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Evaluating an old-age voluntary saving scheme under incomplete rationality

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Abstract
We provide ex ante welfare, fiscal and general macroeconomic evaluation of the voluntary old-age saving scheme recently introduced in Poland (Pracownicze Plany Kapitałowe, Employees' Capital Plans). ECPs provide tax redemptions as well as lump-sum transfers with the objective to foster old-age savings. Reduction in capital income tax revenues and a rise in expenditure needs to be compensated through adjustment in other taxes. We employ an overlapping generations model (OLG) to gauge the plausible magnitude of the macroeconomic and welfare effects and provide insights in terms of microfoundations of these adjustments. Our OLG model features voluntary participation and innovates relative to the literature by introducing agents with hand-to-mouth preferences. We find relatively high crowding out of private savings. In our preferred specification roughly 0.08 to 0.09 PLN of each 1 PLN allocated to ECPs are actually new savings, the rest being displaced from unincentivized private voluntary savings. The plausible values of the effective capital growth range between 0.03 and 0.42 of 1 PLN in ECPs. ECPs reduce welfare of the fully rational agents, unless they offer a sufficiently large annuity. ECPs provide consumption smoothing and interest income to HTM agents.

Keywords:
overlapping generations, ECPs, incomplete rationality

JEL Classification
C68, D63, E17, E21, H55

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1. Introduction

Overlapping generations (OLG) models, as pioneered by Diamond (1965) as well as Auerbach and Kotlikoff (1980), constitute a useful tool to provide an ex ante policy evaluation of potential reforms to the pension system. Recently, in Poland, the voluntary old-age saving schemes were introduced, Employees' Capital Plans (ECPs). They feature tax exemptions and lump-sum transfers to the participants, as well as other nudges to encourage wide participation and foster capital accumulation by the working-age cohorts. The purpose of this paper is to provide welfare, fiscal and general macroeconomic evaluation of this novel instrument.

Notwithstanding the policy objective, there is also an academic aim. Namely, fully rational agents with perfect foresight about the future, do not respond to instruments whose objective is to raise savings, because they have *already optimized* their lifetime consumption and leisure path (Gale and Scholtz, 1994; Garriga and Conesa, 2008; Kitao, 2014). If some government instruments arise, they crowd out private voluntary savings (Poterba et al., 1995; Butler, 2001; Blau 2017). Unless the method of implementation generates strong general equilibrium effects, instruments aiming at raising private voluntary savings for the old-age have neutral effect on economy. Given these rather fundamental premises, we extend an otherwise standard overlapping generations model to incorporate agents with incomplete rationality. To the best of our knowledge, this is the first such extension of an OLG model to analyze voluntary old-age saving schemes

In our setup, a fraction of each cohort exhibits hand-to-mouth (HTM) behavior, which is consistent with a number of empirical regularities identified earlier in the literature (Weil, 1992; Kaplan et al, 2014; Heathcote and Perri, 2018; Olafsson and Pagel, 2018). HTM agents generally consume all the contemporaneous income, hence accumulates no assets in the working periods to finance consumption in the retirement periods. Since replacement rates between earned income and pension benefits are typically lower than 1, this type of agents experiences a sudden drop in consumption at retirement. By providing them with a vehicle to smoothen consumption over lifetime, we expand substantially their choice sets, effectively automatically raising welfare for this group of agents (Krussel and Smith, 1998). The overall effects depend on the magnitude and size of welfare effects for the fully rational agents and the general equilibrium effects for both groups of agents.

There are good empirical reasons to include agents with incomplete rationality into an overlapping generations general equilibrium framework. First, there appears to be a mismatch between the empirical evidence on savings response by the households and the predictions from a structural macroeconomic model. For example, the 1999 change in Polish pension system raised incentives to private voluntary savings – the expected pension wealth was reduced due to expected decline in pension benefits. This phenomenon was empirically analyzed by Lachowska and Myck (2018) who find average increase in savings of approximately 0.3 PLN for each 1 PLN lost in pension wealth (or: 30%). Similar magnitude of the crowing out effects was provided for Spain by Ayuso et al., (2007). Meanwhile, macroeconomic models calibrated to replicate the features of Polish economy (Hagemejer et al, 2017) imply a much stronger reaction. Introducing HTM consumers to an economy allows to align the macroeconomic implications with the microeconometric evidence.

Our study thus combines two objectives: it provides an *ex ante* policy evaluation in a methodologically novel context of overlapping generations with incomplete rationality. Once we develop the model, we use the demographic forecast to simulate the *status quo* (as if ECPs were not introduced at all) and a set of reform scenarios, with several variants of ECPs implementation. Participation in ECPs is endogenous. In the case of each reform scenario we provide an evaluation of macroeconomic (capital, labor, prices) and fiscal consequences (tax revenues, expenditures). We also provide welfare accounting of those reform scenarios. We measure the welfare effects as consumption equivalents, through compensating variation of lifetime consumption.

While to the best of our knowledge this is the first evaluation of ECPs, we are certainly not the first to use OLG to provide ex ante policy evaluation. In the case of Poland, the previous attempts include an analysis of 1999 pension reform (Makarski et al., 2017), analysis of the extensions in the retirement age from 2011 (Bielecki et al., 2016; Makarski and Tyrowicz, 2019) and an analysis of the 2013 changes in the pension system (Hagemejer et al., 2015). In terms of similar instruments, Borsch-Supan discusses evidence from across European countries and evidence for the so-called Riester Plan from Germany. Yang (2016) analyze an instrument very similar to the case of Polish ECPs, as introduce in Taiwan, in an empirical context. Similar studies analyze the effects of private voluntary old-age saving schemes in Canada (Messacar, 2018), as well as the UK and the US (Attanasio et al., 2004), among others.

We find that the crowding out effect of ECPs is considerable. In fact, the general equilibrium effects of ECPs are too small to reduce crowding out among the fully rational agents and effectively only the HTM consumers raise savings. The fully rational agents observe a decline in welfare due to the negative general equilibrium effects – mainly high fiscal cost of ECPs. The HTM agents observe large increase in welfare due to being able to smoothen consumption over lifetime, despite the fiscal costs.

Our study is structured as follows. The following section describes in detail our model. Section 3 discusses the calibration of our model. In particular, we focus attention on how the features of ECPs were translated to the model. The results are discussed in section 4. We analyze several policy scenarios and occasionally refer some of the results to the appendix, in the interest of brevity and clarity. Finally, in the concluding sections, we provide policy implications of our model.

2. Model

Demographics and intra-cohort heterogeneity

The model economy is populated by overlapping generations of individuals who live for $j = 1, 2, \dots, J$ periods facing time and age-specific mortality. We denote the unconditional probability of survival until age j in period t for an individual born in period $t - j + 1$ as $\pi_{j,t}$. Consumers enter the model at the age of 21, which we denote $j = 1$, and immediately enter the labor market. Agents who survive until $j = J = 80$ die with certitude.

Consumers

The economy is populated by $M = \{FR,\ HTM\}$ types of agents, where FR stands for fully rational while HTM stands for hand-to-mouth agents. Individual behavioral characteristics are assigned permanently to an agent at birth $(j = 1)$. Thus, a subcohort $m \in M$ of agents of age $j = 1, 2, \dots, J$ is described uniquely by the assigned characteristics.

Agents of age j belonging to class m in period t derive utility from consumption $c_{j,m,t}$ and leisure $(1-l_{j,m,t})$, where $l_{j,m,t}$ is labor supply out of total time endowment which is normalized to one. We assume the following instantaneous utility function:

$$u(c_{j,m,t}, l_{j,m,t}) = \phi \ln c_{j,m,t} + (1-\phi)\ln(1-l_{j,m,t}) \tag{1}$$

Besides the intra-temporal choice of $c_{j,m,t}$ and $l_{j,m,t}$, agents perform inter-temporal decision. This is done via accumulation of asset $a_{j,m,t}$ which earn the interest rate r_t. Agents' objective to maximize their lifetime utility is defined as follows:

$$\max_{\{c_{j,m,t}, l_{j,m,t}, a_{j,m,t}\}_{j=1}^{J}} U_{j,m,t} = u(c_{j,m,t}, l_{j,m,t}) + \sum_{s=1}^{J-j} \delta^s \frac{\pi_{j+s,t+s}}{\pi_{j,t}} u(c_{j+s,m,t+s}, l_{j+s,m,t+s}) \tag{2}$$

Each period, the fully rational agents divide the income flow between consumption $c_{j,m,t}$, which is burdened with a consumption tax τ_t^c, and accumulating to assets $a_{j,m,t}$. The budget of the working agent ($j < \bar{J}$) consists every period of a labor income, which depends on current period wage w_t and the amount of labor supplied $l_{j,m,t}$ and labor taxes τ^l . In addition to labor income, the agents receive also capital gains: $a_{j-1,m,t-1}(1-\tau^k)r_t$, where τ^k is a tax levied on capital gains and r_t is a the endogenous interest rate. Agents receive accidental bequests $bequest_{j,m,t}$, distributed within a subcohort[1]. In order to capture the transfers and taxes not explicitly modeled in this study, we introduce a *per capita* lump-sum tax Υ. Agents contribute to the universal mandatory pension system, with the contribution rate denoted by τ. Agents receive pension benefit $b_{j,m,t}$ once they retire ($j \geq \bar{J}$).

The instantaneous budget constraint for the fully rational agents has the form:

$$\begin{aligned}(1+\tau_t^c)c_{j,FR,t} + a_{j,FR,t} + \Upsilon_t \\ = \begin{cases}(1-\tau^l)(1-\tau)w_t l_{j,FR,t} + (1+(1-\tau^k)r_t)a_{j-1,FR,t-1} + bequest_{j,FR,t}\ , for\ j < \bar{J} \\ (1-\tau^l)b_{j,FR,t} \qquad\qquad\quad + (1+(1-\tau^k)r_t)a_{j-1,FR,t-1} + bequest_{j,FR,t}\ , for\ j \geq \bar{J}\end{cases}\end{aligned} \tag{3}$$

with an exogenous asset non-negativity constraint, $a_{j,FR,t} \geq 0, \forall_{j\in\{1,2,\ldots,J\}, m\in M, t\in\{1,2,\ldots,T\}}$, which is standard in the OLG literature (Harenberg, 2018). Agents can divest, but cannot borrow in aggregate terms. Highly impatient agents may prefer to borrow when young against the stream of benefits subsequent retirement, which is the main reason to impose non-negativity constraint in this literature. Raising the stream of future incomes by an instrument incentivizing old-age saving could cause similar adjustments in life-time consumption patterns among agents. Notably, the agents do not differ in time preference in our setup, hence the reaction to introducing an instrument incentivizing old-age savings is common across agents, i.e. the non-negativity constraint affects fully

[1] This assumption is equivalent to intra-marital inheritance, which is the dominant inheritance under majority of the European legal systems and reflects well the empirical regularities of assortative mating (Pencavel, 1998; Kalmijn, 1994). Our modeling convention regarding bequests encompasses the fact that accidental bequests are passed to a similar agent, which is consistent with spousal similarities in terms of education and preferences identified in earlier literature. Note that other distribution of bequests would generate lump-sum transfer between subcohorts driving redistribution beyond the direct effects analyzed in this model.

rational and HTM agents in the same manner. The non-negativity constraint reduces the scope for crowding out in our setup and raises the room for fiscal and welfare effects.

The standard Euler condition, that demands that the marginal rate of (inter-temporal) substitution ($MRS_{j,j+s,m,t}$) equals the interest rate $\left(1+\left(1-\tau^{k}\right)r_{t}\right)$ permits to link pension benefit contributions with benefits in the consumer problem (Bütler, 2000). Note that the Euler condition does not always hold in our setup. Namely, once the no borrowing constraint becomes binding, the perceived marginal effective tax rate is not as low as it would have been if the choice set was unconstrained: $MRS_{j,m,t} \geq \left(1+\left(1-\tau^{k}\right)r_{t}\right), \forall_{j\in\{1,2,\dots,J\}, m\in M, t\in\{1,2,\dots,T\}}$. The first order conditions are reported in Appendix A1.

Hand-to-mouth (HTM) agents have no access to storing technology, therefore their assets are always equal to zero:

$$a_{j,HTM,t}=0,\ \forall_{j\in\{1,2,\dots,J\},\quad t\in\{1,2,\dots,T\}}, \tag{4}$$

and their budget constraint is given by:

$$(1+\tau_{t}^{c})c_{j,HMT,t}+\Upsilon_{t}=\begin{cases}\left(1-\tau^{l}\right)(1-\tau)w_{t}l_{j,HMT,t}+bequest_{j,HMT,t}\ ,\ for\ j<\bar{J}\\ \left(1-\tau^{l}\right)b_{j,HMT,t}\qquad\qquad\quad +bequest_{j,HMT,t}\ ,for\ j\geq\bar{J}\end{cases}, \tag{5}$$

The first order conditions are reported in Appendix A1.

Since HTM agents do not hold any assets, the Euler condition does not apply in their case. HTM agents do not use MRS to link the contributions to the pension system with the subsequent pension benefits, which yields an effective marginal tax rate on labor of $\left(1-\tau^{l}\right)(1-\tau)$.

Production

The economy follows an exogenous technological progress rate $\gamma_{t}=A_{t+1}/A_{t}$ with a Cobb-Douglas production function given by

$$Y_{t}=K_{t}^{\alpha}(A_{t}L_{t})^{1-\alpha} \tag{6}$$

With K denoting capital and L denoting labor, where $L_{t}=\sum_{j=1}^{\bar{J}-1}\sum_{m\in M}(N_{j,m,t}l_{j,t,m})$ and $K_{t}=\sum_{j=1}^{J}\sum_{m\in M}(N_{j,m,t}a_{j,t,m})$, where $N_{j,m,t}$ is the number of agents of type m and age j in the total population in period t. The standard first order conditions imply the following real wage w_{t} and return on capital r_{t}:

$$\begin{aligned}w_{t}&=(1-\alpha)K_{t}^{\alpha}A_{t}^{1-\alpha}L_{t}^{-\alpha}\\ r_{t}&=\alpha K_{t}^{\alpha-1}(A_{t}L_{t})^{1-\alpha}-d\end{aligned} \tag{7}$$

where d denotes depreciation rate of capital.

