 1$	ω - D97	$\omega = 1$	ω - D97	$\omega = 1$	ω - D97
α	capital share	0.31	0.31	0.31	0.31	0.31	0.31
τ_l	labor tax	0.11	0.11	0.11	0.11	0.11	0.11
ϕ	preference for leisure	0.538	0.576	0.535	0.577	0.537	0.579
δ	discounting rate	0.981	0.998	0.988	1.003	0.994	1.009
d	depreciation rate	0.042	0.055	0.053	0.055	0.055	0.06
τ	total soc. security contr.	0.063	0.060	0.061	0.061	0.061	0.061
ρ	replacement rate	0.270	0.150	0.253	0.153	0.255	0.155
		resulting					
$\Delta k_t / y_t$	investment rate	21	20.7	21.2	20.7	21.3	21
r	interest rate	7.6	7.5	7.2	7.5	7.2	7.5

Note: D97 denotes calibration according to Deaton (1997) decomposition.

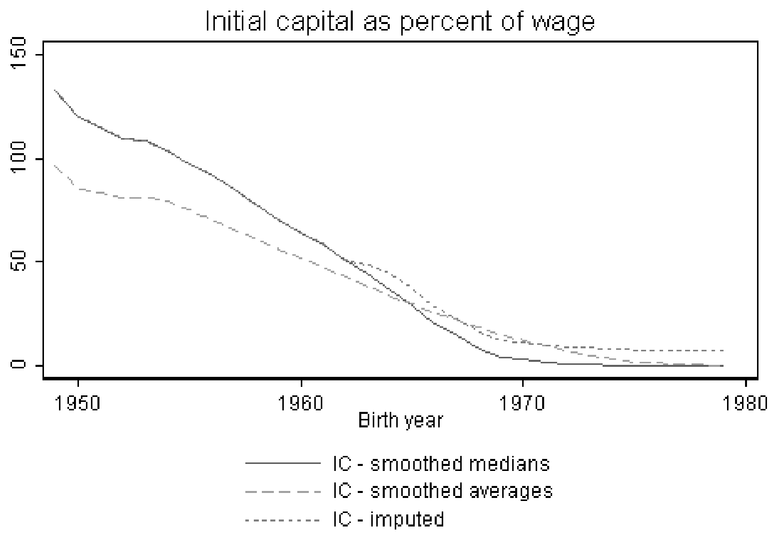


Figure 5: Initial capital. *Source*: own computation based on individual savings data from SIF.

reported initial capital across cohorts means and quartiles were computed. It should be noted, though, that this data should be treated with caution. Namely, all contributors are allowed to request readjustment of the initial capital until retirement, based on any premises they find suitable. This concerns particularly those, who worked discontinuously during that period and never reported to the SIF that some of their contributions are missing. In fact, for younger cohorts as much as 90% of the population reports 0 initial capital, which does not seem likely.

Since income distributions are highly skewed, medians are preferable to means. On the other hand, younger generation suffer from potentially underreported initial income. To address this problem we have used the medians across all the cohorts, but in the case of younger cohorts imposed the age-specific structure as observed on the means, Figure 5. To assure comparability with the model, initial capital is expressed in terms of average wage (w).

The introduction of the pension system reform in Poland involved certain transition periods. The two pillar reform became effective as of January 1st 1999 and was obligatory for all cohorts born on January 1st 1969 and younger. For the cohorts born between 1949 and 1969 the change from pay-as-you-go to NDC was mandatory, but there was no obligation to participate in the II pillar. In other words, the way the benefit was to be calculated changed for these generations, but they could decide that the entire contribution is directed to the NDC pay-as-you-go I pillar in SIF. Finally, generations born prior to 1949 (thus at the age of 50 or older at the moment of pension system reform) stayed in DB pay-as-you-go I pillar in SIF. Using data on actual participation in the II pillar we proportionally split contributions for the 1949-1969 generations between pillar I and pillar II.

5.3 Fiscal closure scenarios

The benchmark scenario - no policy change - involves staying with 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, but more importantly, it produces also the path of utilities across cohorts. In order to assure comparability, lifetime utility of each cohort is discounted to the age of 20.

We consider five scenarios. In the first case, all deficit generated by the reform is contemporaneously financed by with labor taxes. We call it the labor tax closure. Naturally, since all generations pay labor income tax in our model (and in reality), reform is financed in fact by all generations (not just the working ones). However, since the tax is a rate on income, higher income cohorts end up paying higher proportion of the outstanding debt. When running the labort tax closure scenario we assume that government expenditure and government debt as a share of GDP as well as all other tax and contribution rates are the same as in the initial steady state. The labor tax rate is determined endogenously so that the government budget constraint is satisfied.

In the second scenario, financing the gap is postponed to the future generation, i.e. deficit is financed with the government debt. We allow the debt to grow for the first 80 years after the reform or until an upper bound is hit (whichever happens sooner) after 80 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 threshhold and repay it using labor tax, t_l. Hence, this closure is called debt closure with labor tax. 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). Given the growth and stability pact of the European Monetary Union as well as Polish constitutional fiscal rule, maximum debt-to-GDP threshold was set at 70%[16].

The third and the fourth scenario are a mirror image of the first and the second scenario with the main exception, that debt is financed by a consumption tax t_c. The difference between the labor and the consumption tax in our model is not that much of *who* pays it, but rather *how much* of it is paid by each cohorts. Namely, as in Polish legislation, retirees pay the labor income tax too. However, while labor income is highly variable during the working life (due to age-productivity patterns and due to changes in labor supply), consumption is smoothened by the consumers. Thus, at middle age each cohort will end up paying a higher proportion of debt if the debt is repaid by the labor tax (although the same share of income), whereas this portion is constant in the case of debt repaid by the consumption tax.

Finally, we analyze as well fifth scenario in which the debt is instantaneously financed by the lump sum tax Υ which is equal across all cohorts. This scenario is considered for the means of comparison between earlier studies, e.g. Nishiyama and Smetters (2007), Okamoto (2005b). In addition, when drafting the reform, the government expressed intent to finance the gap due to the partially funded pillar with the proceeds from privatization, which is equivalent to a lump sum case scenario.

Naturally, demography and productivity changes display themselves also in the baseline scenario. Since this is the reference for comparison to the policy scenarios, we allow parallel changes in the baseline. For example, in the scenario with the labor tax closure, labor tax grows to satisfy the budget constraint in both baseline of staying with the DB PAYG system and in the transition to the new, partially funded DC system. In fact, this is important for our findings. If taxes are not changed in the DB baseline scenario, the accumulated debt in the pension system grows substantially due to longevity and lowering overall labor supply, Figure 6.

The non-monotonous behavior of benefits in Figure 6 (i.e. wiggles) follows from the adjustments in retirement age, as envisaged by Figure 3. Since age is discrete, if the retirement age increases in a particular year then there are no cohorts retiring, and two cohorts will retire in a subsequent year. The opposite effect works if retirement age is reduced. This non-monotonicity is translated to nearly all simulations in our model.

