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Evaluating an old-age voluntary saving scheme under incomplete rationality

Abstract: We provide an *ex ante* welfare, fiscal and general macroeconomic evaluation of the voluntary old-age saving scheme recently introduced in Poland and known as Employee Capital Plans. ECPs provide tax redemptions as well as lump-sum transfers with the objective to foster old-age savings. A reduction in capital income tax revenue and a rise in expenditure need to be compensated for through adjustments in other taxes. We employ an overlapping-generations model (OLG) to gauge the plausible magnitude of macroeconomic and welfare effects and to provide insights into the 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 a relatively strong crowding-out of private savings. In our preferred specification, roughly PLN 0.08–0.09 of every PLN 1 allocated to ECPs is actually new savings, the rest being displaced from unincentivised private voluntary savings. The plausible values of effective capital growth in ECPs range between 0.03 and 0.42 of PLN 1. ECPs reduce the welfare of fully rational agents unless a sufficiently large annuity is offered. ECPs provide consumption smoothing and interest income to HTM agents.

Keywords: overlapping generations, ECPs, incomplete rationality

JEL Classification Codes: C68, D63, E17, E21, H55

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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, voluntary old-age saving schemes known as Employee Capital Plans (ECPs) were introduced in Poland. They feature tax exemptions and lump-sum transfers to participants as well as other nudges to encourage wide participation and foster capital accumulation by working-age cohorts. The purpose of this paper is to provide a welfare-based, 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. This is because they have *already optimised* their lifetime consumption and leisure path [Gale, Scholtz, 1994; Garriga, 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 aimed at raising private voluntary savings for old age have a neutral effect on the 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 analyse voluntary old-age saving schemes.

In our set-up, a fraction of each cohort exhibits hand-to-mouth (HTM) behaviour, which is consistent with a number of empirical regularities identified earlier in the literature [Weil, 1992; Kaplan et al., 2014; Heathcote, Perri, 2018; Olafsson, Pagel, 2018]. HTM agents generally consume all the contemporaneous income, as a result of which they do not accumulate any assets in their working periods to finance consumption during retirement. Since the 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 substantially expand their choice sets, thereby effectively raising the welfare of this group of agents [Krussel, Smith, 1998]. The overall effects depend on the magnitude and size of the welfare effects for 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 empirical evidence on the savings response by the households and predictions from a structural macroeconomic model. For example, a 1999 pension system reform in Poland raised incentives for private voluntary savings – the expected pension wealth was reduced due to an expected decline in pension benefits. This phenomenon was empirically analysed by Lachowska and Myck [2018], who found an average increase

in savings of approximately PLN 0.30 for every PLN 1 lost in pension wealth (or 30%). A similar magnitude of crowing-out effects was provided for Spain by Ayuso et al., [2007]. Meanwhile, macroeconomic models calibrated to replicate the features of the Polish economy [Hagemejer et al., 2017] imply a much stronger reaction. Introducing HTM consumers to an economy makes it possible to align macroeconomic implications with microeconometric evidence.

Our study 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 a 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 ECP implementation. Participation in ECPs is endogenous. In the case of each reform scenario, we provide an evaluation of macroeconomic (capital, labour, prices) and fiscal consequences (tax revenues, expenditures). We also conduct a welfare accounting exercise for these 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 such evaluation of ECPs, we are certainly not the first to use OLG to provide an *ex ante* policy evaluation. In the case of Poland, previous attempts have included an analysis of the 1999 pension reform [Makarski et al., 2017], analysis of extensions in the retirement age from 2011 [Bielecki et al., 2016; Makarski, Tyrowicz, 2019], and an analysis of 2013 changes to 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] analyses an instrument similar to the case of the Polish ECPs, as introduced in Taiwan, in an empirical context. Similar studies analyse the effects of private voluntary old-age saving schemes in Canada [Messacar, 2018] as well as the UK and the United States [Attanasio et al., 2004], among others.

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

Our study is structured as follows. The following section describes our model in detail. Section 3 outlines the calibration of our model. In particular, we focus on how the features of the ECPs have been translated into the model. The results are discussed in section 4. We analyse 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 examine the policy implications of our model.

Model

Demographics and intra-cohort heterogeneity

The model economy is populated by overlapping generations of individuals who live for $j = 1, 2, \ldots, J$ 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 labour 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 behavioural characteristics are assigned permanently to an agent at birth ($j = 1$). Thus, subcohort $m \in M$ of agents of age $j = 1, 2, \ldots, J$ 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 the labour supply out of the total time endowment, which is normalised 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 decisions. This is done via accumulation of asset $a_{j,m,t}$ which earns interest rate r_t. The agents' objective to maximise their lifetime utility is defined as follows:

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

In each period, the fully rational agents divide the income flow between consumption $c_{j,m,t}$, which is burdened with consumption tax τ_t^c, and accumulating to assets $a_{j,m,t}$. The budget of the working agent ($j < \bar{J}$) consists in each period of labour income, which depends on current period wage w_t and the amount of labour supplied $l_{j,m,t}$ and labour taxes τ^l. In addition to labour income, the agents receive capital gains: $a_{j-1,m,t-1}(1 - \tau^k)r_t$, where τ^k is the tax levied on capital gains and r_t is the endogenous interest rate. Agents receive accidental bequests $bequest_{j,m,t}$, distributed within a subcohort[1]. In order to capture

[1] This assumption is equivalent to intra-marital inheritance, which is the dominant inheritance in most European legal systems and reflects the empirical regularities of assortative mating [Pencavel, 1998; Kalmijn, 1994]. Our modelling 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

the transfers and taxes not explicitly modelled in this study, we introduce *per capita* lump-sum tax Y. 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:

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

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 after retirement, which is the main reason to impose a non-negativity constraint in this literature. Raising the stream of future incomes by an instrument incentivising old-age saving could cause similar adjustments in lifetime consumption patterns among agents. Notably, the agents do not differ in time preference in our set-up, hence the reaction to introducing an instrument incentivising old-age savings is common across agents, i.e. the non-negativity constraint affects fully rational and HTM agents in the same manner. The non-negativity constraint reduces the scope for crowding-out in our set-up and increases the room for fiscal and welfare effects.

The standard Euler condition, which demands that the marginal rate of (inter-temporal) substitution ($MRS_{j,j+s,m,t}$) equals the interest rate $(1+(1-\tau^k)r_t)$, permits linking pension benefit contributions with benefits in the consumer problem [Bütler, 2000]. Note that the Euler condition does not always hold in our set-up. 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: $MRS_{j,m,t} \geq (1+(1-\tau^k)r_t), \forall_{j\in\{1,2,\ldots,J\}, m\in M, t\in\{1,2,\ldots,T\}}$. 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:

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

and their budget constraint is given by:

$$(1+\tau_t^c)c_{j,HMT,t} + Y_t = \begin{cases} (1-\tau^l)(1-\tau)w_t l_{j,HMT,t} + bequest_{j,HMT,t}, \text{ for } j < \bar{J} \\ (1-\tau^l)b_{j,HMT,t} + bequest_{j,HMT,t}, \text{ for } j \geq \bar{J} \end{cases}, \tag{5}$$

another distribution of bequests would generate lump-sum transfers between the subcohorts driving redistribution beyond the direct effects analysed in this model.

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 labour of $(1-\tau^{l})(1-\tau)$.

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 labour, 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 the 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 each period by 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 the pension of an agent retiring in period t is as follows:

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

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2 The former capital pillar operated by Open Pension Funds is assumed away for brevity and because its role has become marginal.

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 each period by g_t: $b_{j,m,t} = g_t b_{j-1,m,t-1}$. The balance of private accounts ($f_{j,m,t}$) accumulated by agents who died prior to reaching retirement age $\bar{J}$ enters $bequest_{j,m,t}$. Meanwhile, the balance of private accounts ($f_{j,m,t}$) accumulated by agents who died after reaching retirement age ($\bar{J}$) automatically enters 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 law regulating Employee Capital Plans (ECPs).