Pension system

In the baseline scenario, all agents contribute to a universal pay-as-you-go defined contribution system (referred to as notionally defined contribution, NDC)[2]. Contributions to the system are recorded on private accounts ($f_{j,m,t}$) and used to finance current pension benefits ($b_{j,m,t}$). Before retiring the recorded contributions are increased every period by a real payroll growth, $g_t = \frac{w_t L_t}{w_{t-1} L_{t-1}}$, i.e.:

$$f_{j,m,t} = g_t f_{j-1,m,t-1} + \tau w_t l_{j,t,m} \tag{8}$$

Upon reaching the exogenous retirement age $j = \bar{J}$ all agents retire and their pension benefit is calculated by dividing the amount recorded in a private account by life expectancy. The formula for pension of an agent retiring in period t is as follows:

$$b_{\bar{J},m,t} = \frac{f_{\bar{J},m,t}}{LE_{\bar{J},t}} \tag{9}$$

Where $LE_{\bar{J},t} = \sum_{s=0}^{J-\bar{J}} \frac{\pi_{\bar{J}+s,t+s}}{\pi_{\bar{J},t}}$ is the conditional life expectancy at retirement. During retirement pension benefits are increased every period by g_t: $b_{j,m,t} = g_t b_{j-1,m,t-1}$. The balance of the private accounts ($f_{j,m,t}$), which was accumulated by the agents who died prior to reaching retirement age $\bar{J}$, enters $bequest_{j,m,t}$. The balance of the private accounts ($f_{j,m,t}$), which was accumulated by the agents who died after reaching retirement age ($\bar{J}$), enters automatically into pension benefits ($b_{\bar{J},m,t}$). Hence, the NDC pension system is generally balanced.

Any imbalances within the NDC system are covered immediately by the government by crediting the NDC system with a subsidy ($subsidy_t$).

$$\sum_{j=\bar{J}}^{J} \sum_{m \in M} N_{j,m,t} b_{j,m,t} = \tau w_t L_t + subsidy_t \tag{10}$$

In the reform scenario, we replicate the features of the Employee Capital Plans (ECPs) legislation.

The government

The government budget inflows consist of taxes collected on: consumption (τ_t^c), labor (τ^l), capital gain (τ^k) and a *per capita* lump-sum tax Υ. We allow consumption tax to vary over time to balance the budget, hence this is the only tax with a time index. The government budget outflows consist of expenses on an unproductive consumption good (G_t), subsidy required to balance the NDC pension system ($subsidy_t$), expenses related to servicing the debt, i.e. $r_t D_{t-1}$.

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[2] The former capital pillar operated by the Open Pension Funds is assumed away, for brevity and because already now its role is marginal.

$$T_t = \sum_{j=1}^{J} \sum_{m \in M} N_{j,m,t} \left[\tau_t^c c_{j,m,t} + \tau^l \left((1-\tau) w_t l_{j,m,t} + b_{j,m,t} \right) + \tau^k r_t a_{j-1,m,t-1} + \Upsilon \right] \quad (11)$$

$$T_t + (D_t - D_{t-1}) = G_t + subsidy_t + r_t D_{t-1}$$

In the initial steady state we close the government budget with lump-sum tax (Υ) and set G_1, D_1 to match the government expenditures and debt to GDP ratios, as reflected by the national accounts. On the transition path we keep constant the debt/GDP ratio. The values of Υ and G_t set in the initial steady state are held fixed in *per capita* terms throughout the transition path in all scenarios. In order to keep government budget balanced on the transition path and in the final steady state we allow for consumption tax (τ_t^c) adjustments.

Market clearing and definition of equilibrium

The goods market clears:

$$C_t + G_t + K_{t+1} = Y_t + (1-d) K_t \quad (12)$$

where $C_t = \sum_{j=1}^{J} \sum_{m \in M} (N_{j,m,t} c_{j,m,t})$.

The labor market clears:

$$L_t = \sum_{j=1}^{\bar{J}-1} \sum_{m \in M} N_{j,m,t} l_{j,m,t}. \quad (13)$$

The asset market clears:

$$K_{t+1} + D_t = \sum_{j=1}^{J} \sum_{m \in M} N_{j,m,t} a_{j,m,t}. \quad (14)$$

A competitive equilibrium is an allocation: $\{ (c_{j,m,t}, l_{j,m,t}, a_{j,m,t})_{j \in (1,..,J), m \in M}, K_t, Y_t, L_t \}_{t=1}^{\infty}$ and prices $\{ w_t, r_t \}_{t=1}^{\infty}$ such that:

- $\forall_{t>1}, \forall_{j \in [1,J]}, \forall_{m \in M} (c_{1,m,t}, \dots, c_{j,m,t+j-1})$, $(l_{1,m,t}, \dots, l_{j,m,t+j-1})$, $(a_{1,m,t}, \dots, a_{j,m,t+j-1})$ solve, given prices, the problem of an agent at age j of type m in period t, i.e.:
  - (1) – (3) for fully rational agents
  - (1) - (2) and (4) - (5) for HTM agents
- Prices are given by (7)
- Equation (11) are satisfied, i.e. government budget is balanced.
- Equations (12) - (14) are satisfied, i.e. all markets clear.

3. Policy reform

The policy reform consists of introducing voluntary pension savings scheme. This scheme replicates the features of Employee Capital Plans (ECPs) introduced in Poland gradually as of 2019.

The key elements of the policy reform are as follows. First, the participation in ECPs is fully endogenous, i.e. consumers individually evaluate if they want to participate in ECPs and if so – at which age they wish to join. This replicates the voluntary feature of the ECPs. Second, participation involves a lump-sum transfer at the moment of joining and subsequently annual lump-sum transfers in every year in which the agents participate in the ECPs. Since in the general equilibrium model every cohort works a fraction of their time endowment, reflecting the actual employment rate in the economy, all consumers in the working age contribute to ECPs and thus receive these annual transfers. In practice, the eligibility threshold for annual contributions is low, so virtually all employed individuals are likely to be eligible. Third, the contributions are exempt from capital income gains taxation. This reflects the basic premise of ECPs. Fourth, the benefits are paid out gradually. Naturally, individuals will be able to claim the contributions back, at a considerable discount, but this is not the intended behavior of majority of ECPs participants and no general equilibrium model is equipped to address such marginally important behaviors.

The instrument such as ECPs is likely to generate crowding out effects. In a general equilibrium model with overlapping generations the agents optimally choose lifetime savings path, hence instruments for additional savings are neutral to the path. If they offer preferential tax treatment, savings are shifted from private voluntary savings to instruments such as ECPs (up to a contribution cap). To limit the scope of crowding out, we introduce two important constraints on consumer behavior. First, in both baseline and reform, the consumers cannot have negative savings flow in any period of their life until retirement age. This condition assures that agents do not borrow in the working years against the future payments from ECPs. Second, some of the consumers in the economy cannot save at all without the ECPs. We assume that they have no access to storage technology, nor savings technology. For this group of consumers ECPs are the only way to accumulate any assets to smoothen lifetime consumption. The presence of this type of consumers limits the scope for ECPs to generate crowding out and hence will yield adjustments in macroeconomic aggregates in the reform scenario, relative to the baseline of no ECPs.

Introduction of the ECPs changes the budget constraint for the agents and the government balance. The budget constraint includes now a contribution rate to the ECPs (τ^{ECP}) and a benefit payed out from the ECPs ($b^{ECP}_{j,m,t}$). The budget constraint at time t for fully rational agents in the reform scenario has the form:

$$(1+\tau_t^c)c_{j,FR,t} + a_{j,FR,t} + \Upsilon_t = \begin{cases} (1-\tau^l)(1-\tau)(1-\tau^{ECP})w_t l_{j,FR,t} + (1+(1-\tau^k)r_t)a_{j-1,FR,t-1} + bequest_{j,FR,t}, & for\ j < \bar{J} \\ (1-\tau^l)b_{j,FR,t} + b^{ECP}_{j,m,t} + (1+(1-\tau^k)r_t)a_{j-1,FR,t-1} + bequest_{j,FR,t}, & for\ j \geq \bar{J} \end{cases}, \quad (15)$$

and for the hand-to-mouth agents it has the form

$$(1+\tau_t^c)c_{j,HMT,t} + \Upsilon_t = \begin{cases} (1-\tau^l)(1-\tau)(1-\tau^{ECP})w_t l_{j,HMT,t} + bequest_{j,HMT,t}, & for\ j < \bar{J} \\ (1-\tau^l)b_{j,HMT,t} + b^{ECP}_{j,m,t} + bequest_{j,HMT,t}, & for\ j \geq \bar{J} \end{cases}. \quad (16)$$

Before retiring the recorded contributions to the ECPs are increased every period by a gross real interest rate r_t (ECPs are exempt from capital gain tax), i.e.:

$$f^{ECP}_{j,m,t} = (1+r_t)f^{ECP}_{j-1,m,t-1} + \tau^{ECP}(1-\tau^l)(1-\tau)w_t l_{j,m,t} \quad (17)$$

Upon reaching the exogenous retirement age $j = \bar{J}$ all agents retire and their pension benefit from ECPs is calculated depending on whether an annuity is offered or not. Pension benefit from ECPs is calculated according to (**17**)(18), with or without annuity[3].

$$b^{ECP}_{\bar{J},m,t} = \frac{f^{ECP}_{\bar{J},m,t}}{LE_{\bar{J},t}} \quad \text{or} \quad b^{ECP}_{\bar{J},m,t} = \frac{f^{ECP}_{\bar{J},m,t}}{10} \tag{18}$$

As ECPs use financial markets in order to generate the rate of return on the accumulated assets the pension benefits are increased every period by r_t: $b^{ECP}_{j,m,t} = (1 + r_t) b^{ECP}_{j-1,m,t-1}$

4. Calibration

The model is calibrated to replicate the features of the Polish economy at the verge of introducing the Employee Capital Plans (ECPs), i.e. 2018. To limit the scope of business cycle fluctuations to affect our results, all macroeconomic targets were obtained averaging data for the available period (usually 1995-2018). Our economy experiences technological progress at an exogenous rate, which is taken from European Commissions Aging Work Group documentation for Poland (European Commission, 2015). This documentation assumes gradual convergence for all catching up EU economies and eventually a flat rate of technological progress of 1.54% per year.

Macroeconomic aggregates

The preference for leisure parameter (ϕ) was set to match the aggregate employment rate in the economy. The production function parameter (α) is assumed at a conventional level of 0.33. The time preference parameter (δ) was set to match the real interest rate observed in the Polish economy, i.e. 6.5% (this is the real rate of interest after all the fees, recorded on average in the Open Pension Funds over 1999-2018). Note that the interest rate is endogenous in the model, conditional on the time preference parameter. Finally, we set the depreciation rate in order to match the average investment rate in Polish economy, i.e. 21%. Table 1 reports the macroeconomic calibrations.

Demographics

Demographic projection of the European Commission (EC, 2015) provides full information on the size of each cohort arriving in the economy as well as survival probabilities ($\pi_{j,t}$) until 2080. After 2080, we assume that the population structure becomes stationary, i.e. the mortality curve does not change any more, and an equal number of agents enter the model each period[4].

Taxes and pension system

All the tax rates were calibrated to replicate the effective tax rates. Using data from OECD and national accounts we derive the shares of respective tax revenues in GDP and calibrate the tax

[3] According to the legislation, annuitization is not mandatory. The default option for the payouts is for 10 years.
[4] Hence, the final steady state population has a stationary structure. This structure is reached in 2160 (the projection until 2080 and 80 subsequent cohorts). Note that population is stable in the initial and the final steady state in our setup.

rates to match these targets. For example, labor tax rate was calibrated such that the total aggregate labor tax revenues, expressed as % of GDP, matched the rate observed in the data, given employment rate and equilibrium wages.

Retirement age $\bar{J}$ is matched to the effective retirement age (61 y/o), following the OECD (2017) data. To match the size of the pension system (i.e. the contribution rate τ) we could not rely on current pension benefit expenditure as a share of GDP, because a part of pensions paid out currently follows the defined benefit rules from pre-1999 pension, whereas the small fraction of the pensions follows the defined contributions rules with additional transition adjustments. Meanwhile, our model starts and ends with a defined contribution pension system (without any additional transitional adjustments). While the legacy from the defined benefit system is likely relevant for the overall macroeconomic development, is not relevant for evaluation of ECPs, relative to the *status quo*. Given this disparity between model setup and aggregate contemporaneous data we use Makarski et al., (2017), who have a similarly calibrated aggregate economy and we use their final steady state share of pensions in GDP as our target value for the contribution rate τ.

Table 1. Calibration of the economy in the initial steady state

Description	Parameter	Target	Outcome	Value
Output elasticity with respect to capital	α	Conventional level		0.33
Depreciation rate of capital	d	Investment rate: 20.6%	20.6%	0.0412
Discount factor	δ	Interest rate: 6.5%	6.5%	0.984
Weight on consumption in utility function	ϕ	Average hours: 52%	52%	0.4665
Effective consumption tax rate	τ^c	Effective rate: 12.1%	12.1%	0.229[5]
Effective capital gain tax rate	τ^k	Effective rate: 19%	19%	0.19
Effective labor tax rate	τ^l	Effective rate: 4.82%	4.82%	0.06725
Effective contribution rate to the pension system	τ	NDC benefits/GDP: 5%	5%	0.07715
Government expenditures as %GDP in initial SS	G	G/Y: 26.6%	26.6%	0.2656
Debt to GDP ratio		Debt/GDP: 55%	55%	0.55

Notes: Data on tax revenues from the OECD Tax Database, the rest of the macroeconomic aggregates following the National Accounts. The target values have been averaged from the data over 1995-2018 (or longest available time series). The target for the pension system following Makarski et al., (2017).

