FOSTERING OLD-AGE SAVING UNDER INCOMPLETE RATIONALITY

Technical Report

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Abstract

Most developed countries provide dedicated old-age savings programs with tax incentives. These programs are typically motivated by the argument that the fiscal incentives absent, people would not save enough for the old-age and thus face the risk of poverty in the last decades of their life. We verify this conjecture. We develop a model in which individuals' age and the subsequent generations of individuals overlap. In this model economy, individuals exhibit many types of bounded (incomplete) rationality, which prevents them from taking the old-age savings decisions such as a fully rational *homo oeconomicus* would take. We study these savings patterns. We then introduce a government-subsidized old-age saving instrument and study participation by incompletely rational individuals, as well as the changes in their savings behavior. Our simulations of this policy instrument are calibrated to the case of Poland, but our results may easily be adapted to any other economy. Key finding of this report is that the government-subsidized old-age saving instruments may raise consumption by the incompletely rational individuals, but will not actually raise wealth accumulated prior to the retirement. We also document who benefits and who loses from fiscal incentives typically featured in old-age voluntary savings programs.

Keywords: incomplete rationality, pension systems, life-cycle

1. Introduction

For a variety of issues well documented in psychology and neuropsychology, humans are not well equipped to imagine future (Gilbert and Wilson, 2007; Schacter et al., 2018, 2012; Seligman et al., 2013). This limitation has paramount consequences for the old-age savings choices: as humans we are unequipped to decide how much time we should devote to making the right choices, let alone what are the actual right choices and how to motivate ourselves to actually follow through on such far-reaching plans.

Meanwhile, the models that governments use to design pension systems assume that we optimize our consumption for our entire lifespan, and that we then stick to this plan vigorously. These models invariably assume that individuals have access to all necessary information, perfect foresight of the future and essentially unlimited capacity to process this data instantaneously and at zero cost. Such rational individuals, who populate standard models, accumulate assets in the working ages and de-accumulate assets after retirement. Meanwhile, there is evidence for persistent lack of savings in the working ages (Weil, 1992; Kaplan, Violante, & Weidner, 2014). Hence, conventional economic models which are used to study the life-cycle asset accumulation produce predictions which are at odds with observational data as demonstrated in a review by Frederick, Loewenstein and O'donoghue (2002).

But with the development of new modeling techniques – and ever growing computing power – we can depart from rational expectations and add real-like people into otherwise standard economic models. We can thus find out about the preferences for accumulating old-age savings by incompletely rational individuals. We find that those individuals have very different life-cycle profiles for labor supply, consumption and accumulation of old-age savings.

The incompletely rational individuals find it optimal to have much less assets at retirement than fully rational individuals – and experience lower consumption profiles in the old-age. These low consumption profiles may be a policy concern in a sense that some level of consumption is necessary to survive (e.g. healthcare services, subsistence consumption, shelter) and the preferred old-age consumption levels may actually, in some cases, fall short of what the society considers minimum consumption. Such cases would usher a policy intervention (e.g. social assistance), which is effectively redistributive.

To see if viable policy alternatives exist, we study the role of government subsidized old-age voluntary pension schemes. Such schemes exist across the OECD countries and typically offer tax redemptions to individuals, who voluntarily choose to contribute private voluntary savings. We study if providing such instruments is attractive for incompletely rational individuals. We also study if participating individuals observe higher accumulated wealth at retirement, and higher old-age consumption. Our simulations account for the fact that these government subsidized old-age voluntary pension schemes are fiscally costly and thus need to be financed through raised taxation.

We answer the following questions:
- o What are the old-age savings patterns by incompletely rational individuals? How do they differ from fully rational individuals?
- o Could a policy bridge the gap between fully rational and incompletely rational individuals in terms of their assets at various points in life?
- o Can the situation of incompletely rational individuals be improved?

2. Homo oeconomicus and other "species"

2.1   What does it mean to be fully rational? In economics, rationality means that the individuals are characterized by three basic features. First, individuals have perfect foresight and their preferences are stable over time. Second, individuals have unconstrained ability to process all this information to absorb it in current and future choices. Third, individuals have unconstrained ability to transfer assets between periods (i.e. accumulate for the old-age or store precautionary savings for the periods of adverse shocks to earned income). These three premises guarantee that individuals in models construct optimal life-cycle profiles, execute optimal plans without any deviations, and use all resources efficiently. It does not mean that all individuals are wealthy, all the less so that individuals are necessarily equal. It may still hold that one is endowed with lower productivity (and so earns less), higher leisure preference (and so works less) or lower patience (and therefore saves less). This is referred to as intra-cohort inequality. Moreover, an individual of a given type has less wealth at the young age than an individual of the same type at older age. This is referred to as inter-cohort inequality. However, these differences (inequalities) in wealth and lifetime profiles reflect merely differences in preferences.

Common for all ages and all types of individuals is the ability to perfectly foresight the future (i.e. all the next periods that are relevant for their decision making). Individuals are assumed not to make mistakes in this foresight. This way of modeling expectations was introduced by Muth (1961) and later popularized by Lucas (1972). Under rational expectations, the individuals use all the available information, thus their perception of prices and tax rates in the future does not differ systematically from the equilibrium outcomes.

Fully rational individuals make labor supply and savings choices such that their lifetime consumption profile is smooth and possibly equal in present value terms. This means that individuals rationally adjust not only with respect to their time preference (patience, i.e. the willingness to postpone consumption to the future periods), but also the probability that they will live long enough to experience this consumption (i.e. life expectancy).

Ability to make foresight is a very powerful tool for individuals, as it enables them to decide about consumption today such that they maximize a lifetime stream of utility and not just instantaneous happiness. Individuals expecting to earn no income in the old-age, will accumulate assets in order to finance old-age consumption. Individuals expecting a pension benefit will accumulate a lower stock of assets, because they will need to only supplement pension benefits. In an extreme case, where pension benefits are equal in present value terms to the earned income (a 100% replacement rate in net present terms), there will be virtually no need for assets accumulation, as the individuals would afford the same consumption throughout life time, without smoothing it by accumulating assets in the working period and dissaving in the old-age. [2]

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[2] It is important to bear in mind that in this study we focus only on saving for retirement. For the sake of brevity we isolate the saving process motivated by consumption needs during retirement from other possible motivations for saving. In general saving may be motivated by other factors as well. They may include inclination to leave bequest or precautionary savings, which are accumulated in order to mitigate hardship caused by temporary unemployment or any other adverse events. All figures in this study will show exclusively retirement savings. This doesn't mean that we deem other savings than those for retirement as not optimal and unnecessary.