6 Results

Together we analyzed five closures for each calibration of age-productivity patterns. However, since potential time inconsistency has been emphasized by the literature to affect the results, we repeated these ten simulations both without time inconsistency (i.e. $\beta = 1$) with relatively small time inconsistency (i.e. $\beta = 0.9$) and with what the literature recognizes to be considerable time inconsitency (i.e. $\beta = 0.8$).

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

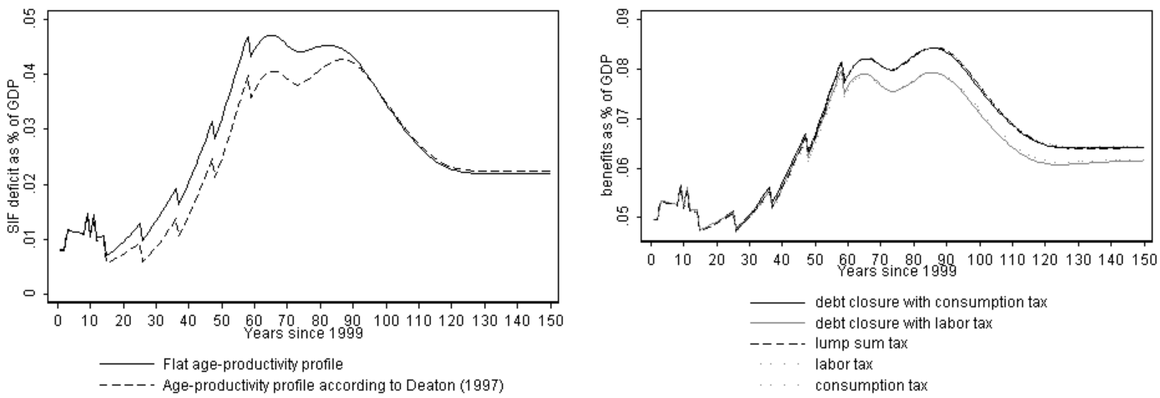


Figure 6: Cumulated changes in SIF balance and pension share in GDP in the baseline scenario of no policy change (no time inconsistency, Deaton (1997) productivity.

We thus run 30 scenarios. In each scenario we first produce the baseline results for the *status quo*, which consists of a PAYG DB system. We then run the same scenario with the system reform, which is a transition to a DC system with partially funded capital pillar. Finally, LSRA comes to play, compensating the generations who loose as a result of the reform.

The proposed reform is efficient, irrespectively of the fiscal closure, i.e. after compensating all the generations that loose out as a result of the reform, LSRA has still net positive wealth to redistribute. Table 2 displays the utility of the initial cohorts (all those born at the time of the reform or before). For comparison purpose this value has been discounted for each cohort to its age of 20 and stationarized (to adjust for the economic growth). It is expressed as utility net of transfers by the LSRA. The general efficiency of the reform is custom in the literature, while indeed gains increase with the extent of time inconsistency, as suggested by Imrohoroglu et al. (2003). The welfare gain comes from collecting gains (measured by consumption equivalence) from all the cohorts that benefit from the reform after compensating those cohorts that loose welfare as a result of the reform.

The contribution of this paper is the comparison across various fiscal closure scenarios. The gap implied by at least partial 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 taxation is distortionary, it may indeed be the case that relatively small distortion across all possible cohorts are superior in terms of welfare to a larger distortion condensed across a smaller fraction of cohorts. Thus, comparing the welfare effects of various fiscal closures is an empirical question. Our analysis shows that there are considerable differences across the three analyzed closures. In fact, taxing labor in the transition phase is superior to taxing consumption or a lump sum tax. This result is robust to both time inconsistency and alternative variants of age-productivity pattern.

Table 2: LSRA net wealth after redistribution

Fiscal	closure	$\beta = 1$		$\beta = 0.9$		$\beta = 0.8$	
		$\omega = 1$	ω - D97	$\omega = 1$	ω - D97	$\omega = 1$	ω - D97
Labor	in units of consumption	0.019	0.008	0.010	0.006	0.005	0.003
tax	% change in consumption	0.039	0.029	0.024	0.021	0.013	0.010
Debt with	in units of consumption	0.019	0.008	0.010	0.006	0.005	0.003
labor tax	% change in consumption	0.039	0.029	0.023	0.021	0.012	0.010
Consumption	in units of consumption	0.019	0.009	0.010	0.006	0.005	0.004
tax	% change in consumption	0.038	0.029	0.024	0.021	0.013	0.010
Debt with	in units of consumption	0.019	0.009	0.010	0.006	0.005	0.003
consumption	% change in consumption	0.038	0.029	0.023	0.020	0.012	0.010
Lump sum	in units of consumption	0.018	0.009	0.010	0.006	0.005	0.003
tax	% change in consumption	0.039	0.031	0.028	0.022	0.019	0.012

Note: When redistributing, LSRA weights by the size of the generation, but otherwise assigns equal importance to each. The bigger the value, the higher the efficiency gain. D97 denotes calibration according to Deaton (1997) decomposition.

Whether the gap should be financed instantenously or postponed to future generations in terms of debt is another question answered by our study. While important differences exist between labor taxation and other taxes, for both proportional taxations there are not that big differences between the closure with the debt and the closure with instantenous taxation. Namely, welfare is slighly lower in the case of debt, but the difference is below 0.1pp of lifetime consumption. We move further to discuss the scale of fiscal adjustment, but intuitively, only slighly lower welfare gain in the case of debt closures is coupled with greater political feasiblity, as opposed to instantenous (and large, as is discussed later) increase in taxation.

Lower efficiency gain in the case of debt closure stems from two features of this model/economy. First, debt share in GDP starts at a relatively high level and accumulates relatively fast, which implies that the upper bound threshold is reached only 15 periods after the change of the pension system. In the baseline scenario of no policy change the threshold debt value is also reached, about 15 years later. Since our horizon encompasses over 250 periods, in fact over majority of time the extent of the fiscal adjustment in reform and in the baseline case are quite similar. Consequently, in both scenarios majority of the fiscal adjustment happens actually *via* consumption taxation leaving relatively less room for the efficiency gain.

Higher efficiency gain the case of labor tax closure is a consequence of the fact that at the moment when the reform is introduced in our economy, the population is still relatively young and the old age dependency rate is relatively low. Thus, although labor tax rate needs to grow, in per capita terms this increase is less than the future increase in the scenario of no policy change.