Behavioral heterogeneity

Our model features hand-to-mouth consumers, who do not save. Implicitly, the larger the share of the HTM consumers, the lower the aggregate crowding out: in the limit an economy with only HTM agents would have no direct crowding out. Meanwhile, there is no clear empirical guidance on calibrating this share. On the one hand, it is customary in macroeconomic literature about the US economy, to set the share of HTM consumers to 50% (e.g. Proebsting et al., 2017). On the other hand, empirical evidence *measuring* the prevalence of incompletely rational preferences struggles with a lot of challenges. First, it is not obvious how to separate preferences of agents (such as present bias/myopia, time inconsistency, and other non-standard preferences) from unobservable constraints on their behavior (such as financial illiteracy, liquidity constraints, barriers in access to financial instruments, etc.), and from incomplete rationality of agents (i.e. lack of ability to fully account for general equilibrium effects in individual optimization and imperfect foresight) and from unobservable idiosyncratic shocks to household budget constraint. The empirical identification of mechanisms behind savings behavior departing from complete rationality rests upon controlled

[5] Consumption tax τ^c is calibrated in the initial steady state in order to match the effective tax rate. On the transition path and in the final steady state τ_t^c is used to balance the government budget so it varies.

experiments in the lab or in the field as well as policy quasi-natural experiments. By consequence, the analyses typically address small scale interventions on relatively small and typically pre-selected samples rather than populations at large and over a short period of time (cfr. overview of the literature in Lusardi, 2009 for interventions focused on raising financial literacy skills as well as Attanasio and Weber, 2010, for general review of the literature). Moreover, studies based on newly available data, plausibly "deeper" in specific contexts (such as the use of credit cards spending patterns, scanner sales data, etc.) reveal that a substantial share of consumers whose behavior departs from rational agent optimization are not financially constrained, nor are they disadvantaged in terms of financial literacy, revealing the prevalence of wealthy hand-to-mouth consumers (e.g. Kaplan and Violante, 2014; Heathcote and Perri 2018, Olafsson and Pagel 2018).

The empirical evidence on behavioral heterogeneity is scarce for Poland. The available data reveal that only a small fraction of households in Poland actually participates in voluntary pension savings schemes which were available prior to ECPs, admittedly, the household may be uninformed about these instruments and may likely consider them unattractive, due to their numerous shortcomings. Empirically, there is not enough data to determine the fraction of a population that has no savings/assets in every period of their life, which would be consistent with hand-to-mouth preferences. For example, Polish Household Budget Survey reveals that on average over the past decade typically 2 bottom income deciles of households have no savings understood as flow, i.e. they do not put aside any income in a given year. However, one cannot interpret this 20% of population to have no savings ever in their *entire* lifetime. The evidence from Polish Household Wealth Survey is scarce in a sense that this is only a cross-section for the time being. It shows that roughly 27% of households has negative or no accumulated wealth. Helas, this figure too cannot be interpreted as a lifetime profile. Finally, empirical evidence from a policy quasi-natural experiment by Myck and Lachowska (2018) reveals that roughly 13% of analyzed households behaved in ways consistent with full rationality, whereas the remaining 87% of analyzed households departed both in ways consistent with various theories about incompletely rational preferences and in ways inconsistent with those premises.

With these insights in mind, in a preferred specification we set the share of HTM agents to 25%. Since this share is in line with the evidence from HBS and HWS, we are convinced that the proportion of HTM consumers is not vastly overstated in our model. Since the share of 25% is much above the participation in voluntary pension savings schemes, we are also convinced that ECPs as modeled in our study will yield more substantial effects than came out of the previously implemented instruments. Finally, since this share is much below the conventional share of 50% used in macroeconomics, our economy should not be radically altered by a relatively small instrument. Given the arbitrariness of this choice, we also present the sensitivity of our results to this assumption, varying the share of HTM agents from 10% to 90%.

The features of ECPs

Lump-sum transfers. ECPs will provide two types of lump-sum transfers: entry bonus and annual bonus. We introduce them to the model. All the lump-sum transfers in ECPs are calibrated to reflect the fraction of an average wage in Polish economy. These fractions are assumed constant, i.e. in our model the lump-sum transfers will increase as the economy observes technological progress.

Legislation does not specify the rules for the indexation of the two lump-sum transfers previewed, but already at the legislative stage many stakeholders suggested that some indexation rule should be specified in law. Hence, one should expect they will not be kept constant in nominal terms.

The lump-sum transfers are conditional on the fact of working in the model, but do not depend on earned labor income. This is a simplification in the model in a sense that in an OLG economy all agents work a certain fraction of their time, hence it would be challenging to translate the legal thresholds to the model (especially prior to the implementation, i.e. without knowing the fraction of salaried workers who were not eligible to the lump-sum transfer due to insufficient contributions). According to the legislation only workers contributing at par with contributions due on a minimum wage for at least 1.5 monthly wages per year[6] are eligible for the annual transfers, which is not a strongly excluding restriction for 12 million salaried workers (out of roughly 16.5 million active working age population). It appears plausible that a majority of workers will be actually eligible to the transfers, once the implementation of ECPs is complete.

Tax exemptions. The share of the contributions paid by the employer are exempt from social security contributions. The share of the contributions paid by the employee are not exempt from social security contributions, nor from labor income taxes. In a general equilibrium model, the wedge between net and gross income cannot be split between employee and employer. Since in reality majority of ECPs contributions is paid out of net income, in the model we assume that all of the ECPs contributions are paid out of net income.

The capital income gains in ECPs are exempt from capital income taxation in general. The model replicates this feature.

The receipts of benefits upon reaching age eligibility in principle continue to be exempt from capital income taxation, which we replicate in the model. We thus abstract from analyzing the cases in which individuals may choose to collect the whole benefit in one transfer payment (but with a deduction of capital income taxes).

Benefits payouts. The legislation of ECPs previews a fixed number of periods for collecting the benefits. A fixed number of periods by construction excludes a lifetime benefit (in the form of an annuitized stream of payments). Meanwhile, rich literature emphasizes the insurance value of old-age benefits (e.g. Hurd, 1987, Hubbard et al., 1995; Li 2018; and references therein). The empirical research as well as theoretical contributions point to the paramount role of insuring against outliving one's on savings. Hence, in the model we compare the two variants, i.e. in one reform scenario we continue with a fixed number of years[7] for collecting the benefits and in an alternative reform scenario we implement an annuitized stream of payments.

Caps. Participation in ECPs is voluntary, i.e. the consumers may decide not to participate at all (contribute 0% of their income). Once a consumer prefers to participate, we assume 3.5%

[6] Strictly speaking, there is income eligibility criterion (below 120% of minimum wage in a given year), which allows to contribute an equivalent of contributions due for 1.5 months of minimum wage in a given fiscal year. For workers with higher earnings, the eligibility threshold consists of contributions due on 6 monthly minimum wages.

[7] We set the number of years for collecting the benefits to ten, which is the default number for the particular ECPs analyzed.

contributions, which reflects the lowest legal threshold.[8] For the sake of completeness, we also include one scenario in which consumers may contribute 8% of their net income (i.e. the legal maximum contribution rate). This additional reform scenario informs about the potential range of outcomes, depending on the actual employees' choices in the future.

5. Results

The results are reported in five substantive parts. First, we discuss the crowding out in an economy with hand to mouth agents. Second, we study the key macroeconomic and microeconomic adjustments subsequent the introduction of incentives to raise old-age savings. Third, we trace the origins of fiscal adjustments and finally. Fourth, we demonstrate the adjustments in the life cycle for fully rational and HTM agents. Finally, we discuss the aggregate and disaggregated welfare effects of such reform. These five points are complemented by a sensitivity analysis, where we purposefully manipulate the share of HTM agents in our economy and study the effects of their share on macroeconomic outcomes.

We study the effects of ECPs in four variants. First, we consider both extreme contribution rates: the minimum imposed by the legislation and the maximum allowed by the legislation: $\tau^{ECP} \in \{3.5\%, 8\%\}$ in nominal terms. Second, the ECPs do not mandated annuity, but do not exclude it either. We thus compare the economies with and without annuitized $b_{j,m,t}^{ECP}$ payments.

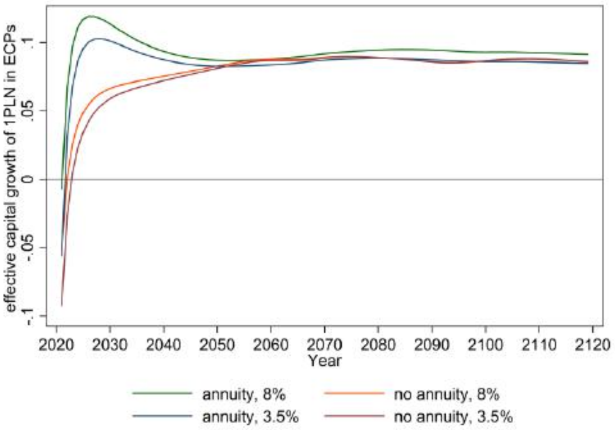
Crowding out

In an economy with fully rational and hand-to-mouth agents, two opposite reactions emerge. The fully rational agents adjust private voluntary savings in response to the introduction of ECPs: they exploit to the maximum the tax advantage offered within the ECPs and reduce assets held in private voluntary savings. The assets remain positive if and only if their individual optimization implies that they should hold more assets than subject to ECPs. The hand-to-mouth consumers, who held no private voluntary savings prior to the introduction of the ECPs, raise old-age savings if participation in ECPs raises overall welfare relative to non-participation. Hence, one should expect considerable crowding out for the fully rational agents and by construction no crowding out for the hand-to-mouth consumers.

The scope of overall crowding out subsequent the introduction of the ECPs in our calibrated economy is reported in Figure 1. We operationalize crowding out as the actual unit of increased assets held by agents relative to 1 unit of assets allocated to ECPs. This comparison involves measuring what would have happened to assets held by the households in a world without the ECPs and comparing it to the assets held by households in a world with ECPs (separately for each type of this instrument and accounting for within cohort behavioral heterogeneity).Overall, the 1 PLN allocated to ECPs generates roughly 0.08-0.09 PLN in additional private voluntary savings – otherwise put, for each 1 PLN allocated to ECPs approximately 0.91-0.92 PLN is displaced from private voluntary savings.

[8] Nominal 3.5% and 8% contribution rates are adjusted to effective rates maintaining the proportion analogous to the universal NDC pension system (the nominal 19.52% contribution rate is effectively 7.715% in the model).

Figure 1. Evaluating ECPs: crowding out for alternative assumptions about ECPs



Notes: % of HTM=25%, crowding out measured as increase in total assets in a scenario with a given type of ECPs relative to total assets in a scenario without ECPs, out of each 1 PLN allocated to the ECPs. An increase of 0.08 - 0.09 PLN means that 0.91 – 0.92 PLN per 1 PLN allocated to the ECPs was displaced from private voluntary savings.

Crowding out for HTM agents is always zero, but crowding out for fully rational agents depends on the features of the instrument: are the incentives mostly displacing savings in the instruments without tax incentives, or are these incentives actually stimulating more savings. To gauge these mechanisms we employ a partial equilibrium analysis. We analyze inter-temporal and intra-temporal choice with and without a given ECPs in partial equilibrium and compare it to the general equilibrium final outcomes (where also wages, interest rates and taxes change as a consequence of implementing the ECPs and when adjustments in labor supply, consumption and savings of all the agents in the economy are fully internalized). In other words, we perform two comparisons of total assets in a world <u>with</u> ECPs, to the total assets in a world <u>without</u> ECPs. First, we compare them in an artificial environment when there was no adjustment of prices (partial equilibrium). Second we compare them in an environment where prices have changed (e.g. interest rate decreased due to enhanced capital accumulation). Table 2 reports the results of this analysis. We measure the effects in the same manner as in Figure 1.

Table 2. Effective assets growth for fully rational agents

Scenario	Partial (behavioral) adjustment	Total (general equilibrium) adjustment
annuity, 8%	-0.25 PLN	-0.18 PLN
annuity, 3.5%	-0.35 PLN	-0.19 PLN
no annuity, 8%	0.05 PLN	-0.18 PLN
no annuity, 3.5%	0.07 PLN	-0.19 PLN

Notes: The decomposition obtained for the final steady state. To obtain the partial equilibrium adjustment we run the model with the additional constraint that changes in wages, interest rates and taxes have not occurred, but ECPs are available. The agents adjust the optimal life-time consumption, labor supply and savings without observing what effects these readjustments have on aggregate economy, and thus subsequently on the final general equilibrium.

ECPs offering annuitized stream of pension benefits induce a decrease in total assets for fully rational agents. This total effect consists of three driving factors in partial equilibrium. First, ability to annuitize private savings effectively raises the rate of return on assets (the survival is fully reflected in the interest earned rather than *via* accidental bequests). As a consequence, the same degree of consumption smoothing may be achieved with lower savings if those savings can be annuitized. While ECPs do not annuitize all the assets held by the households, the assets allocated in ECPs more than fully crowd out the private voluntary assets: with annuity, agents hold less assets in total (inclusive of ECPs) than without them. Second, fully rational agents account for low survival probability for the end of their lifetime, while ECPs with annuity yield relative high income in this period of their life, resulting in consumption higher than they would have planned in absence of the ECPs. With the no borrowing constraint, this further reduces the needs for private voluntary savings. Naturally, ECPs without annuities do not generate this effect. Third effect works in the opposite direction: the ECPs provide lump-sum transfers to the participants: the unconsumed part of this transfer contributes to the assets accumulation, which raises savings.

The general equilibrium (total) effects of ECPs comprise the adjustments in interest rate (due to increased capital from the asset holdings of HTM agents), wages (due to change in K/L ratio and labor supply) and taxes (due to financing costs of ECPs). These overall effects trump the partial equilibrium increases for ECPs without annuity, and yield similar range of negative effects on private voluntary savings for ECPs with annuity. Due to the adjustment in prices, most notably the interest rate, the economy is quite robust to differences in the variants of the ECPs (see Figure 9 in the Appendix A2).