The government

The government budget inflows consist of taxes collected on: consumption (τ_t^c), labour (τ^l), capital gain (τ^k) and *per capita* lump-sum tax Y. We allow the consumption tax to vary over time to balance the budget, so 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 ($subsidy_t$), and expenses related to servicing the debt, i.e. $r_t D_{t-1}$.

$$\begin{gathered} T_t = \sum_{j=1}^{J} \sum_{m \in M} N_{j,m,t} \left[\tau_t^c c_{j,m,t} + \tau^l \left((1-\tau) w_t l_{j,m,t} + b_{j,m,t} \right) + \tau^k r_t a_{j-1,m,t-1} + \mathrm{Y} \right] \\ T_t + (D_t - D_{t-1}) = G_t + subsidy_t + r_t D_{t-1} \end{gathered} \tag{11}$$

In the initial steady state, we close the government budget with lump-sum tax (Y) 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 the debt-to-GDP ratio constant. The values of Y and G_t set in the initial steady state are held fixed in *per capita* terms throughout the transition path in all the scenarios. In order to keep the 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:

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

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

The labour market clears:

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

The asset market clears:

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

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

- $\forall_{t>1}, \forall_{j \in [1,J]}, \forall_{m \in M} (c_{1,m,t}, ..., c_{j,m,t+j-1}), (l_{1,m,t}, ..., l_{j,m,t+j-1}), (a_{1,m,t}, ..., a_{j,m,t+j-1})$ 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
- The prices are given by (7)
- Equation (4) is satisfied, i.e. the government budget is balanced.
- Equations (5)–(7) are satisfied, i.e. all the markets clear.

Policy reform

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

The key elements of the policy reform are as follows. First, 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 time 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, each cohort works a fraction of their time endowment, reflecting the actual employment rate in the economy, all consumers of working age contribute to ECPs and thus receive such 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 the 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 behaviour of the majority of ECP participants and

no general equilibrium model is equipped to address such marginally important behaviours.

An instrument such as ECPs is likely to generate crowding-out effects. In a general equilibrium model with overlapping generations, the agents optimally choose the lifetime savings path, hence the 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 behaviour. First, in both the baseline and reform scenarios, the consumers cannot have a negative savings flow in any period of their life until the retirement age. This condition ensures that agents do not borrow in the working years against their 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 either storage or savings technology. For this group of consumers, ECPs are the only way to accumulate any assets to smooth lifetime consumption. The presence of this type of consumers limits the scope for ECPs to generate crowding-out and will consequently yield adjustments in macroeconomic aggregates in the reform scenario, relative to the baseline of no ECPs.

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

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

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

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

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

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

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. The pension benefit from ECPs is calculated according to (**17**) (18), with or without annuity[3].

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

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

Calibration

The model is calibrated to replicate the features of the Polish economy shortly before the introduction of Employee Capital Plans, 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 the European Commission's 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 the Polish economy, i.e. 21%. Table 1 reports the macroeconomic calibrations.

Demographics

The 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].

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3 Under the law, 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. Such a structure is reached in the year 2160 (the projection until 2080 and 80 subsequent cohorts). Note that the population is stable in the initial and the final steady states in our set-up.

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 the respective tax revenues in GDP and calibrate the tax rates to match these targets. For example, the labour tax rate was calibrated in such a way that the total aggregate labour tax revenues, expressed as a percentage of GDP, matched the rate observed in the data, given the 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 some pensions paid out currently follow the defined benefit rules from pre-1999, whereas a small fraction of the pensions follows the defined contribution 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 to be relevant for the overall macroeconomic development, it is not relevant for the evaluation of ECPs, relative to the *status quo*. Given this disparity between the model set-up 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 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 labour 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].

Source: own elaboration.

[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.

Behavioural 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 at 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 the preferences of agents (such as present bias/myopia, time inconsistency, and other non-standard preferences) from unobservable constraints on their behaviour (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 optimisation and imperfect foresight) as well as from unobservable idiosyncratic shocks to household budget constraints. The empirical identification of mechanisms behind savings behaviour departing from complete rationality rests upon controlled experiments in the lab or in the field as well as policy quasi-natural experiments. As a 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 (cf. overview of the literature in Lusardi [2009], for interventions focused on raising financial literacy skills as well as Attanasio, Weber [2010], for a general review of the literature). Moreover, studies based on newly available data, plausibly "deeper" in specific contexts (such as the use of credit card spending patterns, scanner sales data, etc.), reveal that a substantial proportion of consumers whose behaviour departs from rational agent optimisation 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, Violante, 2014; Heathcote, Perri 2018, Olafsson, Pagel 2018].

Empirical evidence on behavioural heterogeneity is scarce for Poland. 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, households may be uninformed about these instruments and may consider them unattractive due to various shortcomings. Empirically, there is not enough data to determine the proportion of the population that has no savings/assets in every period of their life, which would be consistent with hand-to-mouth preferences. For example, a Polish Household Budget Survey reveals that typically the two bottom income deciles of households have no savings understood as flows, i.e. they did not set aside any income in a given year over the past decade on average. However, one cannot interpret this to mean that 20% of the population has never had any savings over

their *entire* lifetime. The evidence from the Polish Household Wealth Survey is scarce in the sense that it is only a cross-section for the time being. It shows that roughly 27% of households have negative or no accumulated wealth. This figure cannot be interpreted as a lifetime profile, either. Finally, empirical evidence from a policy quasi-natural experiment by Myck and Lachowska [2018] reveals that roughly 13% of analysed households behaved in ways consistent with full rationality, whereas the remaining 87% 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 the HBS and HWS, we are convinced that the proportion of HTM consumers is not vastly overstated in our model. Since the 25% share is far above the actual level of participation in voluntary pension savings schemes, we are also convinced that ECPs, as modelled in our study, will yield more substantial results than any previous instruments. Finally, since this figure is far below the standard 50% share used in macroeconomics, our economy should not be radically altered by a relatively small instrument. Given the arbitrariness of this choice, we examine 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: an entry bonus and an annual bonus. We introduce them to our model. All the lump-sum transfers in ECPs are calibrated to reflect the fraction of the average wage in the Polish economy. These percentages are assumed constant, i.e. in our model lump-sum transfers will increase as the economy experiences technological progress. The law does not specify the rules for indexing the two lump-sum transfers previewed, but already at the legislative stage many stakeholders suggested that some indexation rule should be specified in the law. Hence, one should expect they will not be kept constant in nominal terms.

Lump-sum transfers are conditional on working in the model, but they do not depend on earned labour income. This is a simplification in the model in the sense that, in an OLG economy, all agents work a certain fraction of their time, so it would be challenging to translate the legal thresholds into the model (especially prior to implementation, i.e. without knowing the fraction of salaried workers who were not eligible for lump-sum transfers due to insufficient contributions). Under the law, only workers contributing at par with contributions due on the minimum wage for at least 1.5 monthly wages per year[6] are eligible for annual transfers, which is not a strongly excluding

[6] Strictly speaking, there is an income eligibility criterion (below 120% of the minimum wage in a given year), which makes it possible to contribute the equivalent of contributions due for

restriction for 12 million salaried workers (out of the roughly 16.5 million active working-age population). It appears plausible that a majority of workers will be eligible for such transfers once the implementation of ECPs is complete.

Tax exemptions. Contributions paid by the employer are exempt from social security, while contributions paid by the employee are not exempt from either social security or labour income taxes. In a general equilibrium model, the wedge between net and gross income cannot be split between the employee and the employer. Since in reality most ECPs contributions are paid out of net income, we assume in the model that all ECP contributions are paid out of net income.

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 analysing cases in which individuals may choose to collect the whole benefit in one transfer payment (but with the deduction of capital income taxes).

Benefit payouts. The law regulating ECPs provides for a fixed number of periods for collecting benefits. A fixed number of periods by definition excludes a lifetime benefit (in the form of an annuitized stream of payments). Meanwhile, an extensive body of literature emphasises the insurance value of old-age benefits [e.g. Hurd, 1987; Hubbard et al., 1995; Li, 2018; and references therein]. Empirical research and theoretical contributions point to the paramount role of insuring against outliving one's own 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 benefits, while in an alternative reform scenario we implement an annuitized stream of payments.