With preference for smooth consumption profile in present value terms, the instantaneous savings flows are a consequence of a lifetime plan. This plan results in a peak of accumulated assets just prior to retirement. These premises yield a bell-shaped assets accumulation lifetime profile, with individuals reaching maximum wealth in the year of retirement and gradually de-accumulating in the subsequent years. The exact shape of the bell – curvature – depends on the relationship between the interest rate in the economy, the time preference, and the life expectancy. Individuals expecting higher survival probabilities after retirement – a process referred to as longevity – will accumulate higher wealth at retirement, *ceteris paribus*. Likewise, individuals expecting pension benefits to decline, will increase instantaneous savings flows, *ceteris paribus*.

Figure 1 shows the optimal assets accumulation path of fully rational individuals who are 40 years old today, (i.e. born in 1979).[3] From the very first year of their labor force participation it is optimal to accumulate assets with retirement in mind. The slope of the assets profile of the fully rational individuals is getting steeper during working years, meaning that the rate of asset accumulation is accelerating. This is due to the fact that the more accumulated assets we have – the more interest they accrue every period.

Figure 1: Optimal asset accumulation path of fully rational individuals (depicted are individuals born in 1979)
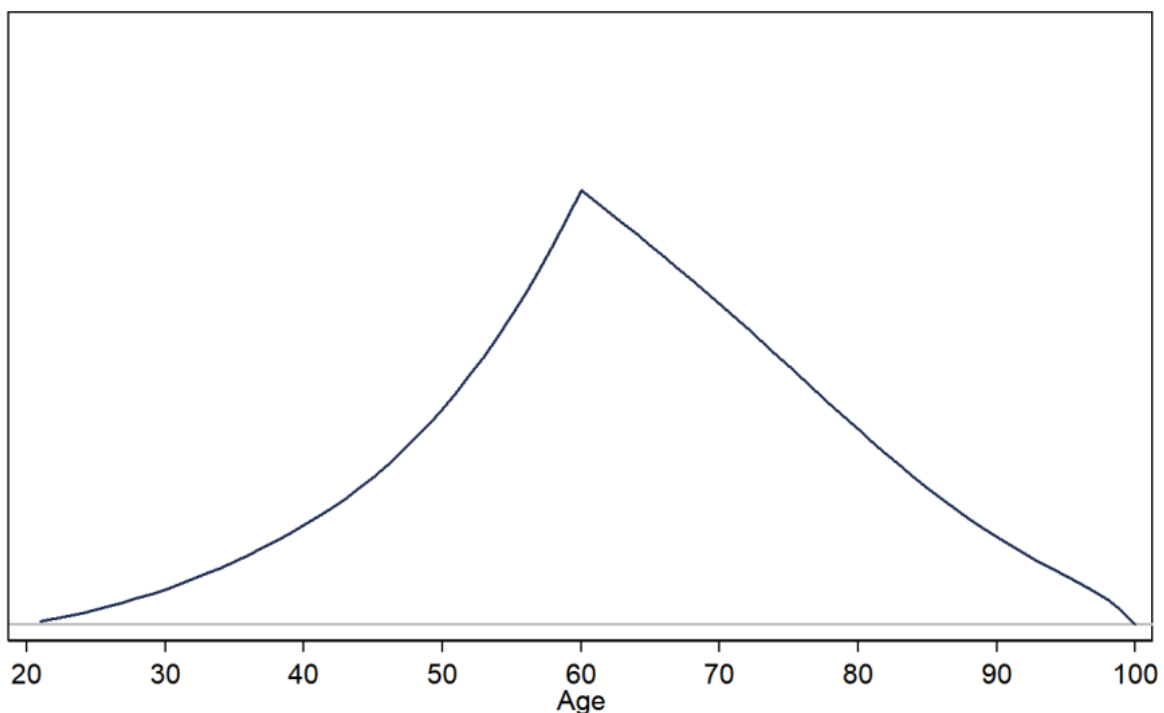
Note: Wealth is measured in model units, i.e. in real terms, adjusted for economic growth and changes in the size of population. These units do not have a natural analog in colloquial terms, hence we abstract from reporting the unit values on the vertical axis. The detailed curvature and peak of this profile will depend on the interest rate in the economy, life expectancy, tax rates on incomes and consumption as well as labor share and preference parameters (leisure preference and patience). To obtain the plot, we made the assumptions consistent with the Polish economy. Note that while the specifics of each profile may depend on the economy, the difference between the homo oeconomicus and the incompletely rational individual will not. Animations showing the changes in this profile as longevity progresses, and the full set of data, are available at the project website: http://grape.org.pl/incomplete-rationality.

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[3] Our model provides optimal paths for all subsequent cohorts in Poland. The full set of data is available at the project website: http://grape.org.pl/incomplete-rationality. For illustrative purposes, in the report we focus on the generation of the current 40-year olds, but at the website you may find animated paths for all the subsequent cohorts, as they experience longevity and as the world in which they live changes.

2.1.1 Optimal assets

In economics, the term assets is pretty comprehensive. Imagine a household which took a mortgage for a couple of decades to buy real estate and expects to inherit some more real estate within a couple of decades. This household is currently in debt, but in economic terms, it has a disciplining device to accumulate wealth over the years to come and has expectation of bequests, which together with the real estate will contribute to the total wealth of this household. Naturally, the year of bequest need not overlap with e.g. retirement planning, whereas the return on the assets is actually the net value between the change of the value of the real estate and the interest on mortgage repayment. However, this exemplary household will eventually have accumulated assets. Note that a loan for a new car is typically not conducive to accumulating assets in economic understanding, because the car is typically considered instantaneous consumption.