The main macroeconomic adjustments

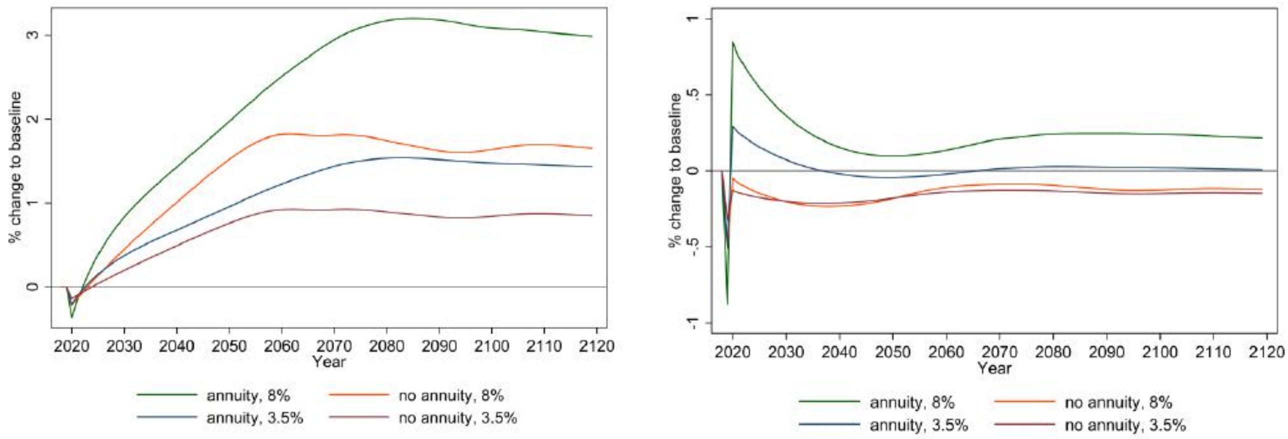
The implementation of ECPs generates strong transitory effects on capital, consumption and labor supply, see Figure 2. The decrease of capital in the first period on the transition path is due to the timing of the ECPs implementation: they are implemented as of 2020 (transition period 2), but the agents are aware of them as of 2019 (transition period 1). Introduction of ECPs brings higher consumption tax, and anticipating this rise, households choose to consume in total more than save when the consumption is still cheaper. Hence the drop in capital in transition period 1. Note that this adjustment concerns only the fully rational agents. The short-term adjustment in labor is associated with the fact that with the implementation of ECPs, effective labor taxation declines as of transition period 2. Inter-temporally, the agents prefer to supply more labor in the periods when taxation is (effectively) lower and less labor in the periods when the tax is still relatively higher. Naturally, the change in labor taxation is implicit, i.e. contributions to ECPs are not viewed as labor taxation, but rather as implicit savings. Contributions to ECPs, due to tax exemptions, are in fact perceived as a negative taxation. Accordingly, the scenarios where the instrument offers an annuity, bring even further reduction of the effective marginal labor tax.[9] Note that these effects concern only fully rational agents. The HTM agents may react to general equilibrium effects through wages.

In the long run, if all savings in ECPs were additional, then 3.5-8% contributions to ECPs out of labor share in the economy should translate to roughly 3.8-8.8% per year. Given considerable scope of crowding out, it is not surprising that the capital formation thanks to ECPs is much lower, see left panel of Figure 2. The overall long-run effects of the ECPs range between 0.8% and 3.0% relative to baseline, for the lower bound not annuitized contributions and the upper bound annuitized contributions, respectively. The long-term effect on labor supply varies between scenarios. ECPs

[9] Upon implementation of the reform (transition period 2) the perceived effective marginal labor tax rate drops for agents at age $j = 1$ by: 3.3pp. (annuity, 8%), 1.6pp. (no annuity, 8%), 1.6pp. (annuity, 3.5%), 0.7pp. (no annuity, 3.5%) relative to baseline. For agents at age $j = 40$ the same rate drops by: 2.9pp. (annuity, 8%), 0.3pp. (no annuity, 8%), 1.3pp. (annuity, 3.5%), 0.1pp. (no annuity, 3.5%) relative to baseline. Within “annuity” and “no annuity” scenarios the differences in the drop of perceived effective marginal labor tax rate are proportional to the contribution rates. Between “annuity” and “no annuity” scenarios the differences in the drop are twofold. First, annuitization of retirement savings is welfare improving on its own. Second, for the “annuity” ECPs assets are held in the instrument for a longer period of time – this increases the overall gain due to capital gains being tax exempt within the ECPs.

with annuity generate modest labor supply increase: 0.22% for nominal contribution rate of 8%, and 0.01% for contribution of 3.5%. Long-term labor supply decreases for ECPs without annuity (0.12% and 0.15%, for 8% and 3.5% contributions respectively). Labor supply is far more responsive to the annuitization of ECPs assets than to the nominal rate of contribution. This is due to the fact that, for a given contribution rate, annuitized ECPs entail both: a larger decrease of a perceived effective marginal labor tax rate, and a larger capital accumulation. Gross interest rate and wage are functions of capital and labor supply in the model economy (see Figure 9 and Figure 10).

Figure 2. Capital (left) and labor supply (right) with ECPs relative to *status quo*



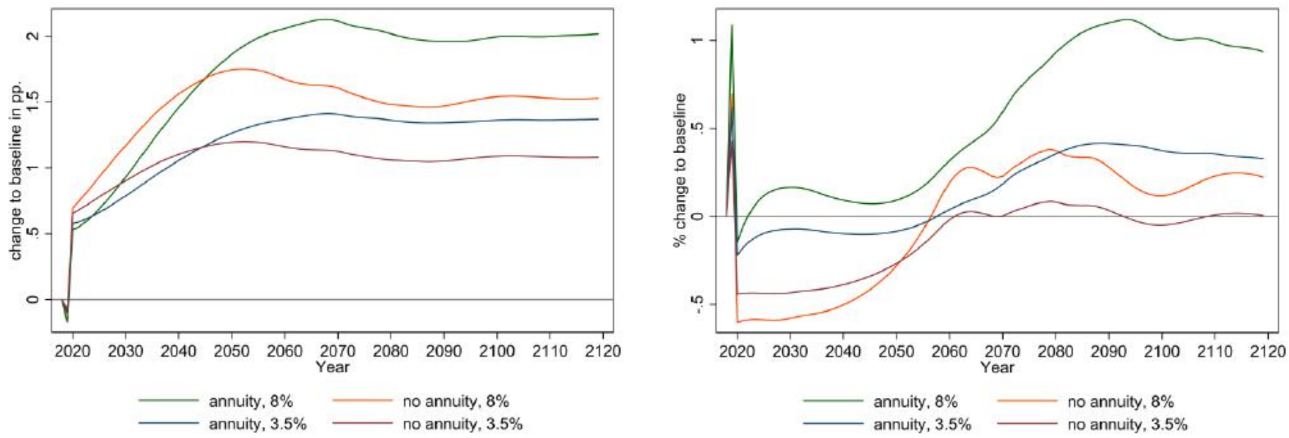
Notes: Paths for capital and labor supply relative to the baseline sceneario of status quo. Both baseline and reform scenario account for declining exogenous technological progress, longevity and declining feritlity. Agents in the model are aware already in 2019 that as of 2020 ECPs are implemented.

The changes to labor supply are caused by four factors working in the opposite directions. First, capital accumulation raises labor productivity and thus wages, which makes it possible for household to maintain the same income with lower hours. Second, the increase in wages renders leisure more expensive, thus increasing hours worked. Third, the increase in total taxation required to finance the ECPs is modelled by an increase in consumption tax. This makes the consumption more expensive relative to leisure. Optimizing households choose less consumption and more leisure, hence supply less hours to the labor market. Fourth, contributions to ECPs offer an implicit subsidy: each unit of contribution to the ECP, brings return in excess of the regular savings due to the capital income tax exemption built into ECPs (and, in some ECPs scenarios, due to annuity). As a result, the perceived effective marginal tax rate on labor is lower in the world with ECPs than without them leading to a higher number of hours supplied to the market. Naturally, this last effect is only present for the fully rational agents (i.e. 75% of the population in our calibration). For the HTM agents, the effective and nominal labor income taxes are equivalent, hence the third effect is absent. The first two effects i.e. income and substitution effects cancel out for our utility function. The overall impact on the labor supply depends on the interplay of the third and fourth the effect, i.e. explicit increase in consumption tax and implicit decrease in labor tax. The latter is stronger for the ECPs with annuity, hence for those scenarios labor supply increases relative to baseline. For the ECPs not offering annuity, the suppressing effect of consumption tax increase has the upper hand, see also Figure 3.

The fiscal aspects of the ECPs

The introduction of ECPs necessitates a rise in taxes by roughly 1 percentage point in the case of scenarios with 3.5% contribution rates and even 2 percentage points in the case of scenarios with 8% contribution rates. Figure 3 reports the necessary adjustment in taxes to balance the government (left) and a change in aggregate consumption (right) relative to *status quo*. Financing the lump-sum transfers and the gap in capital income tax revenues are the original drivers of adjustments in taxation of consumption, but raising the taxation of consumption implies a decline in relative price of leisure, thus consumption (and labor) adjusts accordingly in the inter-temporal choice of the agents. Impact of the ECPs on the aggregate consumption consists of a sharp short-term adjustment (on transition period 1), and a gradual transition towards long-run effects (as of transition period 2). The short-term adjustment stems from the same origin as the short-term adjustment of labor supply. Agents expect future upsurge in consumption taxation (as of transition period 2), hence prefer to consume less in those periods and increase consumption in transition period 1 when the consumption tax is relatively low. The total aggregate effect depicted on the right panel of Figure 3 is a sum of the opposing effects for different types of agents (see Figure 12 in the appendix A2). Sources of the differences in the reaction of aggregate consumption between the types are explained in the following section.

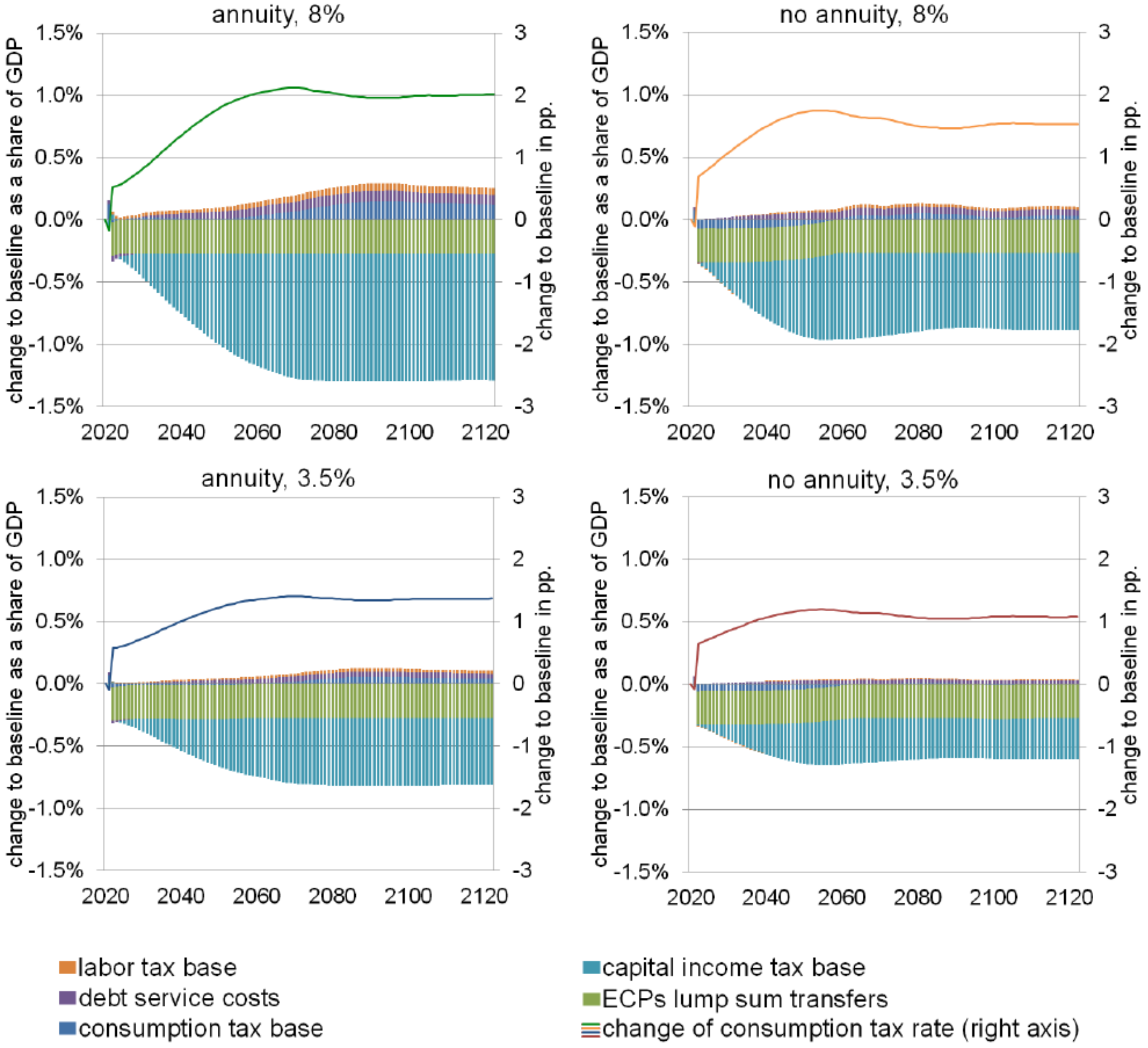
Figure 3. Consumption tax (left in pp) and consumption (right in %), relative to *status quo*



Notes: *Left panel:* taxes relative to baseline of no ECPs, in percentage points.
Right panel: consumption relative to baseline of no ECPs, in percent.

This rise in taxes stems from the fact that ECPs are fiscally costly. ECPs offer financial transfers to participants: entry and annual lump-sum transfers as well as exemption on capital gain tax. These transfers are fiscally costly, while their negative effect on fiscal balance is amplified by a decline in the tax base. The changes to tax base comprise of three factors working in opposing directions. First, the basis for capital gains tax are significantly lower (due to shifting assets from taxable investment to ECPs). Second, labor income is higher in annuity scenarios, but lower in scenarios without annuity (this decline is roughly compensated by the increase in wages). Third, consumption is lower at the beginning of the transition path (since transition period 2) for all reform scenarios. With the time, the consumption grows due to higher consumption at older ages, but the increase is small and it is not positive for the 3.5% scenario without annuity. Overall, these three factors yield a decline in tax base– increase in consumption and labor tax base is far from sufficient to compensate for capital gain tax income loss. Against these declines in fiscal revenues, there is a reduction in fiscal costs: higher capital implies lower interest rate, which reduces the costs of servicing public debt.