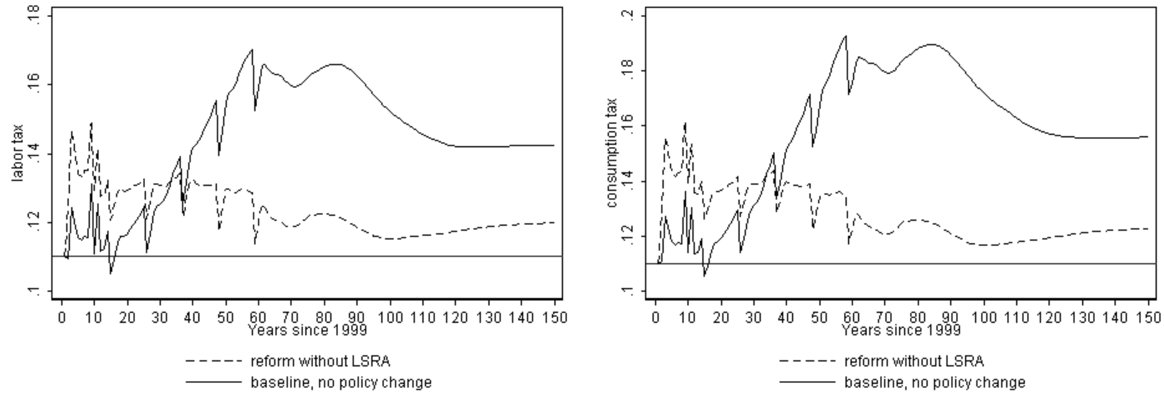
The extent of fiscal adjustment in each of the closures is in fact considerable and justifies relatively large welfare effects, Figure 7. Consumption, labor and lump sum tax grow in the initial phase of the pension system change by roughly 30%, although it should be noted that in the scenario of no policy change these rates would have to increase as well. The increase due to the reform is larger than the contemporaneous increase in the baseline scenario. However, about 30 years since the reform the actual differences resulting from its implementation become visible. The baseline scenario tax rates start to increase sharply, whereas in the reform scenarios majority of adjustment has already taken place. With the reduced deficit in the SIF, tax rates are actually reduced in our framework.

The amount of excessive taxation reaches 6 pp. in the case of labor tax closure, i.e. as much as 50% of the tax rate. It is 3 in the case of a lump sum tax. The overall fiscal adjustment, relative to baseline would be of effectively 2pp in the labor income tax or approximately 1pp in the case of the lump sum tax. Such tax increase would not be feasible in practice. Once the reform is implemented, in the DC steady state, actual tax rates are considerably lower than in the original DB equilibrium, which follows form the fact that SIF deficit does not need to be financed with general taxes. This is consistent with the situation in which lowered replacement rates are off set by higher private savings. This is in line with faster capital accumulation, as will be discussed later on.

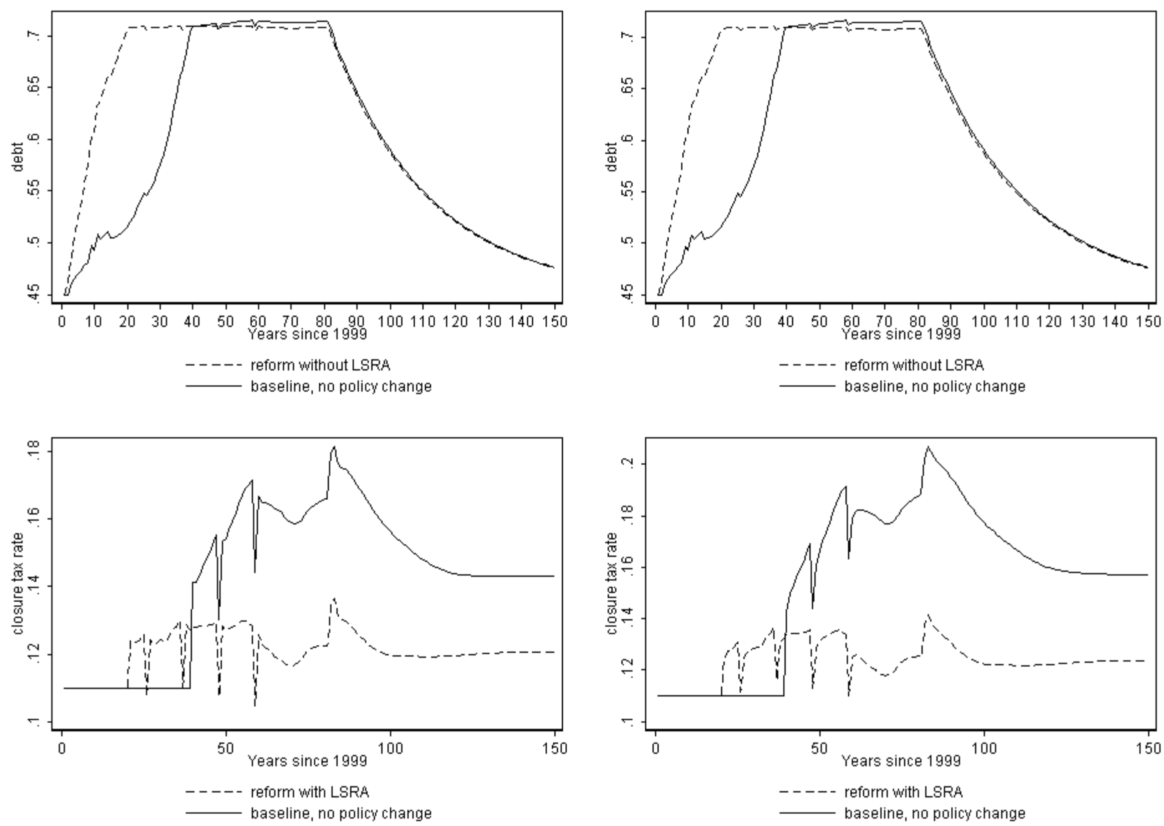
We discuss in detail the properties of the baseline specification, which involves no time inconsistency and employs age-productivity pattern according to Deaton (1997). In the subsequent subsections we show the welfare effects as well as sensitivity analysis with respect to the time inconsistency.

Figure 7: The extent of fiscal adjustments in baseline and policy change scenarios.

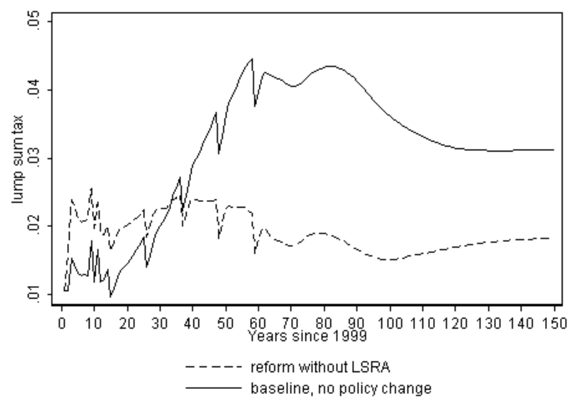
(a) labor tax (left) and consumption tax (right)



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



(c) lump sum tax



6.1 Changes in the economy - baseline specification

Table 3 and discuss the key macroeconomic indicators in the baseline specification for Deaton (1997) age-productivity pattern and for a flat pattern, respectively. Results do not include redistribution by LSRA[17]. The gain in GDP over the baseline scenario amounts to app. 0.5% in a decade and as much as nearly 3% over 50 years. This output gain follows almost entirely from faster capital accumulation, as changes in labor supply are minuscule. In fact, capital grows by app 8.5% to 9% more under the any of the reform scenarios than under *status quo* of no policy change, depending on age-productivity patterns. As has been visible in our calibrations, the initial replacement rate may indeed be lower in those simulations where productivity grows in age. This implies considerable adjustment in income at the moment of retirement, thus forcing savings to grow. This explains why flat age profiles yield lower capital accumulation and thus lower output, *ceteris paribus*.