The main problem with modelling individuals as fully rational is that this assumption implicitly requires the individuals to gather enormous amount of information and to actually possess the ability to process it. Naturally, in reality people have only limited access to information, gathering information is costly, and we all have only a limited ability to derive conclusions. We build on these intuitions about limitations to complete rationality in subsequent sections. Specifically, fully rational individuals exhibit very strong reaction to longevity and immediate reaction to future changes in pension and tax system parameters. These strong reactions tend to be at odds with empirical evidence. For example, most of the time we make choices under incomplete information and under uncertainty. In such circumstances, we often rely on heuristics, which may over-simplify reality and make us choose suboptimally. This line of research, pioneered by Daniel Kahneman and Amos Tversky in the 1970s has demonstrated, among others, that people are not eager to gather all available information and that they process only a fraction of information they already

possess. Furthermore, abundant literature in psychology and economics studies present the so-called commitment problem: we know and acknowledge it is good for us to exercise regularly, but every day, we genuinely believe that the next day is the one to start a daily routine – as argued already in 1950s by Robert H. Strotz (1955).

2.1.2 Incomplete rationality

People differ behaviorally: very similar people can make strikingly different life-time decisions. Even if two people have the same productivity, face the same mortality risk, and have the same time and leisure preference – they can still choose savings for retirement differently. For example, let us assume that the first person is like a rational *homo oeconomicus*, the second person has issues with commitment (keeping up with the original plan), and the third person has issues processing information about the future (prefers to think that things do not change much). We adopt a convention that the first type of individual is fully rational and other types of individuals are incompletely rational. They still make their choices and optimize them, but the way that they make those choices is consistent with experimental literature, rather than with the *homo oeconomicus* set of assumptions.

These limitations on our rationality translate strongly to old-age. For example, studying the reaction of the Polish population to a substantial decline in pension wealth, Lachowska and Myck (2015) show that roughly 13% of the sample adjusted consumption in the directions and magnitudes predicted by the theoretical optimization of the fully rational individuals. Consequently, 87% of the population made a judgment error, and this error will carry over decades ahead to old-age consumption.

2.2 Who is incompletely rational?

There is only one way to model complete rationality in economics. Yet it is important to recognize that alternatives to the standard expected utility model are abundant. We consider individuals who lack any

foresight, individuals who fail to implement their own optimal plan and individuals who are limited in their ability to smooth out consumptions between life periods through accumulating asset. The most extreme version of this restriction is when the individuals cannot store wealth at all. The economic literature calls these individuals hand to mouth individuals. We also consider individuals who can store wealth, but do not receive interest rate on these savings. Thus, the four forms of incomplete rationality which we study violate the assumption of rationality in different ways. These different ways stem from either preferences or abilities.

2.2.1 Adaptive learners

One of the most dominant departures from the assumption about complete rationality stems from the fact that updating expectations (and changing one's mind about what is optimal) is costly. It is thus rational to only update lifetime choices if reality deviates from the previous situation by a sufficient amount. This phenomenon is referred to as rational inattention (see for example Mankiw & Reis, 2002; Sims, 2003; Mackowiak & Wiederholt, 2009;2015; Caplin & Dean, 2015). Individuals with such preferences update their lifetime patterns, when reality "surprises" them (enough), but continue to uphold their expectations until that occurs. In the setup used in this report, knowing model parameters and current exogenous macroeconomic aggregates, the individuals may form expectations about future evolution of prices and taxes, choosing lifetime paths for labor supply, assets and consumption accordingly. The so-called *adaptive learners* do not anticipate any changes. They do see that the world

has changed in the past, but believe that it will remain unchanged for the rest of their lifetime.

Attention about the world around

One of the most pronounced secular trends of our times is growing longevity. This trend was experienced already by the early war generations, but is most pronounced for the post-war generations. Improved diagnosis and treatment of cardiovascular diseases and elimination of the standard contagious diseases (e.g. tuberculosis) has prolonged the lives of the subsequent generations by as much as 10 years. This implies that a current 50-60 year old (post-war generation) should not expect to die at the age of 60-70 years (as was statistically frequent in their grandparents generation), they should not expect to die at the age of 70-80 (as is statistically frequent in their parents' generation), but will on average substantially exceed 80 years of age, with a considerable fraction of each cohort celebrating 90th birthday and more. Yet, in most surveys people tend to report life expectancy short of 80 years of age. Thus, they accumulate lower wealth for the old-age, because they believe they will need to supplement their consumption for much lower number of years than is factually correct.

People also typically remember the tax rates in place when they first paid taxes or when they paid the highest taxes – not the current tax rates. And more frequently they have a perception about tax rates (high/low, increased/declined) than being able to recall actual numbers. Underestimating the growth of taxes in the future, people will not accumulate sufficient wealth (e.g. to maintain net income and/or consumption in gross terms at satisfactory levels).

Table 1: Types of incompletely rational behaviors

Inattention	These individuals believe that the economy remains unchanged in the future.
Present bias	Myopic individuals who procrastinate. They make plans, but do not follow through.
Hand-to-mouth	Consumption every period equals instantaneous disposable income.
Low financial literacy	Individuals unable to earn any significant interest on their assets.

Learning process, as defined here, resembles the real world people much more than the perfect foresight assumed for the fully rational individuals. With a change in macroeconomic aggregates, previous choices of the adaptive learners may no longer be optimal, necessitating adjustment in lifetime paths.

While planning their future, adaptive learners solve an identical problem as fully rational individuals do. However, every period they expect tax rates, wages, interest rates, and survival probabilities (and hence also pension benefits) to remain unchanged relative to the current period. Once the economy and the population stop changing, people who are adaptive learners have nothing more to learn about, making them essentially rational. Except, of course, that the economy and the population always change.

Figure 2 shows the asset profile of adaptive learners born in 1979, compared to a profile of a fully rational individual born in the same year. Adaptive learners save and work less than they should, also, they consume too much when they are young as they

simply expect to live shorter lives at retirement. As a consequence, they accumulate lower wealth than fully rational individuals and thus they cannot consume as much as they would have liked to in their old-age. Longer life expectancy – generally a good information – is not reflected in the choices of adaptive learners, so they accumulate too little assets.