Figure 4. The decomposition of fiscal adjustment



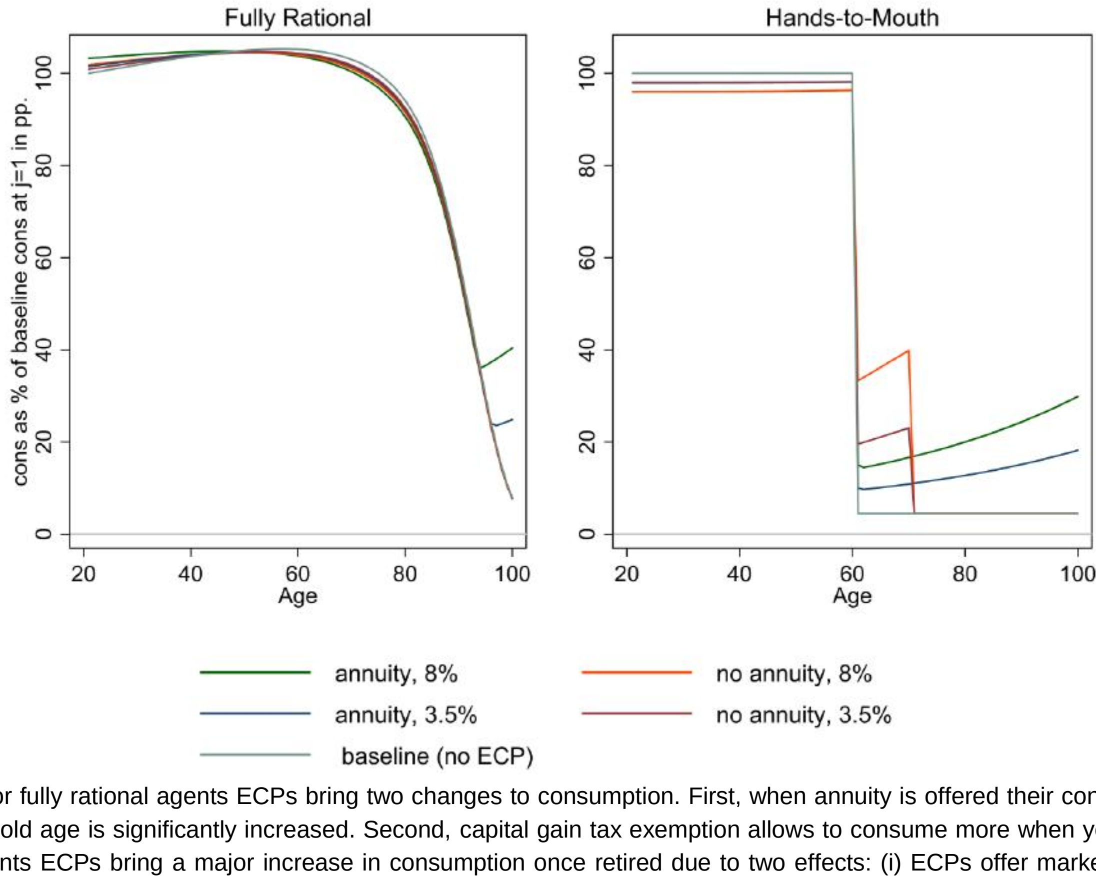
Notes: The pictures depict a complete decomposition of fiscal adjustment, based on the comparison between the baseline and the reform scenarios. The tax base adjustments report the difference in the tax base on a given type of tax between baseline and reform scenario. The debt servicing costs compared in contemporaneous terms. ECPs lump-sum transfer constitute an additional government expenditure relative to the baseline scenario, but are directly tarnsferred to the households: recall that government expenditure in general does not enter household utility in our setup, but ECPs transfers enter positively the budget constraint.

Figure 4 decomposes the sources of tax adjustments for the four analyzed variants of ECPs. Comparing across the maximum and minimum size of ECPs reveals that the size of this instrument matters substantially for the size of fiscal adjustment, which hints that the lump-sum transfers are not the only culprit behind the need to raise taxation in the economy. Indeed, Figure 4 shows that the costs of lump-sum transfers to the ECPs participants constitute roughly 20-30% of the total fiscal costs, whereas the reshuffling of assets between private voluntary (and taxed) assets and ECPs (exempt from taxation) causes a large portion of the fiscal adjustment. Naturally, the general equilibrium effects are of importance. Overall labor income has not changed substantially, which makes this channel non-negligible only for a scenario with high contribution and annuity – here the drop in perceived effective marginal rate of labor taxation is the highest. Large crowding out on capital makes the decline in interest rate much smaller, which implies that the fiscal relief of lower debt's servicing cost is of minor importance as well.

Lifecycle profiles of savings and consumption

In the long run, with the introduction of the ECPs, the hand-to-mouth agents automatically reduce consumption, because disposable income is lower than in the baseline scenario due to ECPs contributions, see Figure 5, where we report lifecycle profiles of consumption in the final steady state. The HTM agents partially compensate for the loss of disposable income by increased labor supply. The decline in consumption in the working age period is also compensated by higher consumption during retirement. Due to accrued interest accumulating over time the net effect on the consumption of the HTM agents is positive: despite increased consumption tax, the consumption of the HTM agents rises.

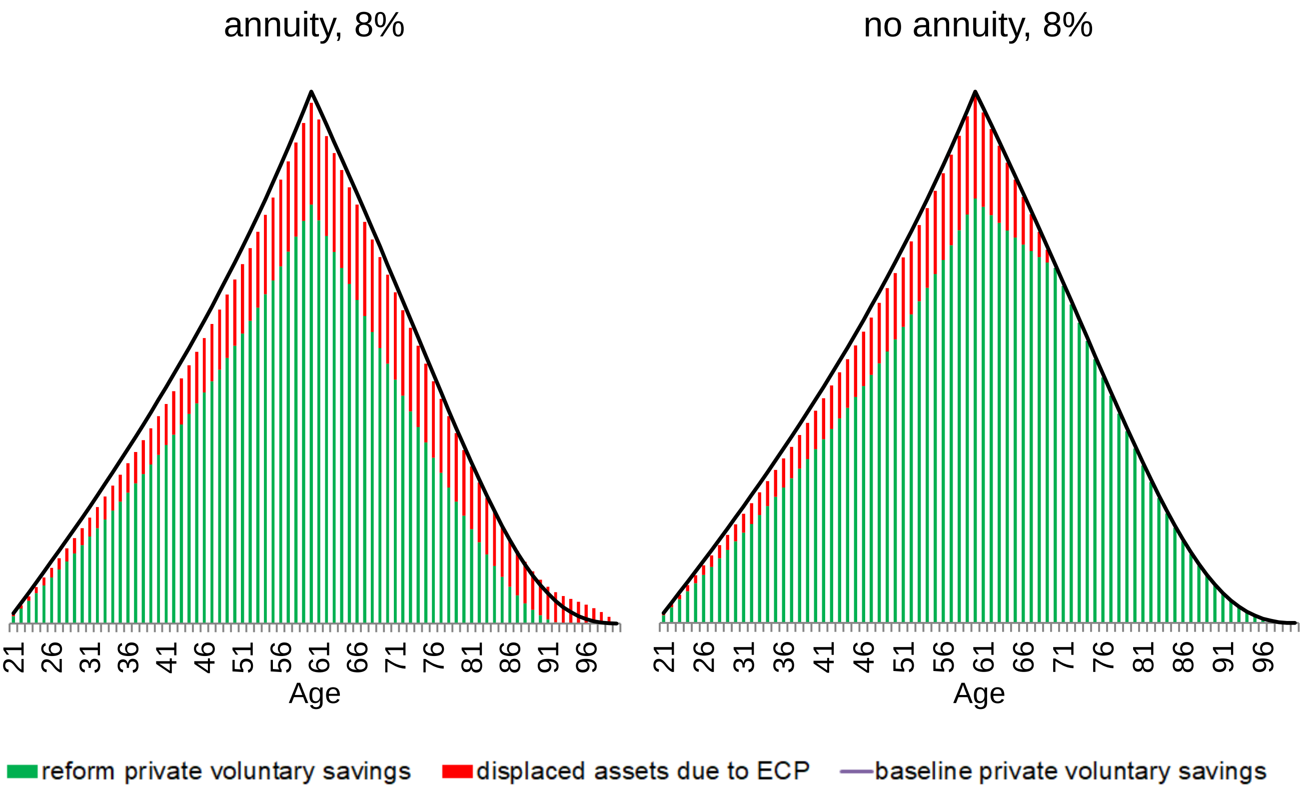
Figure 5. Consumption plans for fully rational and HTM agents, final steady states



Notes: For fully rational agents ECPs bring two changes to consumption. First, when annuity is offered their consumption at a very old age is significantly increased. Second, capital gain tax exemption allows to consume more when young. For HTM agents ECPs bring a major increase in consumption once retired due to two effects: (i) ECPs offer market interest rate (before and after retirement), whereas NDC pension system only delivers indexation at g_t; and (ii) annuity is explicitly received in terms of financial transfers to surviving agents Also consumption while working is decreased due to lower disposable income.

For the fully rational agents, although increase in consumption tax suppresses the consumption, the capital gain tax exemption in the ECPs accrues interest faster, hence allowing to obtain the same level of assets upon retiring with a lower net savings rate. Overall, while HTM agents consume more in the old ages, the fully rational agents raise consumption when young. The net effect on the consumption of the fully rational agents is negative: the increased consumption when young is not enough to compensate the consumption lost due to higher consumption tax. Moreover, if ECPs offer annuity, consumption of fully rational agents in the old ages is higher with ECPs than without them (the sum of pension benefits from NDC system and ECPs being greater than the optimal consumption when very old)[10].

Figure 6. Assets held by fully rational agents baseline *versus* ECPs (8% contribution rate)



Notes: The figure reports the final steady state assets over life-cycle. The solid black line reports the baseline private voluntary assets in baseline scenario, the bars report total assets in the reform scenarios. Green bars represent private voluntary assets in the reform. Red bars represent assets accumulated within ECPs. Note that there are differences between baseline and a sum of both types of assets in the reform scenario (even if minor). ECPs with lower contribution rate (i.e. 3.5%) produce exactly the same dynamics yet with less pronounced effects. Figures for lower bound contribution rate may be found in the Appendix (Figure 11).

Figure 6 depicts the microfoundations of the crowding out: it compares total assets held by fully rational agents[11] under two different ECPs both with contribution rate of 8%, one offering annuity, the other not. Fully rational agents offset the assets accumulated within the ECPs with almost exactly the same decrease of their private voluntary savings. Due to the capital gains tax exemption on assets held in ECPs, the accumulation occurs faster, hence the same level of wealth at retirement may be achieved with lower saving rate. The ECPs which offer annuity effectively raise

[10] After retirement, the HTM agents simply consume their pension benefits only (i.e. for reform scenarios with no annuity, once the set number of payments is over the agents are left with a benefit from NDC pension system only). The sizable difference between the pension benefits paid out of NDC system and ECPs come from the different rates of return. The NDC system uses payroll growth, which in the long-run is equal to the TFP growth rate. The ECPs use gross market interest rate. The long-run TFP growth rate assumed in the model equals 1.54%, while gross long-term interest rate amounts to 4.08% - 4.18% depending on the reform scenario.

[11] HTM agents no private voluntary savings in the baseline scenario, hence under ECPs their total assets simply increase by the holdings in ECPs.

assets held at the end of the lifecycle where there is not enough private voluntary savings to offset the introduction of ECPs perfectly.

Welfare analysis and participation

Policy such as ECPs is likely to generate welfare effects heterogeneous across birth cohorts. The beneficiaries are mainly those who can obtain transfers and qualify for exemptions. Meanwhile, the costs (mainly consumption tax increase and a decrease of interest rate) are spread across the entire population, including e.g. agents who were retired or close to retirement upon ECPs implementation. Moreover, even in the long-run the welfare effects are bound to differ across subcohorts of different behavioral types. The fully rational agents weigh the individual benefits against the aggregate costs (due to raised taxation and declining interest rates). HTM agents obtain superior paths for lifetime consumption once ECPs are implemented (previously they were unable to smoothen lifecycle consumption at all). Table 3 reports aggregate welfare effects for each type of agents, while Figure 13 in the Appendix reports welfare effect for each cohort for each type of agents. Welfare effect is expressed in terms of a consumption equivalent (for each subsequent birth cohort) as a percent of lifetime consumption in baseline scenario.

Table 3. Welfare effects of ECPs

Agent	Annuity, 8%	No annuity, 8%	Annuity, 3.5%	No annuity, 3.5%
Fully rational	0.08%	-0.30%	-0.06%	-0.22%
Hand-to-mouth	46.73%	23.27%	31.17%	17.24%

Notes: Welfare computed as a consumption equivalent of baseline consumption, hence negative numbers signify that agents would need to be compensated in order to accept the change to the reform scenario. Welfare for each birth cohort expressed in their lifetime consumption (discounted to the age of entering the model). Aggregation across cohorts accounts for discounting with the interest rate (relevant for each scenario).

Overall, the adjustments in prices, combined with changed taxation, deliver welfare losses for the fully rational agents. The annuity itself is welfare improving, hence ECPs which offer annuity are always better than those which don't for a give contribution rate. In other words, the fully rational agents would have delivered very similar life-time utility levels without the state intervention, whereas tax exemptions and lump-sum transfers do not outweigh the increased taxation necessary to finance the functioning of ECPs for the whole economy. While annuity out of ECPs assets is valuable for the fully rational households, this value alone is only enough to compensate for the increased fiscal burden over lifetime if the annuity is large enough.

Despite the negative welfare effects, the endogenous participation in the ECPs is always 100%: once ECPs are in place, it is better to obtain the transfers and exemptions than to give them up, as the macroeconomic effects associated with changes to taxes and prices occur irrespectively of individual participation decision. Having the choice between two versions of the world, the fully rational agents would generally opt for a world without ECPs. Specifically, in a political economy model, fully rational agent would vote against ECPs implementation, but once the ECPs are in place, it is more beneficial to participate than to opt out.

Naturally, the HTM agents benefit from ECPs: by design they were unable to smoothen consumption over the lifecycle in baseline and are able to do so to some extent with ECPs they may do so, additionally earning interest on savings. These gains outweigh the welfare cost of increased taxation. These large positive welfare effects for the hand-to-mouth consumers may be interpreted in two ways. If one assumes that HTM behavioral patterns stem from actual barriers to participate in financial markets, instruments such as ECPs may be as beneficial as our simulation suggests, i.e.

raise welfare by 17-47% of lifetime consumption in consumption equivalent terms. However, if HTM behavior stems from preferences (i.e. strong presence bias, highly time inconsistent preferences, etc.) then forcing such agents to save in ECPs raises welfare only formally, but not factually. Given that we lack appropriate measurement of the scale of HTM households in Polish economy, we cannot take the stance on either of these two interpretations.