Caps. Participation in ECPs is voluntary, i.e. consumers may decide not to participate at all (contribute 0% of their income). Once a consumer opts to participate, we assume 3.5% contributions, which reflects the lowest legal threshold[8]. For the sake of completeness, we include a scenario in which consumers may contribute 8% of their net income (i.e. the maximum contribution rate). This additional reform scenario provides information about the potential range of outcomes depending on actual employee choices in the future.

1.5 minimum monthly wages in a given fiscal year. For workers with higher earnings, the eligibility threshold consists of contributions due on six minimum monthly wages.

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

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

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 following the introduction of incentives to raise old-age savings. Third, we trace the origins of fiscal adjustments. 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 a 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.

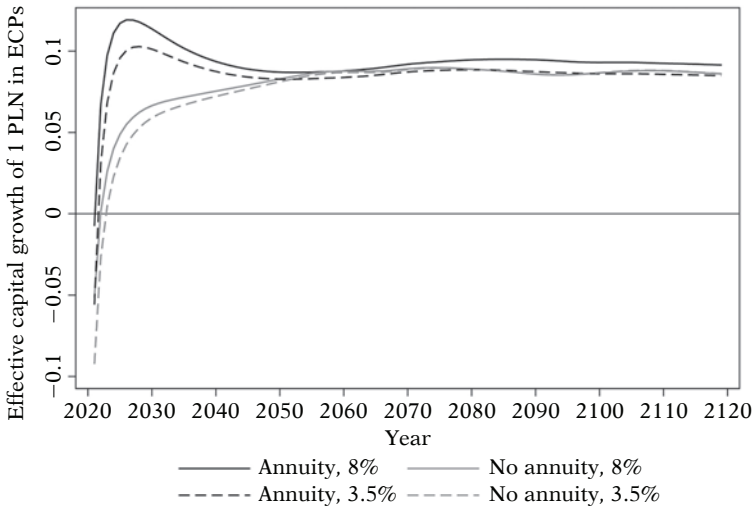
We study the effects of ECPs in four variants. First, we consider both extreme contribution rates: the minimum imposed by the law and the maximum permitted by the law: $\tau^{ECP} \in \{3.5\%, 8\%\}$ in nominal terms. Second, the ECPs do not mandate annuity, but they do not exclude it either. We thus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

Crowding-out

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

The overall level of crowding-out following the introduction of the ECPs in our calibrated economy is reported in Figure 1. We operationalise 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 households in a world without the ECPs and comparing it to assets held by households in a world with ECPs (separately for each type of instrument and accounting for within-cohort behavioural heterogeneity). Overall, every PLN 1 allocated to ECPs generates roughly PLN 0.08–0.09 in additional private voluntary savings – in other words, for each PLN 1 allocated to ECPs approximately PLN 0.91–0.92 is displaced from private voluntary savings.

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



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

Source: own elaboration.

The 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 analyse inter-temporal and intra-temporal choices with and without a given ECP in partial equilibrium and compare it to the general equilibrium final outcomes (where wages, interest rates and taxes also change as a consequence of implementing the ECPs and when adjustments in labour supply, consumption and savings of all the agents in the economy are fully internalised). In other words, we perform two comparisons of total assets in a world *with* ECPs to total assets in a world *without* ECPs. First, we compare them in an artificial environment where there was no adjustment of prices (partial equilibrium). Second, we compare them in an environment where prices have changed (e.g. the 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.

ECPs offering an 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, the 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 sav-

ings 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 private voluntary assets: with annuity, agents hold fewer 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 relatively high income in this period of their life, resulting in consumption higher than they would have planned in the absence of ECPs. With the no-borrowing constraint, this further reduces the needs for private voluntary savings. Naturally, ECPs without annuity do not generate this effect. Third, the effect works in the opposite direction: the ECPs provide lump-sum transfers to the participants: the unconsumed part of the transfer contributes to asset accumulation, which raises savings.

Table 2. Effective asset growth for fully rational agents

Scenario	Partial (behavioural) 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 optimal lifetime consumption, labour supply and savings without observing what effect these readjustments have on the aggregate economy, and thus on the final general equilibrium.

Source: own elaboration.

The general equilibrium (total) effects of ECPs comprise adjustments in interest rates (due to increased capital from the asset holdings of HTM agents), wages (due to changes in the K/L ratio and labour supply) and taxes (due to financing costs for ECPs). These overall effects trump the partial equilibrium increases for ECPs without annuity, and yield a 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 Appendix A2).

The main macroeconomic adjustments

The introduction of ECPs generates strong transitory effects on capital, consumption and labour supply; see Figure 2. The decrease in capital in the first period on the transition path is due to the timing of the 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). The introduction of ECPs brings a higher consumption tax, and anticipating this rise, households choose to consume more in total than they save when consumption is

still cheaper-hence the drop in capital in transition period 1. Note that this adjustment concerns only fully rational agents. The short-term adjustment in labour is associated with the fact that, with the implementation of ECPs, effective labour taxation declines as of transition period 2. Inter-temporally, agents prefer to supply more labour in periods when taxation is (effectively) lower and less labour in periods when the tax is still relatively higher. Naturally, the change in labour taxation is implicit, i.e. contributions to ECPs are not viewed as labour taxation, but rather as implicit savings. Contributions to ECPs, due to tax exemptions, are in fact perceived as negative taxation. Accordingly, the scenarios where the instrument offers an annuity bring a further reduction of the effective marginal labour tax[9]. Note that these effects concern only fully rational agents. 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 the labour share in the economy should translate into roughly 3.8%–8.8% per year. Given the considerable scope of crowding-out, it is not surprising that 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 non-annuitized contributions and the upper bound annuitized contributions respectively. The long-term effect on labour supply varies between scenarios. ECPs with annuity generate a modest labour supply increase: 0.22% for a nominal contribution rate of 8%, and 0.01% for a contribution rate of 3.5%. Long-term labour supply decreases for ECPs without annuity (0.12% and 0.15%, for 8% and 3.5% contributions respectively). Labour supply is far more responsive to the annuitization of ECP 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 in the perceived effective marginal labour tax rate and larger capital accumulation. The gross interest rate and wage are functions of capital and labour supply in the model economy (see Figure 9 and Figure 10).

The changes to labour supply are due to four factors working in the opposite direction. First, capital accumulation raises labour productivity and thus wages, which makes it possible for households to maintain the same income with lower hours. Second, the increase in wages renders leisure more expensive, thus increasing the hours worked. Third, the increase in total taxation

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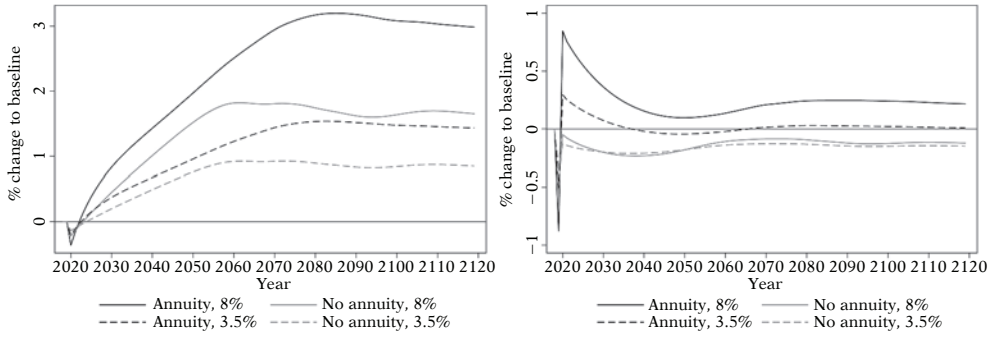
[9] Upon the implementation of the reform (transition period 2), the perceived effective marginal labour tax rate drops for agents at age $j = 1$ by: 3.3 p.p. (annuity, 8%), 1.6 p.p. (no annuity, 8%), 1.6 p.p. (annuity, 3.5%), 0.7 p.p. (no annuity, 3.5%) relative to baseline. For agents at age $j = 40$ the same rate drops by: 2.9 p.p. (annuity, 8%), 0.3 p.p. (no annuity, 8%), 1.3 p.p. (annuity, 3.5%), 0.1 p.p. (no annuity, 3.5%) relative to baseline. Within the "annuity" and "no annuity" scenarios, the differences in the drop of the perceived effective marginal labour tax rate are proportional to the contribution rates. Between the "annuity" and "no annuity" scenarios, the differences in the drop are twofold. First, the 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.