2.2.2   Present bias

Present bias has been at the core of behavioral economics since Strotz (1955), and has been characterized as time inconsistency. In colloquial terms, this phenomenon has been used to model procrastination (belief that in the future one will improve on one's behavior) or myopia (excessively strong discounting of the future) and may be related to a variety of behavioral and cognitive failures of human brains (for review see Ainslie, 1992; Wilson & Gilbert, 2003;2005). Time inconsistency is typically modeled in economics as quasi-hyperbolic discounting, following the formalization by Laibson (1997;1998).

Figure 2: Assets accumulation path of incompletely rational individuals compared to homo oeconomicus (born in 1979)
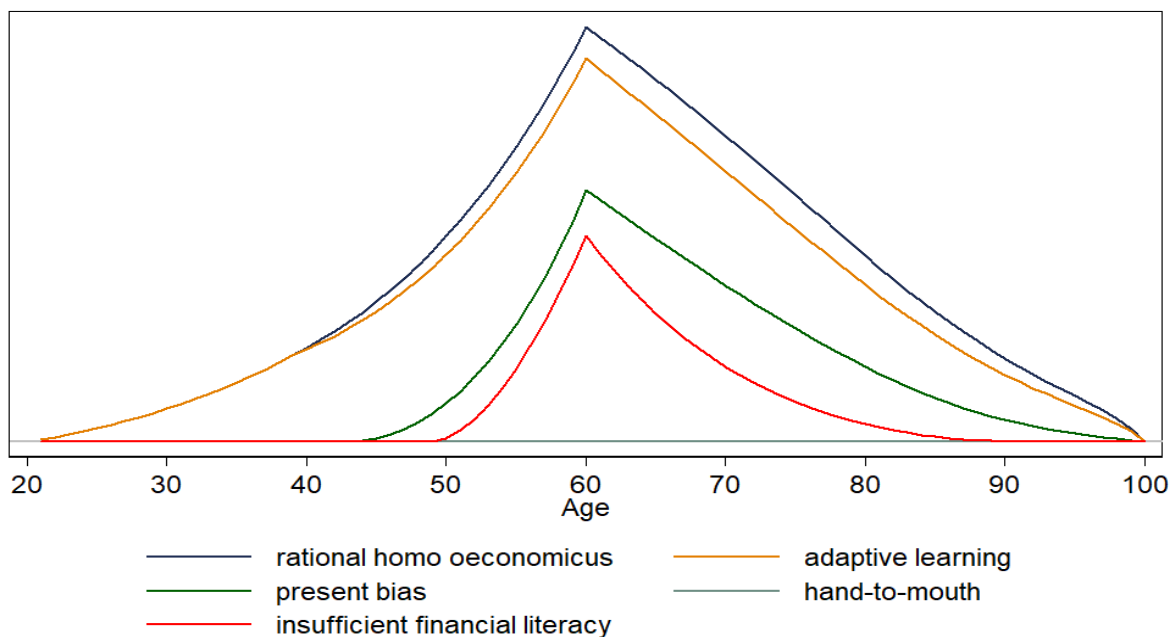
Note: see note under Figure 1. Animations showing the changes in this profile as longevity progresses. The full set of data is available at the project website: http://grape.org.pl/incomplete-rationality.

Time inconsistent individuals understand that future has value and may exhibit generally time preference similar to fully rational individuals. However, they have an additional preference for the present. Consequently, this type of behavior implies that we do not stick to our plans: saving certain fraction of income is viewed as optimal in say 5 years to the future, but when the time for saving comes, this level of savings is actually excessive.

Planning for the old-age usually involves putting money aside. But when it comes to actually putting money aside, for a plethora of reasons, we do not. For example, whatever we do not consume today actually makes us sad immediately, whereas the gratification of future consumption is delayed into the foggy future. Also, putting money aside is not nearly as exciting as spending it immediately. Consequently, we do not meet our own targets in terms of how much wealth is accumulated for the old-age. Moreover yet, we deplete these assets too fast.

The role of pension systems, if individuals display time inconsistent preferences, seems particularly appealing: when old, individuals would like to have their consumption smoothed, but do not do so when optimizing at young age due to discounting the future too strongly. This intuition was formalized by Feldstein (1985) in a two-period overlapping generations economy with inelastic labor supply and no uncertainty: myopic individuals under-save for old age, hence a mandatory pension system can improve welfare, because it provides a commitment device – a stick that makes us stick to our plans.

However, in the setup by Feldstein (1985), the individuals do not decide about labor supply, nor assets. Hence, they cannot react to the features of the pension system at all. In a full-sized computational application with income uncertainty and perfectly elastic labor, Imrohoroglu, Imrohoroglu, and Joines (2003) show, that individuals with sufficient degree of time inconsistency do not find it optimal to participate in the pension system at all,

even if it provides actuarial reward for survivors (i.e. an additional return on top of the equilibrium interest rate). They also show that in the world populated by time inconsistent individuals, pension systems constitute a commitment device, but at a high price in the form of reduced capital stock (and thus smaller economy). In fact, the general equilibrium effects coming from reduced capital stock outweigh the individual gains from more smooth consumption over lifetime.

Figure 2 shows the asset profile of time inconsistent individuals born in 1979 compared to a profile of fully rational individuals born in the same year. Up until mid-forties, time inconsistent individuals save literally nothing. Up until this point the temptation of present consumption and leisure was greater than the fear of old-age poverty. Yet, time inconsistent individuals do recognize that they require assets to finance old-age consumption. From mid-forties onward the accumulation period begins and the savings rate is actually higher than for the fully rational individuals. This requires them to work much more than the fully rational individuals and consume less. Despite this great effort time inconsistent individuals are unable to undo their past choices and they end up with smaller amount of assets accumulated at the moment of retiring than the fully rational individuals. Due to lower assets and higher effective patience, the time-inconsistent individuals reduce assets (and thus consumption) at a faster rate than fully rational individuals, thus further lowering their old-age consumption in comparison to fully rational individuals.