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. If more change was to be expected, it 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. On the other hand, labor market in our model is frictionless and perfectly elastic, which implies one should observe little aggregate changes. Naturally, there are also some incentive effects for the labor supply, but as long as households cannot adapt the retirement age, nor the educational/productivity choices, the effects of system change are bound to be relatively small.

Table 3: Baseline results - no time inconsistency ($\beta = 1$)

Closure		GDP		Labor supply		Capital	
	Period	D97 ω	flat ω	D97 ω	flat ω	D97 ω	flat ω
	10	1.005	1.007	1.000	1.000	1.016	1.023
Labor tax	30	1.016	1.020	0.998	1.003	1.053	1.062
	50	1.025	1.029	1.002	1.012	1.083	1.092
	∞	1.026	1.031	1.000	1.005	1.088	1.096
	10	1.000	1.002	1.004	1.007	1.000	1.006
Debt with	30	1.012	1.018	0.995	0.996	1.041	1.054
labor tax	50	1.023	1.028	1.003	1.014	1.076	1.088
	∞	1.026	1.031	1.000	1.004	1.088	1.096
	10	1.008	1.010	1.000	1.004	1.025	1.030
Consumption tax	30	1.023	1.029	1.002	1.008	1.076	1.092
	50	1.034	1.039	1.005	1.013	1.113	1.124
	∞	1.026	1.030	1.001	1.005	1.085	1.093
	10	0.999	1.001	1.003	1.005	0.998	1.004
Debt with	30	1.012	1.021	0.999	1.005	1.040	1.064
consumption tax	50	1.034	1.040	1.005	1.013	1.114	1.127
	∞	1.026	1.030	1.001	1.005	1.085	1.093
	10	1.006	1.007	1.005	1.009	1.018	1.023
Lump sum	30	1.016	1.021	1.001	1.002	1.052	1.065
tax	50	1.024	1.029	0.994	0.995	1.080	1.092
	∞	1.026	1.029	0.991	0.995	1.086	1.090

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.

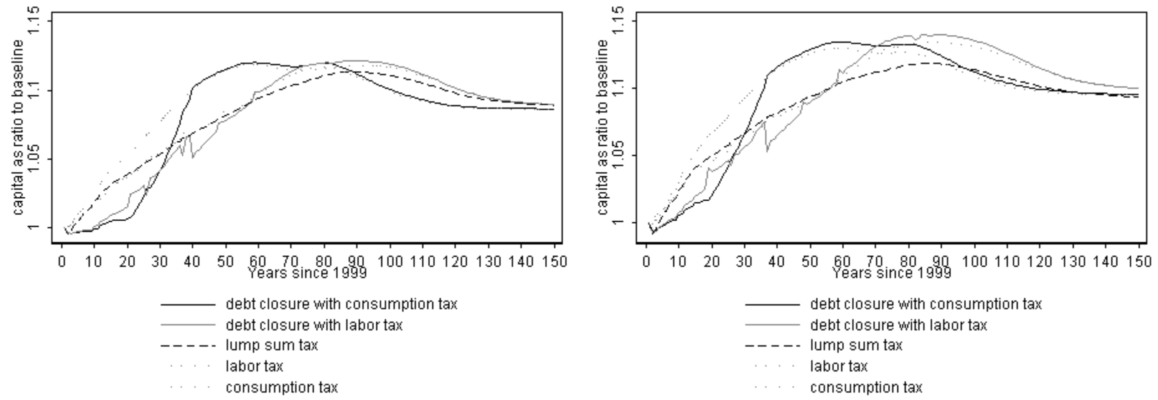
The age-productivity pattern is not neutral to the change in the pension system. Under the DB system it is the replacement rate computed on the last ten years of activity that affects the benefit. On the other hand, with DC system it is the entire lifetime earned income that translates to amount of benefit received. With flat age pattern it is only the labor supply that affects life cycle income profile and thus the pension. However, if the productivity is increasing in age, labor supply is likely to reflect closely this pattern, because the incentives to work change together with productivity. These effects,

[17]Results with redistribution show neutrality for labor supply and slightly lower pace of capital accumulation, but differences are visible at third decimal place.

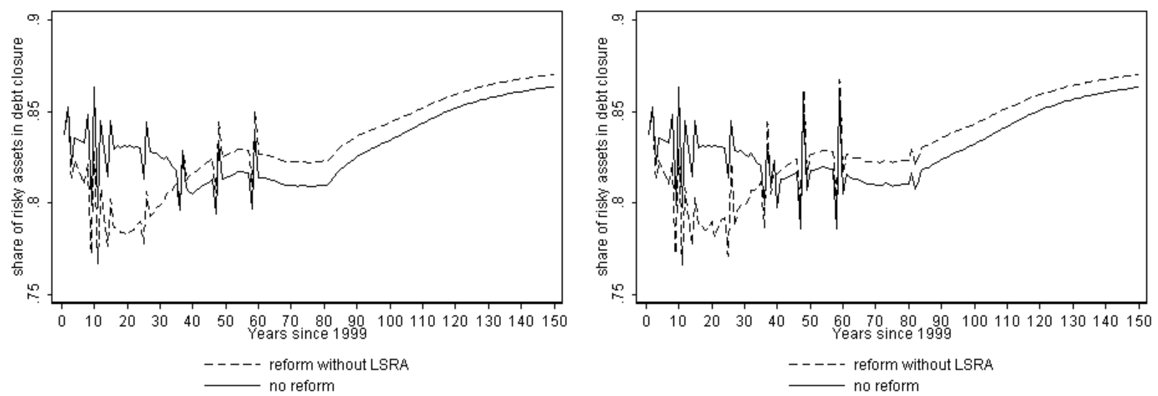
however, are minor quantitatively and matter more for the timing of the increase/decrease in the rate of capital accumulation than for its actual level.

Figure 8: Changes to capital and savings structure

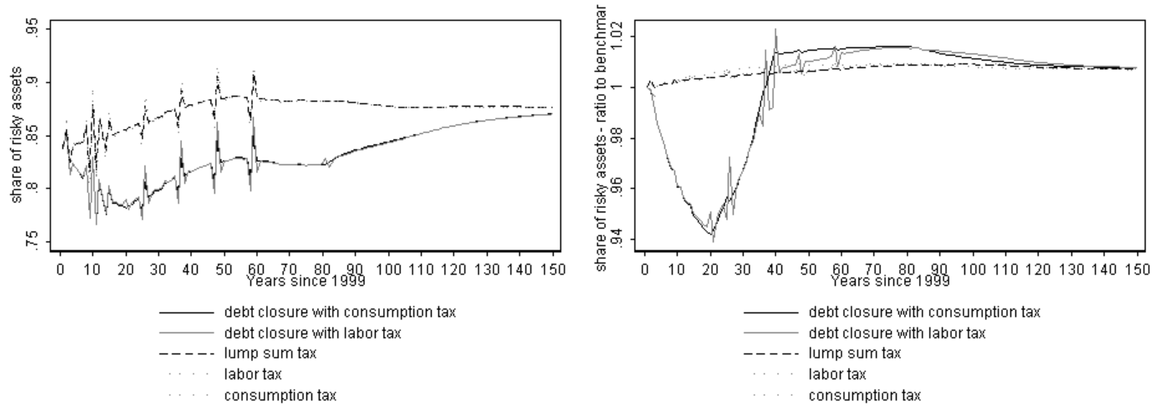
(a) Capital (after LSRA) in reference to no-policy-change scenario, Deaton (1997) productivity (left) and flat age productivity profile (right).