required to finance the ECPs is modelled by an increase in consumption tax. This makes consumption more expensive relative to leisure. Optimising households choose less consumption and more leisure and consequently supply fewer hours to the labour market. Fourth, contributions to ECPs offer an implicit subsidy: each unit of contribution to the ECPs brings return in excess of the regular savings due to the capital income tax exemption built into the ECPs (and due to annuities in some ECP scenarios). As a result, the perceived effective marginal tax rate on labour is lower in a world with ECPs than without them, leading to more hours supplied to the market. Naturally, this last effect is only present for fully rational agents (i.e. 75% of the population in our calibration). For HTM agents, the effective and nominal labour 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 labour supply depends on the interplay of the third and fourth effects, i.e. an explicit increase in consumption tax and an implicit decrease in labour tax. The latter is stronger for ECPs with annuities, hence for those scenarios labour supply increases relative to baseline. For ECPs not offering annuity, the suppressing effect of the consumption tax increase has the upper hand; see also Figure 3.

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



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

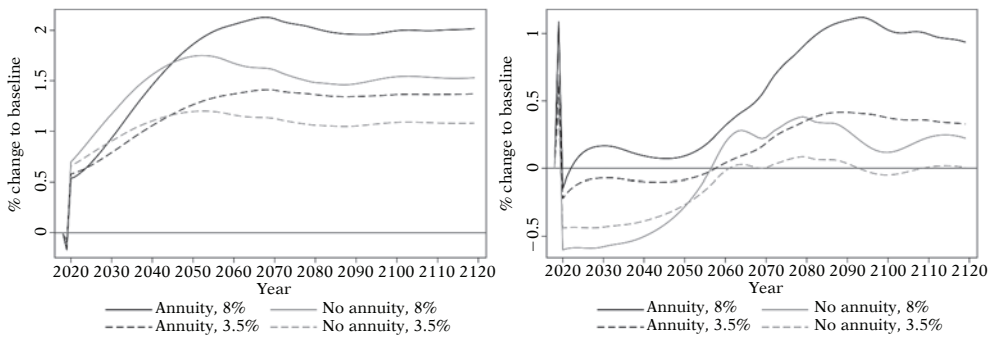
Source: own elaboration.

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 the 3.5% contribution rate and 2 percentage points in the case of scenarios with the 8% contribution rate. Figure 3 reports the necessary adjustment in taxes to balance the government (left) and

a change in aggregate consumption (right) relative to the *status quo*. Financing the lump-sum transfers and the gap in capital income tax revenues are the original drivers of adjustments in the taxation of consumption, but raising the taxation of consumption implies a decline in the relative price of leisure, thus consumption (and labour) adjusts accordingly in the inter-temporal choice of the agents. The impact of the ECPs on aggregate consumption consists of a sharp short-term adjustment (in 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 labour supply. Agents expect a future upsurge in consumption taxation (as of transition period 2). They consequently 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 in the right panel of Figure 3 is the sum of the opposing effects for different types of agents (see Figure 12 in Appendix A2). The sources of differences in the reaction of aggregate consumption between the types are explained in the following section.

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



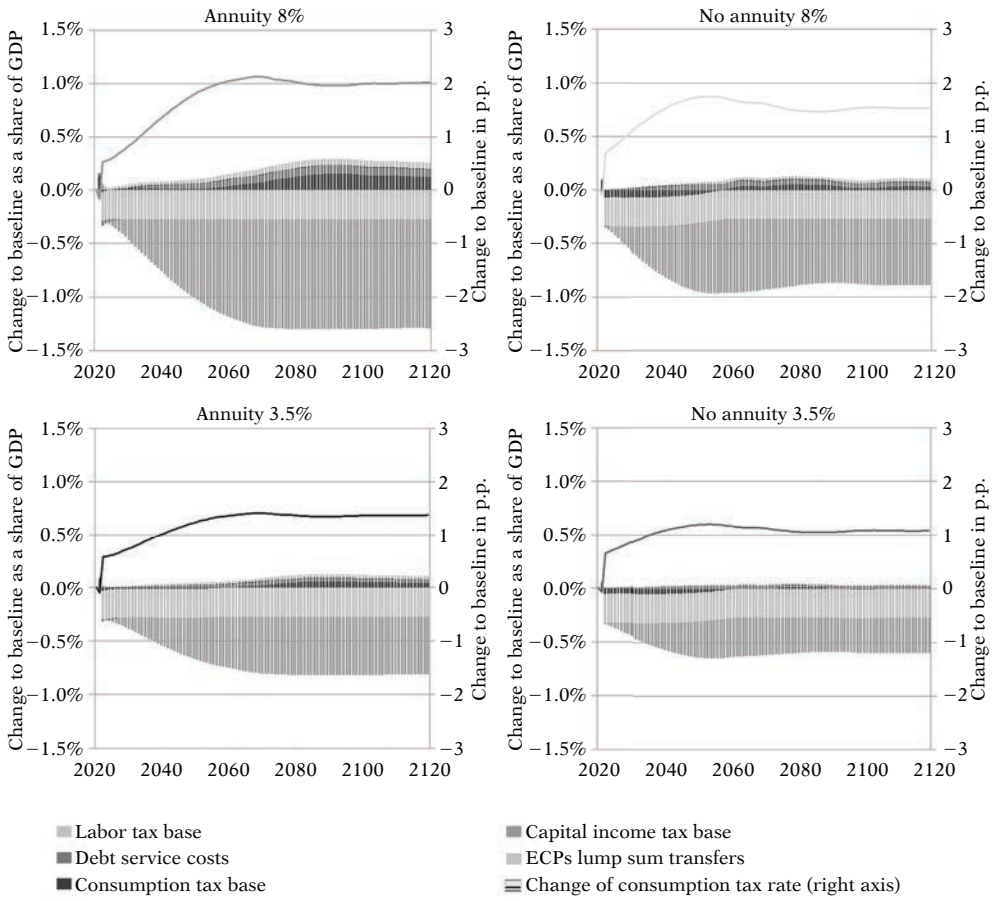
Notes: Left panel: taxes relative to baseline of no ECPs, in percentage points.
Right panel: consumption relative to baseline of no ECPs, in percent.

Source: own elaboration.

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 an exemption from capital gain tax. These transfers are fiscally costly, while their negative effect on the fiscal balance is amplified by a decline in the tax base. Changes to the tax base comprise three factors working in opposing directions. First, the basis for the capital gains tax is significantly lower (due to a shift in assets from taxable investment to ECPs). Second, labour 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 (transition period 2) for all reform scenarios. With time, consumption grows due to higher consumption

at older ages, but the increase is small and not positive for the 3.5% scenario without annuity. Overall, these three factors yield a decline in the tax base. The increase in the consumption and labour tax base is far from sufficient to compensate for the capital gain tax income loss. Against these declines in fiscal revenues, there is a reduction in the fiscal costs: higher capital implies a lower interest rate, which reduces the costs of servicing public debt.

Figure 4. The decomposition of fiscal adjustment



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

Source: own elaboration.