2.2.3 Hand-to-mouth individuals
It is well established in empirical literature that a fraction of each birth cohort holds no assets: be it financial or illiquid (e.g. real estate; see Christelis, Georgarakos, & Haliassos, 2013; Mian, Rao & Sufi, 2013, for Europe and the US, respectively). The phenomenon of households who consume total current income and do not smooth consumption over shocks or into the old ages has been introduced into

macroeconomic modeling by Weil (1992). Subsequent contributions have studied the role of short-term credit (e.g. Parker, 2017), instantaneous wealth (e.g. Kaplan et al., 2014; Olafsson & Pagel, 2018; Heathcote & Perri, 2018) as well as the context of financial literacy (e.g. Lusardi, Michaud & Mitchell, 2017).

The literature has firmly established that some individuals tend to immediately dispose of income, even if their current stream of e.g. labor revenue permits sufficient liquidity for robust instantaneous consumption and non-zero savings rate. This result holds even after adjusting for observable health and labor market shocks.

Hand-to-mouth behaviour

In a compelling study of IT specialists in one of the Nordic countries, it was shown that high and medium earners alike exhibit extreme levels of conspicuous and unnecessary consumption on pay days. Credit card expenditure patterns reveal higher than usual restaurant, clothes and leisure expenses on the pay day, in excess of 400% of typical spending on other days in the month. These patterns are regular (every next pay day) and cannot be explained by e.g. positive or adverse shocks such as a medical service bill, broken car, birthday, promotion, etc. By the end of the month, the studied population had typically not accumulated wealth. Individuals who consume entire instantaneous income have no old-age savings, and thus their old-age consumption is much lower than during the working age.

We model that type of behavior as a rule that consumption equals instantaneous income. We call them hand-to-mouth individuals, as they immediately consume everything that they earn or receive as benefit. In absence of any government-subsidized saving instrument, these individuals simply hold no assets at all. This means that hand-to-mouth individuals are able to smooth consumption thanks solely to the universal and mandatory pension system.

2.2.4 Financial literacy

Extant literature documents insufficient financial literacy around the world (Xu & Zia, 2012; Klapper et al., 2015). An insufficiently knowledgeable individual cannot gain interest on income withheld from immediate consumption. These individuals can store wealth, but cannot earn the market interest rate. Because individuals typically prefer to consume today than tomorrow, if they earn no interest, they typically find postponing consumption not beneficial.

Typically, financial literacy is diagnosed through a set of relatively simple questions, testing an ability to compound interest and turn nominal values into real terms (for a recent overview see: Lusardi & Mitchell, 2014) and Lusardi, 2019) The subjects are not even expected to give actual figures. They are expected to identify the ball park of the correct answer (Lusardi, 2012; Lusardi & Mitchell, 2014). Despite this admittedly low bar for qualifying into the financially literate group, roughly 30% of adults in the advanced economies reach the bar.

Individuals with low financial literacy save very little, because it seems to them that compensation for giving up contemporaneous consumption is too low. Indeed, whatever they actually put aside does not bring them much income, as they earn low or no return in real terms. Hence, they have low savings and these savings only slowly accrue interest.

Given this setup, individuals with low financial literacy save for retirement only relatively late in their life. The assets accumulation profile (see Figure 2) of financially illiterate individuals is similar to those of time inconsistent individuals. There are two important differences though. First, they start to accumulate assets even later in their life-cycle and even more intensively. Second, in the very old age they actually deplete their asset stock completely. This leaves them vulnerable to any adverse shocks as they have no resources left to cover e.g. out-of-pocket medical expenses.

Comparing financially illiterate individuals to fully rational individuals, shows that interest rate is a powerful driver of asset accumulation decisions. Financially illiterate individuals postpone asset accumulation to the last few years of the working period and de-accumulate these assets relatively fast, effectively achieving only little consumption smoothing. In essence, they are able to smooth consumption more than hand-to-mouth individuals, but less than time-inconsistent individuals.

2.3 The pattern of assets accumulation and old-age consumption

Incomplete rationality reduces the amount of potential consumption in the old age. This effect is twofold. First, having accumulated a lower stock of assets upon retiring leaves incompletely rational households with assets which have to be spread thinner over the remaining expected lifetime. Second, incomplete rationality limits the possibility to earn interest on accumulated capital, so consumption depletes the accumulated assets faster than in the case of *homo oeconomicus*. Hence, individuals with incomplete rationality are more prone

to old-age poverty. Figure 3 portrays consumption at various ages of retirement, for each type of studied individual, relative to *homo oeconoicus*.The rapidly falling consumption of incompletely rational individuals relative to fully rational *homo oeconomicus*, are demonstrated. This consumption may be as low as 20-50% of the consumption of a fully rational individual in expected lifetime of roughly 25-30 years after retirement.

Note also that in modelling retirement outcomes models *have to* take into account incomplete rationality, otherwise they end up with individuals with implausibly high old-age consumption. In Figure 3 hand-to-mouth agents consume exactly the equivalent of a pension benefit and it turns out to be 7% of the consumption by *homo oeconomicus*. That entails that a perfect decision-maker should accumulate assets vigorously enough to allow him/her to consume more than tenfold of what a state-provided pension benefit would amount to. Hence, models relying on such fully rational agents simply yield implausibly high financing of old-age consumption from private voluntary savings.