(b) Share of investment assets in savings portfolio in reference to no-policy-change scenario, debt with consumption tax (left) and debt with labor tax (right), Deaton (1997) productivity.



(c) Share of investment assets in savings portfolio in reference to no-policy-change scenario, depending on a closure (left) and relative to *status quo* of no system change (right), Deaton (1997) productivity .



The contention, that all changes to the baseline are driven by the emergence of the funded pillar is further corroborated by an analysis of time patterns, Figure 8a. 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. In fact, the share of investment in the portfolio is lower in the debt scenarios untill the debt is actually repaid, Figure 8b. The size of crowding out amounts to 4% (or app 3.5 pp.). However, 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. Since the final steady state is associated with the same level of debt, regardless of the pension system - shares of investment assets eventually converge to the same level, while capital is about 9% higher in the reform scenario than if the economy kept the PAYG DB system.

6.2 Welfare effects of the reform

In terms of welfare, the reform is generally harmful for older generations and generally beneficial for younger generations. Regardless of the fiscal closure scenario, the reform itself introduces great changes into the utility (with reference to the baseline of no policy change) for almost all generations, Figure 9 and 10. These changes are harmful for the living cohorts and beneficial for the cohorts to be born after the reform. This outcome is a composition of two counterveining effects: on the one hand the reform lowers substantially the replacement rates, but on the other, since pension system has no deficit under the reform scenario, taxes are lower.

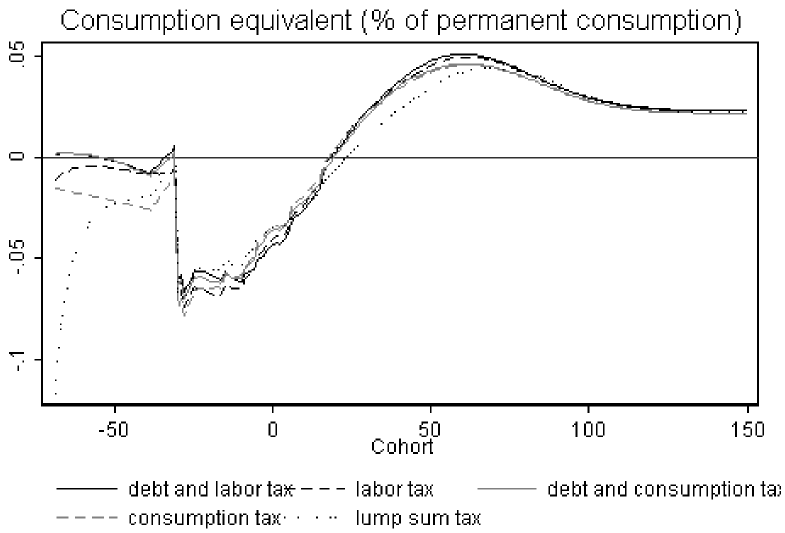


Figure 9: Consumption equivalent depending on the closure. Cohort denotes age $j = 1$ in 1999

However, these welfare changes are a composition of two effects. First, is the change from a DB to a DC system with pension calculated at an actuarially fair basis. Second, part of the contribution is diverted from the SIF to the capital market. Clearly, lowering of the pensions due to moving away from DB towards a DC system is harmful for all those who cannot fully accommodate the decrease in the effective replacement rates and beneficial to all future generations who avoid the tax burden associated with DB unattainability. On the other hand, reducing the burden of adjustment on these generations *via* public debt puts extra burden on future generations who will be forced to repay this debt with interests.

To analyze, which of the two effects dominates we additionally run a set of simulations, where the reform of DB to DC is introduced but no capital pillar is established. Welfare levels of respective cohorts are then compared to the reform with the capital pillar in order to demonstrate, which of the components of the pension system is harmful/beneficial for which cohorts. These results are presented in Figure 11a-11c. The gray bars show the contribution from the introduction of the capital pillar, whereas the line shows the total effect (by induction, the distance between them is the contribution of moving away from a defined benefit to a defined contribution scheme). The negative contribution from the DB-to-DC part implies that the new pension scheme is actually more generous at some periods, imposing extra debt or extra taxation.

Clearly, majority of the welfare effect comes from the DB-to-DC transition. In general, lowering of the replacement rates for the living generations - even if gradual - cannot be accomodated for without reduction in utility. With the exception of few oldest working cohorts, the costs of the reform are considerable, up to 7% of permanent consumption. This suggests that the designed transition into the new system (the mechanism for computing the initial capital) has not been sufficient to compensate older cohorts for the change in the mechanism of computing the pensions. However, the decomposition demonstrates much more than that. Namely, it illustrates the burden of each fiscal closure on respective cohorts coming from both components of the reform.