Although welfare effects differ between fully rational and HTM agents, there are few similar patterns across birth cohorts, as reported in Figure 13 in the Appendix. Cohorts already retired at the moment of ECPs introduction lose due to the change. The cohort which retires at the moment of ECPs implementation experiences the largest welfare decline (they cannot participate in the ECPs, but pay all the costs associated with consumption tax increase). For the subsequent cohorts the welfare gains increase in the number of years of potential participation in ECPs.

Part of the decline in welfare originates from declining consumption, which is partially induced by increased consumption taxation. One could be tempted to consider other fiscal closure. For example, raising labor income taxation would generate welfare and macroeconomics effects on its own, masking the potential effects of ECPs on labor supply and wages. In a similar spirit, raising debt would in our model imply a commensurate rise in taxation (due to higher servicing costs). Raising capital income taxation seems counter-productive if the main objective of introducing ECPs is to foster capital accumulation. Lum p-sum taxation could potentially minimize labor and capital adjustments, but implementation of this type of taxation remains to be a concern, while inter-cohort redistribution effects would be much larger. Finally, reducing the expenditure in a model such as ours would conceal the true scale of fiscal adjustments (the households do not have government expenditure in their utility function or budget constraint).

Sensitivity analysis

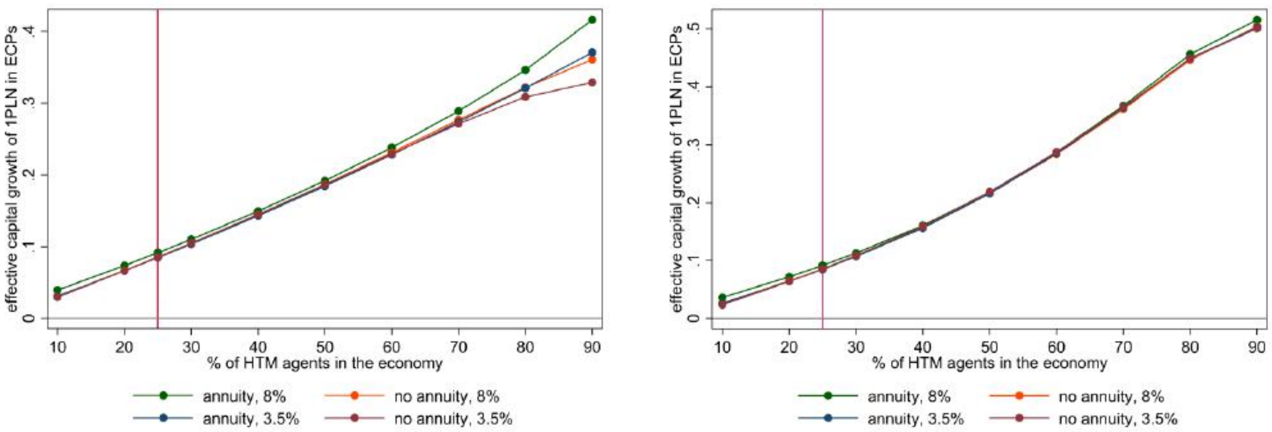
In this section we provide an analysis of how much the results depend on the share of HTM agents in the economy. We show the results for economy with the same parameters (and thus naturally different target values) and for illustrative purposes, we also report analogous analyses if target values are matched but parameters for time preference (δ) and leisure preference (ϕ) are adjusted. In the interest of brevity, we discuss crowding out, consumption taxes and welfare over the long run.[12]

The net effect on capital growth for HTM agents is always positive by construction – in absence of ECPs they hold no other private savings that could be crowded out. On the one hand, the more HTM agents in the economy the more assets are accumulated within the ECPs. This brings positive effects on effective capital growth due to ECPs. On the other hand, the more assets accumulated HTM agents in ECPs, the larger the general equilibrium effects, most notably declining interest rate. Moreover, the savings of the HTM agents in ECPs are not responsive to the changes in the interest rate, which amplifies the link between the share of HTM agents in the economy and assets accumulation by the fully rational agents. Overall, this results in higher crowding out for fully rational agents (see Table 4). The results are of similar magnitudes whether economy is recalibrated or not.

[12] The time evolution of these variables and all the other variables used to obtain figures and tables discussed above, are available for download under the following [LINK]. Note that an economy with 100% HTM agents does not exist (it would have no capital in baseline scenario).

Figure 7. Crowding out in the long-run for alternative % of HTM agents

(a) original model parameters (b) recalibrated economy



Notes: The 25% share of HTM agents is highlighted with a vertical line. Points on this line correspond with the long-run effects presented on Figure 1 The total capital growth comprises of two opposing factors. Positive net effect for HTM agents (they hold no private assets to crowd out in baseline) and a negative net effect for fully rational agents (due to general equilibrium adjustment). Both effects: the positive and negative increase with the share of HTM agents. The details or recalibration reported in Appendix A3.

Table 4. Effective assets growth for fully rational agents – across % of HTM agents

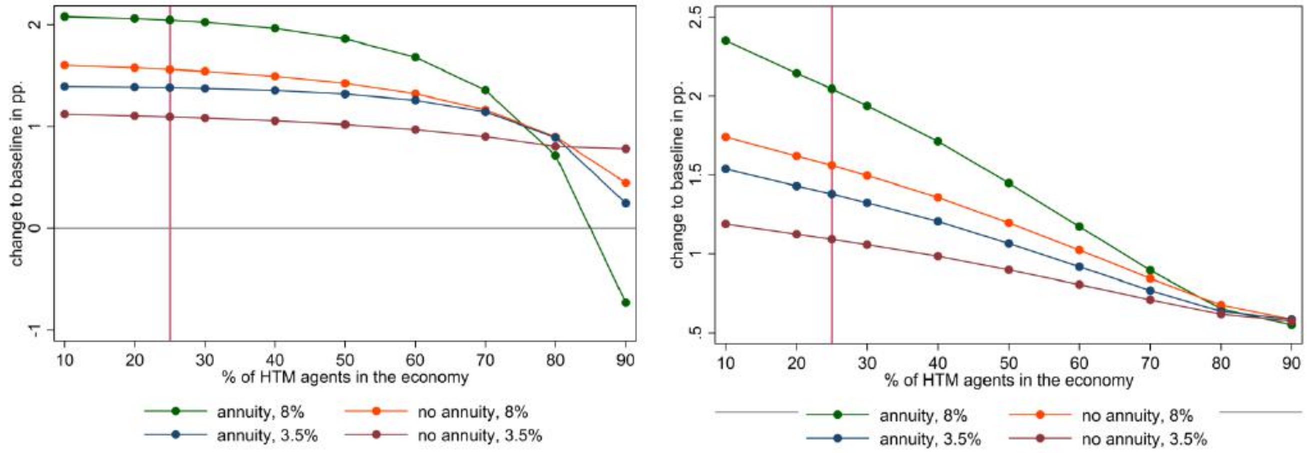
Total (general equilibrium) adjustment										
	% of HTM agents in the economy – original model parameters									
Scenario:	10%	20%	**25%**	30%	40%	50%	60%	70%	80%	90%
annuity, 8%	-0.055	-0.131	**-0.176**	-0.226	-0.348	-0.515	-0.757	-1.149	-1.908	-4.081
annuity, 3.5%	-0.066	-0.144	**-0.189**	-0.241	-0.368	-0.542	-0.799	-1.221	-2.058	-4.547
no annuity, 8%	-0.065	-0.140	**-0.184**	-0.234	-0.356	-0.523	-0.768	-1.171	-1.977	-4.436
no annuity, 3.5%	-0.068	-0.144	**-0.189**	-0.240	-0.364	-0.536	-0.789	-1.212	-2.074	-4.786
	% of HTM agents in the economy – recalibrated economy									
annuity, 8%	-0.059	-0.134	**-0.176**	-0.22	-0.324	-0.444	-0.593	-0.792	-1.114	-2.136
annuity, 3.5%	-0.072	-0.147	**-0.189**	-0.235	-0.341	-0.465	-0.623	-0.842	-1.211	-2.394
no annuity, 8%	-0.071	-0.143	**-0.184**	-0.228	-0.33	-0.447	-0.595	-0.796	-1.126	-2.17
no annuity, 3.5%	-0.075	-0.148	**-0.189**	-0.233	-0.336	-0.456	-0.61	-0.824	-1.187	-2.359

Notes: The 25% share of HTM agents is highlighted, corresponding with the long-run effects presented in Table 2. With an increasing share of HTM agents in the economy the general equilibrium effects of ECPs are increasing in potency as well. This is due to the simple fact that HTM agents have no adjustability when it comes to assets accumulation. The higher their share in the economy, the higher their net impact on the macroeconomic variables. The details of recalibration reported in Appendix A3.

In parallel, to the interest rate, the higher share of HTM agents amplifies the effects of ECPs on tax base. The higher the share of the HTM agents, the higher the debt servicing costs in the baseline and the greater the decline in the debt servicing costs in the reform scenario of implementing ECPs. With higher effective capital growth comes also a higher labor productivity, and by thus higher wages. Finally, in the final steady states higher share of HTM agents implies higher increase in consumption in the old age. These general equilibrium effects jointly act as a fiscal relief. The lump-sum transfer within ECPs is a lump-sum transfer therefore it does not change with the share of HTM agents in the economy. The capital income tax exemptions work in the opposite direction: the effective assets growth for fully rational agents is decreasing with the share of HTM agents, lowering the tax base for capital gain taxes. This fiscal cost increases with the share of HTM agents in the economy. Figure 8 portrays that for most reasonable shares of HTM agents in the economy, the fiscal effects are similar. Only once the share of HTM agents exceeds 70%, the fiscal reliefs brought by introduction of ECPs increase faster than their fiscal costs. For the recalibrated economy, this trend appears to be displayed for all shares of HTM agents, but recall that the recalibration concerns predominantly intra and inter-temporal choice parameters, hence directly affecting the preference for consumption.

Figure 8. Consumption tax relative to *status quo* in the long-run for alternative % of HTM agents

(a) original model parameters (b) recalibrated economy



Notes: The 25% share of HTM agents is highlighted with a vertical line. Points on this line correspond with the long-run effects presented on Figure 3. The details or recalibration reported in Appendix A3.

Table 5. Welfare effects of ECPs

Welfare effects for fully rational agents										
	% of HTM agents in the economy – original model parameters									
Scenario:	10%	20%	**25%**	30%	40%	50%	60%	70%	80%	90%
annuity, 8%	0.28%	0.17%	**0.08%**	-0.03%	-0.37%	-0.91%	-1.82%	-3.34%	-5.96%	-10.27%
annuity, 3.5%	0.05%	-0.01%	**-0.06%**	-0.13%	-0.31%	-0.62%	-1.14%	-2.04%	-3.65%	-6.55%
no annuity, 8%	-0.17%	-0.24%	**-0.30%**	-0.38%	-0.62%	-1.01%	-1.68%	-2.84%	-4.94%	-8.75%
no annuity, 3.5%	-0.14%	-0.19%	**-0.22%**	-0.27%	-0.40%	-0.62%	-0.99%	-1.64%	-2.85%	-5.24%
	% of HTM agents in the economy – recalibrated economy									
annuity, 8%	0.29%	0.17%	**0.08%**	-0.04%	-0.40%	-1.00%	-2.00%	-3.67%	-6.43%	-10.65%
annuity, 3.5%	0.06%	-0.01%	**-0.06%**	-0.13%	-0.34%	-0.67%	-1.24%	-2.18%	-3.75%	-6.24%
no annuity, 8%	-0.17%	-0.25%	**-0.30%**	-0.38%	-0.62%	-1.03%	-1.72%	-2.90%	-4.91%	-8.11%
no annuity, 3.5%	-0.15%	-0.19%	**-0.22%**	-0.27%	-0.40%	-0.63%	-1.01%	-1.67%	-2.80%	-4.61%
Welfare effects for hand-to-mouth agents										
	% of HTM agents in the economy – original model parameters									
Scenario:	10%	20%	**25%**	30%	40%	50%	60%	70%	80%	90%
annuity, 8%	45.91%	46.37%	**46.73%**	47.18%	48.46%	50.40%	53.36%	58.05%	66.22%	85.90%
annuity, 3.5%	30.50%	30.88%	**31.17%**	31.55%	32.61%	34.26%	36.82%	40.99%	48.49%	67.02%
no annuity, 8%	22.85%	23.10%	**23.27%**	23.48%	24.06%	24.93%	26.24%	28.35%	32.11%	41.42%
no annuity, 3.5%	17.08%	17.16%	**17.24%**	17.35%	17.69%	18.24%	19.13%	20.64%	23.44%	30.67%
	% of HTM agents in the economy – recalibrated economy									
annuity, 8%	43.27%	45.45%	**46.73%**	48.33%	52.60%	58.96%	69.23%	87.28%	126.49%	255.81%
annuity, 3.5%	29.12%	30.39%	**31.17%**	32.15%	34.81%	38.70%	45.00%	55.99%	79.24%	154.05%
no annuity, 8%	21.81%	22.74%	**23.27%**	23.90%	25.49%	27.60%	30.53%	34.49%	39.17%	37.25%
no annuity, 3.5%	16.40%	16.93%	**17.24%**	17.61%	18.59%	19.86%	21.65%	24.05%	26.73%	24.55%

Notes: These are aggregate welfare effects. The details or recalibration reported in Appendix A3.

The positive welfare effects for the HTM agents are driven by two main factors. First, ECPs allow otherwise infeasible consumption smoothing – this factor in principle does not depend on the share of HTM agents in the economy. Second, participation in ECPs gives the HTM agents an opportunity to earn interest on savings. If the economy is not recalibrated higher share of HTM agents is equivalent to higher interest rate in the economy, hence higher gains from being able to earn interest on savings. For the fully rational agents, ECPs reduce welfare (unless they are sufficiently large *and* provide an annuity). Larger share of HTM agents is thus consistent with greater distortion and consequently greater welfare loss. We report these results in Table 5.These patterns appear to be concave for the fully rational agents and convex for the HTM agents in the share of HTM agents (see also Figure 14 in the appendix).