Figure 3: Consumption after retirement for incompletely rational individuals given as a percent of consumption of fully rational *homo oeconomicus* (born in 1979).
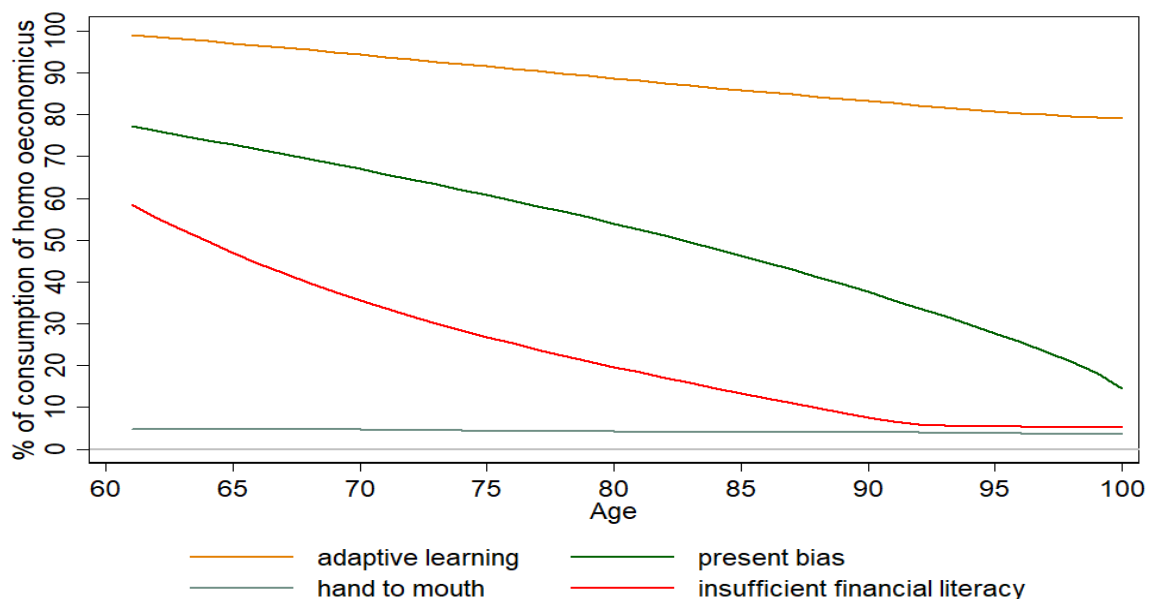
Note: Consumption for each type of incompletely rational individual is given relative to the consumption of fully rational *homo oeconomicus*. Not surprisingly, top to bottom ordering of the behavioral types in Figure 3 and Figure 2 is the same: the less one accumulates when working, the less one consumes during retirement.**Error! Reference source not found.**

2.4 Modelling instruments which encourage pension savings

We develop an overlapping generations general equilibrium model, in line with Makarski & Tyrowicz (2017). The full model setup is presented in a background paper supporting this report, available at http://grape.org.pl/incomplete-rationality. The model uses demographic projections for evolution of longevity and fertility for Poland as of 2018, but our methodology can easily be adapted to any other country and time. The first simulated year in the model economy is 2018, since this year onwards we use the exact expected demographic structure and evolution of the rate of technological progress as per European Commission (2018). Our study abstracts from the role of annuity in the context of old-age saving: the economy is always fully annuitized.

In our model, households of all behavioral types choose how much time to work in each period of their life (the so-called intra-temporal choice) and how much of the current income to save (the so-called inter-temporal choice). These choices are made in order to maximize well-being, which increases with consumption, but declines with labor. Consumers in our model generally like their life-time path of consumption to be smooth: high consumption in working period and the extremely low consumption in the old age makes them less happy than a comparable path of consumption which is spread more equally throughout one's life time. These assumptions are all consistent with the empirical evidence on the behavior of households in the economies. They also help us to make the choices of the households tractable. Thus we can observe how changing economic environment (e.g. taxes or mortality) translate to the choices of the individuals.

Households in our model are heterogeneous in a sense that they solve different optimization problems (behaviorally heterogeneous). Despite solving different problems, individuals of each types are "similar individuals". By this we mean that their productivity, leisure preference, and mortality are the same.

In addition to households, the model economy consists of a production sector, and a government which provides public goods, levies taxes and manages the mandatory state-provided pension system. Using capital and labor, the economy produces a composite final good. Production function takes a standard Cobb-Douglas form.

The model is calibrated to replicate the macroeconomic features of Polish economy, averaging over the years 1995-2018. Using data from national accounts we know the investment rate, which helps us to calibrate the depreciation rate. Using data from the labor force survey, we know the aggregate labor force participation, which helps us calibrate the aggregate preference for leisure. We also use the taxation data from the OECD to adequately calibrate the tax rates for capital, labor, and consumption, so that in the model, the share of those tax revenues in GDP is similar to what was actually observed.

The pension system is set to replicate the features of the Polish economy. We assume all individuals participate in the notionally defined contribution system (NDC) with no capital pillar. This assumption is the same for both the world with and without an instrument, so this model feature does not affect the conclusions referring to effects of different instruments.[4]

We use the OECD data to calibrate the effective retirement age. It varies between 60 and 61 years of age. Given the narrow range, we chose 61 years of

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[4] Naturally, a small fraction of individuals in Poland in 2018 still held assets in the reduced, previously mandatory capital pillar, but (a) it is already substantially reduced both in terms of the contribution rate and the share of the contributing cohorts; (b) it is effectively eradicated during the ten years before retirement due to gradual transformation of accumulated assets in to NDC drawing rights; (c) within a couple of months as of when this report is concluded, the existing capital pillar will seize to exist in its current form and the new form has not yet been determined

age, as plausibly more relevant for the cohorts born after world war II. Note that the retirement age does not change over time and is the same in the simulations with and without the instrument, hence this feature of the model does not affect the conclusions referring to the instrument.

The size of the contribution rate to the mandatory pension system is typically calibrated to match the share of pension expenditure in GDP. However, currently the data on pension expenditure cover both old cohorts receiving pensions from the previous, defined benefit system and the few cohorts receiving pensions already from a defined contribution system. We cannot thus use raw data and thus we follow Tyrowicz and Makarski (2017) who report final steady state values for Poland, once the transition from defined benefit to defined contribution pension system is complete. Their calibration of Polish economy is analogous to ours, with the exception of behavioral heterogeneity.

Our model is a general equilibrium model, which means that all of the macroeconomic variables adjust to changing demographics and behavior of households. For example, as longevity increases, individual households will decide to save a higher fraction of their income during the prime age, which will result in change of the capital stock in the economy, thus affecting labor productivity and interest rates. Indeed, these variables adjust endogenously in the economy.

Also fiscal variables adjust endogenously. The consumption tax adjusts endogenously to satisfy the government budget constraint. In order to mitigate the potential effects of change in fiscal policy on the analyzed processes, we assume that the government continues with the debt-to-GDP ratios as in 2018.

The government needs to adjust taxes for two main reasons. First, evolving demography changes all macroeconomic aggregates (e.g. less people work – as old age dependency ratio increases) and thus taxes require adjustment to satisfy the government budget. Second, the government balances the government expenditure on tax incentives for old-age saving schemes. The government expenditure was set to match the data from national accounts on government expenditure share in GDP. We keep this share constant, because the interest of the analysis is to isolate the effect of incomplete rationality on old-age savings rather than analyze the potential scenarios of government expenditure. Table 2 reports the macroeconomic calibrations.