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

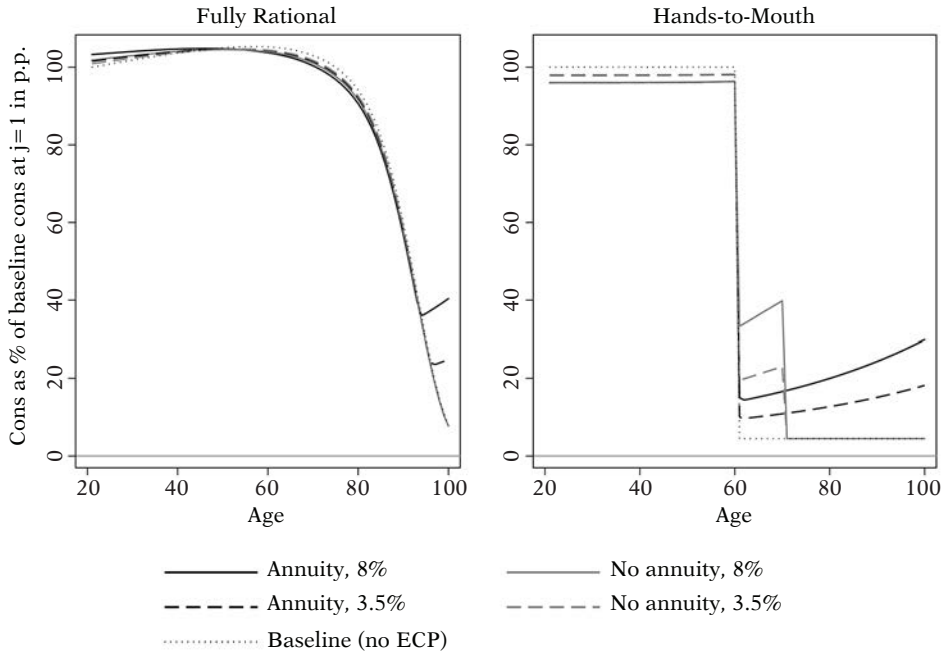
Lifecycle profiles of savings and consumption

In the long run, with the introduction of the ECPs, hand-to-mouth agents automatically reduce consumption because disposable income is lower than in the baseline scenario due to ECP contributions—see Figure 5, where we report the lifecycle profiles of consumption in the final steady state. HTM agents partially compensate for the loss of disposable income through increased labour 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 HTM agents is positive: despite an increased consumption tax, the consumption of HTM agents rises.

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

[10] After retirement, HTM agents simply consume their pension benefits (i.e. for the reform scenarios with no annuity, once the set number of payments is reached, the agents are only left with benefits from the NDC pension system). The substantial difference between pension benefits paid from the NDC system and ECPs comes 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 the gross

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

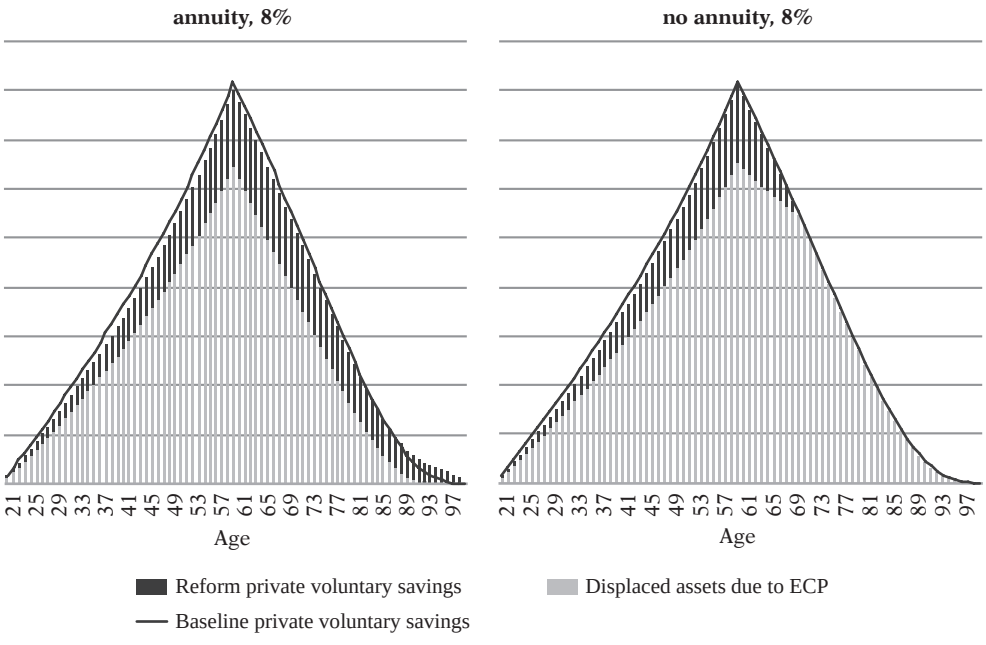
Source: own elaboration.

Figure 6 depicts the microfoundations of crowding-out: it compares the total assets held by fully rational agents[11] under two different ECPs, both with a contribution rate of 8%, one offering annuity, the other not. Fully rational agents offset 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, accumulation occurs faster, as a result of which the same level of wealth at retirement may be achieved with a lower saving rate. ECPs that offer annuity effectively raise assets held at the end of a life cycle when there is not enough private voluntary savings to perfectly offset the introduction of ECPs.

market interest rate. The long-run TFP growth rate assumed in the model is 1.54%, while the gross long-term interest rate ranges from 4.08% to 4.18% depending on the reform scenario.

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

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



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

Source: own elaboration.

Welfare analysis and participation

Policy measures such as ECPs are likely to generate welfare effects that are heterogeneous across birth cohorts. The beneficiaries are mainly those who can obtain transfers and qualify for exemptions. Meanwhile, the costs (mainly a consumption tax increase and a decreased interest rate) are spread across the entire population, including agents who were retired or close to retirement upon the launch of ECPs. Moreover, even in the long run, welfare effects are bound to differ across subcohorts of different behavioural types. Fully rational agents weigh individual benefits against the aggregate costs (due to raised taxes and declining interest rates). HTM agents obtain superior paths for lifetime consumption once ECPs are implemented (previously they were unable to smooth lifecycle consumption). Table 3 reports the aggregate welfare effects for each type of agents, while Figure 13 in the Appendix reports the welfare effect for each cohort for each type of agents. The welfare effect is expressed

in terms of a consumption equivalent (for each subsequent birth cohort) as a percentage of lifetime consumption in the 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 a change to the reform scenario. Welfare for each birth cohort expressed in terms of lifetime consumption (discounted to the age of entering the model). Aggregation across cohorts accounts for discounting with the interest rate (relevant for each scenario).

Source: own elaboration.

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

Despite the negative welfare effects, 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 decisions. Having the choice between the two alternatives, fully rational agents would generally opt for a world without ECPs. Specifically, in a political economy model, fully rational agents would vote against ECP implementation, but once the ECPs are in place, it is more beneficial to participate than to opt out.

Naturally, HTM agents benefit from ECPs. By design, they were unable to smooth consumption over the life cycle in the baseline scenario. They are able to do so to some extent with ECPs, while additionally earning interest on savings. These gains outweigh the welfare cost of increased taxation. These large positive welfare effects for hand-to-mouth consumers may be interpreted in two ways. If one assumes that HTM behavioural patterns stem from actual barriers to participate in financial markets, instruments such as ECPs may be as beneficial as our simulation suggests, i.e. they raise welfare by 17% to 47% of lifetime consumption in consumption equivalent terms. However, if HTM behaviour stems from preferences (i.e. a strong presence bias, highly time-inconsistent preferences, etc.) then forcing such agents to save in ECPs

raises welfare only formally, but not actually. Given that we lack an appropriate measurement of the scale of HTM households in the 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 time of the ECPs' introduction lose out from the change. The cohort which retires at the moment of ECP implementation experiences the largest welfare decline (they cannot participate in the ECPs, but pay all the costs associated with the consumption tax increase). For the remaining cohorts welfare gains increase with 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 closures. For example, raising labour income taxation would generate welfare and macroeconomic effects on its own, while masking the potential effects of ECPs on labour 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 counterproductive if the main objective of introducing ECPs is to foster capital accumulation. Lump-sum taxation could potentially minimise labour and capital adjustments, but implementation of this type of taxation remains to be a concern, while inter-cohort redistribution effects would be much greater. Finally, reducing the expenditure in a model such as ours would conceal the true scale of fiscal adjustments (households do not have government expenditure in their utility function or budget constraint).