6. Conclusions

Increasing longevity challenges the design of individual lifetime consumption paths and savings profiles. In order to reduce old-age poverty, a substantial increase in savings is required. Many governments introduce policies aiming to foster old-age savings. In Poland, as of 2019, Employees' Capital Plans are being gradually introduced. They offer tax exemptions and lump-sum transfers to the participants. We provide an *ex ante* evaluation of this instrument. We add behavioral heterogeneity in the form of the hand-to-mouth agents, to an otherwise standard overlapping generations model. This enriched model is further extended to account for endogenous participation in old-age savings instrument, which replicates the features of ECPs.

Our analysis suggests that the ECPs will cause relatively humble increase in total capital in the economy. Total assets of the HTM agents are increased, but the fully rational agents displace assets from (taxed) private voluntary savings to the ECPs (which are exempt from capital gains taxation). In addition, the general equilibrium effects, mainly increased taxes and decreased interest rate, discourage the fully rational agents from saving. Overall, the increased asset holdings by HTM agents are counterweighed by reduced asset holding by the fully rational agents. Overall long-run effects of the ECPs for capital creation range between 0.8% and 3.0% relative to baseline. Back of the envelope computation which excludes both the crowding out and general equilibrium effect would yield a long-run capital increase of roughly 3.8-8.8% relative to baseline, for the lower bound and the upper bound of the ECPs contributions, respectively. The general equilibrium effects also bring a decrease in labor supply, though when ECPs offer annuity then the implicit decrease in effective marginal labor tax rate is enough to increase aggregate labor supply above the baseline level.

Although there are many factors driving the fiscal costs of the ECPs, two of them quantitatively dominate the others: reduction in capital gain tax base and lump-sum transfers. These two channels account for 84%-94% of the entire fiscal adjustment, which needs to be financed through increased taxation. The consumption tax rates will have to increase by roughly 1-2 percentage points relative to baseline. The increase in the consumption tax is compensated in welfare terms for the hand-to-mouth agents, but is not compensated for the fully rational agents. With endogenous participation, the fully rational agents participate in ECPs, but would rather live in a baseline scenario of *status quo*.

We show that ECPs raise consumption of HTM agents in the old age, whereas for the fully rational agents the ECPs raise consumption increases when the agents are young. The mechanisms which explain these patterns are as follows. Introducing the ECPs reduces disposable income for the HTM agents when they work, but the benefits from ECPs substantially increase their disposable income after retirement. Meanwhile, the fully rational agents can actually increase consumption during the working period, because ECPs offer a capital income tax exemption, which rises effective rate of return on assets.

Those results have to be taken with a grain of salt. HTM agents operationalize a vast plethora of possible behavioral patterns, some of which are conceptually inconsistent with the welfare gain. Notably, if agents do not save because they do not *want* to smoothen consumption, instruments such as ECPs cannot actually raise welfare and HTM agents will opt out of participation. If agents do not save because they *cannot* do so, ECPs will enrich their choice sets and actually raise welfare. Models such as our OLG cannot distinguish between these two types of agents, but also empirical evidence on the sources of hand-to-mouth consumption is scarce at this point, calling for more research in the field.

There are several potential caveats to be mentioned in the summary of our study. Admittedly, agents in our model inhabit a deterministic world with no concerns about the commitment of the government to actually stick to implementing ECPs. In the real world, idiosyncratic labor income and capital income shocks raise uncertainty about future income, the extent of longevity is not fully predictable and governments are known to default on pension obligations and capturing pension assets. We are not aware of any large scale macroeconomic simulation models who would be able to fully account for uncertainty about policy and longevity, but introducing income shocks to our setup could make agents seek safe assets and thus potentially consider ECPs as a superior investment strategy relative to own investment (e.g. due to the ability to fully diversify financial markets risks).

Also, our model *isolates* the effects of ECPs, holding all other economic processes constant between the baseline and reform scenario. Hence, one cannot use the implications of our model as a prediction of what will actually happen in the Polish economy. The introduction of ECPs is going to occur post the peak of the business cycle, accompanied by substantial changes in social transfers and fiscal policy. Isolating the effects of ECPs from those other factors in observational data may indeed be impossible. Moreover, in our model agents could not accumulate old-age savings in any tax incentivized instruments prior to ECPs, whereas in reality there exist some legal vehicles (such as employee pension plans, individual savings account, etc). While participation rates are low for those instruments, our model cannot be used to predict if enrollment in ECPs and those instruments are related.

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Appendices

Appendix A1. First order conditions in the baseline and reform scenarios for fully rational and hand-to-mouth agents.

FOCs for fully rational agents (using additional notation):

$$\widetilde{w}_t = w_t(1-\tau^l)(1-\tau)(1-\tau^{ECP})$$

$$\widehat{\widetilde{w}}_{j,FR,t} = w_t(1-\tau^l)(1-\tau(1-\hat{\tau}_{j,FR,t}))(1-\tau^{ECP}(1-\hat{\tau}^{ECP}_{j,FR,t}))$$

$$l_{j,FR,t} = 1 - \frac{1-\phi}{\phi \widehat{\widetilde{w}}_{j,FR,t}}(1+\tau^c_t)c_{j,FR,t} \qquad \text{for: } j < \bar{J}$$

$$l_{j,FR,t} = 0 \qquad \text{for: } j \geq \bar{J}$$

$$c_{j,FR,t} = \frac{(1+r_t)a_{j-1,FR,t-1} - \Upsilon + bequest_{j,FR,t} + \widetilde{w}_t + \sum_{s=1}^{J-j-1} \frac{\widetilde{w}_{t+s} + bequest_{j+s,FR,t+s} - \Upsilon}{\prod_{i=1}^{s}(1+r_{t+i})} + \sum_{s=\bar{J}-j}^{J-j} \frac{b_{j+s,t+s} + bequest_{j+s,FR,t+s} - \Upsilon}{\prod_{i=1}^{s}(1+r_{t+i})}}{\frac{1}{\phi} + \frac{1}{\phi}\sum_{s=1}^{\bar{J}-j-1} \delta^s \frac{\pi_{j+s,t+s}}{\pi_{j,t}} + \sum_{s=\bar{J}-j}^{J-j} \delta^s \frac{\pi_{j+s,t+s}}{\pi_{j,t}}} \qquad \text{for: } j < \bar{J}$$

$$c_{j,FR,t} = \frac{(1+r_t)a_{j-1,FR,t-1} - \Upsilon + bequest_{j,FR,t} + b_{j,t} + \sum_{s=1}^{J-j} \frac{b_{j+s,t+s} + bequest_{j+s,FR,t+s} - \Upsilon}{\prod_{i=1}^{s}(1+r_{t+i})}}{1 + \sum_{s=1}^{J-j} \delta^s \frac{\pi_{j+s,t+s}}{\pi_{j,t}}} \qquad \text{for: } j \geq \bar{J} \qquad (19)$$

$$a_{j,FR,t} = (1+r_t)a_{j-1,FR,t-1} + l_{j,FR,t}\widetilde{w}_t - \Upsilon + bequest_{j,FR,t} \qquad \text{for: } j < \bar{J}$$

$$a_{j,FR,t} = (1+r_t)a_{j-1,FR,t-1} + b_{j,FR,t} + b^{ECP}_{j,FR,t} - \Upsilon + bequest_{j,FR,t} \qquad \text{for: } j \geq \bar{J}$$

$$a_{j,FR,t} \geq 0$$

Where $\hat{\tau}_{j,FR,t}$ and $\hat{\tau}^{ECP}_{j,FR,t}$ come from the fact that contributions to the pension systems are implicit savings. They amount to:

$$\hat{\tau}_{j,FR,t} = \left[\frac{1 + \sum_{s=1}^{J-\bar{J}}\left[\prod_{i=1}^{s} \frac{g_{t+\bar{J}-j+s}}{MRS_{\bar{J}+s,\bar{J}+s+1,FR,t+\bar{J}-j+s}}\right]}{LE_{\bar{J},t}}\right] \prod_{s=1}^{\bar{J}-j}\left[\frac{g_{t+s}}{MRS_{j+s,j+s+1,FR,t+s}}\right]$$

$$\hat{\tau}^{ECP}_{j,FR,t} = \left[\frac{1 + \sum_{s=1}^{J-\bar{J}}\left[\prod_{i=1}^{s} \frac{1+r_{t+\bar{J}-j+s}}{MRS_{\bar{J}+s,\bar{J}+s+1,FR,t+\bar{J}-j+s}}\right]}{LE_{\bar{J},t}}\right] \prod_{s=1}^{\bar{J}-j}\left[\frac{1+r_{t+s}}{MRS_{j+s,j+s+1,FR,t+s}}\right]$$

FOCs for HTM agents (using additional notation):

$$\widetilde{w}_t = w_t(1-\tau^l)(1-\tau)(1-\tau^{ECP})$$

$$l_{j,HTM,t} = 1 - \frac{1-\phi}{\phi \widetilde{w}_t}(1+\tau^c_t)c_{j,HTM,t} \qquad \text{for: } j < \bar{J}$$

$$l_{j,HTM,t} = 0 \qquad \text{for: } j \geq \bar{J} \qquad (20)$$

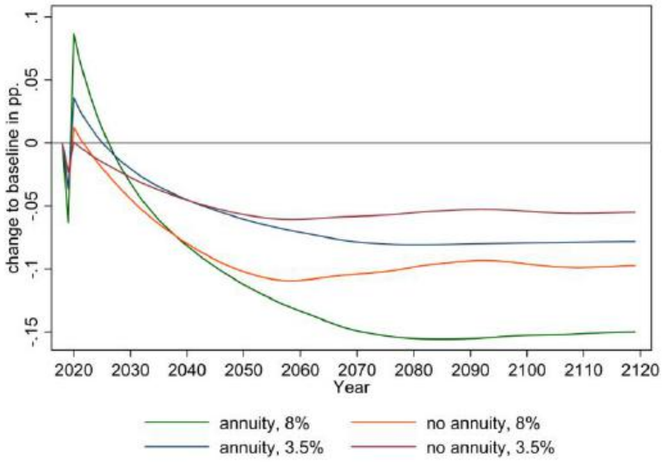
$$c_{j,HTM,t} = \frac{l_{j,HTM,t}\widetilde{w}_t - \Upsilon + bequest_{j,HTM,t}}{1+\tau^c_t}$$

$$a_{j,HTM,t} = 0$$

Please note that HTM agents do not perceive contributions to pension schemes as implicit savings, therefore their implicit labor tax rate is higher.

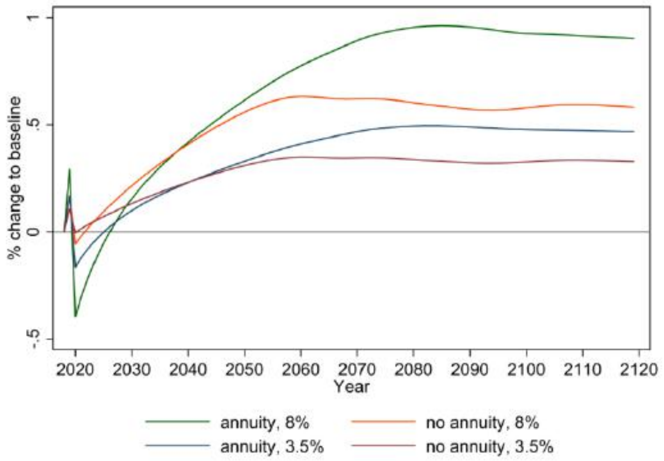
Appendix A2.

Figure 9. Gross interest rate with ECPs relative to *status quo*



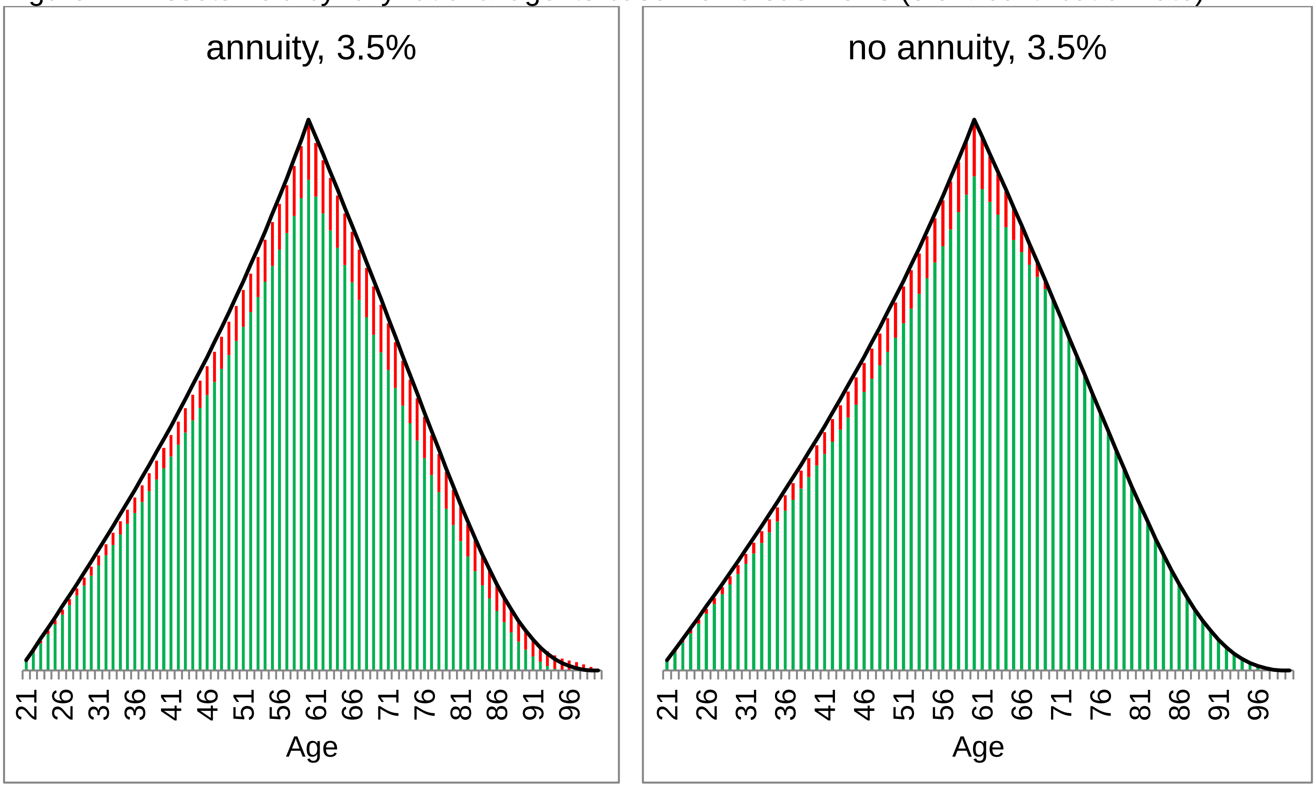
Notes: ECPs effectively increase capital stock in the economy making it relatively more abundant. This is reflected in the decreasing gross interest rate. The greater the capital stock increase under various ECPs, the lower the interest rate. The slight decrease of gross interest rate in the first period on the transition path is due to the gradual implementation of the ECPs: they are implemented as of 2020 (transition period 2), but the agents are aware of them as of 2019 (transition period 1).