Table 2: Calibration of the economy

Description	Target	Outcome
Output elasticity with respect to capital	Conventional level	0.33
Depreciation rate of capital	Investment rate: 20.6%	6.1%
Effective consumption tax rate	Effective rate: 12.1%	12.1%
De iure capital gain tax rate	De iure rate: 19%	19%
Effective labor tax rate	Effective rate: 4.82%	4.82%
Effective contribution rate to the pension system	NDC benefits/GDP: 5%	8.2%
Government expenditures as %GDP in initial SS	G/Y: 26.6%	26.6%
Debt to GDP ratio	Debt/GDP: 55%	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 1998-2018. The target for the pension system following Makarski and Tyrowicz (2017).

3. Do we need government to save for the old age?

Conventional, fully rational individuals smooth their consumption following time preference, which reflects patience. Government programs which "force" them to save more than they would have themselves preferred may reduce old age poverty (e.g. among highly impatient individuals, who prefer to consume when young, thus accumulating little assets in general). However, these programs cannot improve their "life plan" otherwise called felicity or utility. Government subsidies, because they need financing, will be reflected in taxes and can affect the felicity only if they are redistributive in nature: in net terms they take from individuals with one set of characteristics (e.g. high patience) and give to individuals with another set of characteristics (e.g. low patience). Generally, for the fully rational individuals, the split of resources between consumption when old and young cannot be improved by government instruments.

The situation is different once incomplete rationality is considered and it depends on the type of incomplete rationality. In some cases, the necessary intervention requires "fixing" the world, i.e. complementing the existing solutions and instruments with better information and/or better regulation. In some cases, fiscal incentives may be a relevant tool to use.

3.1 Fixing the world

For certain types of incomplete rationality, the proper policy toolset comprises of information and regulation actions, but does not necessitate fiscal incentives. For the adaptive learners, the main problem is that they do not appreciate the extent of longevity. Fiscal incentives to stimulate adequate savings are an expensive way to educate. A cheaper way to achieve the same objective is raising their understanding of the demographic transition and make them aware of longevity. Meanwhile, for people who have barriers in earning the market interest rate (e.g. they do know

how to make a bank deposit, but not how to acquire stocks or how to balance a portfolio), fiscal incentives are trumped by simply making the standardized old-age saving instruments available for them. From the perspective of these individuals, the market is incomplete and proper regulation of the market can increase their lifetime resources. Overall, to address these two types of incomplete rationality, the government intervention consists of education and quality regulation of the financial markets.

3.2 Fiscal incentives

Regardless of the quality of regulation, despite more awareness, people with time inconsistency and people with hand-to-mouth behavior will continue with insufficient (or even zero) old-age savings, unless the government introduces vehicles targeted at overcoming the commitment and behavioral problems of these individuals. People with present bias appreciate a commitment device that makes them stick to their plan. Note that they require incentives at accumulation stage, so instruments which exempt pension contribution from labor taxation, but tax pensions are fully effective in incentivizing the savings. They can also be designed in a fiscally neutral way once the initial transition is complete, that is, when the first young participating birth cohorts reach retirement.

In the case of the hand-to-mouth individuals, the key to proper design of financial instruments is to understand the origins of this behavioral pattern. One way to think about consuming income in its entirety is to acknowledge low income individuals, whose income barely exceeds subsistence consumption. In those cases, fiscal incentives are an attractive way, but the savings vehicles ought to be characterized by small contributions. Consequently, those savings vehicles can finance old-age consumption in negligible magnitudes (likely high fraction, but low in absolute terms). Another way to think about

consuming income in its entirety stems from extreme preference for present (zero or negligible weight attached to future consumption) or commitment issues (leniency towards reckless, compulsive behaviors). To the extent to which the society limits the scope for such behaviors in general (e.g. through road traffic regulations, limiting access to stimulants, etc.), government intervention mandating participation and compensating (at least partially) income lost due to mandatory contribution may be in place.

3.3   Pension system vs. pension savings

Behavior of incompletely rational individuals is not only different when compared to fully rational *homo oeconomicus*, but also it differs between different types of incompletely rational individuals. Incomplete rationality is a heterogeneous phenomenon. It is unlikely that one policy may suit them all.

In this sense, universal pension systems – typically reparticipatory, so based on a pay-as-you-go principle, that is, working age generations pay contributions and older generations collect pension benefits – provide some basic protection against old age poverty. However, the more generous these systems, the greater distortion they provide for the choice of labor supply (contributions may partly be viewed as labor taxation) and the choice of savings (incentives to accumulate private wealth are lower if pension benefits are high relative to earned income). Consequently, the universal pension systems are characterized by a trade-off: they reduce or eliminate old-age poverty, but at the expense of introducing inefficiency to the economy.

This trade-off hints that perhaps private voluntary old-age savings schemes could be an interesting replacement: they should help to alleviate old-age poverty in the same way, without the adverse distortions in labor supply decisions and savings decisions. As was demonstrated in our report, if people are characterized by incomplete rationality, their totally voluntary old-age savings are insufficient.

Individuals with incomplete rationality accumulate lower asset stock during their working life. This renders them prone to old-age poverty.

Our treatment of incomplete rationality thus far isolated one type of behavioral patterns. However, it is plausible, that a given person is characterized by a combination of incompletely rational behavioral patterns. We show that there are effectively two separate channels through which individuals may exhibit incomplete rationality. First, their preferences may be such that their choices are internally inconsistent with their preferred outcomes or are externally inconsistent with reality (and different from a fully rational *homo oeconomicus*). Second, it could be that their sources of revenue cannot stay at par with a fully rational individual: they either cannot store assets (like the hand to mouth behavior) or can put money aside, but do not earn commensurate interest on it (like people with low levels of financial literacy). These departures from fully rational individuals permit to identify specific components of incomplete rationality and their role for old-age saving. The real policy challenge, however, is to identify the prevalence of each of these patterns in the society. What we are able to show with our model is that observing a high fraction of individuals with no old-age savings may signify both a policy challenge (e.g. many households not putting funds aside because they cannot earn interest on it) and a social preference (e.g. many households with present bias). It is the context of this observation (the behavioral origin and the features of the universal pension system) that determine if and what type of policy intervention is needed.