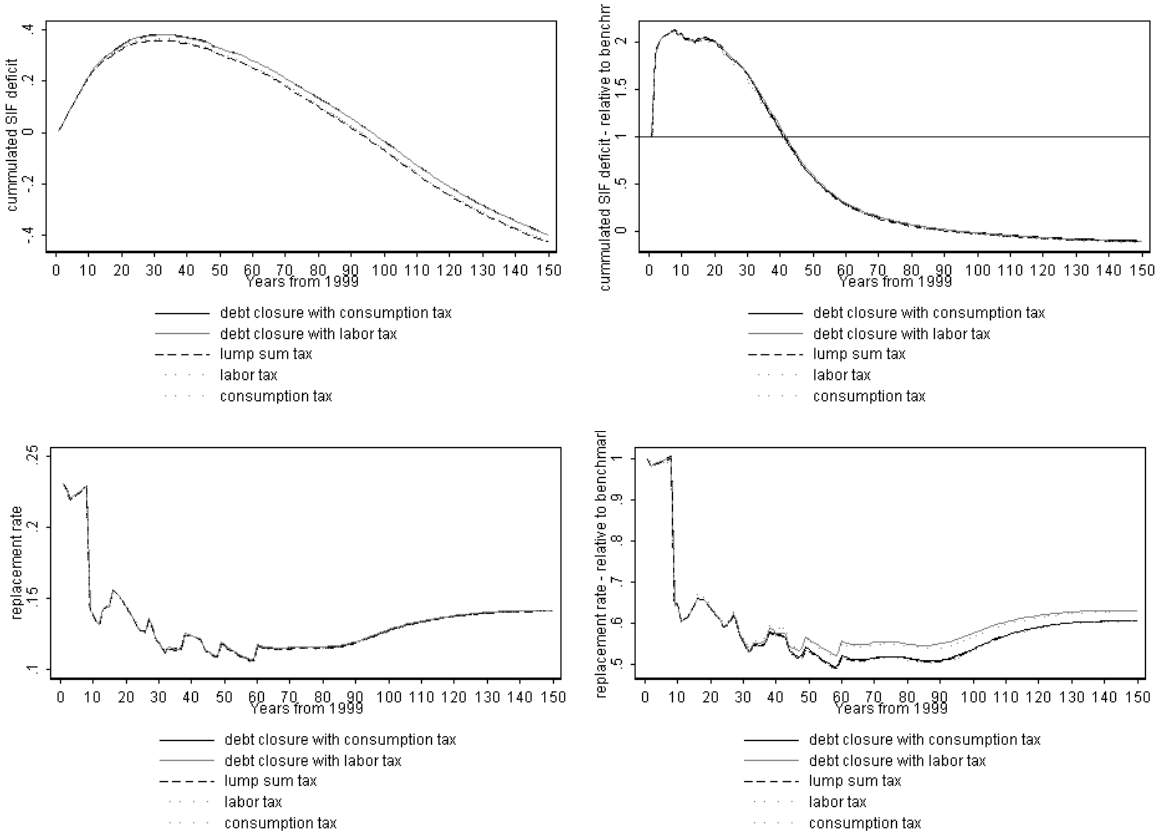


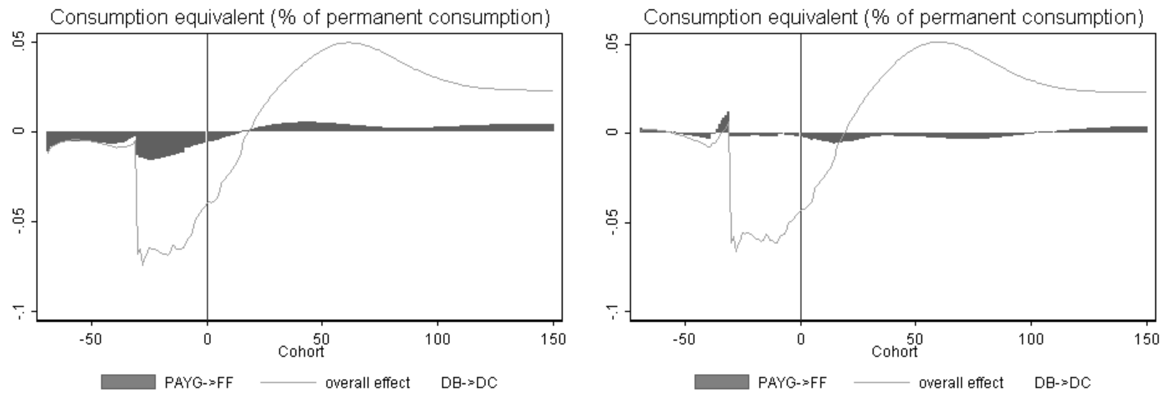
Figure 10: Fiscal side of the pension system reform

Analyzing the welfare effects of introducing the capital pillar, one needs to acknowledge that the utility is typically lower (although, as dicussed earlier, the reform has still enhanced the economic growth). Comparing the taxation mechanisms, labor tax imposes less wealth loss than consumption tax. This stems from the nature of these two taxes, as discussed earlier in the paper. More importantly, when combined with public debt, both types of taxes allow so-to-say equal spread of the costs of establishing the capital pillar among all generations. Beyond hundred years of the reform, welfare effects of having a capital pillar are positive, regardless of the closure, which explains also why the overall effect of having a capital pilar is positive.

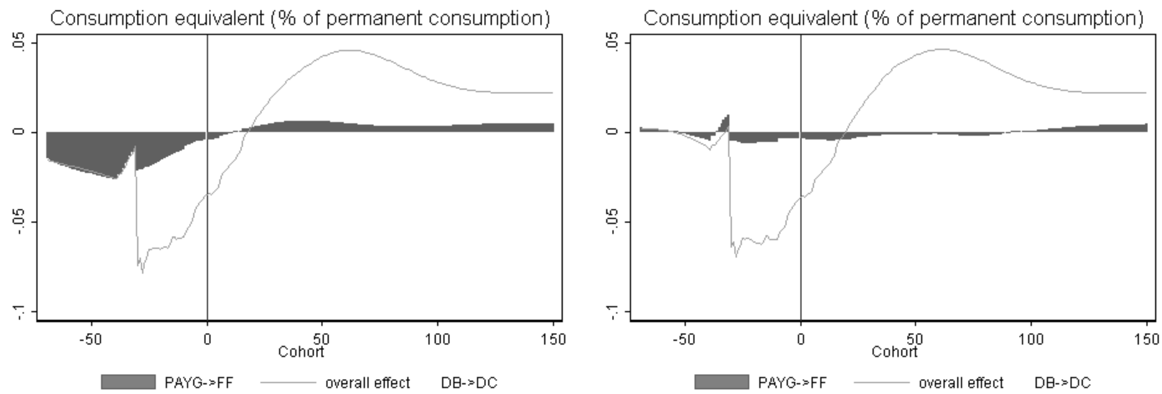
These results are likely to be susceptible to time inconsistency. The rationale is the following. Having a capital pillar on a pension system is generally welfare deteriorating for the living cohorts, due to higher taxation (in our specifications, as in reality, the debt cannot grow beyond some reasonable levels). In fact, it pushes consumers to reduce current consumption and raise savings, at least when compared to a scenario where only DB-to-DC change is introduced. With time inconsistency, the departure from a preferred savings path may be stronger, which could likely influence further the welfare gains from having a capital pillar.

Figure 11: Welfare decomposition, no time inconsistency

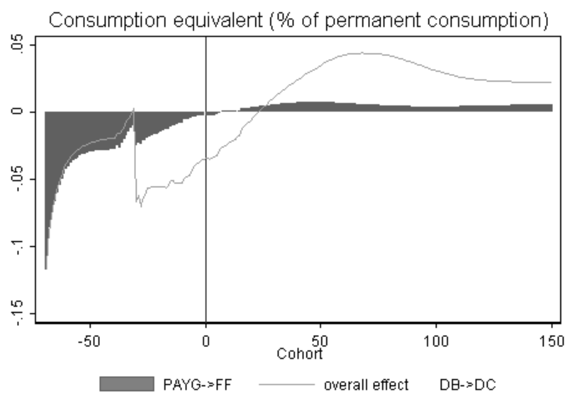
(a) labor tax (left) and debt with labor tax (right)



(b) consumption tax (left) and debt with consumption tax (right)



(c) lump sum tax



Note: cohort denotes age $j = 1$ in 1999

6.3 Sensitivity check - time inconsistency

Higher extent of myopia implies in general lower private savings. This expectation is corroborated by our simulations, Table 4. In such case, compulsory yet private savings in the pension system with a capital pillar help raising capital accumulation, relative to the scenario of no policy change, especially with productivity growing over the life cycle. Indeed, higher extent of time inconsistency leads to slightly faster capital accumulation, relative to the scenario of no policy change. The differencesa are minuscule on the other hand - very high time inconsistency ($\beta = 0.8$) translate to a difference app. 0.003 bigger under the reform than under baseline.