Figure 10. Gross wage rate with ECPs relative to *status quo*



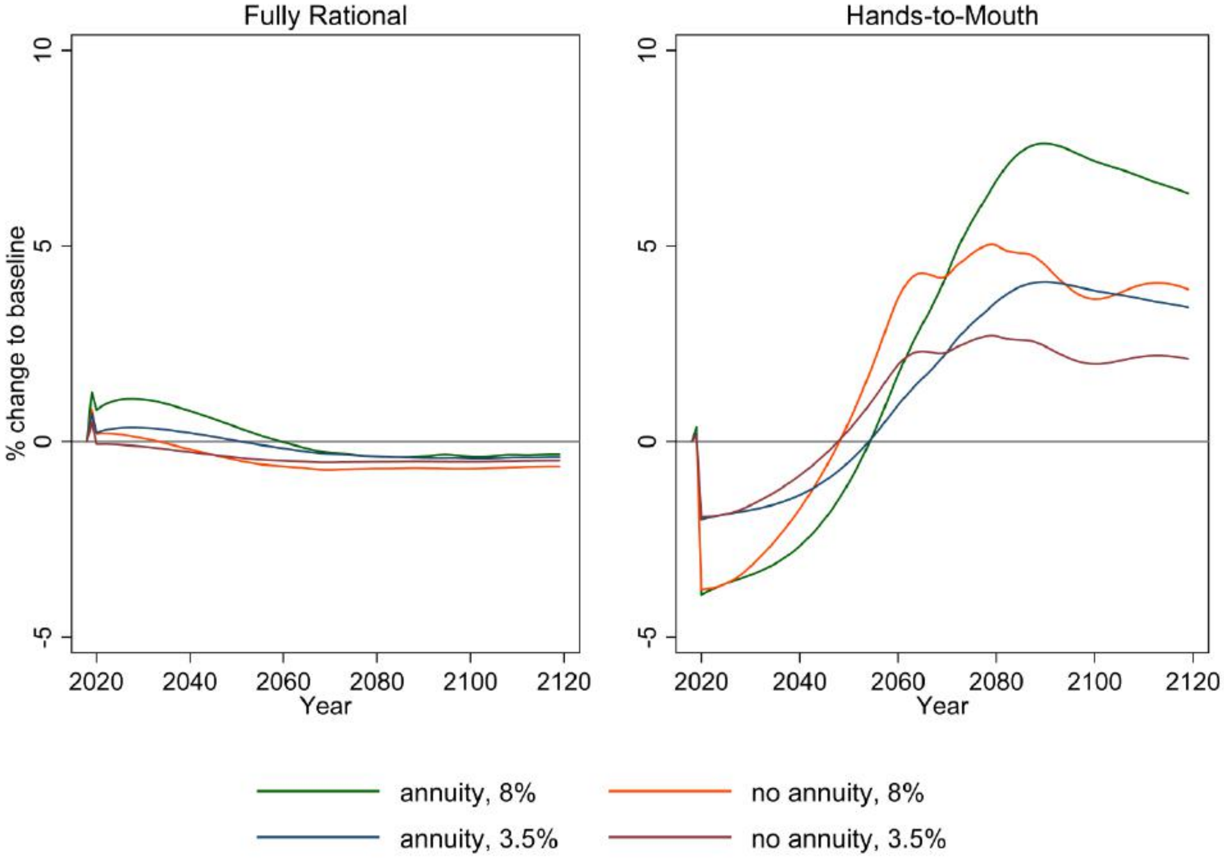
Notes: ECPs effectively decrease labor supply in the economy making it relatively more scarce. This is reflected in the increasing gross wage. The greater the labor supply decrease under various ECPs, the higher the gross wage. The slight increase of gross wage in the first period on the transition path is due to the gradual implementation of the ECPs: they are implemented as of 2020 (transition period 2), but the agents are aware of them as of 2019 (transition period 1).

Figure 11. Assets held by fully rational agents baseline versus ECPs (3.5% contribution rate)



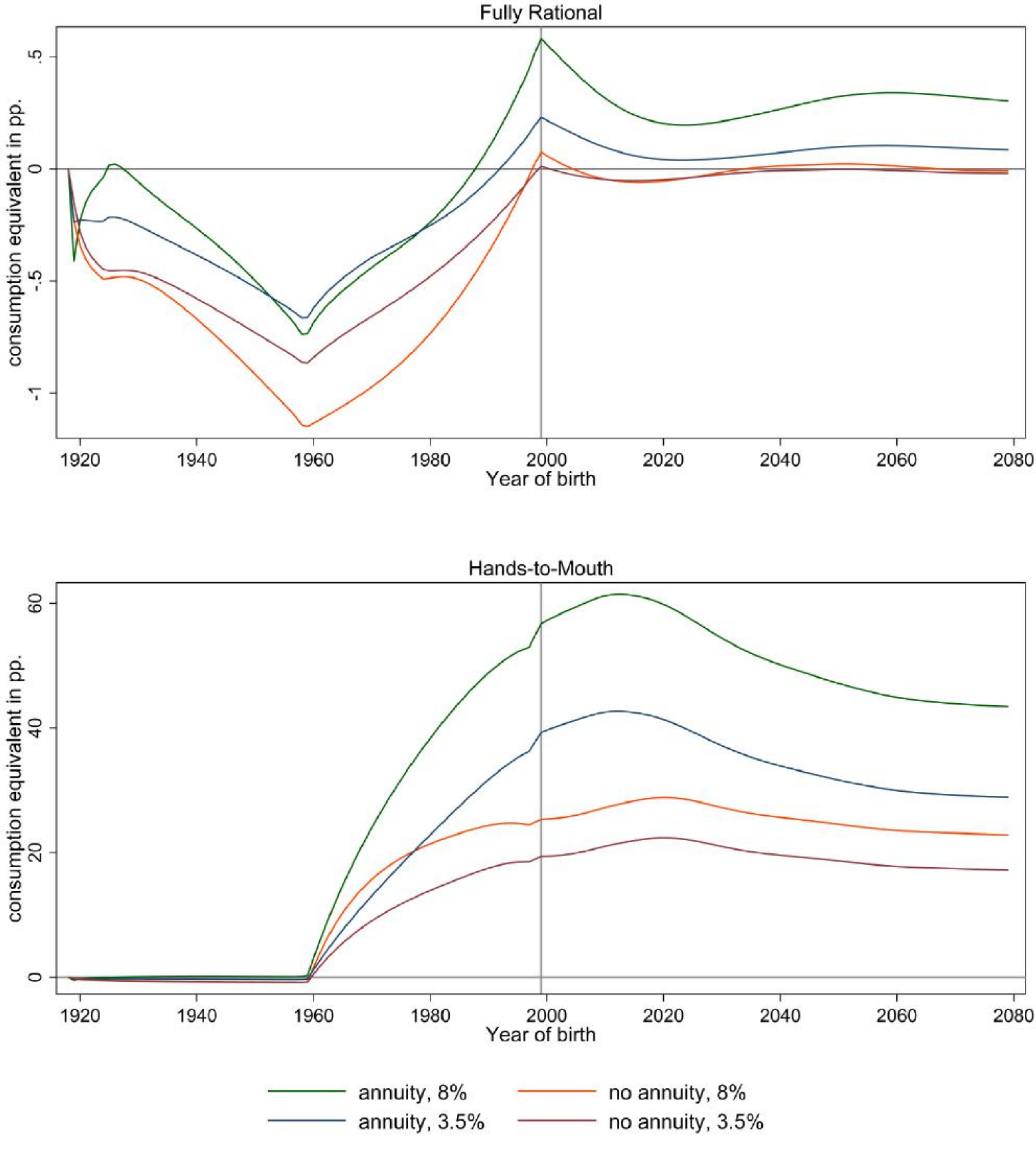
Notes: Fully rational agents offset assets accumulated in the ECPs almost perfectly. For ECPs offering annuity total assets are effectively larger with ECPs than without. During accumulation period (for both types of ECPs: with and without annuity) the total assets are slightly lower. ECPs offer capital gain tax exemption hence the same level of assets at the retirement may be achieved with lower effective saving rates. Dynamics of the wealth accumulation for fully rational agents are the same under 8% and 3.5% contribution rate. The size of the effects are proportionally less pronounced.

Figure 12. consumption (in %) relative to *status quo* for each type of agents separately



Notes: (left panel)	Consumption for fully rational agents changes due to two main factors. First, it decreases across whole life-cycle due to increase in consumption tax rate. Second, in order to arrive with the same *level* of assets upon retiring the capital gain tax exemption in ECPs allows for a lower net savings rate. This allows for higher consumption when young. The long-run effect on aggregate consumption of fully rational agents is negative across all reform scenarios as the second effect does not overcome the first. Yet at the beginning of the transition the effect is positive for most reform scenarios as it takes several decades for the participating cohorts to retire, and by thus for the second effect to be overcome by the first one.
Notes: (right panel)	Consumption for hand-to-mouth agents changes due to three main factors. First, it decreases across whole life-cycle due to an increase in consumption tax rate. Second, it increases during retirement as ECPs offer consumption smoothing that was outside HTM's choice set. Third, as HTMs have no means of consumption smoothing except the NDC pension system and ECPs the whole amount of contribution decrease the disposable income, thus mechanically reducing consumption when working. At the beginning of the transition path net effect is negative. With time participating cohorts retire and after couple of decades the net effect on HTM's aggregate consumption becomes significantly positive.

Figure 13. Welfare effects: consumption equivalent as a % of baseline lifetime consumption



Notes: Gray vertical line on Figure 10 represents the cohort, born at 1999, that enters the labor market on the moment of ECPs introduction – they are the first cohort that may participate for the whole working period. Consumption equivalent expressed in percent of lifetime consumption.

Appendix A3. Sensitivity analysis with model recalibrated for varying share of HTM agent.

Changing the share of HTM agents in the economy influences two things. First, labor market behavior. HTM and fully rational agents decide about labor supply based on different optimization problems. Second, only fully rational agent accumulate private assets. Therefore to arrive with the same set of macroeconomic variables only two parameters need to be manipulated: discount factor (δ) and weight on consumption in utility function (ϕ).

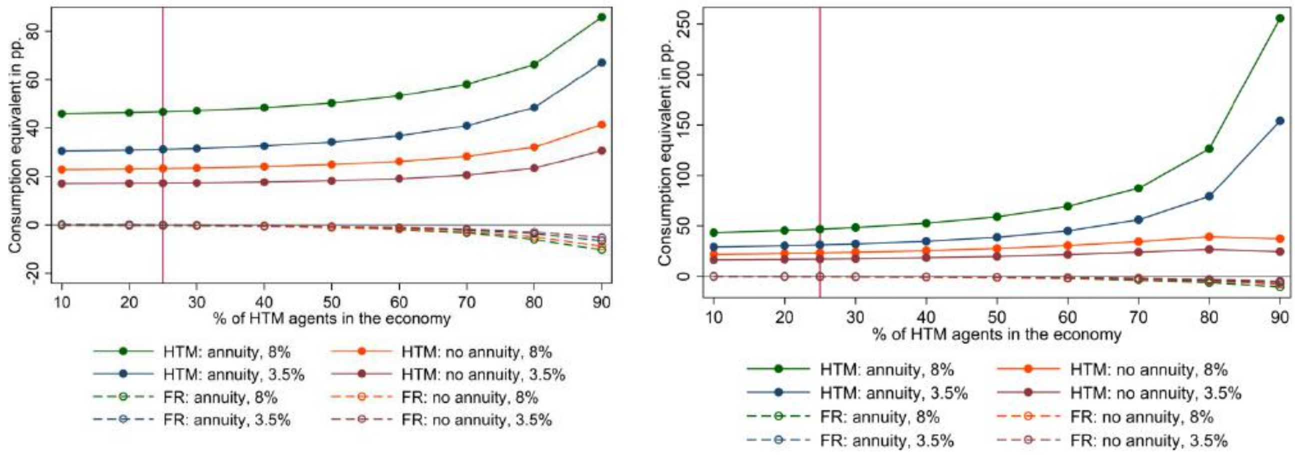
Table 6. Calibration of the economy for different shares of HTM agents

Parameter	Share of Hand-to-Mouth agents in the economy									
	10%	20%	**25%**	30%	40%	50%	60%	70%	80%	90%
δ	0.981	0.983	**0.984**	0.985	0.988	0.992	0.998	1.007	1.023	1.063
ϕ	0.4600	0.4640	**0.4665**	0.4685	0.4730	0.4770	0.4810	0.4830	0.4840	0.4797

Notes: The 25% share of HTM agents is highlighted with a bold font. Target parameters have the exact same values as in Table 1.

Figure 14. Welfare effects of ECPs – for different shares of HTM agents in population

(a) original model parameters (b) recalibrated economy



Notes: The 25% share of HTM agents is highlighted with a vertical line. Points on this line correspond with the figures presented in Table 3. ECPs allow HTM agents not only to smooth consumption over the life-cycle, but also give them some access to the financial markets. The higher the interest rate, the more welfare improving this access is. Therefore HTM agents welfare increases with their share in the economy. The fully rational agents get some utility from the annuity (when offered) but the net welfare effect of the distortions due to ECPs is negative. Hence the more pronounced general equilibrium effects are, the worse for them. The details or recalibration reported in Appendix A3.