3.4   Current state of the debate and insights from our project

Among the OECD members, all have introduced some form of government-subsidized old-age saving instruments (OECD, 2018). The subsidy typically concerns an exempt on capital income gains taxation. These instruments are capped, i.e. legislation imposes a limit on assets that can be

saved (flow, e.g. annually) or held (stock, e.g. a life-time maximum) and be subject to tax exemption. The other savings, even if held with the sole purpose of subsidizing old-age consumption, are not exempt from capital income taxation. Typically, these schemes are voluntary.

Such instruments impose fiscal costs (due to tax exemptions) and are expected to help reducing old-age poverty by raising old-age saving. Typically, the governments judge the success of these schemes by the enrollment rate (a share of citizens choosing to participate in a given scheme).

For the purpose of this report, we study the introduction of a government subsidized old-age saving instrument with endogenous participation. Our instrument replicates the features of many such instruments around the world. First, the instrument provides full exemption from capital gains tax. Second, the participation is voluntary: the individuals endogenously choose the age at which they choose to participate and in principle they may prefer not to enter the instrument at all. Third, the instrument is capped and the participation is binary, that is, when deciding about participation, the individuals consider only two options: no participation (the contribution rate of 0%) and full participation (for a given contribution rate).

The details of this policy experiment are relegated to a background paper available online (http://grape.org.pl/incomplete-rationality). Below, we summarize the key insights.

1. Fully rational individuals change nothing in their behavior.
2. Individuals with present bias and individuals lacking financial literacy may afford smoother consumption paths, but the actual level of old-age wealth at retirement is the same regardless of the government subsidized old-age saving instrument. Hence, it remains below the levels for fully rational individuals.

3. Introducing the instrument raises somewhat their stream of life-time income (e.g. from interest on assets), but is accompanied by reduced labor supply relative to the *status quo* of having no instrument.
4. Individuals with hand-to-mouth behavior gain access to additional income, but at the expense of reducing their consumption in the working age. Generally, their consumption path is smoother.
5. Eventually, all types of individuals choose to participate in the instrument, but individuals with higher preference for the present choose to join later in their lives. Bigger instruments (higher contribution rates) are characterized by participation later in life.
6. Taxes needed to finance this instrument reduce the gains from having access to this instrument at all. The more tax advantages the instrument offers, the bigger this negative effect is.
7. For the fully rational individuals, the necessary rise in taxation results in negative felicity relative to status quo.
8. Participation is not a good measure of success of such programs. Fully rational individuals participate even though introduction of such programs lower their welfare. The welfare loss is due to fiscal cost that is independent of their individual decision to participate, but rather by the participation decision of all the individuals
9. For individuals with incomplete rationality, felicity increases overall.

3. Discussion

Pension choices are difficult not only because many variables are unknown and finding optimal outcomes requires math. They are difficult also because essentially we make them every day, but typically without full understanding of the long-term consequences. Introducing bounded or incomplete rationality to macroeconomic models of pension systems allows us to evaluate how far off "mark" an average person is likely to end up, when that person does not follow a fully rational *homo oeconomicus* life path. We can also then study whether voluntary, government-subsidized pension schemes can help to bridge the gap between potential outcomes and socially desirable low levels of old-age poverty.

We find several important novel insights explaining how **the savings of the incompletely rational individuals differ from a fully rational *homo oeconomicus***. We demonstrate that indeed, incomplete rationality results in much lower levels of accumulated pension wealth. If the universal pension system is not generous, old-age poverty may be a real threat for many types of individuals. This threat is particularly relevant if individuals are characterized by more than one type of incomplete rationality in parallel. For example, individuals who do not update their beliefs and have present bias will observe a greater departure from *homo oeconomicus*, as these departures accumulate.

Second, we ask if **government subsidized old-age savings programs bridge the gap between fully rational and incompletely rational individuals in terms of their assets at various points in life**. Wfound that in fact it is not possible to close the gap. More importantly, the gap cannot be even partially bridged for many age groups. However, it is possible to raise the assets that incompletely rational individuals accumulate for retirement. Here, the type

of incomplete rationality is of significance: policy making requires understanding the types of bounded rationalities prevailing in a given society. The diagnosis requires mainstreaming many well established behavioral economics tools. It is also imperative to develop wealth panel data to be able to observe how individuals and households realize long-run savings plans. This type of data is available for some of the Nordic countries, for example, providing valuable insights into the potential challenges for social policy.

Third, we show that **government-subsidies on old-voluntary age saving schemes may improve the outcomes for the incompletely rational individuals**. However, these instruments cannot eliminate the differences in the wealth accumulated for financing old-age consumption. In fact, such instruments typically allow the individuals to have smoother consumption paths already in the working age, but do not raise the accumulated stock of wealth relative to status quo. The tax incentives are fiscally costly and thus typically reduce efficiency in the economy. If they redistribute between different types of households, some may benefit more than they lose from an overall rise in taxation.

Overall, incomplete rationality does not constitute a case for tax incentives to old-age savings. In the case of some forms of incomplete rationality, the necessary reforms include rising awareness and proper regulation of the markets. The fact that people choose to enroll in government programs does not prove that financial incentives were needed or that they are efficient. As we show in a background paper, fiscal incentives are not the indispensable element of the bundle. For the other individuals, tax incentives may be justified by the fact that otherwise participation in the government scheme at the

working age is "too painful". While we can all always save, postponing consumption by low earners may imply current consumption below subsistence levels. The implementation challenge relates of course to the fact that individually, the type of incomplete rationality is unobservable to the government. This makes it impossible to target the subsidies directly and necessitates trade-offs between inefficient fiscal expenditure (on incentives), leaving some types of households behind (in case incentives were to be absent). More research is needed into relating the insights from behavioral economics into proper design of the savings instruments. Whereas until now behavioral economics was utilized in order to identify effective incentives (nudges) to make people join the government-subsidized old-age saving schemes, our study shows that encouraging participation may be futile and redundant for some age groups. Meanwhile, we call for more research into empirically identifying the prevalence of bounded rationality across the societies. .

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