While the link between time inconsistency and the speed of capital accumulation under various scenarios of fiscal closures is relatively clear, our paper offers an interesting insight concerning the welfare effects. Intuitively, the greater time inconsistency - since it generates suboptimal savings - the greater should be welfare gain from the privatization of social security. This is also the feature of our model. But once lower beta is supplemented with higher delta (to match the initial interest rate) an increase in time inconsistency lowers welfare gain from the reform. Actually, it seems that agents burdened with time inconsistency actually end up in an equilibrium with higher capital, output and labor supply relative to baseline, but the benefits of the reform are higher, recall Table 2. This is because the welfare of all the future generations is lower under time inconsistency than without it, Figures 12a-12c.

Table 4: Capital relative to benchmark - depending on time inconsistency

Closure		$\beta = 0.8$		$\beta = 0.9$		$\beta = 1$	
	Period	$\omega = 1$	ω - D97	$\omega = 1$	ω - D97	$\omega = 1$	ω - D97
	10	1.026	1.017	1.026	1.017	1.023	1.016
Labor tax	30	1.069	1.058	1.071	1.055	1.062	1.053
	50	1.101	1.091	1.103	1.086	1.092	1.083
	∞	1.098	1.094	1.101	1.092	1.096	1.088
	10	1.009	1.000	1.010	1.000	1.006	1.000
Debt with	30	1.061	1.046	1.065	1.043	1.054	1.041
labor tax	50	1.097	1.086	1.099	1.081	1.088	1.076
	∞	1.098	1.094	1.101	1.092	1.096	1.088
	10	1.033	1.026	1.034	1.025	1.030	1.025
Consumption tax	30	1.099	1.082	1.102	1.079	1.092	1.076
	50	1.133	1.121	1.136	1.117	1.124	1.113
	∞	1.097	1.092	1.099	1.089	1.093	1.085
	10	1.007	0.999	1.008	0.998	1.004	0.998
Debt with	30	1.073	1.048	1.077	1.043	1.064	1.040
consumption tax	50	1.133	1.126	1.136	1.119	1.127	1.114
	∞	1.097	1.092	1.099	1.089	1.093	1.085
	10	1.027	1.020	1.027	1.019	1.023	1.018
Lump sum	30	1.071	1.057	1.073	1.054	1.065	1.052
tax	50	1.099	1.087	1.101	1.084	1.092	1.080
	∞	1.093	1.094	1.096	1.091	1.090	1.086

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.

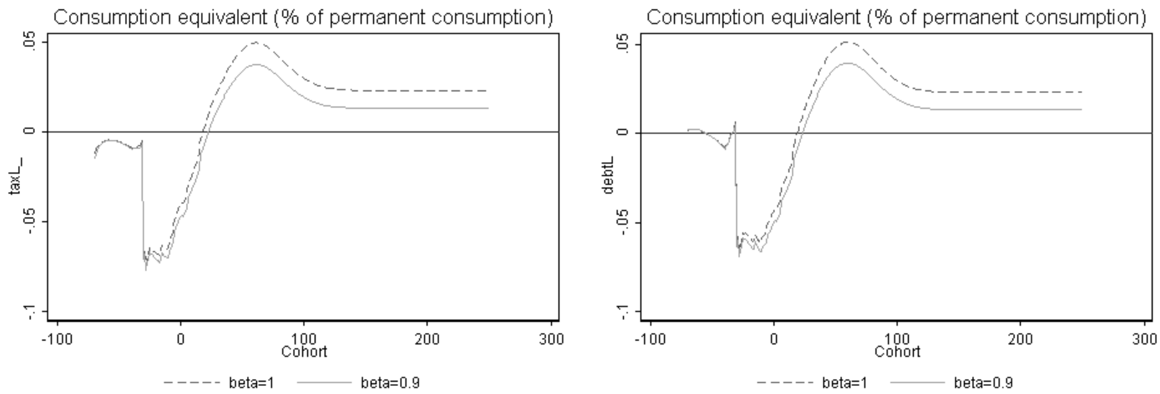
This result implies that a disciplining device in the form of forced pension savings with a (partially funded) DC scheme are in fact welfare deteriorating for the generations living during the reform. While the living generations benefit from the debt closure, future generations will experience welfare gain from lower implied taxation but agents with time inconsistent preferences would rather keep private savings at a lower level than resulting from the obligatory contributions to the funded pillar of the social security system.

Similar observation may be made with reference to the role of setting up the capital pillar across various analyzed fiscal closures. The more myopic the agents are, the higher the welfare loss from the pre-funded pillar, Figures 13a-13e. On the other hand, gains from lower future taxation outweight. In fact, it seems that the forced pension savings exceed the preferred savings rate of the agents, despite substantially lower replacement rates in the PAYG pillar of the pension system.

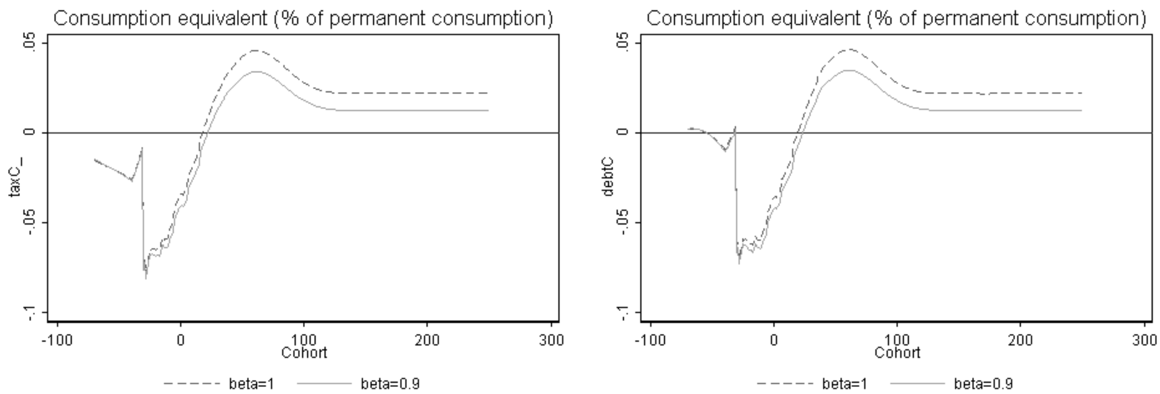
Interpreting these results plainly one obtains that with (large degree of) time inconsistency, although agents should expect longevity and decrease in the speed of productivity growth, the current contribution rates to the capital pillar are binding. Higher speed of capital accumulation lowers the relative price of capital, forcing households to work more or save more to assure the same levels of future consumption. 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. The capital pillar cannot deliver welfare improvement if households would otherwise save less.