Sensitivity analysis

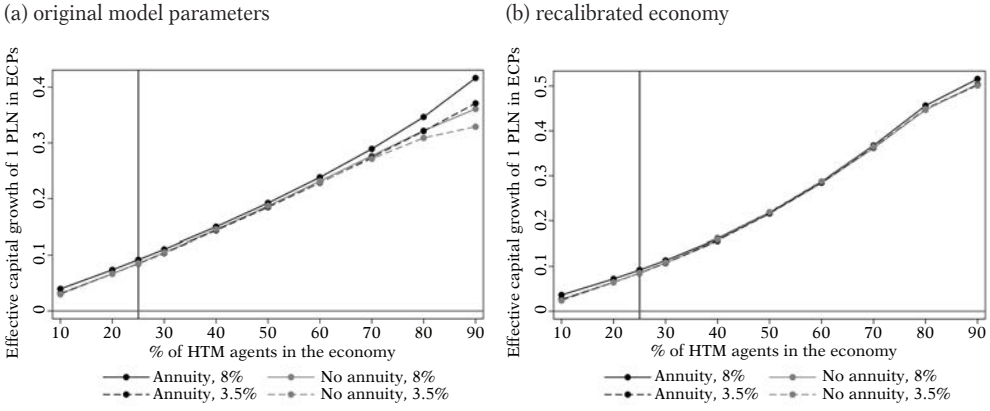
In this section, we provide an analysis of to what extent the results depend on the share of HTM agents in the economy. We show the results for an economy with the same parameters (and thus naturally different target values), and for illustrative purposes we also report analogous analyses if the target values are matched while the 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 the 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 produces positive effects on effective capital growth due to ECPs. On the other hand, the more assets HTM agents have accumulated in ECPs the greater the general equilibrium

[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. Note that an economy with 100% HTM agents does not exist (it would have no capital in the baseline scenario).

effects, most notably the declining interest rate. Moreover, the savings of HTM agents in ECPs are not responsive to changes in the interest rate, which amplifies the link between the share of HTM agents in the economy and asset accumulation by fully rational agents. Overall, this results in greater crowding-out for fully rational agents (see Table 4). The results are of similar magnitude regardless of whether the economy is recalibrated or not.

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



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

Source: own elaboration.

In parallel to the interest rate, the higher share of HTM agents amplifies the effects of ECPs on the 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 ECP implementation. Faster effective capital growth also leads to greater labour productivity, and thus higher wages. In the final steady state, a higher share of HTM agents implies a greater increase in consumption in 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. Capital income tax exemptions work in the opposite direction: effective asset growth for fully rational agents decreases 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 shows that for most reasonable shares of HTM agents in the economy, the fiscal effects are similar. It is only when the share of HTM agents exceeds 70% that the fiscal reliefs brought by the 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 predominantly concerns intra and inter-temporal choice parameters, thus directly affecting the preference for consumption.

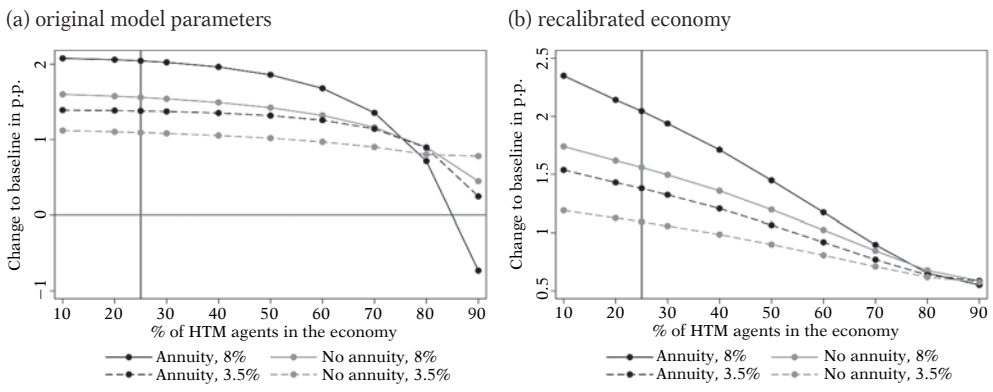
Table 4. Effective asset growth for fully rational agents – across % of HTM agents

Scenario:	Total (general equilibrium) adjustment									
	% of HTM agents in the economy – original model parameters									
	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. The general equilibrium effects of ECPs increase with a growing share of HTM agents in the economy. This is due to the simple fact that HTM agents have no adjustability when it comes to asset accumulation. The higher their share in the economy, the higher their net impact on the macroeconomic variables. The details of the recalibration are reported in Appendix A3.

Source: own elaboration.

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



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

Source: own elaboration.

Table 5. Welfare effects of ECPs

Welfare effects for fully rational agents										
Scenario:	% of HTM agents in the economy – original model parameters									
	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										
Scenario:	% of HTM agents in the economy – original model parameters									
	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 of the recalibration are reported in Appendix A3.

Source: own elaboration.

The positive welfare effects for 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 HTM agents an opportunity to earn interest on savings. If the economy is not recalibrated a larger share of HTM agents is equivalent to a higher interest rate in the economy, leading to greater gains from being able to earn interest on savings. For fully rational agents, ECPs reduce welfare (unless they are sufficiently large *and* provide an annuity). The larger share of HTM agents is thus consistent with the 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 (see also Figure 14 in the Appendix).

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, Employee Capital Plans (ECPs) are being gradually introduced as of 2019. They offer tax exemptions and lump-sum transfers to participants. We provide an *ex ante* evaluation of this instrument. We add behavioural heterogeneity in the form of hand-to-mouth agents to an otherwise standard overlapping-generations model. This enriched model is further extended to account for endogenous participation in the old-age savings instrument, which replicates the features of the ECPs.

Our analysis suggests that the ECPs will cause a modest increase in total capital in the economy. The total assets of HTM agents are increased, but 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 a decreased interest rate, discourage fully rational agents from saving. Overall, the increased asset holdings of the HTM agents are counterweighed by the reduced asset holdings of the fully rational agents. The overall long-run effects of the ECPs on capital creation range between 0.8% and 3.0% relative to the baseline. Back-of-the-envelope computation excluding both the crowding-out and general equilibrium effects would yield a long-run capital increase of roughly 3.8% to 8.8% relative to the baseline for the lower and upper bounds of the ECPs contributions respectively. The general equilibrium effects also bring a decrease in labour supply, though when ECPs offer annuities then the implicit decrease in the effective marginal labour tax rate is enough to increase aggregate labour supply above the baseline level.

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

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

These results have to be taken with a grain of salt. HTM agents operationalise a vast plethora of possible behavioural patterns, some of which are conceptually inconsistent with the welfare gain. Notably, if agents do not save because they do not *want* to smooth 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 increase 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 that need to be mentioned in the summary of our study. Admittedly, the agents in our model inhabit a deterministic world in which there are no concerns about the government's commitment to the ECP project. In the real world, idiosyncratic labour 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 that would fully account for uncertainty about policy and longevity, but introducing income shocks to our set-up could make agents seek safe assets and thus potentially consider ECPs as a superior investment strategy compared to investing on one's own (e.g. due to the ability to fully diversify financial market risks).

Also, our model *isolates* the effects of the ECPs, holding all other economic processes constant between the baseline and reform scenarios. 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 after the peak of the business cycle, accompanied by substantial changes in social transfers and fiscal policy. Isolating the effects of ECPs from other factors in observational data may indeed be impossible. Moreover, in our model, agents could not accumulate old-age savings in any tax-incentivised instruments prior to ECPs, while in the real world there are options such as employee pension plans and individual savings accounts. While the participation rates for such instruments are low, our model cannot be used to predict the link between ECP enrolment and those instruments.