Figure 12: Welfare effects depending on time inconsistency

(a) labor tax (left) and debt with labor tax (right)



(b) consumption tax (left) and debt with consumption tax (right)



(c) lump sum tax

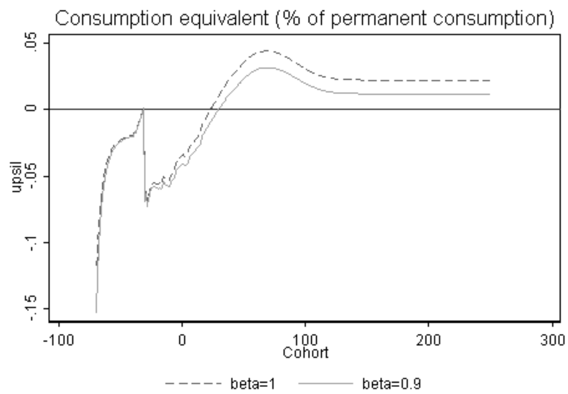
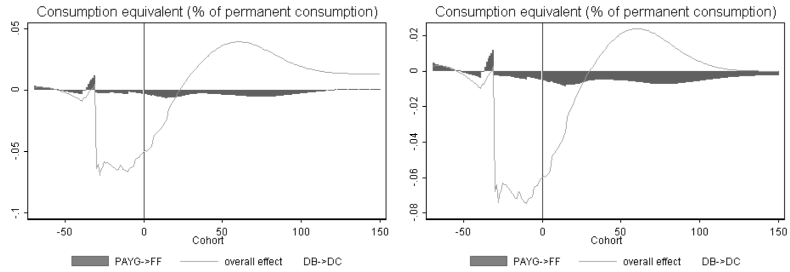
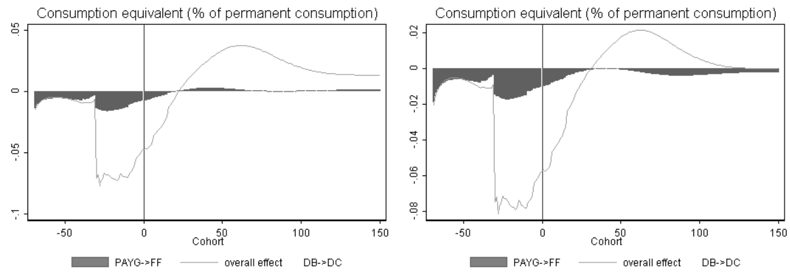


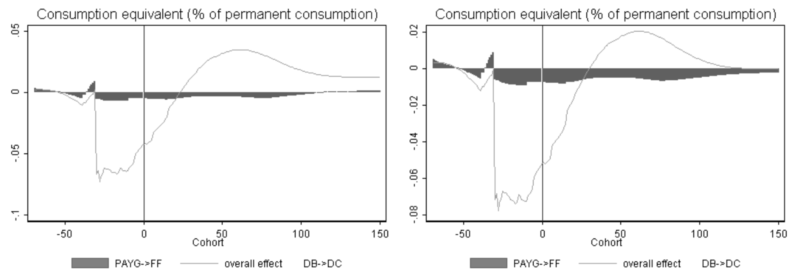
Figure 13: Welfare decomposition depending on the extent of time inconsistency: $\beta = 0.9$ (left) and $\beta = 0.8$ (right). Deaton (1997) productivity profile.



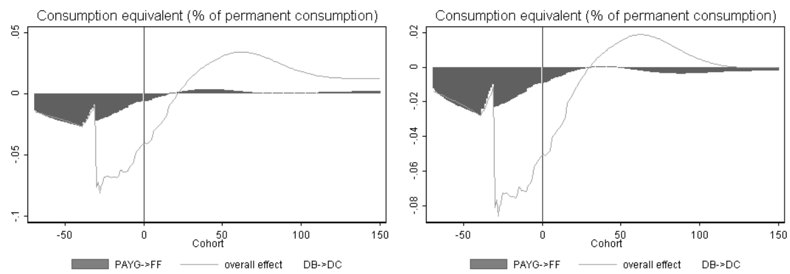
(a) closure with debt and labor tax



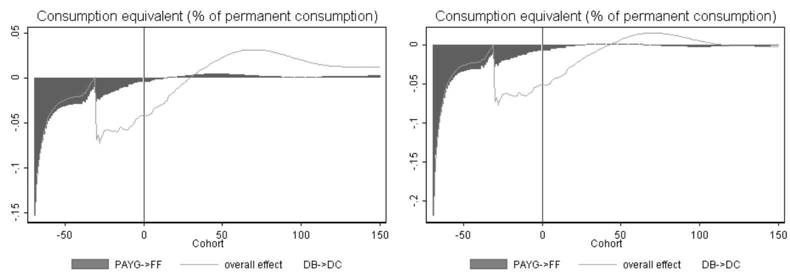
(b) closure with labor tax



(c) Closure with debt and consumption tax



(d) closure with consumption tax



(e) closure with lump sum tax

7 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 been already addressed in the literature, there is considerable differentiation concerning the forms of the fiscal closures adopted in various studies. In addition, the literature typically combines toghether the change from a defined benefit to a defined contribution scheme with establishing a capital pillar.

This paper aimed 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 changing the scheme (DB to DC) and changes due to changing the financing mechanism (PAYG to pre-funding). While the reform itself has welfare effects, so have the fiscal adjustment necessary to implement the reform. We demonstrate that financing the reform with debt yields inferior welfare gains when compared to taxation of the generations living at the moment of the reform. However, this superiority of taxation is not large in aggregate terms, while financing the reform with debt allows to spread the costs of establishing the pre-funded pillar fairly across all generations. This result is robust to time inconsistency as well as assumptions concerning life cycle productivity patterns.

There are at least three weaknesses that need to be addressed for such models to produce comprehensive recommendations for policy. First, retirement age is exogenous in our framework. While it has been marked to data it is likely that endogenous retirement age may change the optimization by the households, hence altering the equilibrium. Moreover, the model assumes perfectly elastic labor supply, which is not supported by the data. Finally, note that the modeling of time inconsistency is relatively simple in our paper. Agents are time inconsistent and - so to say - do not make provisions for that. Sophisticated version of time inconsistency proposes that rational agents should be aware of their time inconsistency and thus make necessary provisions. This approach would potentially decrease the quantitatively already small effects of time inconsistency, but would also be closer to a rational agent assumption. Incorporating sophisticated time inconsistency offers a potentially promising avenue for extending the framework offered in this paper. Another potentially promising direction is better modelling of the labor supply. A number of papers addressses both work incentives and sophisticated modelling of the labor market itself, cfr. Vogel et al. (2012), Keuschnigg et al. (2012). While they already allow for endogenizing the retirement age, little is known about the role of the assumption about perfectly elastic labor supply.

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