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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):

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

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

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

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

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

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

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

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

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

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

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

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

FOCs for HTM agents (using additional notation):

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

$$l_{j,HTM,t} = 1 - \frac{1-\phi}{\phi\tilde{w}_t}(1+\tau_t^c)c_{j,HTM,t} \quad \text{for:} \quad j < \bar{J}$$

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

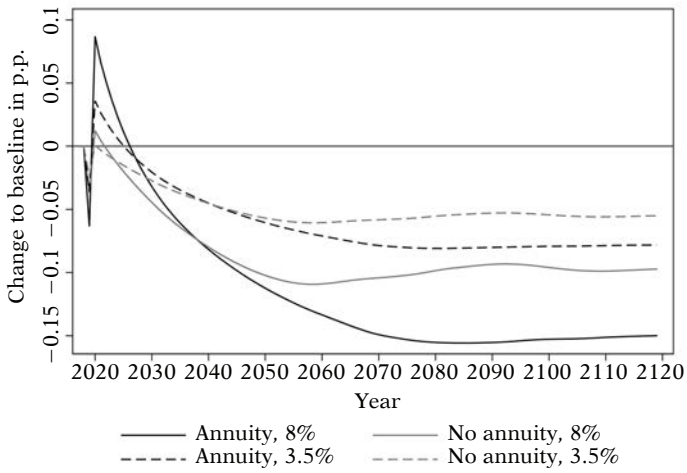
$$c_{j,HTM,t} = \frac{l_{j,HTM,t}\tilde{w}_t - \mathrm{Y} + bequest_{j,HTM,t}}{1+\tau_t^c} \tag{20}$$

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

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

Appendix A2

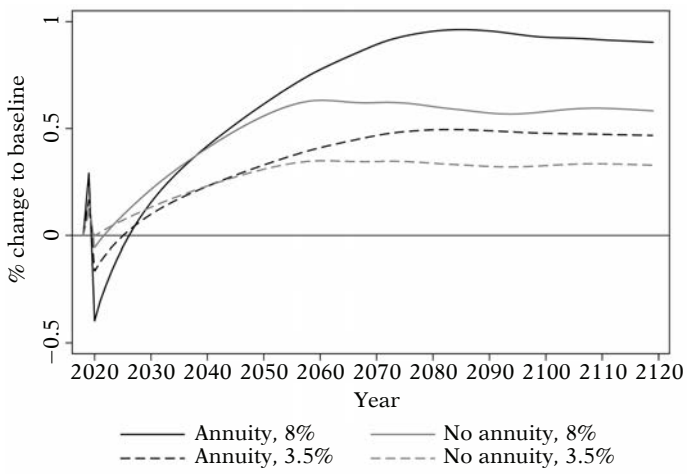
Figure 9. Gross interest rate with ECPs relative to *status quo*



Notes: ECPs effectively increase the 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 the gross interest rate in the first period on the transition path is due to the gradual implementation of the ECPs: they are set to be implemented as of 2020 (transition period 2), but the agents are aware of them as of 2019 (transition period 1).

Source: own elaboration.

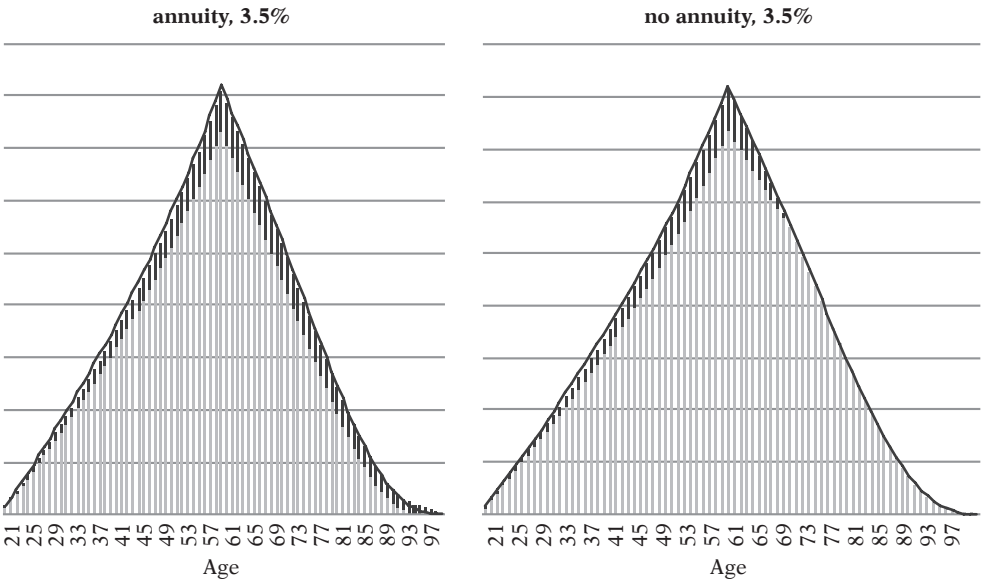
Figure 10. Gross wage rate with ECPs relative to *status quo*



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

Source: own elaboration.

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

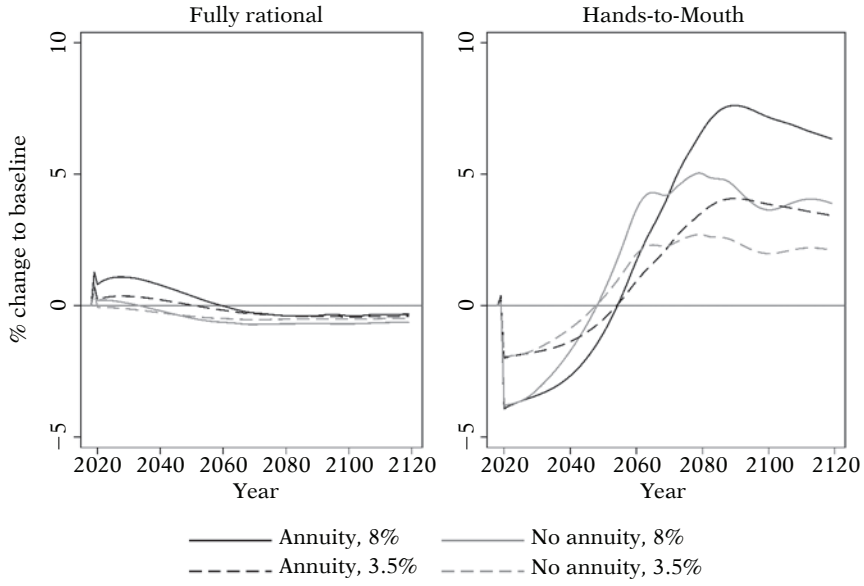


Notes: Fully rational agents almost perfectly offset assets accumulated in the ECPs. For ECPs offering annuities total assets are effectively larger with ECPs than without them. During the

accumulation period (for both types of ECPs: with and without annuities) the total assets are slightly lower. ECPs offer a capital gain tax exemption, and hence the same level of assets at retirement may be achieved with lower effective saving rates. The dynamics of wealth accumulation for fully rational agents are the same under the 8% and 3.5% contribution rates. The effects are proportionally less pronounced.

Source: own elaboration.

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



Notes:

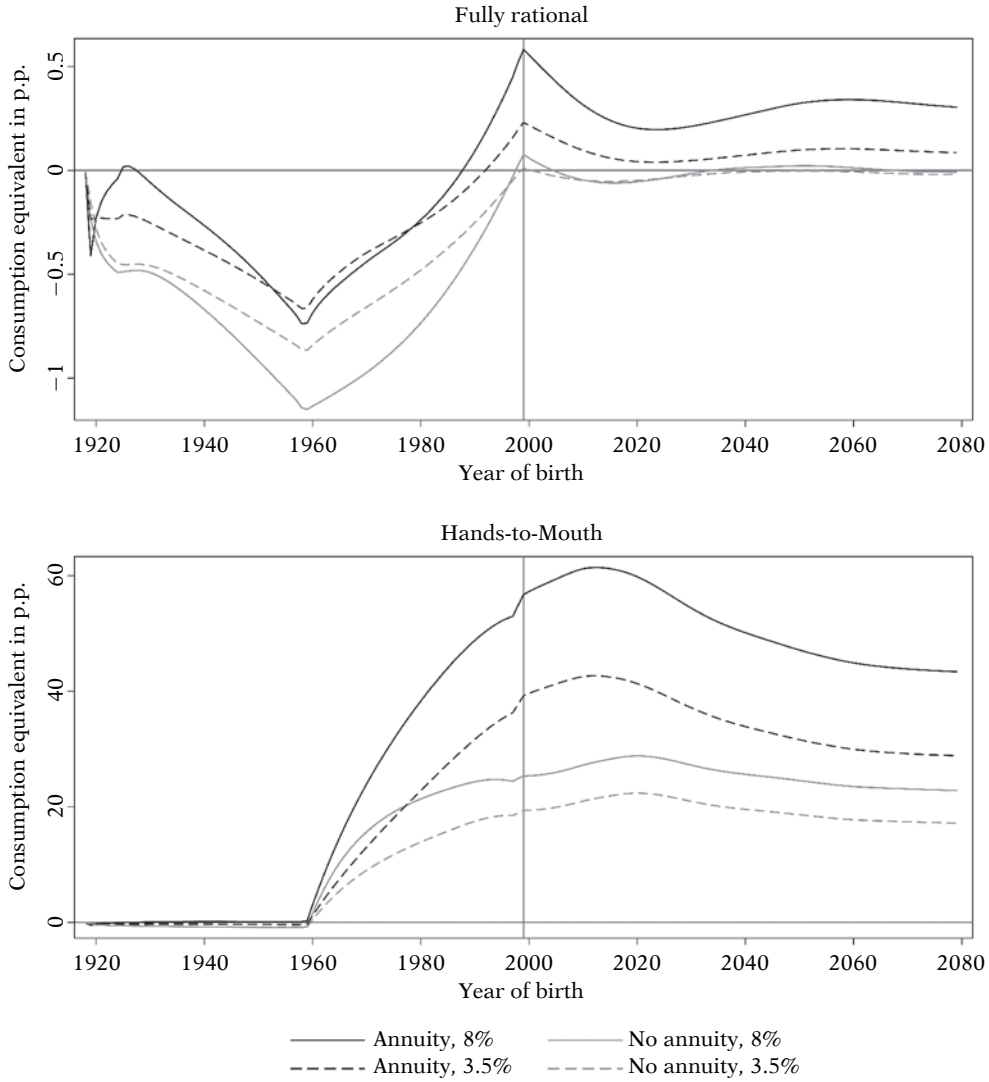
(left panel) Consumption for fully rational agents changes due to two main factors. First, it decreases across the whole life cycle due to an increase in the consumption tax rate. Second, in order to arrive with the same *level* of assets upon retiring the capital gain tax exemption in ECPs allows for a lower net savings rate. This allows for higher consumption when young. The long-run effect on the 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 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 the whole life cycle due to an increase in the consumption tax rate. Second, it increases during retirement as ECPs offer consumption smoothing that was outside the HTMs' choice set. Third, as HTMs have no means of consumption smoothing except the NDC pension system and ECPs, the whole amount of contribution decreases disposable income, thus mechanically reducing consumption when working. At the beginning of the transition path the net effect is negative. With time participating cohorts retire and after a couple of decades the net effect on the HTMs' aggregate consumption becomes significantly positive.

Source: own elaboration.

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



Notes: The grey vertical line in Figure 10 represents the cohort born in 1999, which enters the labour market at the time of the ECPs' introduction – they are the first cohort that may participate for the whole working period. The consumption equivalent is expressed in percent of lifetime consumption.

Source: own elaboration.

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

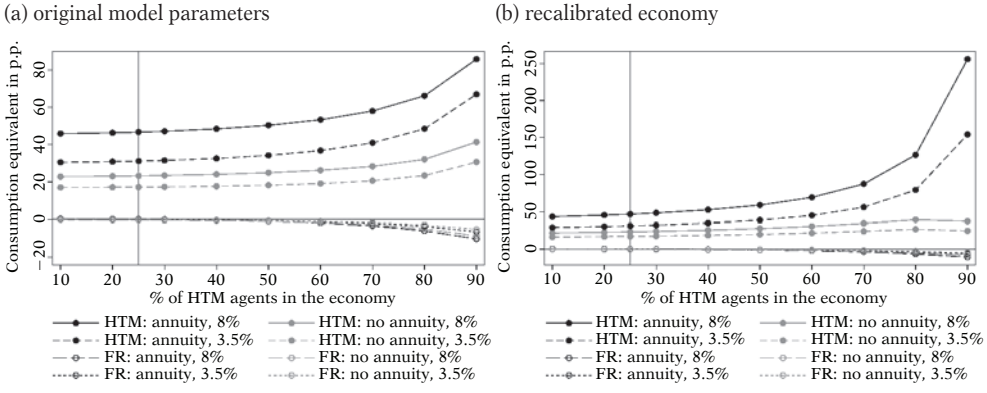
Changing the share of HTM agents in the economy influences two aspects of agent behaviour. First, HTM and fully rational agents decide about labour supply based on different optimisation problems. Second, only fully rational agents accumulate private assets. Therefore to arrive at the same set of macroeconomic variables only two parameters need to be manipulated: discount factor (δ) and the 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 in bold. The 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



Notes: The 25% share of HTM agents is highlighted with a vertical line. The points on this line correspond with the figures presented in Table 2. ECPs not only allow HTM agents to smooth consumption over the life cycle, but also give them some access to financial markets. The higher the interest rate, the more welfare improving this access is. Therefore the welfare of HTM agents increases with their share in the economy. Fully rational agents get some utility from annuities (when offered) but the net welfare effect of the distortions due to ECPs is negative. Hence the more pronounced the general equilibrium effects are, the worse it is for these agents. The details of the recalibration are reported in Appendix A3.

Source: own elaboration.

Pracownicze Plany Kapitałowe – ewaluacja *ex ante* w warunkach niepełnej racjonalności

Streszczenie: Publikacja przedstawia ewaluację *ex ante* efektów dobrobytowych, fiskalnych i makroekonomicznych wprowadzenia Pracowniczych Planów Kapitałowych. PPK oferują ulgi podatkowe i dopłaty, których celem jest pobudzenie oszczędności na starość. Zmniejszenie wpływów budżetowych z tytułu podatku od zysków kapitałowych oraz koszt pokrycia dopłat rocznych powodują konieczność kompensacyjnego podniesienia innych podatków. Do oszacowania skali tych efektów zastosowano model nakładających się pokoleń. W modelu uczestnictwo w PPK jest dobrowolne, a część agentów cechuje się niepełną racjonalnością. Oba elementy stanowią innowację w literaturze przedmiotu. Dla preferowanej przez nas kalibracji wyniki wskazują na relatywnie wysoki efekt wypychania: w przybliżeniu jedynie od 0.08 do 0.09 PLN z każdej złotówki trafiającej do PPK to nowe oszczędności. Prawdopodobne wartości efektywnego wzrostu kapitału wahają się, w zależności od kalibracji, między 0.03 a 0.42 PLN z każdej złotówki w PPK. Wprowadzenie PPK pociąga za sobą istotne koszty fiskalne. Większość z nich ma swoje źródło w uldze podatkowej od zysków kapitałowych oraz w dopłatach. Racjonalni agenci doświadczają utraty dobrobytu, chyba że PPK oferują wystarczająco dużą rentę dożywotnią. Natomiast agentom, którzy nie są w pełni racjonalni PPK zapewniają istotny wzrost dobrobytu.

Słowa kluczowe: model nakładających się pokoleń, PPK, niepełna racjonalność

Kody klasyfikacji JEL: C68, D63, E17, E21, H55

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